Opportunity Characteristics Enabling Commercialization in High Tech Environment: A Study on Indian Telecom Start-ups

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Abstract

Opportunity recognition forms the core of entrepreneurship research. Existing entrepreneurship research has viewed opportunity recognition from varied theoretical lenses with cognition and learning forming the core of most scholarly work. However, prior work has either focused on end result (success or failure) only or more recent work has focused on opportunity recognition process only. But both the aspects need to be analyzed and assessed simultaneously. Moreover, high tech sector is different due to a high component of knowledge intensiveness inherent in it and has been surprisingly ignored in most work. So, we explore a specific high tech sector (telecom sector) in the present paper within an Indian context with the understanding that insights could be utilized by other sectors as well. We employ a detailed case study based approach to identify four characteristics of opportunities that shape the evolution of the opportunity recognition process on its path to commercialization. We also bring out the linkages between characteristics identified by us and existing paradigms in strategic management literature. We further propose that mental heuristics of entrepreneurs is guided by the characteristics identified by us. Our work thus contributes to both theory and practice of entrepreneurship research.

Keywords: Entrepreneurship; Opportunity recognition; Entrepreneurial learning

Introduction

A wealth of evidence suggests that new, small firms grow faster (Wagner, 1994; Tether and Massini, 1998; Brixy and Kohaut, 1999), create more net jobs (Robson, Gallagher, and Daly, 1993; Hart and Oulton, 1999), and distribute wealth more effectively (Schumpeter, 1934, 1942). In the last 25 years, two-thirds of the net new jobs and 95% of the radical innovations have come from entrepreneurial businesses (Timmons and Spinelli, 2003) in developed markets. Entrepreneurship is the common link between invention, innovation, new product development and wealth creation literature. Arguably, the field of entrepreneurship offers a fertile ground for scholarly examination of many unanswered questions. Identification and selection of the right opportunity for new businesses also known as opportunity recognition forms the primary theme of successful entrepreneurship (Stevenson et al., 1985) and thereby developing theoretical explanation for the recognition and development of opportunities is a important aspect of entrepreneurship research (Venkataraman, 1997). But opportunity recognition and formation of firm have been viewed as points of discontinuity in the traditional economics literature driven by output and inputs. Although existing literature has contributed important insights by borrowing theories from multiple disciplines to explain many facets but still there is no consensus on a single theory for opportunity recognition (Short et. al, 2010).

Scholars in the field have reached a consensus on certain aspects of opportunity recognition and development process (in the present paper we use opportunity recognition process to mean both opportunity recognition and development process). Some of these include opportunity recognition being an iterative process that evolves from individual to organizational level; is strongly impacted by situational and social context; creativity and learning process play important role in the process (Dimov, 2007a, b; Short et. al., 2010). However, understanding about characteristics of opportunities that in turn guide the opportunity recognition process from ideation to actual commercialization is limited. This paper employs case based methodology to analyze the dynamic opportunity recognition process and proposes characteristics of opportunity among high-tech start-ups that enable successful commercialization; specifically telecom based start-ups. The rationale behind this narrow sectoral focus is manifold. Firstly, high-tech firms are important in today's knowledge economy because they are viewed by many as set for playing an increasingly important role in the regeneration and growth of national economies (OECD, 2003). Secondly, they offer potential of generating large scale employment as has been observed in developed markets (Timmons and Spinelli, 2003). Moreover, telecom start-ups operate in knowledge intensive and regulatory environment which makes starting and sustaining business in the sector comparatively more challenging and so insights could be extrapolated to other sectors.

This paper attempts to further our understanding about opportunity recognition process without attempting any holistic framework for opportunity recognition or dwelling into mechanics of individual cognitive processes. The main contribution of the paper is to identify four primary characteristics of opportunities leading to commercialization among the start-ups. We do so without missing out on the process aspect of opportunity evolution while at the same time keeping an eye on successful commercialization. The

paper is organized as follows, we begin with a brief literature review, followed by our methodology which leads to analysis framework, analysis, and finally we conclude with discussion.

Literature Review

We begin with a review of various definitions of opportunity recognition, subsequently present a very brief classification of existing opportunity recognition related scholarly work which enables us to identify research gaps and notify resulting research questions.

Kirzner (1973; 1979) defines an opportunity as special knowledge an entrepreneur acquires about goods or services sold in new markets or combined and sold at a profit. DeBono (1978) defines opportunity as a "course of action that is possible and worth pursuing", one that involves non-linear or lateral creative thinking. Hulbert et al. (1997) state that a business opportunity is the chance to meet an unsatisfied need that is potentially profitable. Christensen, Madsen and Peterson (1994) define opportunity recognition as either perceiving a possibility to create a new business, or improving the position of an existing business, in both cases resulting in a new profit potential. Central construct of all major definitions is serving unmet needs by delivering superior value "profitably". Unless the commercial value is recognized or in other words commercialization is achieved there can be no profit. Clearly success in turning an idea to a profitable venture is implicit in these definitions of opportunity. We retain the idea of successful commercialization as the core theme of present work.

