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How open is innovation? A retrospective and ideas forward

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ABSTRACT

This paper sheds fresh light on our 2010 paper *How Open Is Innovation* by taking into consideration notable developments in innovation over the last decade. The original paper developed four types of openness: sourcing, acquiring, selling, and revealing. Reflecting on important technological, organizational, and societal changes in the past decade, we highlight how these changes prompt novel questions for open innovation. While the core features of the original framework still stands, there are many new questions that have emerged in recent years. We end by charting a path for future research that emphasizes opportunities, costs and tradeoffs between different modes of open innovation, the need to better understand the nature of data, new organizational designs and legal instruments, and multilevel aspects and relationships that affect the extent and nature of openness.

1. Introduction

Interest in open innovation has skyrocketed in the last decade (see e.g., Bogers, Chesbrough, and Moedas, 2018; Chesbrough, 2003; Chesbrough and Bogers, 2014; Gassmann, 2006; West and Bogers, 2014). In 2020 alone, academics published hundreds of papers on open innovation (OI). Today, open innovation scholars run dedicated conferences, give PhD courses, and top journals have developed an appetite for open innovation special issues. The field has surely matured.

Ten years ago, we published a paper with the aim of providing some structure and direction to the unsteady, adolescent field of open innovation (Dahlander and Gann, 2010). Our point of departure was simple but fundamental—we wanted to develop a conceptual framework that defined and classified dimensions of "openness." Our ambition was to bring clarity to definitions of open innovation and to encourage the then-emerging community to think deeply about the trade-offs involved by considering the advantages and disadvantages of distinct types of open innovation. In our paper, we reviewed the early literature on open innovation and distinguished between inbound and outbound processes of open innovation, and between pecuniary and non-pecuniary interactions among participants. We identified four types of openness: sourcing, acquiring, selling, and revealing. Since then, the literature has developed to explore the conditions that make open innovation a beneficial and sometimes problematic strategy to pursue. The field abounds with literature reviews that summarize these developments (see e.g., West and Bogers, 2014; Bogers et al., 2018).

This paper is *not* another literature review. Instead, we offer something different and complementary. Our ambition is to reflect on technological, organizational, and societal changes in recent years and discuss how they may alter our thinking about open innovation. Based on these observations, we discuss the implications and opportunities for the next 10 years of open innovation research. To contextualize the topic, we first briefly describe the development of the original paper, showing how it emerged and summarizing what trends were present when the 2010 paper was written.

2. Origins and development of our 2010 paper

How Open Is Innovation has been cited more than 3,000 times, according to Google Scholar, since its publication a decade ago, making it one of the most-cited papers in *Research Policy* in the last 10 years (ISI Web of Knowledge, 2020). The paper emerged from a project we began in 2006 at Imperial College London funded by the Innovation and Productivity Grand Challenge.

Henry Chesbrough had published his book, *Open Innovation: The New Imperative for Creating and Profiting from Technology*, three years earlier (2003). It immediately sparked intense research activity among fellow academics, and papers on open innovation emerged in the major innovation journals. In 2006, we took stock of the growing open innovation literature and tried to offer some thoughts on how to move the literature

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forward conceptually. Our chosen method was a systematic literature review.

We developed keywords to capture all articles published on the topic. Then, we constructed a database, and downloaded and categorized them according to how they dealt with open innovation. Based on this, we uncovered distinct types of openness. Although the inbound and outbound distinction was already clear in Chesbrough's *Open Innovation* (2003), our contribution here was the distinction between pecuniary and non-pecuniary interactions, which brought more clarity to the field. After articulating the four fundamental types of openness, we developed arguments for the advantages and disadvantages of each.

We also discovered that the literature at this point in time was largely unbalanced, mainly focusing on the benefits of open innovation and missing the costs associated with openness. Empirically, only a few studies used large-scale datasets covering multiple industries, most instead relied on case studies of a few successes. In our call for future research, we pointed to the importance of qualitative differences in how open innovation is pursued. We tried to move away from limiting analysis to differences in degrees of openness. We also called for studies on enabling technologies, e.g., information and communication technologies that could make possible, and possibly mediate, open innovation.

After receiving comments from our colleagues at Imperial and beyond, we developed an improved version of the paper, submitted it to *Research Policy*, and received a revise-and-resubmit, with reviewers providing valuable ideas. We made the database public and were surprised by the number of requests for copies from other academics. That was the first important signal among scholars. We have since shared the database more than 100 times. Moreover, we updated it a few years later for a project with the World Intellectual Property Organization.

We have used the paper extensively in the classroom to discuss the advantages and disadvantages of different types of openness, and under what contingencies they are worth pursuing. We have used the paper when teaching and coaching thousands of masters', MBA, EMBA, and executive participants. In these classroom discussions, many new insights and examples have emerged. And in the decade that followed, there have been many developments that have fundamental implications for research on open innovation – the focus of this paper.

3. Recent developments and their implications for open innovation

Ten years sounds like a short period of time, but many important theoretical and empirical developments have occurred that put a new spin on open innovation. Several technological, organizational, and societal trends have raised new questions for research in the field of open innovation.

3.1. Technological developments

3.1.1. Technologies that generate and handle troves of data

Generally speaking, technological developments in the last decade have changed when and how organizations can rely on open innovation (see e.g., Dodgson, Gann, and Salter, 2006). Over the last decade we have witnessed massive advances in key technologies such as artificial intelligence and machine learning, big data and cloud solutions, advanced robotics, blockchain, and APIs (application programming interfaces) (see e.g., Yoo, Boland, Lyytinen, and Majchrzak, 2012). For example, since the publication of our original paper, technological solutions such as Amazon Web Services have been adopted widely. Companies that develop these technologies can indeed profit directly, all in line with classic innovation models. However, and more profoundly, these technologies have enabled firms to implement new kinds of business models. Such business models often rest on the firm's ability to generate and handle massive amounts of data—supported by technologies previously not available (e.g., Björkdahl, 2020; Loebbecke and Picot, 2015; Sjödin, Parida, Jovanovic, and Visnjic, 2020). Here, Amazon is the master. Consumers benefit from Amazon's ability to aggregate and present data used in, for example, customer reviews – data that Amazon does not have to pay for. And Amazon profits directly through increased sales enabled by such "open services innovation" (Chesbrough, 2011). Information systems scholars have argued that digital technologies are inherently dynamic and malleable, and enable the use of data in novel ways to produce new products and services. As a consequence, firms can experience rapid and radical change more frequently than previously considered (see Yoo et al., 2012).

When the iPhone was introduced in 2007 people applauded it as a welcome replacement for the iPod, but most were silent in recognizing it as a "breakthrough internet communication device." In retrospect, the iPhone marked the beginning of a data revolution. Today, just over a decade later, social media is shaping markets and affecting how corporations ingest signals from customers, users, and others on the outside. Many organizations are creating troves of data that might allow them to make more informed decisions. This is a recurring theme in the academic literature, and highlights how openness can build bridges across organizations to make use of data (e.g., Dodgson et al., 2006; Del Vecchio, Di Minin, Petruzzelli, Panniello, and Pirri, 2018). In reality, however, only a small volume of data is put into use in the design of new products and services. Some firms, in particular platform companies such as Google and Amazon, are incredibly successful at using and monetizing data, for example by leveraging their proprietary user data to cross-sell "rundles"—bundles of recurring subscriptions.[1] But their success may eventually lead to potentially devastating externalities due to data breaches, abused privacy, or anti-competitive behavior enabled by proprietary access to data. Such negative externalities were less of a concern in the early open innovation literature.

