Disruptive Innovation and the Two Views of Entrepreneurial Opportunity

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Abstract--**In view of the importance of disruptive innovations (DI) in both emerging and advanced economies, a better understanding of opportunities for disruptive innovations is called for. We provide case study exemplars that illustrate how entrepreneurs have undertaken disruptive innovations for customers of low-end and new markets. These are innovations that have the potential to be disruptive but perceiving and acting on opportunities to innovate in this way is problematic. By extending research on the generation of entrepreneurial opportunities into the arena of disruptive innovations, the paper aims to contribute to understanding of both DI and the nature of opportunity generation and to provide a basis for guidance to practitioners.**

I. INTRODUCTION

Some innovations have the potential to disrupt the market for competing products and services while others sustain the competitive position of incumbent firms. A theory explaining the difference between these innovation types advanced by Christensen and Bower [9] has implications for theories of entrepreneurial opportunity detection and creation. An unexpected disruption occurs when incumbents are unprepared for the erosion of their markets by an innovation that was initially inferior in terms of the performance criteria preferred by mainstream customers but met the needs of other customers in new ways and improved over time to the point of satisfying mainstream customers [7]. A classic case was the unexpected erosion of the market for mainframe computers by the microcomputer in the 1980s. The commercial potential of the microcomputer was first recognized by hobbyists, then by the founders of Apple and only later by the incumbent, IBM which developed their PC in response to the threat from Apple [37]. Moreover whether or not incumbents are disrupted, the new market thus created may be so large as to motivate the creation of new businesses with growth aspirations [6][55]. From the perspective of opportunity recognition, new entrants do not have existing customers to consider and face lower opportunity costs than incumbents, who consequently view the opportunity in a different light. These issues are relevant to assessing changes in the emerging economies that are giving rise to potential new opportunities.

The rapid economic development of China, India, and other Asian countries, coupled with the fact that the majority of their populations cannot afford foreign products designed for the developed world, has made these emerging nations fertile ground for developing and testing innovations that are affordable and good-enough to meet consumers' basic needs at a relatively low cost. Innovators who set out to create such innovations may eventually threaten the higher-end, more costly version of these products, and in this sense they are potential disrupters. The mass markets of the "bottom of the pyramid (BOP)" income groups [45] have caught the attention of companies from around the world, including both local players and multinational companies. Developing disruptive products for such markets offers extensive opportunities for these companies to establish a strong foothold in emerging economies [28] [30]. The possibilities for reverse innovation—creating disruptive products that are initially targeted to emerging markets but can be taken global over time, reversing the usual progress of innovation from developed nations to emerging markets—are also attracting multinational corporations to emerging markets [26] [31].

Over the last decade the concept of disruptive innovation has been clarified as more cases have been examined in the literature [60]. In the past the theory was largely based on empirical evidence of cases that proved successful *ex post*. Christensen holds that the theory could also be used for *ex ante* prediction, citing four successful examples [5]. Scholars take different positions on possible applications of the theory of disruptive innovation [5] [10]. There has also been debate as to whether the theory of disruptive innovation can be used to predict if an early stage innovation might subsequently become disruptive. Research on R&D strategies aiming to create candidate technologies for disruptive applications at the fuzzy front end has also begun to attract scholars' attention [40] [61].

What these studies make clear is that entrepreneurs whose innovations turn out to be disruptive are actively engaged in discovering and creating opportunities. This makes it appropriate to look into literature on the entrepreneurial pursuit of opportunities to see if its themes can illuminate the pursuit of disruptive innovation. In view of the importance of disruptive innovations in both advanced and emerging economies, a better understanding of how the pursuit of opportunities can result in disruptive innovations is called for. We sought case study exemplars that illustrate the way entrepreneurs have engaged in innovations for low end customers and for new markets – innovations that have the potential to be disruptive - and the obstacles they faced in doing so. The cases are also a source of new evidence on the way entrepreneurial innovators have approached opportunities. By extending research on the nature of entrepreneurial opportunities into the arena of disruptive opportunities, this paper aims to contribute to understanding of both DI and the nature of such opportunities and to use this understanding to provide guidance to practitioners.

The paper is organized as follows. Following a review of literature on entrepreneurial opportunity, we explore the

relationship between DI and entrepreneurial opportunity. After describing the research design and methodology we present brief histories of four cases of disruptive innovation and discuss these cases. We conduct analysis for each case and a cross-case comparison by applying to the case evidence the summary framework offered by Alvarez and Barney [2] on differences between opportunity discovery and creation. We go on to examine the relevance of the findings to the literature and conclude with recommendations for practice.

II. LITERATURE REVIEW

A. Entrepreneurial opportunity

Entrepreneurial opportunity is defined in various ways in the entrepreneurship literature. When establishing the contours of entrepreneurship studies, Shane and Venkataraman [52] used Casson's definition of entrepreneurial opportunity, as " *those situations in which new goods, services, raw materials, and organizing methods can be introduced and sold at greater than their cost of production*" [52:p220]. In line with this definition, Eckhardt and Shane [15:p336] proposed that entrepreneurial opportunities are "*situations in which new goods, services, raw materials, markets and organizing methods can be introduced through the formation of new means, ends, or means-ends relationships*." These two definitions view entrepreneurial opportunity as an objective phenomenon resulting from information asymmetry that generates variation in subjective views and incentives among agents.

This approach assumes that market processes ensure that profit incentives automatically motivate action and does not specify the mechanisms through which opportunities come to be pursued and realized. In contrast Sarasvathy, Dew, Velamuri, and Venkataraman [51] point out that the pursuit of an entrepreneurial opportunity includes not only new ideas and inventions needed to achieve economic ends, but also the beliefs and actions that motivate and enable these ends to be realized. This view takes into account the way entrepreneurial perceptions and actions operate to turn a situation into an opportunity, often through persistent trial and error on the part of entrepreneurs, who may shift their goals or ends in order to make best use of the means at their disposal, a process Sarasvathy terms 'effectuation.' In essence, entrepreneurs following this process do not commit themselves to pre-existing goals or ends but instead use the means available to them in pursuing opportunities in a creative and flexible way [50].

