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Antecedents and Implications of Disruptive Innovation: Evidence from China

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Abstract: A growing recognition of the importance of disruptive innovation has led researchers to examine the question of how disruptive innovation comes about and to what extent it reflects "discovery" versus "creation" of opportunities. Earlier research has focused on the organisational preconditions for disruptive innovation to arise. Much less attention has been paid to the role of innovation processes, including their goals and design, in promoting disruptive innovation. In this paper we aim to begin to fill this gap by better understanding how new innovation processes can act as antecedents for disruptive innovation.

We adopt an inductive theory-building methodology using a set of case studies of Chinese firms to develop propositions about how novel R&D and production processes can foster disruptive innovation. We find that in the case of China the adoption of new innovation processes that re-define the focus of innovation and re-engineer traditional R&D processes in ways that allow the novel deployment of Chinese cost advantages can create offerings that incorporate the key elements of disruptive innovation in the sense that they challenge incumbents' established business models. Realising disruptive innovation opportunities requires proactive initiatives. We conclude by discussing the managerial implications and possible responses as well as directions for future research.

Ms. Ref. No.: TECHNOVATION-D-13-00110R4

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Response to Technovation Editor's comments:

(1) 14 cases and 35 interviews - why these specific numbers - presumably some of it is convenience, but I imagine triangulation, saturation, coverage of a range of industries and other factors also played a part. Could you add a few lines on this.

Agreed. The following explanation has been added (Page 11):

"We relied on several data sources: observations, interviews, and archival data such as internal documents, annual reports, websites, and news articles in order to triangulate the data and so improve the accuracy of the picture emerging (Jick, 1979). We aimed to analyse a sufficient number of case studies and range of industries to be fairly confident that the results had some general applicability while limiting the sample so as to enable in-depth interviews within a tractable timescale. Based on these considerations we targeted completion of 12-15 case studies. By the end of the research programme we were successful in conducting two rounds of interviews across 14 companies (detailed in Table 1). The first round of interviews was conducted between March 2010 and January 2011 and a second round between June 2011 and September 2011. The second round of interviews complemented the first by asking follow-up and clarification questions. In some cases were we were able to secure interviews with multiple individuals; here we tried to gain perspectives from employees drawn from different levels in the corporate hierarchy or multiple business units, making a total of 35 semi-structured interviews."

(2) The seminal reference for Disruptive is Research Policy paper by Abernathy and Clark. Could you please give them the credit that is due. I fear that Christensen's work is a bit overstressed and they have been left out completely.

Agreed. The following has been revised (Page 1):

"Disruptive innovation theory has long been studied in the innovation management literature (Abernathy & Clark, 1985; Adner, 2002, 2006; Calia, Guerrini, & Moura, 2007; Christensen, 2006; Christensen & Bower, 1996; Christensen & Raynor, 2003; Danneels, 2004; Govindarajan & Kopalle, 2006; Hall, Matos, & Martin, 2014; Kassicieh, Kirchhoff, Walsh, & McWhorter, 2002; Linton, 2002, 2004, 2009). The concept goes back at least to the seminal work by Abernathy and Clark (1985), who suggested that disruptive innovations often destroyed the value of existing technical competencies. This idea was elaborated by Christensen (1997), again with a focus on technological innovation."

The following paper has also been added to the reference list:

Abernathy, W., & Clark, K. B. 1985. Innovation: Mapping the winds of creative destruction. ***Research Policy***, 14(1): 3-22.

(3) Further development of managerial implications could add to your paper. If you think about this for 15 minutes, I believe you will agree with me. It is likely to really strengthen your papers impact in the future.

Agreed. The following implications have been added (Page 27-29):

"Our findings also have a number of managerial implications. First, they underline the need for managers need to be alert to the fact that disruptive innovation can stem from a much broader set of sources than breakthrough technologies alone. In particular, some of the innovations that are potentially most disruptive to incumbents with legacy products, processes and assets have their antecedents in new processes for R&D, product design and production as well as in market conditions that encourage and facilitate the development of innovative business models. This argues for taking a broad view of where the opportunities and threats from disruptive innovation may emanate. It also suggests that when considering how resource allocation and organisation structure, culture, and incentives can be adjusted to increase the likelihood of successful disruptive innovation arising, managers need to assess how these variables influence broad spectrum of types of innovation, not just traditional R&D activities.

Second, our results suggest that there is a growing possibility that disruptive innovations will arise in emerging markets such as China. Emerging markets appear to provide a particularly fertile environment both for opportunities for disruptive innovation to arise and for this potential to be realised by proactive entrepreneurs. In part, this reflects that fact that innovative product designs and business models that offer a step-change improvement in value for money are required to unlock latent mass-market demand in these economies. It also reflects the need for innovation in R&D, design and production processes in order to benefit from local factor conditions such as the availability of low-cost, but less skilled labour, less legacy assets, and the presence of many first-time consumers with a desire for experimentation. Moreover, as global market growth is increasingly driven by consumers located in developing economies and the "value-for-money" segments in developed economies, this means that, perhaps somewhat surprisingly, incumbents in the developed world may need to look to emerging economies such as China to find some of the keys to delivering the kinds of innovation that will allow their companies to thrive and prosper in the next round of global competition. In response, managers will need to find better ways to tap into the antecedents of disruptive innovation in emerging economies such as China. This will probably require that R&D units in emerging markets be tasked with seeking out opportunities for disruptive innovation and realising them locally, rather than focusing on limited adaptation of imported product designs. An alternative approach may be to develop alliances with emerging market players in order to tap into local know-how and a conducive environment for disruptive innovation. This last approach might be particularly attractive to small- and medium-sized foreign companies that face financial,

regulatory and knowledge barriers to commercialising potentially disruptive innovations at home.

Third, our results suggest that incumbent firms exposed to disruptive innovation may need to re-engineer their existing R&D and innovation approaches to create new processes. This would involve adopting process changes such as industrialising R&D, pushing the boundaries of parallel processing, modularising product development and pragmatic and rapid decision making in the innovation cycle described in this paper. Even when these can run effectively in parallel with established procedures, however, the barrier to unlearning existing approaches to innovation may need to be overcome to achieve this kind of change."

(4) A lazy reader who is in a hurry could think that this paper is about China. The message also relates to other economies - can you make this clear - what types of economies are like this and why? (For example are African firms use of mobile telephony another example of this?)

Agreed. To make this clearer we have changed the title to:

"Antecedents and Implications of Disruptive Innovation: Evidence from China"

The following explanation has been added (Page 2):

"At the same time, a growing body of evidence suggests that emerging economies are becoming an important source of disruptive innovation (Hart & Christensen, 2002; Li, 2013). Emerging market environments can stimulate disruptive innovation because changes to product design and business models that drastically lower costs and improve value for money are often a prerequisite for unlocking mass-market segments of customers with limited disposable income in these economies. Large numbers of first-time consumers with less established preferences and expectations, less regulation, and fewer legacy assets may also mean it is possible to launch, test and improve disruptive innovations more rapidly and cheaply than in developed markets (Williamson, Ramamurti, Fleury & Fleury, 2013). These conditions have given rise to successful disruptive innovations such as the India company Bharti Airtel's disruptive business model for mobile telecommunications incorporating innovative marketing, pricing and billing systems specially adapted to appeal to low-income consumers that allowed the company to revolutionise market in 20 countries across Africa and Asia. Likewise Brazil has been a leading source of disruptive innovation in sustainable biofuels using flexible-fuel vehicles that now accounts for some 35% of the total Brazilian transport fuel market and has begun to be applied in Africa and Asia (Angelo, 2012).

