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A firm-level perspective on windows of opportunity

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ABSTRACT

The concept of windows of opportunity (WoO) has been put forward as a perspective for understanding industrial catching up in developing and emerging economies. A related, but separate literature (capability literature) has focused on the learning processes of developing country firms as they build technological capabilities. In this paper, we examine the insights that can be drawn from the capability literature in order to provide a more nuanced and micro-level perspective on WoO. Through a review of the capability literature, we highlight the intra-industry differences and capability-building trajectories of individual firms as they respond to technological, demand, and institutional WoO. The paper underscores the importance of devoting attention to firm-level differences to understand how these may influence firms' responses to WoO.

1. Introduction

One strand of development studies research has sought to explain the gap that has persisted between the relatively small group of industrialized countries and the vast majority of so-called *latecomers,* whose development is often hampered by a set of seemingly fixed constraints. One perspective that has gained traction over the last thirty years centres on the notion that over time discontinuities along an otherwise linear path of technological development produce variation in these constraints, representing a window of opportunity (WoO) for latecomers to catch up and even surpass industry leaders [1]. First introduced by Perez and Soete [1], WoO can be understood as a set of idiosyncratic conditions arising from systems of technological change in individual industries. More recently, Lee and Malerba [2] put forward a framework that considers WoO from within the dynamics of sectoral innovation systems. Sectoral innovation systems represent a common context, including the infrastructure, university system, human capital, institutions and policies of a given country [3]. WoO may arise from changes in technology, demand and institutions in a given sectoral innovation system. Latecomers and incumbents are likely to respond differently to these windows, which can result in changes to industry leadership. For instance, a disruptive technology may require significantly higher switching costs for incumbents compared to more agile latecomers, increasing domestic demand in an emerging market may result in locational advantages favouring domestic firms, and public policy may remove initial barriers to catching up by favouring domestic firms.

Lee and Malerba [2] identify four stages in the industry catch-up cycle: (i) *entry and initial growth*, in which the latecomer first enters the industry; (ii) *gradual catch-up*, where the latecomer begins to reduce the gap with industry leaders by building increasingly advanced capabilities; (iii) *forging ahead*, in which the latecomer surpasses the industry leader by taking advantage of windows of opportunity; and (iv) *falling behind,* when the new industry leader is unseated by a new latecomer. A number of empirical studies have applied Lee and Malerba's [2] framework to explain catching up in industries such as steel [4], cameras [5], wine [6] and mobile phones [7]. These studies provide solid evidence for the influence of WoO on changes in industrial leadership and demonstrate how catch-up cycles differ between industries. However, as Lee and Malerba [2] acknowledge, a great deal of heterogeneity exists among firms and in how they respond to windows of opportunity (WoO), both within and across sectors, while, as Figueiredo and Cohen [8] point out, little is known about the micro-level learning processes that enable firms to respond to WoO. Furthermore, as noted by Hansen and Hansen [9], the WoO literature tends to overlook the specifics that vary within sectors and is vague about 'who' exactly is doing the catching up: the country, the industry, a sub-set of firms within a given industry or individual firms? For instance, the WoO literature tends to disregard the dynamics and features of groups of firms within sectors. Drawing on data from the wind and solar PV sectors, for example, Hansen et al. [10] highlight the importance of adopting a disaggregated perspective focusing on 'sub-sector'-level factors in the catching up process and found that knowledge diffusion differed most between firms of different sizes than between the two sectors studied. Similarly,

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Figueiredo and Cohen [8] found large differences between firms in the paper and pulp industry in Brazil in terms of how they responded to WoO. Given the central role of individual firms as core actors of sectoral innovation systems [11], it is perhaps surprising that the WoO literature pays relatively little attention to firm agency and the question of how firm-level learning efforts influence firms' ability to catch up via WoO. As Bell and Figueiredo [11] point out, most studies adopting the sectoral innovation systems perspective aim to identify differences between sectors, rather than considering these differences as independent variables that may influence innovation and capability-building in individual firms (see e.g. [12,13]). Furthermore, as Hansen et al. [10] show, innovation-related characteristics, such as the learning mechanisms, knowledge sources and production systems of different firms or groups of firms, may transcend the sectoral innovation systems that are used to define them. Moreover, others have stressed the importance of combining macro- and micro-level perspectives in order to achieve a more nuanced understanding of the catch-up cycle [7,8,14].

In this paper, we review a body of literature that addresses similar questions relating to catching up by latecomer firms. This literature (henceforth referred to as the capability literature) focuses on the conscious and purposeful efforts of firms in developing countries to acquire and develop technological capabilities and thus enable them to engage in innovation [15–17]. In contrast to sectoral innovation systems and WoO perspectives, the capability literature tends to deal with catching-up at a micro-level of analysis, typically drawing on rich firm-level data to shed light on the specific learning mechanisms and capability-building of a single firm or a small group of firms. Furthermore, while the WoO perspective, as set out by Lee and Malerba [2], tends to assume a common set of conditions that apply to all firms within a given sectoral innovation system, the capability perspective emphasises the heterogeneity of firms across and within sectors. As Bell and Figueiredo [11] point out, there are likely to be distinct characteristics, even within specific industries (e.g. differences in high- or low-volume production) that will have important implications for capability-building at the firm level.

