POMS PRODUCTION AND OPERATIONS MANAGEMENT

PRODUCTION AND OPERATIONS MANAGEMENT POMS

Vol. 26, No. 4, April 2017, pp. 633–651
ISSN 1059-1478 | EISSN 1937-5956 | 17 | 2604 | 0633

DOI 10.1111/poms.12664


# Research on Idea Generation and Selection: Implications for Management of Technology

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Idea generation and selection are fundamental activities in innovation. Scholars in many disciplines have written about these activities, addressing diverse perspectives. In this study, we synthesize the research findings most applicable to the management of technology. First, we present findings on the process of idea generation: the importance of problem recognition and the many decisions made in organizing the effort. Second, we present findings about the process of idea selection, focusing on the different types of information that can be used in that decision. Third, we turn our attention to the organizational context in which both idea generation and selection occur: the corporate culture, use of incentives, organizational structure, and use of teams. Finally, we conclude, emphasizing that although idea generation and selection are as old as human decision making, changes in technology still affect these fundamental processes.

*Key words:* innovation; idea generation; idea selection; organizational context of innovation
*History*: Received: September 2015; Accepted: June 2016 by Cheryl Gaimon, after 2 revisions.

## 1. Introduction

Advances in technology play dual roles in innovation. First, advances in technology affect the objectives of idea generation and selection. As technology improves, new capabilities emerge, and these new capabilities prompt a new set of needs and opportunities throughout the supply chain. Firms will generate new ideas around those needs. Consider the telephone in the late nineteenth century: it was a new technology which enabled verbal communication in real time across vast distances. Of course, for such a technology to achieve its potential required new means of transmitting signals, routing, and switching stations, etc., all of which were new challenges. That is, there were gaps between the status quo and what was needed, and the solutions were not readily obvious. Companies generated and selected ideas to fill the gaps.

Second, advances in technology affect the process of idea generation and selection. The introduction of the telephone allowed information to be transferred from those people who experienced a need to those people tasked with solving this need, thus enriching the idea generation process. More generally, advances in communications technology allow people to engage in a lively debate, despite being dispersed across the globe, thus enhancing the idea selection process.

With these different roles, effective management of technology is needed in two ways: organizations must carefully manage their idea generation and selection processes to keep pace with the rapid evolution of technology (Gaimon 2008), and organizations must carefully monitor the emergence of new technology to ensure their idea generation and selection processes are operating in the most effective manner. Research in operations, marketing, management, psychology, and economics informs what we know about these deliberate efforts.

In this study, we curate research, interpreting the practical relevance to management of technology and hoping to inspire further research. The literature related to idea generation and selection is vast, and we do not attempt to survey it all. First, we present findings about the process of idea generation: the importance of problem recognition and the many decisions made in organizing the effort. Second, we present findings about the process of idea selection, focusing on the different types of information that can be used in that decision. Third, we turn our attention to the organizational context in which both idea generation and selection occur: the corporate culture, use of incentives, organizational structure, and use of teams. Finally, we conclude, emphasizing that although idea generation and selection are as old as human decision making, changes in technology still affect these fundamental processes.

## 2. Idea Generation

Idea generation is an important step in innovation. In different domains of innovation, the word idea means different things. Ideas can be descriptions of new product concepts in a product development process. Ideas can be solutions to organizational or societal problems such as "how can we identify great employees?" or "how can we encourage people to eat more healthfully?" Ideas can be methods to improve processes such as "how can we better apply a uniform coating to this rolled steel?" or alternatives for technology choices such as "which information storage technology should we use?" We define ideas as discrete, or enumerated, descriptions of solutions to a problem posed. Ideas can have different degrees of elaboration and certainly can be incomplete or partial proposals.

With this broad definition of what ideas are, we discuss findings and open issues related to the process of idea generation. We begin with a typology of problem recognition and discuss how the type of problem recognized relates to the idea generation process. Naturally, if we plan to generate ideas to solve a specific need, we also must understand the boundaries on the solutions we seek; we address the constraints and how these relate to the idea generation process. Subsequently, we shift our attention from the characterization of the type of need and solution space to the questions of how an organization should seek ideas and from whom.

### 2.1. Problem Recognition and Constraints

How do we know there is a problem to be solved? Goldenberg et al. (2001) describe five ways a problem may be recognized: need spotting, solution spotting, mental invention, market research, and trend following. Need spotting, market research, and trend following can be loosely grouped as market-driven triggers: there is some signal from the market that a new solution would be welcome. In other words, the market reveals some dissatisfaction with the status quo – a gap between a consumer's needs and existing solutions – and this gap forms the foundation for the problem recognition. This type of prompt is known as a "market pull" or "demand pull" (Di Stefano et al. 2012).

Solution spotting can be thought of as the opposite of "market pull," namely "technology push" (Di Stefano et al. 2012), having a (technology) solution prior to the identification of a particular problem. In the case of technology push, the solution is identified first and the idea generation that follows is geared toward finding problems that could fit the pre-existing solution. Smith et al. (1995) echo the market pull vs. technology push dichotomy, using language of function and form, respectively. Terwiesch and Ulrich (2009) use a similar framework, defining an innovation as "a new match between a need and a solution," mapping to demand and technology. As a final category of problem recognition, Goldenberg et al. (2001) use the phrase "mental invention" to describe the occurrence of an idea "suddenly born in the mind" of the inventor, or a process where the idea comes from a "decision to innovate and ... [an] internal cognitive process rather than on external market stimulus."

An organization's strategy helps to shape its problem recognition. If an organization aspires to be on the cutting edge of technology, then innovation efforts may include a technology push. For example, organizations in many sectors can challenge themselves to discover useful applications of the latest mobile computing advances or Internet-of-Things developments. It is common to find organizations upstream in a supply chain who push their technology on downstream partners. This is often the case for companies such as Corning who conduct basic research to develop new materials to push the boundaries of performance. However, the new materials that emerge do not always have an immediate use. For example, the original variant of Gorilla Glass, Chemcor, was marketed in 1962 and ultimately shelved in 1971, due to the inability to find a suitable application. In 2005, Corning began investigating it for use in cell phones and watches, and it was not until 2007 when Steve Jobs called upon Corning to develop the iPhone screen that the glass was finally put to use (Gardiner 2012).

Just as an organization maintains a portfolio of initiatives to support its strategy, their portfolio of initiatives may require different types of problem recognition. Corning achieved success with Gorilla glass through technology push; they subsequently sought to capitalize on this success through a directed effort with key customers to learn their specific needs (Holstein 2013). In this sense, Gorilla glass found success through technology push, and building upon this, they realigned this portion of their business around a market pull strategy.

The type of problem recognition frames the problem to be solved. In turn, that framing provides the conceptual breadth of the problem, dictated by implicit or explicit constraints. If a "mental invention" takes the form of a "decision to innovate," the scope of innovation effort will be very broad, essentially a charge to the organization to come up with something new. For example, the college dean who convenes a task force to explore ways that undergraduate education can be improved in the school has given a very broad scope to the task force, with relatively few constraints. In contrast, if the problem is framed in a manner consistent with solution-spotting, the dean may convene a task force to explore ways to implement the changes made in an executive format MBA to a full time MBA, which represents a significantly more (and differently) constrained problem.

Is it the case that more breadth in problem definition is better? From one perspective, the answer may seem to be yes: In mathematical optimization models, constraints impair performance, so in a formal optimization sense, fewer constraints are better. However, in human behavior generally, and in generative activities specifically, constraints are shown to enhance performance, as measured by assessments of creativity or market value (Finke et al. 1992, Moreau and Dahl 2005). Therefore, in general, the answer is no, more breadth is not necessarily better.