B. Opportunity discovery vs. Opportunity creation

Sarasvathy, Dew, Velamuri, and Venkataraman [51] pointed out that: "*An opportunity presupposes actors for whom it is perceived as an opportunity; at the same time, the opportunity has no meaning unless the actor/s actually act upon the real world within which the opportunity eventually has to take shape.*" [51: p79]. In the literature on entrepreneurship, there is an ongoing debate on whether opportunities are discovered or created and how the two views can be reconciled and synthesized [56]. Among the contributions to this debate are: 1) the comparison of the ontology of the two views [2][22][34][42]; 2) reconciliation of the two views based on structuration theory [4] [49]; 3) a synthesized view of the ontology of the two concepts based on (i) the behavioral theory of the firm or (ii) an organizational learning framework [13][62]; and 4) the epistemology of the two concepts [1] [58].

There are numerous other contributions to the theory of opportunity discovery and creation in a very extensive literature (cf the compilation edited by Shepherd and Gregoire [53]). In this paper, we draw from the framework provided by Alvarez and Barney [2] that simplifies the ontological debate on the discovery and creation perspectives and explores implications of the distinction for practice. In setting out our research methodology below we explain why and how we draw on this account to analyse disruptive innovation. We summarise its main dimensions in what follows.

Alvarez and Barney [2] offer a way to operationalize constructs from the theory by identifying specific actions and strategies associated with each perspective. In particular they identify three dimensions of difference in the assumptions of the two theories: 1) the nature of opportunities; 2) the nature of entrepreneurs; and 3) the nature of the decision making context. They argued that the "*debates about whether an opportunity is a discovery or creation opportunity, by themselves, are without empirical content*." [2: p 205]. They believe that investigation of the implications of these theories for the kinds of entrepreneurial actions required in different settings are the most fruitful way to proceed. They discuss the implications of the two theories with respect to seven aspects of entrepreneurial action - in the areas of leadership, decision-making, human resource practice, strategy, finance, marketing, and sustaining competitive advantage. They summarize the assumptions implied in the theory of opportunity discovery by entrepreneurs as follows: opportunities occur in pre-existing markets and their identification relies on the entrepreneur's prior knowledge or experience. The context is subject to calculable risk and information is available for prediction and risk control, making it possible to anticipate skill requirements. Such information makes possible relatively complete and long-term strategies, the attraction of external funding and specification of the required marketing mix. However, once information about the opportunity is made public by the entrepreneur's actions, competitive imitation will soon follow. Hence to protect a new business the entrepreneur needs to achieve speed to market, maintain secrecy and erect other entry barriers.

In contrast, they summarize the assumptions embodied in the theory of opportunity creation as taking place where there is no pre-existing market inefficiency to be remedied. In their account, entrepreneurs rely on experience to detect a latent need and translate this into effective demand for their

innovation. They draw on their charisma to evoke trust. Unable to predict the future, these entrepreneurs make decisions on an iterative, inductive, and incremental basis and engage in emergent and flexible strategy making. They recruit general and flexible human capital, usually from their current social network, and raise funds informally. There is no pre-defined model of marketing; this emerges as part of the opportunity creation process. Finally, according to this account that competitive advantage is achieved by creating a unique business which is hard to imitate and hence can be sustained by tacit knowledge and path-dependent learning. Alvarez and Barney [2] provide detailed guidance as to what behaviours are involved in these aspects of the entrepreneurial process.

C. DI and Entrepreneurial opportunity

Disruptive innovation (DI) is defined as "*a process by which a product or service takes root initially in simple applications at the bottom of a market or in a new market, and then relentlessly moves 'up market', eventually displacing established competitors*"[1]. The concept implies that it is not simply a new product or service based on a specific technology that makes it a disruptive innovation. An innovation becomes disruptive when the opportunity on which it is based also involves certain demand conditions – whether from unmet needs of low-end market segments or from latent demand by un-served potential customers or from a potentially new market segment.

As the theory of DI was originally based on examples of innovations that turned out to be disruptive without having been conceived initially as such, the predictive power of the theory has been challenged [60]. That a certain technology has the potential to fill a market gap or create a new market does not guarantee that it will be disruptive. A number of researchers have put forward guidelines for identifying innovations with disruptive potential. Contributions on this theme include guidance on predicting future disruptions by identifying the drivers [43]; measures of disruptiveness which may be used to make *ex ante* predictions about the type of incumbent firms best positioned to develop disruptive innovations [20][24][48]; how an incumbent may identify a potential disruptive threat [46]; how industry change may stimulate disruptive innovations [8], and a criteria sheet for comparing the relative competitive advantages of incumbent and entrant firms [33]. Govindaraja and Kopalle [25] presented an extended framework for DI to include all innovations that offer new value propositions which are unattractive to the mainstream customers at the time of introduction due to inferior performance on the attributes that these customers value, but attractive to a different customer segment. These innovations establish their roots in the niche market and over time are improved to be good enough for the mainstream customers. Sainio and Puumalainen [48] proposed an alternative framework to evaluate the disruptiveness of a technology in a strategic corporate context in terms of five criteria: changes in product characteristics and added value; technology and market uncertainty; changes in product-market positions; possible competence disruption and changes in value network positions. Ganguly, Nilchiani, and Farr [20] also proposed metrics for evaluating disruptiveness of a technology in terms of target market segment; maturity level of the incumbent technology; rate of technology adoption and an expected utility metric for both the incumbent technology and the disruptive technology. Hang, Chen, and Yu [29] proposed a further assessment framework for disruptive innovation which looks at market positioning (market potential and possible competition); technology positioning (incumbents' possible performance overshoot and technology improvement potential), and other favorable drivers (including market potential based on ancillary features).