The focus of entrepreneurship research underwent a fundamental change in the late 1980s and early 1990s with authors proposing a more holistic approach to the study of entrepreneurship as opposed to an overemphasis on the personality traits of the entrepreneur which till then formed the bulk of scholarly work (Gartner, 1985, 1988; Bygrave and Hofer, 1991). In terms of ontological position; two primary contenders have emerged. Gartner et al. (2003) have talked about two differing ontological positions in entrepreneurship theory one related to the "positivist or realist" position wherein discovery approach is propagated with opportunity waiting to be discovered. The other ontological position is related to interpretive or social constructionist perspective on reality which is the enactment approach. Dutta and Crossan (2005) have discussed the above parallel approaches to entrepreneurial opportunities in a slightly different manner; namely the Schumpeterian view and the Kirznerian view. The authors adopting the Schumpeterian view believe that opportunities are created and the role of entrepreneur's personality traits affects the way the opportunities are discovered. Kirznerian view on the other hand focuses on knowledge and information asymmetry that exists between the people in the market. Both perspectives emphasize on idiosyncratic knowledge and its significant role in the opportunity recognition but invoking differing ontological paradigms has led to series of scholarly work focusing on antecedents alone or focusing on process alone.

Studies focusing on identifying antecedents impacting opportunity recognition have brought out several insights. For example, Hayek (1945) had recognized the role of knowledge and information dispersal in entrepreneurship and his work has further been

built upon by Venkataraman, (1997), Shane and Venkataraman (2000), Shane, (1999), Eckhart and Shane, (2003). Ardichvili et al., (2003) use Dubin's (1978) theory building method to impress upon the role of prior knowledge related to markets, industry, customers etc. Knowledge in the form of experience has already been established to be an important construct in the opportunity recognition process (Vesper, 1990; Bingham et. al., 2007). Shane (1999) has specifically looked at the role of technological breakthrough and it was found that when same information was presented to different individuals with differing prior knowledge it led to different opportunities being recognized. Haynie et. al. (2009) have attributed this to entrepreneurs being attracted to opportunities that are complementary to existing knowledge. Daft and Huber (1987) and Crossnan et. al., (1999) have pointed out differences in the way a novice and an expert assess and interpret the same situation. Clearly prior knowledge plays a critical role in the opportunity recognition process but how the interplay between information asymmetry and experience lead to opportunity recognition is still not clear, though there is consensus on this being iterative.

While the above work focuses on factor based studies and causality; a parallel strand of work has been studying opportunity recognition from a process point of view. A growing strand of literature relates creativity and cognition to opportunity recognition. Baron (1998) and then Busenitz and Barney (1997) bring out the fact that entrepreneurs use heuristics and biases in decision making and this enables them in taking much less time in arriving at conclusions even in very complex situations. Ward (2004) connects creativity to cognition and knowledge and points out that depending upon how knowledge is utilized through cognition, knowledge will either provide a new opportunity or may block the path of an opportunity. He points at conceptual combination, analogical reasoning and a few others as possible ways of generating novel ideas along with method of abstraction and problem formulation of the individual which may invoke the way knowledge is stored and information retrieved as important aspects. Lumpkin et al. (2003) too have argued in favour of creativity based approach to opportunity recognition and have proposed a five step model inspired from Csikszentmihalyi (1996) basic elements of creativity. The fives steps proposed are preparation, incubation, insight, evaluation and elaboration with first three stages describing discovery and the other two describing formation. Dimov (2007a) on the other hand has argued that creativity in isolation without bringing in the learning process or the social context cannot present satisfactory explanations.

Corbett (2005, 2007) extends the creativity and knowledge aspect by bringing in learning asymmetries or the difference in the way people assimilate knowledge. This difference is due to the differences in the learning process that different individuals predominantly follow (assimilative, convergent, divergent or accommodative). Also each of the learning process is effective to differing degrees in the different stages of opportunity recognition. Lumpkin and Lichtenstein, (2005) have proposed a conceptual model for opportunity recognition as a process of organization learning with three forms of learning namely behavioral, cognitive and action learning impacting discovery and formation process differently. Cognitive learning has the potential of opening up new markets whereas behavioral learning seems more adaptive in nature helping more in the formation process.

Action learning enables course correcting process of organizations which enables both the cognitive and behavioral learning by questioning the existing norms and thus leading to double loop learning (Argyris and Schoen, 1978). Dutta and Crossan (2005) too have positioned the opportunity recognition process as a learning process and have applied the 4I (Intuition, Interpretation, Integration and Instutionalization) framework of organizational learning to the opportunity recognition process and have further tried to bring a convergence in the ontological positions of Schumpeterian and Kirznerian entrepreneurship by linking intuiting and interpreting to enactment and integration and institutionalization to objective reality. Dimov (2007b) has furthered this perspective by arguing that prior knowledge and learning style match with existing situation is necessary for appropriate action towards developing an opportunity. Also, overtime there has been a general agreement among the organizational learning researchers about the opportunity recognition being multi-level and happening across multiple time frames. Dimov (2007a) has been particularly categorical regarding temporal dynamics of opportunity recognition.

