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# Multidexterity—A New Metaphor for Open Innovation

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**Abstract:** Open innovation will have an important role to play in recovering from the aftermath of the coronavirus and it has already made a crucial contribution. The prism of COVID-19 ("COVID" hereafter) has made more vivid both the complexity and unpredictability of managing innovation. This article considers why today's open, intrinsically unpredictable business environments require updated theories for managing innovation. Concept formation lies at the heart of all social science progress and in this paper, we propose a new concept to accurately reflect the turbulence and complexity of managing open innovation in a post-COVID world. We argue that the innovator's dilemma—a still influential argument that suggests exploiting current resources necessarily reduces the likelihood of successful exploration for new resources—is an increasingly problematic theoretic anchor. Furthermore, the prescription based on this line of thinking that organizational leaders should foster ambidextrous capabilities is increasingly suspect as leadership is more broadly shared and organizational processes become less easily dichotomized and controllable. We argue that the operating context for organizations is now so complex and ambiguous that it is time to revisit and revise the widely accepted concept of "ambidexterity" and we describe the updated and expanded construct as Multidexterity. "Multidexterity" is the organizational ability to simultaneously carry out multiple search and selection activities based on diverse strategic logics and levels of knowledge to generate a portfolio of innovative outcomes. We describe a number of case studies of extreme and unique collaboration to underpin our revised concept. Our paper reveals the advantages of the updated view, outlining the fresh insights it can generate. We conclude by setting out an agenda for future research and suggesting that joint empirical research by academics and practitioners is needed to further develop this approach to innovation.

**Keywords:** innovation; open innovation; ambidexterity; Multidexterity; COVID; innovation leadership

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## 1. Introduction

As Cankurturan and Beverland [1] note, few could have predicted the COVID outbreak, the subsequent government responses, and the resulting almost immediate loss of markets, as rapid collapse in consumer demand ensured the bull-whip effect quickly took hold within supply chains [2,3]. The disruptive and, often catastrophic, events caused by the pandemic do conform to the characterization of "wicked problems" [4] and in seeking to address such problems, managers are required to break out of an established pattern of thinking. COVID-19 manifests as an urgent, global challenge, the like of which the innovation community has not seen for a century. However, as countries, businesses, and societies erect barriers and close down, the innovation community has done the opposite. It has opened up to an historic degree by forging new partnerships, sharing information, resources, people, and know-how in a collaborative effort to defeat the virus. The level of these collaborations; their motivation; the variety of partners and their leadership show that this has created a new inflection point in the practice of open innovation.

The COVID pandemic has changed the landscape for innovation and has led to a drastically altered environment for, in particular, the practice of Open Innovation [1]. At the core of the Open Innovation paradigm are the dual processes of, first, generating a palette of novel, high-potential ideas to solve a problem or exploit an opportunity and then, second, selecting the most promising and appropriate ideas to resource and pursue. We argue that these twin mechanisms have become considerably more complex, in new and hitherto unimagined ways, and have outgrown the dichotomized model that characterizes the existing state of knowledge. We explore a range of examples of collaborations that have been initiated in response to the pandemic. This is the first study, to our knowledge, to approach the research gap around the scale, type, and complexity of partnerships and collaborations that have come into being exclusively to mitigate the impact of the pandemic.

With this study, we propose a new framework, both to illustrate and provide a deeper understanding, of the multiple, diverse innovative practices. Our analysis allows us to contribute to an evidence-based evaluation on the changing innovation landscape triggered by the COVID crisis. Our objective is to advance the discussion of ambidexterity and to suggest that the current crisis exposes the limits of this dualistic concept. Instead, we suggest that Multidexterity might be a better umbrella concept to accommodate the complexity now inherent in Open Innovation collaborations, especially those catalyzed by COVID. We also provide examples of COVID-induced innovation that help illustrate the diversity of innovation activity in a time of crisis.

For some time, a dominating strand of thought about how innovation should be managed, especially in corporations, has focused on how to overcome the innovator's dilemma—Clayton Christensen's [5,6] persuasive argument that firms successfully adapting to meet the needs of current customers become less capable of discovering new ideas and technologies for those customers' latent, unarticulated needs. Similar theoretic arguments about the inherent paradoxes of innovation can be found in March's [7] binary juxtaposition of exploitation and exploration [8]; the contrast of openness and control (or differentiation and integration) in managing open innovation [9]; the characterization of either solvers or seekers [10]; the paradox of separation and integration [11]; the likelihood of core capabilities turning into core rigidities [12]; "outbound" and "inbound" flows of innovation [13]; outside-in and inside-out [14]; and the large amount of work describing critical differences between incremental and radical innovations [15–18].

The problematic organizational dynamic associated with the innovators' dilemma is based on the argument that meeting the needs of current customers makes it difficult to appreciate and respond to very different needs from future customers [19–22]. However, it is increasingly recognized that when the innovator's dilemma is conceived as an internal organizational challenge, it does not adequately recognize the increasingly open and external nature of innovation. Although suggestions for addressing the paradoxical demands of innovation are increasingly nuanced [23,24], they continue to be framed in binary ways (See above). This dichotomous mindset is one that we and others believe creates a dilemma in itself [25,26]. It is based on a reductionist view of internal innovation processes at a time when the external, commercial environment is increasingly characterized as, not only inherently risky, but also volatile, uncertain, complex, and ambiguous [27]. It is also more likely that increasingly open, uncontrolled, and layered connections are common among individuals, teams, organizations, and networks [28–32].

