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Catching-up During Technological Windows of Opportunity: An Industry Product Categories Perspective

ABSTRACT

There is empirical evidence of how challengers in an industry can take advantage of technological discontinuities that open “technological windows” of opportunity, which allow them to reduce their market share gap with market leaders, a phenomenon known as “catching-up.” However, this literature has examined leader–challenger catching-up processes within a particular industry as a whole, without considering the different product categories that can usually be identified within that industry. In fact, firms may have different market shares depending on the category under consideration, and technological discontinuities can be product category related. We extend the literature on windows of opportunity and changes in market leadership and show that the chance a challenger has to reduce the market share gap with the market leader in a product category during a technological window depends on (a) whether the market leader in the focal product category is also the market leader in other product categories, (b) the share of a challenger’s business in the focal product category relative to its overall business in the industry, and (c) the relative size of the product category with respect to the other product categories in the industry. We contend that such across-category factors influence the leaders and challengers’ propensity to exploit opportunities resulting from technological discontinuities in a product category. We test a set of hypotheses using data on 31 mobile phone makers competing in India from 2003 to 2020 in the feature phone and smartphone product categories.

Keywords: catching-up, windows of opportunity, technological discontinuity, market leader, product category.

JEL codes: L11, L63, O33.

1. Introduction

A central issue in strategic management and industry evolution studies is to understand how firms sustain their leadership, dethrone leaders, or close the market share gap between themselves and leaders (Abernathy and Clark, 1985; Christensen and Bower, 1996). Several studies since the mid-1980s have shown that radical changes in a firm's technological environment caused by the introduction of a breakthrough innovation that gradually displaces the old technology, also referred to as a technological discontinuity (Tushman and Anderson, 1986), open technological windows of opportunity (also called simply "technological windows" [Lee and Malerba, 2017; Malerba and Lee, 2021]) for challengers to catch up with the market leader (Ansari and Krop, 2012; Miao, Song, Lee, and Jin, 2018; Park and Lee, 2006). The technological windows of opportunity argument was initially proposed by authors in the technological change literature (e.g., Perez and Soete, 1988) and was based on the idea that technological discontinuities offer challengers "temporary" opportunities to catch up with larger rivals; from there, the idea of a "window" emerged, that is, something that opens (i.e., at the beginning of the technological discontinuity) but will close at a certain point. The concept was that during a period of technological change, challengers have an opportunity to reduce the market share gap with market leaders because the introduction of a new technology that displaces the old one is likely to (1) destroy the value of the knowledge and competences accumulated by firms through the life cycle of the old technology so that every rival, market leaders included, is a "beginner with the new technology" (Christensen and Bower, 1996; Tushman and Anderson, 1986) and (2) weaken the competitive position of those incumbents that continue to rely heavily on the old technology and fail to understand the potential of the new emerging technology (Christensen and Bower, 1996). In fact, firms winning in the old technology are more likely to fall into "competency traps" (Leonard-Barton, 1992; Levitt and March, 1988), in which a firm has difficulty in reconfiguring its resources and capabilities to adapt to the new technology and exploit the opportunities it offers. Levitt and March noted that (1988, p. 328) "a competency trap can occur when favorable performance with an inferior procedure leads an organization to accumulate more

experience with it, thus keeping experience with a superior procedure inadequate to make it rewarding to use.” Such difficulty in exploiting opportunities offered by new technology results in organizational inertia (Tripsas and Gavetti, 2000), that is, a firm’s tendency to continue on its current trajectory. Inertia may arise from a firm’s self-confidence in the use of the old technology, which results in a lack of *attention* to technological discontinuities (Barr, Stimpert, and Huff, 1992; Eggers and Kaplan 2009; Ocasio, 1997; Vuori and Huy, 2016), or from the firm’s fear of cannibalizing revenues and resources related to the old technology, which results in a strong strategic *commitment* to the use of the old technology (Benner and Waldfogel, 2016; Rosenbloom and Christensen, 1994; Sull et al., 1997).

Previous studies on technological windows have identified various firm-level factors that may cause a firm to fail to exploit the opportunities arising from a technological discontinuity, such as a firm’s size, supply chain relationships, organizational structure, complementary capabilities, and top management characteristics (for a recent comprehensive review on this topic, see Eggers and Park [2018]). The extant literature has provided robust evidence that during pronounced changes in technology, market leaders become the rivals who are more likely to fall into a competency trap and thus lose their leadership position. However, this literature has focused on how market leaders sustain their number one position in an industry as a whole (e.g., see Lee and Malerba [2017] for a special issue on this topic and Ansari and Krop [2012] for a review of studies on the incumbent–challenger dynamics), without considering the different technological discontinuities that may occur and the market leadership that firms may have in the various product categories that exist within an industry. We use the term “categories” to refer to socially constructed partitions or taxonomies that divide the social space into groupings of objects – products in our case – that are perceived to be similar in terms of certain parameters (Negro, Hannan, and Rao, 2011). Specifically, a product category refers to a group of products that are substitutes (albeit imperfectly) for one another in terms of certain features, for example, functionalities and esthetic elements (Ethiraj and Zhu, 2008). In fact, there are usually multiple categories of products within an industry,

and firms do not necessarily compete in all of them (Suarez, Grodal, and Gotsopoulos, 2015). In technology-intensive industries, products belonging to different categories present marked differences in terms of the technologies they incorporate, and this results in different functionalities and performance. For example, cars can be categorized based on engine type, thereby distinguishing between electric and fuel vehicles (Bohnsack, Pinkse, and Kolk, 2014). Printing machines can be categorized in terms of their printing technology, which mainly distinguishes between digital printers and ink-jet printers (Clymer and Asaba, 2008). Wristwatches can be categorized based on their display type, thereby distinguishing between analog and digital types (Stephens and Dennis, 2000). Medical diagnostic imaging products can be categorized based on their scanning technology, such as nuclear medical, ultrasonic, computed tomographic, magnetic resonance, and digital radiographic products (Mitchell, 1991). Likewise, mobile phones are usually categorized as feature phones and smartphones depending on whether they are equipped with a basic or advanced operating system (Giachetti and Marchi, 2017). In all these industry cases, some key facts can be observed: (a) different product categories within an industry coexist over time; (b) competing in different product categories within an industry implies that the firm needs to adopt different technologies; and (c) industry rivals may have very different market shares depending on the product category in which they compete. If an industry is formed by coexisting product categories, this means that technological discontinuities can be product category related and thus may occur in the different product categories at different points in time so that a technological window in a product category is not necessarily accompanied by technological windows in the other product categories. However, the literature lacks an analysis of product category-level technological discontinuities and related changes in leadership among rivals within a product category. We address this gap by developing several hypotheses about leader–challenger dynamics in industry product categories.

We draw from the literature on windows of opportunity (e.g., Lee and Malerba, 2017) and studies on the effect that managerial attention and strategic commitment have on the way a firm

responds to technological discontinuities (e.g., Eggers and Kaplan, 2009; Maula, Keil, and Zahra, 2013; Rosenbloom and Christensen, 1994), and contend that the chance a challenger has to reduce the market share gap with the market leader in a product category during technological windows depends on across-category factors related to the market leader, the challenger, and the product category itself. More specifically, first, we examine whether the rate of market share gap erosion between the market leader and a challenger in a product category – that is, the extent to which the gap in market shares narrows between the two firms from one period to another – is greater during technological windows in that product category. Second, we examine how the effect of technological windows on market share gap erosion is shaped by: (a) the fact that the category leader is also a market leader in the other product categories in the industry; (b) the share of a challenger’s business in a focal product category (i.e., its sales in a product category relative to its total sales); and (c) the relative size of a product category in an industry with respect to the other product categories in that industry. We contend that each of these three factors may cause the leader or the challenger in a product category to have a “myopic” perspective in facing technological discontinuities (Christensen and Bower, 1996), thereby guiding their attention and strategic commitment either to or away from the related opportunities so as to affect their market share performance. We test our hypotheses in the context of the Indian mobile phone industry using data from 31 mobile phone makers (i.e., those firms that market handsets under their brand name) from 2003 to 2020 in the feature phone and smartphone product categories.

2. Theory and Hypotheses

2.1. Technological windows in a product category and market share gap erosion

Catching-up has been described as the process in which gaps in market shares between leading firms and smaller rivals are closed (Lee and Malerba, 2017). Authors have argued that catching-up opportunities are particularly relevant during periods of radical technological change. In this sense, technological discontinuities open technological windows of opportunity for challengers (Park and Lee, 2006; Perez and Soete, 1988) since the discontinuities change a firm’s

technological environment and require the firm and its rivals, market leaders included, to reconfigure their resources and capabilities or to markedly change their strategic behavior in order to adopt the emerging technology (Henderson, 2006; Leonard-Barton, 1992). In some cases, the large incumbents ultimately respond successfully to new technologies (Bergek et al., 2013; Tripsas, 1997), but most of the time such technological shifts have disastrous consequences for larger firms, the market leaders in particular, which are often the least willing to adapt to technological discontinuities. This results in a situation in which market leaders are often slower than smaller competitors in reconfiguring their capabilities to exploit the opportunities offered by the new, emerging technology (Henderson and Clark, 1990), and thus are less effective when retaliating against rivals (Giachetti and Li Pira, 2022). There are two main reasons for this. First, there are psychological factors related to the market leader's *attention* to technological changes, namely the extent to which it is aware of problems and opportunities related to such changes: larger firms are more likely to pay attention to products and technologies with which they are familiar in competitive arenas in which they dominate and, thus, be overly confident that alternative technological trajectories should be ignored because they do not bring any further opportunity to their current market dominance (e.g., Eggers and Kaplan, 2009). Second, market leaders have a strong strategic *commitment* to capitalize on the resources they have invested in those products and technologies that helped them to become dominant, which are assets usually difficult to reverse (Ghemawat, 1991), and so are more reluctant to invest in new technologies for the fear of having to cannibalize their existing resources and performance (e.g., Rosenbloom and Christensen, 1994). Such a myopic view drives the market leader's interest away from the opportunities offered by radical innovations, often resulting in their dethronement (Abernathy and Clark, 1985; Chandy and Tellis, 2000; Christensen and Rosenbloom, 1995).

Although the existing literature has greatly enriched our understanding of how technological discontinuities may represent opportunities for challengers to catch up, it has treated technological discontinuities as shocks that affect the industry as a whole, while such discontinuities may be

related only to one or some of the product categories of the industry, and thus, a firm's market share performance may markedly change depending on the product category under consideration. In other words, previous studies on windows of opportunity have examined how the introduction of radical innovations in an industry affects the market shares of rivals in the entire industry at the worldwide level or in specific countries without examining market share evolution in the different product categories within an industry. For example, technological windows and changes in market leadership have been examined in the global mobile phone industry (Giachetti and Marchi, 2017), the global steel industry (Lee and Ki, 2017), the global camera industry (Kang and Song, 2017), the global memory chip industry (Shin, 2017), the Chinese mobile communication industry (Li, Capone, and Malerba, 2019), and in Brazil's forestry and pulp industry (Figueiredo and Cohen, 2019). However, evidence from scholars and industry experts seems to suggest that (a) technological discontinuities can be product category related and thus affect the market share of firms competing in that product category, and (b) product categories may coexist with other product categories within the same industry. For example, Lawless and Anderson (1996) found evidence of the coexistence of product categories in the U.S. microcomputer industry during the 1980s as well as the occurrence of different category-related technological discontinuities. Eggers (2014) found that in flat panel displays, technological discontinuities occurred both in the plasma and LCD product categories which had coexisted for years. Nair and Ahlstrom (2003) showed the occurrence of different technological discontinuities in coexisting product categories in steel-making and kidney disease treatment industries. In the wristwatch industry, technological discontinuities in the analog (Glasmeier, 1991) and digital (Stephens and Dennis, 2000) display categories occurred at different points in time, and the two product categories never stopped coexisting over time. In the medical diagnostic imaging industry, after the introduction of conventional x-ray and electrodiagnostic, "beginning in the early 1950s, several distinct technical subfields [...] emerged [...] and coexisted (Mitchell, 1991, p. 89). In the US bicycle industry, for a period of about thirty years from the end of the 19th century to the beginning of the 20th century, a large variety of

bicycle categories coexisted, some of which went through radical innovations that determined the survival of some manufacturers and caused the exit of others (Dowell and Swaminathan, 2000). In the mobile phone industry, especially in developing economies like India and many African countries, industry experts have observed a long coexistence of two product categories, that is, phones with basic multimedia capabilities and the more advanced smartphones, both of which experience category-level technological discontinuities caused by the introduction of radical innovations in their operating systems (Mishra, 2019). We thus contend that to better understand catching-up processes during windows of opportunity, the analysis should be conducted at the product category level, especially in those cases in which a technological discontinuity is strictly related to a product category and thus offers windows of opportunities for challengers to catch up with market leaders in that specific product category. That is why we will refer to “technological windows in a product category.”