Arguably the predominate source of disruptive innovations among emerging markets, however, has been China where examples span a wide variety of industries from medical diagnostic equipment and lithium-ion batteries through to innovative business models for e-commerce and social media portals (Williamson & Yin, 2013). With the aim of better understanding how new R&D and production process innovations can act as antecedents for disruptive innovation in this paper, therefore, we have chosen to analyse a set of case

studies of Chinese firms pursuing potentially disruptive innovation and then to explore some of the implications of these innovations for incumbent competitors from the developed markets."

(5) You offer a table with some examples of the case studies. As you only have 14 cases (a manageable number), it would be nice if you could add the rest of the cases to the table. This may take a page of journal text, but is worth it.

Agreed. Table 1 has been revised to list the 14 case studies as follows:

Table 1: Case Studies of Disruptive Innovation from China

R&D and production process innovations	Disruptive Impact	Case firms	Results
Industrialising the R&D process	Providing adequate functionality, rapid installation, higher levels of customization, sooner than incumbents and at lower prices.	Huawei	(1) Founded in 1987 as a distributor of imported telecoms products (2) Now the largest telecommunications equipment maker in the world
		Wuxi AppTech	(1) Founded in 2000 (2) One of the largest open-platforms for pharmaceutical R&D
		Yichen JCG Science & Technology Dev. Co	(1) Founded 1995 (2) Networking (Ethernet and wireless) product manufacturer
		Guangdong Cranes Corp.	(1) Founded in 1961 (2) Major manufacturer of cranes and port machinery
Parallel processing in R&D	Reducing the total time and cost required to develop a product that offers greater value for money to consumers.	Lenovo	(1) Founded in 1984 as a reseller, distributor for foreign brands (2) Now the world's second-largest personal computer vendor by unit sales
		Pearl River	(1) Founded in 1956 (2) Now the world's largest piano maker
		Mindray	(1) Founded in 1991 (2) A leading developer and manufacturer of medical devices worldwide
Modularising product development	Reducing the total time and cost required to develop a product that offers greater value for money to consumers by speeding up the rate at which multiple aspects of the product can be improved.	Tianyu	(1) Both started as an OEM or a distributor channel for leading brands (2) Shanzhai products by these and other firms are ranked second in the Chinese mobile phone sector with 16.1% market share in 2012
		Jinli Group	
		SIM Technology	(1) Listed on the Hong Kong

		Group	Stock Exchange in 2005 (2) Leading mobile communication and "Internet of Things" developer in China
		Tencent	(1) Founded 1998 (2) China's leading social media and Internet portal
		Broad Group	(1) Founded 1988 (2) Designer and manufacturer of non-electric air conditioning systems and modular, sustainable buildings with installations in over 80 countries
Pragmatic decision making in the R&D process	Reducing the total time and cost required to develop a product that offers greater value for money to consumers by facilitating the development and implementation of cost, application and business model innovation.	Tianyu Jinli Group	(1) Both started as an OEM or a distributor channel for leading brands (2) Shanzhai products by these and other firms now ranked second in the Chinese mobile phone sector with 16.1% market share in 2012
		Wide Industrial Group	(1) Founded in 1997 (2) Research, design and manufacture of commercial air conditioning
		Alibaba Group	(1) Founded 1999 (2) China's largest e-commerce company

Thank you again for your helpful suggestions. We hope these revisions have substantively addressed them.

*Title page with author details

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INTRODUCTION

Disruptive innovation theory has long been studied in the innovation management literature (Abernathy & Clark, 1985; Adner, 2002, 2006; Calia, Guerrini, & Moura, 2007; Christensen, 2006; Christensen & Bower, 1996; Christensen & Raynor, 2003; Danneels, 2004; Govindarajan & Kopalle, 2006; Hall, Matos, & Martin, 2014; Kassicieh, Kirchhoff, Walsh, & McWhorter, 2002; Linton, 2002, 2004, 2009). The concept goes back at least to the seminal work by Abernathy and Clark (1985), who suggested that disruptive innovations often destroyed the value of existing technical competencies. This idea was elaborated by Christensen (1997), again with a focus on technological innovation. Over years, the concept of disruptive innovation widened to include not only technologies but also products and business models (Christensen, 2006; Christensen & Raynor, 2003; Markides, 2006, 2012). For example, Christensen and Raynor (2003) suggest that disruptive innovations include discount department stores; low-price, point-to-point airlines; cheap, mass-market products such as power tools, copiers, and motorcycles; and online businesses such as bookselling, education, brokerage, and travel agents.

The growing recognition of disruptive innovation as an important phenomenon in competitive strategy has led researchers to examine the question of how disruptive innovation comes about. A substantial body of literature has explored the conditions under which disruptive innovation is likely to arise from an organisation, including its resource allocation processes (Chao & Kavadias, 2007; Hogan, 2005; Nelson & Winter, 1982); its organisational structure (Cohen & Klepper, 1996; Lee & Chen, 2009; Tsai & Wang, 2005); and its organisational culture (Henderson, 2006; Tushman & O'Reilly, 2002). Despite the progress, the nature of the innovation processes that enable disruptive innovation deserves further

examination (Yu & Hang, 2010). In particular, our understanding of what kinds of R&D and opportunity discovery and creation processes are likely to give rise to disruptive innovation is limited.

At the same time, a growing body of evidence suggests that emerging economies are becoming an important source of disruptive innovation (Hart & Christensen, 2002; Li, 2013). Emerging market environments can stimulate disruptive innovation because changes to product design and business models that drastically lower costs and improve value for money are often a prerequisite for unlocking mass-market segments of customers with limited disposable income in these economies. Large numbers of first-time consumers with less established preferences and expectations, less regulation, and fewer legacy assets may also mean it is possible to launch, test and improve disruptive innovations more rapidly and cheaply than in developed markets (Williamson, Ramamurti, Fleury & Fleury, 2013). These conditions have given rise to successful disruptive innovations such as the India company Bharti Airtel's disruptive business model for mobile telecommunications incorporating innovative marketing, pricing and billing systems specially adapted to appeal to low-income consumers that allowed the company to revolutionise market in 20 countries across Africa and Asia. Likewise Brazil has been a leading source of disruptive innovation in sustainable biofuels using flexible-fuel vehicles that now accounts for some 35% of the total Brazilian transport fuel market and has begun to be applied in Africa and Asia (Angelo, 2012).

Arguably the predominate source of disruptive innovations among emerging markets, however, has been China where examples span a wide variety of industries from medical diagnostic equipment and lithium-ion batteries through to innovative business models for e-commerce and social media portals (Williamson & Yin, 2013). With the aim of better understanding how new R&D and production process innovations can act as antecedents for disruptive innovation in this paper, therefore, we have chosen to analyse a set of case studies

of Chinese firms pursuing potentially disruptive innovation and then to explore some of the implications of these innovations for incumbent competitors from the developed markets.

