1 The roots of organizational ingenuity: how do qualitatively superior ideas come about?

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INTRODUCTION

The ability to continuously innovate has long been cited as the cornerstone of growth and regeneration (Burgelman, 1983). It is also clear that some firms are able to innovate better than others, for example larger firms (Damanpour, 1992), new entrants (Foster, 1986), or firms with access to greater resources and capabilities (Methe et al., 1997). Furthermore there have been studies to understand the impact of internal organizational processes on innovation, for example researchers have studied the impact of culture (Tellis et al., 2009), leadership (Elenkov et al., 2005), learning (Ahuja and Lampert, 2001) and knowledge (Zhang and Li, 2010) on innovation.

In contrast to the rich research on these perspectives, little research exists that examines the relationship between constraints and innovation, especially the qualitative nature of the outcome. Why are some organizations able to create innovative solutions within structural constraints using limited resources and imaginative problem solving (Lampel et al., 2011), while others succumb to sub-optimal performance? It would seem that the organizations that make a break from the sub-optimal are often characterized by a ‘can-do’ ambition in the face of these constraints coupled with ‘out-of-box’ thinking. It is this rare combination that delivers transformational leaps rather than incremental progress. At the heart of this combination are ingenious ideas that represent a qualitative jump in the nature of the solution and have often changed the course of industries not just the organizations that show ingenuity. These ideas result in a quantum leap in the design of products, services or business models and become the new standard. Consider the history of the evolution of jet engines, which reveals many episodes where ingenious ideas had a profound impact on shaping the industry.
Engine Overheating

Towards the end of the Second World War the Germans and the Americans were competing to build more powerful jet engines for their aircrafts. The problem facing both parties was material fatigue due to overheating. The Americans, under relatively fewer resource constraints, pursued a significantly costly approach to develop a more durable alloy for the engine. This was targeted at solving the problem of material fatigue. While the Germans, under significant financial constraints and restrictions relating to trade of metals, pursued a cost effective approach to solve the overheating problem by designing a more efficient cooling system. The war ended before the Germans could implement their design, but the ‘cooling’ solution was so elegant that it is still used in jet engines. (Adapted from Gibbert and Scranton, 2009)

For us, ingenuity is reactive creativity in problem solving. It is reactive to the constraints that do not allow the pursuit of linear problem solving methods. Ingenious solutions are also specific to a problem and to that extent their impact cannot be compared across cases. For example, even a small problem can be solved ingeniously.

Ice on the Nose of the Engine

As jet engines became more powerful and could now take aircrafts to higher altitudes, it was found that the nose of a jet engine often froze, which led to the accumulation of ice on its tip. Sometimes chunks of ice would break free from the tip and crash into the blades of the engine. Even though these hits were not critical, they still had a long-term effect on the maintenance and longevity of the blades.

When this problem was put to the engineers at a reputed aeronautical firm, the solution was obvious. The jet engine produces tremendous heat and so they needed to find a way to divert some of this heat back to the nose, i.e. remove the ice by heating or melting it. The ‘heating’ solution required some design modifications and would have been expensive to implement but nevertheless met the required objective. However, working under cost constraints, an alternate solution was proposed. It was to use a rubber tip on the nose which would not allow ice to form on it. The ‘rubber nose’ solution was significantly cheaper and also qualitatively superior to the other option. All jet engines now have a rubber tip on the nose to prevent the formation of ice on it. (Adapted from Dewulf and Baillie, 1999)

These examples show that some organizations are able to create innovative solutions within structural constraints using limited resources and imaginative problem solving (Lampel et al., 2011). The examples also show that solutions that were triggered by the constraints were in fact qualitatively better than the ones designed without constraints. Constraints play a central role in triggering the generation of these ingenious solutions and we define them as any inhibiting condition that is beyond the control of
The roots of organizational ingenuity

It is always easy to notice an ingenious solution with the benefit of hindsight, but can we find some common characteristics of all ingenious solutions?

CHARACTERISTICS OF INGENIOUS SOLUTIONS

Before we turn our attention to reviewing the theoretical frames, it is worth defining what makes a solution ingenious. Based on examples of ingenuity, we identify the conditions that a solution must satisfy to be ingenious.