All other things being equal, we expect a technological discontinuity in a product category to open a window of opportunity for challengers in that product category, thus increasing their chance to catch up with the product category leader. Therefore, we offer the following baseline hypothesis, which we include for theoretical completeness rather than for its original contribution.

Baseline expectation: *All other things being equal, the rate of market share gap erosion between the market leader and challengers in a product category of an industry is greater during technological windows in that product category.*

2.2. Market leadership in multiple product categories of the industry: the role of the market leader's attention

In this section, we ask whether the likelihood that a market leader in a product category will fall into competency traps and then lose its market share gap with respect to a challenger is dependent on the extent to which the category leader is also the market leader in other product categories, a factor that – we argue – is likely to distract the category leader's *attention* from the opportunities offered by technological discontinuities in that product category. We build this

hypothesis by drawing on a growing body of studies that highlight the important role of managerial attention in developing effective organizational responses to technological discontinuities (e.g., Barr et al., 1992; Kaplan, Murray, and Henderson, 2003). Organizational attention is defined as “the distinct focus of time and effort by the firm on a particular set of issues, problems, opportunities, and threats and on a particular set of skills, routines, programs, projects, and procedures” (Ocasio 1997, p. 188). Authors in this field suggest that an incumbent’s degree of responsiveness to technological discontinuities is shaped by how much attention its managers pay to technological discontinuities (Daft and Weick, 1984) and how they translate this cognition into effective strategic action (Bourgeois and Eisenhardt, 1988) to reconfigure their capabilities (Henderson and Clark, 1990). These studies argue that when technology radically changes, an incumbent’s attention allocation processes are central to determining the effectiveness of an incumbent’s response to such changes (Eggers and Kaplan 2009). An incumbent’s weak attention to technological discontinuities will refrain it from reconfiguring its capabilities to exploit the opportunities offered by the new technology, and then from defending its competitive position (Henderson and Clark, 1990). Factors that distract an incumbent’s attention from radical changes in the technological environment become sources of organizational inertia that are likely to lead to the incumbent’s failure (Christensen and Bower, 1996; Henderson and Clark, 1990). As we discussed when deriving our baseline expectation, due to their dominant position, market leaders tend to be self-confident in the use of the old technology, and a firm’s self-confidence in the use of the old technology usually results in a lack of attention to technological discontinuities, which in turn slows down its capability reconfiguration process.

Previous studies have provided ample evidence that managers of incumbents usually focus their attention on information from familiar factors within their industry as a whole, such as their existing competition (Peteraf and Shanley, 1997; Porac et al., 1995) or inter-organizational relationships (Maula et al., 2013). However, although managers often interpret information using knowledge categories based on past experiences (Leonard-Barton, 1992), technological

discontinuities are often based on knowledge that is distant from the incumbent's existing knowledge base (Kaplan and Tripsas, 2008) and, therefore, may lead to strategic decisions that directly contradict the experiences of an incumbent (Kaplan et al., 2003; Tripsas and Gavetti, 2000). As a result, the opportunities which derive from such technological discontinuities are often misinterpreted by incumbents.

These studies have enriched our understanding of how factors, such as an incumbent's size, previous experience, the composition of its top management team, the CEO's future orientation, and inter-organizational relationships, influence its attention to technological discontinuities. However, these studies have first assumed that incumbents have the same profile (e.g., in terms of market share, experience, CEO, and top management team orientation), and then "self-confident attitude", in all the different product categories in which an industry can be segmented, even though an incumbent's competitive position may significantly change depending on the product categories within an industry (Suarez et al., 2015). Second, these studies have not considered that technological windows may open in different product categories within the industry, and thus, the way an incumbent will respond to such windows depends on the profile (self-confident attitude) it has both in the product category in which the technological window has opened and in the other product categories in which it competes. Therefore, we should expect that certain characteristics of an incumbent that may cause a lack of attention to technological changes in a product category – like its market leadership (as predicted in our baseline expectation) – can lead to inertia, and the incumbent's lack of attention might be aggravated if its inertial behavior is reinforced by similar "inertia-fostering" characteristics in the other product categories in which it competes.

We contend that an important element that limits a market leader's attention to a technological window that opens in a product category is whether the market leader for the product category is also a market leader in other product categories, which would then represent a source of organizational inertia that, in turn, is detrimental for the market leader's performance in the focal product category. This is because when a technological window opens in that product category, the

category leader's confidence in the use of old products and technologies will be reinforced by the self-confident attitude the category leader holds in the other categories in which it dominates. We thus expect that the leader's likelihood of falling into a competency trap increases if it also holds a leadership position in other product categories within an industry. More specifically, this means that if the leader in a focal product category in which a technological window is open is also the leader in other product categories of an industry, then there are two additive factors that weaken its attention on the opportunities offered by the emerging technology in that focal product category, namely: (1) its leadership in that focal product category (as described in the baseline expectation) and (2) its leadership in other product categories. In other words, the self-confidence in the use of familiar technologies and the reluctance to change that the focal category leader cumulates in the other product categories in which it holds market leadership positions are transferred to the focal product category, making the leader less responsive to opportunities offered by technological changes in that category. By contrast, a category leader that does not hold leadership positions in other product categories navigates industry dynamics also with the eyes of a challenger, and so it is more aware of the importance of finding opportunities to catch up with larger rivals (in those product categories where it does not hold number one positions), and thus will be quicker in reconfiguring its capabilities during technological windows. Although it is reasonable to assume that the higher the *number* of product categories in which a firm holds market leadership positions, the greater the likelihood it will fall into a competency trap, we do not theorize on this component and treat multicategory leadership as a dichotomous construct. This is also consistent with the empirical analysis we will present later in the paper, which uses as a setting an industry with only two product categories. Following these arguments, we offer the following hypothesis:

Hypothesis 1: *The rate of market share gap erosion between the market leader and challengers in a focal product category during technological windows is greater if the market leader in that product category is also the market leader in other product categories of that industry (instead of being the market leader only in that focal product category).*

2.3. *The share of a challenger's business in a focal product category: the role of a challenger's commitment*

In this section, we examine whether, and how, the share that a certain focal product category represents for the overall business of a firm – that is, the firm's sales in a product category relative to its total sales in the industry – can translate into a facilitating or hindering factor in the ability of the firm to reach the category leader when a technological window opens in that focal category.

Previous studies have noted that a firm's reactivity to environmental change can be influenced by its strategic *commitment*, defined as a set of decisions that have long-term impact and are difficult to reverse (Ghemawat, 1991; Rosenbloom and Christensen, 1994). The strategic commitment of a firm to an existing technology is often determined by the revenue the firm generates from sales of that technology or by the investments it has made to develop it. Authors have noted that the greater a firm commitment to an existing technology, the less capable it is of changing strategies to one that better suits a new technology (Rosenbloom and Christensen, 1994) and the greater its propensity to stick to the status quo (Benner and Waldfoegel, 2016; Sull et al., 1997). The inertial effects of commitment are often caused by a firm's fear of cannibalization of the revenues obtained from (or the investments made in) the existing technology, and thus the perceived risk that the new technology will reduce the value of its existing resources (Chandy and Tellis, 2000).

We contend that the greater a challenger's focus on a product category, the greater its commitment to maintaining the status quo, and the lower the likelihood it will be willing to reconfigure its resources and capabilities in that product category during a period of technological change. This is because the making of investment mistakes in the reconfiguration of the assets a challenger holds in a product category that is a large share of its business would put the stability of its performance at stake and thus compromise its survival. Therefore, the challenger itself may have a "myopic" perspective in facing technological innovation (Christensen and Bower, 1996) if the

technological change occurs in a product category that represents a large share of its business. Thus, we posit:

Hypothesis 2: *The greater the share of a challenger's business in a focal product category in an industry relative to its overall business in that industry, the lower the rate of market share gap erosion between the market leader and the challenger in that product category during technological windows.*

2.4. The relative size of a product category in an industry: the role of the market leader's stakeholder attention

The relative size of a product category in an industry represents the degree of product category dominance (Suarez et al., 2015). Within an industry, different product categories of different sizes may coexist, with the relative size of a product category given by the aggregate sales of products belonging to the category relative to the sales generated by the whole industry. The product category with the largest size is often the dominant category. “The dominant category is a socio-cognitive construct that is triggered primarily by the need of stakeholders to communicate meaningfully with other stakeholders regarding their activities [...]. Successful categories facilitate information exchange between disparate parties [...] and attract the attention of stakeholders” (Suarez et al., 2015, p. 440). In fact, since the bulk of an industry's revenue is generated by its larger product categories, usually, such categories are more discussed in the media, and are subject to greater scrutiny by industry experts and business analysts, which are likely to publish a wide variety of information that are at the disposal of a firm's stakeholders (Bednar, Boivie, and Prince, 2013). In other words, dominant categories make easier the exchange of information between the various actors within an industry value chain – e.g., clients, suppliers, investors, and government agencies – by conveying and strengthening the awareness of the attractiveness of the category relative to the other categories.

Authors have noted that the greater the size of a product category in which a firm competes relative to the other categories in the industry, the greater the *attention of a firm's stakeholders* on

how the firm makes decisions (e.g., uses its resources) to sustain its performance (Navis and Glynn, 2010). Smaller categories are less likely to capture the attention of stakeholders of a firm competing in such categories, and such stakeholders are then less likely to monitor the strategic conduct and the performance of a firm (Bingham and Kahl, 2013). Under this circumstance, we contend that a market leader of a large product category will have its strategic decisions scrutinized by a wide variety of stakeholders at all levels of the value chain, and thus will inevitably have to make technology adoption decisions by sharing ideas with stakeholders. This is because the market leader accounts for the bulk of a category's revenue and thus huge losses for the market leader in a dominant category might also represent huge losses for its stakeholders, such as shareholders, component suppliers, and distributors. We thus expect that this scenario puts the market leader of a large product category in a situation in which it will respond to technological changes in that category promptly, making the catching-up process more difficult for challengers. By contrast, a market leader of a small category competes in an environment that has not yet captured (or captured only in the past if the category was large in the past) the attention of a large audience of stakeholders. With this lack of stakeholder support (attention) in strategic decision-making, the market leader is more likely to miss the opportunity offered by technological windows and fall into the competency trap. Consequently, we posit:

Hypothesis 3: *The greater the relative size of a product category in an industry with respect to the other product categories of that industry, the lower the rate of market share gap erosion between the market leader and challengers in that product category during technological windows.*

3. **Methods**

3.1. *Setting and sample*

We tested our hypotheses using a sample of 31 mobile phone makers –i.e., firms introducing their own branded mobile phones (Giachetti and Marchi, 2017; Klingebiel and Joseph, 2016)– competing in the Indian mobile phone industry from 2003 to 2020. Notable examples of mobile

phone makers are Samsung and LG of South Korea, the US-based Apple, Sony of Japan, Xiaomi of China, and the Indian firms Micromax, Karbonn, and Reliance Jio.¹ Table 1 provides the full list of firms included in our sample. Not all 31 firms were operative in India at the beginning of our observation period, and some of them exited the Indian market before 2020, thus leading to an unbalanced panel. Throughout our observation period, the aggregate annual market shares of our sampled firms covered, with few exceptions in some years, more than 90% of units sold in India.

Please insert Table 1 about here

The Indian mobile phone industry offers an interesting setting for us to test our hypotheses for several reasons. First, over the last decade, the industry has been described as the second fastest-growing electronic market in the world after China (Pathak, Shah, and Richardson, 2018). In 2003, only 18 million mobile phones were sold in India with a mobile phone penetration rate (i.e., number of handsets per hundred inhabitants) of 3%, while in 2020, nearly 240 million units were sold with a mobile phone penetration rate of about 84%. This means that within our observation period, we are capturing most of the entire life cycle of the industry from introduction to maturity.

Second, the mobile phone industry is characterized by two clearly distinct product categories, namely feature phones and smartphones. Feature phones are relatively cheap mobile phones capable of providing basic multimedia functionalities, while smartphones are more expensive mobile phones that mount an advanced operating system (OS) which gives the device PC-like capabilities, for example, to download applications. While the first smartphones were introduced in developed economies in the late 1990s by Nokia (Giachetti and Marchi, 2017),² the

¹ It is worth noting that, as highlighted by previous studies (Giachetti and Marchi, 2010), firms in the mobile phone industry that market handsets under their brand name, which some authors have called “branded handset producers” (Alcácer and Oxley, 2014), cut across a wide variety of different kinds of player, which are also involved in activities at different levels of the supply chain. For example, in addition to marketing handsets under their brand name, some firms are (or were) also directly involved in the design of handsets and/or own production plants (e.g., Samsung, Nokia, Motorola, Huawei). Also, some network operators (e.g., Vodafone, Reliance Jio) market handsets under their brand name, as well as suppliers of components such as camera modules, microchips, software, and operating systems (e.g., Sony, Google, Microsoft). All these players are able to operate as “mobile phone makers”, regardless of the supply chain activities in which they were involved before the product commercialization to end users.