This analysis bears on one of the main themes of this Special Issue: the sources of innovation opportunities; in particular, the debate on whether opportunities are discovered or created by entrepreneurs (Alvarez & Barney, 2007; Sarasvathy, 2001; Shane & Venkataraman, 2000), especially in the area of disruptive innovation. It has been argued that opportunities for innovation are often created by changes in technology, demographics, and geographic distribution of markets for innovations (Hang & Garnsey, 2011). Emerging economies can provide a particularly conducive environment for innovation opportunities to arise because they often act as a crucible where new customers with fluid needs and behaviours, a growing number of competitors, a flexible business and institutional context and newly introduced technologies come together. In the context of this debate we certainly find that China's fast-changing environment throws up many opportunities for disruptive innovation. But while emerging economies such as China provide a fertile environment for opportunity discovery, we also find that realising these opportunities requires very proactive initiatives by entrepreneurs. This is at variance with Alvarez & Barney's (2007) characterisation of discovery opportunities as arising independently of the actions of those discovering them. Instead, we observe that many disruptive innovations in China have their antecedents in the actions of entrepreneurs who re-engineer traditional R&D and innovation processes to deliver disruptive innovations. In this sense, entrepreneurs are proactively creating much of the disruptive innovation in China.

The paper is structured as follows. We begin by examining the existing literature on theories of disruptive innovation. This leads us to identify a gap in our existing understanding about how changing innovation processes might give rise to disruptive innovation and some broad conjectures about what kinds of R&D and innovation processes might promote

disruptive innovation. The next section on methods and data explains the case study methodology we deploy to explore these issues and conjectures and how data were collected and analysed to develop a set of propositions about the antecedents of disruptive innovation. We then report findings from the case studies of Chinese firms, and followed by a discussion of the implications for the changing nature of global competition. We conclude by outlining the possible contributions of the present study to existing theory and practice and suggestions for further research.

THEORETICAL BACKGROUND

The theory of disruptive innovation provides the context for interpreting the empirical results and theoretical contributions of this study. In this section we first review the disruptive innovation theory. We then examine new approaches of disruptive innovations that Chinese firms have developed. This leads us to identify a gap in the literature which gives rise to the research question addressed in the remainder of this paper: What are the antecedents of disruptive innovation currently emerging in China?

Theoretical insights into disruptive innovation

Christensen (1997) first comprehensively examined the concept of disruptive innovation in his seminal book titled *The Innovator's Dilemma*. According to Christensen, disruptive technologies are technologies that provide different values from mainstream technologies and are initially inferior to mainstream technologies along the dimensions of performance that are most important to mainstream customers. In its early development stage, each product based on a certain disruptive technology could only serve niche segments that value its non-standard performance attributes. Subsequently, further development could improve the performance of the disruptive technology to a level sufficient to satisfy

mainstream customers by focusing solely on key attributes. This was often possible because the performance of the mainstream technology may have already exceeded the demand of mainstream customers, resulting in 'performance overshoot' with over-served customers. Market disruption then occurs when, despite its inferior performance on focal attributes valued by existing customers, the new product displaces the mainstream product in the mainstream market. According to Christensen (1997) there are two preconditions for such a market disruption to occur: there is performance overshoot on the mainstream attributes of the existing product, and there are asymmetric incentives between an existing healthy business model and the potentially disruptive business model. Christensen documented these processes in numerous contexts including hard disk drives, earthmoving equipment and motor controls.

In *The Innovator's Solution* (Christensen & Raynor, 2003) the authors proposed that the innovator's dilemma could be resolved by well-managed incumbent firms if they developed their own disruptive technologies within their sustaining competitive paradigms. By adopting this strategy they could avoid their own dethronement. Interestingly for our current purpose, however, in this second book the authors replaced the term “disruptive technology” with a new term “disruptive innovation”, suggesting the application of the theory could be broadened to include not only technological products, but also services and business models innovation, such as discount department stores, low-price, point-to-point airlines and online businesses education. Christensen (2006) admitted that he had been mistaken to equate the phenomenon of disruptive innovation with a disruptive technology in *The Innovator's Dilemma*. Disruptive innovation does not only arise from new technologies that surpass the performance of the existing technologies dominant in a market. Disruptive innovation may also arise from changes in the business model or underlying processes that enable superior or novel value to be delivered to consumers.

Taking this idea further, Markides (2006) classifies disruptive innovations into three different types: technological, business model, and radical product innovations. All of these different types of disruptive innovations may follow a similar process to invade existing markets and may have equally disruptive effects on incumbent firms. But Markides argued that a disruptive technological innovation is a fundamentally different phenomenon from a disruptive business-model innovation or a disruptive product innovation: These innovations arise in different ways, have different competitive effects, and require different responses from incumbents. To distinguish disruptive innovation from other types of innovations, Markides (2012) proposed two criteria: First, a disruptive innovation must start out as inferior in terms of the performance that existing customers expect, but be superior in terms of price; Second, it must evolve so as to become "good enough" in performance while at the same time remaining superior in price. These criteria reflect the idea that a disruptive innovation challenges the established value propositions and business models of incumbents.

It is worth emphasising that one of the key insights from this analysis is that innovations do not need to need to embody radical advances in either technology or product functionality in order to be disruptive. In fact, many innovations that might otherwise be described as “imitative” (Huang, Chou & Lee, 2010) can be disruptive because they challenge the existing value propositions and business models in the market.

Building on these insights, Yin and Williamson (2009) studied different types of innovations introduced by Chinese firms that had proven to be disruptive in the market. They found that these innovations commonly fell into three categories within their samples. First was “cost innovation”: reengineering the cost structure in novel ways to offer customers adequate quality and similar or higher value for less cost (Zeng & Williamson, 2007). Second was “application innovation”: finding innovative applications for existing technologies or products (Yu & Hang, 2011). Third was “business model innovation”: the well-worn idea of

changing one of the four core components of the business model (customer value proposition, profit formula, key resources or new processes) but with a twist - adjusting those aspects that can be changed quickly and at minimal cost. All of these three types of innovation can be considered disruptive in the sense that they attack performance overshoots on the mainstream attributes of an existing product while also creating asymmetric incentives between incumbents' existing business models and the new business model.

Enabling potential disruptive innovation

Building on the research that established the concept of disruptive innovation and developed a more complete typology of disruptive innovations, a substantial body of literature has elaborated on how organizations enable disruptive innovation. The explanations can be divided into three sets of pre-conditions: resource allocation; organizational structure; and organizational culture.

First, resource allocation has been shown to influence a firm's capability for disruptive innovation. Firms often fail to embrace disruptive innovation because of resource dependence. For example, their leaders become locked into perpetuating businesses in which they have accumulated resources and or they fail to see the need for innovation because they listen to their current customers (Christensen, 2006). Firms also tend to invest more in established businesses that already have scale and perceived advantage (Yu & Hang, 2010). Consequently when facing the competition from rivals, they often respond by making investments aimed at improving the established technologies used by their current customers, thus missing the opportunities for disruptive innovation (Christensen & Bower, 1996).

To enable disruptive innovation, Christensen and Raynor (2003) suggest that an additional team at the corporate level is required to be specifically responsible for collecting disruptive innovation ideas and realising them in practice. Moreover, given the uncertainties

surrounding disruptive innovations, long-term-oriented, subjective-based incentive plans should be adopted instead of short-term-oriented, formula-based incentive plans for key executives (Govindarajan & Kopalle, 2006), so that the senior managers will not be confined by rigid incentives (such as market size, growth rate, profitability). Empirical research also suggests that resource allocation processes using strategic buckets to manage sustaining versus disruptive projects independently are more effective in allowing disruptive innovation to flourish (Chao & Kavadias, 2007; Hogan, 2005). Companies should allocate financial and human resources to identify new potential customers, construct relationships with these customers, and develop knowledge about them (Danneels, 2002, 2003, 2004), because it is the emerging segments that value disruptive innovations at the time of their introduction (Govindarajan, Kopalle, & Danneels, 2011).