These measures and assessment tools for scouting out potential disruptive innovations point to the entrepreneurial process involved in opportunity discovery strategies and in opportunity creation strategies [2] [41]. The contexts for disruptive innovation are diverse, but fall into two main categories. Thus Christensen and Raynor [6] differentiates low-end DI in an existing market setting from DI for new markets; the latter represents a new context of consumption and competition (i.e. new value networks).

III. METHOD

A. Evidence

Case studies are widely regarded as appropriate to examining complex issues that are not yet well grounded in theory and on which there is still limited evidence and understanding [59], as is the situation regarding DIs for emerging and new markets. Multiple case studies provide a range of rich and comparable evidence useful for exploring new areas and complex processes where quantification may be premature or prone to distortion [32] [16][54]. Firms for case analysis were selected because they provide revealing instances of the phenomenon under study [17] [23]. We present four pertinent cases from a dataset of DI cases previously compiled and analysed by the authors [47] [61] [21]. These cases satisfy the definition of DI found in Christensen's work [6] [7]. Christensen's arguments point to criteria for identifying disruptive innovations: 1) The an innovation is disruptive when it has inferior performance on attributes that mainstream customers value at the time of product introduction, but 2) with new features appreciated by low-end or new/niche customers (typically cheaper, smaller, easier to use, etc); 3) its business model is "disruptive" rather than "sustaining" relative to all the significant incumbent firms in the industry [38] [39].

Qualitative evidence was obtained through both primary and secondary sources, covering different types of data, as recommended by Yin [59]. Initially, secondary sources were

[1] Source: http://www.claytonchristensen.com/key-concepts/ last accessed on Oct 30, 2013.

obtained from extensive archival research. Case histories based on these material informed semi-structured interviews with the company founders and senior managers together with scientists or engineers. This interview material provided a subjective account of developments, which was compared with the initial 'objective' case history obtained from documentary and other non-interview sources. Subsequently, our case histories were shared with and checked by the informants. The four firms selected for case studies are listed in Table 1.

B. Analysis

We began by collecting the evidence for each case from archival data and interviews [17] [59]. We organized this material chronologically to create case histories and summaries. We then sorted the material, using iterative abstraction to summarise key themes in the transcripts. Critics of formal coding methods object that these are reductionist and deprive the evidence of its individuality and variety [12] [19].

To avoid this danger, we retained links to the typed transcripts and checked these between summaries to ensure that these did not lose sight of subtleties raised by interviewees. Thus the first stage of analysis of the emerging economy cases involved surfacing key themes and issues presented to us by informants. The second stage involved identifying the DI elements of the cases by examining relevant evidence from the case documents and interviews. The third stage involved identifying whether attributes of the entrepreneurial process described by Alvarez and Barney [2] could be found in the case evidence. On this basis we highlighted evidence on the outlook of key actors, the actions taken and strategies pursued to make the opportunity realizable.

IV. SUMMARY CASE HISTORIES

A. Disruptive innovation for low-end of existing market

1. Suzlon

Suzlon's founder, Tulsi Tanti, moved into the wind power business because his business was threatened by the erratic power supplies and rising energy costs at his textile mill in Gujarat, India. Tanti decided to experiment with the provision of energy from wind power. In the early 1990s, there was no wind energy developer in India. Tanti assembled his own team of four engineers from his textile plant and arranged for them to visit the existing wind farms in India for a month. Thereby informed, they identified the vendors and equipment suppliers needed to build and install the first two wind turbines.

Tanti soon discovered that although the wind turbines could not provide the capacity of conventional power generators, they provided a reliable and cheaper source of energy. They were also environmentally friendly. Discovering this business potential from his observation of the existing energy market, he made the decision to exit his textile business and set up Suzlon Energy in 1995 with a modest capital of $600,000. Suzlon's strategy has been to capitalize on India's low manufacturing costs and provide end-to-end customized solutions at affordable prices to its Indian industrial clients. From the outset, Tanti aimed to build a vertically integrated business – integrating every process in-house (i.e. R&D, manufacturing, installation, service, etc.) - so that "*he could control the process better, gather feedback in a better way, and enjoy economy of scale better*", said his deputy general manager Mr. Ravi Krishnan. After an extensive search, Tanti identified one small German company, Suedwind, which was willing to sell its technology for $1 million. Suzlon obtained ten turbines from Suedwind's inventory, and assembled the turbines with the help of the German engineers alongside their own two turbines. When Suedwind was faced with closure in 1997 due to financial difficulties, Suzlon bought it, retaining its R&D center and turbine manufacturing facilities in Germany. Shortly after, Suzlon acquired a rotor-blade manufacturer in the Netherlands; the acquisitions broadened Suzlon's reach, bringing a product range that included wind turbine generators in capacities from 350 KW to 2.1 MW with

TABLE 1 CASE DIMENSIONS

Case	Luyuan	Suzlon	Tata Swach	ARM
Country	China	India	India	E.U.|
Founders	Ni Jie and Hu Jihong	Tulsi Tanti	Ratan Tata	12 engineers from Acorn Computers, Robin Saxby, Hermann Hauser
Year founded	1997	1995	2009[2]	1990
Disruptive innovation	Electric bike	Wind turbine and solutions	Water purifier	RISC Chip requiring low power
Interviews	3	4	3	8
Informants	Founders, CEO, CTO	Founder, Deputy general manager, Global head of brand and group corporate communications, Senior general manager	Head of operations, General manager of marketing, Senior engineer	Founders; CEO, Chief operating officer, Chief staff engineer and others

[2] This is the year when the Tata Swach project was launched in the Tata group, involving three subsidiaries: Tata Chemicals, Tata Consultancy, and Titan.

customized versions suitable for a variety of climates. In 2006, Suzlon acquired Hansen Transmission International – a world leading manufacturer of gearbox and drive trains for wind turbines. In 2007, Suzlon acquired Repower Systems AG, a technology leader of multi-megawatt wind turbines. Leveraging R&D capabilities in Europe and low cost manufacturing capabilities in Asia, Suzlon managed to bring down the cost of their wind turbines to 20% below their European competitors. Meanwhile, their installation time was shorter and maintenance cost was lower than their competitors'.