As a result, innovation models based on "rationally" setting and controlling innovation goals and processes are much less likely to be successful than previously theorized [33]. Instead, organizations seek strategies that foreground agility, flexibility, dexterity, openness, and resilience—all more suited to dynamic, unpredictable operating environments [34]. In this paper we contribute to conversations about how theories of innovation must be re-imagined to design better outcomes [35–41], perhaps now more than ever, as we face the greatest global crisis in recent history: a crisis which has catalyzed a multitude of new alliances and forged new and unimagined partnerships.

We begin this paper by defining our concept of organizational multidexterity as the ability to simultaneously carry out multiple activities based on diverse strategic logics and levels of knowledge to generate and select a portfolio of innovative outcomes. While not a new term, prior [42] use of the term multidexterity has been in the more specific context of customer relationship management in situations where there may be complex and competing stakeholder agendas. However, organizational multidexterity is applied to the wider challenges of innovation which is increasingly important because of the acute challenges facing innovation managers in generating and selecting novel ideas. It seems clear that orchestrating partnerships, selecting the right opportunities to resource and managing stakeholders require a set of skills that go beyond ambidexterity.

We then develop the observation by Benner and Tushman, two authors who have made important contributions to the ambidexterity literature in the past (2003), but more recently claim that digital and open environments require rethinking previous theory and carrying out new empirical observations ([22], p. 502). We expand the 2 × 2 framework proposed by Lakhani et al. [43] and used by Benner and Tushman and others [44,45] to categorize the broader portfolio of innovation activities characteristic of organizational multidexterity. In our model, the multiple innovation activities inherent in organizational multidexterity are on a continuum of possibilities along the two key dimensions originally specified by Lakhani et al. [43]: (a) the generation of promising new innovation ideas or possibilities for the organization, and (b) the selection of which of those ideas to progress, pursue and invest in. Drawing on Lakhani et al. [43], the X axis of our framework describes the distribution of "knowledge required to generate possible solutions/innovations." This axis draws on design thinking which has as its ambition "the generation of more and different options" [35]. It acknowledges the importance of firms seeking new ideas that are distinctive, compelling, and original: "higher ground rather than common ground" [46]. On the Y axis, we consider how organizations choose which options to resource and progress. In some cases, these decisions are taken in the C-Suite (which we categorize as limited) but, at the other extreme, choices might be made by customers themselves through various mechanisms including online communities (categorized as broad).

We then discuss how organizational multidexterity can help in the re-imagining of theories of innovation as it captures: (1) the intrinsic uncertainty of open environments, (2) the inevitability of shared leadership in open environments, (3) the increasing difficulty of controlling innovation activities in these complex settings, (4) the generative capacity of open innovation to expand innovative rationality and solution space, and (5) customizable commonalities as a desirable outcome of innovation efforts. Drawing on these various literatures, as well as our own experience, we believe that "multidexterous" capabilities can be created and used in successful innovation in contexts than cannot be considered stable and predictable. We find COVID-related examples or case studies of innovation projects to illustrate all nine sections of our new, expanded model.

In conclusion, our contribution to the literature on organizational innovation is an updated and expanded framework, a new, exploratory concept which explicitly recognizes an intermediate level of knowledge used both to generate options and select solutions. This suggestion explicates and expands mid-level contributions that are being developed by individual entrepreneurs within and beyond the organization. The mid-level of innovation encounters we describe are not examples of the "stuck in the middle" behavior Michael Porter [47] once cautioned against. Instead, we emphasize a unique opportunity for using open innovation when relevant knowledge used for generating and evaluating innovation ideas within an organization is incomplete. The contribution of describing innovation in this way is to first show that ambidexterity no longer adequately describes the spectrum of innovation options and challenges faced by organizations: it deals only with the extremes. We then argue that managers can benefit from this more nuanced approach to innovation, which we label multidexterity.

## 2. Materials and Methods

*Managing the Expanding Focus of COVID-Induced Innovation*

The global crisis that emerged following the discovery of the novel coronavirus SARS-CoV-2 [48] and the subsequent spread of COVID has been described as a twofold crisis [49] Not only has the health crisis rendered it, literally, a life and death matter to develop new therapies and vaccines, but, also, the infection control practices introduced by a number of governments worldwide to manage the health crisis have catapulted us into an economic crisis [50], as demonstrated, for instance, by the reaction of financial markets [51]. Both aspects of the COVID crisis are likely to trigger an unprecedented level and type of innovative behavior to address and, hopefully, mitigate the consequences of the global crisis.

The prism of COVID has forced managers to break free from established patterns of thinking. Many instances of this are noted in Chesbrough's 2020 paper examining some of the managerial implications of COVID. In conventional management theory, the question, at the root of open innovation; "make or buy" often depends on which option costs less. However, in the midst of a pandemic, where there is an existential threat to life and health, cost is far less important than speed [14]. The principal mechanism by which Open Innovation works is its "distributed innovation process involving purposive knowledge flows across organizational boundaries for monetary or non-monetary reasons." However, scholars agree there have been radical and dramatic changes to how open innovation works from "normal times" to our present crisis [14]. We have seen the rapid mobilization and collaboration of scientists, governments and pharmaceutical companies on an unparalleled level. We have also seen an unprecedented "openness" in terms of sharing copious amounts of hitherto privileged information between organizations as diverse as Medtronic and the White House Office of Science and Technology.