3.1.2. Technologies that mediate interaction

APIs and login services are technologies that mediate interaction on a colossal scale. Ten years ago APIs were in their infancy. Today there are thousands of APIs in existence, and it is estimated that the average app uses between 10 and 15 of them.[2] The number of API calls has thus gone from a modest number to hundreds of billions per month. For example, the API platform Rapid API processes 400 billion calls per month. This has also led to several companies with business models focused on using APIs to diversify revenue streams or fuel the innovation process by allowing for more recombination. For example, Salesforce has used APIs since its launch, driven by the need to share sales data across platforms allowing it to integrate with existing systems. APIs today account for 90 percent of their revenue.

However, using APIs can also lead to challenges. Some companies have experienced setbacks because of potentially collecting too much data. One case in point is the scandal around Cambridge Analytica, which collected personal data from Facebook profiles without users' consent. In 2014, Aleksandr Kogan created an app called "*thisisyourdigitallife*" that used Facebook's login feature. Some 270,000 people used their Facebook Login to create accounts and thus opted in to share personal profile data with Kogan, who then shared the data with Cambridge Analytica. Back in 2014, Facebook also allowed developers to collect some information on the friend networks of people who used Facebook Login. This meant that while a single user may have agreed to hand over their data, developers could also access data about their friends. This was not a secret—Facebook says it was documented in their terms of service. These, however, have since been updated to disallow APIs to share friends' data with apps.

The implication for open innovation is that openness enables

[1] https://www.inc.com/anne-gherini/the-rise-of-rundle-a-new-trend-for-subscription-based-services.html

[2] https://techcrunch.com/2018/03/13/rapidapi-an-api-marketplace-that-processes-half-a-billion-api-calls-each-month-raises-9m-led-by-a16z/

collaboration and value creation for some, but can lead to exploitation and value destruction for others. Such inherent trade-offs—call it the darker side of open innovation more generally—are largely overlooked in the open innovation literature now, but they will need to take center stage in future research (see e.g. recent work on the dark side of digitalization, Trittin-Ulbrich, Scherer, Munro, and Whelan, 2020).

3.1.3. Technologies that automate decision-making

Attention deficit is a common problem in all organizations, and research has, time and again, illustrated how information consumes attention and how attention has become a scarce resource affecting decision-making (Simon, 1947; Ocasio, 1997). Open innovation has aggravated these problems, for example when sourcing ideas (Dahlander and Piezunka, 2014). In the last decade, more and more organizations have used crowds and consumers to gain insights on their needs, get them to solve problems, or simply articulate their true desires. While we noted in our original paper that being exposed to many ideas consumes attention, we were surprised by the sheer volume of ideas and observed with interest what organizations *do* to cope with these challenges.

There are several strategies (Alexy, Criscuolo, and Salter, 2012). For example, some use signaling to ensure better alignment between need and solution or turn to multi-stage competitions to economize on attention. And, patents are often used as an entry ticket for conversations—non-patent holders are simply denied entry at the door to minimize future risk and unnecessary costs. Similarly, it has become more common to use a dual selection environment where ideas are generated *and* evaluated by crowds (Beretta, 2019). This helps organizations sift through the options available to them by aggregating their crowd members' preferences. However, this is an approach that may come at the danger of revealing stark differences between the organization's and the crowd's interest. There are several examples where the crowd championed one idea and the organization wanted something else, which led to friction. For example, researchers examining the SPAR Bag Design Contest demonstrate that perceived unfairness and dissatisfaction with the outcome can stir unrest and spread negative word-of-mouth (Gebauer, Füller and Pezzei, 2013). Another approach to dealing with attention problems is to use artificial intelligence to pre-select ideas that the company can later consider. Analysis of data from the Danish company LEGO show how machine learning can detect ideas in online communities (Christensen, Nørskov, Frederiksen, and Scholderer, 2017). The challenge, though, is that it may be difficult to identify novel ideas, as machine learning is trained on historical data. The immediate possibility is currently to detect ideas of a certain threshold level of quality (Christensen et al., 2017). Going forward, it will be exciting to see how machine learning can improve its ability to ease the selection burden on humans—and whether these developments will afflict new challenges on humans and organizations.

3.1.4. Technologies that expand search

Expanding the search horizon to identify external knowledge is a cornerstone of open innovation (e.g., Laursen and Salter, 2006; Lopez-Vega, Tell, and Vanhaverbeke, 2016; Trantopoulos, von Krogh, Wallin, and Woerter, 2017). In the last decade several search-expanding technologies have emerged. For example, crowdsourcing and crowdfunding platforms have skyrocketed in popularity. InnoCentive—one of many crowdsourcing platforms—has attracted lots of research interest motivated by its success in connecting problems with creative solutions (Jeppesen and Lakhani, 2010). Though InnoCentive has created value for solution-seekers, their model has struggled to create value for themselves. It is expensive to hire people to formulate problems and develop ways to evaluate the winning solutions. Kickstarter, one of the leading crowdfunding platforms, has backed close to half a million creative projects since its founding less than 15 years ago—likely several orders of magnitude greater than any venture capitalist. Then, after the passing of the Jumpstart Our Business Startups (JOBS) Act in 2012, it became easier for entrepreneurs to use crowdfunding to acquire resources. Although some skeptics may say that the sums invested from crowdfunding pales in comparison to what venture capitalists invest every year, this might be important for open innovation scholars for reasons other than pure funding. As Mollick (2014) notes, for example, these platforms allow prospective entrepreneurs to gain early insights into what potential consumers like. In fact, getting market insights is the primary reason for using Kickstarter, which highlights a new form of sourcing. Similarly, crowdsourcing may expand distant search (Afuah and Tucci, 2012) but simultaneously create attention problems (Piezunka and Dahlander, 2015). While these technological developments do not fundamentally alter our original conceptualization of openness, they underscore that access to distant and distributed knowledge has expanded at an impressive rate, potentially changing who can play the open innovation game, and from where. The literature has underscored the reach one can get with both crowdsourcing and crowdfunding, but it has also begun to illustrate that this comes at a cost of selecting between alternatives.

3.2. Technological developments and new questions

Units of information—data—are becoming core to any business enterprise. Open innovation research needs to incorporate various facets of data generation with other key resources. Ten years ago we did not properly understand the scale of data generated and how data could become integral to a firm's business model. Our framework still applies, but it needs to be reinterpreted to generate new insights considering these developments. In congruence with our original framework, data can be acquired, sourced, sold, and revealed. But data is often generated as a byproduct to use and is not necessarily acted upon strategically. While it is true that some companies already pursue data-driven busines models—especially platform companies such as Amazon, Google, and Facebook (as documented by, e.g., Cusumano, Gawer, and Yoffie, 2019) as well as some traditional industrial companies (as documented by, e.g., Björkdahl, 2020; Sjödin et al, 2020)—most efforts are still at a relatively early stage and are often associated with severe challenges. For example, moving from selling products to selling services is associated with a number of data management challenges, such as creating, capturing, and sharing data within and across firms (see Björdahl, 2020, for an in-depth analysis). As such, data-driven business models will likely be even more central to realizing the ideas presented in Chesbrough's work on open services innovation (Chesbrough, 2011). Future research should thus pay more attention to questions pertaining to the acquision, use, and sharing of data in order to realize the promise of data-driven business models and open services innovation.

