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Disruptive innovation in global markets: Cross-industry differences in the impact of rising Chinese competitors

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ABSTRACT

The purpose of this paper is to assess the differential impact across 30 global industries of disruptive innovation from Chinese companies. The paper presents a model of disruptive innovation to identify the conditions under which Chinese competitors can win a substantial share of global markets at the expense of incumbents. Analysing data on the market share gains by Chinese companies among the top five competitors in each industry between 2006 and 2018 we show there are marked differences both in the extent of disruption and the speed with which this occurs. Based on case study evidence, the inter-industry differences appeared to be largely explained by a mix of the product and industry characteristics that influenced competitive efficacy of strategies commonly used by leading Chinese companies. We suggest that the threat of ongoing global market disruption from Chinese competitors should not be underestimated, not least because it is backed by well-developed, dynamic capabilities in cost and accelerated innovation and in accessing, absorbing and leveraging technologies and knowledge being generated throughout the world.

Contribution/ Originality: The extant literature has not answered the question of the conditions under which disruption is most and least likely to occur. In this study we begin to fill this research gap by developing a model of disruption innovation to explain the conditions for disruptive innovation to occur.

1. INTRODUCTION

Back in 2006 The Boston Consulting Group (BCG) published a report entitled "The New Global Challengers: How 100 Top Companies from Rapidly Developing Economies Are Changing the World" (Aguiar et al., 2006). They argued that "These challengers will be major players, reshaping many markets and forcing incumbent companies to respond." (Aguiar et al., 2006). Soon after the publication of this influential BCG report, a widely circulated book *Dragons at Your Door*, subtitled "How Chinese Cost Innovation is Disrupting Global Competition" traced the rise and international expansion leading Chinese companies and showed how, instead of simply relying on low costs to win market share through low prices, leading Chinese companies were using their cost advantages in innovative ways to disrupt the prevailing business models of global incumbents (Zeng & Williamson, 2007). Recent work further echoes this view (Tse, 2015; Williamson, Guo, & Yin, 2021; Yip & McKern, 2016).

But are Chinese companies as disruptive as these commentators suggest? If so, which industries have been disrupted and why? This last question is even more pertinent as a new wave of Chinese technology companies are now taking a leading role in e-commerce, mobile payments, AI, next generation infrastructure, quantum computing

and so on in the digital and AI era. The likelihood of these industries being massively disrupted by Chinese firms may be even greater. If they do, the disruption may well be a game changing one that results in the entire industries being reconfigured beyond shaking up existing market leadership. Investigating the "to-be-disrupted" industries by newly established technology firms from China is, therefore, a critical issue with significant theoretical and managerial implications.

Despite the progress of the disruptive innovation theory in the past several decades, the concept of disruptive innovation is still evolving and deserves further study to explain the conditions in which disruption is most and least likely to occur (Christensen, McDonald, Altman, & Palmer, 2018; Si & Chen, 2020; Yu & Hang, 2011). Scholars have observed that the speed of disruption varies significantly across different industries (Christensen, 1997; Raynor, 2011). However, the extant literature has not answered the question of the conditions under which disruption is most and least likely to occur. This is an important area that deserves further research. In this study we begin to fill this research gap by developing a model of disruption innovation to explain the conditions for disruptive innovation to occur.

Drawing on the theories of industry ecosystems (Ron Adner, 2002; Ron Adner & Zemsky, 2006; Ansari, Garud, & Kumaraswamy, 2016) we postulate that the extent of Chinese disruption in any global industry will depend on four factors. First, the nature of Chinese firms' sources of competitive advantage including the degree to which they have achieved technological improvements through cost innovation, accelerated innovation, and "learning from world". Second, the demand-side characteristics of each market, importantly distribution barriers, buyer risk aversion, procurement policies, and the size of the Chinese market relative to global demand. Third, the nature of global incumbents' competitive advantages, including proprietary technology, brand loyalty, scale economies and first-mover advantages. Fourth, the characteristics of the institutional environment in potential disruptors' home country, such as Chinese government policy and public investment on R&D.

In order to further investigate these propositions, we begin by reviewing the literature on disruptive innovation in order to establish a workable definition of disruption. We then develop the model of disruptive innovation. We then assemble data on the extent to which by 2018 Chinese companies have displaced incumbents to win significant share among the top five companies globally in a sample of 30 product markets worldwide. We use the disruptive innovation model to explain the cross-industry differences that are analysed drawing on case study evidence. The antecedents of disruptive strategies used by Chinese companies are explored as a way of developing possible explanations of why these have been much more successful in disrupting global incumbents in some industries and not in others. Finally, the paper makes a number of suggestions for fruitful avenues of future research.

2. THEORETICAL BACKGROUND

As a starting point, we review the literature of disruptive innovation to establish a workable definition of disruption. Christensen (1997) focused primarily on technological innovation. He argued that 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 *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 Christensen and co-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 model innovation, such as discount department stores, low-price, point-to-point airlines and online businesses education.

Over years, the definition of disruptive innovation has further widened to include not only technologies but

also products and business models (Christensen, 2006; Christensen & Raynor, 2003; Markides, 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.

Building on these insights, Yin and Williamson (2011) 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 (Williamson & Yin, 2014). 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.

These developments in our theoretical understanding of the nature of disruptive innovation have a number of important implications for how we might conceptualise and measure the extent to which the rise of Chinese competitors has actually disrupted global competition. In order to measure the level of disruption by Chinese firms in the global marketplace in addressing our first question, i.e., have Chinese firms really disrupted global competition to date, we require a measure that captures the competitive impact rather than one that focuses on the type of innovation (such as technological breakthroughs). We need a measure that captures the impact of a very broad range of innovations including those that deliver improved value for money, choice, and customisation, and those that result in newly competitive business models.

Second, we would ideally focus on the impact of new Chinese competition on incumbent competitors, rather than necessarily changes in the market as a whole. There are many reasons why the size and structure of a market may change including growth in the number of potential customers, their geographic distribution globally, changes in their tastes and fashion preferences, and the availability of information across the market. In order to identify competitive disruption, therefore, we need a measure that isolates the impact on incumbent competitors. As we discuss in detail the "cross-industry differences in the extent of Chinese disruption" section below, these considerations lead us to measure the disruptive impact in terms of the market share by value Chinese companies have won among the top five competitors in each global industry.

3. A MODEL OF DISRUPTIVE INNOVATION

The literature review on disruptive innovation in the previous section highlights the growing understanding of the core principles of disruptive innovation (such as the definition and types of disruptive innovation). Despite this progress, however, Christensen et al. (2018) suggest that an important area that deserves further research pertains to where and how rapidly disruption occurs. Specifically, how does the speed of disruptive innovation vary across different industries? And more importantly, what are the circumstances in which disruption is most and least likely occur, and what are the factors that make certain industries vulnerable to disruption or largely immune?