Second, organizational structure has been found to influence the probability of disruptive innovation. Both case studies and surveys in high-tech industries have shown that the size of the firm is negatively correlated to the success of disruptive innovation (Christensen & Raynor, 2003; Tushman & O'Reilly, 2002). The implication is that a large corporation wishing to promote disruptive innovation should attempt to foster flexibility by having smaller business units. New start-ups, meanwhile, are frequently found to be relatively fertile ground for disruptive innovation, but lack complementary assets that are often critical to develop potentially disruptive ideas, while the necessary complementary assets are captive within incumbent leaders (Rothaermel, 2001). Collaboration between incumbent firms and start-ups, therefore, can facilitate potential disruptive innovation. The creation of separate organizational units can also foster the development of disruptive innovations because developing disruptive innovations may require new processes and new routines, and the creation of autonomous units will help to break from current routines and processes (Benner & Tushman, 2003).

Finally, a firm's culture has also been identified as a critical precondition for the emergence of disruptive innovation. Firm culture refers to a core set of attitudes and practices that are shared by the members of the firm (Detert, Schroeder, & Mauriel, 2000; Martin, 2002; Schultz & Hatch, 1996). It is an effective way of controlling and co-ordinating people without elaborate and rigid formal control systems (Tushman & O'Reilly, 2002). A culture that fosters relentless innovation may help the firm to stay constantly at the leading edge of innovation (Tellis, Prabhu, & Chandy, 2009). However, culture is a double-edged sword that may also lead to the failure of innovation (Yu & Hang, 2010). This is because cultural inertia is a key reason why managers often fail to introduce change and innovation, even when they know that it is needed (Christensen & Raynor, 2003; Henderson, 2006).

To promote disruptive innovation existing research suggests that it is important for incumbents to prepare for and institute organizational change and unlearn deeply entrenched values at the advent of potential disruptive innovation. Unlearning is defined as the process by which people and firms eliminate old logic and substitute it with something fundamentally new (McGill & Slocum, 1993; Baker & Sinkula, 2002; Sinkula, 2002). The ability to unlearn is one of the most critical competencies people require to overcome pre-judgement and obsolete mental models that otherwise act as key barriers to disruptive innovation (Assink, 2006; Ferriani, Garnsey, & Lorenzoni, 2012). This unlearning is especially critical for successful incumbents (compared with latecomers or newcomers), because they often find it difficult to abandon business models, R&D and design strategies and other processes that have worked well in building their current market positions. On the other hand, elements of culture such as entrepreneurship, risk-taking, flexibility and creativity, need to be instilled, preserved and valued in order to develop disruptive innovations (Govindarajan & Kopalle, 2006). It is also argued that an adhocracy culture works better to promote the development of disruptive innovations at an organization than a clan culture, in which loyalty, tradition, and

emphasis on internal maintenance could lead to a lack of attention to changing market needs (Deshpande, Farley, & Webster, 1993).

All of these findings can help guide the management of firms to create the right pre-conditions for disruptive innovation to emerge. However, this extant literature on how R&D and production process innovations impact the extent of disruptive innovation even when preconditions are favourable is scarce. Notable exceptions are the work by Linton (2004) and Yu and Hang (2011), who explained how to create technology candidates that could facilitate disruptive innovation in due course. Drawing on the evidence from Chinese firms, we hope to further contribute to filling this gap by exploring new process innovations that can enable firms to promote, and then deliver on, opportunities for disruptive innovation in the context of China. By doing so we also hope to shed further light on the debate as to whether disruptive innovation opportunities are discovered or created.

METHODS AND DATA

As we have already noted, evidence suggests that China is becoming an important source of disruptive innovation (Hart & Christensen, 2002; Li, 2013; Williamson & Yin, 2013). Existing research also suggests a number of factors that encourage Chinese firms to focus on disruptive innovation including a lower number of legacy customers, a relatively small installed base compared with the potential future size of their domestic market, intense pressure to make a step-change improvement in value for money to unlock the Chinese mass market, low income levels of the majority of Chinese consumers encouraging focus on "good enough" or "sufficient" product performance on key attributes, shortage of capital invest and lack of experience in traditional R&D focused on higher performance and extended functionality (Zeng & Williamson, 2007). The study of Chinese firms is therefore a potentially fertile ground for examining what R&D and innovation processes can be deployed

deploy to convert these opportunities and demands into disruptive innovations.

In seeking to answer this question we rely on inductive theory building using multiple cases (Eisenhardt, 1989). We chose this multiple case study methodology because it has proven particularly effective in developing new theory from consistent patterns within case data using replication logic in which each case serving to confirm (or disconfirm) the emergent theory (Eisenhardt, 1989; Martin, 2011). Moreover, multiple case studies are more likely to yield more generalized, robust, and parsimonious theory than single-case studies (Langley, 1999; Yin, 2003).

Data Collection

We relied on several data sources: observations, interviews, and archival data such as internal documents, annual reports, websites, and news articles in order to triangulate the data and so improve the accuracy of the picture emerging (Jick, 1979). We aimed to analyse a sufficient number of case studies and range of industries to be fairly confident that the results had some general applicability while limiting the sample so as to enable in-depth interviews within a tractable timescale. Based on these considerations we targeted completion of 12-15 case studies. By the end of the research programme we were successful in conducting two rounds of interviews across 14 companies (detailed in Table 1). The first round of interviews was conducted between March 2010 and January 2011 and a second round between June 2011 and September 2011. The second round of interviews complemented the first by asking follow-up and clarification questions. In some cases were we were able to secure interviews with multiple individuals; here we tried to gain perspectives from employees drawn from different levels in the corporate hierarchy or multiple business units, making a total of 35 semi-structured interviews. We started the interviews by asking background questions such as the name of the informant, their role in their firm, and how many years have he/she worked with their firm. We encouraged informants to provide more details when their descriptions

were brief or when novel strands of narrative emerged (Martin & Eisenhardt, 2010; Strauss & Corbin, 1990). Data collection stopped when theoretical saturation was reached (Strauss, 1987). Interviews commonly lasted for between 30 minutes to two hours. Interview notes were written down immediately after each interview, normally within 24 hours.

Data Analysis

We used within-case and cross-case analyses following recommendations for multiple case studies (Eisenhardt, 1989; Miles & Huberman, 1994). We started by writing up individual cases that triangulated all of our data including observations, interviews, documents (Jick, 1979). We then conducted a cross-case analysis using replication logic across firms, treating each firm as a case. During the cross-case analysis we probed for alternative theoretical relationships and constructs that might fit the data better than our initial emergent theory (Eisenhardt, 1989; Gilbert, 2005). Some of novel conceptual constructs and new theoretical relationships were revised or deleted if we found they did not replicate across the cases. Using replication logic, we stopped data analysis until we reached a strong match between emergent theory and the empirical data.

CASE STUDY FINDINGS

Because traditional R&D processes in most organisations are generally not designed to create and deliver disruptive innovation (Christensen, 1997) we conjectured that new innovation processes with a different modus operandi as well as different goals and performance criteria might need to be implemented in order to promote disruptive innovation. The first finding of our research is that leading Chinese companies have developed organisational routines to enable them to create and deliver on opportunities for disruptive innovation -- especially of the types of innovation, cost, application, and business model innovation found to be common in earlier research (Williamson & Yin, 2013). The

innovation routines that we found underpinning this disruptive innovation in our case studies included: industrialisation, parallel engineering, modularisation, and pragmatic decision-making. During our investigations in China we came across many firms that did not adopt these models, but rather relied on low factor costs to offer the lowest possible prices in a "race to the bottom". This suggests the firms that developed specific R&D and innovation routines to leverage abundant resources and low factor costs available in China in novel ways did so as a conscious strategic choice to try to gain advantage against competitors who also enjoyed similar access to abundant and low-cost resource pools. The ways in which these innovation routines enabled Chinese companies to deliver different types of disruptive innovations to the market are summarized in Table 1. This evidence led us to define the high-level model of the antecedents of disruptive innovation depicted in Figure 1. In what follows we detail these relationships.