Hence, by drawing on recent insights from the capability literature, we aim to provide further nuances to enrich the WoO concept as it applies to latecomer firms in developing and emerging economies. This paper reviews the capability literature through the lens of the WoO framework to explore the following overarching question: *How can recent research in the capability literature contribute to an improved understanding of the WoO concept?* By drawing together micro-level insights on latecomer catching-up across the range of industries and countries covered in the literature, we provide new knowledge on whether and how latecomer firms take advantage of WoO to develop innovation capabilities and catch up with incumbents. Before proceeding, it should be emphasised that our paper aims to offer a constructive critique of the WoO perspective, seeking to refine rather than discard its valuable insights. Hence, while a firm perspective can contribute to enriching the WoO perspective by providing further nuance, a sectoral perspective remains hugely important for understanding and studying the catching up of latecomers.

The paper is structured as follows. In section 2, we introduce the WoO and capability perspectives respectively. Section 3 explains our methods of data collection and processing. In section 4, we review the capability literature to present evidence on firms' responses to WoO, which is discussed in section 5. We provide the main conclusions of the paper in section 6.

2. Conceptual framework

In this section, we elaborate on the two main conceptual perspectives of interest in this paper, WoO and technological capabilities, as they apply to catching up by, respectively, latecomer countries and latecomer firms.

2.1. Windows of opportunity

The fact that, historically, very few developing and emerging economies have succeeded in catching up with the relatively small group of industrialized countries has lent support to dependency theories, which attribute this outcome to structural gaps between latecomers and advanced economies in the form of entry barriers that persist or continue to widen over time [1]. Given an initial stage of development, more advanced countries can leverage their advantages through, for example, economies of agglomeration to widen their lead further by investing in productive assets, infrastructure etc. In contrast, latecomer countries experience the opposite effect and, rather than increasing their advantages, they are faced with fixed constraints.

However, the rapid industrialization of a small number of latecomer countries—most notably the Asian Tigers, beginning in the 1960s—appeared to contradict this reasoning, prompting efforts to find alternative theories. One such theory, proposed by Perez and Soete [1], builds on the notion that the constraints preventing latecomers from catching up, in particular in relation to the development of knowledge and skills, can vary over time as a result of fundamental techno-economic paradigm shifts. Such shifts can be described as 'the emergence of radical discontinuities in overall technological evolution' ([1], p. 460) and can, in some cases, favour latecomers by removing these constraints, thus representing a 'window of opportunity' (WoO).

More recently, Lee and Malerba [2] developed the WoO concept further by applying an evolutionary perspective [18,19] treating WoO as phenomena that arise with the evolution of sectoral innovation systems. Lee and Malerba [2] propose that, as industries undergo changes, WoO open relating to (i) technology and knowledge (technology window), (ii), demand conditions and business cycles (demand window), (iii) public policy and institutional setting (institutional window).

Technology windows occur when a new technology or innovation is introduced, which may erode the advantages incumbents have gained through their investments in the old technology. By contrast, latecomers who are at an earlier stage of their development are likely to be more agile in their responses, as they have not invested in the old technology to the same extent. Lee and Malerba [2] discuss the example of the technological regime in the memory chip sector and show how the nature of the product life-cycle has influenced how latecomers were able to catch up. Demand windows can be created with the occurrence of new demand by domestic or global users and consumers. Leading firms may not respond if they are already successful in their own markets. Likewise, foreign incumbents may not respond fast enough to match rapidly growing domestic demand in a developing or emerging market country, which represents an opportunity for latecomer firms. Institutional windows occur when institutional conditions or public policy create an asymmetric environment that favours latecomers. This may be in the form of protectionism (subsidies or tariffs) or government efforts to support domestic firms through, for instance, national R&D or skills development programmes. The important point here is that these different types of windows can create opportunities for latecomers to catch up with incumbents at various points in time along their development trajectories.

2.2. Capability literature

It should be noted that the term *capabilities* has been used to describe a number of different concepts belonging to separate streams of literature. These include the strategic management literature and the resource based view of the firm [20], e.g. dynamic capabilities [21], and the literature on social and human development (e.g. [22]). However, the capability literature, as it is defined in this review, aims to understand how firms in late industrializing countries (latecomer firms) deal with technological change with a focus on how such firms acquire and develop technological capabilities in order to progress towards, and eventually 'catch up' with, industry leaders at the international

technology frontier. Technological capabilities, represent the resources firms need to manage technological change and can be defined as firm-specific skills, knowledge and experience that are accumulated over time [17]. Central to the capability perspective is the notion that transferring technology from advanced to latecomer firms is a costly process that requires purposeful efforts by the firm to build the capabilities that are necessary to use a given technology effectively [11,16]. In other words, capability-building does not occur passively or automatically, but rather through conscious efforts by the firm. Firms acquire capabilities in a path-dependent and cumulative manner that requires an existing base of knowledge, skills and experience in order to develop or absorb increasingly advanced levels of capabilities. Much work in the capability literature has been devoted to defining and evaluating capabilities that vary in complexity and the extent to which they relate to innovative activity [23,24]. For instance, a distinction is made between production capabilities and innovation capabilities. Production capabilities refer to the capabilities required to produce goods and services using a given technology, which may lead to incremental improvements in efficiency and performance. Innovation capabilities denote the ability to create new configurations of technology or organizational processes, including, but not limited to, R&D activities. Innovation capabilities also refer to the ability to modify and improve existing technology [25]. The capability perspective treats capability-building as a highly idiosyncratic process. Firms may achieve similar levels of capabilities by following different capability-building trajectories, or they may employ different learning mechanisms or draw on different knowledge sources.