Based on above theoretical underpinnings, many opportunity recognition models have been developed during last decades (Bhave, 1994; Schwartz and Teach, 1999; Singh et al., 1999; De Koning, 1999; Sigrist, 1999). These models borrow their conceptual basis from wide range of disciplines, such as cognitive psychology, Austrian economics etc. All the above mentioned scholarly works have enriched our understanding of opportunity recognition, but they tend to focus on only one of the several aspects of the process. For example, some authors such as Shane (1999) focus only on the prior knowledge and experience whereas authors such as De Koning (1999) and Hills et al. (1997) focus on the social network and its role in opportunity recognition. An inherent limitation of all the above mentioned scholarly works has been the specificity which enhances understanding about one aspect but at the same time dilutes focus on other aspects which might be equally important factors. Clearly from a theoretical standpoint opportunity recognition needs a converging view that encompasses existing work and represents the actual inter-disciplinary nature of the construct (for an excellent literature review refer Short et. al., 2010). However, present work is not an attempt towards presenting any converging view rather it aims to look at the opportunity recognition process from a strategic management perspective (Ketchen et. al., 2007).

Above mentioned literature informs us on various dimensions but does not offer some specific insights about more knowledge intensive sectors. Although from a definition perspective most scholarly work mentions commercialization as primary but most research has sought not to focus on the success part alone for a variety of valid reasons and in the process an important aspect has been ignored. We have already mentioned that the central theme of our work is commercialization of opportunity without compromising on process aspect of opportunity evolution. While it has been accepted that opportunity recognition process is iterative and evolving but existing work does not inform us about what factors determine the path to be followed in the process towards commercialization. From an initial idea to final step what are the characteristics of opportunity that need to be invoked or in other words what are the questions that need to be answered by entrepreneurs to move towards success in the market. Although we accept that extent of uncertainty and serendipity form important moderators for success in market but still

certain generic markers to guide entrepreneurs could definitely be sought out. Specifically, our research questions are:

a. What are the key characteristics of opportunity that enable successful commercialization?
b. How do these characteristics impact the opportunity recognition process in its evolution towards successful commercialization?

We try to answer these questions in the coming sections using telecom start-ups as the context.

Method

It has been emphasized by many scholars (Dimov, 2007a; Short et al., 2010) that since context and environment are primary in opportunity recognition research, ordinary survey based cross sectional studies do not capture the context properly. Scholars have rather recommended experimental, quasi-experimental and field study based work as better fit for such work. Given the nature of research questions posed by us our methodology was guided by two key points. Firstly, given our context of studying a dynamic process which evolves we need to be sensitive to temporal aspects of opportunity recognition process. Secondly, with limited existing work on the aspects being studied by us our study has a high exploratory content. In order to answer our research questions, we identified field study based case study approach as the most appropriate for our context. Case based study is ideally suited to answer questions related to process inquiry, exploratory work as well as answering how and why kind of questions (Eisenhardt, 1989; Yin, 1994).

Two important aspects of multiple case based studies are case sampling and number of cases to be studied. According to Eisenhardt (1989) and Miles and Huberman (1994) for sampling in an exploratory work a good strategy is maximum variation on various parameters. This is particularly good strategy for process based studies as firms which are far apart in terms of various parameters could be studied for theoretical or literal replication and thus help in coming up with robust answers and thus aids in external validity. In terms of number of cases the idea to reach a certain saturation level such that incremental data addition does not lead to newer insights and generally, four or more case studies (Eisenhardt, 1989) are helpful in this respect.

We identified 20 different companies within the telecom sector operating in different domains such as voice over Internet Protocol (VoIP) infrastructure development, technology platform for offering value added services, equipment manufacturers, network management etc. All the start-ups were essentially B2B (business to business) companies looking to sell their product to mostly either telecom service providers (TSPs) or the Internet service providers (ISPs). Also all these companies had their registered corporate head offices in India and none of them were promoted by large diversified groups. The reason for the above filter was that companies starting out of India would face a different external environment in terms of the ability to raise capital, the risk appetite of the entrepreneurs and investors and commercialization environment as compared to that in India. Similarly a company promoted by a large conglomerate would be a diversification move rather than an independent start-up company. It is essential to

control for variables that are not a part of our study and can disrupt the interpretive process.

We sent letters to all the companies and sent mails to them identifying ourselves and explaining the purpose of our work. We requested each of the companies to let us have a session with each of the founders to understand and assess the conditions during the opportunity recognition process. We finally chose seven companies based on our strategy of maximum variation, availability of founder members for detailed interviews and willingness to share detailed information about firms. Table-1 gives details regarding the firms and their inherent differences.

Among the seven companies one of the companies is no longer in existence and had to be closed down due to various reasons. Getting data about failed ventures is mostly a very difficult task but we could include this company into our analysis as it could offer us a potential data point for better comparison among the start-ups. We talked to the co-founders in all cases separately and this helped in triangulation of data that we collected. We conducted 3-4 interviews per company (total of 21 interviews) and most interviews lasted around 1.5-2 hours and were recorded with permission. Our respondents were the entrepreneurs themselves and so they are aware of every aspect of their company with minutest of details. Apart from the founding members we also talked to earliest employees of the teams wherever possible. We also collected newspaper report and other archival data from the company websites (Cardinal et al., 2004; Danneels, 2010). Once data was collected, the interviews were transcribed verbatim and converted to case histories to focus on the questions to be answered. This was followed by data analysis wherein memos (Strauss, 1987) were generated that helped us in proceeding from data analysis to theory by continuously contrasting the finding and refining the upcoming themes. We had to move between data and theory over several iterations (Eisenhardt, 1989; Burawoy, 1991) and in this process we at times had to connect back to interviewees to obtain a clear understanding of issues (Hirschman, 1986). Subsequently clear themes emerged which resulted in conceptualization of characteristics of opportunity that shape the path of opportunity recognition process towards commercialization. Next we present the emergent themes and their linkages with strategic management literature.