Well-known consumer-side examples of data-driven business models are how social media and cell phone users—sometimes unknowingly—reveal valuable information to app developers and platform companies such as Google and Facebook. These companies source this data with no monetary compensation to consumers and also participate in creating markets for data so that it can be acquired and sold (Alexy, George and Salter, 2013). For open innovation research, such business practices open up to consider the ethical and legal dilemmas grounded in data ownership. Future open innovation research could, for example, ask what the tensions are between revealing data and capturing value from data. The first set of inquiries that emanate from this question concerns abuse, for example in the form of an unethical and potentially illegal breach of privacy when handling and profiting from data. Also, abuse in the form of use of market power when platform operators use their de facto monopolies to extract data from platform users with few alternatives. Consider university students who are "forced" to use a specific platform to access online learning during a pandemic. What rights do they have to protect personal data from which others can profit? A second set of questions considers the longer term and asks how sustainable an abusive system can—or even should—be. Future research could model or empirically investigate tipping points for when users

believe they are revealing too much for too little gain.

At the same time, these questions stretch beyond revealing preferences in a given system and thus have strong ethical and policy dimensions as to what the system should be. And these problems do not stop with consumers. More and more traditional industries, such as automotive and manufacturing, are facing related issues (see e.g., Björkdahl, 2020). For example, ensuring access to critical data prompted the German automotive industry to come together to develop their own alternative to Google Maps. Here, the automotive industry concluded that there was a risk that they would be excluded from accessing data, exposing the tension between generating and profiting from data.

There are also interesting competitive strategy questions for scholars to address, such as: How can companies pool data to create new opportunities and ensure they are not barred from accessing critical data? For example, pooling data challenges can arise when firms integrate internet of things technology into traditional machinery. Consider the operator of a wood grinder who adds sensors to optimize energy consumption. The operator can clearly benefit from pooling data from the added sensor with data from upstream and downstream activities to optimize use, maintenance, and energy consumption. However, the modification might break the contract with the grinder manufacturer, especially if the manufacturer aspires to start selling its products as services or to use the data for selling predictive maintenance. Here, open innovation researchers should consider the wider picture. Research has often focused on the use of open innovation from one target firm's perspective. But as data is growing in importance and the practice of open innovation becomes ubiquitous, inherent trade-offs are revealed and need to be addressed. These concerns clearly connect open innovation to the growing field of ecosystems (e.g., Leten, Vanhaverbeke, Roijakkers, Clerix, and Van Helleputte, 2013; Chesbrough, Kim, and Agogino, 2014; Holgersson, Granstrand, and Bogers, 2018). The data economy pushes us to consider competitive dimensions of open innovation where data may not be freely available and where the interests of multiple players must be considered simultaneously. For example, a recent paper exposes how conflict and cooperation can coexisit within an ecosystem (Vasudeva, Leiponen, and Jones, 2020). Considering our wood grinder example above, future research should also consider conflicts between overlapping ecosystems. In other words, data-driven business models often force companies to consider a multiplex of actors. And this propels the incorporation of ecosystem perspectives into open innovation research.

Preliminary work on firm use of "open data" suggests that policies for using and sharing data will be integral to most firms' business models (Temiz, Holgersson, Björkdahl, and Wallin, 2020). These "data issues" have policy implications as well, not least for the treatment of intellectual property and the ownership and use of data. Data rights vary across jurisdictions. Consider differences between the European Union implementation of its General Data Protection Regulation (GDPR) and implementation or lack thereof in other jurisdictions—such variance of rights, specifically data rights, were nothing we considered pertinent 10 years ago. For open innovation research this means that context matters a lot more, and that one-size-fits-all solutions will probably not work for organizations pursuing open innovation. Here, open innovation scholars can glean insights from international business studies and how this field has approached the co-evolution of multinational enterprises (one of the key analytical targets in this literature) and the institutional environment (e.g., Cantwell, Dunning, and Lundan, 2010). Overall, open innovation research ought to become more sensitive toward irregularities and changes over time and across jurisdictions and geographies. Another policy implication is the degree to which access or non-access to data could alter the cumulativeness of technical advancement, perhaps unintentionally but with broad implications for the trajectory of innovation (cf., Breschi, Malerba, and Orsenigo, 2000).

3.3. Organizational developments

3.3.1. Platforms as creators and mediators

Platforms are undoubtedly one of the key organizational developments that is transforming how organizations create and capture value (Gawer, 2014; Gawer and Cusumano, 2002; Cusumano et al., 2019; Hagiu and Wright, 2015; Parker, Van Alstyne, and Choudary, 2016). These platforms are "products, services, or technologies developed by one or more firm, and which serve as foundations upon which a larger number of firms can build further complementary innovation" (Gawer and Cusumano, 2014: 420). Indeed, many of today's most successful companies, such as Amazon, Apple, Facebook, Google, Microsoft, and Tencent are platform companies. For these companies, openness, or at least some degree of openness, constitutes an essential part of the platform business model (see e.g., Nambisan, Siegel, and Kenney, 2018). Platforms are distinct from traditional companies in the way they mediate transactions across particpants and how they create network effects (Gawer, 2014). Platforms create value by connecting unconnected groups. But more profoundly, such connecting allows the platform owner to pursue an extremely effective division of innovative labor that is heavily dependent on incentivicing and organizing input from several stakeholders. The platform as an "organizational form" thus provides standardized interfaces (APIs and software development kits) and governance mechanisms (Saadatmand, Lindgren, and Schultze, 2019; Ghazawneh and Henfridsson, 2013) to support innovation through value co-creation (Adner, 2017). This "platform revolution" has implications for firms' open innovation strategies, not least because of the uneven profit sharing in winner-takes-all markets where open innovation firms need to actively carve out an attractive position within an ecosystem of collaborating and competing actors. And it pushes scholars to think deeply about the governance and organizing principles of open innovation.

3.3.2. Practices to reveal internal ideas

Tesla provides an interesting example of organizational developments of the last decade. In 2014, the electric vehicle manufacturer published its "good faith" patent pledge in an effort to advance electric vehicle technology. Elon Musk said: "Tesla Motors was created to accelerate the advent of sustainable transport... If we clear a path to the creation of compelling electric vehicles, but then lay intellectual property landmines behind us to inhibit others, we are acting in a manner contrary to that goal… Tesla will not initiate patent lawsuits against anyone who, in good faith, wants to use our technology." While the pledge received considerable public attention, it is far from the open source-like license that Tesla alluded to. For example, companies using Tesla's intellectual property under this pledge are bound to not sue Tesla for any infringement on their part. Yet Tesla's move is interesting for several reasons. It is a novel way to signal to potential partners that Tesla is open for business, willing to strike a deal—without risking or giving anything away. More profoundly perhaps, Tesla is shaping the competitive battleground for a new automotive industry. In revealing their electric vehicle intellectual property they effectively say that competition is not within the electric vehicle industry but against the traditional fossil-based automotive industry (a clear nod to innovation ecosystem scholars that something is changing along the traditional industry boundaries). For example, in a blog post, Musk claims that given the annual new production of roughly 100 million vehicles per year and the global fleet being approximately 2 billion cars, it is impossible for Tesla to build electric cars fast enough to address the carbon crisis.