Seen from the perspective of the individual latecomer firm, the emergence of a WoO may offer an external opportunity for accelerating the speed at which capability building occurs. However, as pointed out by Bell [26] research on firm capability building across various sectors and countries shows that the process of catching up with incumbents tends to occur over relatively long timeframes, typically spanning around 30–40 years. In any case, this line of research has repeatedly stressed that rather than being a linear process, capability building typically takes place in distinct steps and 'learning events' depending on a range of firm external and internal factors, most important of which are the deliberate actions by firms to pursue different opportunities [14]. As such, WoO can be one among many factors in the external environment of firms influencing whether, how and how fast they will eventually manage to catch up.

3. Research methodology

In this paper, we perform a systematic review of the capability literature with a focus on the firm-level factors that are related to changes in industry leadership, i.e. the factors that influence *whether* and *how* firms catch up and take advantage of WoO. Following Paul and Criado [27], the review is domain-based and involves a framework-based review, which is useful for conducting a systematic assessment of an existing theoretical framework with the objective of developing it further. A systematic approach was chosen in order to identify the most relevant papers and to avoid overlooking papers with important insights of high relevance for the paper. A less systematic approach could have resulted in important papers being overlooked and potentially given rise to selection bias that could have reduced the reliability of the findings presented. While the capability literature goes back at least to the 1980s [28], in this paper we limit ourselves to focusing on the most recent papers published in this field of research in the period 2010–2020. This decision was made for three main reasons. First, in keeping with the evolutionary perspective, where firm-level innovation occurs within the context of a broader innovation system that changes over time, the most recent studies are arguably more relevant for guiding future research based on present-day innovation systems, and even the underlying and more slowly evolving techno-economic paradigms [29]. Second, albeit with a different focus, the last major review of the capability literature was carried out in 2012 by Bell and Figueiredo [11]. Hence, with a small overlap, we aim to gather insights from capability studies that have not been presented or analysed together in a recent review. Finally, since the most recent contributions in the literature on WoO have been published in this period, the findings presented in this paper are topical in their relevance.

3.1. Data collection

The papers selected for the review were limited to peer-reviewed journal articles. We decided not to include grey literature or other non-peer-reviewed papers in order to establish a manageable sample, the quality of which could be verified and identified by systematically applying search strings. The intention was not to create an exhaustive list of all relevant articles, but rather to identify a thematically relevant sample that may provide insights into the research questions. The papers collected for the literature review were selected from Elsevier's citation database, Scopus, following a systematic approach [30,31]. Scopus was chosen due to its functionality and quality filters [32].

First, an initial sample of relevant articles was established using the search string (TITLE-ABS-KEY("technological capabilit*" OR "innovat* capabilit*") OR KEY ({capabilities}) AND TITLE-ABS-KEY ("latecomer")), which resulted in 135 documents. The sample was then refined to include journal articles only, resulting in 96 articles, 71 of which were published between 2010 and 2020. The 96 journal articles (before filtering by year) were used as the basis for generating a list of forward and backward citations [33,34], in order to capture additional articles that were thematically aligned but missed by the initial search strings. The forward citation search (documents that cited the original 96 articles) yielded 1264 citations, which were reduced to 834 journal articles appearing between 2010 and 2020. To refine the relevance of the selection further, the search strings "innovation capabilities" OR "technological capabilities" were used, which reduced the 834 articles to 523. Finally, the term 'latecomer' was applied to exclude articles that did not explicitly address latecomer firms, resulting in 288 forward-citing articles. The forward-citing articles were then parsed with the original 71 articles to remove duplicates. This resulted in 76 forward-citing articles published between 2010 and 2020. The PDFs of the 76 articles were downloaded and reviewed to identify the theoretical perspectives applied. Of the 76 articles, 38 applied a technological capability-building perspective (e.g. [16,17,35]). The remaining articles followed alternative perspectives to capability-building belonging mostly to the strategic management literature focusing on firms in advanced economies.

The 71 original journal articles published between 2010 and 2020 were then screened according to the same criteria, i.e. that they applied a technological capability-building as opposed to a strategic management perspective to developing or emerging economies. This resulted in 22 articles. The 96 original articles were then used to generate a list of backward citations (papers cited by the original 96 articles) using Scopus' backward citation function, resulting in 594 Scopus documents published between 2010 and 2020. These were then further refined using the search strings "technological capabilities OR "innovation capabilities" and subsequently "latecomer firm" OR "catch* up", resulting in 141 documents. The majority of these were already included in the original or forward citations sample; hence, only 3 additional (unique) documents were added.

Finally, the 22 core articles were combined with the 38 forward citations and 3 backward citations, resulting in a final sample of 63 articles published between 2010 and July 17, 2020 (Table 1). Further information about the papers included in the review is provided in the appendix.

3.1.1. Data collection: considerations and limitations

The original sample of 96 papers was not limited by year in order to capture forward citations at the beginning of the 2010–2020 time

Table 1
Article selection.

	Initial search	Forward citations	Backward citations	Total
Journal articles 2010–2020 before filters	71	834	594	1499
Journal articles 2010–2020 after filters applied	22	38	3	63

period. Furthermore, some of the original 96 articles applied IB and strategic management frameworks, including resource-based views. However, the boundary between the IB/strategic management literature and the capability-building literature [16,17,36] is often blurred, and many papers combine frameworks from both literatures. Hence, we decided to generate forward citations from all 96 original papers, which resulted in a high number of articles that fell within the thematic scope of this review.

Several relevant articles were not captured by the search strings (e.g. some were excluded by the search word 'latecomer'). However, when broader terms or multiple terms were used, the list of documents generated was too large and too thematically diverse to manage. Several articles in the sample focussed on a time period before 2010. However, since these articles still represent the issues that the research community perceived to be relevant at the time of publishing, they were included in the sample.