Let us assume a case where a problem P has n known solutions, which belong to the stock of solutions $S_{\text{known}} = \{S_1, S_2, S_3, \ldots, S_n\}$ and that the solutions can be ordered by the amount of resources needed to apply them in order to solve P. However, none of the solutions from $S_{\text{known}}$ can be applied due to structural constraints or non-availability of resources, then a new solution $S_i$ would be an ingenious solution if it satisfies the following conditions:

a. Novelty condition: $S_i \not\in S_{\text{known}}$

b. Efficiency condition: $S_i$ consumes significantly less resources compared to the known solutions $S_{\text{known}}$

c. Specific solution condition: $S_i$ is generated to solve a particular pre-defined problem P

d. Usefulness condition: $S_i$ can be applied to solve P within the structural constraints and available resources

e. Dominant solution condition: Over time $S_i$ becomes the dominantly accepted solution to the problem P

When we apply the above conditions on the two examples of ingenuity, we find that both the cooling solution to solve the engine overheating problem and the rubber nose solution to prevent the formation of ice on the nose of the engine meet the criteria of being ingenious solutions.

Cases of ingenuity are clearly a subset of the literature on innovation. The Schumpeterian view of innovation (i.e. a new good or a new quality of a good; a new method of production; a new market; a new source of supply or a new organizational structure (Scherer, 1986)) is largely accepted as the foundation of innovation studies. From this definition it is evident that all ingenious solutions are also innovations, but not all innovations are ingenious. From a process perspective, what sets apart an ingenious solution from any novel and useful innovation is that structural constraints exist and in fact are at the heart of triggering the generation of the solutions. From the perspective of the outcome, we find that ingenious
solutions adapt to structural constraints and are qualitatively superior to other solutions, thereby often setting a new industry standard. Therefore, within the innovation literature, it is useful to look for relevant theoretical frameworks that may explain the emergence of ingenious solutions.

In our search for answers, we review three frameworks that address innovation under constraints. We start with the theory of constraints, which proposes ways to optimize a solution under constraints. We then review the literature on organizational slack, which studies the relationship between the availability of resources and the generation of new ideas or performance, and conclude with a review of bricolage, which studies value creation under resource constraints. We argue that none of these frameworks adequately explain ingenuity and propose that researchers need to pay closer attention to the aspirations behind the pursuit of ingenious solutions. In particular we focus on the conceptualization of aspirations in the behavioural theory of the firm and propose an interaction effect with constraints. Our contribution in this chapter to the emerging field of ingenuity is to propose the interaction of high aspirations and constraints. To further that agenda we conclude by proposing future directions of research for scholars studying ingenuity.

THREE FRAMEWORKS DEALING WITH INNOVATION UNDER CONSTRAINTS

Theory of Constraints

Pioneered by E.M. Goldratt (Goldratt, 1987) in the 1980s, the theory of constraints looks at how constraints limit the ability of achieving higher levels of performance relative to the goal (Aryanezhad et al., 2010). Rooted in the operations management literature, it builds on the principles of continuous improvement, but its point of departure from such theories is that it takes a systems perspective (Dettmer, 1997). For instance, a standard continuous improvement methodology would prescribe that all components of a process must be optimized to their full potential to achieve the best performance, whereas the theory of constraints would highlight the interdependence of the processes and their links with constraints to prescribe ways to exploit constraints, i.e. get the most out of the system as a whole under constraints. Goldratt’s central premise is that organizations exist as systems of interacting and not independent processes.

The theory of constraints is not so much a management theory devised to explain creative problem solving under constraints as a theory aimed at the optimization of a solution in an iterative process. As Dettmer (1997)
notes, it is a collection of ‘system principles and tools, or methods for solving the problem of improving overall system performance’ (p.xxi). Since its introduction, the theory has been steadily enriched by a wide range of tools and techniques applicable in diverse settings, from accounting to operations research. The theory is fairly broad in its consideration of constraints like equipment, people and policy.

Its main limitation with regards to studying the creation of ingenious solutions is that it does not provide a theoretical basis to understand how the solutions arise in the first place. In our definition of ingenious solutions, the theory of constraints does not explain the first condition i.e. the novelty condition. For example in the case of the ‘cooling’ solution a theory of constraints approach can help optimize the solution but does not comment on the triggers to creative solution ideation.