All along, Tanti had very clear vision for his company. He said : "*In Suzlon, we focus on bringing down the cost of power - lower than gas. Our R&D, business model (end-to-end solution), and strategy (vertical integration and scaling-up) are all for this purpose. We also focus on fast installation and reliable and good service*." Although Suzlon's products are not suitable for replacing conventional power generation in urban areas, they were welcomed by customers with large manufacturing or other operations in rural areas that had poor or costly access to conventional power supplies. By working closely with the customers and local government, Suzlon adapted its products and services to fit a variety of grid infrastructures and regional planning systems. Suzlon became India's major wind power provider and the world's fifth largest wind turbine manufacturer with a market share of 7.6%[3].

2. Tata Swach

The idea of Tata Swach came from a research result dating back to the 1980s, which showed that rice husk ashes (RHA) could remove visible particles in water. In 2005 this idea was used in the Sujaal water purifier -- one of Tata's corporate social responsibility projects during the tsunami rescue. Sujaal was an over-simplified model for emergency point-of-use water treatment which could not deal with the germs that can cause water-borne diseases.

In India water pollution was a major problem and fewer than 5% of urban families and 1% of rural families used water purifiers. In 2009, Ratan Tata decided to make a water purifier to sell at the price of Rs1,000 ($16) based on the Sujaal model. At that time a number of incumbents were exploring the low-end segment of the market. For example, Unilever had launched a chlorine based machine (PureIT) in 2004 and in 2008 it was sold at Rs2,000 ($32), but this was too expensive for the average Indian family and met with resistance in the market. Hence Ratan Tata's vision for Tata Swach, as described by Tata Swach general manager Ms Amrita Dey, was to "*make a mobile compact product, running without electricity or running water, no harmful chemicals in long run (e.g. no chlorine), and eliminating water-borne diseases. He wanted the product to have the lowest product price and lowest running cost, with performance meeting the international standard.*"

Tata Sujaal's unique rice husk ash material is a natural substitute for more commonly used water purification substances (i.e. carbon or silica). It is much cheaper and more readily available in India, which lowers the cost and increases the life of the purifier. But rice husk ashes (RHA) could not remove micro-organisms in the water as required to meet the international standard. Silver is known to be a micro-biocide, but regular use of silver is costly and damaging to health. It was decided that scientists in Tata Chemical would work on a nano-version of biocide-quality silver based on their existing technologies. By combining RHA with nano-silver, Tata's new product developers ultimately reached the necessary standards of purification. As their target customers were people who only store water for long enough to let the husks sink before use, the original idea was to sell the purification bulb itself and leave users to provide their own water container. But after a six-month market test, they found that people preferred a complete water purifier product over the component bulb. Accordingly they found a low cost substitute for the plastics needed to make the containers and assemble the products near to the market.

Tata Swach created a market segment for water purifiers at under Rs1, 000 ($16). In 2009 when it was first launched at the price of Rs899 ($15), there was no competition for the product. In the following years, every incumbent firm entered this segment. But thanks to its patented RHA and nano-silver technologies, Tata Swach remains the market leader.

B. Disruptive innovation for new or emerging markets

1. Luyuan

From the mid-90s, a few visionary Chinese companies started to build products needed by the growing urban Chinese population who faced increasing transport problems. Although companies like Yamaha had already released E-bikes in the Japanese market, they were too expensive for Chinese customers at that time. The founders of Luyuan, a company started in Zhejiang, China, reverse engineered an existing E-bike model and used the knowledge gained to build their first generation E-bikes, assembling motors, lead-acid batteries, battery chargers and controllers, in 1996. As most of the key components of the E-bike were available from suppliers in the market, Luyuan's assembled E-bikes were much cheaper than the Yamahas, although their performance was initially inferior. In other words, the E-bike in China took a modular design from its birth. Nevertheless, because of its affordability and ease of use, Luyuan's E-bikes gradually attracted a new demographic: active older customers -"*the people exercising in parks*", said Mr. Jie Ni, the CEO founder of the company - and young mothers who could use electric bikes to take their children to school. Based on this group of customers, Luyuan built its foothold in a new niche market. When several major cities started to ban motorcycles in the late 1990s, Luyuan, along with other early

[3] Source: http://www.suzlon.com/about_suzlon/l2.aspx?l1=1&l2=1, last accessed on Feb 20, 2013.

established E-bike manufacturers, were able to offer E-bikes to fill the market gap.

Luyuan's initial business model, which heavily relied on outsourcing the component manufacturing, was challenged in 1999 by a large-scale battery crisis, in which over 3000 batteries broke down just within 3 months (the life expectancy is normally 2~3 years). The reasons were both under-developed technologies and low quality production in the battery supply industry. This crisis made Jie Ni to realize the importance of advancing the key technologies and securing the supplies of the battery. He recalled all the problematic E-bikes and actively responded to the litigation undertaken by the supplier. As an academic entrepreneur, Jie Ni himself undertook the research in the battery related technologies. He published several articles in a well-regarded Chinese trade journal and presented his papers in annual meetings of battery associations. He actively sought R&D collaboration with battery manufacturers. He also initiated the setting up of the national standard for E-bike batteries that came into effect in 2001. Moreover, Luyuan took part in specifying the National Standards of General Technical Requirements of Electric Bicycles (National Standard GB1776 -1999), which was formally launched in 1999.