In this section we take a first step towards developing a model of disruption innovation to fill this research gap. Firms are not alone, and they are part of the industry ecosystems which are business networks of interconnected firms that depend on each other to survive and prosper (Adner, Csaszar, & Zemsky, 2014). An industry ecosystem includes the producers and competitors from the supply side, users and consumers from the demand side, and regulators and other interested stakeholders from the institutional side (Ron Adner & Zemsky, 2006; Ansari et al., 2016). Drawing on the theory of industry ecosystems we develop a model of disruption innovation as shown in

Figure 1. We postulate that the extent of Chinese disruption in any global industry will depend on four factors: (1) the nature of Chinese firms' sources of competitive advantage; (2) the demand-side characteristics of each market; (3) the nature of global incumbents' competitive advantages; and (4) the institutional characteristics of home country.

3.1. The Nature of Chinese firms' Sources of Competitive Advantage

The nature of Chinese firms' sources of competitive advantage includes the degree to which they have achieved technological improvements through cost innovation, accelerated innovation, and "learning from world". Continuous technology/product improvement is an important precondition for disruption to occur according to the literature on disruption innovation, because disruption can only happen when the technology/product is improved to a sufficient level that meets the need of mainstream customers (Christensen, 1997; Christensen & Raynor, 2003).

Cost innovation is defined as "the strategy of using Chinese cost advantage in radically new ways to offer customers around the world dramatically more for less" (Wan, Williamson, & Yin, 2019; Zeng & Williamson, 2007). These authors identify three vectors of cost innovation: 1) offering customers high technology at low cost; 2) presenting customers with an unmatched choice of products in what used to be considered standardized, mass-market segments; and 3) offering specialty products at dramatically lower prices, turning them into volume businesses.

The second innovation strategy pursued by Chinese competitors is accelerated innovation. Chinese companies opened up a new front in disruptive global competition by re-engineering research and development and innovation processes to make new product development dramatically faster and less costly (Williamson & Yin, 2014). This represents a different way of deploying Chinese cost and volume advantages in global competition. One prong of this accelerated innovation approach involves industrializing the innovation process: diving development down into a large number of small, simplified steps and allocating large numbers of technicians to each. Another prong involves pushing the boundaries of simultaneous engineering by borrowing not from the concept of assembly lines used in manufacturing, but from the idea of "parallel processing" commonly used in supercomputers (Wan, Williamson, & Yin, 2015). A third route adopted by Chinese disruptors to accelerate innovation involves modularising product development. By limiting the re-design to small increments in one module, 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.

The third innovation strategy taken by Chinese competitors to rapidly close the technological gap to enable disruptive innovation is "learning from the world" (Doz, Santos, & Williamson, 2001). Chinese firms have sourced international knowledge through human flows and social networks. Superior technologies have been transferred to China by returned highly skilled diaspora workers and many Chinese students educated abroad (Fu, 2004, 2015). They have played an important role in the development of some emerging industries such as renewable energy, electrical cars and biotechnology in China (Wang, 2012). Chinese companies have also acquired advanced knowledge by setting up R&D collaboration with advanced country universities and research institutes (Liefner, Si, & Schäfer, 2019). Licensing and acquisitions is another mechanism Chinese competitors have used to learn from the world (Deng, 2009; Rui & Yip, 2008). By "learning form the world" Chinese competitors have been making rapid technology improvement to enable disruption.

3.2. The Demand-Side Characteristics of Each Market

The competitive positions of Chinese firms are influenced by the demand-side characteristics of each market such as distribution barriers, buyer risk aversion, purchasing relationships, and the Chinese market dominance in the global market. Teece (1986) suggests that to profit from innovation, an innovator must gain access to complementary assets such as distribution network. However complementary assets are not fully or freely available

to all firms, especially to MNEs operating in foreign countries (Hennart, 2009). An effective distribution network, for example, is often difficult and time consuming to establish given the need to break into tightly controlled local networks or as result of local government restrictions on new entrants, especially foreign companies (Hennart, 2009). Chinese MNEs face high entry barriers in foreign markets, given that their distribution channels are not well-established internationally (Liu & Buck, 2009). However, with the development of e-commerce platforms established by firms such as Amazon and Alibaba, Chinese MNEs may face lower distribution barriers in those industries (such as TVs, Microwave ovens) that can be distributed effectively using e-commerce platforms.

Another important characteristic of domestic demand is buyer risk aversion, a phenomenon long been studied by scholars (Okada, 2010). A buyer will enter into an exchange only if the exchange item's value is certain and there is a sufficient motive for doing so (Okada, 2010). In cross-cultural settings, risk aversion refers to one's general tendency to avoid uncertainty, which reflects the extent to which people feel threatened by ambiguous situations (Zhou, Su, & Bao, 2002). The behaviour of western customers tends to be heavily influenced by a large installed base of durable/safe goods and legacy purchasing decision, compared to customers in emerging markets (Mooij, 2019). This is particularly acute in those industries (such as Types) where safety is a primary concern.

Purchasing relationships and management is another important determinant of a potential supplier's competitiveness. On average, industrial firms spend more than half of sales income on purchased products (Noordewier, John, & Nevin, 1990). Sophisticated and established industrial and commercial buyers have built long term supply chain relationships and purchasing alliances (Buvik & John, 2000). Early supplier involvement such provides an advantage for incumbents to present buyers to switch to new suppliers. For business-to-business transactions, disruption is often difficult if incumbents have established long-term purchasing relationships because purchasing arrangements for repetitively used industrial supplies can reduce transaction cost (Noordewier et al., 1990). For Chinese competitors, it is not surprising that it takes time for them to establish purchasing relationships with buyers on the global market.

3.3. The Nature of Global Incumbents' Competitive Advantages

Chinese competitors challenge and disturb the business models of ecosystem incumbents who are likely to resist and defend their positions (Ansari et al., 2016). In mounting this defence, incumbents from developed countries often enjoy competitive advantages (Rugman, 1987) such as first-mover advantages, proprietary technology, economies of scale, and the benefits of global brand equity. They can then exploit those competitive advantages to defend their leading positions in their industries. In industries where the existing business ecosystem is well developed, disruptors may even confront a dilemma: they may be forced to gain the initial support of the very incumbents they are seeking to disrupt (Ansari et al., 2016).

Another factor that works in favour of incumbents is first-mover advantage. This advantage has been researched in detail in the economics and management literatures with most of the empirical studies finding significant support for a positive relationship between order of market entry and performance (Lieberman & Montgomery, 1988). First movers protect themselves from competition through "isolating mechanisms" such as experience curve effects, preemption of input factors and preemption of ideal market space (Boulding & Christen, 2008). Thus, incumbents often enjoy first-mover advantages which can last for a long period of time (Kerin, Varadarajan, & Peterson, 1992) and this makes difficult for Chinese competitors (late comers) to gain global market share. But competitive advantages based on first-mover advantages also vary across different industries. Based on the empirical studies over the last 20 years, for example, Lieberman and Montgomery (1988) conclude that early movers enjoy advantages in many industries, but by no means all.

Proprietary technology is another important competitive advantage deployed by incumbents to defend their leading positions. Many Chinese firms lack proprietary technologies which constrains their speed to disrupt the global competition, especially in high technology industries such as pharmaceuticals, information and

communications technology, and aircraft (Xiao, Tylecote, & Liu, 2013). For example, Google have come to dominate the search engine industry in most Western countries (64% in the United States and 80% in Europe) by leveraging their proprietary search technology and algorithms (Waller, 2011).