Constraints can help performance in many ways. Constraints can serve to keep the ideas more relevant (Sinfield et al. 2014). Constraints can also help solve the problem of "too much choice" extensively documented in consumer psychology. Schwartz (2004) dubs the effect the "paradox of choice" and Iyengar and Lepper (2000) show people are demotivated by the unconstrained freedom of choice. And constraints can help people overcome cognitive fixation, the tendency to generate ideas resembling existing solutions or highly accessible examples (Jansson and Smith 1991). Ward (1994) explains how constraints can move people off the path of least resistance, toward more novel ideas. The phenomenon of cognitive fixation at the individual level is analogous to the concept of core rigidities at the organizational level (Leonard-Barton 1992, Leonard-Barton et al. 1994). However, at the organizational level Leonard-Barton et al. suggest removing traditional constraints to move organizations out of dominant modes of operation. In the end, applying the right constraints, or removing them, can help move not just individuals, but also organizations, out of ruts.

Of course, the underlying mathematical logic that constraints impair performance is still in force. If an innovation problem is framed too narrowly, that can exacerbate cognitive fixation, or simply not allow enough room for creativity. Year after year, we see a student in our innovation classes define their innovation along the lines of "a pedal-operated toilet seat," a goal that is too narrow to foster creative idea generation because the goal itself basically suggests the solution. And year after year, we have to nudge that student to broaden the scope by identifying the implicit unmet needs and by considering other ways to meet them. Given all of these forces at play, there is not a simple optimal level of breadth in problem framing (Erat 2015, Kornish and Ulrich 2011).

The different modes of problem recognition do not just vary by the strength of the constraints, but also by the nature of the constraints. Comparing technology push to market pull, we see constraints take shape in different ways. Technology push acts to constrain the technical dimensions of the solution: what needs can be better addressed with this solution than the status quo? For example, consider the case of Research in Motion (RiM). RiM had deep technical knowledge of data transfer over wireless networks and mobile pagers. Their expertise in securely transmitting messages led them to develop a mobile device with a keyboard that allowed for email transmission over wireless networks in 1992 (Seigts and Bigus 2012). Thus, RiM set out to use existing technology to satisfy a latent need: the exchange of mobile email messages. That is, they had a technological solution and adapted it to fit a new unmet need through the eventual launch of the Blackberry in 1997, the first consumer device of its kind able to send and receive e-mail messages over a wireless network. If a domain of innovation draws on highly technical knowledge—either process technology in the case of glass manufacturing or product technology in the case of a Blackberry—then problem recognition focused on technology has clear merits.

If, instead, in that technical domain, a need were to be the primary frame or constraint, then there will be a secondary constraint, perhaps implicit, that the solution must use existing technologies. When branching into other areas of technical expertise is prohibitive, it makes sense to lead with the technology. For example, if an electronics manufacturer wants a flexible display material for wearable devices, it is likely that Corning would implicitly rule out solutions involving specialty plastics. When technical knowledge is central to solutions and costly to develop, technical constraints act as hard constraints, and problems should be framed accounting for them.

The constraints may be more flexible in domains where problems are recognized via market pull and technical knowledge is less central, less costly, or can be applied more flexibly. A recognized market need serves as a constraint on the problem framing, but it would be foolish for an organization to slavishly adhere to an original statement of the problem and not adjust course based on new market, competitive, or technical information. Those adaptations are more realistic than ones that require an organization to invest in costly new technologies. As an example, consider Tote, a mobile shopping app launched in 2009. Tote originally billed itself as "window shopping" on a smartphone, meeting the need of curation and discovery of great products to purchase. Business stalled, however, due to the difficulty of mobile payments. Tote revived itself as Pinterest, the "visual discovery" social network, a need similar to the original, but distinctly different (Baribeau 2012). Treating an identified need as a constraint can marshal the benefits of a constraint in reducing distractions and encouraging novelty, even if the reality is that the constraints arising from need spotting are flexible.

Given the dueling effects of constraints, there is no universal answer to whether tight or loose constraints or hard or flexible constraints are best. Di Stefano et al. (2012) find, in a recent review of the most influential articles on the sources of innovation, that neither technology push nor market pull is unambiguously more successful. Instead, they find that the two approaches work in concert to influence the success of innovation.

### 2.2. Solvers: Who, How Many, Where, and How Often?

Once the problem has been defined and responsibilities and resources assigned, there are many decisions to make about how to get people to contribute ideas. Academic research has addressed decisions such as who and how many people will participate in the idea generation process and how organizations should structure their efforts to access the most valuable ideas *across* a broad set of stakeholders.

An important insight about *who* should be involved in idea generation comes from Von Hippel (1976, 1978, 1986), who introduced the concept of lead users. Lead users have an acute need for something that might have broad appeal in the future. They are an especially valuable resource in sectors with rapid change, such as technology. Von Hippel (1994) also demonstrates the importance of connecting people who have deep knowledge of a problem with those who have deep knowledge of how to solve the problem. There is often some geographic, physical, societal, or other barriers that make it difficult to transfer information on a problem from its current location to a location where people are equipped to address it.

The broad lessons and specific practical advice in von Hippel's work continue to be extremely relevant for management of technology. We also see a complement to von Hippel's work focused on specific, high-impact lead users in the work on tapping the creativity (Shalley et al. 2016) of larger groups or crowds of people. The twin ideas of crowdsourcing (Howe 2006) and "open innovation" have been around for over a decade (Chesbrough 2005) and have continued to spread. Some companies have crowd input as part of their essential make-up: Threadless, where the crowd contributes the designs for t-shirts sold on the site, or Quirky, where community members contribute ideas for new consumer products that Quirky develops and sells. Other companies have established platforms that let "seekers" and "solvers" connect. The seeker/solver language comes from Innocentive, one of the original platforms for connecting organizations that need ideas or solutions ("seekers") with people who will generate them ("solvers"). Such platforms have proliferated: there are specialized sites, such as 99designs for graphic design, or general ones, like challenge.gov, for contests sponsored by US federal agencies. King and Lakhani (2013) give an excellent overview of current issues and best practices with open innovation.

The term open innovation does imply involvement from people outside the organization, but the basic logic of crowdsourcing is agnostic about whether the crowd is internal or external. Comparing internal and external resources directly, Poetz and Schreier (2012) address the dilemma of whether the inclusion of external users in the idea generation crowd is, indeed, beneficial. The argument against external solvers is that they would not generate ideas with the proper fit for a particular organization's capabilities. Poetz and Schreier find that a blind evaluation of ideas generated by internal experts, and those generated by (external) users, the users' ideas generally scored higher in terms of creativity and novelty. Moreover, the users' ideas also scored well on feasibility. In fact, those ideas which were deemed best overall, a composite measure, were more likely to have come from a user. There is potential for more research in this area to help us understand what characteristics of a problem lend themselves to productive use of external solvers.

One element of managing the solvers is giving them feedback. Wooten and Ulrich (2015) run a field study to understand the best way to do that. In the study, they use the graphic design platforms 99Designs and Crowdspring to solicit logo designs for companies or new products. They compare no feedback, random feedback, and directed (or "true") feedback. They find that directed feedback does encourage participation more than the other conditions, but it does not actually improve the best ideas.

Beyond determining who should be involved, another question is how large the pool of idea generators should be. The traditional trade-off at play is that more ideas translate into higher performance (Dahan and Mendelson 2001, Terwiesch and Ulrich 2009), but more people also translate into lower effort (Taylor 1995). However, Terwiesch and Xu (2008) note that performance depends on more than just effort, the diversity of the ideas matters too. And when this is considered, they find the benefit from the inherent diversity of a larger pool of people may offset any decrease in effort, resulting in a net benefit of more people. Boudreau et al. (2011) cite the competitive impact of more participants, specifically, increased competition means less effort provision, thus reducing the quality of the ideas. The conclusion is therefore that more participants are not unambiguously better. The context within which a contest occurs and the nature of the problem to be solved matters. Clearly, this is an area where much more guidance is needed regarding the design of contests and the number of participants.