Industrialising the R&D process

Some Chinese firms we studied have enabled disruptive innovation by industrialising the R&D process by adopting an "assembly-line" approach analogous to that used in manufacturing. Huawei, for example, is a Chinese multinational networking and telecommunications equipment and services company headquartered in Shenzhen, Guangdong province. It was founded in 1987 as a distributor of imported telecoms products with an initial registered capital of merely USD 3,000. The company then disrupted the telecoms industry by offering telecommunications equipment to operators with adequate functionality and reliability that could be installed rapidly, customized easily to local requirements, and serviced remotely all at a lower price than its major competitors. This enabled it to become the largest telecommunications equipment maker in the world, having overtaken Ericsson in 2012 (Economist, 2012). Its products and services have been deployed

in more than 140 countries and it currently serves 45 of the world's 50 largest telecoms operators.

In order to complete a complex R&D task, Huawei often finely divides the process down into a multitude of specific activities. It then assigns an engineer, or even a group of engineers, solely to that specific, mini-task. So that while a company like Apple might dedicate a total of 10 engineers to a particular R&D project, Huawei would assign a 100-person team to the same opportunity. By increasing the total number of researchers and assigning each individual or small team working to a narrowly defined task within its "R&D assembly line", Huawei can reduce the total time necessary to complete a project. This enables Huawei to deliver innovations much faster than competitors who deploy only a small team of researchers on each project where each individual must tackle a broader set of more complex, multifaceted tasks (Zhang, 2011). This is possible because of the large supply of qualified engineers available in China, allowing companies like Huawei to gain economies of scale and specialisation in R&D, not just in manufacturing. This industrialised R&D process is generally poorly suited to "traditional innovation" that typically focuses on developing completely new technologies or substantially pushing forward the boundaries of functionality. But it does appear to work well when the aim is to disrupt incumbents who have created performance overshoot by providing sufficient functionality with improved value for money, greater reliability, flexibility or shorter cycle times – goals that are often core to the extended concept of disruptive innovation that has emerged from the literature.

WuXi AppTec, a pharmaceutical, biopharmaceutical, and medical device outsourcing company with operations in both China and the United States, has introduced disruptive innovation to the drug discovery process using this industrialized approach. Its work on a new treatment for chronic hepatitis C provides a good example. As with most drugs, the development cycle involves discovery, pre-clinical and clinical trials, regulatory approval and

marketing. Rather than relying on a small team working in the laboratory with a few machines, however, WuXi AppTec began by dividing the R&D process into a series of eight steps, with dozens of people assigned to each step. The initial creation of the reactive intermediates required specialized staff, with at least Masters degrees and considerable research training. The other steps required "R&D workers" (graduates of trade colleges), from which WuXi AppTec hires thousands each year. Rather than relying on automation, (with the associated high capital costs and risk of bottlenecks), WuXi AppTec uses manual techniques that can be quickly scaled up or down as required to keep the project moving rapidly. Efficiency was increased by using SAP's enterprise resource planning software adapted from a manufacturing assembly line to manage the innovation process. This highly industrialized approach has enabled WuXi AppTec to complete projects between two and five times faster than comparable projects using conventional approaches the company benchmarked in the United States.

By industrialising R&D in these ways to leverage the huge pool of engineers and other staff available in China, therefore, Chinese companies are able to develop the products and processes necessary to exploit opportunities for cost, application and business model innovation at much lower levels of investment and more rapidly than using traditional R&D processes designed to develop technologies designed to innovate on the basis of improved functionality or more sophisticated products. Industrialized R&D processes therefore enable Chinese companies to bring products adequate to meet the basic functionality and reliability demanded by mainstream, mass-market consumers with a wider choice of incremental features, more customization, faster and at lower prices than competitors using traditional innovation processes are in a position to deliver. This enables them to market innovations that while they are in some respects imitative, are also disruptive in the sense that they up-end conventional wisdom about the relevant bases of competition in an industry and undermine

the existing business models of incumbent firms.

This analysis leads us to the following proposition:

Proposition 1: Industrialising the R&D processes can facilitate disruptive innovation in China by reducing the total time and cost required to develop a product that offers greater value for money to consumers by incorporating uniquely market-relevant features and/or performance and offering these to consumers sooner than incumbents and at lower prices.

Parallel Processing in R&D

We found that some leading Chinese firms such as Lenovo adopted a different approach to accelerating disruptive innovation, borrowing not from the concepts of assembly lines used in manufacturing, but from the idea of "parallel processing" commonly used in supercomputers. Lenovo is a Chinese multinational technology firm with headquarters in Beijing, China and Morrisville, North Carolina, United States. The company was founded in Beijing in 1984 as a reseller, distributor for foreign brands such as IBM. In 1990, Lenovo started to manufacture its own personal computers (PCs) and by 1997 became the market leader in China over international leading firms such as Dell, HP and IBM. In 2004, Lenovo made a strategic choice to expand abroad and bought IBM's PC business (including the brand ThinkPad) for USD 1.25 billion. The company then disrupted the global PC sector by supplying the IdeaPad computers, which target home customers, and the ThinkPad computers (many are simpler versions of the original ThinkPad computers), which target business customers at low price and became the world's second-largest personal computer vendor by unit sales (Gartner, 2013).

Following their acquisition of IBM's personal computer business back in late 2004, Lenovo adopted many of the R&D disciplines and procedures IBM had developed over decades of successful innovation. But Lenovo also modified the IBM R&D blueprint by

introducing a parallel-processing approach. Instead of treating R&D as a linear process, Lenovo began to create a new R&D process that allows various functions that are normally sequential steps to be conducted simultaneously.

The Pearl River Piano Group – the world's largest maker of pianos with 25% global market share, owner of the *Ritmüller* brand and supplier to Steinway & Sons, also applied the same approach to innovate in the manufacture of musical instruments. Creating a new piano requires the development of four key components: the resonance system, the keyboard, the pedal system, and the case. Western competitors, such as piano makers in Germany, develop designs sequentially using a team of two or three professionals working over a period of two years. We found that Pearl River, by contrast, deploys a simultaneous engineering approach. For its recent high-end, Kayserburg line of pianos, for example, Pearl River assembled a total team of 23 staff including: six designers; ten personnel seconded from all relevant divisions of the company from procurement to sales; two testers; and three computer engineers. A further 40 craftspeople were assigned to making prototypes of possible new designs. The project was completed in just five months, resulting in a line of ten new Kayserburg designs at a total cost of $1 million. The company estimates that incumbent competitors using traditional design processes and small teams would require an investment of around $10 million over several years to compete a similar set of new designs.