Economies of scale is another important factor that influences the ability of incumbents to defend their position identified by the management and economics literature (Junius, 1997; Stigler, 1958). The theory of the economies of scale is "the theory of the relationship between the scale of use of a properly chosen combination of all productive services and the rate of output of the enterprise" (Stigler, 1958). Economies of scale reduce the unit costs of the firm with an increase of the current output at that point in time, and also with an increase in its cumulative output (Junius, 1997). This scale advantage underpins the ability of the incumbents to defend their positions against potential disruptors who suffer from sub-scale volumes and have less accumulated experience that would drive them down the learning curve. The position of Chinese manufacturers on the scale and learning curves differs widely between different sub-sectors. Most potential Chinese disruptors have surpassed minimum efficient scale in sectors such as mining industry and light industry. But in food processing, chemicals, the medical industry, transportation equipment, electrical and communications equipment, many Chinese firms are at a slight scale disadvantage compared to leading global competitors (Wang, Jiang, & Zheng, 2020).

Brand equity is a strategic asset that is difficult to trade and imitate, scarce, and appropriable that bestow a firm's competitive advantage (Teece, Pisano, & Shuen, 1997). Based on the data from 3,300 consumers in 41 countries, Holt, Quelch, and Taylor (2004) suggest that the primary reason why consumers choose one product over another is based on three main characteristics of a global brand: the level of quality as measured by some objective indicators; the cultural myths that brands carry; and the firms' efforts to address social problems such as environment protection for sustainable development. The image of China is regarded as low in dependability, originality and glamour, and China still has a long way to go to improve the typical image perceived by the standard Western consumer (Ille, 2009). A distinctive handicap of Chinese competitors is their lack of global brands (Ramamurti & Hillemann, 2018). Chinese firms have been trying to build their global brand presence. Some have been successful in certain industries, such as Huawei in telecommunications equipment, Lenovo in personal computers and related peripherals, and Haier in whitegoods. In other areas, however, Chinese companies have as yet failed to establish strong global brands, especially in consumer goods. TCL in audio-visual equipment, Tsingtao in beer, and Li-Ning in athletic sportswear are all examples (George & Kumar, 2017).

3.4. The Institution-Side Characteristics of Home Country

The institutional environment of a company's home country, including government policy and public funding, can significantly impact both its domestic and global competitiveness. One area where this has been found to be particularly important is in the area of technology improvement. Regulatory bodies can develop institutional mechanisms and policies to "steer" the technology development process of companies headquartered in their jurisdictions (Kemp, Schot, & Hoogma, 1998). Important innovation policies published by the Chinese government to encourage innovation include "regulations on promoting technology introduction digestion and absorption" in 1986; "law on promoting the transformation of scientific and technological achievements" in 1996; "state industrial technology policies" in 2002 and 2009; and "notice of promoting on industry technological innovation strategic alliance" in 2008, 2009 and 2010 (Fu, 2015). These policies have facilitated and encouraged Chinese competitors to learn from the world and make rapid progress in cost and accelerated innovation.

The impact of public financing of innovation has long been studied by researchers (Link & Scott, 2013) and in general it has been found to have positive impacts on innovation performance (Howell, 2017). For example, the Chinese government allocated more than US$ 77.82 billion to invest in science and technology in 2011 (Fu, 2015). At the same time, the R&D-to-GDP ratio has increased from 0.56% in 1996 to 2.06% in 2015 which is in par with the average for OECD nations (Gao & Zhao, 2019). As a result, Chinese disruptors have moved faster than its peers

in the developing world in establishing world-class innovation capabilities.

In what follows, we use this model of disruptive innovation underpinned by the extant literature to explain the different levels of global disruption achieved by Chinese companies across the 30 industries in our sample.

4. CROSS-INDUSTRY DIFFERENCES IN THE EXTENT OF CHINESE DISRUPTION

Given our core research question: whether the rise of leading Chinese companies have disrupted global competition in different industries, we focused our data collection on measuring the changing shares of the global market in 30 case industries (listed in Figures 1, 2, and 3).

Obviously, it is difficult to obtain a reliable measure of the total sales in an industry across every country in the world. The independent research agency, Euromonitor, does however estimate the global market size based on research in 200 countries, along with the shares of leading players for a wide variety of industries. Drawing on Euromonitor International's Global Market Information Database (GMID) database, we were able obtain what we believe are reliable estimates of the market shares by value of the 5 leading players in 30 case industries for each year between 2006 and 2018.

Given the relatively recent rise of Chinese companies, we believe this time period is likely to capture the most significant potential competitive disruption to global incumbents. The sample industries span a wide variety of industries including: manufactured goods such as microwave ovens, automobiles and heavy earth-moving machinery; fast moving consumer goods such as laundry detergent and bottled water; and a small number of service industries such as Internet retailing. We excluded large, domestically-focused industries such as electricity, water, and telecommunications services because global competition in these industries is very limited, often by regulatory barriers.

Using these data, we calculated two main statistics for each industry. First, the percentage of the total global market share of the five competitors with the largest sales in each industry by value captured by Chinese companies during 2018. Thus, for example, if there were two Chinese companies within the top five competitors, we calculated the percentage of the market share of the top five competitors won by these Chinese companies. If there were no Chinese competitors among the top five companies measured by global market share, the percentage captured by the Chinese would measure zero, suggesting the disruptive innovation to global market incumbents from China had been negligible.

If, on the other hand, all five of the top global competitors were Chinese in 2018, our statistic would imply that the competitive disruption of the global incumbents had been complete at 100%.

The second statistic we calculated was the increase in the share of Chinese companies within the global market share of the top five competitors over the decade between 2006 and 2018. This gives a more direct measure of the disruptive impact of Chinese competition over the period (allowing for the fact, for example, that the Chinese share of the global market might already have been high in 2006). It also gives a sense of the speed of disruption over the decade.

4.1. Patterns of Global Disruption

In six of the 30 industries in our sample, by 2018 the Chinese competitors had wrested over 50% of the global market share by value from global incumbents (Figure 2). The most extreme case was humidifiers, where the leading Chinese players had won nearly 90% of the share of the top five players. For Jewellery, the figure was above 50%. In these industries, the disruptive innovation from China to incumbents appears to have been massive.