Framework for Analysis

Based on our transcriptions we could identify four primary characteristics of opportunities that drive the opportunity recognition process towards successful commercialization among the firms of our sample.

a) Expanding the boundaries by questioning existing norms and pushing the limits of technology to the next level to serve a pressing need:
   One of the most critical aspects of opportunity is that it should be aimed at serving a pressing/strong need of the target audience for example broadband in India at affordable price is such a requirement. Before we proceed further we need to appreciate the emerging country context better. The first complexity in this context is the fact that price is a major issue. Customers are ready to trade-off

some quality aspects if the price is suitably low. Similarly, customer numbers are often low within specific localities although on a state/region wise level the numbers might be substantial. However, most paradigms in western world are so geared that they are focused on high quality and a humungous scale within a local region which is achieved at a very high price. In order to suitably provide a service or product the idea has to be re-conceptualized and in ways so as to often turn the existing concepts on their head. We will discuss and try to bring out this aspect through all our case specific discussions. From a strategic management theory perspective this idea is closely related to concepts of motivated search (Chandler et. al., 2002) exploration (March, 1991), double loop learning (Argyris and Schoen, 1978) and dynamic capability (Teece et. al., 1997; Eisenhardt and Martin, 2000; Winter, 2003; Teece, 2007) among firms.

b) Knowledge based entry barrier:
Start-ups look to develop opportunities that enable creation of credible knowledge barrier between them and other existing as well as newer start-ups. This knowledge barrier serves as an immediate entry barrier and also ensures competitive advantage for certain time period to capture the benefits of their product from the market before product is imitated or is rendered obsolete. Consequently, in telecom related software space not every opportunity is worth exploring unless the entrepreneurs believe in certain minimum expected life of the opportunity. From a theoretical perspective this idea borrows the concept of knowledge as a capability. This specialized knowledge ensures short term competitive advantage which might transform to sustainable competitive advantage depending upon the fungibility of knowledge level and learning process being adopted (Dierickx and Cool, 1989; Peteraf, 1993; Grant, 1996; Zollo and Winter, 2002; Kiel, 2004).

c) Minimum dependence of the business model on incumbent vendors/service providers and geared towards maximum scalability:
Most telecom start-ups are dependent on established/incumbent telecom service providers (TSPs) or other major players (MNC equipment vendors) in the market for generating business. This reliance on incumbents could bring in quick scales and revenues if the product clicks but on the flip side, such dependence could at times lead to locking in on a particular product/service or a business model which is no longer relevant. For example, an established firm may decide to discontinue a particular service leading to decimation of a start-up. In order to hedge over this risk most start-ups try to develop those opportunities that have the potential for a larger customer base. Although these firms operate in a B2B market, they try to create products that are relevant for a larger number of end customers of TSPs to reach a scale which makes them more pertinent for TSPs. Where ever possible firms try to find ways to minimize their dependence by diversifying customer and service portfolio; at times even outside the B2B telecom domain. From a theoretical perspective this corresponds to “mitigating the impact of imbalance in market power”.

d) Co-evolution of mental model of the entrepreneur and the product idea:
Initial product idea although innovative might be wrongly conceived in terms of needs it serves; might be lacking in terms of either implementation or suffer from operational issues or unseen problems or at times the product might solve one problem but actually create a new potential problem. Level of mismatch between product idea and actual customer requirement primarily depends upon experience level of the entrepreneur and granularity of conceptualization. Even after careful planning and development certain pain points might still persist. As understanding about customers and market increases through continuous feedback or evaluation by different entities an active rectification/modification process sets in. Finally, this enhanced understanding (learning) about changes in the market requirements enables unraveling a strategic fit for the market. From a theoretical perspective "adaptation" (Brown and Eisenhardt 1998; Eisenhardt and Martin, 2000) within strategic management literature fits the explanation mentioned above.

We will discuss our sample firms within the above mentioned themes in order to bring forth the germination of opportunity in each of the cases and its subsequent evolution to reach the final shape which finally resulted in sales for the startups.