Moving away from an ‘optimization’ perspective to understand if the lack of resources can ‘trigger’ the creative problem solving process, we turn our attention to two other concepts, namely organizational slack and bricolage. In both these concepts the generation of novel solutions is central to the argument and therefore meets our first criterion, the novelty condition.

**Organizational Slack**

Researchers have often used organizational slack to understand the effect of availability of resources on innovation. Nohria and Gulati (1996) define slack as resources that are in excess of the necessary minimum amount required to run the operations of a firm. While it is recognized that by nature slack resources can be diverted or redeployed for the achievement of organizational goals (George, 2005), scholars have also noted that some types of slack resources are more easily redeployed than others. Therefore, the slack construct is often studied as a contrast between slack that is easy to recover (i.e. high-discretion or unabsorbed slack) and slack that is not easy to recover (i.e. low-discretion or absorbed slack) (see Nohria and Gulati, 1996; Sharfman et al., 1988; Singh, 1986 for further details on the type of slack). In our discussion, we are interested to understand what may be the effect of availability of slack (i.e. no resource constraints) and non-availability of slack (i.e. resource constraints) on innovation outcomes.

It has been theorized that the presence of recoverable slack in an organization acts as a buffer. Scholars have argued that the presence of such a resource buffer can have a positive as well as a negative effect on performance outcomes. For instance, organizational theorists who draw parallels between the firm and an organism view the ultimate goal of organizations as survival and growth (Cyert and March, 1963; Salancik
and Pfeffer, 1978). In that context, while the organization theorists recognize the cost of slack to the firm in the short term, they propose that it is necessary for the survival of the firm in the long term. They argue that the presence of slack resources buffers the core of the firm in times of distress (Cyert and March, 1963; Levinthal and March, 1981) and from environmental shocks (Meyer, 1982) thereby impacting the long-term performance. This ‘buffer’ also enables the firm to take risks and experiment with innovations. With more experimentation, it is argued, the firm is more likely to produce more innovation (Nohria and Gulati, 1996) and better performance (Bromiley, 1991; Singh, 1986). Consistent with organizational theory, the presence of slack facilitates multiple other functions in the organization (Tan and Peng, 2003) and therefore the definition of slack from an organization theory perspective as proposed by Bourgeois (1981, p. 30) is:

A cushion of actual or potential resources which allow an organization to adapt successfully to internal pressures for adjustment or to external pressures for change in policy, as well as to initiate changes in strategy with respect to the external environment.

Therefore, according to organization theorists, slack translates into innovation outcomes because organizational actors inherently seek innovations. In contrast to this view, agency theorists consider the firm as a nexus of contracts between principals and agents (Fama, 1980). Therefore, agency theory explicitly rejects the notion of the firm as an organization and in the words of Davis and Stout (1992) turns the organization theory perspective ‘upside down’. The agency argument is that managers acting as agents inherently have a set of goals that are not always aligned with the principal (for example, pursuit of power, prestige, money, and job security). Managers may use slack to engage in excessive diversification, empire-building, and on-the-job shirking (Tan and Peng, 2003). These agency theorists go on to claim that slack is in fact the source of the agent problem, i.e. firms are inefficient in allocating resources termed as ‘X-inefficiency’ (Leibenstein, 1980). From this perspective, the presence of excess slack resources has also been found to diminish competitiveness in organizations (Davis and Stout, 1992).

Building on this tension between organizational theory and agency theory, researchers have therefore proposed a curvilinear, i.e. an inverted U, relationship between organizational slack and innovation outcome (Nohria and Gulati, 1996).

To summarize the implications of slack, we find that while resources are necessary for innovation, too little or too many resources are not conducive to produce new solutions. Therefore, we can infer that depending on
the level of slack in the organization, an increase in constraints may indeed improve performance. As a next step we should therefore have a closer look at how the variables slack and performance are operationalized in research. Table 1.1 summarizes the highly cited literature in this space and the corresponding variables used.