3.1.2. Data-processing

All documents were reviewed and coded according to the three WoO (Table 2). Additional themes relating to WoO were also identified and applied as codes via an iterative process. For instance, themes such as firm agency, pre-existing capabilities, sectoral interdependence and knowledge networks were identified repeatedly as important factors that enabled firms to catch up in the presence of WoO.

4. Firms' responses to WoO

In the following sub-sections, we present relevant findings from the capability literature on each of the three WoO related to technology (4.1), demand (4.2), and institutions (4.3). It should be noted that the specific papers cited are used as examples illustrating the empirical findings that have emerged and that resonate across the papers included in the review.

4.1. Technological WoO

In sectors characterized by short product life-cycles, such as electronics and IT, rapid technological change can present an opportunity for latecomer firms. Catching up in such sectors depends crucially on the speed at which individual firms are able to adapt to new and emerging technologies. Several studies in the capability literature provide evidence of catching up through capability-building in the presence of a technological WoO. Generally, these studies find evidence of varying levels of capability-building in several different sectors, including electronics in China [41] and Taiwan [42]; forestry, pulp and paper in Brazil [8]; pharmaceuticals in India [38] and Brazil [43]; telecommunications in India [44] and China [45,46]; and software in India [47]. These studies all show, in one way or another, how one or more latecomer firms have either reached or made significant progress towards the global innovation frontier. In the following, we will focus on the efforts of individual firms to build capabilities in response to a technological WoO. In particular, we examine their development trajectories and sources of knowledge to explore how these differ between firms.

4.1.1. Pre-existing capabilities, sources of knowledge and firm agency

It is evident from the reviewed articles that considerable variation exists between firms, including those in the same sector, in terms of the levels of capabilities achieved, their capability-building trajectories and their predominant sources of knowledge and chosen learning mechanisms.

Several studies have focused on understanding how a small group of

Table 2
Coding matrix illustration.

	Technological WoO (relevant excerpts)	Demand WoO (relevant excerpts)	Institutional WoO (relevant excerpts)
Figueiredo [37]	'Such a deepening of their innovation capabilities does not signify that the firms in question have moved towards a pre-determined technological frontier. Instead, they have rather opened up a new segment in the established technological trajectory, especially in the upstream forestry area.' (2010, p. 1103)		
Kale [38]		'This research also highlights that developing biosimilars for the domestic market was technologically more challenging and also involved greater market effort contributing to development of advanced technological capabilities in the Indian firms.' (2019, p. 382)	
Kiamehr et al. [39]		'In contrast to the export led strategies of the former, the Iranian firm overcame market and technological barriers to entry through the supply of project management services for the domestic market, rather than manufacturing for overseas export markets. In contrast to the latter, Mapna did not start its life by operating and maintaining foreign capital goods but instead entered by delivering CoPS project services for local clients, followed quite rapidly by developing local technological capabilities.' (2015, p. 1249)	'Although government policies supported accumulation of manufacturing capabilities at this stage, we could not find evidence of government policies encouraging the growth of engineering and design capabilities, as identified by Bell and Pavitt [40], at this stage.' (2015, p. 1248)

Brazilian firms achieved world-leading innovation capabilities in the paper and pulp sector (e.g. [8,48]). In the 1950s, industry-leading firms in Scandinavia and North America followed a capability-building trajectory in the established technology of long-fibre pulp. However, rather than attempting to catch up with industry leaders by moving up the established technological trajectory, several Brazilian firms began experimenting with a new short-fibre technology based on eucalyptus pulp, a material that, though abundant in Brazil, was not at the time considered suitable for the production of paper. Interestingly, only some of the firms pursued capability-building along the new technological trajectory, and only some achieved world-leading capabilities. The rates of capability-building varied substantially, with firms taking between 26 and 57 years to achieve the same level of innovation capability. Some firms remained at the same level and did not progress beyond the 'advanced' level of capabilities. The firms that did achieve world-leading levels of innovation capabilities were able to establish R&D collaborations at an early stage. Perhaps more importantly, they also shifted from a reliance on external sources of R&D to the accumulation of innovation capabilities based on internal research efforts, making them more resilient to technological change. These studies suggest that the firms themselves played a significant role in *creating* the WoO arising from the new technology, as they purposefully diverged from the established technological path by developing what Figueiredo [37], p. 1103) refers to as '*low-end disruptive innovation*'. Firms' strategic choices and management style are thus key factors in terms of reaching the most advanced stage of innovation capability.

Several studies in the capability literature have shown that the relevance of pre-existing capabilities for subsequent catching up through a technology WoO is likely to depend on the type of technological change present. Yu et al. [41], for example, identify three types of technological change: technological substitution, technological upgrading and technological leapfrogging. Chuang and Hobday [42] investigated the capability-building trajectories of two world-leading Taiwanese firms in the TFT-LCD[1] industry and found that they were able to respond rapidly to technological change by diversifying into new products and numerous emerging technological fields, resulting in the development of technologies that were new to the firms and to the industry. They attribute this to the firms' pre-existing capabilities, which allowed them to internalize knowledge taken from external sources. They moreover stress the importance of non-R&D capabilities, in particular engineering and design capabilities, which, interestingly, they acquired from other sectors, such as semiconductors, petrochemicals and colour filters. They argue that these capabilities formed the basis for developing more advanced capabilities, including R&D. Aeron and Jain [44] provide similar findings in their study of capability-building in seven telecom start-ups in India. During a period of rapid technological change and shifting consumer preferences in the Indian sector, they show how some firms were able to close significant technology gaps by combining existing resources to create new knowledge (*bricolage*) and by learning from their customers. This enabled some firms to develop technologies that were new to the market or to adapt existing technologies to changing consumer preferences.