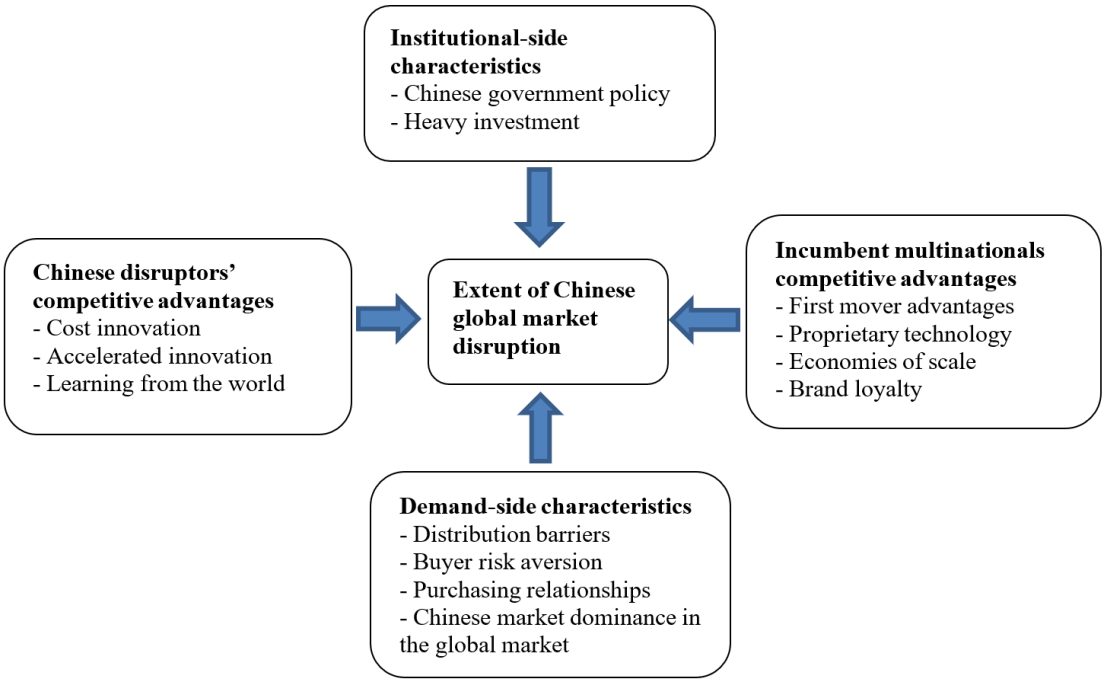

Figure 1. Model of disruption innovation.

It is worth noting, of course, that the Chinese market is included in the global market figures, so that some of the impact represents the success of leading Chinese companies in China. Unfortunately, we have not yet been able to obtain data breaking out the contribution of China market share to the global market share of each company. This limitation obviously needs to be borne in mind when interpreting the amount of global competitive disruption implied by these results. In order to gain an indication of how much of our estimate of global market disruption might be biased by Chinese companies' success in the China market, we examined three factors: the size of the Chinese market relative to the global market, the average number of Chinese firms in the top 5 global competitors, and the average share of these Chinese competitors in their home market.

In 2018 Chinese nominal Gross Domestic Product (GDP) accounted for approximately 16% of total global GDP. Parenthetically, that compares with 23.8% of global GDP accounted for by the US market (World Bank, 2021) and so might bias the global market shares of US firms to their success in their home market even more. There is an average of 2.2 Chinese players within the top five globally. The average market share in China of each of the top Chinese competitors included in the top five global players was 19%[1]. Finally, the total global market shares of the top five players (Chinese or foreign) across the industries in our sample averaged 48%. Taken together, these statistics imply that approximately six percentage points of the global market shares of the Chinese top players, on average, relate to their market share in China.

In fifteen of the 30 industries in our sample, by 2018 the Chinese competitors had wrested between 25% and 50% of the global market share by value from global incumbents (Figure 3). These included washing machines, cookers, steel, wind turbines and smart phones. In all these industries, our data suggest Chinese competitors have substantially disrupted the global market.

Within in this group of industries two anomalies are worth mention: Internet retailing and electrical goods retailing primarily reflected a combination of the huge growth of the Chinese market relative to the rest of the world and the dominance of the leading local players. In the case of Internet retailing, while Alibaba Group has expanded overseas (notably by acquiring Lazada Group SA, the largest e-commerce company in South-East Asia and establishing sites in Japan and Korea) much of its global share reflects the massive size of the Chinese e-

[1] Based on the 14 industries for which separate data on market shares in China was available.

commerce market – estimated at double the size of the US – and Alibaba's dominant, 40% share). Likewise, although leading Chinese electrical goods retailer Suning has expended aggressively in Japan, most of its global share as measured by our statistics related to its 1.5% share of the Chinese market is a global industry that is fragmented (the top-five electrical goods retailers controlled just 2% of the global market).

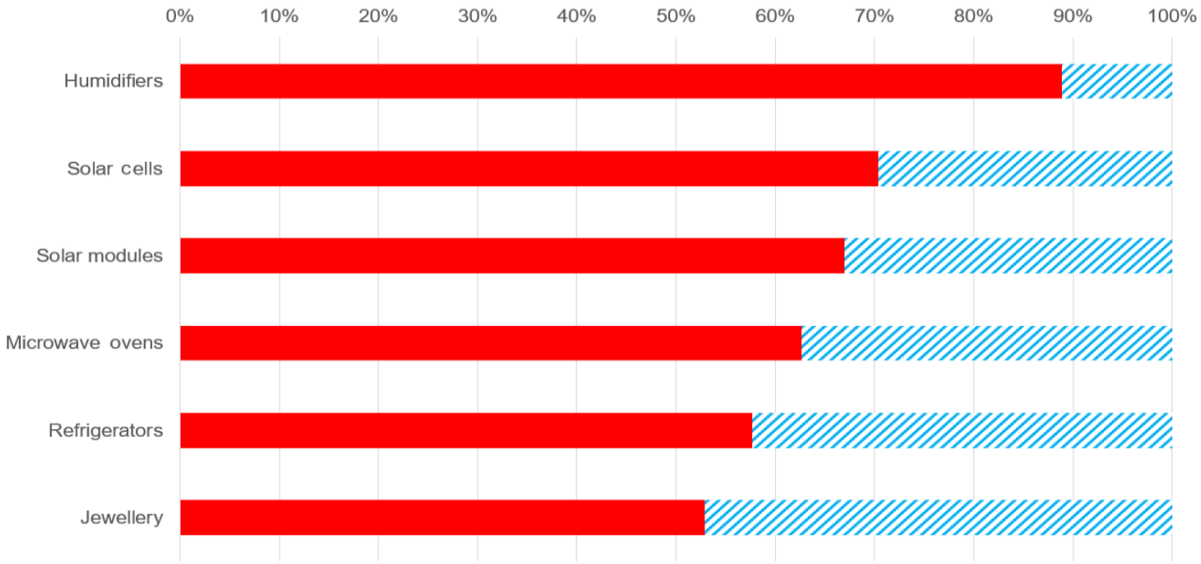

Figure 2. Chinese penetration > 50% in the market share of the top five players globally.

Among the remaining nine industries in our sample, the results suggest that Chinese competitors have caused relatively low level, down to only minimal, disruption for the leading global incumbents (Figure 4). There was still a significant disruptive impact of Chinese competition on the global incumbents (Chinese winning 20% share of the top five global players) in Automotive and Computer Tablets. Among the industries that had seen minimal disruption from emerging Chinese competitors were Fast-Moving Consumer Goods (FMCG) – such as laundry detergent and bottled water. Here Chinese companies had won significant shares of the Chinese market but had little impact on the global incumbents outside China. This was also true for Tyres and Internet Advertising.