Although the COVID crisis is unique, we can draw on insights about innovation in situations of crises by looking at prior human-made crises such as the 2008 financial crisis [52] or natural crises such as the humanitarian crises resulting from earthquakes or tsunamis [53] Some scholars conclude that crises seem to have a negative effect on the overall innovation activity in economies [54] and this might have been predicted to be the case with the current COVID crisis as well [55]. However, the old adage of "never waste a good crisis" might be more applicable in this particular case. Crises, do after all, offer the chance for new entrants to collaborate in order to cater to new needs with innovative solutions [56] However, the COVID crisis has set a new high watermark for open innovation practices and innovation outcomes. Harari [57] notes that in previous eras when society faced other catastrophes like the Black Death or the Spanish Flu, there was little idea of what caused it nor how it could be halted. In 1918, all the world's scientists could not identify the strain of the deadly virus and attempts to develop a vaccine were intense but in vain. COVID has illustrated the capacity of open innovation to forge new models. The first warning bell of this pandemic was sounded in China in December 2019. By 10 January 2020, scientists had not only isolated the responsible strain but they had sequenced the entire genome and, in an unprecedented act of openness, published all the information online to help the scientific and medical community to find a mechanism to defeat the virus.

Even as the need for multiple, simultaneous, and varied innovation activities is increasingly recognized by organizations and management scholars, ambidexterity as a solution continues to be celebrated [58]. The term was originally deployed to explain the balance between exploration and exploitation [59] or the "ability to simultaneously pursue both incremental and discontinuous innovation and change" ([60], p. 24). It has subsequently achieved prominence in other facets of business beyond the realm of innovation: inter alia, customer relationship management uses the term to describe the actions of customer acquisition and retention [61]. It also is used in University Technology Transfer Offices to describe how academics can balance their traditional duties of research and teaching with involvement in technology commercialization [62].

Design thinking has been closely linked with ambidexterity [63], and it has been applauded for its ability to tackle the limits of dualism. For example, design thinking has been described as a balance between analytical thinking and intuitive thinking [64]. Design Thinking uses abductive reasoning to explore the possibility of what might be [65], and challenges what exists, asking "What if?" questions [66]. Thus, design-led approaches facilitate the creation of new knowledge and insight [67], as designers "focus on workable solutions [that] are 'assertion-based rather than evidence-based'" ([68], p. 386–387). Design thinking also shifts the focus to how things ought to be and to the pursuit of novelty [69].

Modern organizations are typically involved in multiple simultaneous, sometimes competing, initiatives which might include geographic expansion, operational excellence, new product and service development, and the implementation of new organizational structures and possibly collaboration with new partners. This complex pattern of commercial activity demands that employees fulfil multiple organizational roles, each of which involves different modes of collaboration. The critical management challenge is to achieve more complex patterns of organizational integration, but without impeding flexibility, agility and responsiveness [70]. The competing needs for stability and transferability and, at the same time, for flexibility and dynamism, suggest the importance of multidexterity to underpin the delivery of complex, nuanced business goals [71].

The increasingly open nature of innovation means that efforts to find novel ideas now likely to extend beyond the boundaries of firms. Firms are adopting new approaches to two related innovation challenges: how they generate solutions or options to address innovation problems, gaps or opportunities; and how they select the best ones from among those available solutions [72]. A slightly modified version of Lakhani, Lifshitz-Assaf, and Tushman's [43] influential depiction of this expanded landscape of open innovation is shown in Figure 1.

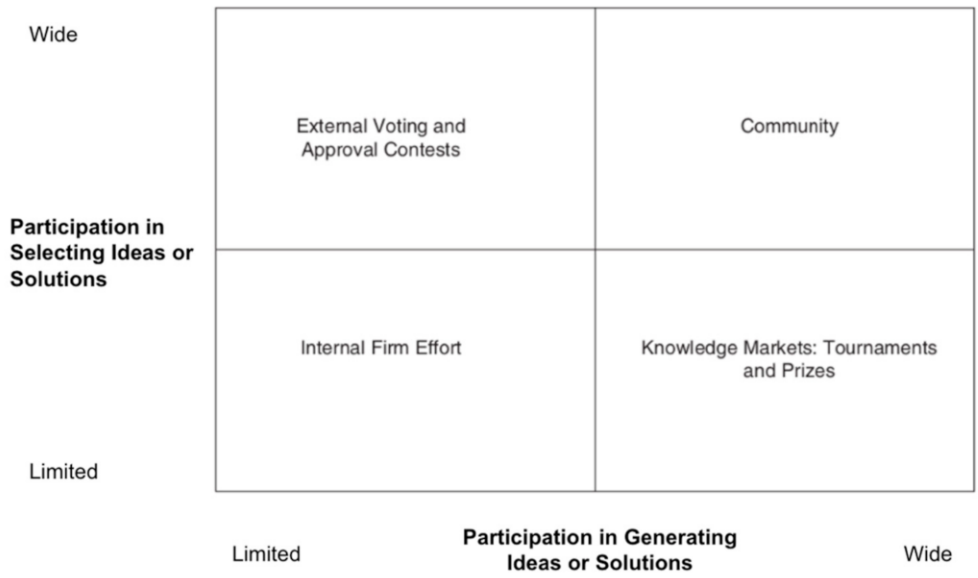


**Figure 1.** Generating and Selecting Ideas. Adapted from: Lakhani et al. (2013), Figure 19.3.

A primary message of this paper is that Figure 1 helps establish the outer parameters of open innovation and some of its defining characteristics, but it misses many exciting developments in the innovation domain. Figure 2 is an expanded framework that focuses on the expanding modes of innovation that draw in a range of contributors.