As we see from the table, the measurement of organization slack is often a combination of various financial metrics capturing different types of slack. For example, Bromiley’s (1991) highly cited study takes three different combinations of financial metrics to define available, recoverable and potential slack as predictors of the firm’s risk taking behaviour and performance measured in terms of financial performance as return on total assets (ROA), return on equity (ROE) and return on sales (ROS). For the purpose of our discussion it is important to note that the empirical evidence on the theory of slack considers the outcome variables as the financial return or the incidence of innovation over a period of time as opposed to the quality of each innovation or solution.

Going back to our conditions of ingenious solution, while slack can potentially explain the novelty condition, it does not shed light on the other conditions, most notably the efficiency condition. For example, in the case of jet engine development, we find that the theory of slack can explain the incidence of innovations, i.e. why innovation would drop with too few or too many resources. In 1971, while developing the next generation jet engines for Lockheed, Rolls-Royce went into bankruptcy due to the costs of the project. RB 221, the first three spool turbofan engine could only be completed after the British government nationalized the company and restructured it (divesting the automotive unit). The new nationalized company kept funding the RB 221 project, which on completion catapulted Rolls-Royce to the big league in the airline industry. But slack does not shed light on how some firms are able to make a qualitative leap in their solutions – only that it provides enough resources to ensure the completion of a project.

**Bricolage**

Another body of literature cited in this context of innovation under resource constraints is that of bricolage. Originally proposed by Claude Levi-Strauss in his seminal book in 1962, *La pensée sauvage* (English version published in 1966 as *The Savage Mind*) in the field of anthropology, it later gained popularity in management literature in various contexts like innovation research and organization theory (Duymedjian and Rüling, 2010). This emergence in management theory is fairly recent; as Boxenbaum and Rouleau (2011) note, of all the papers published in
<table>
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<th>Primary theoretical lens</th>
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<td>Organization theory</td>
<td>Singh, 1986</td>
<td>Absorbed slack (selling, general, and administrative expenses and working capital) and unabsorbed slack (cash and securities)</td>
<td>Performance measured as a composite measure of financial performance and top executive subjective response to questionnaire</td>
<td>A high level of absorbed and unabsorbed slack is related to good performance</td>
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<td>Organization theory</td>
<td>Hambrick and D’Aveni, 1988</td>
<td>Unabsorbed slack (equity-to-debt ratio and working capital as a percentage of sales)</td>
<td>Performance measured as financial bankruptcy</td>
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<td>Organization theory</td>
<td>Bromiley, 1991</td>
<td>Available slack (current ratio), recoverable slack (selling, general, and administrative expenses divided by sales), and potential slack (debt-to-equity ratio)</td>
<td>Performance measures as return on total assets (ROA), return on equity (ROE) and return on sales (ROS)</td>
<td>Slack, particularly available and potential slack, increases performance</td>
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<td>Organization theory</td>
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<td>Recoverable slack (accounts receivable/sales, inventory/sales, and selling, general, administrative expenses/sales)</td>
<td>Performance as measured by ROA</td>
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<td>Organization theory</td>
<td>Reuer and Leiblein, 2000</td>
<td>Recoverable slack (accounts receivable/sales, inventory/sales, and selling, general, administrative expenses/sales)</td>
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<td>Agency theory</td>
<td>Davis and Stout, 1992</td>
<td>Cash flow</td>
<td>Performance measured by ROE. To the extent that takeovers are meant to discipline underperforming firms, those that are earning higher returns should be subject to less risk of takeover.</td>
<td>Greater cash flow increases the risk of being taken over.</td>
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<tr>
<td>Inverted U relationship</td>
<td>Nohria and Gulati, 1996</td>
<td>A single composite measure of slack based on two questionnaire items</td>
<td>Performance measured by subjective responses from top executives.</td>
<td>There is an inverse U-shaped relationship between slack and innovation: both too little and too much slack may be detrimental to innovation.</td>
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<td>Prior performance</td>
<td>Greenley and Oktemgil, 1998</td>
<td>Generated slack (6 measures) Cash flow/investment, debt to equity, earnings before interest and taxes (EBIT)/interest cover, market to book value, current assets/current liabilities, sales per employee Invested slack (4 measures) Administration costs/sales, dividend pay-out, sales/total assets, working capital/sales</td>
<td>Performance (5 measures) Sales revenue, return on investment (ROI), return on net assets (RONA), ROS, ROE</td>
<td>A positive relationship between slack and performance exists only for high-performance firms; it does not exist for low-performance ones.</td>
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the database ABI/INFORM between 1992 and 2009 with the keyword bricolage, 87 per cent were published after 2000.