Tesla's revealing strategy is interesting for open innovation research, not least because it expands what revealing is and what it can achieve. Tesla's revealing is not "free revealing" as in giving up "all existing and potential property rights" thus providing a public good (Harhoff, Henkel, and von Hippel, 2003: 1753) but rather a case of a "patent pledge" where the patent owner pledges to out-license their patents, with or

without restrictions, for a small or non-exisitng fee (Ehrnsperger and Tietze, 2019). Our original paper was quite focused on *revealing* as a mechanism to cause direct benefits in a relatively narrow space close to the original innovation (cf. Alexy, West, Klapper, and Reizig, 2018). The Tesla example, however, shows how revealing in open innovation can have indirect effects, such as driving demand for new technologies and solutions like electric cars. It should now be clear that open innovation is not only about solving a particular firm problem but also about growing the pool of potential solutions and increasing the overall speed of outside development—returning to the roots of "collective invention" (Allen, 1983). Here, the indirect and cumulative effects of revealing and open innovation need further elaboration. For instance, revealing has a strong signaling value, and can potentially be used for purposes other than advancing the knowledge frontier. These strategic implications need further attention.

3.3.3. Legal devices that expand and narrow search

Legal issues of ownership and control continue unabated. For example, the open source movement used copyrights and licenses to combat code restrictions (Raymond, 1999; Stallman, 1999) – and is still relying on an array of legal devices to prosper by enabling extensive reuse of software components (Haefliger, von Krogh, and Spaeth, 2008), thus expanding search in a cost-effective manner. Without licenses that govern the inspection, modification, and use of the source code, open source would likely have followed a very different trajectory and found it much harder to achieve the global integration into hardware and systems it has today. Clearly, in many cases intellectural property rights (IPR) are the basis for open innovation and enable markets for technologies to function efficiently (Chesbrough, 2003; Arora, Fosfuri, and Gambardella, 2004). This is underscored in the development of new and complex technologies that require multiple partners to manage cost, risk, and competence. The case of IMEC, a public research institute in Belgium, focusing on nano-electronics is revealing. In their collaborative multi-partner programs the institute has devised a model that balances common and exclusively owned IP to incentivize knowledge sharing and enure equitable appropriation (Leten et al., 2013). Similarly, managers in R&D intensive firms in Sweden are reporting that open innovation and patenting go hand in hand – both in order to protect technologies and to secure freedom to operate (Holgersson and Granstrand, 2017). And evidence from the solar industry suggests that new entrants pursue more open innovation when they also engage in patenting (Zobel, Balsmeier, and Chesbrough, 2016). Another example is pharmaceutical firms using open innovation to expand search in upstream drug development. In the pharmaceutical industry, Bayer Healthcare initated their Grants4Targets program to expand search in upstream drug development (Lessl, Schoepe, Sommer, Schneider, and Asadullah, 2011). To incentivize start-ups and research groups at universities to submit novel targets Bayer explicitly ensured that the IPR remained with the partner.

At the same time, legal issues can inhibit initiatives that fall under the umbrella term *sourcing*. Sourcing is commonly used by organizations to get early insights on developments and partial ideas that can be further developed inside the company. But intellectual property can often stand in the way of adopting open innovation (Alexy et al., 2009; Sieg, Wallin, and von Krogh, 2010; see Laursen and Salter, 2014 for evidence and discussion on the positive and negative aspects of appropriability for openness). For example, many organizations are concerned about threats of litigation arising from getting an idea from someone through conversations. However, just as open source licenses enabled massive collaboration, intelligently designed intellectual property rights have the potential to widen the search space within and across industries. As Arrow (1962) notes in the information paradox, once knowledge is explained to a potential partner, they will have little incentive to pay for the information as it has already been communicated. Although we observed this 10 years ago, the "no patent, no talk" strategy permeates many industries (Alexy et al., 2009). In many conversations with executives after our original paper was published, we learned that it is difficult to break away from this strategy. Although savvy lawyers could design intellectual property rights more efficiently, this is not necessarily happening in practice. Sadly, the implication for organizations is that they cast a narrow net without the benefits of broad and distant search.

Our original paper elaborated on neither the challenges posed by legal concerns nor how legal instruments and intellectual property rights could be used as a force for open innovation. The software industry has very much led the way in terms of generating a great number of different licenses that cater to various needs and priorities (He, Puranam, Shrestha, and von Krogh, 2020), and a number of new licenses have been launched during the last decade, e.g., the Eclipse Public License introduced in 2017. Interestingly, these open source licenses provide for quite different kinds of openness. For example, so-called permissive licenses (e.g., MIT, Apache, BSD) allow for proprietary derivative work (i.e., later derivative work can be released as proprietary software) whereas so-called copy-left licenses (e.g., GPL, AGPL, LGPL) do not, thus effectively limiting both firms' freedom to operate and their means of appropriation (Holgersson and Wallin, 2017). Going forward, open innovation research needs to acknowledge the variety of legal instruments that underpin the creation and capturing of value from open innovation.

Here, it is worth considering developments in trade secrecy law that have given firms more tools to protect their assets. With the passage of the Defend Trade Secrets Act in 2016 US companies can now sue in federal court if they believe their trade secrets have been misappropriated.[3] For example, when Waymo, the Alphabet subsidiary developing autonomous driving technologies, suspected that ride-hailing company Uber had illegally obtained Waymo intellectual property from a former employee, they sued in federal court. The two companies settled, with Uber giving 0.34 percent of its stock to Alphabet.[4] A hefty price for Uber, sure, but the former Waymo engineer at the center of the case perhaps paid the highest price as the judge then referred the case to a US attorney for criminal prosecution. The engineer was later sentenced to 18 months in prison and ordered to pay $756,499.22 in restitution.[5] Clearly, both firms and individuals need to consider the legal ramifications using intellectual property developed elsewhere (Sharapov and MacAulay, forthcoming).[6]

3.3.4. The drive for corporatization of commons

Observations on open source communities influenced much of the early research on open innovation. The last decade's developments merit further scholarly attention, not least in terms of the increasing corporatization of commons – commons resources publicly available for use (O'Mahony, 2003). While early research noted how some corporations had an "insider" to obtain early insights and influence open source communities (Dahlander and Wallin, 2006), this approach appears to have accelerated in recent years.

Many developers raised concerns in June 2018 when Microsoft announced their $7.5 billion acquisition of GitHub, the world's leading software development platform. Microsoft communicated its aim to strengthen commitment to developer freedom, openness, and innovation and that GitHub would continue to operate independently. And the CEO claimed that the acquisition came with the responsibility to empower developers to address pressing challenges. Yet, it is hard not to

[3] https://www.forbes.com/sites/ericgoldman/2016/04/28/the-new-defend-trade-secrets-act-is-the-biggest-ip-development-in-years/#9adae644261e

[4] https://www.nytimes.com/2019/09/10/business/dealbook/levandowski-trade-secret-uber.html

[5] https://guce.techcrunch.com/copyConsent?sessionId=3_cc-session_eea33367-4102-4488-a88c-279b873d925b&lang=sv-SE

[6] The Waymo engineer was later pardoned by President Trump in his final hours in office, https://www.theguardian.com/us-news/2021/jan/20/anthony-levandowski-google-uber-pardon-donald-trump

acknowledge the power that comes with controlling GitHub. Today almost every company seems to have become a software company, and information technology is impacting every industry. And as developers drive several business processes and functions across organizations, GitHub has become the most popular destination for open source projects and software innovation. There are some 50 million developers using its platforms, running 85 million code repositories and representing more than 1.5 million companies in healthcare, manufacturing, technology, financial services, and retail, among others. Clearly an important player and mediator of open innovation is now in the hands of Microsoft, which was previously seen as a nemesis of the open source movement.