Analysis

1. Company C1:
For company C1 the first opportunity emerged when a leading MNC customer of the founders' earlier employer (well-known Indian telecom Software Company) wanted to develop a product (3G base station) suited to developing countries with low power output, low power requirements and consequently low cost as well. Expectation was that due to lower cost of product chances of mass acceptability and deployment across the segment of population who could value the services provided by the product would increase manifold. The founders of C1 based on their mental model of future communication needs perceived the idea to be feasible and worth pursuing independently. The requirement that was laid down could be satisfied only by questioning the existing norms about base stations. *Base stations were viewed as being high end equipment with the ability to support a million users. The idea of affordability and limited number of users for a base station was unheard of*. Founders of company C1 successfully developed a low cost base station meant for limited number of users. *This is analogous to the process of double loop learning where the entrepreneur questioned the existing paradigm and created a new norm in accordance with what an entrepreneur perceived as a product or service that could be a market fit*. As a result two key characteristic properties of expensive and large were reformulated in the above context to affordable and small. Although C1 went further with development on little fund they raised and successfully created the product, they could not move further in the market as the MNC that was to be the (only) prospective customers lost interest in the idea. *The complete dependence on the vendor was the primary reason non-realization of this opportunity.*

The second opportunity was recognized when founder was trying to solicit funds and new customers for their 3G base station. Several investors (mostly US based) advised him to get into the WiMax space. Around mid-2005, WiMax was being promoted across the world as the next major technology and around round the same time Indian telecom regulator Telecom Regulatory authority of India (TRAI) too announced its tentative policy direction with respect to WiMax. The founding team and other members of the company together deliberated on this issue. In the process they weighed their technical strengths, had discussions among themselves about the business models for WiMax, possible customers base, *about the problems of 3G platform dependency on large vendors (most patents in the 3G space are held by large MNC telecom companies and so any development in this arena would mean paying royalties to them), learning WiMax and thereby creating a knowledge barrier that cannot be breached within a short timeframe.* Finally they decided to develop a WiMax base station that could be mounted on a house top. In the second phase the investors played a major role in recognition of the opportunity related to the choice of WiMax. *However, from the perspective of idea evolution the earlier idea of compact and low power base station was extended and combined with a more commercially promising technology. Here the mental model of the entrepreneur was modified by the feedback received from the evaluators and this in turn led to modification of the product idea (co-evolution).*

2. Company C2:
   The initial idea emerged from prior experience, understanding of the business environment and a mental model of the entrepreneurs about the possible shape of communication infrastructure in future. As early as 2000 they were thinking of "convergence", bringing voice communication and data communication together when most of the existing networks looked at the two as different. The initial idea that the founders had was to develop an application that would enable the customers to get access to their e-mails through ordinary phone line using text to voice converter engine. *Clearly, idea of convergence and usage of wireline phones for directly accessing the emails involved questioning the existing norms and pushing the technological limits.* Both the founders were convinced about the feasibility of this application and developed a business plan wherein they expected to scale-up through a subscription based business model. But when they started visiting various investors for funds they got a different feedback. *Detailed interaction with investors stressed upon them the fact that the kind of service that they were planning was to be completely dependent on the network infrastructure of the telecom service providers and so the investors pushed them to think of ways to overcome this dependency*.

   During this time regulation was passed making VoIP services legal between PCs in India to phones, mobiles and PCs abroad. *The founders while trying to develop voice based application had developed high end technical skills around voice based file transfer and handling. This constituted a knowledge barrier for the other firms.* They found VoIP services to be an ideal opportunity for them to be

able to use their technological skill. The business idea was to develop VoIP infrastructure for the service providers who already had a network of their own and let them offer the VoIP services to their customers using the product developed by C2. *The business model although still dependent on service providers was several notches independent then earlier model envisaged for wireline phones. Thus again we see entrepreneurs vying for minimum dependence on incumbents*. *Here we also see an instance of behavioral or adaptive learning taking place that modified the initial mental model and corresponding change being incorporated into the original product idea by the entrepreneurs*.

3. Company C3:
   Here too the prior experience and shared vision among the founders about the possible shape of communication requirements in future played a major role in the opportunity recognition process. The initial idea evolved as a result of realization of infrastructure bottleneck because of copper based last mile connectivity in India and corresponding problems in providing other enriched services including both data and video on the existing network. The existing wireline based voice networks were circuit based and offered several features like guaranteed quality of service, fast restoration and reliability but were lacking in terms of bandwidth. On the other hand, IP (Internet Protocol) packet based networks offered better capacity utilization and scalability. The existing technologies for broadband were mostly xDSL based and suffered from overheads and issues of service provisioning and management when integrated with IP based networks. Founders realized that most offices in India already had an Ethernet based LAN (Local Area Network) infrastructure. The idea was to provide triple play (voice, data and video) capabilities using Ethernet as the core which could keep cost low as minimum capex would be required. *The idea of offering triple play capability over Ethernet was like pushing the limits and questioning the existing norms of the existing network technologies. Offering a triple play product over Ethernet involved high end technological work related to protocol development and this was seen as knowledge barrier that was difficult to scale for most firms in the industry.* This intuition was further developed into a concrete idea due to detailed interaction with an industry expert that led to the realization of the actual problems being faced by the service providers and identified issues with present conceptualization of the product. *Based on above learning corresponding modifications were introduced into the product design (co-evolution) however, the extent of modification required to actually implement the idea completely was high and this required significant investment and time posing an obstacle towards commercialization*.