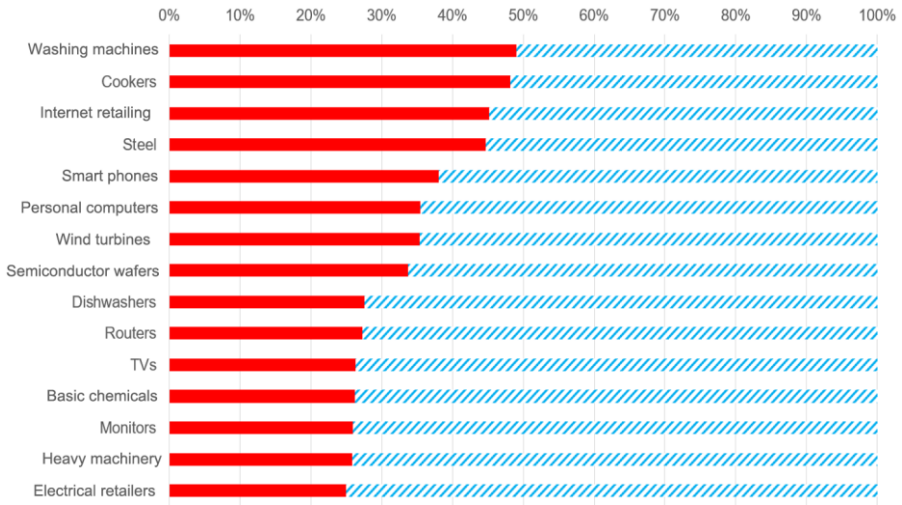

Figure 3. Chinese penetration 25%-50% in the market share of the top five players globally.

The results looking at our second measure of disruption, the percentage point change in the market shares of Chinese companies among the top five global players over the decade from 2006 to 2018 add some further insights to the patterns observed in the absolute levels of share wrested from global incumbents by 2018. Since 2006,

Chinese competitors have significantly and rapidly disrupted global incumbents in solar cells, solar modules, Internet retailing, jewellery, smart phones, semiconductor wafers, wind turbines, and routers, and some categories of white goods including cookers and refrigerators (Figure 5). A prominent example of the disruptive power of Chinese competitors in the whitegoods category was General Electric's sale of its global appliance business to Haier for $5.4 billion in January 2016.

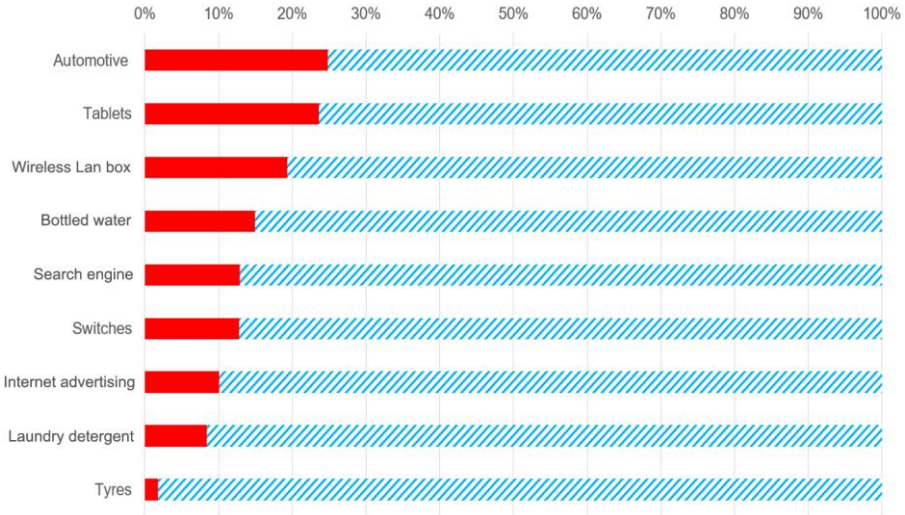

Figure 4. Chinese penetration <25% in the market share of the top five players globally.

The two sets of statistics, showing the magnitude of Chinese disruption to the strategies of global incumbents and the speed of disruption between 2006 and 2018 respectively, can then be combined to highlight some of the key differences in disruptive Chinese competition across different industries (Figure 6). The industries that have been subject to rapid, major disruption by emerging Chinese competitors include solar cells, solar modules, Internet retailing, jewellery.

Another set of industries was also subject to major disruption by Chinese competitors, but this occurred over a much more extended timeframe. These industries included appliances such as humidifiers, microwave ovens, refrigerators, and washing machines, as well as steel. Interestingly, in all of these industries Chinese competitors had already wrested over one third of the total market share held by the top five players from incumbents by 2006.

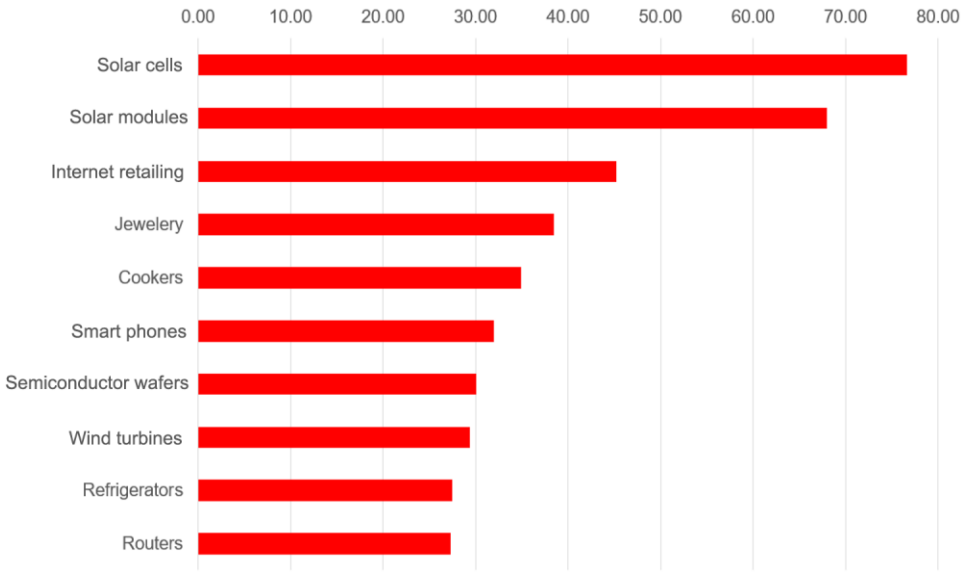

Figure 5. Percentage point increase in Chinese market share among the top five players globally 2006-2018.

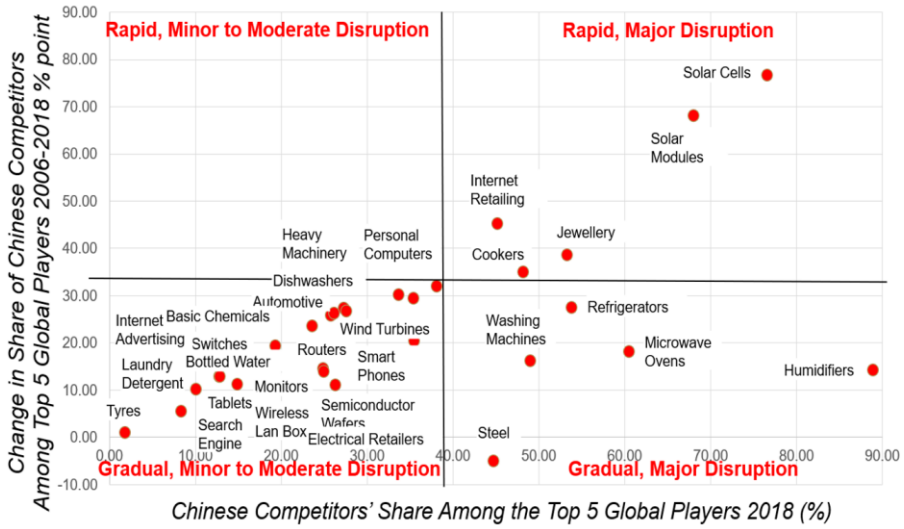

Figure 6. The magnitude and speed of competitive disruption by Chinese challengers.