Another decision is about time frame. The organization must decide whether to have an ongoing effort (Dell IdeaStorm, MyStarbucksIdea) or to have a specific end date (like the challenge.gov time-limited contests). (Those examples happen to use crowdsourcing, but the same decision is relevant for internal-only efforts.) Bayus (2013) studies the Dell IdeaStorm community. One interesting conclusion from that study is that successful community members, that is, the people who contributed ideas that were accepted, are less likely to have a subsequent idea also accepted than unsuccessful ones. Although not the focus of that paper, the finding could be related to this question of ongoing vs. a specific end date. It would be interesting to compare an ongoing and static call for ideas with one that has a specific end date. Is there something about repeating a number of contests with specific end dates (Dahl and Moreau 2007) that renews people's participation and effort compared to an ongoing open call for ideas? To our knowledge, the strengths and weaknesses and applicability of conducting either an open call for ideas or a series of contests where each one has a specific end date has not been studied. This is something that could reasonably be examined in a laboratory or field setting.

## 3. Idea Selection

Once ideas have been generated, organizations need some way to select the ones that will receive additional investment. Because our focus is on sets of discrete ideas, idea selection involves choices between the ideas, rather than optimization of some continuous variable. Idea selection is often a multi-round process, described as a funnel or a tournament. We present two perspectives on idea selection processes, one that is focused on making predictions from assessments, ratings, or intentions, and one that is focused on gathering real market data. The two perspectives are not completely disparate, but the key distinction is that the latter puts some (perhaps minimally) developed version of the idea into a market where the collected data is not what a person *would* do but what they *did* do.

### 3.1. Selection Processes Based on Data Collection for Prediction

One view of idea selection is that, at its core, it is a prediction task. In the face of great uncertainty, organizations try to select the ideas that will be the best, according to some criteria. Even if the criteria are crystal clear, good predictions are hard to make. In the context of idea selection, the task is even more challenging because there may be a large number of ideas from which to select. The more ideas there are, the less detail one is likely to have about the feasibility and market potential of each, and the less attention there will be to devote to each one. Although idea selection is a difficult prediction task, research and practice guide how it should be done: what should be asked, who should be asked, and how to use the information collected.

The decision about what questions to ask to best support the idea selection process is dependent on the specific domain. For example, with consumer packaged goods, new ideas are routinely tested using a concept test, which includes a purchase intent question ("how likely would you be to purchase a product based on this idea?") with five standard likelihood responses. In contrast, in a more industrial setting, for example, development of scientific instruments, idea selection would focus more on the technical feasibility of the ideas.

Each domain, and indeed, each specific organization, will have its own articulation of the criteria for selection. For example, the product development website Quirky.com articulated a set of Design, Market, and Viability criteria to use in concept selection (as shown in Table 1). Although these criteria are somewhat tailored to their consumer durables businesses, they are relatively general.

Once an organization has a set of criteria, there are different approaches to making a selection. One consideration is whether to explicitly rate by criteria or to rate holistically. Ulrich and Eppinger (2015) give examples of systems to rate by criteria. The criteria-rating approaches have a certain logical appeal, but become challenging with large sets of ideas. There is

**Table 1 An Example of Selection Criteria used at Quirky**

Design score
- Does it solve a significant problem?
- Does it have a wow factor?
- Could it win design awards?

Market score
- Is it easy to market?
- Is the market size large?
- Does it fit with the sales channels?
- Does it fit with the product mix?
- Would it grab attention on the shelf?

Viability score
- Is it manufacturable?
- Will costs be workable?
- Is it going to be free from legal problems?

*Source:* Quirky (2011).

also a question of how to weight the different criteria, although decisions are often insensitive to the exact weights chosen (Dawes 1979).

Wilson and Schooler (1991) show that purposeful reasoning and decomposition may, in fact, yield worse results than when judgments are made holistically, based on an aggregate feeling. People know *how* they feel, yet they do not necessarily know *why* they feel this way. The act of asking a subject to decompose an idea into specific dimensions may cause their perception of the idea to change. In Wilson and Schooler's study, these perceptions change for the worse; the preferences of subjects who reason through their decisions are less correlated with Consumer Report's expert ratings than are the subjects who do not reason through their decisions.

A different consideration is whether to collect data from people who are considered experts or novices. Research across different disciplines repeatedly shows that predictions of experts may not be better than novices (Hoch 1988, Kornish and Ulrich 2014, Tetlock 2005). Studies do confirm, at least for consumer products, that novices' stated intentions are predictive of purchase behavior (Morwitz et al. 2007) and sales (Kornish and Ulrich 2014). A natural question that remains unresolved is under what conditions certain types of experts would, in fact, yield better results. After all, when we use the descriptor "expert," we need to qualify along what dimension we consider them to be an expert. For example, if a paper company wants to launch a line of printers and they seek experts to judge the potential ideas for printing equipment, what constitutes an expert? Someone with experience in the printing equipment industry, or the paper industry, or someone knowledgeable in diversifying organizations? Implicit in the decision on what type of expert is best suited is the question of what dimension is most critical. Is strategic fit the most critical aspect, or knowledge of the organization's existing capabilities potential to acquire new ones?

The broader question is how an organization can effectively use the data and resources available to make the best selection decision possible. Although aimed at forecasting geopolitical events, The Good Judgment Project (GJP), has several findings that are highly relevant to idea selection. Their results show how to take novices and make them more expert at the process of prediction, thereby improving their predictive power. The GJP studied prediction markets and direct group communication to learn how people should be encouraged to share information to get the best prediction from a group (Mellers et al. 2015, Tetlock and Gardner 2015, Tetlock et al. 2014, Ungar et al. 2012), something of direct relevance to idea selection. They found that both prediction markets and direct group communication provided better predictions than averages of individual predictions.

Prediction markets have been studied and used for many years (Arrow et al. 2008). More recent work demonstrates their productive use in idea selection: Dahan et al. 2010, 2011 describe the securities trading of concepts (STOC) system. The GJP, however, provides further evidence of their predictive validity. For direct group communication, the GJP assembled teams of 15–20 people who used an asynchronous online environment to communicate information and comment on one another's forecasts. The process and structure used in the GJP are relevant and feasible to conduct predictions in the service of idea selection.

There are many questions that would benefit from additional academic research and could have a big impact on practice. First, how can new data sources be leveraged for better prediction and idea selection? Second, more attention is needed on the question of whether ideas should be rated holistically or by attributes. And should participants be asked for judgments about quality or about outcomes? Third, who should participate? How should participants be recruited and what incentives should be offered? If the ideas are product concepts for a commercial enterprise, how should secrecy be handled? Fourth, how well would this process scale?

Idea selection viewed as a prediction task does, however, make an implicit assumption: it assumes some knowledge of what needs predicting. That is, it aims to predict performance relative to some "known unknown" but does little to uncover the "unknown unknowns" (Loch et al. 2011, Sommer and Loch 2004). Selection processes based on data from real markets are better suited for this.

### 3.2. Selection Processes Based on Data from Real Markets

In the previous subsection, we described how rating, intention, and prediction data can guide idea selection. Now we turn our attention to an alternative approach that has gained momentum in recent years. This approach uses customers more organically in the decision by testing ideas in a real market. The notion that the idea selection decision can be enhanced through experimentation is not new (Thomke 1998). This notion follows a long tradition of research that shows how learning through experimentation can vastly help guide and improve product and process development (Huchzermeier and Loch 2001, Leonard-Barton 1995, Loch and Terwiesch 1998, Pisano 1994, Thomke 1998, Thomke and Bell 2001). This stream of research is primarily focused on resolving uncertainty through tests conducted within the organization. More recently, though, organizations are increasingly applying these same principles *external* to the organization, using flexible development processes (MacCormack et al. 2001, Thomke and Reinersten 1998) to gather real market-based information. First we explain the roots of this movement, and then we give examples of how companies are implementing it.