² Although many industry experts consider the handset maker Nokia to be the pioneer in the smartphone category, with its line of Nokia Communicators and Symbian OS phones introduced in the late 1990s and early 2000s, a very first

first smartphones in India were launched in 2005. Handset makers in India were not uniform in their positioning within these two categories with some firms competing in both categories while others focused on only one of the two. Throughout our observation period, 17 handset makers in our sample competed (i.e., sold phones) at least for one year in both product categories, nine handset makers competed only in the smartphone category, and five handset makers competed only in the feature phone category.

Third, after the “smartphone revolution” at the end of the 2000s triggered by Apple’s iPhone in 2007 and Google Android OS in 2008 (Giachetti and Marchi, 2017), smartphones quickly replaced feature phones, especially in developed economies. However, in developing economies like India and most African countries, these two product categories have coexisted for a significant number of years and are still coexisting thanks to the affordable price of feature phones. As shown in Figure 1, in 2018, India’s feature phones still captured a larger percentage of mobile phone users (52%) than smartphones (48%). In the subsequent years (i.e., 2019 and 2020), the share of the feature phone category decreased. As can be observed in Figure 1, sales of smartphones in India decreased for the first time in 2020 when the COVID-19 pandemic hit the global economy.

Fourth, over our observation period, we have observed changes in both product categories in market leadership positions among handset makers. Specifically, in the feature phone category, Nokia was the leader from 2003 to 2013, it was overtaken by Samsung from 2014 to 2017, which was overtaken by the Indian handset maker Reliance Jio in 2018; Reliance Jio was then overtaken by Samsung in 2019, which was finally dethroned by the Chinese handset maker Transsion in 2020. In the smartphone category, Nokia was the leader from 2005 (when the first smartphones were introduced in India) and was dethroned in 2012 by Samsung, which was then overtaken by the

attempt to market a phone with PC-like capabilities was made by IBM in the first half of the 1990s. IBM’s “Simon” was launched in 1994. It had an operating system capable to support images and icons, as well as basic applications accessible by means of a rudimentary touchscreen. Moreover, the user could plug into the phone different PC cards, which would expand the phone’s functionality, similar to the way apps expand smartphone functionality today.

Chinese handset maker Xiaomi in 2018, the handset maker that was still the leader at the end of our observation period (i.e., 2020).

Fifth, the Indian mobile industry was characterized by two technological discontinuities that opened up windows of opportunity for challengers to catch up in the smartphone and feature phone categories, respectively: the launch of Android OS in the smartphone category in 2009 and the launch of KaiOS in the feature phone category in 2017. As for the smartphone category, prior to 2009, smartphones were a niche and were mainly targeted at corporate clients. Operating systems like Nokia's Symbian OS and Microsoft's Windows Mobile were not user-friendly, constraining the growth of the smartphone category. However, Apple in 2007 introduced a new concept for the smartphone, the iPhone, which was first launched in India in 2008. The iPhone with its advanced operating system iOS allowed the user to access many more applications than did the existing competing OS, and it was optimized for multitouch displays that offered greater usability. Apple's iOS was proprietary and not licensed to any competing mobile phone maker, but in 2008, Google introduced its advanced operating system, Android, which was first available in India in 2009. Android created a window of opportunity for handset makers because it was similar to iOS but was open-source and licensed (almost) for free to all handset makers that wanted it to be mounted on their devices. Android by 2010 (only three years after its introduction) was installed in nearly 25% of smartphones sold at the worldwide level (Giachetti and Marchi, 2017). In 2011, nearly 50% of smartphones were Android-based. Android gave a great boost to the diffusion of smartphones and worldwide sales surpassed sales of feature phones in 2013 for the first time. In 2011, the former CEO of Nokia, Stephen Elop, stated in an internal memo sent to employees (Singh, 2018):

“Apple disrupted the market by redefining the smartphone [...] And then, there is Android [...]

Google has become a gravitational force, drawing much of the industry's innovation to its core.”

Regarding the feature phone category, the main technological discontinuity we observed was the introduction of KaiOS in 2017, a lightweight operating system with a user interface optimized for feature phones' basic hardware. KaiOS was developed by KaiOS Technologies Inc. which is based

in California. KaiOS allows feature phone users to perform functionalities that previously were not available on such cheap phones, such as surfing the Internet and downloading basic applications (Shah, 2018). KaiOS runs on a web-based platform which makes application downloads unnecessary in the phone memory storage. The main selling point of this OS is thus its low memory requirement. KaiOS is a proprietary operating system, and its developers partnered with mobile phone manufacturers interested in having this OS on their devices in order to offer customized versions of the OS. The main difference, when compared to advanced operating systems like iOS and Android, is that KaiOS has quite a few available apps, and some of the same apps available on iOS and Android are also available on KaiOS but only in their basic versions, which means the user cannot do anything too complex. Already in 2019 (only three years after its introduction), KaiOS was installed on nearly 25% of feature phones sold at the worldwide level (Leung, 2019a). The CEO of KaiOS, Sebastian Codeville, stated in an interview in 2019 (Leung, 2019b):

“The majority of people who get a KaiOS-powered phone are going online for the first time. Life helps them find digital content and services that are relevant, genuinely useful, and will make their lives easier.”

Please insert Figure 1 about here

3.2. *Dependent variable*

Market share gap erosion. Our dependent variable captures the extent to which a challenger gets closer to the market leader in terms of market share (that is, reduces the market share gap) in the Indian market, while distinguishing between market share gap erosion in the feature phone and smartphone categories. Following Ferrier, Smith, and Grimm (1999), we computed market share gap erosion by calculating the market shares of market leaders and challengers in both product categories using data on their units sold which was primarily collected from the business intelligence providers Counterpoint Research, International Data Corporation (IDC) and Euromonitor and then triangulated with further information we found in business magazines

collected using LexisNexis.³ Next, we computed the market share gap for each challenger with respect to the market leader in a given product category and in a given year by taking the difference of the logarithm of the two firms' market shares, as follows:

$$Gap = \ln(MS_{leader}) - \ln(MS_{challenger})$$

Where MS_{leader} is the market share of the leader in a product category and $MS_{challenger}$ is the market share of the challenger in the same product category.⁴ We then measured the rate of erosion of the market share gap as a change in the market share gap from year to year, as follows:

$$Erosion = (Gap_{t-1} - Gap_t)$$

Positive values of the variable indicate a narrowing (i.e., erosion of) market share gap between the leader and the challenger, while negative values reflect an increasing gap.

3.3. Independent variables

Technological window. We measured the occurrence of a technological window in a product category by first identifying all the technological changes that happened in both product categories from 2003 to 2020. The two radical innovations we observed were Android in the smartphone category in 2009 and KaiOS in the feature phone category in 2017. Technological changes open windows of opportunities for firms to adopt new technology, but the likelihood of gaining an advantage with new technology diminishes over time, as the technological window progressively closes (Lee and Malerba, 2017). This is because the more evident the superiority of the new technology becomes in the eyes of all the players within the industry to the point at which the new technology becomes the new dominant design (i.e., most rivals adopt it), the lesser the possibility the focal firm will have to obtain a differentiation advantage over the late adopters (e.g., the market

³ We selected a number of keywords to conduct our search in LexisNexis. Moreover, LexisNexis provides several filters at the "industry-" and "geography-" levels that served us to orient our search toward articles related to our topic. LexisNexis searches all English and non-English published news (covered by the search engine). Although the majority of articles we found were in English, non-English articles were found by LexisNexis using the English keywords that we employed, and they were translated into English using LexisNexis's automated translation feature.

⁴ A firm's market share may range from 0 to 1, with 1 = 100%. When a challenger had zero units sold in a category, it was assumed as not being operative in that category, and so its market share gap with respect to the leader was not computed.

leader) that were the victims of the competency trap. Therefore, our technological window variable was calculated through a clock measure which was built on measures of technological discontinuity as proposed in previous empirical studies (e.g., Amburgey, Kelly, and Barnett, 1993). The variable takes the value of 0 until the occurrence of the event – that is, the introduction of a radical innovation in a product category opening a window of opportunity – when the variable takes the value of 1. Afterward, the variable is measured as $1/n$, where n is the number of years elapsed from the introduction of the radical innovation. In this way, we assumed that the greatest opportunity to catch up to the leader in a product category arose at the beginning of a technological window since it is then that the market leader is more likely to fall into the competency trap (Lee and Malerba, 2017) and miss early-mover opportunities.

Multiproduct category leader. To identify if the leader in a given year in a focal product category is also the leader in other product categories, we used a dummy variable which takes the value 1 if the leader in the focal product category is also the market leader in the other product category and the value 0 otherwise. The mean of this dummy variable was 0.619, meaning that, for about 60% of observations in our sample, when a firm was the leader in a product category it was the leader also in the other product category.

Product category focus. To capture the share of a challenger's business in a product category relative to its overall business, we considered the challenger's units sold in each product category, and we measured the variable by dividing the challenger's units sold in a product category in a given year by the firm's total units sold in both categories in the same year.

Product category relative size. We measured the relative size of a focal product category by dividing the total units sold in a product category by all handset makers in a given year by the total units sold in both product categories by all handset makers in that same year.

3.4. Control variables

3.4.1. Firm-level controls

Consistent with previous studies, we controlled for various factors that may affect a firm's reasons to adapt to technological windows and then affect their performance relative to rivals. First, we controlled for *firm market share* in a focal product category, which is the expression of its relative size and resource endowment (McKendrick and Wade, 2010), as measured by the natural logarithm of a firm's market share in the product category. Since both firms that produce and sell products locally (co-locating) can often benefit from cost advantages, lower import duties, shorter time to market, a better understanding of local consumers, and stronger support from local authorities (Gertler, 1995), we introduced the variable *manufacturing in India*, measured as a dummy variable taking the value of 1 if in a given year a firm's mobile phones sold in India were also produced or assembled in India (in the firm's own plants or in the Indian plants of contract manufacturers) and 0 otherwise. Information on the periods in which firms started (and eventually ended) manufacturing or assembling mobile phones in India was collected from the LexisNexis database and company annual reports. We also wanted to control for whether a mobile phone maker was likely to have advantages deriving from its *country of origin*. The windows of opportunity literature suggests that latecomer firms from developing countries may have cost advantages over established rivals from developed economies which may favor the catching-up process (Lee and Lim, 2001; Lee and Malerba, 2017). At the beginning of the 2000s in the Indian mobile phone industry, both the feature phone and smartphone categories were dominated by developed country-based firms, who localized a relevant part of their value chain activities in their home countries. With respect to developing country-based firms, Chinese handset makers have traditionally based almost their entire manufacturing and R&D activities in China where the key contract manufacturers and component suppliers are also located. In contrast, Indian handset makers are likely to have benefited from a deeper knowledge of local institutions that have traditionally favored local firms by granting easier access to capital (Mudambi, Saranga, and Schotter, 2017). We thus used two dummy variables to control for a firm's country of origin, which takes the value of 1 if a firm's country of origin is China or India and 0 otherwise.

3.4.2. Industry-level controls

Since the rapid growth rate in consumer demand has been shown to create opportunities for challengers to catch up, we controlled for a *category growth rate* by calculating the annual growth rate of aggregate units sold in a product category (Xiang, Soberman, and Gatignon, 2021). Moreover, we introduced *year dummies*, which capture the time dimension and the possible change in market conditions from one year to another (Wooldridge, 2002).

Means, standard deviations (S.D.), and correlations are reported in Table 2.

Please insert Table 2 about here

4. Results

4.1. Hypothesis tests

Our empirical models were estimated using fixed-effects (FE) regression (i.e., with firm fixed-effects) with robust standard errors. The Hausman test suggested that the fixed-effects estimator was preferable to random-effects (RE). Table 3 presents the results of the regression analysis. Model 1 includes only control variables. In Model 2, we added technological window to test the baseline expectation. In Model 3, the moderators were added, that is, multiproduct category leader, product category focus, and product category relative size. Models 4–6 tested one-by-one the three interaction effects between the technological window variable and the three moderators on market share gap erosion. Model 7 presents the full model. In Model 8, we repeated the analysis using a random-effects estimator which allowed us to include the two time-invariant controls related to firms' country of origin. Given the three interaction terms in our regression model, all variables were standardized to prevent multicollinearity (Aiken, West, and Reno, 1991). We calculated variance inflation factors (VIFs) for our full model to determine whether there was a multicollinearity issue in our analysis. The mean VIF score was 3.36 (1.77 excluding year dummies), which was less than the recommended threshold of 10 (Chatterjee and Hadi, 2006).