   However, the business model of C3 was *completely dependent* on the telecom service providers as it had to be embedded in their network. Without any service provider actually giving them a chance they could not sell their product. Company C3 still went on with the plan as again it was realized that the kind of products available with major telecom equipment MNCs were high end, not just in terms of cost but also the scales it could support whereas the telecom service providers in

India were looking at entry level equipment due to uncertainty related to the demand for broadband and other services in India. So, they could see a substantial market for a technology product that could bridge the above problems. Although the company went forward with its plans of manufacturing and did achieve some success in its development efforts but due to several reasons (including overdependence on service providers) C3 could not sustain itself and was closed down in mid-2007.

4. Company C4:
   The founders worked for well-known software companies in their telecom software divisions. They could sense a business opportunity in developing sub-components for speeding up product development in mid-level telecom software companies that were engaged in creating mobile related applications. Given their experience with this kind of work they developed several sub-components for mobile applications within a very short time. However, two problems were identified by the founders, firstly their *clients were mostly US or UK based making this not very scalable and at the same time over dependent on these overseas clients*. Secondly margins in this business were much lower. So, they decided to put together various sub-components developed by them to offer something in the upcoming m-commerce domain with a suite of products enabling m-ticketing, logistics etc. *However, soon they realized the lack of volumes in m-commerce related business and again this model was completely dependent on the telecom service providers for its success*.

   In order to reduce their dependence on the telecom service providers C4 decided to move to Bluetooth based product development wherein C4 would transform community centers into Bluetooth enabled zones for promotion and advertising over existing mobile handsets. *Creation of Blue-Fi zones on the lines of Wi-Fi zones was in itself a very revolutionary idea which had not been explored and involved pushing the limits and questioning existing norms of wireless technology*. Moreover, development of Bluetooth based protocol stacks, synchronizing transmitters/receivers as well as backend servers for *developing complete Bluetooth infrastructure for community centers involved a considerable knowledge barrier vis-à-vis existing firms*. Apart from this a transition from sub-component development to m-commerce application development to finally Bluetooth product development is an instance of co-evolution between mental model of the entrepreneurs and product idea.

5. Company C5:
   Both the founders were employed with the telecom software division of a major Indian software firm. During their regular installation and support stint related to IVRS for a client they sensed an opportunity for developing SMS related infrastructure for CDMA based network. During 2001-02 the SMS infrastructure was well developed for the GSM network but was absent in the CDMA network. *Again we see questioning of the existing norms and pushing the limits to arrive at an idea that is perceived as strategically fit given the context*. For the next few

months they spent time collecting relevant documentation, reading, discussing and conceptualizing the overall idea. Once they were convinced about the feasibility of developing such an application they quit and started their own company. However, when they did interact with one prospective customer, they were asked to develop bulk SMS gateway on a priority basis so that the client could capitalize on existing business available for bulk SMS based advertising in the international market. This required reconceptualization and modification of the original idea. C5 was able to deliver the product within the desired time frame, however, this arbitrage opportunity for their customers was short lived and soon C5 was back to work on the original product idea of developing SMS-C and other infrastructure for CDMA networks in India. They were able to develop the SMS-C, which was lapped up instantly by their customer. However, this placed a new problem before C5, although product was novel in India but only 2-3 CDMA players operated in India and as such scalability was a big issue. To overcome this impediment, C5 modified their product to a more generic product that could be used in both GSM and CDMA network. *Activities of C5 were essentially aimed at creating a business model that was less dependent on a few customers. Moreover, working on SMS related infrastructure for two different standards involved understanding telecom messaging related protocols to minute details and this provided a knowledge barrier with respect to other firms*.

Although C5 did acquire some customers but the problem of scalability was still not sorted out. During their interaction with various telcos, founders realized that a demand for support services for solving various operational issues of telcos and innovative services to be offered to end customers of telcos could help in creating a suite of offerings that could bring volumes for C5. They sensed one such opportunity in solving roaming related problems for mobile companies by utilizing intelligent network (IN) paradigm. C5 was also among the earliest firms to develop location based services for the telcos. *In C5, we see consistent opportunity sensing; co-evolution of entrepreneurial mental model and product ideas with the aim of developing a self-sustaining business model with minimum dependence on few customers or vendors*.

6. Company C6:
   Both the founders are well-known academicians as well as serial entrepreneurs with several successful firms behind them, which were set up under the umbrella of TeNeT group of IIT Madras. As various start-ups started growing and gained new customers, members of TeNeT group came to understand of several issues that were of considerable importance to the telecom service providers but were not being adequately addressed by the existing solutions. One such thing they realized was that with the increase in sophisticated elements, managing the network was becoming difficult. Unlike the traditional PSTN system wherein most of the intelligence and element management is concentrated in the exchange; modern telecommunication system which provide data as well as voice, consists of several components such as exchanges, base stations, CPEs etc., each with its own processing power. For the network to work well, all the network elements

need to be managed without people going to each of these places for the purpose of monitoring and management. There was a need to have remote management system to be able to monitor and control these millions of elements in the network. We note that C6 is fundamentally different from other firms in the sense that it had serial entrepreneurs at the helm of affairs that had spent considerable time in the sector and so the existing knowledge level was high. *As a result the co-evolution of mental model and product idea is self-evident in the basic idea itself*. However in terms of dependence and scalability C6 had problems because the model was completely dependent on uptake by the telecom service providers. *To remedy this overdependence and gain volumes C6 later positioned the product as a comprehensive solution for large equipment vendors also*.