The move to extend experimentation outside of the organization has its roots in two seemingly disparate areas, tied together by a focus on the consumer. Many would argue that flexible development first took hold in software development, where it is commonly referred to as the *agile development movement*. Agile software development prescribes specific practices (available at agilemanifesto.org), placing a priority on the customer being satisfied. The broader philosophy encompassed within agile is not specific to software. Although the principles are stated differently, Lean operations and the Toyota Production System (Cachon and Terwiesch 2013, Ohno 1978) share a common focus that all activities should add value to the customer. Any work that does not add value to the customer is considered a waste. Thus, the relentless elimination of waste found in lean is synonymous with agile's objective to satisfy the customer. Thus, while lean is rooted in manufacturing and agile is rooted in software, entrepreneurs like Ries (2011) and Feld and Cohen (2010) show how this same mindset can be applied beyond software and manufacturing to help deliver a better solution to the customer in a more efficient manner.

Followers of lean, agile, or more generally, any flexible development practice follow a set of project management guidelines that stand in stark contrast to the traditional "waterfall" method (Royce 1970). In a waterfall project, a team completes one step (e.g., system design) before the next step (e.g., coding) begins *and* solutions are not shared with the customer until they have achieved full functionality. In a flexible development process, working through all steps until a product is fully functional may create a lot of non-value added work if the functionality that was implemented is not aligned with the customer needs. In a flexible development process, a team will share low fidelity (Thomke 2001) versions of the product early on in an attempt to eliminate non-value added work.

Boehm et al. (1984), MacCormack et al. (2001), and Thomke (1997) document the effectiveness of flexible development across industries. The first two are studies of software projects, the third is a study of integrated circuit boards. Of course, flexibility has costs. The cost–benefit trade-off tips toward flexibility when there is more uncertainty about consumer needs or about the ability of the technology to profitably meet those needs. (A similar argument can be made in a more traditional operations context: flexible manufacturing will be superior to a static assembly line when there is sufficient uncertainty.) Ultimately, flexible development processes do not so much delay the final selection of an idea as much as they allow a selected idea to evolve, based on what is learned from customers' reactions. That learning is greatest when there are unknown unknowns, that is, aspects of a project that cannot be identified at the outset of a project (Sommer and Loch 2004).

There are diverse examples of how companies are collecting this real market data. Retailers such as Starbucks have found innovative ways of gathering it (Oppmann 2010). In an effort to test new ideas in actual market settings Starbucks created "stealth" cafes where consumers were not necessarily aware that they were in a Starbucks branded cafe. This allowed them to test new ideas and products and get real market data without tarnishing their brand. However, there are more accessible means to gather market data than to establish an off-brand retail outlet.

A more accessible means for gathering real market data is a crowdfunding platform. The establishment of crowdfunding platforms is an important development in real market idea selection. Crowdfunding platforms, such as Kickstarter, allow participants to vote for a product they like by providing financial support. Participants must commit to provide money prior to a product being ready for launch. When participants financially support a product, they receive something in return. What they receive depends on the level of financial support, and usually includes an option to pre-order the product. Moreover, at Kickstarter, unless a preestablished funding goal is met, a company does not receive any of the financial support offered from participants as all contributions are returned to the participants, for example, the ZPM Espresso machine that failed to launch in 2015 (Lewis-Kraus 2015). That is, unless there is sufficient real market appeal, the product is not funded at all, a very clear indicator of (low) market appeal.

In a related practice, companies run search ad campaigns to test demand for their products before they exist (Ries 2008). In this real market, consumers are not expressing their preferences by spending money as they do with crowdfunding. Instead, they are communicating their interest by choosing which (paid) search results to click on, and which ones not to click on. This example is a specific type of A/B testing, a common practice in web development to compare which version of some web content exhibits better user engagement.

Google is well known for the market-based approach: "The Googly thing is to launch [products] early on Google Labs and then iterate, learning what the market wants—and making it great. The beauty of experimenting in this way is that you never get too far from what the market wants. The market pulls you back" (Marissa Mayer quoted in Salter 2008).

One important feature of these examples is the scale at which they operate. Idea generation efforts can produce dozens, hundreds, or even thousands of ideas. These market approaches to selection operate best when a few ideas remain. Comparing the market approaches to the data collection for prediction approaches addressed in the previous subsection, we have an accuracy vs. efficiency trade-off (Terwiesch and Ulrich 2009). The data collection for prediction approaches are more efficient and less accurate. They are better at winnowing large lists of ideas down to a few, recognizing that the selection decisions will be made with a lot of noise. The market approaches are more accurate and less efficient. They are better at providing more detailed, higher fidelity information about ideas.

We believe there is an opportunity for more academic research here. One open question is how to scale market approaches to idea selection. When people use Kickstarter to test an idea, they are generally posing a choice between two alternatives: pursue this idea, or not. Are there ways to allow more ideas to be evaluated at a reasonable cost and effort? A second open question is how the behavioral data observed in a market, that is, the actual decisions that people make—be they clicks or purchases, correspond to analogous non-market data collected from surveys such as concept tests asking about purchase intent, predicted usage frequency, and uniqueness.

Although we have made a distinction between data collection for prediction and data experienced in real markets, we acknowledge that there can be practices that span both approaches. For example, in Threadless, the community can both vote on and preorder designs, in a process that spans input to predictions and real market action. Likewise, the simulated STOC (securities trading of concepts, Dahan et al. 2011) has both prediction and market characteristics.

# 4. Organizational Context for Idea Generation and Selection

The two previous sections focus on issues specific to the processes of idea generation and idea selection. In this section, we focus on the organizational context in which those processes take place. Gaimon (2008) emphasizes the fundamental role that the management of knowledge workers plays in MOT. The highly skilled employees who perform idea generation and selection are undoubtedly knowledge workers, and the organizational context in which they work affects how they perform those activities. We cover how four elements in the organizational context—corporate (or organizational) culture, motivation with incentives, organizational structure, and use of teams—affect idea generation and selection.

## 4.1. Culture and the Match with Objectives

The norms, routines, and shared values within an organization have the potential to substantially influence idea generation and selection (Cyert and March 1963, Schein 2010). When we speak of an organization's norms, routines, and shared values we are referring to the organizational culture (a.k.a. corporate culture). The culture is the shared beliefs and perceptions held by the people inside the organization that are more homogeneous than those held outside (Lazear 1995, Van den Steen 2010a,b). Many large corporations have strong and well-defined cultures. For example, 3M is widely regarded (O'Reilly 1989, Von Hippel et al. 1999) as being an innovative organization, with a high tolerance for failure. The roots of that culture date back to at least 1948, when William L. McKnight, the president of 3M at the time, stated, "Mistakes will be made. But if a person is essentially right, the mistakes he or she makes are not as serious in the long run as the mistakes management will make if it undertakes to tell those in authority exactly how they must do their jobs…Management that is destructively critical when mistakes are made kills initiative. And it's essential that we have many people with initiative if we are to continue to grow" (3M Website).

An organization's culture allows its members to interpret events and interactions in a common way. For example, organizations often develop their own vernacular, refer to tasks, tools, processes, locations, etc., with acronyms or abbreviations, immediately deciphered only by insiders. Similarly, generic words may take on their own specific meaning when used within an organization. For example, a senior executive may ask a general manager to select the most promising initiative from a set of potential candidates. To an outsider the term "most promising" may be a vague statement. It could mean to make sure it is successfully implemented, a low risk alternative, and just as easily, it could be interpreted as a statement to push the boundaries on what is possible, a higher risk alternative. Yet in some organizations with a strong culture, this may be enough to communicate precisely what the senior executive wants.