In the case of steel which has recently become the subject of intense political discussion, Chinese companies had already won 50% market share among the top 5 global competitors by 2006. This reflected a combination of the increasing importance of China in global steel demand as well as rising Chinese steel exports over the 1990s and early 2000s. In fact, in the decade after 2006, the leading Chinese steel companies have seen their share of the top-five global steelmakers fall some five percentage points as global companies, led by Arcelor-Mittal, drove consolidation of non-Chinese players in the industry. It is clear from our results that the rise of Chinese companies and international expansion, first as exporters and more recently as foreign direct investors and cross-border acquirers, has resulted in a significant wave of disruptive innovation buffeting global incumbents. In a number of industries Chinese competitors have captured over 50% market share held by the top five global players. In many other industries, the Chinese challengers have wrested away more than 20% of the share held by the top five incumbents. Our data suggest that the share won by Chinese competitors came primarily from global incumbents, rather than smaller players, because the average share of the top five global players in our sample of 30 industries rose just three percentage points, from 45% to 48% over the period 2006 to 2018. This implies the strategies of global incumbents were disrupted by the new Chinese competitors.

One of the most intriguing aspects of our findings is the cross-industry variation in the diverse set of industries in our sample. In what follows we discuss the possible reasons for these patterns of cross-industry variation by comparing our results with the findings in existing literature about the sources of competitive advantage and disadvantage of Chinese competitors in the global market.

4.2. Industries where Chinese Disruption has been Very Significant

Let us begin with two of the most outstanding examples of major and rapid disruption by Chinese competitors: solar panels (modules and solar cells). Chinese entered this market the late 1990s when Germany faced shortages of solar modules and cells following the implementation of powerful government incentives to promote rooftop panels for power generation. Much of the technology and knowledge that helped the Chinese producers get established was licenced from Germany, then the leader in the industry, as she sought to create new sources of supply. In 2010 the Chinese government designated expanding renewable energy as one of the seven categories of business that receive special attention including loans and tax incentives under its next five-year plan. The US Department of Energy estimates that the Chinese government, at national, provincial, and local levels, earmarked $47 billion to help build Chinese solar manufacturing into a "strategic industry" (Fialka, 2016).

This huge investment in new capacity for solar cells and solar modules allowed Chinese competitors to reap economies of scale and race down the learning curve, leading to rapid improvements in product and process designs,

improved yields and productivity, and dramatic reductions in costs. Combined with a glut in supply, these improvements led to world prices to drop by 80 percent between 2008 and 2013. The disruptive impact on foreign incumbents was huge. By 2016, SunEdison of Belmont, California, had filed for bankruptcy, while the share prices of two other leading US companies, First Solar and SunPower, declined to 13 and 6 percent of their former values respectively (Fialka, 2016). German companies such as Q-Cells and Phoenix Solar, former leaders in the industry, struggled to survive (Spiegel, 2011). Next is a traditional industry exemplified by jewellery. Here disruption has been achieved by a combination of cost innovation (huge variety of design) and the massive economies of scale available to a small number of competitors, led by Lao Feng Xiang (established in 1848), who have been able to achieve dominance in the Chinese market and then began expanding internationally. Lao Feng Xiang started with Hong Kong and Canada to establish 2,300 sales outlets across the globe, eventually reaching Fifth Avenue, New York in 2014 (Real Estate Weekly, 2014).

In the case of home appliances including humidifiers, refrigerators, cookers, microwave ovens, and washing machines, the roots of Chinese global disruption are different. This reflects the convergence of three developments. First, the emergence of one or two dominant players in each type of product in China, such as Haier and Midea in washing machines and refrigerators, Midea in humidifiers, and Galanz in microwaves ovens. Second, a combination of cost innovation (primarily by offering massive choice of varieties and customisation at low cost as described by Zeng and Williamson (2007) and successive waves of accelerated innovation over an extended period that enabled improvements in the value for money offered to customers over global incumbents (Williamson & Yin, 2014). Third, Chinese competitors used this combination of cost innovation and accelerated innovation underpinning more consumer choice and better value for money to enter foreign markets and win share. They were helped in overcoming traditional entry barriers by leading retailers, such as Walmart, who were looking for new brands on which they could earn higher margins than permitted by incumbents.

In the case of the global dishwasher market Chinese disruption has been led by Haier who successfully accessed and integrated design skills obtained by its acquisition of the New Zealand company Fisher and Paykel Appliances Holdings in, one of the acknowledged global leaders in dishwasher design in 2012. By combining these design skills with its own process innovation and manufacturing scale and expertise, Haier was able to increase its global share of among the global top-five players by 5 percentage points in the subsequent four years. In the process, Haier disrupted leading incumbents, causing their margins and volume to decline. This resulted in the decision in late 2015 by GE to sell global appliance business. Electrolux of Sweden bid for this asset in an effort to consolidate its global position. Haier, however, believed its ability to leverage GE's brands, distribution networks and design capabilities (especially in respect of larger, commercial machines) justified a higher acquisition price. As a result of this acquisition in 2016, Haier's share among the top-five players leapt by another 17 percentage points.

Disruption in the global personal computer (PC) market was led by Lenovo who, leveraging their technology links with the Chinese Academy of Sciences, was able to pursue the cost innovation strategy of bringing high technology to the mass market at low cost (Zeng & Williamson, 2007). After deploying this strategy to begin its global expansion organically, Lenovo made a step-change in its global presence when it acquired the IBM's global PC business with $13 billion of revenues (about 7% share of the global PC market) in 2005 (IBM, 2005). It was then able to build on this base to expand its global market share to 22% (40% of the top-five incumbent's share) by 2018, significantly driven by accelerated innovation relative to global competitors (Williamson & Yin, 2014).

The gateway to disruption by Chinese competitors of the smartphone industry was opened by the disaggregation of the value chain, starting with component specialisation in the early 2000s and pushed further by Google's launch of its open operating system platform, Android, in 2008. Today, the more than 1,000 smartphone manufacturers around the world enjoy easy and inexpensive access to the components it takes to build a phone. Google provides Android software for the operating system; ARM, owned by Japan's Softbank, licenses its design for RISC chipsets; core modules are offered by companies such as Taiwan's MTK; microphones, antennas, and

camera components are available from Chinese companies such as AAC Technologies. This disaggregation and modularisation of the value chain has enabled many Chinese competitors to enter the market, focusing their efforts almost exclusively on managing the product development process to maximise the speed with which they can launch new variants (Wan et al., 2015). This strategy, combined with business model innovation (especially in distribution) has allowed successful companies such as Xiaomi, Vivo and Oppo to rapidly build share in China, becoming leading players in as little as three years. Despite some penetration of emerging markets in South-East Asia, Africa and in India, however, these companies have generally not been able to significantly disrupt the strategies of global incumbents outside China, especially in developed-country markets. The exception is Huawei who is, for example, now the top smartphone seller in Portugal and the Netherlands and the second biggest in Italy, Poland, Hungary, and Spain and number three in the world after Samsung and Apple.