Some studies have shown that the ability of firms to benefit from a technological WoO depends on sources of knowledge and learning opportunities in the external environment, as well as firms' related and existing 'search capabilities' [43]. Kale [38], for example, showed how a single firm acquired capabilities mainly by hiring international biotech scientists, which increased its capacity to absorb relevant capabilities in response to a technological shift towards biotechnology in the pharmaceutical sector in India. Furthermore, Lema [47,49]) provides an example of catching up by twelve Indian software suppliers, who, to varying degrees, were able to develop solutions to address new and emerging technologies and rapidly changing standards-based protocols in the telecoms sector. The firms did so by actively combining internal capabilities with external knowledge, for instance, from users. Lema [47] stresses the importance of firm-internal efforts and investments as the key factor in determining the diffusion of innovation capabilities from lead firms to domestic software suppliers. Lema [49] emphasises the importance of firms' internal efforts to acquire knowledge from sources other than R&D. For instance, interactive learning with customers was identified as a crucial strategy that allowed some firms to acquire exclusive knowledge (e.g. market/user data) enabling them to co-create cutting-edge software solutions in line with the most recent technological developments. Similarly, Dantas and Bell [50] highlight the role of firms' efforts and existing capabilities in shaping their knowledge networks, as opposed to the other way around. Based on an in-depth study of Petrobras, a leading Brazilian firm, they propose that firms' networks are formed through a two-way evolutionary process, in which firms draw on existing capabilities to actively create knowledge-sharing links. This supports the notion that, while knowledge may be available to firms in a given industry, the extent to which such knowledge is relevant and thereby accessible varies widely and is dependent on the existing capabilities of individual firms and their efforts to establish knowledge-sharing networks.

The above account seems to suggest that catching up in a technology-based WoO depends on the ability of firms to innovate along a new technological trajectory. The studies quoted show how firms responded to technological WoO by identifying, combining and internalizing external sources of knowledge with firm-internal learning efforts. However, these studies suggest that the ability to do so was conditioned by unique combinations of existing capabilities that are present in individual firms. In other words, the relevance of external sources of knowledge to individual firms varies considerably within and across sectors.

4.2. Demand WoO

New demand within a given sector represents a WoO that is largely due to location-related advantages, especially in the case of domestic demand, which typically favours domestic firms. Strong domestic demand allows latecomer firms to establish closer links between production and deployment [51], enabling, for instance, the rapid testing of new products. Furthermore, as Huenteler et al. [52] found, the size of the existing domestic market can to a large extent determine the potential for cost reductions resulting from technological learning. Hence, a large domestic market is often necessary for innovation to take hold [38,53]. In the case of global demand, the WoO may emerge due to the slow responses of incumbents.

The capability literature presents several examples of latecomer firms that have advanced close to the global innovation frontier by achieving advanced and even world-leading levels of innovation capability. These firms typically emerged in markets with strong domestic demand in countries such as Brazil, China and India. Examples in the literature are most common within strategic or resource-based industries, such as software [49], aircraft [54], petroleum [55] and mining [56].

With regard to demand WoO, the WoO literature distinguishes between incumbents and latecomers, foreign and domestic firms, in terms of how conditions brought about by increasing demand are likely to affect them. However, little attention has been paid to evaluating how and to what extent individual domestic firms progress towards industry leaders and how their capability-building efforts may differ as they respond to demand WoO [9].

4.2.1. Number of firms

The WoO perspective typically evaluates catching up at the industry level, often on the basis of market share or innovation indicators, such as patent numbers. However, such an approach provides little insight into how innovation is distributed across the firms in a given sector and

[1] Thin film transistor-liquid crystal display.

overlooks the variation between firms in respect of their progress towards the international innovation frontier. On examining the capability literature, it becomes evident that catching up in relation to demand WoO, in terms of the levels of capability that individual firms have acquired, is often disproportionately represented by a small number of domestic firms [54,57]. For instance, Haakonsson et al. [51] examined the rise of China's wind-turbine manufacturing industry by focusing on knowledge-sharing between Chinese wind-turbine manufacturers and mostly European knowledge-intensive business services (KIBS). Rapid growth in domestic market demand for wind turbines provided a WoO for Chinese wind-turbine manufacturers. They point out that thirty-five per cent of the world's installed wind-power capacity is provided by China. However, this achievement can mostly be attributed to the top three firms, which represented twenty-seven per cent of the world's installed wind capacity [51]. While the local industry benefited as a whole from locational advantages—high transportation costs have further increased with the size of wind turbines—the demand WoO alone does not explain the considerable differences between firms. They argue that KIBS played a vital role in the catching up of China's wind-turbine manufacturing sector, but they also found that the most innovative firms adopted an active strategy of internalizing knowledge, for instance, by acquiring foreign design companies or innovation centres, and made use of other learning mechanisms, such as hiring staff from the US and Europe.