Another example of the corporatization of the commons is the IBM acquisition of Red Hat. The $34 billion deal in July 2019 positioned IBM as the leading hybrid cloud provider: Red Hat's open hybrid cloud technologies could now be paired with the scale and depth of IBM's innovation, industry expertise, and sales leadership in more than 175 countries. The primary drive behind the acquisition was IBM's ambition to bring its products to any public or private cloud. Red Hat is supposed to remain and operate as an independent unit.

Yet another example is the Linux Foundation, a non-profit technology consortium with the intention of promoting, standardizing, and protecting the development and use of Linux, an open source operating system. The Foundation has more than 800 members at all levels, but Platinum sponsors—those required to pay $500K/year—number just a few: Google, AT&T, Cisco, Fujitsu, Hitachi, Huawei, IBM, Intel, Microsoft, NEC, Oracle, Qualcomm, Samsung, and VMware. The Foundation has been charging such amounts for some years already, but in 2016 it cut independent board seats, removing the provision that allowed for the election of two board members by the groups' individual affiliates. Now the entire board membership is selected by the corporate members of the Foundation.

These recent trends beg the question, what will remain *open* and how will this alter the contribution patterns of people who share knowledge voluntarily? So far, though, we lack large-scale empirical data across organizations to analyze these changes. The corporatization of commons, and specifically a critical account of the increased power of large corporations in steering open innovation, has been largely absent from scholarly attention. While platform companies can indeed reinvigorate and sustain development in open source projects, there may be a darker side to this kind of open innovation. An example along these lines is Amazon, where Amazon Web Services has been accused of copying open source software tools, launching their own versions, and using market power to dissuade open source companies from monetizing their original projects.[7] At the same time, these examples call for connecting open innovation to literature on strategy and competitive dynamics. The fact that first-movers do not necessarily profit from innovation, and that holding key complementary assets explains success, have been known for a long time (e.g., Teece, 1986; Teece, 2006). This is true for open innovation as well, but recent developments underscore the importance of taking the competitive aspects of open innovation more seriously.

3.3.5. Accelerators to obtain ideas from the outside

Many large companies struggle to attract talent to source ideas from the outside. They have also tried to create cool hangout spaces for employees to work and play in, but many have realized that innovation is more complicated than decorating spaces with colorful bean bag chairs. As a result, large incumbents are seeking new ideas directly from outside entrepreneurs. Hence, the emergence of corporate accelerators to attract talent, develop ideas, and build companies (Cohen, 2013). Accelerators connect to the ecosystems of new technology ventures by providing them with the space to develop and grow (Cohen, Fehder, Hochberg, and Murray, 2019; Hallen, Cohen, and Bingham, 2020; Pauwels, Clarysse, Wright, and Van Hove, 2016). These spaces are meant to help circulate ideas and provide the freedom to innovate without the interference of the mother organization. For example, Microsoft recently created its new Microsoft for Startups program to connect its technological platform and marketing skills with the creativity of startups.[8] While there are plenty of accelerators, many have integration issues with the larger organization (Dahlander and Wallin, 2018). This is to say that the blending of large and small firm relative advantages and disadvantages, a long-standing issue in innovation management, has not yet been resolved. Another issue that confronts open innovation research are the opportunity costs faced by incubated firms when they tie the knot with large incumbents. Here, open innovation literature has an opportunity to emphasize small firm challenges with outbound open innovation (Brunswicker and Vanhaverbeke, 2015; van de Vrande, De Jong, Vanhaverbeke, and De Rochemant, 2009) and start addressing the OI literature's bias toward large, R&D-intensive firms and stop ignoring the unique characteristics and challenges faced by SMEs (Vanhaverbeke, Frattini, Roijakkers, and Usman, 2018; Vanhaverbeke, 2017).

3.3.6. Realizing the potential in the fringes

There is comparably more research on outside-in innovation than inside-out (West and Bogers, 2014). A key tenet of this literature is that companies hoard unused ideas that are shelved inside the company. As the OI literature points out, there seems to be unleveraged potential to either spin-out a stand-alone company or sell to other companies better suited to commercializing the idea. Lots of statistics, however, point out that this is not happening (Arora, Fosfuri, and Gambardella, 2001). Compared with the sheer number of people working as R&D scientists inside a company, there are very few people involved in licensing patents or other internally developed ideas. Take the pharmaceutical company Bayer: They employ 7,000 scientists, hold thousands of patents, many of which are unused, and they have just two employees responsible for licensing out (Chesbrough, 2019). Scholars have suggested that this kind of hoarding happens because of over-valuing internal resources and a perception that the idea will one day be put to use (Rivette and Kline, 2000). Chesbrough and Chen (2013: 93), for example, noted that pharmaceutical executives are sometimes reluctant to spin-out abandoned compounds because of the risk of "becoming the person who passed on the next commercial blockbuster." Another potential reason is that licensing technology to smaller companies may not move the needle for a large company, and might increase administrative burdens.

It may very well be that research has underestimated the challenges of external engagement, that it is not just about hiring more employees for licensing. Consider the case of open innovation and crowdsourcing company InnoCentive (see e.g., Boudreau and Lakhani, 2009). Through a network of "solvers" the company helps technology companies solve various innovation problems—like they did for Exxon after the oil spill disaster in Alaska, when InnoCentive figured out how to separate oil from water. They identified a solver from a completely unrelated industry—concrete—that offered a relatively simple solution to the problem of separating freezing liquids. Yet, despite the intuitive appeal of the model, InnoCentive has not become the dominant model of sourcing innovation. Earlier research has documented some of the challenges of employing sourcing platforms (e.g., Sieg et al., 2010; Wallin, von Krogh, and Sieg, 2018, addressed challenges to formulate suitable problems fitting for outside solving; Beretta, Frederiksen, Wallin and Kulikovskaja, forthcoming, addressed how managers' individual motives and cognitive frames impact platform results). Similarly, there is a large literature on absorptive capacity that could help explain friction and the challenges of external engagement (e.g., Spithoven,

[7] https://www.nytimes.com/2019/12/15/technology/amazon-aws-cloud-competition.html

[8] https://techcrunch.com/2018/02/14/microsoft-revamps-its-startup-programs-with-500m-commitment-and-new-co-selling-program/

Clarysse, and Knockaert, 2010; Zobel, 2017; Ter Wal, Criscuolo, and Salter, 2017). To better analyze and explain such friction and challenges to open innovation in the fringes, OI research could connect to the literature on organizational design (see e.g., Foss, Lyngsie, and Zahra, 2013; Bianchi, Croce, Dell'Era, Benedetto, and Frattini, 2016). Such an approach could potentially help explain why collaborations among universities are increasingly subject to formal contracts.