When the variable technological window was included with only controls ($\beta = -0.059$; $p > 0.1$) in Model 2, and in the full Model 7 that includes all variables ($\beta = 0.037$; $p > 0.1$), its coefficient was never significant. Interestingly, this would mean that all other things being equal, challengers are no more capable of exploiting a technological window of opportunity in a product category than are market leaders. Therefore, our baseline expectation is not supported.

Hypothesis 1 predicts that the variable multiproduct category leader positively moderates the relationship between technological window and market share gap erosion. As shown in Model 7, the estimated coefficient for the interaction is positive and significant ($\beta = 0.169$; $p < 0.05$), thus providing support for Hypothesis 1. To visualize this moderation effect, we plotted the interaction in Figure 2a using the method indicated by Aiken, West, and Reno (1991) as well as the average marginal effects with 90% confidence intervals (CI), as shown in Figure 2b. As can be observed from both figures, when the category leader is the market leader in just the focal category, a technological window in that category can be even beneficial for the category leader relative to challengers. However, the effect of a technological window may turn out to be favorable for challengers if the category leader is also the dominant player in the other category.

Hypothesis 2 predicts that the variable product category focus negatively moderates the relationship between technological window and market share gap erosion. The estimated coefficient for the interaction term is negative as predicted and significant ($\beta = -0.212$; $p < 0.1$). Hence, Hypothesis 2 is supported. The interaction is plotted in Figure 3a and Figure 3b. As can be noted in Figure 3b, the moderating effect is significant for only high values of the (standardized) variable product category focus, meaning that challengers' attempt to catch up during a technological window is constrained only if they are highly focused in that product category.

Hypothesis 3 predicts that the variable product category relative size negatively moderates the relationship between technological window and market share gap erosion. As shown in Model 7, the estimated coefficient for the interaction is negative (as predicted) but insignificant ($\beta = -0.066$, $p > 0.1$). Thus, Hypothesis 3 is not supported. The interaction is plotted in Figures 4a and 4b.

Please insert Table 3, Figure 2a 2b, 3a 3b and 4a 4b about here

Finally, in Model 8 (Table 3), we repeated the full model by using a random-effects regression, which allowed us to add the two time-invariant country of origin controls. As can be observed, results remained consistent with those of Model 7.

4.2. *Additional analyses*

Expanding on the idea of windows of opportunity resulting from technological discontinuities, various studies have progressively extended the concept of the window of opportunity to include changes occurring in market demand and governmental regulations and interventions (e.g., Fuentelsaz, Garrido, and Maicas, 2015; Guennif and Ramani, 2012; Lee and Lim, 2001). Authors have recently called these “demand windows” and “regulatory windows”, respectively (Lee and Malerba, 2017; Malerba and Lee, 2021). A demand window refers to a new form of demand, a significant shift in local demand, or a business cycle. Leaders might not respond to this new demand because they are successful within their existing markets and customers. Regulatory windows are changes determined by public policy interventions or changes in a firm’s institutional environment to which a firm may refuse to adapt, despite the opportunities they offer.

During our observation period, the Indian mobile phone market was characterized by both pronounced changes in the growth rate of demand for mobile phones and important regulatory interventions. We thus wanted to investigate the extent to which a challenger during a technological window in a product category can take advantage of or be hindered by the leader-, challenger-, and category-level factors we presented in our hypotheses as well as whether this depends on the concurrent influence of other types of windows, that is, demand and regulatory windows.

In measuring demand windows, we considered the annual growth rate of the aggregate sales in each product category and distinguished between high and low demand growth, with high growth in demand representing an opportunity for handset makers. In particular, we considered the demand growth in a product category to be “high” when the annual growth rate of the aggregate sales in a

product category was above the median of the growth rate in that category, and “low” otherwise. We thus repeated our analysis of two subsamples, considering only observations with high- and low-demand growth, respectively, which are reported in Table 4 (Models 9 and 10).

Regarding regulatory windows, the Indian government had a significant influence on the development of the mobile phone ecosystem (Bhatia, 2017). The government set up the Make-in-India initiative in 2014 to promote manufacturing in India. It was considered the most important regulatory intervention in the Indian mobile phone industry because it was launched by the government to boost the manufacturing sector to create employment opportunities and to make it simpler and easier to do business. The government through this initiative set very high duties on imported handsets and low duties on locally manufactured handsets (Pathak, 2015). This helped firms in the industry to enjoy some benefits when they invested, produced, or assembled their products in India (Mudambi et al., 2017). We thus repeated the analysis with two subsamples, one considering only those observations related to the 2014–2020 time period, that is, when the Make-in-India was put in place, and another subsample with observations occurring before the Make-in-India initiative (i.e., 2003–2013). These two models are reported in Table 4 (Models 11 and 12).

As can be seen in the fixed-effects regression analysis in Table 4, the results of Models 9 and 11 show that both during a demand window and a regulatory window in a product category, the positive effect of a technological window in a product category on market share gap erosion is significant ($\beta = 0.323$; $p < 0.05$; $\beta = 1.437$; $p < 0.05$), as predicted in our baseline expectation. But when demand growth is low (Model 10), the main effect of the variable technological window is not significant, and in the absence of regulatory windows (Model 12), the main effect of a technological window is even negative. This suggests that technological windows in a product category are likely to result in opportunities for challengers to catch up with market leaders if they occur concurrently with demand or regulatory windows.

When we examined the moderating effect of a multiproduct category leader (Hypothesis 1) for different levels of demand growth, its effect was supported only during high demand growth

(Model 9), that is, during demand windows ($\beta = 0.272$; $p < 0.001$). With regard to the subsample analysis based on regulatory windows, we found such moderator to be significant in both subsamples (Models 11 and 12) with similar levels of significance ($\beta = 0.167$; $p < 0.05$; $\beta = 0.560$; $p < 0.05$).

When we examined the moderating effect of product category focus (Hypothesis 2) for different levels of demand growth, its effect was not supported during demand windows ($\beta = -0.185$; $p > 0.1$), even though the p -value was not that high ($p = 0.192$), nor for low levels of demand growth. In the subsample analysis based on regulatory windows, it was supported only when such windows were open ($\beta = -0.227$; $p < 0.1$), that is, during the Make-in-India initiative. This means that when a technological window occurs concurrently with a demand window, the fact that a challenger holds a great share of its business in the focal product category is not necessarily detrimental to its chance to catch up with the leader. When a technological window occurs concurrently with a regulatory window, a challenger with a great share of its business in the focal product category is likely to have a “myopic” perspective in the face of technological innovation and thus lose market share vis-à-vis the leader.

Finally, the moderating effect of product category relative size was negative and significant during demand windows ($\beta = -2.827$; $p < 0.01$) and regulatory windows ($\beta = -13.790$; $p < 0.05$), and was thus in line with our expectations in Hypothesis 3. This suggests that a product category’s relative size is likely to represent a factor that helps challengers to catch up with market leaders during a technological window in a product category if the technological window occurs concurrently with a demand or a regulatory window.

Overall, the results of these additional analyses suggest that our hypotheses find greater support when demand or regulatory windows in a product category are also opened.

Please insert Table 4 about here

5. Discussion

5.1. *Implications for theory*

The technological change literature has provided strong empirical evidence for the proposition that established incumbents are likely to lose their market share vis-à-vis challengers in the period of ferment following a technological discontinuity (e.g., Fuentelsaz et al., 2015; Henderson, 1993; Leonard-Barton, 1992; Lee and Malerba, 2017; O'Reilly and Tushman, 2008). In what has been termed as incumbent myopia (Christensen and Bower, 1996), authors have shown that market leaders lose their leadership because their organizational inertia (Trispas, 1997; Trispas and Gavetti, 2000) during periods of radical technological change causes them to fall into the competency trap. Nonetheless, to the best of our knowledge, no attempt has previously been made to investigate the phenomena of technological windows of opportunity and changes in market leadership through a product category perspective.

Our study suggests that to better understand whether the opening of technological windows in a focal product category may help challengers to catch up with market leaders, certain leader-, challenger-, and category-level factors need to be considered. More specifically, we predicted that a challenger has a better chance to catch up with a market leader in a product category during a technological window in that category if: (a) the market leader in the focal product category of an industry is also the market leader in other product categories in that industry, (b) the challenger's share of business in the focal product category is low, and (c) the relative size of the product category with respect to the other product categories in the industry is small. Drawing on studies of the role of managerial attention and commitment in developing effective organizational responses to technological discontinuities (e.g., Barr et al., 1992; Bingham and Kahl, 2013; Eggers and Kaplan, 2009; Maula et al., 2013), the mechanisms we discussed to explain how the across-category contingencies shape the relationship between technological windows and market share gap erosion in a product category were related to the market leader's attention, the challenger's commitment, and the attention paid by the shareholders of the market leader to technological discontinuities.

First, our results show that the rate of market share gap erosion between the market leader and challengers in a focal product category during technological windows is greater if the market leader in that product category is also the market leader in other product categories of that industry. We explain this finding by arguing that the market leader's self-confidence in the use of familiar products and technologies and then its aversion to change that accumulates in other product categories in which it maintains market leadership is transferred to the focal product category, making the firm less receptive to technological changes in that category. If the adoption of a breakthrough technology necessitates the development of a completely new knowledge to exploit the opportunities it offers, market leaders are the ones who would have to reorganize the most resources and, hence, are less inclined to assume the risks of investing in new technology that has yet to be validated. Our research adds to the literature on the growing role of managerial attention when it comes to creating successful organizational responses to technological disruptions (Barr et al., 1992; Eggers and Kaplan, 2009; Kaplan et al., 2003) and sheds light on how the market leader's attention and then responsiveness to technological changes (Giachetti and Li Pira, 2022) in a product category can be influenced by its market leadership in other categories within that industry.

Second, our results show that the greater the share of a challenger's business in a focal product category of an industry relative to its overall business in that industry, the lower the rate of market share gap erosion between the market leader and the challenger in that product category during technological windows. This hypothesis theorized on inertia-fostering factors that may constrain a challenger's attempt to catch up. Some previous studies have proposed arguments to refute the universality of an incumbent's decline during technological changes (e.g., Ansari and Krop, 2012; Hill and Rothaermel, 2003; Rosenbloom, 2000; Tripsas, 1997). Consistent with this literature, our results illustrate that not only can leaders fall into competency traps, but also that challengers will likely be reluctant to adopt emerging technologies in a focal product category if the category represents most of their overall business. We explain this finding by drawing on studies of challengers' commitment to the status quo (e.g., Benner and Waldfogel, 2016; Sull et al., 1997).

The idea is that the greater a challenger's share of business in a focal product category in comparison to other product categories in the industry, the greater will be the commitment to that focal product category – and thus, the greater the fear of making investment mistakes by channeling resources into emerging technology in that product category. Our findings complement the existing literature by shedding light on the reason challengers (as opposed to market leaders) may have a myopic perspective in responding to technological discontinuities.

Third, contrary to our predictions, our results show no significant effect from the relative size of a product category in helping the leader to sustain its market share advantage during technological windows. Ex-post, the explanation for this result could be that all other things being equal, the relative size of a focal product category is not a sufficient factor to drive the attention of a firm's stakeholders. In fact, some studies have shown that in the face of high environmental uncertainty, stakeholders of an established incumbent may believe it possesses enough information to understand how the industry will evolve and then alleviate monitoring processes (Benner, 2007). Other studies have noted that stakeholders may even hinder an incumbent's ability to acquire knowledge that is incompatible with the incumbent's current technology, thus obstructing its adaptation to changing technologies (König, Kammerlander, and Enders, 2013). Moreover, in high-tech industries, innovative start-up firms that have stakeholders with a greater risk attitude, which makes them more responsive to technological discontinuities than stakeholders in larger and more consolidated product categories, may sometimes populate small product categories. This would mean that the nature of the business may also influence the attention of a firm's stakeholders.

Lastly, our additional empirical analyses provide the earliest quantitative empirical attempt to examine the joint influence of different types of windows of opportunity – technological windows with demand and regulatory windows – on the rate of market share gap erosion between leaders and challengers in a product category. Although the windows of opportunity literature argues that the occurrence of catching-up between firms or countries is related to the intensity and number of windows of opportunity (e.g., Guennif and Ramani, 2012; Lee and Lim, 2001; Malerba

and Nelson, 2012), the empirical support for this hypothesis was almost exclusively qualitative (e.g., see Lee and Malerba [2017] for a special issue). Overall, the results of our additional analyses show that, first, all else being equal, both demand and regulatory windows improve the opportunity for challengers to catch up with the leader in a product category during technological changes in that product category. And second, the extent to which across-category factors related to the market leader, the challenger, and the product category itself shape a challenger's catching-up process during technological windows is more significant when demand and regulatory windows are also open. Therefore, our additional findings have shed light on the nuances of catching-up processes, not only during technological windows in product categories but also under the concurrency of technological windows with demand and regulatory windows.