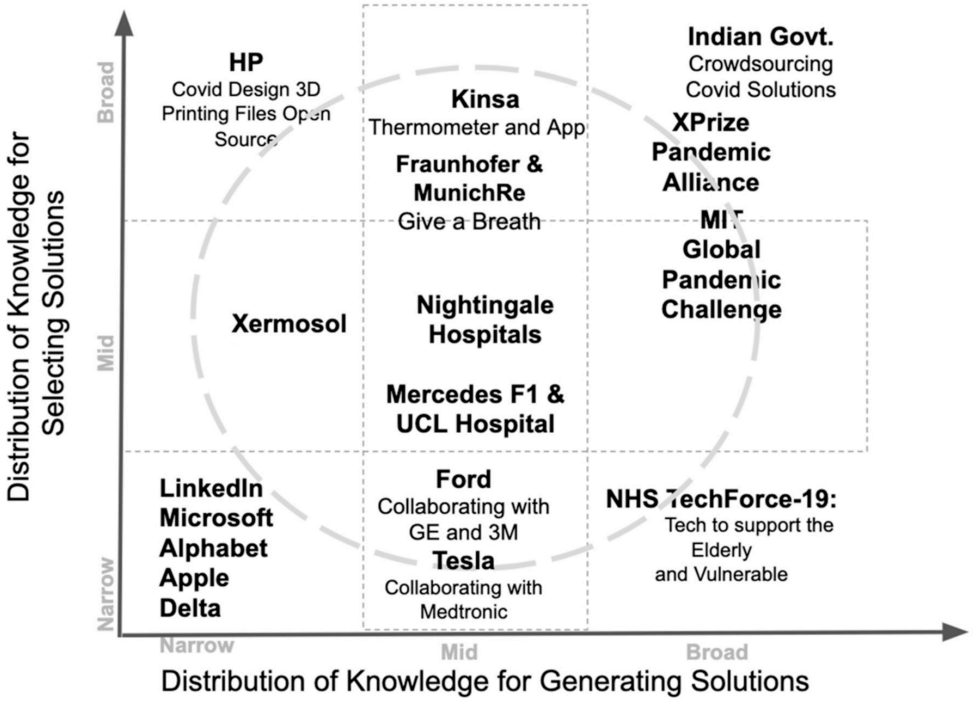


**Figure 2.** The Multidexterity Framework.

In Figure 2 we have adapted the Lakhani and Tushman [43] 2 × 2 model and extended it so that it better reflects contemporary opportunities and possibilities for collaboration and innovation. We maintain the same axes: our X Axis describes the Generation of Ideas and Solutions, which ranges from narrow, suggesting an innovation, some knowledge or a solution developed by one individual (inventor) or perhaps an R&D team or even just one corporation. This axis spans right the way across to broad which connotes a wider participation in the idea generation process, perhaps crowdsourcing through closed groups right up to national or global innovation tournaments, at the most extreme point. Lakhani, Lifshitz-Assaf and Tushman ([43], p. 365) described this as "radically decentralized, cooperative and self-organizing modes of problem solving and production." This axis is most consistent with individuals or groups of solvers engaging in value creation who bring new knowledge to issues and markets often through outbound open innovation mediated through online platform interactions [73,74].

Our y-axis describes the process of selecting the ideas, knowledge or solutions. This axis ranges from narrow, where one person or one organization can make the decision on which ideas to progress and adopt. At the broad end of the spectrum, the selection decision is shared or distributed between multiple actors and stakeholders as would be the case in some international innovation contests. This axis is closely related to the seeker, who has traditionally been the center of attention in OI [75]. Crowdsourcing, as a digital marketplace for the exchange of ideas, tends to be anonymous and is characterized by often vast physical distances between stakeholders and competing incentives between solvers and seekers [76].

## 3. Results—COVID Related Case Evidence for Multidexterity

### *3.1. Case Study of Innovative COVID Responses*

The research and innovation communities have long been international in scope but the current pandemic has tended to amplify this: it has heightened the collaboration between the commercial, medical and scientific community in a way that no other issue has before. Some scientists have referenced the AIDS epidemic in the 1990s as the closest comparison to this [77] when doctors and scientists locked arms to combat the disease. However, today's technology and the speed of information sharing is far greater than

30 years ago. COVID has accelerated a number of innovation initiatives and prompted a number of encouraging developments [14] that we classify in our Multidexterity framework. To contextualize the framework, we shall populate its four corners and then we discuss the mid-level activities which are a focal point of our paper.

To clarify our concept of Multidexterity, we find examples or cases of outbound and inbound flows of knowledge taking place at a global level with the objective of mitigating the impact of the pandemic. The rationale for a case study research is when it represents a critical case in testing a promising theory and where the case represents an "extreme case or a unique case" ([78], p. 47). Our cases are both extreme and unique. The case study process allows researchers to work at the depth and detail necessary for capturing the "hows" and the "whys" rather than merely the "whats" [79]. In our case, we aim for theoretical generalizability and we argue that the associations for which we have found evidence in our case study are likely to be sustained over time and warrant the development of a new framework to help position and explain them.