3.4. Organizational developments and new questions

These organizational developments pose new theoretical questions for open innovation. Much of the early open innovation literature studied how organizations can leverage external ideas, yet we have exciting questions ahead dealing with the way in which they change *how* we work, especially if we liberate ourselves from the notion that open innovation is about solving one particular problem with outside help. Today, we know that open innovation is more than that – new ways of organizing are required to implement OI (Chesbrough 2019; Chiaroni, Chiesa, and Frattini, 2011; Giannopoulou, Ystrom, and Ollila, 2011). Research should acknowledge this and take the indirect effects of open innovation seriously. This is particularly important when and if open innovation matures and moves from a fringe activity to a core activity, i.e., "the way we do innovation." Empirically, researchers could start by documenting who outside of R&D and marketing is affected by the onslaught of open innovation. Theoretically, researchers could devote more effort to exploring tensions between functions or organizational roles resulting from new organizational configurations created to enable, grow, and sustain open innovation (Alexy, Henkel, and Wallin, 2013). When open innovation was in its infancy such concerns were few. There are internal aspects that prevent or limit how we can use open innovation (Alexy et al., 2009). Alexy et al. study how legal requirements of transferring property can become roadblocks for collaboration, but there are other kinds of friction that can arise as well. Our original paper did not address these issues sufficiently. A potential avenue for future research is to investigate further the processes and sequences organizations go through to become more open or closed over time (see e.g., Enkel, Bell, and Hogenkamp, 2011).

There are three relevant categories of organizational developments. One is purely internal and focuses on how widespread open innovation is—as we noted in our original paper, for many companies OI is a peripheral activity. Working with OI also poses challenges about how to reward employees and change the culture inside the company. This makes it harder as it is not about adopting new collaboration tools but changing the way companies work. A second category of organizational changes is new "boundary-organizations" arrangements (O'Mahony and Bechky, 2008; Perkmann and Schildt, 2015) designed to render companies more responsive to the outside, for example by setting up accelerators. A third is how organizations are changing the way they work in communities and crowds over which they cannot enforce direct control. The developments in recent years highlight these tensions where companies' involvement through acquiring companies with a community dimension, such as Github, can stir strong negative reactions. If this alters contribution patterns then it becomes important to consider whether this is lasting or whether it will wane after an initial drop.

A true, balanced, and helpful account of open innovation needs to consider the gloomier parts as well. For example, the corporatization of commons can have positive as well as negative effects, but the negative effects on particularly the weaker party needs more attention, especially with regard to the longer-term effects on open innovation. Here, we recall how an early choice of open source license can have lasting effects on the success of a project and the ability of companies to profit. Companies that release open source code may need to think upfront about strategic trade-offs: should they select the permissive license route that allows themselves (and others) to close subsequent code and monetize directly (but potentially fail to attract developers)? Or should they adopt a copy-left approach that guarantees subsequent code will remain open (but potentially fail to monetize)? Clearly, the license is a means to influence communities over which the company has no direct control, and potentially to safeguard against exploitative firms with significant legal and economic clout.

3.5. Societal developments

3.5.1. Adjusting to global developments

Chesbrough's 2003 book and early contributions to open innovation use examples mainly from the United States, and to some extent from Europe. However, the institutional context in which open innovation takes place has changed dramatically, and it is one of a range of different societal developments in the last decade.

Although the Chinese Internet giant Alibaba, the world's largest B2B commercial platform, was already 10 years old when we wrote our original paper, the plethora of similar companies that have since emerged in Asia is remarkable. Moreover, the hegemony of the global world order has come under serious attack in the last decade. The trade wars between the US and China make it more difficult to collaborate across nation states. While in Europe, there is the ongoing issue of Brexit, which threatens to reignite borders and paperwork that most had forgotten about.

These developments suggest new lines of inquiry for open innovation scholars. For example: How should firms collaborate and compete in an unstable region? How should firms open up in this context? Or is opening up a dangerous strategy? From our own observations, companies in China are approaching OI with a different mindset. Alibaba's CTO made a prescient comment to one of us, saying that in the "Information Age" we thought that success came from controlling information, but now, in the "Data Age" we know that smart people outside the organization might make better sense of data than we can, so we share it.

Another anomaly in the usual patterns of innovation observed in the US and Europe is the Chinese home appliance firm Haier. Their "Rendanheyi" model has transformed the company into a platform for open innovation, allowing and encouraging their employees to branch out and become their own CEO within the Haier corporation. Open innovation scholars have started to document these developments (e.g., Chesbrough, Sogvi, and Mei 2020; Lewin, Välikangas, and Chen, 2017), but we still lack a comparative and comprehensive understanding of how these companies approach OI differently. Chesbrough et al. (2020), for instance, use content analysis of presidential speeches of high-speed rail and semiconductor industries in China to understand the role of the government as an orchestrator of open innovation. This work points out the importance of governments in shaping OI. More work is needed from different institutional settings.

3.5.2. Relying on open innovation in times of crisis

When we conducted research for the original paper, the data we used from the systematic literature review did not really reflect the financial crisis that was unleashing havoc across the world economy. We published in 2010, but we did our work between 2007 and 2009 when the financial crisis was taking hold. It was difficult to conceptualize how it would affect the macro-picture, let alone the micro-level: how firms operate and why they might plan to ingest ideas from outside or export ideas that were not creating value for themselves. Since then, we can see that there has been a crisis in the leadership and governance of large businesses, while competition has forced them to search more widely for novel ideas.

When we wrote the first version of this manuscript, we had not yet witnessed a crisis of similar magnitude to the financial one (see e.g., Chesbrough and Garman, 2009, on the effect of the financial crisis). Then Covid-19 happened. In the early stages of the pandemic, companies and other organizations formed often unexpected collaborations to solve acute problems (see e.g., Dahlander and Wallin, 2020; Chesbrough, 2020). This echoes a link to the behavioral theory of the firm, of

how crises may stimulate exploration and shape collaborations between previously disconnected partners. The question for open innovation scholars, though, is how lasting these collaborations are and whether lessons from a time of crisis extrapolate when more normal times return – or whether the Covid crisis will mainly cause companies to adopt an OI rethoric to impose R&D cuts, which happened during financial crisis a decade earlier (Chesbrough, 2019).

3.5.3. The need to address wicked problems

Ten years ago we and most of our open innovation colleagues were primarily concerned with company-specific problems. Truth be told, this is where the vast majority of open innovation literature remains. However, climate change and hard-to-solve environmental problems are real. In New Delhi, people are choking to death on toxic air caused by pollution. Wildfires have raged in California and Australia. Countless species are going extinct before we have even classified them. There is ongoing destruction of the rain forests and coral reefs. Life expectancy is decreasing for the first time in two centuries. The likelihood of major contagious diseases killing millions due to antibiotic resistant bacteria is rising, not to mention the ongoing Covid-19 pandemic.

These problems are "wicked" in the language of Rittel and Webber (1973) in part because there is no definite formulation of such problems. Typical examples of wicked problems are environmental and political issues of high complexity, problems where there is little consensus in terms of what the actual problem is. OI research has thus far mainly addressed problems of lesser complexity, problems that may be difficult to solve but where problem formulations can be worked out when sufficient manpower is available. Going forward, OI researchers have an opportunity to advance theory with the potential to build a better society. This is where closer links can be forged between OI and ecosystems (see e.g., Adner, 2017; Jacobides, Cennamo, and Gawer, 2018). There is a clear link between the literatures in that the ecosystem literature highlights how different actors are interlinked and depend on each other. The early OI literature was also quite transactional, not fully appreciating how organizations can shape the environment around them and create advantage.