At Zappos, an e-commerce site that sells shoes and accessories, the culture is about creating happy employees who will provide great service to customers by "forming personal, emotional connections with [the] customers" (Hsieh 2010). The second of the ten core values is "Embrace and Drive Change," and employees understand that that must be done in service to the first core value, "Deliver WOW Through Service" (Zappos Website). With those values salient in the work environment, Zappos employees have substantial guidance about how to deal with non-routine events. For example, if there is incorrect information showing to consumers on the website, or if there is an error in a shipment from a supplier, employees should understand that it is preferred to troubleshoot and fix the source of the error rather than just addressing the immediate problem.

Not all organizations have strong cultures, nor is it a prerequisite for success to have a strong culture. After all, if an organization's performance is based on generally routine tasks, then effective monitoring and formal controls may be sufficient to induce the proper actions from employees. Likewise, there is little need for established norms beyond what exists in the general population if decisions do not involve much ambiguity, and/or information is communicated and processed with clarity.

However, if an organization seeks to pursue a new technology, pursue a new market, or pursue any substantial innovation, the required tasks will not be routine. Rather, the required tasks are uncertain with an abundance of potential solutions. When this is the case, there is much greater potential for an organization's culture to have a substantial impact. After all, it would be essentially impossible for senior management to monitor and enforce a formal contract for a creative activity like idea generation or for a process fraught with uncertainty like idea selection.

Organizations considered to be highly capable innovators share a number of common norms (O'Reilly 1989). One of those norms in innovative organizations is their tolerance for failure (Hutchison-Krupat and Chao 2014, Manso 2011). One dimension of an organization's tolerance for failure is the penalty organizational members will impose on a manager of a failed initiative. At the extreme end of the spectrum, an employee may be terminated. Alternatively, an employee may be punished more implicitly through means such as organizational status, or the organization's reluctance to consider the manager for a promotion. Hutchison-Krupat and Kavadias (2015) evaluate the relationship between penalties, which are imposed on managers of failed projects, and the initiatives an organization pursues. When harsh penalties are imposed on managers of failed initiatives, the set of initiatives an organization can effectively pursue is significantly reduced. More challenging initiatives are eliminated, effectively reducing the opportunity space.

Another important norm in innovative companies is autonomy (O'Reilly 1989). Autonomy can be at the individual level, for example, in companies like Google, 3M, or Hewlett-Packard that allow employees to pursue their own ideas (see, e.g., Goetz 2011). Or, autonomy can be for organizational units. Puranam et al. (2006) argue for the importance of the balance between autonomy and coordination with technology acquisitions. Likewise, even after Amazon's acquisition of Zappos in 2010, Zappos still runs as a relatively autonomous organization, still using its own brand name and maintaining its emphasis on forming deep relationships with customers.

Other cultural traits, such as a short-term focus on hitting revenue goals or a strong adherence to tradition, can stifle innovation. Sorensen (2002) observes that organizations with a strong culture are slower to adapt to a changing environment. As Van den Steen (2010a, p. 1719) states, "[A] strong culture tends to favor exploitation over exploration." Such was the case with Firestone in the 1970s (Sull 1999). Their culture was so strong around exploiting what they did well—produce bias ply tires–that they failed to be able to respond to the rapidly changing technology—radial tires. Moreover, this was not for lack of foresight. To the contrary, Firestone had predicted that radial technology would take over, however, they were unable to implement the needed changes, largely because they had such a strong culture around doing what they had historically done well. In the language of Leonard-Barton (1992), a core capability had become a core rigidity.

The leadership of an organization may recognize that either the strength or the nature of the culture is hampering the organization's ability to innovate. Unfortunately, changing culture can be a slow and painful process. Scholars such as Nelson and Winter (1982), Lazear (1995), and Chassang (2010) model the development of organizational routines as an evolutionary process. Evolutionary processes are path dependent. An organization may want to change its culture to be friendlier to innovation, but because innovation has so much uncertainty in it, that path dependence is particularly challenging. It can be hard to tell if employees did a poor job of idea generation and selection, or were just unlucky.

An ongoing research question of practical importance is how an organization can adopt the traits associated with innovation. Can all organizations simply declare more autonomy and tolerance for failure, or are there specific conditions that must be in place first? Related to that question, is there some way to speed up change in the evolutionary process? For example, is there some way to increase the number, frequency, or influence of interactions that people have with individuals with the desired cultural traits?

### 4.2. Incentives

Van den Steen (2010a) explains how culture can align the interests of owners and employees. Another, practical way to align interests is through explicit incentives. Various literatures address questions related to incentives and motivation for idea generation and selection such as how incentives encourage people to generate good ideas, the limits to the effectiveness of monetary incentives for creativity, and how the selection of ideas should be rewarded. The issues for idea generation and selection are reasonably distinct, so we treat them separately, starting with idea generation.

**4.2.1. Incentives in Idea Generation.** Economists have analyzed how to motivate effort for novel solutions to problems, using incentives in competitive settings, or contests. The contests can be tournaments (a set of competitors try to produce the best solution to the problem posed) or races (a set of competitors try to be the first one to develop an acceptable solution). In a classic paper, Taylor (1995) studies the optimal design of research tournaments. The tournament host decides how many participants to invite, the level of the prize, and the entry fee. Building on that work, Moldovanu and Sela (2001) consider whether there should simply be a single prize or a first prize and second prize, to increase the motivation for effort across the board. Further, Erat and Krishnan (2012) add a dimension of problem specification to influence the breadth of the solutions proposed by the participants. These studies treat contests generally, allowing for internal or external participants.

Taken together, these contest models catalog a set of choices one faces when designing a competitive contest, highlighting the interplay among the choices. The models capture the idea that participants will tailor their effort to the environment. If the prize is bigger, it is worth trying harder. However, a bigger prize will also attract more participants, and a bigger pool of participants reduces the chances of winning, thereby reducing the incentive to exert effort (like in Boudreau et al. 2011). Using multiple prizes can help motivate more effort from a broader swath.

In contrast to competitive incentives based on idea quality, Toubia (2006) examines the effect of incentives for idea production. He examines payment for an individual's idea production vs. payment for the group's performance, measured as the number of ideas that build on an idea someone contributed. A hybrid incentive system, based on a combination of individual and group performance, outperforms either one alone.

Given these optimal results for competitive incentives and piece-rate incentives (i.e., payment per idea) separately, the next logical step is to compare the effectiveness of the two approaches. Erat and Gneezy (2016) do just that in a series of experiments. They find that piece-rate incentives produce more creative results than competitive incentives.

Interestingly, Erat and Gneezy (2016) also find that even the piece-rate incentives do not lead to more creative results compared to a condition in which no incentives are offered at all. This finding supports work in psychology (Amabile 1998) that creative tasks require intrinsic motivation, and that extrinsic motivation like payments can actually interfere with performance in creative tasks. This concern about explicit or financial incentives is consistent with work in psychology such as Fiske (1992), Heyman and Ariely (2004), Gneezy and Rustichini (2000), and Lepper et al. (1973).

Ederer and Manso (2013) offer a clever reply to this paradox of the perverse effects of incentives on performance. They show that an incentive system that encourages initial exploration improves performance. In particular, they design a system that is forgiving of early failure, encouraging a broader consideration of option in initial stages, coupled with later performance incentives. This finding echoes the findings that a corporate culture with a tolerance for failure encourages people to innovate.

The Ederer and Manso (2013) solution cautions us against incentives with a short-term perspective. Many organizations repeatedly turn to a stable group for idea generation. That group may be employees, external partners, or even a consumer community (e.g., IdeaStorm, MyStarbucksIdea, Threadless, Quirky). There are many reasons that incentives are problematic; those reasons are even stronger when considering them to sustain creative energy over the long term.

Although explicit financial incentives may crowd out intrinsic motivation, in some cases, they are a necessary reality. With a captive, invested audience such as employees, "community" members, or subjects participating in an experiment, financial incentives may have a perverse effect. But in real settings, contest holders need to attract people away from other ways they could spend their time, and prizes seem to capture attention and recruit participants. Absent the $20,000 in prizes, presumably few people would choose to work on challenges from the US Bureau of Reclamation about "Ideas and technologies for next generation, novel fish tracking solutions" (Bureau of Reclamation). Therefore, an open question is how effective are the various schemes—competitive (relative) financial incentives, participation (absolute) financial incentives, non-financial incentives, and "no" incentives—when the contest holder has to attract involvement?