At the bottom left of the framework lies narrow Knowledge for Generating Solutions and narrow Knowledge for Selecting Solutions. Internal firm efforts are placed in this quadrant as in the original 2 × 2 matrix [43]. There are a growing number of examples from companies developing internal corporate COVID innovation initiatives. Many are donating money or equipment to hospitals and healthcare services, for example (including Tesla, Giorgio Armani, Prada, Salesforce, and French luxury group, Kering). In addition, particularly in the US, many organizations are covering the sick-leave costs of their workers during the period that the remote working or furlough protocols for combating the virus mean they are unable to come to work, including Alphabet, Apple, McDonalds, Disney, Walmart, Uber, and Amazon, among others. Other organizations are providing free services or offering heavy discounts for those most impacted by the pandemic; these include, Loom, U-Haul, LinkedIn, Comcast, T-Mobile, Sprint, Adobe, Amazon, Meero, and Microsoft. Moreover, some companies are showing leadership by forgoing some or all of their own remuneration. Delta's CEO is forgoing his salary for the year, for example. Musicians, like John Legend and Keith Urban have also helped lighten the mood by giving free concerts.

At the bottom right of the framework lies broad Knowledge for Generating Solutions and narrow Knowledge for Selecting Solutions. This space is where we see tournaments and prizes that are targeted at a specified or narrow challenge. The UK's National Health Service (NHS) has initiated a crowdsourcing contest specifically to yield ideas relating to the support of the elderly and isolated, for example. In addition they are offering £500,000 funding for innovators who can find digital solutions to support those self-isolating because of coronavirus. The objective is to quickly deploy tools for remote social care support, identify tools for recruiting, training and coordinating local volunteers, and to find digital tools for self-managing mental health and wellbeing [80]. As a third example, Take on COVID is an online innovation tournament from IBM which seeks broad solutions for the narrow specific issues: crisis communication, remote education, and community cooperation.

At the top left of the framework: narrow Knowledge for Generating Solutions and broad Knowledge for Selecting Solutions, Hewlett Packard is helping to combat the spread of the virus in novel ways. This one company (narrow) has gifted thousands of 3D printed parts to healthcare facilities. Aside from this HP has created proprietary designs for vital medical equipment, including face masks and shields, 3D printed door handles (which do not need to be touched by hand), and field respirators, all of which can be quickly manufactured using 3D printing technology. Universities, tech firms and even 3D printing enthusiasts have been responding to the call in a move some are calling the "citizen supply chain" [81]. They have uploaded these designs as CAD files which are open source and free to use by healthcare professionals and institutions all over the world (broad). Similarly, Medtronic is freely sharing its own design specifications for a basic ventilator model for use by any company that wants to be involved in producing it for hospitals [82].

At the top right of the framework is broad Knowledge for Generating Solutions and broad Knowledge for Selecting Solutions. One example can be found in the government of India's launch of an international COVID Solution Challenge that seeks solutions from solvers all over the world. The solutions will be selected by a broad panel of international experts from many disciplinary fields (again broad). In the same quadrant, we position Amazon's Diagnostic Development Initiative which is being run by its cloud arm, AWS. The Diagnostic Development Initiative is a global programme to support healthcare professionals who are working on faster and more accurate diagnostic solutions. The programme has a prize fund of $20m to promote better collaboration and accelerate better diagnostic research. In a similar vein, a number of high profile crowdsourcing initiatives have been initiated which land in or near this quadrant, including the MIT Solve's Global Pandemic Challenge, the X Prize Global Pandemic Alliance or the "Give a Breath Challenge" run by Fraunhofer and MunichRe that wants "to identify the best 3D-printable designs to enable the immediate, decentralized production of emergency ventilation equipment"—again a "broad-broad" initiative.

### *3.2. Mid Level Initiatives*

The four edges of Figure 2 describe efforts of solvers or seekers that would be found in an ambidexterity framework. However, when we try to classify COVID efforts we find that there are many additional efforts that do not easily fit at the extremes of an explanation based on ambidexterity. The intended contribution of this paper is to make room for a valuable and oft-overlooked "middle" space for co-creation. The collaborative efforts by the Mercedes Formula One team provide one example. Partnering closely with the University College London Hospital [83], the Mercedes-AMG Formula One team analysed and disassembled an off patent respiratory device and deployed high-tech computer simulations to improve the device's design and achieve a state-of the-art product that is capable of swift, efficient, mass production. The medical device has already received fast-track regulatory approval by the Medicines and Healthcare products Regulatory Agency (MHRA) and has gone into production.

In other instances, groups or clusters of corporations have been asked or have elected to partner with one another and set aside their normal production activities to redirect efforts towards the design and sometimes production of a range of much needed, pre-specified medical equipment [84], instances we classify as "mid-range" efforts. Ford Motor and General Electric are teaming up to build tens of thousands of ventilators in a massive effort to retool existing U.S. manufacturing and supply chain capabilities for the treatment of COVID patients. General Motors is embarking on a similar effort to build ventilators with partner Ventec Life Systems. Elon Musk has begun collaboration talks with Medtronic [85]. In these cases there is clearly some important knowledge available to draw on in developing solutions, but little in-house knowledge available a priori to select solutions.

In the middle of the matrix is Nightingale, which will be the UK's largest hospital and built in London's Docklands just 9 days after military logistics teams were first scrambled to build it exclusively for Coronavirus patients. The hospital, located in the cavernous ExCel conference center was designed to accommodate 3500 people. The project is a collaboration between military specialists, the NHS and commercial building and design contractors. The UK government envisages this project as the blueprint for a series of such hospitals to be built in Birmingham, Manchester, Harrogate, Glasgow, Cardiff, Llanelli, and one at a former prison in Belfast. This effort was inspired by a similar project in Wuhan, the city at the heart of the outbreak, where two hospital facilities were built in just over a week [86].