Accordingly, when R&D efforts resulted in key technology advances which significantly improved the E-bike performance (e.g. BLDC motor), Luyuan was among the first to embrace them. When SARS broke out in China in 2003 and many people wished to avoid public transportation, the whole E-bike industry expanded exponentially in China. Luyuan quickly expanded its manufacturing capacity and established its brand name in exclusively branded outlets and through high quality after sales service. In 2008, Luyuan diversified to gain further control over the battery by setting up its own battery company called Green Power. In 2009, Luyuan launched a new production base in Shandong, expanding the annual production capacity up to 1 million E-bikes. When the E-bike was banned in a few cities due to obsolete standard and unresolved regulation issues, Jie Ni participated in national debates and negotiated with the policy makers along with several other industry leaders. They successfully persuaded a few cities to lift the ban or loosen the regulations. When the urban market in the major cities was becoming saturated, Luyuan diversified their designs into models for specific applications such as the 3-wheel and 4-wheel E-bikes for older customers, patrol cars for police stations, tour buses, 2 or 3-wheel electric vehicles for goods distributions and after sales services, and foldable E-bikes for urban markets. Foldable bikes in particular were targeted at customers in advanced countries. More recently, they planned to establish motor production base, electric car production base and R&D center overseas. Luyuan continued to lead the industry, not only by means of its R&D capabilities but also through its lean production, nation-wide exclusive distribution system, and reliable after-sales service.

2. ARM

When Acorn Computers, based in Cambridge UK, aimed to improve the performance of their PC product by using 32 bit microprocessors, they were dissatisfied with those available on the market. They found that the Berkeley Reduced Instruction Set Computing (RISC) chip design could bypass many problems involved in standard chip design. Their developers decided to see if they could build a microprocessor using RISC technology. The only way they could make progress with the limited resources at their disposal was by keeping their innovation very simple. The Acorn RISC Machine (ARM) was a CPU of very small size, designed with few transistors and running on extremely low power consumption. The case study company, ARM, was a spin-out from Acorn Computers, for which Acorn's RISC technology provided a disruptive innovation.

In 1985 ARM, was formed as a joint venture between Apple Computers and Acorn Computers. Initially this was to develop a microprocessor for Apple Computer's Newton Notepad. When the Newton Notepad failed to gain market acceptance, the business model adopted for the new venture was significantly changed to licensing the intellectual property in their RISC chip (ARM Annual Report, 2005). Robin Saxby had been recruited as ARM's first CEO from Motorola, where he had acquired extensive marketing expertise. This was combined with the advanced technical skills of the 12 engineers who moved to ARM from Acorn's Advanced R&D department. Saxby proved to be a charismatic leader who encouraged his engineers to develop skills in sales and customer support.

Microprocessors which offered small size, lower cost and lower power consumption did not provide performance factors of interest in the PC sector. For this reason Intel, for example, did not pursue this market. But ARM recognized that there were new customers who needed these performance factors in the emerging mobile device sectors. But it was not enough to identify the opportunity, to activate a new range of opportunities in emerging areas a new business model was needed. While they had initially sub-contracted production of their chip design to VSLI, the team at ARM chose to change direction and began to offer design and customer support services to customers in a range of sectors including the still-emerging mobile device markets [21]. When a then relatively unknown Finnish company, Nokia, was seeking a CPU design for its mobile phone that would work reliably in the background, use minimum power, and be well supported with design tools, models and applications, ARM could readily meet its requirement. Building on this experience, ARM's processor was developed as a programmable tool for other customers developing Complex Systems on Chips. ARM could offer customers the capability to customize their designs for low power-consumption chips for highly integrated applications such as cell phones, personal digital assistants, information appliances and other embedded systems. This process was supported by the development of a distinctive IP centred business model. Expansion continued as the smart phone emerged: Apple Computer's iPhone was

powered by ARM chips. Their strategy enabled chips designed by ARM to become the de facto global standard in embedded devices, and it has remained so to this day in high volume applications in the wireless, consumer electronics and networking markets.

V. CASE DISCUSSION

A. Issues of special interest in a selected case

1. Suzlon

While the case of Suzlon case fits the category of opportunity discovery in most respects, the way in which Suzlon sustains its competitive strategy is distinctive. Our interviews with Suzlon's founder Tulsi Tanti, and other executives, revealed that there was no unique technology in the wind turbine industry and the very few incumbents had similar technologies, suppliers, and R&D activities. What distinguished Suzlon from competitors were its low price, rapid installation, cheap and reliable maintenance and reputation, most of which are based on tacit learning achieved over time together with its customers all over the world. The leadership style at Suzlon was partly based on expertise and experience and partly charismatic. For instance, Mr. Rajesh Dhrangadharia – the head of commissioning/global operations and one of the founding members of Suzlon, made clear that there were important technical achievements in Suzlon's turbines and extensive experience of turbine installation in various countries. Mr. Tulsi Tanti articulated a clear vision, commitment to building on Suzlon's competitive advantages, and insight on the future of the industry. Finally, we found that Suzlon's HR practices in the early days were not confined to specific human capital. Instead, they relied heavily on general and flexible human capital recruited from pre-existing social networks – the engineers from Tanti's textile factories. To sustain competitive advantage the entrepreneurial firm had to extend its innovative activities into the supply chain, eventually taking on a number of activities previously performed by suppliers, some of which were bought up by Suzlon, in order to control key supplies.