5.2. *Managerial implications*

Our study offers also important implications for practice. First, executives of firms challenging the category leader can use our model to estimate the chance they have to take advantage of a leader's lack of attention towards technological discontinuities in the product category: if the category leader is also the market leader in other categories, it will be slower in adapting to the new, emerging technology, and it is here that managers of rival firms should invest more to reconfigure their capabilities to build a solid differentiation advantage with respect to the market leader. By contrast, if the category leader is not the leader in other product categories, executives of rival firms should expect a stronger and more rapid retaliatory behavior by the category leader, since it is likely to be more aware of the opportunities it must not miss with the new technology, and this, in turn, would constrain rivals' attempt to catch up. In the mobile phone industry, this helps us to shed more light on the reason why, for example, in the early 2010s Nokia lost its number one position in the smartphone category in India, as well as in many other countries. During the smartphone revolution triggered by Android OS, it was the market leader both in the smartphone and feature phone categories, with solid market share gaps with respect to challengers. This created overconfidence in the way Nokia used its capabilities to compete in the smartphone

category, and then a lack of attention towards the opportunities offered by Android, which was for free to all phone makers and better performing than Nokia's Symbian OS (Vuori and Huy, 2016).

Second, our results should alert executives of firms that have a large share of their business in a product category, that they run the risk of being overly committed to maintaining the status quo in that product category during a technological window, for the fear of losing an important source of revenues. However, reluctance in capability reconfiguration to adapt to the new, emerging technology, is likely to weaken a firm's sales performance vis-à-vis rivals, the category leader included. For example, at the beginning of the smartphone revolution in India –i.e., in the second half of the 2000s, and early 2010s– challengers like Research in Motion (RIM) and HTC were exclusively focused on the smartphone category. The former refused to substitute its BlackBerry OS with Android, while the latter, despite adopting Android in some of its models, remained overly committed to the high-end of the market, failing to understand how to design Android-based smartphones for a country mainly populated by price-sensitive consumers. By contrast, makers like Micromax, Karbonn, and Celkon in those years kept a significant foothold also in the feature phone category, despite the fast diffusion of smartphone devices, and this allowed them to more effectively understand how to tackle the heterogeneous dynamics the industry was going through and adapt their capabilities to launch Android phones that better fit with the Indian consumers' needs. Interestingly, a “focus strategy” on the smartphone category was more effective when the technological uncertainty around Android was resolved. In fact, one of the reasons handset makers like Xiaomi, Oppo, and Vivo, which entered the Indian market in the mid-2010s (when Android was clearly the dominant design), were able to quickly erode market shares to Samsung, was that they focused all their resources (e.g., marketing, R&D, manufacturing) in the smartphone category.

Third, executives of firms challenging the market leader in a product category should also be aware that the relative size of the product category is an important factor they should consider when organizing their resources to catch up during a technological window. A challenger has a better chance to catch up with the category leader in smaller product categories, because market leaders

are less likely to reconfigure their capabilities in a timely manner in these categories due to the lack of support from their stakeholders in understanding how and whether it is worth adapting to the new, emerging technology in the product category. For example, when Nokia progressively weakened its market share dominance in the smartphone category from the end of the 2000s, the smartphone category in India was still a niche, much smaller than the feature phone category, on which, in that period, the attention of Nokia's stakeholders – like subcontractors, state agencies, regulators, unions, politicians and the company's shareholders – was concentrated (Lindén, 2021).

It is worth noting that executives should be aware that the three across-category contingencies we examined, offer greater opportunities for challengers to catch up when, in addition to technological windows, also demand or regulatory windows are simultaneously opened (see Table 4). For example, demand growth in the smartphone category in India in the 2010s helped Xiaomi to exploit more effectively the opportunities offered by Android. Likewise, the temporary rejuvenation (i.e., high demand growth after a period of slowdown) in the feature phone category between 2016 and 2018 (see Figure 1), helped Reliance Jio to rapidly catch-up with Samsung during the technological shift triggered by KaiOS in India. Similarly, handset makers like Samsung, Vivo, and Xiaomi, leveraged the opportunities of the Make-in-India initiative to navigate more effectively the technological windows. In fact, already in the mid-2010s, they all manufactured and/or assembled in India most of the phones that they sold in the country, unlike competitors like Apple, which had no production facilities in India when the Make-in-India was started.⁵

5.3. *Limitations and suggestions for future research*

Although this study captures important insights on technological windows of opportunity and changes in market leadership with the help of the concept of an industry product category, it has some limitations that suggest opportunities for future research. First, our empirical analysis is based on catching-up dynamics in an emerging market (i.e., India), which may have specific

⁵ Information on handset makers manufacturing strategies were collected mainly from Counterpoint Research.

characteristics that would not be encountered with any frequency in other countries. Therefore, our findings might be validated and further extended using data from other developing countries as well as developed economies.

Second, although the sample data extracted from the Indian mobile phone industry constituted a unique dataset with the classification theme used to identify the two product categories – feature phones and smartphones – widely legitimated by scholars and industry experts, a diverse classification theme (e.g., subcategories within the two categories identified) or an industry with a wider product category range may provide additional insights.

Third, when presenting our theory, we introduced various mechanisms that represent possible explanations for the causal relationships we hypothesized, but – as is usually the case in hypothesis-testing quantitative empirical research – these mechanisms were not measured and tested with our data. We theorized on the contingencies moderating the relationship between technological windows in a product category and a category leader's market share erosion by developing arguments about the market leader's attention, a challenger's strategic commitment, and the market leader's stakeholder attention. Although our additional analyses compared the predicted causal relationships in situations in which the theoretical mechanisms are more likely versus less likely to hold (Bettis et al., 2014), primary data would be required to empirically measure and test these three mechanisms, for example, the use of in-depth interviews with top management teams, which would be very difficult to obtain given the number of firms in our longitudinal panel. Therefore, we hope future studies will test our theory with alternative data collection methods and analyses, such as surveys or multiple case studies.

Fourth, our study does not take into account that mobile phone makers do not operate in isolation, but are often formally involved in joint ventures, joint manufacturing, and marketing agreements, and often outsource the production of key components and the assembling of phones to third-party players with huge market power. These partnerships with actors upstream and downstream of the value chain may help or constrain the way handset makers navigate

technological windows of opportunity in a product category. For example, most mobile phone makers are not vertically integrated firms because they outsource phone assembly to contract manufacturers, phone design and prototyping to original design manufacturers, distribution of phones to telecom carriers by using carriers' retail stores, and the design and production of key hardware and software components to various suppliers. Moreover, depending on the product category, a firm's strategic partners may be different, and the way mobile phone makers partner with such actors upstream and downstream the value chain –for example, the ability to establish exclusive agreements and long-term relationships– may imply the transfer of know-how and learning (Alcácer and Oxley, 2014), which are crucial to successfully navigate uncertain technological environments (Bergek et al., 2013). In fact, the rapid diffusion of iPhone-like smartphones favored by the introduction of Android OS, as well as the rapid diffusion of KaiOS in the feature phone category, changed the way mobile phone makers developed their devices, creating uncertainty on how to manage supply chain relationships in a rapidly evolving technological environment. As noted already more than thirty years ago by Hamel, Doz, and Prahalad (1989, p. 134), “learning from partners is paramount. Successful companies view each alliance as a window on their partners' broad capabilities. They use the alliance to build skills in areas outside the formal agreement and systematically diffuse new knowledge throughout their organizations.” Therefore, we hope that future research will expand our theory by drawing on the vertical integration, strategic alliance, and coopetition literatures to examine further contingencies shaping the relationship between technological windows and catching-up in product categories.

Fifth, our study does not take into account the extent to which a firm –i.e., a challenger and a leader– has accumulated previous knowledge during periods of radical technological changes, i.e., technological windows, as well as periods of technological stability or however incremental technological changes. In fact, the innovations that firms adopt over the industry (and product categories) evolution may have a different degree of “radicalness”, and then trigger different levels of technological uncertainty for leaders and challengers (Henderson and Clark, 1990). Moreover,

although capabilities reconversion during technological windows can be a difficult and slow decision, particularly for market leaders, authors have noted that the knowledge a firm has at a certain point in time is usually the result of a long process of knowledge accumulation. This means that when a technological window opens, usually firms already have a certain experience with technologies, and such experience may be very heterogeneous among firms. Thus, innovation capabilities are built on top of an existing well-defined knowledge set. To survive, firms must find the right capabilities to navigate both technological discontinuities and periods of stability at the same time, constantly blending exploration with exploitation, a capability that authors have named “organizational ambidexterity” (Brunswick and Schecter, 2019; Colombo and Delmastro, 2002; Pufal and Zawislak, 2021). In 1996 (p. 24), Tushman and O'Reilly argued that organizational ambidexterity –defined as “the ability to simultaneously pursue both incremental and discontinuous innovation”– was required for long-term firm survival. Several authors have later noted that in industries in which firms face themselves to navigate –and then need the right capabilities to manage– periods of incremental as well as radical changes, organizational ambidexterity is key to sustaining a firm’s sales and profits (e.g., Lin et al., 2013; O'Reilly and Tushman, 2013). For example, Lin et al. (2013) have shown that firms engaging in high levels of both incremental and radical innovation outperform rivals that undertake only one form of innovation. How a firm’s (and market leaders’) well-balanced experience with product categories characterized by technological stability and product categories that went through technological shifts can affect the firm’s attention towards a technological window when it opens in a product category? Do the effects of the three across-category contingencies we have examined in this study hold both for ambidextrous and non-ambidextrous firms? We hope future studies will respond to these questions, and then expand our theory, by bringing the concept of ambidexterity into the windows of opportunity and catching-up literature.

Finally, future studies may extend our theory by taking a microfoundations perspective which revolves around the role of individuals in driving strategy and performance, by examining

their individual characteristics and decisions (Felin, Foss, and Ployhart, 2015). For example, a firm's different product categories which compete in a country may be managed by a single department within the firm or by personnel belonging to different departments who have different prior experiences with windows of opportunity, technologies, and industries as well as with different levels of autonomy with respect to the superstructure. All these individual-level factors may affect their (and, in turn, the firm's) attention and commitment toward technological shifts and, thus, their ability to exploit technological windows of opportunity.

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References

- Abernathy, W.J. and Clark, K.B., 1985. Innovation: Mapping the winds of creative destruction. *Research Policy*, 14(1), 3–22.
- Alcácer, J., and Oxley, J., 2014. Learning by supplying. *Strategic Management Journal*, 35(2), 204–223.
- Amburgey, T.L., Kelly, D., and Barnett, W., 1993. Resetting the clock: The dynamics of organizational change and failure. *Administrative Science Quarterly*, 38, 51–73.
- Ansari, S.S. and Krop, P., 2012. Incumbent performance in the face of a radical innovation: Towards a framework for incumbent challenger dynamics. *Research Policy*, 41(8), 1357–1374.
- Barr, P.S., Stimpert, J.L. and Huff, A.S., 1992. Cognitive change, strategic action, and organizational renewal. *Strategic Management Journal*, Summer Special Issue 13, 15–36.
- Bednar, M. K., Boivie, S., and Prince, N. R., 2013. Burr under the saddle: How media coverage influences strategic change. *Organization Science*, 24(3), 910–925.
- Benner, M.J., 2007. The incumbent discount: Stock market categories and response to radical technological change. *Academy of Management Review*, 32(3), 703–720.
- Benner, M.J., and Waldfoegel, J., 2016. The song remains the same? Technological change and positioning in the recorded music industry. *Strategy Science*, 1(3), 129–147.
- Bergek A, Berggren C, Magnusson T, and Hobday M., 2013. Technological discontinuities and the challenge for incumbent firms: Destruction, disruption or creative accumulation? *Research Policy*, 42, 1210–1224.
- Bettis, R., Gambardella, A., Helfat, C., and Mitchell, W., 2014. Quantitative empirical analysis in strategic management. *Strategic Management Journal*, 35, 949–953.
- Bhatia, H., 2017. 'Make in India' to 'Design in India' - Leaders' insight on successful transition strategies. Counterpoint. <https://www.counterpointresearch.com/make-india-design-india-industry-leaders-insights-successful-transition-strategies/> [Assessed 1 Oct. 2021].
- Bingham, C.B. and Kahl, S.J., 2013. The process of schema emergence: Assimilation, deconstruction, unitization, and the plurality of analogies. *Academy of Management Journal*, 56(1), 14–34.
- Bohnsack, R., Pinkse, J., and Kolk, A. 2014. Business models for sustainable technologies: Exploring business model evolution in the case of electric vehicles. *Research Policy*, 43(2), 284–300.
- Bourgeois, L.J. III and Eisenhardt, K.M., 1988. Strategic decision processes in high velocity environments. *Management Science*, 34(7), 816–835.
- Brunswick, S. Schechter, A. 2019. Coherence or flexibility? The paradox of change for developers' digital innovation trajectory on open platforms. *Research Policy*, 48(8), published online.
- Chandy, R.K. and Tellis, G.J., 2000. The incumbent's curse? Incumbency, size, and radical product innovation. *Journal of Marketing*, 64(3), 1–17.
- Chatterjee, S. and Hadi A.S. 2006. *Analysis of Collinear Data. Regression Analysis by Example*, 4th edn. Chichester: Wiley.
- Christensen, C.M., and Bower, J.L., 1996. Customer power, strategic investment, and the failure of leading firms. *Strategic Management Journal*, 17(3), 197–218.
- Christensen, C.M., and Rosenbloom, R.S., 1995. Explaining the attacker's advantage: Technological paradigms, organizational dynamics, and the value network. *Research Policy*, 24(2), 233–257.
- Clymer, N. and Asaba, S., 2008. A new approach for understanding dominant design: The case of the ink-jet printer. *Journal of Engineering and Technology Management*, 25(3), 137–156.
- Colombo, M. G. and Delmastro, M. 2002. How effective are technology incubators? Evidence from Italy. *Research Policy*, 31(7), 1103–1122.