We place two other cases at the perimeter of our mid-level initiatives. In the middle of the top row of broad solution knowledge, *Kinsa* is a digital "smart" thermometer with a paired phone app enabling the company to take consumers' temperature data from across the country and provide real-time insights into emerging COVID hot spots. Researchers at Kinsa Health, which has marketed its Bluetooth-enabled thermometers and a service to direct consumers to health services for several years, discovered that its data could identify

unusual instances of people with abnormally high temperatures. The early results in mapping data from across the country has now become important in helping government agencies identify areas where there is a higher-than-expected concentration of people with fevers—one of the leading indicators of infection with the COVID virus [87]. Conventional test results are a lagging indicator of the prevalence of infection, while Kinsa is able to detect patterns and clusters of high temperature that might give predictive data on potential clusters of infection.

Within the space where the generation of knowledge is narrow but the potential selection and adoption is potentially quite broad, we place Xermosol. Technology student, Rayvon Stewart, based in Jamaica and studying in University of Technology, set about finding a way to curb the spread of harmful germs. He took part in an exhibition on the theme "Universal Health Coverage: Reaching the unreached, ensuring that no-one is left behind" which highlighted how young people are tackling age-old challenges with modern technology and disruptive thinking. In Rayvon's case, he focused on the most common places where bacteria and viruses could easily be left by one person and picked up directly by another. He came up with what he calls "Xermosol"—a simple-to-install device that automatically disinfects door knobs and handles after each use. The innovation uses ultraviolet light to target and specifically kill harmful microorganisms while being harmless to human beings.

The potential impact of Rayvon's invention is now even more important than when he first conceived it, as the world battles the frightening COVID pandemic. The coronavirus reputedly stays up to two or three days on stainless steel and metal, and several hours on fabric depending on factors such as temperature and humidity. Field and laboratory testing has validated Xermosol's efficiency in killing more than 99.9% of deadly pathogens. In addition to health facilities, Rayvon hopes it could help reduce the transmission of germs in other public spaces such as schools and businesses. It is now in production and being rolled out, first, across the Caribbean countries.

## 4. Discussion: Multidexterity and the Dynamics of Open Innovation

Concept formation lies at the heart of all progress in social science [88]. Our paper proposes a revised concept in management theory: Multidexterity. In our summary of the literature, we have shown how many of the current definitions and frameworks are binary and dichotomous. Whereas, in our summary of extant innovation activities, we have shown that the variety, sophistication and complexity of OI ventures which have been initiated in various collaborations to combat COVID go far beyond the dichotomous definitions that have characterized the field for so long. Concept definition and specification has been the subject of scholarly debate, according to Podsakoff et al. [89] since the original publication of the treatise on logic by journalist, MP and philosopher, John Stuart Mill in 1882 [90]. Indeed, a number of the concepts we have discussed in our paper have been criticized for polysemy or for having managed, despite much research, to elude precise, agreed, universal definition. Design thinking, for instance, has been described as being in danger of "construct collapse" [91]. The theory of dynamic capabilities has also received criticism for similar reasons: "while the concept of dynamic capabilities is appealing, it is rather a vague and elusive one which has thus far proven largely resistant to observation and measurement" ([92], p. 653).

Attempting to revise old or advance new concepts carries some well-known hazards; chief among them is the risk of concept proliferation. Proliferation is where the concepts have different names but their domains overlap and, in acute cases, this can lead to the development of different terms for the same concept. Nevertheless, when practice advances in response to a Black Swan event to the degree that the current frameworks are inadequate to describe the complexity of what is happening, then scholars should try to forge new theories to better describe such new practices. Concepts help make sense of the phenomena in the world around us and to find meaningful patterns and describe their attributes [89]. This is our motivation for writing this paper and for suggesting the new

concept of Multidexterity. It is well recognized when academics attempt to revise or update existing concepts that they often encounter opposition suggesting it represents little more than "old wine in new bottles" [93–96]. We have tried to avoid this characterization by providing conceptual clarity at both the conceptual and operational level. We provide this conceptual clarity by applying five tests to our proposition.

The following discussion develops theoretic underpinnings for this revised view of an established theory [88]. We suggest that there are five specific reasons to reconfigure our perspective on ambidexterity: (1) the intrinsic uncertainty of open environments, (2) the inevitability of shared leadership in open environments, (3) the increasing difficulty of controlling innovation activities, (4) the generative capacity of open innovation to expand innovative rationality and solution space, and (5) customizable commonalities as a desirable outcome of innovation efforts.

### *4.1. Theoretical and Practical Benefits of Multidexterity*

"Uncertainty is ubiquitous in today's complex world" [78]. It is more and more widely recognized that organizations face "contingency and ambiguity as endemic features of an interactive and connected world" ([92], p. 1253). The increasing presence of digital technology is an important contributor to this ambiguity and uncertainty. Yoo et al. [97] argue that as the locus of innovation moves outside of the boundary of a single design hierarchy and the edge of the network evolves constantly, the challenges of heterogeneity are amplified. As a result, traditional centralized tools to support knowledge management and virtual teams need to be augmented with new tools that can handle heterogeneity and discontinuity in knowledge. Yoo et al. [97,98] also contend that digitalization expands the "physical materiality of a product" which results in possibilities for new "experiences, processes and organizational forms" (2012: 1398–1399). The converging nature of diverse technologies means that firms need to interact with groups outside of existing product-market combinations.