The concept of simultaneous engineering is certainly not new (Clark & Fujimoto, 1991), but in the Chinese disruptive innovators we studied it had been adopted more extensively than appears to be the case in most incumbent firms, involving more development stages and greater timing overlaps. Pushing this parallel processing in the innovation process beyond accepted limits clearly carries risks, not least because the information necessary to shape the next step maybe incomplete or unavailable when the tasks are undertaken in parallel. But for disruptions such as cost, application and business model innovation where

the underlying technology remains unchanged this risk is relatively small. Because the overall architecture of the tasks to be performed and the interfaces are already pre-defined by a standardised approach, it is not always necessary to work sequentially. Instead, much of the work can proceed in parallel relying on standardised interfaces to make sure the results of each task come together in a coherent whole. Within the context of many forms of innovation that are disruptive according to recent broader definitions in the literature even through they do not involve revolutionising the underlying product architecture nor redesigning the interfaces between stages of the innovation process, parallel processing can be efficacious. Based on this observation from our case research, therefore, we advance the following proposition:

Proposition 2: Parallel processing in R&D can facilitate disruptive innovation in China by reducing the total time and cost required to develop a product that offers greater value for money to consumers by incorporating uniquely market-relevant features and/or performance and offering these to consumers sooner than incumbents and at lower prices.

Modularising product development

We observed that modularisation of the product development process (not only the more common technique of designing a modular product) was another important process tool used by Chinese firms to enable disruptive innovation – especially in helping them to test the market potential of cost, application and business model innovation ideas by launching them onto the market in rapid waves. This advantage is potentially significant because in Christensen's model of disruptive innovation rapid improvement of the performance of disruptive technology allowing it to attract new customers and gain economies of scale is key.

In mobile handsets, starting as an OEM (Original Equipment Manufacturer) or a distribution channel for leading brands, Chinese companies such as Tianyu Longtong and

Jinli Group, among others, have captured a high share of the mid- and lower-tier markets by breaking down the design process into separable modules, so that redesign focuses only one attribute at a time. By limiting the re-design to small increments in one aspect of the functionality, rather than waiting until they have a model that is more completely new, successive upgrades and new models of cheaper me-too phones with added features can be released into the market every few weeks. These me-too alternatives are labelled as shanzhai phones (after "shanzhai": the mountain fortress where outlaws hide, hinting at their illegal nature). In 2012 shanzhai products ranked second in the Chinese mobile phone sector with 16.1% market share. In some instances new shanzhai phones reach the market even ahead of market launch of the models of leading brands that inspired them!

Modularisation of the product development process is key to the shanzhai manufacturers incredible speed to market. Many buy the core modules that form the heart of the phone from MTK, based in Taiwan. MTK, through its past experience in the DVD market has integrated the parts required for a mobile phone into a set of basic hardware modules. It can also supply its customers with the software to knit these modules together, forming a platform capability of underpinning a wide range of alternative functions. Shanzhai phone manufacturers, therefore, simply need to purchase the relevant modules from MTK, commission a design firm to redesign particular features or attributes such as the exterior case and then undertake the final assembly of the handset. This means they can focus the efforts almost exclusively on managing the product development process to maximise the speed with which they can test new models in the market. The rapid "launch-test-improve" cycle of innovation is particularly well suited to cost, application and business model innovation.

The use of modularization for Disruptive Innovation development has also been confirmed in other research (Brown & Hagel, 2005; Hang, Chen, & Subramian, 2010). Brown and Hagel (2005) explained that Chinese motorcycle manufacturers in Chongqing

adopt "localized modularization" for disruptive innovation - a loosely controlled, supplier-driven approach that speeds up a company's time to market, cuts its costs, and enhances the quality of its products. Hang, Chen and Subramian (2010) indicated that Yadea, a Chinese electric bike maker, shifted to modular architecture, coupled with high volume, quickly brought down the price for mass-market consumption. These findings lead us to posit:

Proposition 3: Modularising the product development process can facilitate disruptive innovation in China by reducing the total time and cost required to develop a product that offers greater value for money to consumers by incorporating multiple, uniquely market-relevant features and/or performance and offering these to consumers sooner than incumbents and at lower prices.

Pragmatic decision making in the R&D process

The traditional decision making processes that have become embedded in many global corporations understandably reflect the demands mature markets for which they were developed. In these markets legacy customers are often cautious, while regulatory constraints and risk aversion all militate against the launch of new products or business models until these have been thoroughly researched and tested. Rules, regulations and "standard operating procedures" originally designed for routine activities have permeated many large companies including the supposed crucible of creativity: R&D. Meanwhile the move away from traditional corporate hierarchies towards so-called "flat organisations" has necessitated extensive consensus building, involving key members of every department or team that might be impacted, before radical changes are decided upon and implemented. Such consensus building is generally time consuming because each different department has their own agenda in mind and is prone to the pursuit of local optimisation rather than taking the perspective of what is best for the entire organization.

An increasing number of large companies are coming to recognise these problems associated with highly structured and corporate consensus-driven R&D and innovation processes leading them to engineer a shift towards more decentralised models that enable more localised and rapid decision making. General Electric's disruption of its own internal structure and processes is a good example (Immelt, Govindarajan, & Trimble, 2009). Hamel (2007) has gone even further suggesting that innovation will lead to competitive advantage primarily when it is based on a novel management principle that challenges some long-standing orthodoxy and is part of an on-going programme of rapid-fire invention where progress compounds over time.

Interestingly in our sample of Chinese firms we observed that their organisation structures tended to be more hierarchical than is the norm observed by researchers in Western companies (Rajan & Wulf, 2006). We found that in Chinese firms a single, senior individual often overlooked the entire R&D process and his or her word was proverbial "law". Such dependence on the judgement of a single executive increases the risk that R&D efforts end up moving in a completely unproductive direction. But this hierarchical structure and decision making does speed up the process of initiating, developing and launching innovations. At the same time, we observed that the innovation processes adopted by Chinese companies provided extreme horizontal flexibility to marshal and re-combine resources from different departments and functions horizontally across the organisation behind a favoured idea. Whenever a problem arose in the R&D process the most common approach for Chinese companies is to call for an immediate meeting attended by the heads of relevant departments. A quick diagnosis was performed and solutions often swiftly decided upon, after which immediate action was taken by the participating party (in large part because of intense pressure from the vertical hierarchy on the entire group to deliver). This process might be dubbed "huddle-and-act".

Chinese companies can also often afford to take decisions to back a potential innovation more quickly than firms in high-cost locations because even moderate market success will take them beyond their lower break-even levels. The economics of creating a new mobile phone again provides an instructive example from our case studies. For a company located in Europe or the USA, such as Nokia, such a project needs to cover an investment of millions of dollars before it becomes profitable. Each new innovation project therefore represents a significant decision for which the probability of success must be thoroughly assessed before proceeding.

By focusing on a different set of disruptive cost, application and business model innovation opportunities, by contrast, we observed that Chinese firms were able to launch as many as 20 new models for the same total investment as their Western competitors. Each innovation therefore represented a small, rapid-fire bet. Only a small proportion of these bets needed to succeed in order to make the whole programme profitable so that each launch decision could be taken quickly even if the available information is incomplete, allowing Chinese phone makers to respond to rapidly changing consumer preferences and fashion trends.

A combination of hierarchical vertical, but horizontally flexible organisational structures, low break-even points and a highly fluid home market with lighter regulation and less loyal customers more willing to experiment, therefore, has encouraged Chinese competitors to develop flexible R&D and decision making processes that can create new opportunities, especially for disruptive cost, application and business model innovation. Based on the above evidence, we advance the following proposition:

Proposition 4: Pragmatic and rapid decision making in the R&D processes can facilitate potential disruptive innovation in China by reducing the total time and cost required to develop a product that offers greater value for money to consumers by incorporating uniquely

market-relevant features and/or performance and offering these to consumers sooner than incumbents and at lower prices and by facilitating the development and implementation of cost, application and business model innovations.