People who participate in idea generation efforts have mixed motives, at the very least, love, glory, and money. (Those are the motivations identified by Malone et al. 2010 for the broader class of crowd-production activities, not just idea generation.) The existing studies that pertain to incentives for idea generation compare different monetary schemes or monetary to non-monetary schemes. How can we design incentives that tap into the appropriate mix of these motivations? Toubia (2006) and Ederer and Manso (2013) show how "hybrid" incentive schemes work well; how can that hybrid idea be expanded across a broader set of possibilities?

**4.2.2. Incentives in Idea Selection.** There are also incentive issues related to selection. How should people be rewarded, or punished, for selecting a good, or bad, idea? That question is challenging because the outcome of the idea selection is confounded with the execution of the idea. Kornish and Ulrich (2014) find that the quality of the raw idea (in a sample of innovative household goods) accounts for only a small amount of the variance in ultimate market outcomes. In spite of that noise, incentivizing idea selection is often done by rewarding performance. In fact, in Ederer and Manso's (2013) incentive scheme, they reward performance, which reflects both idea generation and selection.

Other authors have probed how the context of the workplace and one's career provide incentives for idea selection. The work of Siemsen (2008) provides insights into how the idea (or project) selection reflects an employee's reputation. He argues that a less capable person may choose a more difficult idea to pursue, so that if the idea fails, others may attribute failure to the idea's difficulty, not to the person's capability. For example, consider a beverage company that seeks to update their containers to make their brand more current. A highly capable designer may simply do a refresh of the graphics and logo. A less capable designer, however, may seek to add features to the containers aimed at addressing user needs beyond just enhancing the logo, clearly a more complex solution. The implication, at a strategic level, though, is that senior managers may take on drastically more complex, risky, and costly solutions where a much simpler and more straightforward solution could have achieved equivalent results. To mitigate this potential disconnect between the interests of employee and those of the company, Katok and Siemsen (2011) then show that these reputational considerations can be managed with performance rewards.

Incentives become inherently more complex to manage when they involve teams. Schlapp et al. (2015) evaluate how to structure incentives according to the degree of certainty that can be placed on the evaluation of information. Their findings indicate that managers who compete for resources on more novel projects, where the selection process is inherently uncertain, should be offered incentives that emphasize a shared objective, such as overall division performance. Whereas Schlapp et al. evaluate incentives to managers who compete for resources, Hutchison-Krupat and Kavadias (2016) evaluate specialists on a cross-functional team. They concur that when a project is associated with more uncertainty, incentives should be structured based on a more inclusive performance metric. Specifically, they argue that high uncertainty calls for incentives to be based on an inclusive measure of performance, for example, profit as compared to revenue, and high complementarities prompt the need for a more organizationally inclusive metric, for example, project performance as compared to component performance.

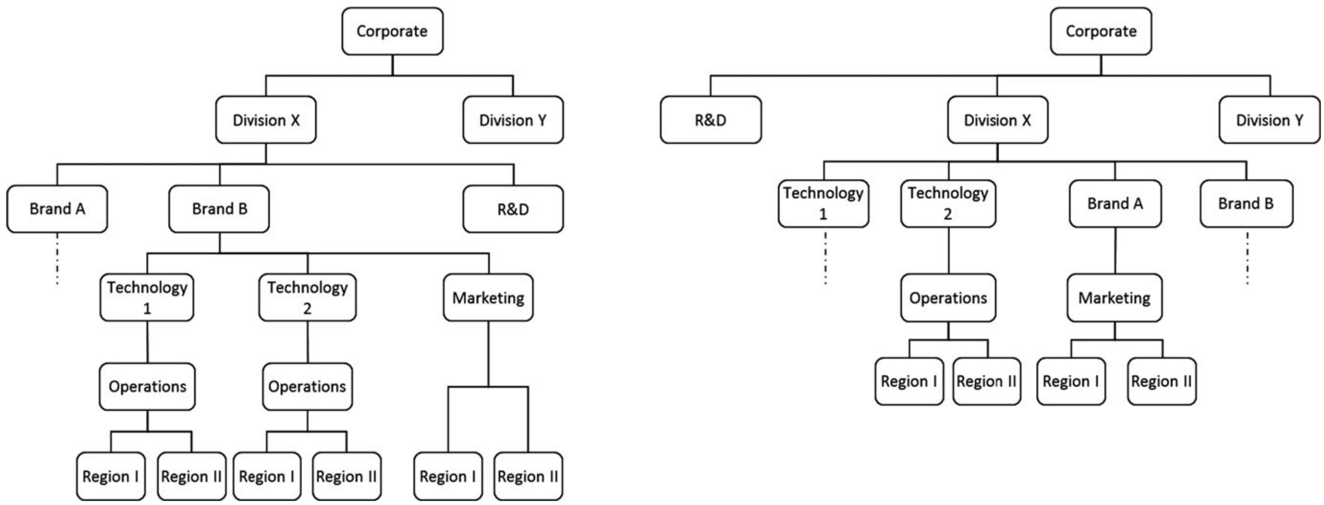
Finally, we note that idea selection is a multistage process, often depicted as a tournament or funnel. Chao et al. (2014) study the incentives in the context of a stage-gate process, a process with intermediate decisions to stop or continue the process. Their abstraction of the process captures two sources of uncertainty that require different consideration. In particular, the early phase of the process centers on the quality of the idea and requires incentives that induce truthful revelation, that is, to avoid the strategic selection discussed by Siemsen. Later in the process, the incentives are aimed at ensuring adequate effort is allocated to the development of the idea into a reality. They find that the senior management may reject projects despite them having a positive NPV: the incentives required to ensure the best idea is selected, make it such that an idea may need to show more promising potential than just a positive NPV.

There are many ways that incentives can be used for idea generation and selection. Innovation takes place in inherently uncertain and complex settings. That uncertainty and complexity mean that there are no perfect incentive schemes, and sometimes explicit incentives have the opposite effect from what was intended. While much interesting research has highlighted how incentives must balance different forces, there are still unanswered questions there. In particular, there is still work to do to understand the interactions between explicit financial incentives for idea generation and selection and more implicit reward mechanisms such as status or career concerns, embedded in the organization's culture. In addition, there is the question of how incentives can be used, if at all, to offset undesirable cultural routines that inhibit productive idea generation and selection.

### 4.3. Organizational Structure

Every organization has its own structure. An organization's structure is defined by the formal reporting relationships between organizational members. Figure 1 shows examples of two organizational structures. The organizational structure is relevant for idea generation and selection because it can have a big

**Figure 1 Hypothetical Organization Structures**




impact on whether an idea surfaces and on which ideas are selected.

**4.3.1. Where Decisions are made in the Organization.** A key issue, especially for selection decisions, is the locus of decision rights. There are two opposing forces. First, when decisions are made higher up in the organization, or in a more centralized function, they are more likely to consider the "big picture," both in terms of organizational objectives and the breadth of the opportunity space. The second, countervailing force is that when idea generation and selection decisions are made further down in the organization, or in a more decentralized function, they can draw on the deep and specialized knowledge of people who are most familiar with the relevant context.

Argyres and Silverman (2004) demonstrate one of the reasons for the centralization of selection decisions. They study whether R&D decisions should take place centrally and serve decentralized divisions or whether R&D should be housed within the divisions. In Figure 1, the structure on the right has R&D centralized, and the figure on the left has R&D decentralized, reporting to a division. Argyres and Silverman argue that more impactful innovation is better suited to centralized R&D; a centralized R&D manager has better visibility into the entire organization's R&D activities and can better identify and assess overall opportunities. The more ambitious innovations are, usually, those that cross boundaries, and those are likely to require support at a higher level.