The two main keys to Huawei's success in disrupting the market have been its long-standing relationships with providers of telecommunications services around the world and accelerated innovation. Huawei's decades of experience manufacturing and selling telecom networking equipment (it had overtaken Ericsson to become world number one in 2014) meant it had close relationships with telecoms operators in markets worldwide—with the conspicuous exception of the United States. These relationships allowed Huawei to gain immediate access to distribution because the majority of smartphones sales take place as part of a mobile services bundle in many markets around the world (Tsan, Barton, Gulati, & Lund, 2012). Second, Huawei used accelerated innovation to add new and improved features to their phones faster than both their Chinese and global competitors (Zhang, 2011). Huawei's P9 model, for example, brought dual-camera systems to consumers some months before they were available from Apple with the iPhone 7. Huawei brought improved camera lenses, in partnership with Zeiss, and improved antennas – drawing in their knowledge of mobile signal processing from the equipment business – in series of rapid product upgrades. Since 2019, however, Huawei has suffered setbacks as a result of new government restrictions in a number of countries on suppliers policy-makers regard as a national security risk (Cheng & Li, 2020). The wind turbines industry has followed a similar pattern to solar, but with somewhat less long-term impact, largely because the global incumbents have been more successful in responding to disruptive innovation from China. None the less, the disruptive impact and loss of market share has still been significant.

The early development of Chinese companies in wind turbines was driven by the rapid growth of the domestic market based almost entirely on technology from Europe. The purchase of licenses from European companies was key to helping Chinese companies get off the ground. Additional technology was brought in through a mix of joint ventures and the establishment of subsidiaries who trained local staff also played a role (Lema, Berger, & Schmitz, 2013). The emerging Chinese competitors then built on this base by investing in large R&D departments in China. They also established R&D centres in Denmark and Germany, two countries leading technological advancement in the industry, providing access to world-class design and engineering capabilities. This allowed Chinese companies to combine advanced technologies and designs with accelerated innovation, including deployment of large numbers of technical staff and simultaneous engineering, to achieve rapid cycles of incremental improvements to wind turbine efficiency, up-time and durability (De Marchi, Giuliani, & Rabellotti, 2018). The allowed the leading Chinese competitor, Goldwind, for example, to increase its market share among the top five global players from just over 5% in 2006 to reach 26% by 2019.

The extent of the loss of market share among the global incumbents in wind turbines, however, was reduce by decisive moves to improve efficiency, introduce technology that would expand the potential market, and compete aggressively in China. The leading Danish firm, Vestas for example, which has been in China for three decades, built its largest integrated manufacturing complex in Tianjin. A strong Chinese supply chain was developed to support these factories and take advantages of lower Chinese costs. Vestas also developed new technologies that could operate efficiently in low and ultra-low wind areas extending the potential market into areas where wind power generation had previously been regarded as impractical (China Daily, 2007). The wind business of German

engineering giant Siemens, meanwhile, was merged with the leading Spanish turbine maker, Gamesa in 2016. The combined company was able to reap greater economies of scale and gain improved efficiencies, helping them reduce the cost gap Chinese disruptors. China has long been the largest market for semiconductors, accounting for over 50% of the global market in the last five years to 2020 (Daxue Consulting, 2020). Historically China imported 70% of the semiconductors it used in its manufacturing (Castellano, 2017). But as part of a 10-year plan announced by the Chinese government in 2014, about $150 billion is being invested by the government and equity firms in the Chinese semiconductor industry (Carbourne, 2017). This investment, combined with large imports of state-of-the art semiconductor fabrication equipment and expansion of the local technological knowledge base, in both design and fabrication, through a combination of returnees and local training, meant that the ratio of local production to imports increased to over 30% by the end of 2016. This disruption of the position of global incumbents looks set to continue (Castellano, 2017).

The antecedents of Chinese disruptive innovation in these industries where substantial global market share has been wrested from the top-five global incumbents, either rapidly or over a decade or more, are summarised in Table 1. We see that in a number of industries undergoing rapid growth and technological change and considered strategic for the future development of China (including semiconductors, solar cell and modules, and wind turbines), government policy has been critical. Policy interventions have enabled the financing of massive investment and rapid growth of the Chinese market (partly though subsidies and incentives for adoption). This has been combined with a remarkable ability of Chinese competitors to rapidly close the technological gap by "learning from the world" (Doz et al., 2001) through licensing, acquisitions (Deng, 2009; Rui & Yip, 2008; Williamson & Raman, 2011) and hiring staff trained by multinationals in China, combined with high absorptive capacity (Cohen & Levinthal, 1990). Having accessed leading-edge technology from abroad, leading Chinese companies have applied their cost and accelerated innovation capabilities as they moved rapidly down the learning curve to disrupt the global market by offering potential customers dramatically improved value for money.

There is then a set of industries, centred on whitegoods (appliances), but also including personal computers and smartphones, where the antecedents of disruption are a combination of cost and accelerated innovation, learning from the world (through accessing knowledge overseas and acquisitions), gaining economies of scale and rapidly moving down the leading curve as a result of large size of the Chinese market and the dominance achieved by leading players. The ability to reap economies of scope across business lines has also played a role in enabling disruption in the whitegoods industry and in smartphones, where Huawei, for example, was able to leverage relatedness between telecommunications equipment and handsets.

4.3 Industries Where Global Disruption Has Been Limited

There is a set of industries (below the medium 27.3% of the top-five incumbent's share) were Chinese disruption has been only minor to moderate and the pace gradual. Prominent among these are FMCG markets, such as laundry detergent and bottled water where consumer loyalty to existing global brands acts as important barrier to winning share and where there has been only modest innovation in the product and manufacturing process in the last decade. Others, such as tyres, heavy construction machinery and power switchgear, are industries where customers exhibit high risk aversion. In the case of tyres this reflects a combination of high safety risks of failure and established brands with a strong safety record. In heavy construction equipment and power switchgear, meanwhile, the costs of failure in terms of lost activity, disruption to critical path of project competition resulting in an idle workforce or materials left in inventory, and penalties for late completion are high relative to the cost of the equipment.

Table 1. Antecedents of Chinese disruptive global competition*.

Industry	Government policy	Heavy investment	Cost innovation	Accelerated innovation	China market dominance	Learning from the world	Economies of scope
Solar cells	✓	✓	✓	✓	✓	✓	
Solar modules	✓	✓	✓	✓	✓	✓	
Humidifiers			✓	✓	✓	✓	✓
Jewellery			✓		✓		
Internet retailing				✓	✓	✓	
Refrigerators			✓	✓	✓	✓	✓
Microwave ovens			✓	✓	✓	✓	
Cookers			✓	✓	✓	✓	
Washing machines			✓	✓	✓	✓	✓
Steel	✓	✓			✓		
Personal computers			✓	✓	✓	✓	
Smart phones			✓	✓	✓	✓	✓
Wind turbines	✓	✓	✓	✓	✓	✓	
Semiconductor wafers	✓	✓		✓		✓	
Dish washers			✓	✓	✓	✓	✓

Note: * Industries ranked by magnitude and speed of disruption (High to low).