A timely example is the emergence of new pressing questions concerning how the development and manufacturing of vaccines should be organized. Collaboration is essential to reach the necessary scale in research efforts, production, and distribution. How should big and small companies organize their R&D to meet these grand challenges? Perhaps they can find inspiration in Danish beer manufacturer Carlsberg's sustainability initative to develop its "Green Fiber Bottle" together with partners (see e.g., Bogers, Chesbrough, and Strand, 2019).[9] Another example is how UC Berkeley spinoff company Amyris that, with funding from the Bill & Melinda Gates Foundation, developed a synthetic version of artemisinin, a chemical needed for antimalaria drugs, and then licensed the production to French pharmaceutical firm Sanofi.[10] Is OI helpful in tackling problems like this? Likely yes, as grand challenges require a "coordinated and collaborative effort" (George, Howard-Grenville, Joshi, and Tihanyi, 2016: 1880) that "good" open innovation theory and practice can provide. Theory and practice that can resolve issues such as "who" should coordinate and how we should address the division of labor and specialization when collaborating on wicked problems and grand challenges.

3.5.4. Big science and citizen science

Although de Solla Price (1963) noted decades ago how expensive scientific instruments can be, this has escalated in certain areas. Even large universities and corporates cannot afford to play on their own, which has resulted in increased *centralization* to a few places. For instance, the biggest scientific collaboration ever is ITER, a $20 billion investment to create a fusion research reactor in France. This is bigger than the European Organization for Nuclear Research (more commonly known as CERN), and few if any countries can do this on its own. As a result, teams are becoming larger and more multi-disciplinary (Wuchty, Jones, and Uzzi, 2007). One implication is that in some areas of science, scientific endeavors are concentrating around a few leading institutions.

But to deliver results they need to collaborate, and this is changing the nature of OI. These are the global flywheels for new ideas, because they are magnets for talent and have leading scientific infrastructure. They are skewing economic growth due to the spillover benefits of talent and spinouts. The large hubs attract inward investment and create a self-reinforcing circle that attracts talent. By concentrating talent in a few places because of access to facilities, corporates must select collaboration partners in these locations to connect their OI activities. Robaczewska, Vanhaverbeke, and Lorenz (2019) study Janssen Pharmaceuticals and its global R&D center in Belgium. This work illustrates how companies can make a strategic effort to shape the surrounding environment, and call for a greater appreciation for linking OI to ecosystems.

Some of these issues are also dealt with in an emerging literature on "open innovation in science" (see e.g., Beck et al., 2020, for an overview) but many issues remain unresolved and open for OI scholars to address. An opposing trend to centralization caused by expensive instrumentation is that we have witnessed a greater *democratization* of science in other areas (Sauermann and Franzoni, 2015). Crowd science allows people around the world to self-select into an area to jointly develop the knowledge frontier. This trend suggests a greater dispersion of activities in a geographical area. Interestingly, this allows for an open and distributed model of innovation where revealing is key.

3.6. Societal developments and new questions

These societal developments have wide implications for OI research. The Covid-19 pandemic has spurred unexpected collaborations, yet the need to tackle other big questions beyond this remains. For instance, it is unlikely that a single organization can tackle global warming, which will hopefully lead to new collaborations should this crisis become even more severe. Our original paper was very company-focused, ignoring wicked problems that require new and ongoing collaborations. There is room for OI research to think more systematically about solving problems of higher complexity, problems systemic in nature and where problem formulation and problem solving are hard to disentangle (for a contrast see e.g., Wallin et al., 2018). Societal developments and demands push OI research in a direction away from rather simple sourcing of defined R&D inputs. While such research has merits and is associated with managerial challenges, OI scholars should dare to dive into the deep water.

4. Discussion

One reason for writing our paper in 2010 was that we felt the word "open" in "open innovation" was misleading. The open source software movement influenced much of the early OI reasoning – and when talking to managers responsible for open innovation, they often confused OI with "freely available" as in "no ownership" and "no constraints on IP." The open innovation literature has since developed a much more nuanced interpretation of open innovation, explaining the contingencies under which it makes sense to be open (see e.g., Felin and Zenger, 2014; Laursen and Salter, 2006). While we did not set out to update and modify our original framework (sourcing, acquiring, selling, and revealing), it is comforting to conclude that these archetypes remain helpful when analyzing a more multifaced OI phenomenon. As such, the framework's application can be widened from a steady state to a situation where organizations are managing a portfolio of evolving OI cases. Indeed, the literature has begun to investigate the sequences

[9] We thank an anonymous reviewer for highlighting this example to us.

[10] https://news.berkeley.edu/2013/04/11/launch-of-antimalarial-drug-a-triumph-for-uc-berkeley-synthetic-biology/

organizations go through to become more open or closed (Enkel et al., 2011) and the temporal sequences depending on the maturity of the form or project (Bahemia, Sillince, and Vanhaverbeke, 2018). This is important theoretically as organizations start at different places, have different history and capabilities, and may walk very different paths to end up with similar strategies. Looking back we can also conclude that the distinction between inbound (sourcing and acquiring) and outbound (selling and revealing) OI identifies a bias toward the former (Chesbrough and Bogers, 2014) but that growing interest in "data-enabled" business models and ecosystems will likely put more emphasis on the latter going forward.

Since 2010 a growing body of literature reviews and empirical papers have explored open innovation at substantial length. The conferences spearheaded by Henry Chesbrough and Eric von Hippel and colleagues have formed a community that has contributed to widespread adoption. Interestingly, the open innovation literature has also been increasingly accepted in mainstream journals, and we have perhaps even witnessed a certain degree of what Merton would label "obliteration by incorporation," where original ideas have been forgotten or taken for granted because of widespread use and incorporation into everyday language. Moreover, OI has been incorporated into public policy in many countries, as well as at the European level (Bogers, Chesbrough, and Moedas, 2018). When policymakers use terminology, it becomes even more important to consider its boundary conditions and results, to which Chesbrough (2019) himself has recently paid more attention.

While our elaboration on technological, organizational and societal changes highlighted new questions for scholars of OI, there are many shared elements and, in practice, these changes need to be considered together. For example, it is very much through technological and organizational changes – such as improvement in data processing capability and new IP management practices – that we now can start addressing societal challenges that span organizations and sometimes even countries and continents. Below, we elaborate on the implications and what it means for the field, and chart interesting avenues for future research.

Develop theory and stay true to empirics. Some scholars have pointed out that OI is often theory-light (Alexy, West, Klapper and Reitzig, 2018; Alexy, Frederiksen, and Hutter, 2020), which has resulted in a modest share of papers published in top journals. This number is growing and some of them are heavily cited (see e.g., Laursen and Salter, 2006). We concur with the call to connect OI to other general management theories (Randhawa, Wilden and Hohberger, 2016; Alexy et al., 2019; Felin and Zenger, 2014; Laursen and Salter, 2020). Yet, we believe it is important to remember that research on OI has been successful *and* relatively phenomenologically driven: It has documented cases that existing innovation theory often struggled to explain. If we set the bar too high for theory development, we may distance the research from grounded observations about what happens in innovation. The solution may be to develop middle-range theory (Merton, 1957) able to connect empirics with more general theory. In such a way, OI research can further increase its predictive power to have more testable predictions. One avenue for future research is to move beyond conceptual papers at different levels (Bogers et al., 2017) and begin to collectively test the most interesting predictions of the theory. Different forecasting projects have moved in this direction by having multiple teams analyzing the same dataset (Landy et al., 2020; Silberzahn and Uhlmann, 2015) and using prediction markets to improve reproducibility (Dreber et al., 2015). The OI community could be inspired by these ideas and collectively test the most important predictions on different datasets, which a single team would be unable to do. In other words, we can turn our lessons of collaboration on ourselves to extend the field further.