DISCUSSION

Our multiple case study research suggests that new or unconventional R&D and innovation processes are important antecedents to the disruptive innovations previous research has identified as being prevalent in Chinese companies. In particular, moves to industrialise R&D processes, extend the use of parallel processing to more development stages with greater timing overlaps, modularise product development processes, and adopt pragmatic and rapid processes for R&D decisions, appear to underpin and facilitate disruptive innovation. These findings beg the question of whether developments in the approach of Chinese firms to re-engineering the process of innovation matter for competitors in the wider global market? We believe they do necessitate a re-think among incumbent competitors, especially in developed economies, for two key reasons. First and foremost, emerging markets, especially the BRIC (i.e. Brazil, Russia, India and China) and VISTA (i.e. Vietnam, Indonesia, South Africa, Turkey and Argentina) are becoming increasingly important as drivers of global demand. As the *Economist* magazine has pointed out, already by 2005 the combined GDP of emerging and developing economies had risen to above half of global GDP when measured at purchasing-power parity (The Economist, 2010). On average developing country markets are now also growing an order of magnitude faster than those in the developed world. The capabilities to succeed in emerging markets, therefore, will be decisive in the next round of global competition (Knight & Cavusgil, 2004). Yet these capability requirements are often substantially at variance with those associated with success in a world where global demand had been dominated by consumers in developed markets

(Prahalad, 2004). Because a step-change in the price/performance ratio and value for money is usually required to unlock the mass market in developing markets, capabilities that enable the realisation of opportunities for disruptive cost, application, and business model innovation will often be critical to success. New types of R&D and innovation processes that can underpin these types of innovation will, therefore, be necessary to win a substantial share of future global growth opportunities.

A second important shift in the global market stems from the fact that China's 1.3 billion people (including a potentially active labour force of 800 million) cannot move from economic isolation to become an integrated part of the world economy without a downward pressure on global labour rates. And that process, which began in 1978 when China started to open up to the world, still has a long way to go: there are at least 500 million Chinese still to move from low-productivity agriculture to be efficiently employed in manufacturing and services. That is even before we take account of another 1 billion that might make this transition in India and other developing countries over the next decades. While these shifts continue, and there is little reason to suppose they will stop, at the macro level downward pressure on wages will continue. These forces have led real income levels of a significant segment of the working population in the developed world to stall or even to decline (especially among less-skilled workers in the North America and Europe). Many also feel their job security is under threat. As a result, a substantial, and growing, market segment of consumers in the developed world have become acutely focused on seeking out the lowest prices and best "value for money". At the same time, they want to maintain interest and excitement by being able to choose products they see as keeping up with new trends and are loath to restrict their choice of variety. From our research it seems that Chinese firms are developing R&D and innovation processes that will improve their chances of delivering disruptive innovation that will enable them to prosper from this growing segment that

demands “every day low prices” and increased value for money for innovative products as well as commodities (Tan, 2011). In order for incumbents to compete as their existing profit engines based on ever-increasing functionality and product sophistication are disrupted by this shift in market demand and competition from China, they will need to rethink both how they identify opportunities for innovation and the capabilities needed to realise them.

A successful response probably involves both a shift in mind-set and an extension and re-engineering of innovation capabilities. First, incumbents may need to reassess their exposure to disruptive innovation and broaden the focus of their innovation efforts to give greater weight to opportunities for cost, application and business model innovation relative to pure technological advancement. Second, to improve the likelihood of delivering these kinds of innovation, R&D and innovation processes may need to be re-engineered to create new processes that can run in parallel with established approaches. This re-engineering is likely to involve more industrialisation of some R&D processes, greater use of parallel processing in more development stages with greater timing overlaps, more modularisation of the development processes for products aimed at mainstream and value segments and the adoption of less process-bound and more pragmatic and rapid decision making in respect of R&D projects.

In fact, our findings from case study evidence in China suggest that this kind of re-engineering of the R&D processes may be critical to the implementation of what has been termed “reverse” innovation (Govindarajan & Trimble, 2012) or “Jugaad” innovation (Radjou, Prabhu, & Ahuja, 2012). This is because these kinds of innovation are unlikely to be delivered effectively and efficiently by R&D and innovation processes that were designed to support innovation focused on technological improvements, additional functionality or greater sophistication.

Of course, given the relatively small sample size our results are preliminary. The

findings do suggest, however, that further research designed to understand the antecedents of disruptive innovation across a broader range companies in China as well as those headquartered in other countries where R&D and innovation processes may be being re-engineered would be worthwhile.

CONCLUSION

The antecedents of innovation on the technological frontier or that focused the development of greater functionality have been extensively studied (Scott & Bruce, 1994; Tienne & Mallette, 2012). Existing research has also explored the pre-conditions under which disruptive innovation is likely to arise within an organization. There has been much less investigation, however, of the nature of the R&D and innovation processes that might facilitate disruptive innovation. At the same time, the literature has increasingly recognised that disruption can arise from innovation that is largely imitative in terms of base technology and functionality but instead challenges incumbents by introducing new value propositions and business models. These types of disruptive innovation include cost innovation, application innovation, and business model innovation. Viewed through this lens, it is evident that a significant amount of disruptive innovation has been coming from Chinese firms in recent years. An analysis of the antecedents of this disruptive innovation from China, therefore, promised to shed light on how the R&D and innovation processes adopted by a firm alter the probability of launching successful disruptive innovations as well as whether opportunities for disruptive innovations are discovered or created.

Based on multiple case studies of Chinese firms we found that their adoption of new or somewhat unconventional R&D and innovation processes did seem to facilitate the realisation of various kinds of disruptive innovation. Specifically, the industrialisation of R&D processes, the extended use of parallel processing in more development stages with

greater timing overlaps, the design of modular product development processes, and the adoption of pragmatic and rapid processes for R&D decisions, did all appear to underpin and facilitate disruptive innovation in our sample of firms.

From a theoretical standpoint our results suggest that in understanding the antecedents of disruptive innovation it is not sufficient to explain the preconditions that create a favourable environment for disruptive innovation to emerge, including: the characteristics of its human resource pool; its organizational culture; its resource allocation processes; and its organizational structure. It is also important to model another important link in the logic chain: the mechanisms by which the R&D and innovation processes firms choose to adopt facilitate (or impede) the successful emergence of disruptive innovations.

This conclusion also has relevance to the long-standing debate on whether opportunities for disruptive innovation are discovered or created by entrepreneurs. Our findings show that the Chinese market undoubtedly shapes the kinds of innovations that are emerging there and throws up many opportunities for disruptive innovations. However, the fact that many disruptive innovations in China have their antecedents in new R&D, design and production processes that entrepreneurs have consciously put in place demonstrates the very significant role that the creation of opportunities for disruptive innovation (rather than solely discovering them) plays in stimulating such innovations. Realising opportunities for disruptive innovation seems to require very proactive initiatives by entrepreneurs, including the adoption of supportive R&D and innovation processes. These opportunities are not simply discovered in the sense that they arise independently of the actions of those discovering them.

Our findings also have a number of managerial implications. First, they underline the need for managers need to be alert to the fact that disruptive innovation can stem from a much broader set of sources than breakthrough technologies alone. In particular, some of the

innovations that are potentially most disruptive to incumbents with legacy products, processes and assets have their antecedents in new processes for R&D, product design and production as well as in market conditions that encourage and facilitate the development of innovative business models. This argues for taking a broad view of where the opportunities and threats from disruptive innovation may emanate. It also suggests that when considering how resource allocation and organisation structure, culture, and incentives can be adjusted to increase the likelihood of successful disruptive innovation arising, managers need to assess how these variables influence broad spectrum of types of innovation, not just traditional R&D activities.