Our interest is to understand how the concept of bricolage is used in the context of innovation. We find that there are two ways to look at this literature: from the perspective of the central actor called the bricoleur (for example, the entrepreneur or the artist), or from the process perspective (for example, resource mobilization). These two ways do intersect and it is at those points of intersection that we find examples of bricolage but our primary interest is more on the process side of the literature.

In Levi-Strauss’s original conceptualization, the artisan or bricoleur plays a central role in bringing together seemingly redundant artefacts in order to compose something meaningful. Therefore, it is not surprising that many scholars, such as Miner et al. (2001) and Garud and Karnøe (2003), have highlighted the characteristics of the involved actors, most notably their resourcefulness and ability to improvise. Here the ability to improvise is used as a personal quality of the bricoleur. Improvisation as a process is a construct that is closely related to bricolage – but it does not necessarily imply bricolage. The distinction between improvisation and bricolage is an important one and will be made clearer from a process perspective.

Bricolage is understood as a process of resource mobilization when the usual resources to meet an objective are not available (Desa, 2012). Such resource mobilization can lead to novel solutions and entrepreneurial ventures as noted in Baker and Nelson’s (2005) definition, ‘making do by applying combinations of resources already at hand to new problems and opportunities’ (p. 333). This view is close to ‘improvisation’ and therefore the two constructs have often been studied in close association (Moorman and Miner, 1998; Weick, 1998). However, as Baker notes ‘while bricolage may imply improvisation, bricolage also occurs in the absence of improvisation, and that it is therefore important to recognize that they are separate constructs’ (Baker, 2007, p. 698). We therefore briefly pursue the literature on improvisation to understand how it is different from bricolage.

In the study of improvisation, scholars like Weick (1993) and Baker et al. (2003) take an ‘amalgamated’ view in which there is significant overlap and spontaneity in the design and execution of novel activities. Furthermore, in the improvisation construct there is no separation between the creator and the interpreter, and between the design and production of the result (Weick, 1993). Therefore, in improvisation thinking and doing unfold simultaneously and is marked by retrospective sense making (Weick, 1996), implying that a way to reconcile these two constructs could be to think that ‘bricolage may be a cause of
improvisation’ (Baker, 2007, p. 698). While improvisation consists of assembling elements based on simple rules in order to yield an original composition (Duymedjian and Rüling, 2010), it does not necessarily depend on resource constraints. For example, improvisation has been consistently observed in many creative disciplines where constraints are not observed, such as musical improvisation (Chase and Portney-Chase, 1988; Kernfeld, 1997), theatre (Knapp, 1985; Spolin, 1999), and sports (Bjurwill, 1993). In summary, we find that the central difference between bricolage and improvisation is that improvisation can happen without constraints whereas the central theme of bricolage is ‘scavenging’ for resources by the bricoleur.

Within the innovation literature, bricolage has been used in two contexts which are known to have resource constraints. First in the context of entrepreneurial ventures often termed as entrepreneurial bricolage (Baker and Nelson, 2005) and second to understand social ventures, termed as social bricolage (Di Domenico et al., 2010). Table 1.2 lists the central theme of some of the cited studies on bricolage.

So far we find that, while bricolage is a powerful theory, it however looks at value creation in general, i.e. creating something from nothing (Baker and Nelson, 2005), as opposed to a specific case of problem solving or comparison between solutions to solve the same problem. Therefore, while the theory of bricolage at best provides a basis to understand value creation in resource constrained environments (often termed as ‘frugal innovation’ or Jugaad – Radjou et al., 2012) it does not address goal oriented problem solving and the qualitative nature of one innovation outcome over other outcomes. Going back to the criteria of ingenious solutions that we defined earlier, bricolage is limited in explaining the dominant solution and specific solution conditions.