Although equipment vendors had proprietary solution for their network elements but the problem was further accentuated in Indian context because most TSP network had equipment from more than one vendor and this led to problems of inter-communication between elements not belonging to the same vendor. *Clearly, the idea of developing an encompassing network management system that could remotely monitor, control and enable communication between equipment belonging to different vendors was pushing the existing limits and questioning the existing norms in place. Moreover, this involved working around bridging protocols to enable different equipment to communicate with each other which meant high knowledge barrier for any firm trying to enter this domain*.

7. Company C7:
   C7 was founded by a group of engineers with experience across several companies engaged in software development related to telecom products. The group met in an earlier start-up and tried several products but finally the start-up could not sustain and was disintegrated. Group was particularly passionate about voice recognition technology and decided to develop the technology for India and subsequently commercialize by exploring various options in the telecom space. The very concept of voice recognition is technologically challenging and more so in the Indian context wherein accents are numerous and very different from each other. However, across the world not much success had been reported in either voice recognition or business models based on voice recognition. But the members of C7 were convinced that in India with deep mobile penetration but lack of English literacy among the masses (especially rural), voice recognition could give a fillip to uptake of value added services. *This is an instance of questioning the existing norms and pushing the limits to develop an application that fits well in the given context*. *Moreover, in case C7 was successful in developing voice recognition engine, knowledge barrier would be insurmountable for existing and new firms given the complexity involved*.

   After C7 was able to develop a successful prototype for the technology, they started looking for ways to offer value added services to the end customers of TSPs, especially in cases where interactive response was required. The interactive response in these services was not limited to pressing of keys but could be sought

verbally. C7 offered services for searching restaurants over mobile, getting stock quotes over mobile, searching songs and downloading ringtones etc. *These services were developed as a result of careful modification of basic product idea on the basis of changing mental model among the C7 members about possibilities of exploiting voice recognition technology (co-evolution)*. Further, C7 worked towards taking the product idea to enterprises which could utilize interactive response verbally and these included various banks, travel agencies etc. C7 even roped in a direct to home broadcaster as customer for one such service. *This was typically aimed towards minimizing dependence on TSPs and achieving volumes for sustenance*.

General observations related to opportunity recognition:
In addition to above insight our work has also enabled us to verify several other aspects related to opportunity recognition that have been brought to light by prior scholarly work that we have touched upon in the literature review section.

a) Our work clearly verifies the role of personality traits. The role of motivation in starting such an endeavor or even persisting with the adaptive and at times lengthy process of opportunity recognition, creativity in recognizing new ideas, self-confidence and optimism in subjecting the ideas to scrutiny and finally zeroing on or stabilizing with an idea are all equally important in the process. At no point can the role of such personality traits be ignored in the opportunity recognition or entrepreneurship in general.
b) To be able to offer any product in the telecom domain it is required to understand how the telecom network works as well as a deep understanding of how the telecom market works. In fact the role of technical knowledge about hardware, software, protocols stacks, data transmission, and communication protocols is a prerequisite to be able to enter the telecom domain. So higher education and relevant industry experience play a primary role.
c) The entrepreneurs have access to information that is received and processed by them from varied sources such as mentors, professional acquaintances and friends, regulatory announcements, investors or potential investors, potential customers and also standard bodies. Regulatory changes and investor advice are particularly significant triggers for potential new products and services. Thus the sources of information act to reduce the information asymmetry among the entrepreneurs.
d) Presence of high stock of knowledge and relevant information cues together enable the entrepreneur to build mental models or schemas about how the communication needs will change in future and consequent requirements of the telecom market. The above process can be mapped as a cognitive learning process wherein the information from relevant sources is analyzed by the entrepreneur employing her existing stock of knowledge. The cognitive learning clearly plays a very prominent role in the ability of the entrepreneurs, active in the high tech industries in extrapolating their ideas to the future.

Discussion

Prior work on opportunity has attached significance to commercialization as well as process part of the evolution of an opportunity; however, methodologically the two have been dealt with only individually. In the present work we look at both the aspects simultaneously. This paper brings to light several insights for the advancement of both theory and practice.

From a theoretical perspective we invoke the concepts deep rooted in strategic management literature to explain the characteristics of opportunity that determine the evolution path followed in pursuit towards commercialization. The four characteristics that we discuss in the paper are questioning the existing norms to push the limits; knowledge based entry barrier; minimum dependence on incumbents, geared towards maximum scales and co-evolution. We have already discussed linkages between these characteristics and existing concepts in strategic management. A closer look further reveals that first characteristic conveys a notion of birth whereas others convey notion of sustenance. Within the entire process the role of entrepreneurial team and its cognitive prowess is fundamentally connected to the capabilities that start-up decides to develop. Within this evolutionary process the heuristics of entrepreneurial team and thereby decision making are primarily guided by the characteristics that we have identified. In other words the entrepreneurial mindset is constantly evaluating these above mentioned four characteristics without actually engaging in a formal process.

From a practitioner's point of view, this paper identifies markers that entrepreneurs, venture capitalists or policy makers could follow in order to understand the existing situation of a start-up and even predict which characteristic is not up to mark and needs to be worked upon to ensure commercial success. This could in many ways be utilized as a health check of for start-ups.