Brazil's mining sector, which holds a leading global position, is another example of advanced catching up by a developing-country industry in which a small number of lead firms account for most of the progress. In this case, a single firm, Vale, represents over fifty per cent of domestic mineral production and is the world's largest iron-ore producer, while Nexa Resources is one of the largest zinc producers globally. Figueiredo and Piana [56] provide a detailed overview of the key events throughout the two firms' capability-building trajectories as they responded to several WoO. Increased mineral prices and rapid growth by large customers, such as India and China, together with high domestic growth rates in Brazil represented a WoO and marked the beginning of the 'forging-ahead' phase [2] in which both companies transitioned from advanced to world-leading levels of capability. In response to this demand WoO, both firms intensified their internationalization efforts through, for example, acquisitions. Vale in particular engaged in research-based learning, for instance, by incorporating the acquired firm's Base Metals Technical Excellence centre. They point to the close links with the Brazilian government (Vale was a state-owned firm) in the earlier stages and the importance of strategic management decisions in explaining the company's leading position.

Many of the most advanced examples of catching up, those in which firms progressed most during demand-based WoO, were found in highly consolidated domestic markets, often in industries involving complex product systems (COPS), such as aircraft [54], hydroelectricity [24], gas turbines [58] and biomass boilers [14]. In these industries, demand-based WoO are often linked to government purchasing programs. As Francelino et al. [54] found in their study of capability-building by a domestic aircraft producer in Brazil, demand-side policies in the form of a procurement programme of the Brazilian department of defense enabled the aircraft producer to develop world-leading capabilities. A long-term relationship with the Brazilian defense force required particularly high engineering standards, acquisition of which enabled the local producer to compete internationally.

4.2.2. *Types of firms*

A WoO arising from changes in domestic demand is often accompanied by an increase in foreign investment aimed at meeting that same demand [59]. Several studies in the capability literature examine capability development in foreign-owned subsidiaries of multinational companies (MNCs), which are generally considered as a sub-category of latecomer firms [11,60]. MNC subsidiaries are unique with regard to the variety of potential knowledge sources available to them as a result of their links to both foreign and local networks MNC–subsidiary relationships have been shown to involve deep knowledge-sharing and the localization of innovation capabilities, as Hansen et al. [61] demonstrated in their study of the Indian subsidiary of a Danish wind-turbine manufacturer, which was established in response to growing domestic demand in India. They found that knowledge and capabilities related to even the most advanced and sensitive technologies were transferred from the parent company to the subsidiary. They show that dedicated efforts by the MNC to promote local capability-building resulted in numerous patents and world-leading innovations in India. Indeed, while market entry was prompted by a large increase in domestic demand, they found that the development of local innovation capabilities could be attributed to purposeful efforts by the firm and the decision to adopt a knowledge-augmenting rather than a knowledge-exploiting mandate. Similarly, in a study of the Brazilian subsidiary of a Danish biotechnology MNC, Figueiredo et al. [62] found that the subsidiary rapidly acquired advanced levels of innovation capabilities in response to an increase in domestic demand for enzymes in the bioethanol industry. The subsidiary did this by combining local knowledge, acquired, for instance, through user-producer interactions and local research collaborations, with foreign expertise to develop solutions that were specific to the bioethanol sector in Brazil. The authors highlight the subsidiary's deliberate efforts to acquire capabilities by engaging in innovation activities, as opposed to production-based activities alone. However, in contrast to Hansen et al. [61], they found that, while the subsidiary achieved an advanced level of innovation capabilities, world-leading capabilities remained at the MNC headquarters, which, they suggest, was a strategic choice on the part of the parent company.

Some industries, such as agriculture [63] and natural resource-based industries [64], tend to involve localized and idiosyncratic knowledge, compared, for example, to consumer electronics or ICT services.[2] This can encourage the development of localized and context-specific innovation capabilities, as Figueiredo et al. [62] found in their study of a subsidiary operating in the bioethanol industry in Brazil. Such an environment may represent a challenge for foreign MNCs to acquire relevant knowledge and, when combined with an increase in domestic demand, may encourage them to localize innovation activities through their subsidiaries. For local firms that have already acquired basic, but highly context-specific capabilities, growing local demand may result in further industry consolidation. For instance, in a study of capability-building in Indian pharmaceutical firms, Kale [38] highlighted the strict regulations and technological complexities of the local (Indian) market, which required a high level of capability. Kale [38] also found that only a small number of Indian firms were able to succeed in this environment by adopting distinctive strategies to develop advanced capabilities that ultimately allowed them to compete successfully in global markets. Collinson and Wang [65] found that, during a sharp increase in the demand for semiconductors, the ability of Taiwan-based subsidiaries of foreign MNCs to access specialized knowledge embedded in external host-country networks was critical to their catching up. They found that embeddedness in host-country networks became increasingly important as domestic demand and local production increased and as supply chains, customers and other local partners became more localized. They point to subsidiary autonomy as an important factor and find that only some firms maintained long-term links with local partners, which contributed to the development of superior capabilities. This illustrates how, in a given industry, sources of local knowledge were relevant at the firm rather than industry level.

Summarizing the above account, we find that sectoral catching-up in demand-based WoO can often be attributed to a small number of firms.

[2] In the case of agriculture or natural resource-based industries (mining, for instance), production activities are fixed in a given location. By contrast, consumer electronics can be produced globally and typically involves a globally dispersed supply chain.

The prevailing knowledge sources available to firms, and thus their opportunities for capability-building, can change with fluctuations in demand by, for example, encouraging market entry by foreign firms. The extent to which value chains are localized was shown to influence capability-building. Conditions for capability-building in demand WoO depend on whether the demand is local or global. The literature shows that the relevance of various knowledge sources varied not only between industries but also between firms.