Unavoidable, or intrinsically, uncertain environments thus require firms to find new ways to innovate [92]. This entails a shift in emphasis within organizations from identifying the problem to be solved to expanding the set of options available through processes that produce new knowledge through collective social interaction [39]. Teece and Leih [92] argue that increased uncertainty calls for organizations to "detect potential market changes" and to have the capability to "rapidly ideate, test and deploy new innovations" (2016).

### *4.2. Multidexterity and the Dynamics of Open Innovation—The Leadership Dimension*

The expanding locus of innovation activities creates both intra- and inter-organizational challenges in terms of how innovation is managed [43]. As the knowledge required to identify and/or select solutions becomes more broadly dispersed, organizations inevitably lose the ability, in at least some segments of the innovation value chain, to take charge and lead the innovation process. Increased co-ordination may involve lead firms playing a role in what Puranam, Alexy and Reitzig [99] identify as the "provision of information" problem (2014: 166). Design offers an alternative to internal innovation but it requires facilitating innovation while also enabling rapid collaboration between multiple partners in a project [100]. The refocus has implications for managers setting directions, making decisions, coordinating activities, and motivating people may need to be re-conceptualized. Good ideas can come from anywhere which makes openness even more of an imperative in this crisis [14].

### *4.3. The Inevitability of Reduced Control: From Direction Setting to Balancing "Layered Platforms"*

There is inevitable organizational tension between exercising managerial control and the exploration activities required for discontinuous innovations [97]. Earlier efforts to express and analyze a strong trade-off between monitoring and control of the innovation process, like the stage-gate process [101], proved efficient for control and risk management [99],

but lacked flexibility, so that innovative outcomes tended to become more incremental in nature as creativity processes became increasingly structured and routine [102].

Arrighi, Le Masson, and Weil [103] argue that the design perspective necessarily shifts the managerial and organizational focus from controlling the innovation process and selecting from innovation alternatives, to an emphasis on managing (and not over-managing) divergence in both the innovation process and the accumulation of knowledge. In the context of products with high technical specifications, they suggest that organizations can manage the tension of exploration and control through a modular design process, whereby innovation occurs through modular components in the context of a stable product architecture, or a concept-shifting process that allows designers to shift product design by selecting initial concepts and emerging solutions [103]. More specifically, discontinuous innovation projects are characterized by high levels of interactions and need "try and learn" approaches [104], organizational learning, new competence management.

### *4.4. The Generative Capacity of Open Innovation: Expanding Generative Rationality and Solution Space*

Generative processes create unpredictable complexity, resulting in "how we come to see things in new ways" ([105]; p. 138). Zittrain describes generativity from a technological perspective as "a technology's overall capacity to produce unprompted change driven by large, varied, and uncoordinated audiences" ([106], p. 1989) A consequence of the generative elements of innovation is that the "boundary of a product is unknowable and the product or service remains incomplete" [107].

Verganti argues that the radical innovations that characterizes the Italian manufacturing firms he studied included "actions of influencing and modifying the sociocultural regime" ([108], p. 445), a process that reflected knowledge sharing within a network that extended outside the boundaries of the firms. Arrighi et al. [103] suggest processes of identifying critical constraints that allow "a deep exploration of possible, related breakthroughs" (p. 387) creating what they refer to as generative constraints, helping organizations to manage the generative elements of innovation processes.

Organizations need to monitor and control the exploration space in a way that does not cauterize their ability to make new connections and search for new solutions. In their discussion of on-line communities Faraj et al. [109] argue that organizations must build environments that create opportunities for what Yoo et al. refer to as constrained serendipity ([98], p. 1403). However, as Schreyögg and Sydow [110] note, the shifting or blurring organizational boundaries and more fluid organizational forms that more broadly dispersed knowledge and more interactions require, challenge organizations to manage contradictions and paradoxes rather than displacing the need for organizations as problem solving entities.

### *4.5. The Productive Possibilities of Customizable Commonalities*

As organizations learn how to adapt to the intrinsic uncertainties of today's open and digital environments, an increasingly important strategy is to seek "customizable commonalities". Yoo et al.'s [98] term is "combinatorial innovation". It is possible because first, innovation with pervasive digital technology brings previously separate user experiences together. Second, digital technology is increasingly embedded into previously nondigital physical artifacts, creating so-called "smart" products and tools. . . . each of which previously required a separate product or tool. Third, the initial convergence of media and products . . . bring[s] together previously separate industries [98]. COVID is the trigger for a number of such examples where digital technology can enhance and expand the usefulness of products, services and experiences. In China at Zhongnan hospital, for example, AI is being used to assist busy (and overworked) radiologists to detect visual signs of the pneumonia associated with COVID on images from lung CT scans. The software being used at Zhongnan was developed by Beijing startup Infervision, and has now been deployed at 34 hospitals in China and used to review more than 32,000 cases. The startup, founded in 2015 with funding from investors including early Google backer

Sequoia Capital, is an example of how China has embraced applying artificial intelligence to medicine. In the US, an example we share above, Kinsa thermometers are adding a vital layer of predictive insight to the identification of potential clusters of infection.

Ambidexterity is the ultimate dualistic innovation theory and we believe that COVID stretches ambidexterity to the point where a new perspective; an expanded approach is warranted.