Although our context was telecom start-ups but the findings seem generic enough to be extrapolated to other high tech sectors as well. A better understanding of opportunity recognition processes and subsequent commercialization in such technology oriented sectors would have benefits in helping government develop and refine appropriate policies and support programmes that could go a long way in developing an ecosystem in for promoting technology entrepreneurship.

Future work could look into operationalizing and confirming the above mentioned findings in a statistically significant sample, however it will entail collecting time dependent data about the relevant variables. We also believe that more work needs to be done in developing an understanding about heuristics that play a role in decision making in the minds of entrepreneurs. Further, although borrowing theoretical constructs from different disciplines has enriched management education but an effort needs to be made to extend the existing concepts in more creative ways or else the field of management research could actually end up becoming a battleground of varied theories with focus getting lost on research that positively contributes to actual business on the ground. A converging view that links existing strategic management literature and borrowed theories is an urgent requirement for the field in today's context.

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Table-1 Details of Firms Under Study

(Under mentioned details capture the snapshot of firms at the time of data collection during 2008-09)

	Company Name						
Parameter	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**
Location	Bengaluru	Chennai	Mumbai	Bengaluru	Bengaluru	Chennai	Bengaluru
Birth Year	2005	2000	2002	2004	2002	2001	2007
Founders' education and prior experience	Both had Post graduate degrees in technology. Both were first generation entrepreneurs without any prior start-up experience. The founders worked for well-known telecom related companies which included exposure to both hardware as well as software.	Both had Post graduate degrees in management; one founder was also a graduate from (IIT[1]) Bombay. Both were first generation entrepreneurs without any prior start-up experience. One founder had prior experience working for well-known software MNC and	All founders possessed Post graduate degree or above in engineering from premier institutions. First founder was an experienced faculty member at IIT with years of consulting experience. Second founder was running a successful family owned business related to	Both had Post graduate degrees in management and graduation in technology. Both founding members were first generation entrepreneurs without any prior start-up experience. The founders worked in telecom software division for well-known software	Both founders were engineering graduates with 2-3 year experience in telecom division of Indian software MNC. Both were first generation entrepreneurs.	Both the founders were PhD in respective engineering disciplines from prestigious universities abroad apart from being IIT graduates. Both were engaged in teaching at one of the IIT, and were known for creating several successful start-up telecom and software	Founders were a group of seven engineering graduates with varied experience in software and telecom industry. All were first generation entrepreneurs although they had worked together in an earlier start-up related to telecom and networking.

[1] Indian Institute of Technology

		then for an Indian ISP in various capacities.	manufacturing CPE. The third co-founder had about 2 years of experience in software development.	companies and also worked for a telecom start-up in both technical and managerial positions prior to starting up.		companies. Both were first generation entrepreneurs.	
Technology	WiMax (wireless)	Voice over Internet Protocol (VoIP)	Circuit emulation over Ethernet	Bluetooth (wireless)	SMS-C and Assorted mobile VAS	Network management infrastructure	Voice recognition for mobile VAS
Area of operation	Equipment Development	Platform Development	Equipment Development	Platform Development	Platform Development	Platform Development	Platform Development
Product Novelty	Small base station using the chipset developed by Wavesat (semiconductor manufacturer) for their CPE[2]. The base station could be mounted on	Specific software to enable ISP/TSP[3] to offer VoIP services. The pivotal innovation was the development of soft	Working to develop a multi-service interface that could use the existing infrastructure but provide data, voice and video capabilities	Bluetooth based product to convert community centers into Bluetooth enabled zones for promotion and	Earliest SMS-C development for CDMA networks in India, also earliest Location Based Service developed	Comprehensive remote network management product for assessment and control of large networks including reporting tools	Replacing interactive voice response by pressing keys to verbal mode using voice recognition

[2] Customer Premises Equipment
[3] Internet Service Providers/ Telecom Service Providers

	a tower or house top for broadband access.	switch which de-coupled application server and front end.	with Ethernet at the core of the network.	advertising over existing mobile handsets.			
Hardware/software	Hardware intensive	Software intensive	Hardware intensive	Software intensive	Software intensive	Software intensive	Software intensive
Incubation	No	IIT Madras (TeNeT[4] group)	IIT Bombay (SINE[5])	No	No	IIT Madras (TeNeT group)	No
Venture Capital investment	No	Yes	Yes	Yes	Yes	Yes	Yes
Customers (all B2B) (Tech Vs Non tech)	ISP/TSP (Tech)	ISP/TSP (Tech)	ISP/TSP (Tech)	Community center, retail malls (Non tech)	ISP/TSP (Tech)	ISP/TSP (Tech)	ISP/TSP and other enterprises (Tech)
Patent Status (Granted/Pending/not Applied)	Yes (Pending)	Not Applied	Yes (Granted)	Yes (Pending)	Not Applied	Not Applied	Not Applied
Average employee strength	30	30	30	50	50	75	20
Success/Failed	Success	Success	Failed	Success	Success	Success	Success

[4] Telecommunications and Computer Networks Group
[5] Society for Innovation and Entrepreneurship