4.3. Institutional WoO

Institutional WoO typically emerge due to policy-making in late-comer countries. This may take the form of policies that seek to level the playing field through tariffs, subsidies or import substitution, or of other policies that aim to encourage domestic innovation by, for instance, initiating knowledge-sharing collaborations between firms and research institutes. However, as Binz et al. [66] demonstrate, the effectiveness of industrial policy-making varies between industries according to technology- and industry-specific innovation processes. For instance, they show how import substitution-based catching-up policies were more effective in the case of design-intensive products, such as wind turbines, whereas other industries, such as manufacturing or CoPS, required policies that supported bottom-up agency and knowledge transfers from foreign sources. Furthermore, as the capability literature shows, innovation processes also vary at the firm level. As such, responses to institutional WoO are far from alike and differ according to firms' unique characteristics, such as knowledge-sharing relationships and networks [50], existing levels of capabilities [14,24,43] or type of ownership [67,68].

4.3.1. Knowledge-sharing relationships and networks

Many of the examples in the capability literature of catching up in the presence of an institutional WoO involve policies that either intentionally or unintentionally target capability-building in specific firms. This is often found in CoPS industries, where government participation is common, for instance, as an equity stakeholder or customer (e.g. [54]). This is exemplified by Kiamehr et al. [39], who show how close links between suppliers and government buyers prompted capability-building in project management services, allowing the late-comer Mapna, a thermal power-plant producer, to transition into other, more capital-intensive aspects of the business, such as manufacturing and design. In this case the Iranian government awarded large packages of projects to Mapna, which encouraged foreign firms to enter the Iranian market and enabled Mapna to licence technology from these firms on favourable terms. However, as Majidpour [58] finds in a similar study, to a large extent, Mapna's success in acquiring capabilities from foreign firms was made possible by its ability to synthesize imported knowledge with indigenous expertise, existing capabilities and knowledge-sharing relationships with, for example, local universities. Other examples of public policy initiatives that aim to target knowledge-sharing include the 'Innovation Law' and 'Good law' introduced in Brazil to encourage interaction between firms and universities. However, as Figueiredo and Piana [56] found, catching up varied widely across firms. They identify several distinct strategies that firms employed in response to institutional WoO, which relied on the various knowledge inputs that the individual firms had at their disposal. The authors emphasise the importance of decentralized inputs for the development of innovation capabilities, such as those embedded in production activities or in closely linked organizations, as opposed to knowledge generated in public organizations, R&D institutes, etc. (see also [69]).

In their study of a leading Chinese manufacturer in the air-separator industry, Guo and Chen [70] examine the firm's capability-building efforts in response to China's import substitution-focused industrial-development program, in which large state-owned enterprises were encouraged to purchase equipment from local firms. The local firm adapted its product lines according to changes in government policy, which required rapid capability-building, as it shifted from the design and manufacture of one product to another. They found that the firm was able to overcome the initial technology gap from the market leaders by absorbing external expertise embedded in their networks in processes of 'learning by decomposition' and 'learning by recombination' (see also [51,71]). For instance, the firm collaborated with public research institutes and industrial clients on government-led projects to co-create key industrial technology and equipment.

Guo et al. [46] examined capability-building in a leading Chinese telecommunications firm (Huawei) as it responded to several WoO. In one case, the Chinese government's 'technology for market' mandate resulted in a cluster of Sino-foreign joint ventures being established to manufacture digital switches. However, Huawei, which was part of this cluster, made the decision to develop capabilities independently by establishing collaborative R&D projects with local research institutes and recruiting talented engineers from elite universities and the telecoms industry. They found that this enabled the firm to build the basic innovation capabilities that were necessary for the development of its own digital switches. They emphasise the willingness of Huawei's founder to take bold and risky decisions as a crucial factor shaping the firm's response. In the second case, the Chinese government publicly called for policy and financial support for Huawei, which was singled out as an example of local manufacturing success. As a result, several state-owned banks provided a significant amount of buyer credit, enabling Huawei to win contracts with local telecoms operators. In response, Huawei developed increasingly advanced R&D capabilities, which allowed it to service the urban market segment with 'world-class' technology and to become China's largest supplier of digital switches.

Ribeiro and Furtado [55] examine capability-building by a group of Brazilian firms supplying the industry-leading state-owned oil producer, Petrobras. A WoO was created when the Brazilian government implemented a procurement policy during the construction of a large oil-drilling platform. In an attempt to foster local innovation in the Brazilian oil industry, the policy mandated that Petrobras source all inputs from local subcontractors. However, the authors found that the policy resulted in very little technological development among the firms being studied, most of which outsourced their knowledge-intensive and high value-added activities to foreign subcontractors. Technological learning was only observed in one firm, including one instance of what they describe as 'inventive, R&D-based learning' ([55], p. 179). The authors conclude that the general lack of capability-building by local firms was due to the firms' limited stock of existing capabilities, which prevented them from carrying out innovative tasks. They also point to the government's tendency to focus on local content requirements, rather than providing support for capability-building specifically (see also [66]).

4.3.2. Ownership

Foreign- and domestically owned firms are likely to differ in terms of the knowledge networks they are embedded in, as well as in their pre-existing levels of capability [15,65,68]. In order to gauge the effectiveness of government policy in supporting knowledge-sharing in a given sector, it is relevant to examine capability-building in firms with different types of ownership.