Open innovation as peripheral or core. Open innovation can bring benefits, but it is also important to consider it in light of other activities within companies. A sober approach is not only considering its costs, but also comparing it to other efforts inside companies. One case in point is corporate accelerators that can generate fresh opportunities for companies. For a large company, however, this form of open innovation really occurs at the fringes, involving a minuscule part compared to the rest of the organization. Also, recall Chesbrough's (2019) point on outbound innovation, where he noted how a company such as Bayer employs thousands of scientists working in R&D labs, producing thousands of patents each year but only has two people responsible for outlicensing. It is important to use this perspective to put open innovation into context. Even if the OI component of innovation is small compared to all other activities, the implication is often that there is more potential. Our study of IBM, for example, shows a company striking an interesting balance between closed and open innovation (Dahlander, O'Mahony, and Gann, 2016). It is not a matter of open *or* closed, it is rather a matter of degree. The question is not *if* to use open innovation, but *when* to use it.

Substitute vs. complementarity to internal R&D. The question of whether external sources are substitutes or complementary to internal R&D remains open to debate – and will likely become more important to untangle as open innovation becomes increasingly ubiquitous. Recall that in their influential paper Lauren and Salter (2006) rejected the complementarity hypothesis – rather their results from the UK manufacturing industry pointed toward a substitution effect. The authors attributed these results to a "product of the NIH [Not-Invented-Here] syndrome—that greater attention to openness for external sources confronts internal resistance from some of the company's technical staff." (p. 145) In an analysis of pharmaceutical firms, however, Hagedoorn and Wang (2012) found such a complementarity, but only at higher levels of internal R&D. In other words, what appears to matter is not the clear-cut distinction between substitute and complementarity but how firms can organize to reach different open innovation goals. For example, there is qualitative evidence that using OI can cause internal friction—employees feel threatened, wondering whether it would replace their jobs. It may threaten their identity by questioning how work is done (Lifshitz-Assaf, 2018). The NIH syndrome also highlights that some employees are skeptical of ideas originating outside the organization. Hannen et al. (2019), for example, study how NIH emerged and what companies can do to overcome the NIH syndrome.

The approach in the literature to date has been to empirically measure internal R&D and external engagement and look for moderation effects that shape how well companies use open innovation. This is useful for showing average effects across organizations, but we lack detailed information about how internal resources are spent. How do companies qualitatively organize differently as a result of working with OI? How are people rewarded and motivated? We have learned that some companies are first trying to tap out internal expertise before going outside so that internal employees feel they have been recognized. From our experience, managers still face overlooked OI challenges. The literature has moved in this direction (see e.g., Ter Wal et al., 2019; Hannen et al., 2019), but there are open questions regarding which people to task with the external search, how many there ought to be, and how best to integrate the insights gained.

Grand challenges and wicked problems. A welcome change in the last decade is the turn to using OI for grand challenges and wicked problems (see e.g., Majchrzak, Griffith, Reetz, and Alexy, 2018; McGahan, Bogers, Chesbrough, and Holgersson, forthcoming). This has also altered *how* we use OI. The earlier literature's focus was on obtaining ideas and integrating them. However, the premise of finding an idea on the outside may not suffice. Instead, a more ongoing, deeper collaboration is necessary to advance the knowledge frontier similar to the long-standing literature on co-creation (West and Bogers, 2014). Some early OI research depicted ideas as readily out there and the strategies companies can implement to find and integrate them. This opens up new challenges. Individuals and companies alike often overestimate their contribution to collaboration, which makes it difficult to decide how to allocate returns. As a result, many of the wicked problems have

happened in non-profit settings where challenges to designing contracts, resolving IP-issues, and dividing rewards are less pronounced or non-existent. This provides opportunities to mobilize communities and work across organizational boundaries (Dahlander and Wallin, 2006). The recent developments that we review suggest a challenge where companies are moving with a heavy hand, which may ultimately decrease the motivation for volunteers to engage.

From organizational to individual-level and its limits. There has been a shift in OI research from the organizational- to the individual-level (see e.g., Bogers et al., 2017; Dahlander et al., 2016; Salter, Ter Wal, Criscuolo, and Alexy, 2015). This research neatly complements a wide range of papers using the Community Innovation Survey or similar datasets (see e.g., Laursen and Salter, 2006; 2014). This research formalized and expanded Chesbrough's (2003) work by testing generalizability. However, research at the organizational level masks important differences within companies. It resembles the average effects of company policies when there may be vast differences between individuals within the same company. Dahlander et al., for example, show that there is vast heterogeneity at the individual-level in how scientists and engineers tasked with OI obtain external ideas.

There may also be differences at the project-level (Salge, Farchi, Barrett, and Dopson, 2013; Du, Leten, and Vanhaverbeke, 2014), where some projects are open and others closed, masking important differences between companies. An implication is that for some types of research that potentially involves more people (such as sourcing ideas), there are big within-company differences. For others, such as out-licensing previously unused ideas, there are very few people involved. We believe there is ample room for investigating how OI changes internal organizational structures. Lifshitz-Assaf (2018) documents this at NASA, but there are many aspects we still do not fully understand. Working with OI often requires changes in how to reward people, changing internal mindsets, and overcoming the NIH syndrome (Salter, Criscuolo, and Ter Wal, 2014; Ter Wal et al., 2017; Mortara and Minshall, 2011). New deep ethnographic or qualitative research can reveal more of these tensions, which would open up novel questions for more large-scale quantitative work.

Strategic choices and cost-benefit analysis. The ambition of our 2010 piece was to be more precise about the advantages and disadvantages of openness. While the literature has moved to document more OI failures (see e.g., Chesbrough, 2019; Dahlander and Piezunka, 2014), we still believe there is room to do a careful cost-benefit analysis of openness. This is a core tenet in strategy research and has not received enough attention in OI research. The difficulty is time frames. Innovation is by definition long term, and there are other observed and unobserved factors that happen simultaneously. Considering the cost benefits of OI, however, is too important to be overlooked despite its empirical difficulties. As the recent trends we have reviewed suggest, there are also costs and benefits at a more aggregated societal level. For example, openness can be used to reach quick adoption and beat competitors, and when competitors are shaken out, companies could potentially benefit from being more closed.

We hope that we have provided some ideas for how to think about openness in the next decade and beyond. While our original distinctions between inbound and outbound innovation, and between pecuniary and non-pecuniary interaction still hold, we have charted a path that emphasizes interactions and tradeoffs between modes of open innovation, the need to better understand the nature of data, new organizational designs and legal instruments, and multilevel aspects and relationships that affect open innovation in terms of technological, organizational, and societal developments. Our aim has not been to provide a new theory of open innovation, but rather to gaze into the future of open innovation research and to inspire a new generation of open innovation researchers.

Credit Author Statement

LD, DMG and MWW all contributed equally and are listed alphabetically.

Declaration of Competing Interest

No.

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