Second, our results suggest that there is a growing possibility that disruptive innovations will arise in emerging markets such as China. Emerging markets appear to provide a particularly fertile environment both for opportunities for disruptive innovation to arise and for this potential to be realised by proactive entrepreneurs. In part, this reflects that fact that innovative product designs and business models that offer a step-change improvement in value for money are required to unlock latent mass-market demand in these economies. It also reflects the need for innovation in R&D, design and production processes in order to benefit from local factor conditions such as the availability of low-cost, but less skilled labour, less legacy assets, and the presence of many first-time consumers with a desire for experimentation. Moreover, as global market growth is increasingly driven by consumers located in developing economies and the "value-for-money" segments in developed economies, this means that, perhaps somewhat surprisingly, incumbents in the developed world may need to look to emerging economies such as China to find some of the keys to delivering the kinds of innovation that will allow their companies to thrive and prosper in the next round of global competition. In response, managers will need to find better ways to tap into the antecedents of disruptive innovation in emerging economies such as China. This will

probably require that R&D units in emerging markets be tasked with seeking out opportunities for disruptive innovation and realising them locally, rather than focusing on limited adaptation of imported product designs. An alternative approach may be to develop alliances with emerging market players in order to tap into local know-how and the environment conducive for disruptive innovation. This last approach might be particularly attractive to small- and medium-sized foreign companies that face financial, regulatory and knowledge barriers to commercialising potentially disruptive innovations at home.

Third, our results suggest that incumbent firms exposed to disruptive innovation may need to re-engineer their existing R&D and innovation approaches to create new processes. This would involve adopting process changes such as industrialising R&D, pushing the boundaries of parallel processing, modularising product development and pragmatic and rapid decision making in the innovation cycle described in this paper. Even when these can run effectively in parallel with established procedures, however, the barrier to unlearning existing approaches to innovation may need to be overcome to achieve this kind of change.

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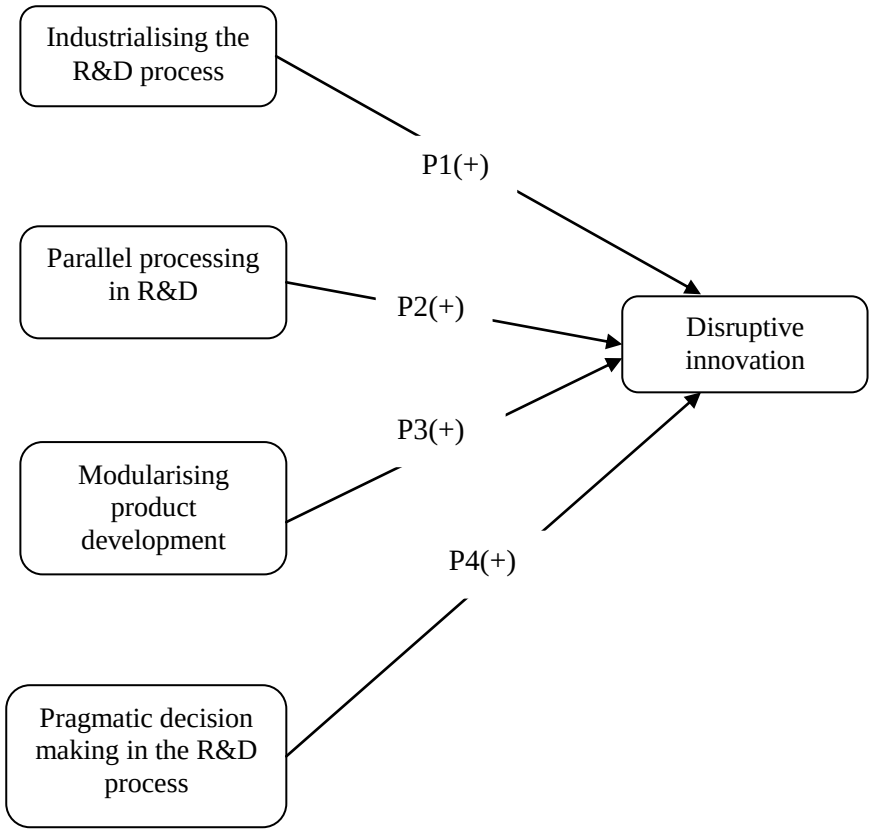
Table

Table 1: Case Studies of Disruptive Innovation from China

R&D and production process innovations	Disruptive Impact	Case firms	Results
Industrialising the R&D process	Providing adequate functionality, rapid installation, higher levels of customization, sooner than incumbents and at lower prices.	Huawei	(1) Founded in 1987 as a distributor of imported telecoms products (2) Now the largest telecommunications equipment maker in the world
		Wuxi AppTech	(1) Founded in 2000 (2) One of the largest open-platforms for pharmaceutical R&D
		Yichen JCG Science & Technology Dev. Co	(1) Founded 1995 (2) Networking (Ethernet and wireless) product manufacturer
		Guangdong Cranes Corp.	(1) Founded in 1961 (2) Major manufacturer of cranes and port machinery
Parallel processing in R&D	Reducing the total time and cost required to develop a product that offers greater value for money to consumers.	Lenovo	(1) Founded in 1984 as a reseller, distributor for foreign brands (2) Now the world's second-largest personal computer vendor by unit sales
		Pearl River	(1) Founded in 1956 (2) Now the world's largest piano maker
		Mindray	(1) Founded in 1991 (2) A leading developer and manufacturer of medical devices worldwide
Modularising product development	Reducing the total time and cost required to develop a product that offers greater value for money to consumers by speeding up the rate at which multiple aspects of the product can be improved.	Tianyu Jinli Group	(1) Both started as an OEM or a distributor channel for leading brands (2) Shanzhai products by these and other firms are ranked second in the Chinese mobile phone sector with 16.1% market share in 2012
		SIM Technology Group	(1) Listed on the Hong Kong Stock Exchange in 2005 (2) Leading mobile communication and “Internet of Things” developer in China
		Tencent	(1) Founded 1998 (2) China’s leading social media and Internet portal
		Broad Group	(1) Founded 1988 (2) Designer and manufacturer of non-electric air conditioning systems and modular, sustainable buildings with installations in over 80 countries

Pragmatic decision making in the R&D process	Reducing the total time and cost required to develop a product that offers greater value for money to consumers by facilitating the development and implementation of cost, application and business model innovation.	Tianyu Jinli Group	(1) Both started as an OEM or a distributor channel for leading brands (2) Shanzhai products by these and other firms now ranked second in the Chinese mobile phone sector with 16.1% market share in 2012
		Wide Industrial Group	(1) Founded in 1997 (2) Research, design and manufacture of commercial air conditioning
		Alibaba Group	(1) Founded 1999 (2) China's largest e-commerce company

Figure 1
R&D and production process innovations enabling potential disruptive innovation



TECHNOVATION-D-13-00110R2 SI: Opportunity Recognition Disruptive Innovation from China: Antecedents and Implications

Highlights:

- We explore how new innovation processes act as antecedents for disruptive innovation
- We use inductive theory-building based on a set of case studies of Chinese firms
- China is an significant source of disruptive innovation
- Novel R&D and production processes can foster disruptive innovation
- Realising disruptive innovation opportunities requires proactive initiatives