2. Tata Swach

The case of Tata Swach is a better fit with the entrepreneurial process involved in opportunity discovery than creation. The huge untapped market in India for low-end water purification devices was an obvious opportunity to many companies, mostly incumbents. What distinguished Tata Swach from its competitors was the determination of its visionary leader Ratan Tata to make the device ultra cheap in terms of both price and running cost. Ratan Tata's leadership was not only charismatic but also based on his successful experiences in other businesses. From our interviews with several members of the founding team at Tata Swach we found that they had carefully investigated the existing products in the market and also collected information to estimate the potential market. The team was assembled under the direct leadership of Ratan Tata and it engaged specific R&D and marketing talents from three Tata subsidiaries -- Tata consultancy, Titan, and Tata Chemical.

The innovation was based on their earlier research result – using RHA in their initial Sujaal water purifier. The R&D team leveraged the existing technologies and capabilities in Tata Chemical to raise the purification performance level. The strategy and the marketing mix (the product, price, distribution, promotion, and customer service) were almost all fixed from the beginning, although they did change the product from a purification bulb to a full-fledged device (including the water containers) after the initial market test. To sustain its competitive advantage, Tata Swach patented all the major technologies, including 4 patents for nano-silver and 16 design patent registrations. Furthermore, through their R&D and marketing processes, the team accumulated knowledge about the customers' needs, the distribution channels, and the characteristics of each specific geographic region (e.g. the quality of water varies across different regions). This tacit knowledge also protected Tata Swach in the subsequent competition with the other incumbents.

3. Luyuan

Luyuan in many respects represents a case of opportunity creation. In the mid-1990s, there was hardly any market demand for E-bike in China. Relying on their knowledge and experience, Luyuan's founder and CEO Jie Ni and his wife Jihong Hu - also the CTO of the company, envisioned that E-bike would become a major transport solution for rapidly urbanizing Chinese regions. Although there was little information on the basis of which to predict the future, they moved into this highly uncertain business and pioneered early R&D and marketing efforts in the industry.

At first, they bought most of their components in the market, assembled their E-bikes, and tried to sell them to retired people. Later on, when the key technologies of the industry matured, they started to integrate the R&D and manufacture of the battery with their business activities and participated in the formulation and enactment of the national standards of E-bike and battery. When the E-bike was banned in a few cities, increasing the uncertainty of this business, Jie Ni undertook interactions with policy makers and successfully persuaded a few to accommodate this new vehicle in their cities. When the E-bike industry boomed during and after the SARS period, Luyuan quickly adjusted its strategy to focus on brand building, distribution channel, and after sales service. This helped Luyuan to survive in this industry at the time when there were low entry barriers and thousands of small and medium sized follower-entrants. Once Luyuan was established as one of the leading incumbents, they focused on establishing their R&D capabilities in battery and other key technologies.

As markets became more competitive they diversified into a range of related specialist products for niche markets. The marketing mix – the product, price, distribution, promotion, and customer service were all part of this changing process, in which they created and adjusted their business model by

trial and error. Their vision for electric vehicles, their persistent pursuit of their vision, and their knowledge and R&D capabilities made them both charismatic leaders and industry experts. Finally, we found that Luyuan used accumulated tacit knowledge in a path dependent process to protect their competitive advantage. This knowledge was based on their years of R&D effort on battery technology for the E-bike battery, experience and feedbacks inform their after sales service, and lean production methods. In all these respects the attributes of the company align with the context of opportunity creation, but in contrast with the predictions of the opportunity creation concept regarding the way entrepreneurs become distinctive ex post, we found that the founders of Luyuan were distinctive in their outlook from the outset.

4. ARM

At ARM, opportunities were recognized largely as a result of the company's special expertise in RISC chip technology which was well suited to emerging mobile devices. However to make it possible for the venture to realize opportunities it was necessary to undertaken a change of strategy, since the initial business model proved unviable. The decision making context was highly uncertain and the leadership style charismatic. The 12 engineers who helped to found ARM were specialists, but they became generalists by learning sales skills, while the CEO, Saxby, was a generalist. They pursued a very economical business model to reduce reliance on venture capital and rapidly became revenue earning as they altered their market focus in response to the opportunities they were creating on the basis of their specialist knowledge. Thus they did not rely on informal funding sources, nor did they have recourse to venture capital; instead they bootstrapped the company by generating early revenues, made possible by their status as a spin out from a company Acorn Computers) where the technology had already been proven and they had secured customers. This prior knowledge of RISC technology facilitated a creative switch in business model. "*We had to find ways to turn our enemies into friends*", we were told by the CEO of ARM, Robin Saxby. They found a means to avoid engaging in direct competition with better-resourced CPU producers. They did this by providing design and support services to potential competitors and their customers. They sustained their competitive advantage both through their special expertise and unique customer relations and also because their IP was protected by powerful customers who did not want to see infringement of the licenses they had paid for.

B. Cross-case analysis

The case comparison takes the form of applying the template offered by Alvarez and Barney [2] to the case evidence in Tables 2 and 3. Findings on attributes of entrepreneurial behavior related to Opportunity Discovery are summarized in Table 2 where we tally attributes that are aligned (✓), strongly aligned (✓✓) and not aligned (×) with those expected from the framework derived from Alvarez and Barney (2007). Where the evidence did not allow judgment, no tally is made. Suzlon and Tata Swach had innovations for low end existing markets. These cases present twelve instances of alignment in terms of features expected in relation to opportunity discovery attributes. In one instance, their features are not aligned with those expected from the framework applied. In the case of Luyuan and ARM, which had innovations for new markets, there are six instances of alignment with expected features of Opportunity Discovery but seven instances of non-alignment. Thus the cases targeting low end markets show features closer to those expected for opportunity discovery than do the cases targeting new and emerging markets for innovations.

Table 3 summarizes whether attributes associated with Opportunity Creation are found in the case study firms. In the case of Suzlon and Tata Swach, targeting the low end of existing markets, the tally of attributes aligned with those expected for opportunity creation (6) is lower than for those attributes that are not aligned (7). However in the case of the firms targeting new and emerging markets, Luyuan and ARM, the tally shows twelve aligned attributes and none that are non-aligned. Thus the cases targeting new markets show features closer to those expected for opportunity creation than do the cases targeting low-end markets.