- Daft, R.L. and Weick, K.E., 1984. Toward a model of organizations as interpretation systems. *Academy of Management Review*, 9(2), 284–295.
- Dowell, G., and Swaminathan, A. 2000. Racing and back-peddalling into the future: New product introduction and organizational mortality in the US bicycle industry, 1880-1918. *Organization Studies*, 21(2), 405–431.
- Eggers, J.P., 2014. Competing technologies and industry evolution: The benefits of making mistakes in the flat panel display industry. *Strategic Management Journal*, 35(2), 159–178.
- Eggers, J.P. and Kaplan, S., 2009. Cognition and renewal: Comparing CEO and organizational effects on incumbent adaptation to technical change. *Organization Science*, 20(2), 461–477.
- Eggers, J.P. and Park K.F., 2018. Incumbent adaptation to technological change: The past, present, and future of research on heterogeneous incumbent response. *Academy of Management Annals*, 12(1), 357–389.
- Ethiraj, S.K., and Zhu, D.H., 2008. Performance effects of imitative entry. *Strategic Management Journal*, 29(8), 797–817.
- Felin, T., Foss, N.J., and Ployhart, R.E. (2015). The microfoundations movement in strategy and organization theory. *Academy of Management Annals*, 9(1), 575–632.
- Ferrier, W.J., Smith, K.G., and Grimm, C.M., 1999. The role of competitive action in market share erosion and industry dethronement: A study of industry leaders and challengers. *Academy of Management Journal*, 42(4), 372–388.
- Figueiredo, P.N., and Cohen, M., 2019. Explaining early entry into path-creation technological catch-up in the forestry and pulp industry: Evidence from Brazil. *Research Policy*, 48(7), 1694–1713.
- Fuentelsaz, L., Garrido, E. and Maicas, J.P., 2015. Incumbents, technological change and institutions: How the value of complementary resources varies across markets. *Strategic Management Journal*, 36(12), 1778–1801.
- Gertler, M.S., 1995. 'Being there': Proximity, organization, and culture in the development and adoption of advanced manufacturing technologies. *Economic Geography*, 71, 1–26.
- Ghemawat, P., 1991. *Commitment: The Dynamic of Strategy*. The Free Press, New York.
- Giachetti, C., and Li, Pira S., 2022. Catching up with the market leader: Does it pay to rapidly imitate its innovations? *Research Policy*, 51(5), 1-14 Published online March 2022.
- Giachetti, C., and Marchi, G., 2010. Evolution of firms' product strategy over the life cycle of technology-based industries: A case study of the global mobile phone industry, 1980 – 2009. *Business History*, 52(7), 1123-1150.
- Giachetti, C. and Marchi, G., 2017. Successive changes in leadership in the worldwide mobile phone industry: The role of windows of opportunity and firms' competitive action. *Research Policy*, 46(2), 352–364.
- Glasmeier, A., 1991. Technological discontinuities and flexible production networks: The case of Switzerland and the world watch industry. *Research Policy*, 20, 469–485.
- Guennif, S. and Ramani, S.V., 2012. Explaining divergence in catching-up in pharma between India and Brazil using the NSI framework. *Research Policy*, 41(2), 430–441.
- Hamel, G., Doz, Y., and Prahalad, C.K., 1989. Collaborate with your Competitors - and Win. *Harvard Business Review*, 67(1), 133-139.
- Hill, C.W. and Rothaermel, F.T., 2003. The performance of incumbent firms in the face of radical technological innovation. *Academy of Management Review*, 28(2), 257–274.
- Henderson, R., 1993. Underinvestment and incompetence as responses to radical innovation: Evidence from the photolithographic alignment equipment industry. *The RAND Journal of Economics*, 24(2), 248–270.
- Henderson, R., 2006. The innovator's dilemma as a problem of organizational competence. *Journal of Product Innovation Management*, 23(1), 5–11.

- Henderson, R.M., and Clark, K.B., 1990. Architectural innovation: The reconfiguration of existing product technologies and the failure of established firms. *Administrative Science Quarterly*, 35(1), 9–30.
- Kang, H., and Song, J., 2017. Innovation and recurring shifts in industrial leadership: Three phases of change and persistence in the camera industry. *Research Policy*, 46, 376–387.
- Kaplan, S., Murray, F., and Henderson, R.M., 2003. Discontinuities and senior management: Assessing the role of recognition in pharmaceutical firm response to biotechnology. *Industrial and Corporate Change*, 12(4): 203–233.
- Kaplan, S., and Tripsas, M., 2008. Thinking about technology: Applying a cognitive lens to technical change. *Research Policy*, 37(5), 790–805.
- Klingebiel, R., and Joseph, J. 2016. Entry timing and innovation strategy in feature phones. *Strategic Management Journal*, 37(6), 1002–1020.
- König, A., Kammerlander, N., and Enders, A., 2013. The family innovator's dilemma: How family influence affects the adoption of discontinuous technologies by incumbent firms. *Academy of Management Review*, 38(3), 418–441.
- Lawless, M.C., and Anderson, P.C., 1996. Generational technological change: Effects of innovation and local rivalry on performance. *Academy of Management Journal*, 39(5), 1185–1217.
- Lee, K., and Ki, J., 2017. Rise of latecomers and catch-up cycles in the world steel industry. *Research Policy*, 46, 365–375.
- Lee, K., and Lim, C., 2001. Technological regimes, catching-up and leapfrogging: Findings from the Korean industries. *Research policy*, 30(3), 459–483.
- Lee, K., and Malerba, F., 2017. Catch-up cycles and changes in industrial leadership: Windows of opportunity and responses of firms and countries in the evolution of sectoral systems. *Research Policy*, 46(2), 338–351.
- Leonard- Barton, D., 1992. Core capabilities and core rigidities: A paradox in managing new product development. *Strategic Management Journal*, 13(S1), 111–125.
- Leung, E., 2019a. *The birth of smart feature phone revolution*. KaiOS Technologies. <https://www.kaiostech.com/the-birth-of-the-smart-feature-phone-revolution/> [Assessed 30 December 2021]
- Leung, E., 2019b. *Life, a new initiative by KaiOS to help first-time internet users make the most of mobile internet access*. KaiOS Technologies. <https://www.kaiostech.com/life-a-new-initiative-by-kaios-to-help-first-time-internet-users-make-the-most-of-mobile-internet-access/> [Assessed 30 December 2021]
- Levitt, B. and March, J.G., 1988. Organizational learning. *Annual Review of Sociology*, 14, 319–340.
- Li, D., Capone, G., and Malerba, F., 2019. The long march to catch-up: A history-friendly model of China's mobile communications industry. *Research Policy*, 48(3), 649–664.
- Lin, H. E., McDonough III, E. F., Lin, S. J., and Lin., C. Y. Y., 2013. Managing the exploitation/exploration paradox: The role of a learning capability and innovation ambidexterity. *Journal of Product Innovation Management*, 30(2), 262–278.
- Lindén, C.-G., 2021. *Kingdom of Nokia. How a Nation Served the Needs of One Company*. Helsinki University Press, Helsinki.
- Malerba, F., and Lee, K., 2021. An evolutionary perspective on economic catch-up by latecomers. *Industrial and Corporate Change*, 30(4), 986–1010.
- Malerba, F. and Nelson, R.R., eds., 2012. *Economic Development as a Learning Process: Variation Across Sectoral Systems*. Cheltenham: Edward Elgar Publishing.
- Maula, M.V.J., Keil, T. and Zahra, S.A., 2013. Top management's attention to discontinuous technological change: Corporate venture capital as an alert mechanism, *Organization Science*, 24(3), 926–947.

- McKendrick, D.G., and Wade, J.B., 2010. Frequent incremental change, organizational size, and mortality in high-technology competition. *Industrial and Corporate Change*, 19(3), 613–639.
- Miao, Y., Song, J., Lee, K., and Jin, C., 2018. Technological catch-up by east Asian firms: Trends, issues, and future research agenda. *Asia Pacific Journal of Management*, 35(3), 639–669.
- Mishra, V., 2019. *KaiOS eyes global expansion but replicating India's success would be a challenge*. Counterpoint. <https://www.counterpointresearch.com/kaios-eyes-global-expansion-replicating-indias-success-challenge/> [Assessed 29 December 2021]
- Mitchell, W., 1991. Dual clocks: Entry order influences on incumbent and newcomer market share and survival when specialized assets retain their value. *Strategic Management Journal*, 12(2), 85–100.
- Mudambi, R., Saranga, H., and Schotter, A., 2017. Mastering the Make-in-India challenge. *MIT Sloan Management Review*, 58(4), 59–66.
- Nair, A., and Ahlstrom, D., 2003. Delayed creative destruction and the coexistence of technologies. *Journal of Engineering and Technology Management*, 20(4), 345–365.
- Navis, C. and Glynn, M.A., 2010. How new market categories emerge: Temporal dynamics of legitimacy, identity, and entrepreneurship in satellite radio, 1990–2005. *Administrative Science Quarterly*, 55(3), 439–471.
- Negro, G., Hannan, M.T. and Rao, H., 2011. Category reinterpretation and defection: Modernism and tradition in Italian winemaking. *Organization Science*, 22(6), 1449–1463.
- Ocasio, W., 1997. Towards an attention- based view of the firm. *Strategic Management Journal*, 18(S1), 187–206.
- O'Reilly III, C.A. and Tushman, M.L., 2008. Ambidexterity as a dynamic capability: Resolving the innovator's dilemma. *Research in Organizational Behavior*, 28, 185–206.
- O'Reilly, C. A., and Tushman, M. L., 2013. Organizational ambidexterity: Past, present, and future, *Academy of Management Perspectives*, 27(4), 324–338
- Park, K.H. and Lee, K., 2006. Linking the technological regime to the technological catch-up: Analyzing Korea and Taiwan using the US patent data. *Industrial and Corporate Change*, 15(4), 715–753.
- Pathak, T., 2015. “*Make in India*” Impact: Half of all smartphones will be made in India. Counterpoint Research. Available at: <https://www.counterpointresearch.com/make-in-india-impact-half-of-all-smartphones-will-be-made-in-india/> [Assessed 21 Jun. 2020].
- Pathak, T., Shah, N., and Richardson, P., 2018. *India: Mid-Tier Smartphone Segment to Grow 4x in Next Five Years*. Counterpoint Research. Available at: <https://www.counterpointresearch.com/wp-content/uploads/2018/10/India-Mid-Tier-Smartphone-Segment-to-Grow-4x-in-Next-Five-Years.pdf> [Assessed 21 Jun. 2020].
- Perez, C. and Soete, L., 1988. Catching-up in technology: Entry barriers and windows of opportunity. In: G. Dosi, C. Freeman, R.R. Nelson, & G. Silverberg (Eds.), *Technical Change and Economic Theory*. London: Printer Publishers.
- Peteraf M. and Shanley M., 1997. Getting to know you: A theory of strategic group identity. *Strategic Management Journal*, 18(S1), 165–186.
- Porac, J.F., Thomas, H., Wilson, F., Paton, D. and Kanfer, A., 1995. Rivalry and the industry model of Scottish knitwear producers. *Administrative Science Quarterly*, 40(2), 203–227.
- Pufal, N. A. and Zawislak, P. A. 2021. Innovation capabilities and the organization of the firm: evidence from Brazil. *Journal of Manufacturing Technology Management*, 33(2), 287–307.
- Rosenbloom, R.S., 2000. Leadership, capabilities, and technological change: The transformation of NCR in the electronic era. *Strategic Management Journal*, 21(10- 11), 1083–1103.
- Rosenbloom, R.S. and Christensen, C.M., 1994. Technological discontinuities, organizational capabilities, and strategic commitments. *Industrial and Corporate Change*, 3(3): 655–685.
- Shah, N., 2018. *KaiOS: bridging the digital divide*. Counterpoint Research.