When we look at the examples of the cases presented at the beginning of the chapter through the bricolage lens, we find that while the element of creativity under resource constraints is common, ingenious innovations diverge from the example of bricolage in their qualitative superiority over existing solutions. For example the ‘cooling’ solution or the ‘rubber nose’ solution are not make-do solutions but clearly a quantum jump in the design: triggered by constraints, such that they have set the new standard in solving that particular problem.

From the brief review of the three frameworks that are commonly cited in the context of innovation under constraints (i.e. theory of constraints, organizational slack and bricolage) we found only a partial explanation for the emergence of qualitatively superior solutions. We found that the theory of constraints, rooted in production management, takes a systems perspective to optimize solutions in an iterative process. Its main
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<td>Garud and Karnøe, 2003</td>
<td>Bricolage as a process</td>
<td>Case study on the emergence of wind turbines in Denmark and the United States</td>
<td>As a process that could harness the inputs of distributed actors who are embedded in accumulating artefacts, tools, practices, rules and knowledge.</td>
<td>A process of bricolage has been more successful than a process aiming to generate ‘breakthrough’ innovation</td>
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<td>Baker and Nelson, 2005</td>
<td>Bricolage as a process Entrepreneurial bricolage</td>
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<td>Di Domenico et al., 2010</td>
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<td>8 social enterprises</td>
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<td>Inventors with less assimilative capacity and more creative capacity in teams where there is relevant experience will promote inventor bricolage</td>
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limitation is that it focuses on optimization and does not comment on how the solutions come up in the first place. A review of the literature on organizational slack revealed that the focus has been on the quantitative aspects of the generation of solutions but it does not shed light on the qualitative comparison between solutions i.e. if one solution is better than another. Bricolage explains the process of scavenging for resources to create value from seemingly nothing, but once again does not address qualitatively superior problem solving and also how a solution becomes the industry standard to solve the problem.

As discussed in the introduction to this chapter, one of the common elements of the examples of ingenuity, apart from the existence of structural constraints, is the high level of aspiration of the teams working on the innovation project. These aspirations can be set by the strategic intent of the organization (Hamel and Prahalad, 1989), past performance or the performance of peers. While an assessment of the aspirations of the actors may have been out of the scope of these perspectives, it plays a central role in triggering ingenious solutions. We therefore propose to take a closer look at a possible interaction effect between high aspirations and constraints on the innovation outcome.

DO ASPIRATIONS CONDITION THE EFFECT OF CONSTRAINTS?

Since Cyert and March’s publication of *A Behavioural Theory of the Firm* in 1963, it has had a profound impact on both organization theory and strategic management. A full-scale review of the behavioural theory of the firm would be beyond the scope of this chapter but for a detailed review of research on the behavioural theory of the firm see Argote and Greve (2007) and Gavetti et al. (2012). Our interest is in using the foundations of the behavioural theory of the firm to understand if there would be an interaction between high aspirations and constraints on the qualitative nature of the innovation outcome. More precisely, is there an effect on the search behaviour of such an organization?

We know from the central postulates that make up the cognitive foundations that individuals do not maximize, they *satisfice*. This implies that as the knowledge of all possible and optimum solutions is limited; decision makers (within the limited knowledge) are likely to seek a solution that meets their *aspirations* – and not necessarily the optimum solution. These aspirations are set as a result of past (historical) and social (peer) performances. Aspirations can also be set by the strategic intent (Hamel and Prahalad, 1989) of the organization.
Simultaneously, processes in an organization are governed by rules or standard operating procedures which are built on past experiences. However, if performance falls below aspirations, it triggers changes in these rules such as the organization’s search behaviour. This leads to problemistic search – implying that the search for new solutions is motivated by the objective to achieve goals when performance falls below aspirations. As a result of the cycle of search and change, the organization learns by adapting the rules and procedures.

Our interest is focused on understanding if the behavioural theory can shed some light on how ingenuity is triggered. The central concepts that we would like to focus on are aspirations, defined as ‘the smallest outcome that would be deemed satisfactory by the decision maker’ (Schneider, 1992, p.1053), and problemistic search – triggered when performance falls below aspirations. There is strong empirical evidence to show that firms indeed trigger problemistic search when performance falls below aspirations; for example, we know that firms tend to invest more in R&D (Antonelli, 1989; Hundley et al., 1996), as well as seek new R&D processes (Bolton, 1993), when their performance is below aspiration levels. Therefore, when performance falls below aspirations an organization triggers problemistic search processes.