VI. DISCUSSION AND CONCLUSIONS

A. Implications of our findings for understanding DI

On the basis of the above analysis we propose that the cases of low-end DI align with the context for "opportunity discovery" whereas DIs for new markets align with the context for "opportunity creation" as specified by Alvarez and Barney [2]. DI that targets the low-end market segment is predicated on the existence of the unmet needs of a certain group of customers, independent of the actions of entrepreneurs, albeit only those who have either technical expertise or industry experience in the field are able to detect unmet needs of this kind.

The risks associated with such contexts are relatively predictable and can be measured and calculated on the basis of market research. On the other hand, for new markets, disruptive innovation involves opportunities which depend on making potential customers realize that they have needs of which they may not have been aware. Entrepreneurs who attempt to provide innovations for as yet unexplored markets need to be prepared to shift their goals (i.e. ends) as relevant knowledge arises, using such means as are at their disposal - that is they have to effectuate [50] and make creative use of resources [3]. Since the latent needs of customers are unknown even to themselves and thus unpredictable ex ante, the uncertainty level involved in exploiting such DIs is high.

We find that entrepreneurs who undertake what become disruptive innovations for new and emerging markets have to conceptualize the way they might be able to fulfill unmet needs. Rather than recognize and remedy a specific market

TABLE 2 OPPORTUNITY DISCOVERY IN DI CASES

	Low-end DI		New market DI		
FEATURES OF OPPORTUNITY DISCOVERY	Suzlon	Tata Swach	Luyuan	ARM	**Total***
1. Leadership (Based on expertise and experience)	✓	✓	✓	✓✓	6✓0×
2. Decision making (Risk-based data collection tools)	✓	✓	×	×	2✓4×
3. HR practices (Specific human capital recruited broadly)	✓	✓	-	✓	5✓0×
4. Strategy (Relatively complete and unchanging)	✓✓	✓✓	×	×	3✓3×
5. Finance (External capital sources: banks and venture capital firms)	✓✓	-	×	×	3✓2×
6. Marketing (New opportunities may be manifest in changing marketing mix)	✓✓	✓✓	×	✓	4✓2×
7. Sustaining competitive advantage (Speed, secrecy, and erecting barriers to entry may sustain advantages)	×	✓✓	✓	✓	5✓1×
Total*	6✓1×	6✓0×	2✓4×	4✓3×	29✓10×

TABLE 3 OPPORTUNITY CREATION IN DI CASES

	Low-end DI		New market DI		
FEATURES OF OPPORTUNITY CREATION	Suzlon	Tata Swach	Luyuan	ARM	**Total***
1. Leadership (Based on charisma)	✓	✓	✓	✓	5✓0×
2. Decision making (Iterative, inductive, incremental decision making; use of biases and heuristics; importance of affordable loss)	×	×	✓	✓✓	4✓2×
3. HR practices (General and flexible human capital recruited from pre-existing social networks)	✓	×	-	✓	3✓2×
4. Strategy (Emergent and changing)	×	✓	✓✓	✓✓	4✓2×
5. Finance ("Bootstrapping" and/or "friends, family and fools")	×	-	✓	✓	1✓3×
6. Marketing (Marketing mix may fundamentally change as a result of new opportunities that emerge)	×	×	✓✓	✓	4✓2×
7. Sustaining competitive advantage (Tacit learning in path dependent process may sustain advantages)	✓✓	✓✓	✓✓	✓✓	6✓0×
Total*	3✓4×	3✓3×	6✓0×	7✓0×	28✓11×

* In the tally of alignment shown in this table, the positive tally is counted only once to obtain either an aligned or non-aligned score.

TABLE 4 TYPES OF DI ASSOCIATED WITH OPPORTUNITY DISCOVERY AND CREATION

	Low-end DI (Discovery Context)	New market DI (Creation Context)
Nature of Opportunities	Opportunities exist in the low-end under-served market segment.	Opportunities lie in the latent market where the needs of the customers are to be stimulated.
Nature of Entrepreneurs	People with technical expertise or industry experience	People who experiment, shift goals if necessary and are prepared to change strategic direction.
Nature of Decision Making	Risks are more or less measurable and calculable, ex ante.	The potential for a new market is uncertain.

failure in the provision of goods or services, for example to an identifiable market segment, they may have to hypothesize as to what kind of offering is appropriate (what end to pursue) and how to pursue it, engaging in an experimental process that calls for improvisation in response to unexpected constraints. Moreover continuous improvement of the product or service is required if the innovation is to become disruptive. We find analogies between DI conceived in this way and Sarasvathy's approach to the process of effectuation, in that entrepreneurs attempting DI are addressing the ends, the means, and the entrepreneurial actions involved in the entrepreneurial process.

In these cases of more or less deliberate attempts to produce a disruptive innovation, evidence led us to categorize low-end DI, as exemplified by the cases of Suzlon and Tata Swach, as an opportunity discovery context, while new market DI as exemplified by the case of ARM represents an opportunity creation context. In sum, our evidence shows that entrepreneurial activities associated with opportunity discovery were more common in the low-end DI while those activities associated with opportunity creation were seen to be required in new market contexts.

However the two contexts are not completely distinctive; there is overlap where companies that can be classed as predominantly engaged in opportunity creation nevertheless had features aligned with certain attributes of discovery. For example companies starting from opportunity discovery, Suzlon and Tata Swach, had charismatic entrepreneurs who

were proactive in creating conditions conducive to their innovations. At ARM prior knowledge enabled the engineers to detect opportunities for RISC technology, but they had to be creative in devising an innovative business model to realize and sustain this opportunity.