## 5. An Agenda for Future Research

The framework we have just outlined provides a tool to categorize and thus manage innovations that overcome new, potentially unimagined challenges. It suggests that dichotomous thinking is insufficient because it is too constraining: it fails to make sufficient allowance for interactions with important consequences made with varied levels of expertise. The multidexterity lens highlights an important middle ground of managerial coping strategies, and, it opens up a landscape of relatively unexplored research avenues, as follows:

First, corporate innovation management approaches often focus on extreme cases. Systematically identifying a broader portfolio of innovation practices and possibilities will reveal the richness and reach of open innovation possibilities in the context of corporate innovation strategies for further development.

Second, innovation management landscapes in corporations are often a highly path-dependent product of the past. Innovation in start-ups, by contrast, often create new approaches, new business models and a fresh look even for well-established and well understood processes and businesses. Both path-dependency and path-creation have their pros and cons. Though some important research has been done [107], more needs to be done in the open innovation context.

Third, a design oriented approach to innovation, including rapid prototyping and piloting, helps organizations manage the increased uncertainty of increasingly open innovation spaces. Research is needed that identifies in what phase of the innovation process and in what organizational contexts a design oriented approach improves innovative performance.

Fourth, the numerous and diverse approaches illustrated in Figure 1 illustrate the fast pace at which practice is experimenting and improvising with Open Innovation. While it would be naïve to think, one optimal model will emerge as a blueprint for other organizations, nevertheless, longitudinal case studies tracking open innovation efforts would be immensely helpful in helping to guide the OI process and plans being developed and deployed by other firms.

Fifth, the dichotomy inherent in the lens of ambidexterity also has echoes in the examples we have described where organizations seem, in the multidexterous era, to have moved quickly from "not all the smart people work here" to channeling their search exclusively externally, thus apparently signalling "actually, none of the smart people work here!" In particular, needed research would focus on hybrid models that finesse solutions both from within and without the organizations.

Sixth, when the corporate system receives an unexpected and exogenous shock like COVID, the innovation ecosystem is resilient and defies the political and corporate norms of shutting things down and slowing the pace of activity. Instead, research on rare events like COVID could act as a catalyst for more numerous and often more ingenious methods of collaboration.

## 6. Conclusions

Some authors suggest that the global economy's growth engine needs a reboot to recover from the pandemic. Open Innovation will be the new trigger for economic growth [111]. In this paper we use a number of case studies which demonstrate the level and sophistication of open innovation practices have altered so dramatically that the practice itself needs a new framework to keep pace with contemporary developments. The

business environment is turbulent and in constant change. What is different in today's digital age is that changes are occurring at unprecedented rates of velocity and scale [112]. The destructive current situation brought by the global pandemic of COVID is but an extreme example. Other mega trends include globalization, environmental anxiety, political instability, changing demographics and increasing urbanization. COVID has caused the practice of business to change in unprecedented ways [113], and hence theories of innovation need also to be reimagined. Our model imagines the Schumpeterian model of an open innovation economy system [114] which includes the private, public, and third sector, all collaborating together. This includes the quadruple helix model which encompasses connections between citizens, technology, markets, government, and academia [110].

We argue in this paper that there are critical problems with theories of innovation based on the language of explore/exploit, incremental/radical and related dichotomies. They oversimplify the opportunities available to organizations and they assume that leaders and those they appoint can effectively manage and control the innovative process. While these assumptions may continue to fit some circumstances, they have decreasing relevance for an increasingly open, digital, connected, and unpredictable world.

In this paper we develop several alternative perspectives. First, "multidexterity" is a more useful term than ambidexterity to describe the capability needed for and created by interacting with a portfolio of innovation options. We claim more attention should be paid to how multidexterity can be facilitated and made part of a general understanding of innovation programs that are likely to be ongoing in an open and digital world. Second, mid-level open innovation provides useful information about innovative solutions from interactions among varied participants with mixed levels and kinds of knowledge. Theoretic discussions of open innovation have tended to ignore these complexities in favor of crowdsourcing [44,45]. We claim that mid-level interactions make important contributions to innovation portfolios, and they are likely to be more rewarding than exploitive innovations that rely primarily on current knowledge, or explorative innovations that utilize knowledge with little or no connection to current position and recent experience.

We also suggest the following implication for practice. First, our open innovation framework presages a shift in the way managers charged with responsibility for open innovation need to think about innovation based on the notion of multidexterity. It identifies a practical and inventive framework allowing managers to include a wider variety of stakeholders in the innovation process while reducing the risk involved in new innovations created through this interaction. This framework is not merely intended as an academic categorization exercise but it can, equally, to help guide the action of managers who are tasked with finding or generating innovative solutions under conditions of unusually high uncertainty.

Second, methods for broader interaction are particularly important in situations of intrinsic uncertainty such as the current COVID crisis, in which all important influences moving forward cannot be identified, nor the effect of many interactions among influences be predicted. Third, using the idea of multidexterity, managers can widen both the idea generation process and the idea selection process of innovation by drawing on varied actors including staff, customers, lead-users or super-users, academic and/or industry experts.

The COVID crisis presents researchers with a rare and valuable opportunity to highlight new, complex and hitherto unimagined levels of collaboration in the cause of innovation. Our study has contributed to an evidence based perspective of the changing innovation terrain triggered by the pandemic. We have provided illustrative case studies to characterize the increasingly open, unpredictable, and digital landscape for innovators. We have called out cases which are illustrative of megatrends that will inevitably evolve over the next number of years but for which COVID was the initial catalyst.

In summary, despite the emphasis on a middle level of contribution, innovation efforts are increasingly likely to confront the completely unexpected, as the recent rise of COVID amply illustrates. Massive changes in the environment create outcomes that overcome any existing organization or consortium. New ones, of varied duration, develop.

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