Note that a behavioural theory based explanation of quality of innovation from problemistic search does not preclude the role of slack based search or from acquiring solutions available in the environment. Therefore, a firm may build a solution stock using slack resources or by acquiring knowledge from the environment (Greve, 2003).

In such a context we propose that the introduction of constraints would have a moderating effect on the applicability of the existing stock of solutions in meeting the performance targets. If the performance falls below the aspirations we expect one or a combination of the following:

a. Lowering of aspiration levels of the decision maker. Given the limitations in resources, the decision maker may satisfice by accepting that the current performance is the best possible under the circumstances and therefore adjusts the aspiration level. In the case of extreme resource constraints, the decision maker may simply ‘give up’.

b. Generation of a novel solution that meets the performance expectations within the resource constraints. This approach builds on an interactive process (Slappendel, 1996), wherein innovations are created by the interaction of individual traits and structural influences. In this possibility the firm may be able to produce a solution that meets the conditions of being an ingenious solution.
This leads us to propose that:

When faced with resource constraints a firm either reduces aspiration levels and meets the lower performance level or a firm maintains high aspiration levels and pursues ingenious solutions that have high performance even under constraints.

Figure 1.1 shows the theoretical model for these effects.

Considering the conditions and examples of ingenuity that we had introduced earlier, we find that an explanation based on the cognitive foundations of the behavioural theory of the firm may provide a more comprehensive explanation of the qualitative nature of the outcome. For example, in the ‘engine overheating’ case, when the Germans and Americans were competing to build a stable jet engine, the presence of resource constraints on the German side forced them to search for solutions that would still work within their resource constraints, ultimately leading to a better quality solution. Whereas the Americans pursued what would appear to be a slack solution to solve the same problem. Similarly, in the ‘ice on the nose’ case, the solution only emerged as the engineers were forced to search for cost effective solutions. In either case, the teams could have settled to lower their aspiration levels and chosen a solution from the existing stock of solutions – instead they pursued the path of developing ingenious solutions.

FUTURE DIRECTIONS FOR RESEARCH

In our pursuit to find the roots of organizational ingenuity we found only partial explanation for the effect of structural constraints on the quality of innovation outcomes from the theory of constraints, bricolage and organizational slack. However, going back a step and introducing the moderating effect of constraints on an explanation based on the behavioural theory of the firm provides exciting opportunities for further investigation. This proposal clearly does not preclude the individualistic perspective of innovation which focuses on individual level constructs (Amabile et al., 1996; Scott and Bruce, 1994) but instead calls for multi-level research to understand the phenomenon.

Questions such as what influences the organization’s ability to create qualitatively superior solutions within structural constraints using limited resources and imaginative problem solving can only be answered through creative and robust research across different dimensions of innovation (e.g. product/process, technological/administrative). Furthermore, research is needed to understand why only a few firms produce hugely influential products or services regularly (e.g. Apple, Dyson) or innovations in environments that by nature have structural constraints. It is important to highlight that structural constraints need not be limited to resources but can arise from other sources such as conditions set by a management team or culture.

While measuring innovation outcome, researchers have also shown a bias towards measuring productivity in terms of the commercial success of products or incidence of innovation. For example, number of patents filed has been the preferred measure of innovation output for many decades. However, this clearly does not capture the quality of the innovation. New variables that aim to capture the quality of innovation should be encouraged in mainstream innovation research. For example, recent studies by Joshi and Nerkar (2011) and Lahiri (2010) used a patent citation index to measure the quality of the innovation. While these variables are not error free they still enable us to derive a more balanced view of innovation quality.

And finally this enquiry into ingenious problem solving would not be complete without extending it to other units of analysis like teams and individuals that work under constraints. We need to develop a better understanding of how these units perceive and react to constraints. After all, ‘creative’ is an anagram of ‘reactive’, reactive to constraints.
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