- <https://www.counterpointresearch.com/kaio-bridging-digital-divide/> [Assessed 10 May 2021].
- Shin, J.-S., 2017. Dynamic catch-up strategy, capability expansion and changing windows of opportunity in the memory industry. *Research Policy*, 46, 404–416.
- Singh, R., 2018. Finnish handset maker Nokia is making a bold comeback in its new avatar, but can it relieve it glory days? *Forbes India*.
<https://www.forbesindia.com/article/boardroom/reclaiming-glory-nokia-reloaded/50417/1>
 [Accessed 10 February 2019]
- Stephens, C., and Dennis, M., 2000. Engineering time: Inventing the electronic wristwatch. *The British Journal for the History of Science*, 33(4), 477–497.
- Suarez, F.F., Grodal, S. and Gotsopoulos, A., 2015. Perfect timing? Dominant category, dominant design, and the window of opportunity for firm entry. *Strategic Management Journal*, 36(3), 437–448.
- Sull, D.N., Tedlow, R.S., and Rosenbloom, R.S., 1997. Managerial commitments and technological change in the U.S. tire industry. *Industrial and Corporate Change*, 6(2), 461–500.
- Tripsas, M., 1997. Surviving radical technological change through dynamic capability: Evidence from the typesetter industry. *Industrial and Corporate Change*, 6(2), 341–377.
- Tripsas, M. and Gavetti, G., 2000. Capabilities, cognition, and inertia: Evidence from digital imaging. *Strategic Management Journal*, 21(10– 11), 1147–1161.
- Tushman, M.L. and Anderson, P., 1986. Technological discontinuities and organizational environments. *Administrative Science Quarterly*, 31, 439–465.
- Tushman, M. L., and O'Reilly III, C. A., 1996. Ambidextrous organizations: Managing evolutionary and revolutionary change. *California Management Review*, 38, 8–30.
- Vuori, T. O., and Huy, Q. N. 2016. Distributed attention and shared emotions in the innovation process: How Nokia lost the smartphone battle. *Administrative Science Quarterly*, 61(1), 9–51.
- Wooldridge, J. M. 2002. *Econometric Analysis of Cross Section and Panel Data*. Cambridge, MA: MIT Press.
- Xiang, Y., Soberman, D., and Gatignon, H., 2021. The effect of marketing breadth and competitive spread on category growth. *Production and Operations Management*. Published online, 1–23.

Table 1. Sampled mobile phone makers in the Indian market (2003-2020)

#	Mobile phone maker's name	Country of origin**	Product category (years of category leadership)***
1	Apple	US	Smartphone
2	AsusTek	Taiwan	Smartphone
3	Best IT World	India	Feature phone
4	Celkon	India	Feature phone; Smartphone
5	Gionee*	China	Feature phone; Smartphone
6	HTC	Taiwan	Smartphone
7	Huawei	China	Feature phone; Smartphone
8	Intex	India	Feature phone; Smartphone
9	Karbons*	India	Feature phone; Smartphone
10	Kyocera	Japan	Feature phone; Smartphone
11	Lava	India	Feature phone; Smartphone
12	LG	South Korea	Feature phone; Smartphone
13	Maxx Moblink	India	Feature phone
14	Micromax	India	Feature phone; Smartphone
15	Motorola / Google / Lenovo*	US / US / China	Feature phone; Smartphone
16	Nokia / Microsoft / HMD*	Finland / US / Finland	Feature phone (2003-2013); Smartphone (2005- 2011)
17	OnePlus	China	Smartphone
18	Oppo	China	Smartphone
19	Panasonic	Japan	Feature phone; Smartphone
20	Pantech	South Korea	Feature phone
21	Realme	China	Smartphone
22	Reliance Jio	India	Feature phone (2018)
23	RIM (BlackBerry) / Optimus Infracom*	Canada / India	Smartphone
24	Samsung	South Korea	Feature phone (2014-2017; 2019); Smartphone (2012-2017)
25	Sony Ericsson / Sony*	UK / Japan	Feature phone; Smartphone
26	Spice*	India	Feature phone; Smartphone
27	Transsion*	China	Feature phone (2020); Smartphone
28	Videcon	India	Feature phone
29	Vivo	China	Smartphone
30	Xiaomi	China	Smartphone (2018- 2020)
31	ZTE	China	Feature phone; Smartphone

Source: data primarily collected from the business intelligence providers Counterpoint Research, International Data Corporation (IDC) and Euromonitor, triangulated with information in business magazines collected using LexisNexis.

*Those firms involved in an acquisition in which the acquirer was a firm not operative in India, which undertook the full control of a handset maker operative in India to enter the Indian market, were considered as a single entity (i.e., the acquirer and the target firm entered the database with a single firm ID) in the empirical analysis. Instead, if two firms were initially operative independently in the Indian mobile phone industry, and at a certain point in time one was acquired by the other, we considered them as separate entities (i.e., with different firm IDs) until the acquisition date. We followed a similar logic for those handset makers that licensed their brand assets to a third-party company, which, in turn, designs, manufactures, and sells their branded devices in India. Details on acquisitions and brand licensing agreements are presented as follows: Gionee's Indian subsidiary was sold to Karbon in 2018; Motorola's mobile phone business unit "Motorola Mobility" was acquired by Google in 2012, which sold it to Lenovo in 2014; Nokia's mobile phone business unit was acquired by Microsoft in 2014, which sold it to HMD in 2016; Sony acquired Ericsson's stake in the Sony Ericsson joint venture in 2012; Transsion in 2018 formed a joint venture with Spice's handset division in India, in which Transsion held 80% stake, while Spice the remaining 20%; RIM (BlackBerry) in 2017 began licensing the Indian company Optimus Infracom to design, manufacture, and market handsets under its brand in India, however, its sales from 2017 were so small that our sources did not report them (probably sales of Optimus Infracom from 2017 were included into the category "others").

**The country of origin refers to the country where the firm has located its headquarters. In the case of acquisition, for those cases in which the acquirer and the target firm entered the database with a single firm ID, the focal firm's country of origin changed if the acquirer's country of origin was different from the target's country of origin.

***Per each firm, the data is reported if the firm competed (i.e., sold phones) at least for one year in a given product category or both product categories (feature phones and/or smartphones), from 2003 to 2020, in India. The years when the firm was a leader in a product category are reported in parentheses.

Table 2. Descriptive statistics and correlations

	Mean	S.D.	1	2	3	4	5	6	7	8	9	10
(1) Market share gap erosion	0.073	0.796	1.000									
(2) Technological window	0.164	0.222	-0.055	1.000								
(3) Multiproduct category leader	0.619	0.486	-0.032	-0.101 ⁺	1.000							
(4) Product category focus	0.776	0.320	0.120 [*]	-0.175 ^{**}	0.160 ^{**}	1.000						
(5) Product category relative size	0.559	0.288	0.088	-0.458 ^{***}	0.083	0.351 ^{***}	1.000					
(6) Firm market share (<i>ln</i>)	-3.777	1.359	0.296 ^{***}	0.093 ⁺	0.009	-0.087	-0.079	1.000				
(7) Manufacturing in India	0.526	0.500	-0.237 ^{***}	0.248 ^{***}	-0.131 [*]	-0.176 ^{**}	-0.179 ^{**}	0.108 ⁺	1.000			
(8) Country of origin (India)	0.409	0.492	0.067	0.091	-0.191 ^{***}	-0.315 ^{***}	0.025	0.103 ⁺	0.108 ⁺	1.000		
(9) Country of origin (China)	0.170	0.376	0.068	-0.064	0.016	0.109 ⁺	0.050	-0.020	0.067	-0.377 ^{***}	1.000	
(10) Category growth rate	0.296	0.477	0.029	0.109 ⁺	0.064	-0.102 ⁺	-0.434 ^{***}	0.057	-0.388 ^{***}	-0.322 ^{***}	-0.083	1.000

Notes: $N = 323$; Mean and S.D. are based on unstandardized variables.

Significance: ⁺ $p < 0.10$, ^{*} $p < 0.05$, ^{**} $p < 0.01$, ^{***} $p < 0.001$

Table 3. Estimates on market share gap erosion

	Model 1 FE	Model 2 FE	Model 3 FE	Model 4 FE	Model 5 FE	Model 6 FE	Model 7 FE	Model 8 RE
Technological window		-0.059 (0.077)	-0.001 (0.070)	-0.170 ⁺ (0.092)	0.135 (0.085)	-0.036 (0.064)	0.037 (0.111)	0.039 (0.093)
Multiproduct category leader			0.478* (0.199)	0.332 (0.213)			0.174 (0.264)	-0.237 (0.260)
Product category focus			0.423* (0.172)		0.512** (0.163)		0.472* (0.179)	0.349** (0.127)
Product category relative size			0.066 (0.205)			0.343 ⁺ (0.189)	0.026 (0.198)	-0.016 (0.098)
Technological window × Multiproduct category leader				0.208* (0.084)			0.169* (0.079)	0.197** (0.065)
Technological window × Product category focus					-0.200 ⁺ (0.116)		-0.212 ⁺ (0.116)	-0.278* (0.140)
Technological window × Product category relative size						-0.117 (0.193)	-0.066 (0.168)	-0.120 (0.181)
Firm market share	0.365** (0.128)	0.367** (0.126)	0.325* (0.126)	0.387** (0.126)	0.334** (0.115)	0.428** (0.137)	0.365** (0.130)	0.378*** (0.094)
Manufacturing in India	-0.144 (0.094)	-0.147 (0.092)	-0.117 (0.087)	-0.169 ⁺ (0.088)	-0.140 ⁺ (0.078)	-0.133 (0.091)	-0.164* (0.077)	-0.160* (0.064)
Country of origin (India)								0.187* (0.095)
Country of origin (China)								0.188 ⁺ (0.102)
Category growth rate	-0.226* (0.092)	-0.184 ⁺ (0.093)	-0.093 (0.118)	-0.081 (0.098)	-0.103 (0.103)	-0.032 (0.129)	-0.003 (0.128)	0.133 (0.117)
Year dummies	Included	Included	Included	Included	Included	Included	Included	Included
Constant	0.864*** (0.233)	0.793** (0.232)	0.050 (0.166)	0.412*** (0.113)	0.225 (0.314)	0.351 (0.390)	-0.101 (0.221)	-0.361 (0.250)
N	323	323	323	323	323	323	323	323
R-squared	0.419	0.420	0.451	0.434	0.459	0.436	0.470	0.353
F-test vs Model 1	-	0.60	6.80***	4.53**	3.45*	1.17	5.49***	-

Notes: FE = fixed-effects; RE = random-effects. Estimates are based on standardized variables. Robust standard errors in parentheses. The two country of origin controls were excluded in Models 1–7 (FE) because time-invariant. Within R-squared is reported in models using FE, while overall R-squared is reported in the model using RE.