A centralized perspective broadens the scope of innovation, and it also aligns the decision making objectives with the overall organization's goals, away from the narrower objectives of an individual unit. Rivkin and Siggelkow (2003, 2007) demonstrate this effect. Drawing on Bower's (1970) conceptualization of a resource allocation process, they study a simple hierarchy, a CEO and two direct reports. They consider when active coordination by the CEO is beneficial, compared to a passive, rubber-stamping CEO. A key driver of the result is the intensity of interactions among the subordinates' decisions. For example, a high level of interaction would occur if one unit's new products would cannibalize sales of the other unit's products. The result is that the benefit of active coordination is increasing in the degree of interactions. In other words, more centralized decision making helps when there are more interactions among subordinates' decisions.

In addition, a manager with a centralized view of decision making is helpful when subordinates are prone to search extensively. Indeed, without anyone to coordinate their decisions, subordinates may find themselves engaged in extensive "problem solving oscillations" that extend the time it takes to converge to a solution (Mihm et al. 2003). As interactions between the subordinates' decisions become sparser, the value of an actively involved manager is diminished. In this more independent case, the added level of decision making simply represents a bottleneck in terms of time and information processing. Now, rather than speeding up decision making, a top-level manager may in fact prolong decision making, and even reduce solution quality by converging to a solution too soon.

Other studies have focused on the benefits of locating selection decisions at a lower level in the organization. Mihm et al. (2010) build on Rivkin and Siggelkow's (2003) findings, but examine the benefits of specialization of units farther down the structure. They model a hierarchy with greater than two levels and greater than two departments and find that specialized groups also speed up decision making (like the coordinating superior). Yet, this too comes at the cost of solution quality because specialized groups search in narrower domains.

Hutchison-Krupat and Kavadias (2015) also focus on benefits from below, in particular, inside knowledge of how resources will, or will not, contribute to the success of a project. They acknowledge that decisions made higher up in the structure benefit from greater alignment with an organization's objectives, but argue that senior managers lack the necessary—task specific—knowledge required to make accurate resource decisions. Further, it is the difficulty of the project that determines the optimal trade-off between higher (and thus alignment with organizational objectives) and lower (and thus specialized knowledge). Project difficulty is the degree to which increased resources increase probability of success. The main effect is that the more difficult the initiative, the better it is to have the resource decision made at the lower level. They also confirm that, within some organizational cultures, it may be best to maintain decision rights higher up, regardless of the difficulty of the initiative.

A comparison of the choices of two pharmaceutical companies illustrates how the balance can swing either toward centralized—locating decision rights with senior managers—or decentralized—delegating decision making lower down in the organizational hierarchy. GlaxoSmithKline (GSK) reorganized their drug discovery process (Huckman and Strick 2010) so that decisions that benefitted from greater task specific knowledge were pushed lower down in the organization, away from corporate. In contrast, Wyeth Pharmaceuticals reorganized their development process to make it more centralized (Pisano et al. 2010). The key drivers behind these two structural decisions were that GSK viewed the "state of knowledge" to be more of an art, whereas Wyeth viewed knowledge to be more general and science-based such that it was more important for centralized decision making to insure the organization's interests were adequately considered. Wyeth was more concerned with differing objectives, and GSK was more concerned with the locus of knowledge.

Chao et al. (2009) add to this line of inquiry by considering not just where the selection decision is made, but also the decision on the level of funding. They contrast a scenario where a division's overall budget is decided upon by someone external to the division, that is, provided by the more senior corporate office, with a scenario where the division determines its own budget. When a division manager is responsible for funding their own R&D investments (decentralized decision rights), their budget strongly depends on their own revenue stream. In contrast, when corporate establishes the budget (centralized decision rights), the budget is decoupled from the division's revenue stream. Note, however, that regardless of where decision rights on the budget reside, the detailed allocation for specific initiatives, that is, the selection decision, resides with the division manager. Chao et al. find that when a manager has decision rights over their own budget, which they equate to greater autonomy, the manager increases their overall investment in R&D. This said, consistent with Argyres and Silverman (2004), Chao et al. find that decentralized decision rights also prompt managers to favor more incremental initiatives.

This literature shows many aspects of the trade-off between decisions higher and lower in an organizational structure. Organizations need to carefully strike a balance between the search for new solutions—through highly specialized and capable subordinates—and the benefits that come from a focus on the objectives of the overall organization.

Much of the work we have addressed here is theoretical. The questions about the optimality of where to locate decisions in an organization are challenging to study empirically, but would be very interesting. Although true field experiments might be prohibitive, there could be settings for natural experiments, where an acquisition or merger exogenously changes company policy about the locus of decision rights.

As technology evolves, and new organizational forms emerge, there are open research questions about whether the existing findings still apply. As "the sharing economy" makes virtual organizations more possible, with more fluid boundaries between inside and outside, are there new possibilities of structure and decision rights that need to be studied? And if so, what are the implications for idea generation and selection in these new organizational forms?

**4.3.2. Multiple Decision Makers.** In the previous subsection, we discussed issues of whether idea generation and selection decisions should be made higher up or lower down. Now we turn our attention to the possibility that there are multiple decision makers.

Sah and Stiglitz (1986) offer an important finding about idea selection and structure: if a selection decision has to move up a deep chain of organizational levels (a hierarchy), it has a lower chance of surviving compared to a flatter organization (a polyarchy). In the hypothetical organizations of Figure 1, we could think of this as a scenario where a division has allocated funds to each brand with a specific mandate that the funds are to be used to improve quality in the regional operations. In the left, more hierarchical, organization, the regional operation must first submit an idea to the technology unit. Then, if it is deemed acceptable, it moves up the chain to a brand manager.

Thus, the hierarchy is represented by decision points which are in series. If approved by the brand manager, the project is funded. They compare that structure to a flatter organization, as represented by the brand manager level of the right organization (Figure 1) where an idea is submitted to both brand managers. If either one of the managers deems it acceptable, then the project is funded. Thus, the polyarchy is represented by decision points which are in parallel.

Sah and Stiglitz (1986) conclude that flatter organizations are more lenient. The relationship between mixed perceptions and idea selection is readily evident. If two managers disagree on whether an idea is good or bad, a hierarchy is guaranteed to reject the idea and a polyarchy is guaranteed to accept it. Leniency is not necessarily a good thing; in their analysis, polyarchies commit more Type 1 errors (an accepted proposal that should have been rejected), while hierarchies commit more Type 2 errors (a rejected proposal that should have been accepted).

Another way that multiple decision makers become involved is through group decision making, for instance, a team of executives who decide whether to add a new initiative to their portfolio. This is the problem that Oraiopoulos and Kavadias (2012) study. They recognize that the perspectives of the committee may differ along two dimensions. First, committee members may have differing objectives, for example, an initiative which helps solidify marketing's position may be a nightmare to commercialize. Second, people differ in the degree to which they adapt their own preferences based on the information provided by others.

Oraiopoulos and Kavadias find that diverse objectives hinder committee decisions and increase the likelihood of both Type 1 and Type 2 errors; the committee approves projects they should have rejected *and* rejects projects they should have pursued. In contrast, diversity in the degree to which individuals incorporate others' information can help to mitigate the errors of the committee that result from their different objectives. When we combine these findings with those related to an organization's culture and incentives, we further see the importance of establishing shared values around a common goal, while still ensuring that organizational members have sufficient differences.

Questions related to multiple decision makers have been studied for many decades: the seminal work of Arrow (1951) in economics shows that even with innocuous-seeming ground rules (e.g., transitive preferences), we cannot count on individual preferences combining to form a coherent group preference. The normative models we cite above are economic models with value-maximizing actors. Another perspective that would be useful in studying group decisions in organizations comes from psychology. The work of Sunstein et al. (2002) about jury deliberations shows some perverse effects, for example, the group decision can be more extreme than all of the individuals' positions. Further work is required to understand the implications of interpersonal dynamics when ideas are being generated and selected.