B. Implications of our findings for understanding entrepreneurial opportunities

Our evidence confirms that the existence of an opportunity does not simply depend on ability to supply a new technology and fill a demand gap in the market. The innovator's outlook and actions are also critical. The practical implications of the two perspectives on opportunity (discovery vs. creation) are important because they reveal, both for theory and practice, what actions and strategies are likely to be effective. From the perspective of practice, the cases point to the need to prioritize different types of actions for different types of DI.

We show that strategies associated with opportunity discovery were more intensively used in the cases of low-end DI while actions and strategies associated with opportunity creation are more frequently used in the cases of new market DI. Since entrepreneurial outlook is critical for opportunity creation, the characteristics and the training of people who can discover or create DI is no less important than their technology and business model, as was proposed by Dyer Gregersen, and Christensen [14] when they put forward the idea of "innovators' DNA". The potential benefits of training that can raise awareness of opportunities for commercialization of research and technology that can meet unmet needs is a practical implication of this finding.

However, features of both sets of strategies are found in all cases, as shown by the non-aligned scores in the tally. This suggests that entrepreneurs would be better positioned if they remain open to deploying processes associated with both discovery and creation of opportunities in order to launch disruptive innovations [13] [62].

C. Implications of the DI cases for understanding entrepreneurial opportunity

In summary, we propose that opportunity creation is critical if a DI is to be produced for new markets while discovery of unmet needs is of particular importance for DIs serving lower end customers in existing markets. Nevertheless, we find that entrepreneurs used both opportunity discovery and opportunity creation approaches in the development and commercialization process of these DIs.

There are features of these cases that show further how opportunities can be discovered for disruptive innovation. Two of the technologies started by solving problems internal to the company that initiated the innovation: Acorn computers needed a 32 bit microprocessor that they could not obtain at an affordable price on the market, while Suzlon had direct experience of inadequate conventional power supplies and recognized the opportunity to sell the solution they had devised for themselves to other companies. In doing so they realized that their offering might not meet the expectations of mainstream customers in existing markets, but that their alternative could prove attractive to a new set of customers in different markets. If a technology can meet the innovator's own needs in new ways, there may be other customers who would be attracted to this innovation. Disruptive innovations that address widespread basic needs will open up larger markets than those targeted at special needs in niche markets, though the latter can provide a bridgehead to the former [11].

The innovators were all enabled to create further opportunities beyond those they originally discovered by adopting frugal business models that released resources for scaling up. In the case of Suzlon this involved vertical integration while in the case of ARM (facing higher labour costs than Suzlon) the frugal business model involved licensing the technology, providing design and customer support services and avoiding production costs. Tata Swach leveraged resources and capabilities from other parts of the Tata conglomerate, made use of the waste (i.e.RHA) and other cheap substitute for the water container, and set up assembly factories near the market to meet the low cost target set by their leader in the beginning. Luyuan began with a business model based on bought-in components, so keeping down their up-front capital costs, but were able to use growing revenues to adapt their business model and engage in enough vertical integration to exert more control over their supplies.

Some of these frugal innovations have begun to make their ways back to the advanced market [26] [31]. For example, Suzlon started its overseas market in the US in 2003 and now is the fifth largest wind turbine providers in the world. Luyuan and many other leading E-bike companies in China have started to advance into the electric-3 or 4-wheeler vehicle sectors. Given time, these frugal electric vehicle (EV) models have the potential to erode the market of the sophisticated electric vehicle models made in the billion-dollar R&D labs of the leading automobile companies.

An important set of actions for realizing the opportunities detected by these innovators involved building relations with participants in their supply chain. This was a key part of the opportunity creation process for all four cases. These external relations involved a wider ecosystem where, as in the case of Luyuan and ARM, the innovators played an active part in setting relevant regulations, requiring good relations with regulators. A distinction between the innovators targeting low-end markets and those targeting new or emerging markets was that the former could enter an existing ecosystem. Those offering innovations for lower end markets became players in the existing supply chain, gradually taking control of key supply activities (Suzlon) and in the case of Tata Swach, extending their activities to encompass all the constituent activities (nano-tech purification; container production) required for the innovation. This was how they improved the performance of their product to reach international standards, with the consequence that they could

subsequently compete with incumbents in mainstream markets.

Those innovating for new and emerging markets also had to ensure that their innovative activities extended out into their supply chain. Thus Luyuan was faced with a crisis resulting from deficiencies in their key component, the E-bikes' batteries. To address this crisis they strove to raise the standard of their suppliers' products, engaged in relationships with regulators to help influence standards of safety and reliability, and eventually took on battery R&D and production themselves. In the case of ARM, relations with the OEM customers were critical to expanding the range of markets and of devices that adopted their chip design. Thus ARM sought to extend their innovation into the supply chain by a different route from that taken by Suzlon and Luyuan; they devised a business model that involved disintermediation rather than vertical integration. Instead of selling a product, they offered design and manufacturing support services to their customers and their customers' customers. Thus those innovators aiming at new or emerging markets had to create an ecosystem in which they could function effectively.

In applying a well attested distinction between activities involved in discovering and creating opportunities to evidence from our case studies, we found that the distinction is a robust one, as shown in our tallied results in Tables 2 and 3. Nevertheless, the entrepreneurial innovators engaged in behaviours that overlap both perspectives on opportunity. The distinction aligns with differences between DIs for the low end of existing markets, on the one hand, and DIs for new or emerging markets on the other. It also reveals further distinctions between the two target markets for DIs, in that innovators can enter existing ecosystems in low end markets but must create new ecosystems in new markets. However in both types of market, entrepreneurs and their enterprises need to secure their position in their ecosystem as critical feature of creating opportunities. This is an important issue that bridges studies on how individual entrepreneurs discover and create opportunities and studies on the collective creation of opportunities.

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