Foreign markets for services such as Internet advertising and search engines have proven difficult for Chinese competitors to penetrate where they are late comers (which is the case for most developed markets). A combination of first-mover advantages and dominant local players enjoying huge economies of scale and cope locally, as well as strong brand recognition, put Chinese challengers at a strong disadvantage. For these reasons, Chinese competitors have mainly been able to win share in China. Their main gains in overseas share have been in other emerging markets where they could also benefit from a combination of deep pockets, first mover advantages, and the benefits of China as a lead market.

These barriers to disruption of global markets by Chinese competitors, based on case study evidence and earlier author interviews, are summarised in Table 2.

Table 2. Barriers to Chinese disruption of global competition*.

Industry	Brand loyalty	Buyer risk aversion	Purchasing relationships	Distribution barriers	Proprietary technology
Tyres	✓	✓		✓	
Laundry detergent	✓			✓	
Internet advertising	✓		✓		✓
Power switches		✓	✓		
Search engine	✓				✓
Bottled water	✓	✓		✓	
Wireless Lan box	✓			✓	
Tablets	✓			✓	
Automotive	✓	✓		✓	
Electrical retailers	✓			✓	
Heavy machinery		✓	✓	✓	
Monitors	✓		✓	✓	
Basic chemicals		✓	✓	✓	
TVs	✓			✓	
Routers	✓	✓	✓	✓	✓

Note: * Industries ranked from by magnitude and speed of disruption (Low to high).

The results suggest that brand loyalty enjoyed by established global incumbents, customer risk aversion, and barriers to breaking into distribution are the most important reasons why emerging Chinese competitors have failed to disrupt global markets. As we saw for whitegoods, Chinese disruption has been relatively greater in industries such as TVs, monitors and Wireless Lan Boxes where large retailers such as Walmart, cable TV companies or telecommunications providers have been willing to provide a gateway into distribution because of the potential to improve their own margins.

Automotive has seen only moderate global disruption as a result of two opposing forces. First, barriers including brand loyalty, risk aversion and difficulties in accessing distribution in mature, developed markets. On the other hand, the importance of value for money, large numbers of first-time buyers, and patch established distribution have provides greater opportunities for Chinese disruption of the automobile market in developing countries.

In business-to-business sectors, such as heavy machinery, power switches, and basic chemicals established purchasing relationships, risk aversion, and sometimes distribution barriers have played a significant role in reducing the impact of disruptive Chinese competition.

Finally, it is interesting to note that proprietary technology seems to have played little role in shielding incumbents from disruptive Chinese competition in most industries. This aligns with the observation that leading Chinese companies have proven adapt in accessing technology from around the world, absorbing it, and then adding incremental innovations that improve the attractiveness of their offerings in the market.

5. DISCUSSION AND CONCLUSION

This paper began by reviewing the literature on disruptive innovation with the aim of developing a model of disruptive innovation to explain the market conditions for disruption to occur. We also developed a suitable definition and empirical measure to address the question of whether the rise of Chinese companies has really disrupted global competition. We computed two statistics to gauge the magnitude and speed at which leading Chinese competitors has wrested market share from among the top-five global incumbents in 30 industries between 2006 and 2019.

We found that over 50% of the global markets in our sample had seen either major or substantial disruptive innovation by emerging Chinese competitors. Both the magnitude and speed of the impact of this disruptive innovation, however, varied widely across different industries. Based on case study evidence, these inter-industry differences appeared to be largely explained by a mix of the product and industry characteristics that influenced competitive efficacy of strategies commonly used by leading Chinese companies, such as cost and accelerated innovation and learning from the world, by government policy, and by barriers to Chinese penetration of global markets including established brand loyalties and purchasing relationships, risk aversion, and barriers to distribution access.

Our study makes several important theoretical contributions. First, Christensen et al. (2018) suggest that exploring cross-industry variations in the disruption process is an area that deserves further study because some scholars found that the rate of improvement varies quite significantly by industry (Christensen et al., 2018). For example, technology improved quickly in the disk drive industry (Christensen, 1997). While Disruption played out gradually over several decades in industries like steel and discount retailing (Christensen & Raynor, 2003). However, in the hotel industry it has been difficult for low-end entrants to challenge the incumbents such as the Four Seasons (Raynor, 2011). Drawing on data for 30 global industries, our study thus provides further evidence to suggest that the speed of disruption does systematically vary across different industries.

Second, we take a first step towards developing a model of disruptive innovation to explain the cross-industry difference in disruption and conditions for disruption to occur. The extant literature on how to enable disruptive innovation focuses on technology improvements as an important precondition for disruptive innovation occur (Christensen, 1997; Christensen et al., 2018). In this study we extend this literature and identify three additional conditions for disruption to occur, which are the demand-side characteristics of each market, the nature of global incumbents' competitive advantages, and the institution-side characteristics of home country. The model of disruption innovation developed in this study helps us to understand the full picture of enabling disruption and also deepens the concept of disruption.

Third, in the past disruptive innovation has largely been explored using case study evidence. This paper therefore makes another contribution to existing literature by empirically investigating the phenomenon of disruptive innovation using market share data for a significant cross-section of industries over a decade-long period.

Our findings also have several managerial implications. First, as global market growth is increasingly driven by consumers located in developing economies and the "value-for-money" segments in developed economies (Wan et al., 2015) these findings suggest that incumbents may need to look to emerging economies such as China to find some of the keys to delivering the kinds of cost innovation that will allow their companies to thrive and prosper in the next round of global competition. Incumbent firms increasingly exposed to disruptive innovation may also need to re-engineer their existing R&D and innovation approaches to create new processes more suited to accelerated cycle of incremental innovation. Even when these can run effectively in parallel with established procedures, the barrier to unlearning existing approaches to innovation may need to be overcome to achieve this kind of change. R&D focused on developing sophisticated, proprietary technology alone seems insufficient to counter disruption.

A second managerial implication is that incumbent global firms probably need to work harder to leverage local learning by their subsidiaries in China. Deploying that learning could help them develop strategies and capabilities

to counter the disruptive innovation emerging from China. That might include expanding their R&D activities in China with the aim of learn new ways of R&D and production process innovations. For incumbent firms, the goal of internationalizing their R&D activities can be disruptive innovation seeking rather than technical knowledge seeking.

Third, our results suggest that the force of Chinese disruption might be countered by increased investments in building brand loyalty, buyer relationships, and distribution barriers in industries where these factors are relevant to the competitive mix.

More generally, we conclude that the threat of ongoing global market disruption from Chinese competitors should not be underestimated, not least because it is backed by well-developed, dynamic capabilities in cost and accelerated innovation and in accessing, absorbing and leveraging technologies and knowledge being generated throughout the world. This also suggests that further research into the disruptive strategies would be fruitful; in particular, to better understand cross-industry differences in the extent and speed of disruption, as well as the antecedents of Chinese competitive disruption of global markets and the effectiveness of current and potential future responses by incumbents.

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