Significance: ⁺ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

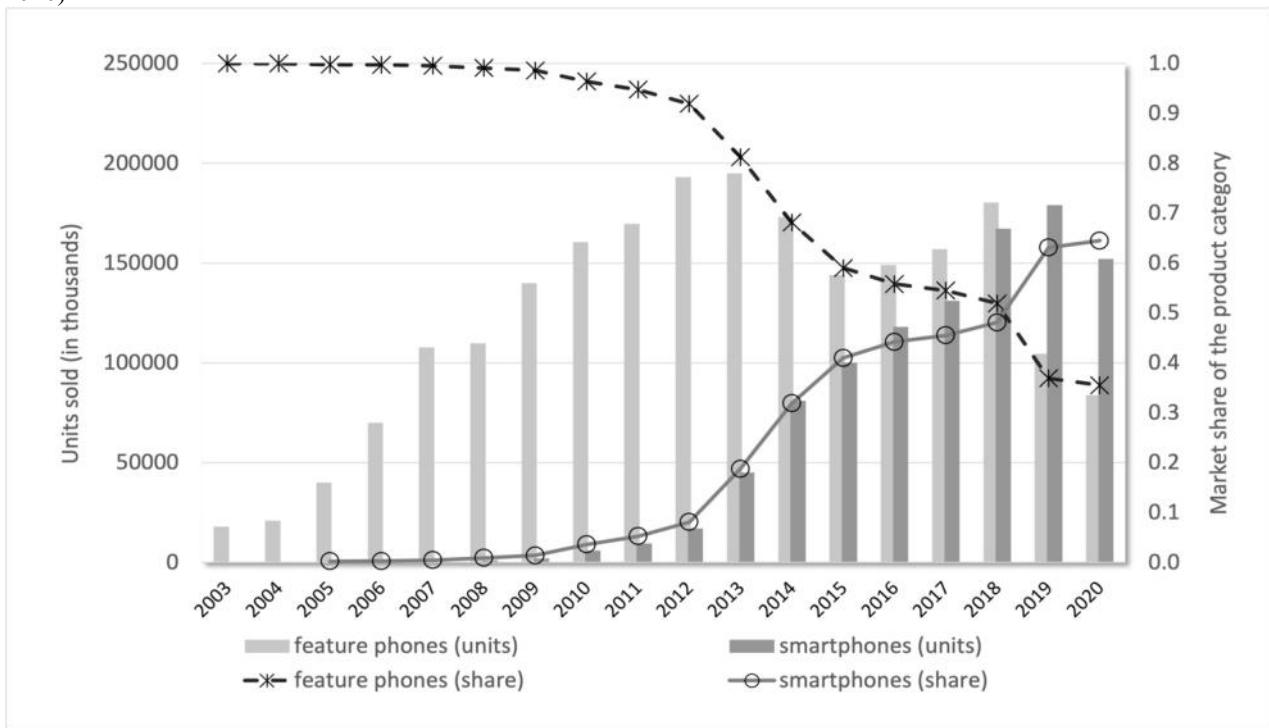
Table 4. Additional analysis on market share gap erosion: Subsample analyses by demand windows and regulatory windows

	Model 9 High demand growth (<i>Demand window</i>)	Model 10 Low demand growth	Model 11 Make-in-India (<i>Regulatory window</i>)	Model 12 Pre Make-in-India
Technological window	0.323* (0.116)	0.388 (0.467)	1.437* (0.541)	-24.506* (11.409)
Multiproduct category leader	-0.060 (0.085)	0.117 (0.078)	-1.687+ (0.977)	-1.127 (0.739)
Product category focus	0.258 (0.539)	0.316 (0.208)	0.140 (0.281)	0.897* (0.385)
Product category relative size	-0.054 (0.307)	-0.710* (0.340)	3.453* (1.679)	-4.985+ (2.482)
Technological window × Multiproduct category leader	0.272*** (0.060)	-0.371 (0.361)	0.167* (0.078)	0.560* (0.256)
Technological window × Product category focus	-0.185 (0.137)	-0.183 (0.156)	-0.227+ (0.124)	0.056 (0.154)
Technological window × Product category relative size	-2.827** (0.747)	-0.016 (0.532)	-13.790* (6.136)	-17.974* (8.497)
Firm market share	0.566** (0.170)	0.326* (0.149)	0.646** (0.215)	0.578** (0.177)
Manufacturing in India	-0.103 (0.086)	-0.146 (0.094)	-0.132+ (0.069)	-0.076 (0.121)
Category growth rate	-0.288* (0.130)	-0.077 (0.114)	2.640 (1.653)	0.239 (0.208)
Year dummies	-	-	Included	Included
Constant	-1.381** (0.362)	-0.383* (0.175)	0.109 (0.208)	-17.278* (7.777)
N	153	170	188	135
Within R-squared	0.554	0.332	0.458	0.501

Notes: All models are based on fixed-effects regression. Estimates are based on standardized variables. Robust standard errors in parentheses. Year dummies were excluded in Models 9 and 10 because of multicollinearity.

Significance: + $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

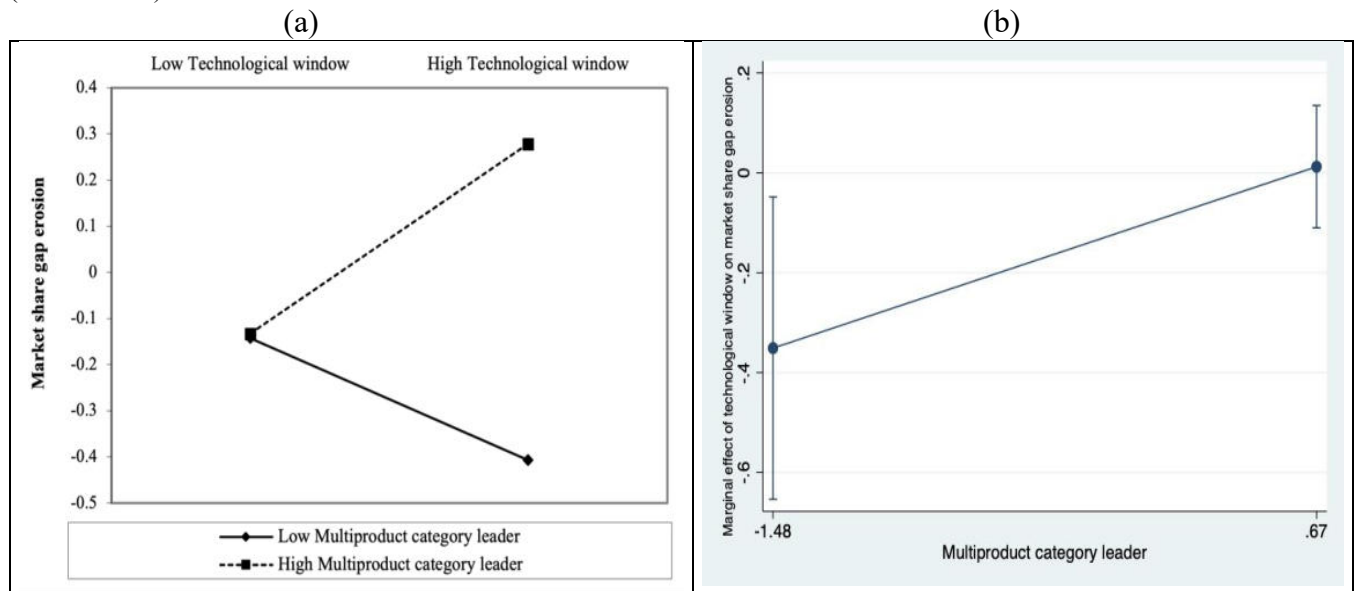
Figure 1. Mobile phone units sold and percentage share in the feature phone and smartphone categories in India (2003–2020)



Notes: market shares of product categories may range between 0 and 1, and add up to 1, with 1 = 100%.

Figure 2 (a). Moderating effect of multiproduct category leader on the relationship between technological windows and market share gap erosion.

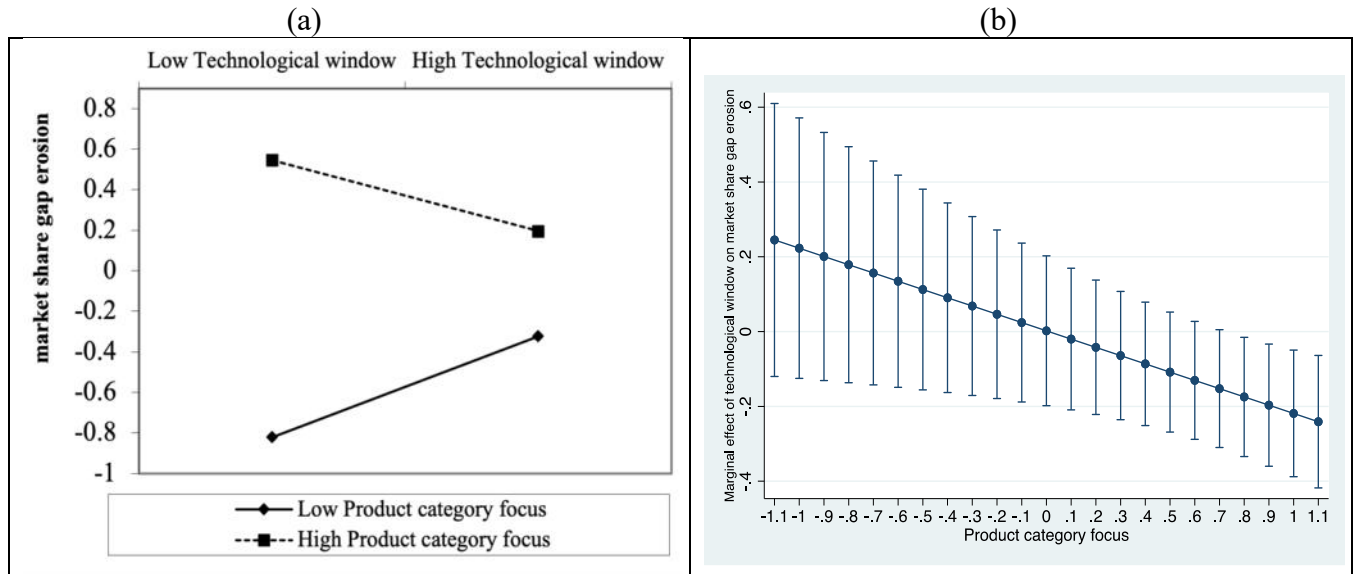
Figure 2 (b). Average marginal effects of technological windows for different levels of multiproduct category leader (with 90% CI).



Notes: Results are based on standardized variables.

Figure 3 (a). Moderating effect of product category focus on the relationship between technological windows and market share gap erosion.

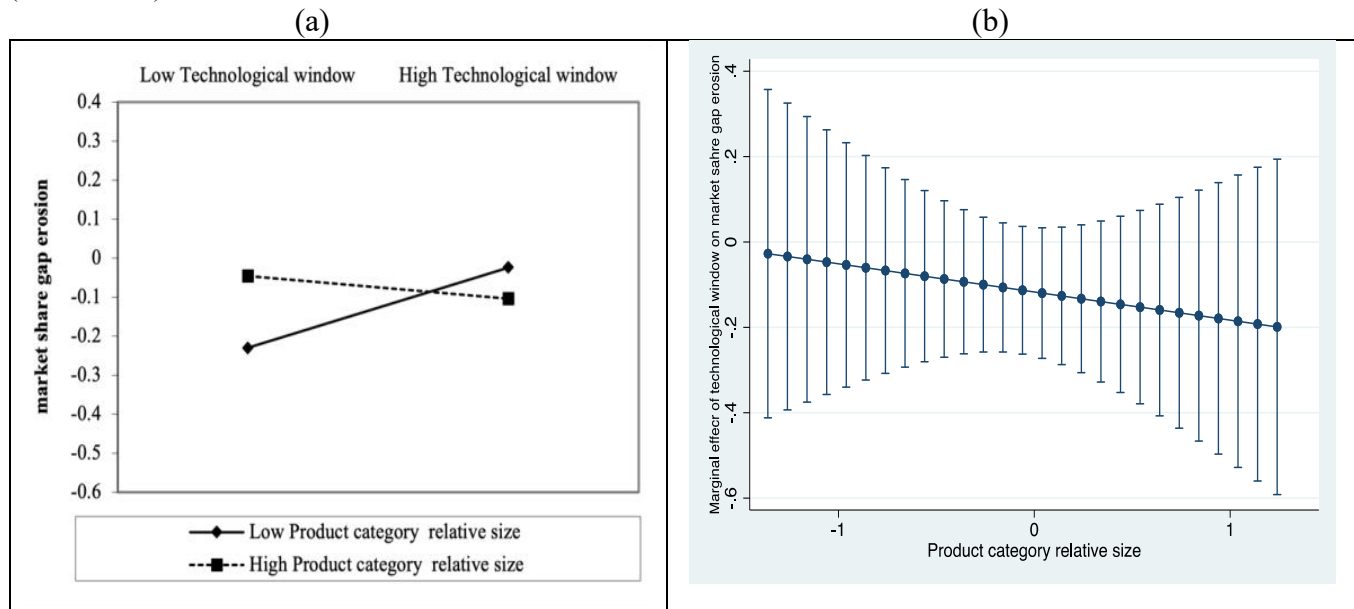
Figure 3 (b). Average marginal effects of technological windows for different levels of product category focus (with 90% CI).



Notes: Results are based on standardized variables.

Figure 4 (a). Moderating effect of product category relative size on the relationship between technological windows and market share gap erosion.

Figure 4 (b). Average marginal effects of technological windows for different levels of product category relative size (with 90% CI).



Notes: Results are based on standardized variables.