The research we synthesize here addresses key elements of organizational structure and the assignment of decision rights for idea generation and selection. The location of the decision rights and the cast of people involved in the decision influence which ideas get selected and funded. There are two fundamental tensions at work: the tension between expertise and perspective and the tension between Type 1 and Type 2 errors.

### 4.4. Teams

Another important issue related to the organizational context in which idea generation happens is how teams work together. Technology allows for new forms of collaboration (Bardhan et al. 2013, Peng et al. 2014), and some of those new possibilities influence how teams, and how well teams, generate ideas.

One long-standing debate across psychology, management, and marketing literatures is whether it is better to have a group of people together in a room to generate ideas, that is, a brainstorming meeting, or whether it is better to have people work apart from one another,that is, parallel search (Kornish and Ulrich 2011, Sommer and Loch 2004) or nominal teams. Osborn (1953) introduced the term brainstorming, underscoring the benefit of having the right people in the room, so they can build on one another's ideas. Diehl and Stroebe (1987) and others raise concerns about brainstorming. The main point of contention is Osborn's (1953) claim that a brainstorming group produces more (twice as many) and better ideas than would be obtained through a nominal group of individuals (the same number of individuals coming up with ideas on their own and then assembling the complete set). Indeed, Diehl and Stroebe argue there is no difference between the groups with the exception of production blocking (because only one person can speak at a time, an individual who would like to voice an idea must wait for a turn, thus imposing a constraint on the rate at which ideas can be voiced), and therefore find that brainstorming groups generate fewer ideas.

Sutton and Hargadon (1996) maintain that effectiveness is not captured by measuring the number of ideas. Under a broader definition of effectiveness, they show that brainstorming does have advantages over nominal groups. Kavadias and Sommer (2009) examine the context in terms of problem complexity and show that there are benefits to brainstorming groups that can outweigh these concerns. They find that cross-functional problems benefit from brainstorming by a diverse group, assuming the problems are not extremely complex. However, there is no restriction that organizations must do either group brainstorming or individual. Indeed, as Girotra et al. (2010) show, hybrid teams, where people first work independently and then together outperform teams that work exclusively together.

Further investigation of team structure reinforces the conclusion that a simple comparison of group vs. individual work oversimplifies the real choices organizations face with teams. As our discussion of brainstorming reveals, a team is more than simply a collection of individuals, the composition and overall dynamic of a team has its own properties, and its own biases. A well-known bias in individuals is the degree to which an individual will attribute successful outcomes to their own doing and failed outcomes to external factors, for example, if an individual bets on a horse and it wins, an individual attributes the outcome to their ability to spot winners, but if the horse loses the individual attributes, the outcome to the horse being too tired or the jockey having pushed too hard at the start.

This same bias is also observed when the unit of analysis is a group, and it affects idea generation. Goncalo and Duguid (2008) show that it matters whether the group's outcome is attributed to characteristics of individuals in the group (Adam is considerate or Barbara is a risk-taker) or group characteristics (the team lacks diversity). They show that if outcomes are attributed to an individual, a team is more willing to explore a broader set of alternatives. However, this only holds true for positive outcomes. A negative outcome did not affect the group's willingness to explore more alternatives, because, regardless of whether outcomes are attributed to individual or group characteristics, a negative outcome is attributed to external factors.

Team interaction is an area where technology continues to have a significant impact. As far back as 1999, de Lisser reported that greater than half of the organizations with more than five thousand employees used virtual teams. As Martins et al. (2004) pointed out, technology impacts the "virtualness," or the extent to which a team operates through technology as opposed to face-to-face interactions, of nearly all teams. In other words, even team members who work in the same building or city may rarely interact in person, choosing instead to communicate via email, messaging, video chat, etc. Virtual teams blur locational, temporal, and relational boundaries, which allow teams to assemble around knowledge and skills as opposed to organizational identity, or one's own network (Martins et al. 2004).

Collaboration technologies, in general, hold the promise to mitigate some of our biggest concerns with idea generation and selection in teams. For example, with regard to brainstorming, anonymous submission of ideas may reduce the fear of evaluation. Similarly, asynchronous submission of ideas may reduce the impact of production blocking. Likewise, additional transparency can be provided, that is, individual contributions can be tracked, thus exposing potential free riders.

The market is filled with "idea management software" or "idea management platform" offerings, allowing people to contribute and discuss ideas, so that everyone's input is captured. These sorts of platforms can be used purely internally, to facilitate collaboration of teams, or they can be opened up to include the contributions of partners, suppliers, customers, or even the "crowd" more generally. For global companies, such platforms facilitate information sharing among drastically dispersed groups and twenty-four hour progress, as the workday rolls across the world's time zones.

However, in spite of this promise, there are some documented downsides, and some remaining controversies about the use of virtual teams for idea generation and selection. While Sproull and Kiesler (1986) argue that technologies such as email reduce the negative consequences of status, El-Shinnawy and Vinze (1998) do *not* find this same effect when studying virtual team decision making. Griffith et al. (2003) find that technology can be a double-edged sword when it comes to the accumulation of organizational knowledge. Technology benefits the organization through effective codification of tacit knowledge, however, this may also discourage the generation of new knowledge. They argue that, if an organization does not address potential downsides, the benefits of increased technology may help the organization in the short term and hurt it in the long term. Similarly, Gaimon et al. (2011) explain how new technologies hold promise for improving workforce performance, but require multiple types of training to generate benefits.

With these opposing ideas about how technology can help or hurt innovative activity, there is more work to be done about the best ways to use technology to enhance teamwork for idea generation and selection.

In this section, we have presented four elements of organizational context, culture, incentives, structure, and teams, and discussed the research about how these elements affect idea generation and selection.

We have focused on four elements that are largely internal to an organization. Other elements of organizational context are more external, for example, partnerships and alliances with supply chain partners or even competitors. Undoubtedly, those elements of context have an effect on idea generation and selection, too.

## 5. Conclusion

The goal of this study is to highlight the two-way relationship between technology change and idea generation and selection. Advances in technology trigger new ideas, and new technologies, specifically communication technologies, facilitate new ways to perform idea generation and selection. We have stressed the results we think are most relevant to the management of technology.

Idea generation, as a creative activity found in so many different circumstances, is a multi-faceted process. The activity has aspects related to psychological processes, social interactions, communication, economic incentives, and organizational efficiency. Therefore, it is not surprising to find work on this topic in many of the business disciplines—operations, marketing, organizations—as well as psychology, economics, and various branches of engineering. Likewise, idea selection has many angles. We must consider who is involved, what information will be used, how the information will be used, and what the consequences of the selection will be for the individuals involved and for the organization. With such varied considerations, again it is not surprising to see the topic of idea selection studied by so many different stripes of scholars.

We consider these bodies of work in aggregate. We notice that changes in technology affect both micro and macro management questions. Technological change shapes the constraints in problem recognition. Technological change, specifically communications technologies, affects the way people can connect to generate and evaluate ideas. Finally, technological change, more generally, also plays a dual role in its relationship with an organization's culture and structure. Advances in technology may enable more efficient communication and information processing, allowing for sparse physical arrangements. On the one hand, such arrangements may not provide the rich environment needed to establish or maintain shared values—strong cultures—within an organization. On the other hand, organizations with strong cultures and rigid organizational structures that operate in environments of increasingly rapid technological change may find it hard to make the required changes necessary to stay at the leading edge of their industry.

Although much has already been said about innovation and the management of technology, given the complexities of both topics, there are great opportunities for future work.

## Acknowledgments

The authors are grateful to Cheryl Gaimon and an anonymous reviewer for their comments and guidance, as well as Sanjiv Erat and Karl Ulrich for helpful comments.

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