Torres and Hasenclever [43] examined capability-building in 24 private and state-owned firms in the pharmaceutical sector in Brazil. Following the Brazilian government's introduction of a policy aimed at supporting domestic growth in the pharmaceutical sector, foreign firms were 'invited' to collaborate with local pharmaceutical firms to produce drugs whose patent was about to expire. While they highlight the large differences in capability levels between individual firms, they also found that private pharmaceutical firms achieved a higher level of innovation capability when compared to state-owned ones or start-ups. They attribute this to their previous experience and existing capabilities, which gave them a greater capacity to absorb new knowledge from

foreign sources. Similarly, Collinson and Wang [65] found that knowledge-sharing through links between subsidiaries and local organizations was directly related to the development of the semiconductor industry in Taiwan (60% of worldwide revenue), which in turn was partly funded and coordinated by the government.

Furthermore, Figueiredo [72] investigated capability-building in a subsidiary in the ICT sector in Brazil. A WoO emerged when the Brazilian government initiated a new policy for information and communication technology (ICT), which, through fiscal incentives, aimed to stimulate innovation within the ICT sector by strengthening the links between local firms and research institutes and universities. However, managers at the subsidiary found that there was a shortage of professionals in the Brazilian labour market and that local universities were not supplying graduates with sufficient skills. In response, the subsidiary took two specific measures to develop capabilities. First, they began to build the required skills internally by training new employees in the parent company. Second, they sought to set up a pioneering education and training programme with local universities. However, being a foreign-owned entity created its own challenges, as several local universities were reluctant to engage with foreign subsidiaries for reasons of nationalist sentiment. By drawing on previous business connections, the subsidiary was eventually able to co-design an education and training programme in software development in collaboration with a local research institute and university. This illustrates (i) that WoO apply differently to firms with different forms of ownership, and (ii) that, although the initial impetus was provided by the government, it was firm-level efforts, including management decisions and pre-existing (search) capabilities, that resulted in capability development. In this case, the ability to combine expertise from the parent company with local capabilities resulted in the development of a new mobile phone and established a local industry benchmark for collaboration between local ICT firms and research organizations. This again demonstrates the influence of firm-level factors underlying the idiosyncratic responses of individual firms to institutional WoO. As emphasised repeatedly in the literature, individual firms differ in their pre-existing knowledge and their embeddedness in knowledge-sharing networks, which may explain the large variation in catching up by individual firms within a sector [65].

In summary, the capability literature demonstrated how institutional WoO might only be relevant to a small group of firms within a sector. In particular, the literature provided evidence from several strategically important industries in which the relevance of an institutional WoO was shown to depend on existing relations between individual firms and governments. Perhaps more importantly, the literature demonstrated how catching up within an institutional WoO depended on firm-level factors, such as ownership, existing levels of capability and the agency and resources of key individuals within the firm (see Table 3).

Table 3
Summary of insights from the capability literature on firms' responses to different WoO.

	Firm responses
Technological WoO	- Established early R&D collaborations with research institutes, followed by accumulation of innovation capabilities by internalizing research efforts. - Bold management decisions combined with purposeful internal research efforts allowed firms to diverge from the established technological path and essentially *create* a WoO. - Firms' pre-existing capabilities, acquired at different times from their experience in other sectors, allowed them to internalize knowledge from external sources in response to technology WoO. - Dedicated efforts to combine existing capabilities with external knowledge, e.g. from customers or by hiring foreign experts, allowed firms to adapt rapidly to emerging technological trends. - Firms acquired crucial knowledge by actively shaping and expanding their knowledge-sharing networks.
Demand WoO	- Demand WoO often resulted in catching up by a small number of firms. - Levels and speed of capability-building varied significantly between firms in the same sector. - Responses were enabled or constrained by firm-level characteristics, e.g. being an MNC subsidiary. - Ability to access locally specific knowledge through collaboration with research institutes was crucial for capability-building in response to a domestic demand WoO. - Demand WoO can influence the sources of knowledge available to latecomer firms.
Institutional WoO	- Institutional WoO may only be relevant for a few firms depending on existing links and prior experience collaborating with government agencies. - Firms' responses to institutional WoO were inhibited by their lack of existing innovation capabilities. - Despite favourable policies, catching up was shown to depend on the strategic choices of individual firms, which sometimes deviated from the industrial development programmes set out by the government. - Owing to high levels of existing capabilities, foreign firms were better able to take advantage of institutional WoO. However, MNC subsidiaries faced challenges in accessing locally embedded knowledge.

Source: authors' own elaboration

5. Discussion

In the foregoing pages, we have analysed the WoO concept, as put forward by Lee and Malerba [2], from a firm-level capability-building perspective by reviewing a recent sample of the relevant literature. While recognizing the key differences between the two bodies of literature we consulted, we argue that the capability literature can provide further nuances to enrich the WoO literature on a number of aspects.

During a WoO, a developing- or emerging country *industry* may achieve a leading position in terms of global market share. Yet, as we argued initially, studies applying the WoO framework typically do not address the issue of *who* is catching up, and often refer to catching up by countries, sectors and firms interchangeably. Hence, industrial catch-up may be explained by one or two latecomer firms who have become industry leaders, as shown for the aircraft [73] and mobile-phone sectors [7]. In other cases, catching up at the country or sector level may be due to the collective progress of many firms, which together represent a leading position, as in the case of the wine industry [6].

The literature we reviewed revealed considerable variation among firms in the same sector. Firms were shown to vary widely in terms of their levels and rates of capability-building (e.g. [15,65,74]). This variation underscores the need to explore in greater depth the underlying firm-level factors that contribute to catching up during WoO. The review demonstrated that the capability literature could provide some insights in this respect. In the following, we first provide a discussion of the empirical findings before moving to assess the theoretical implications of these findings.

5.1. Discussion of empirical findings

With regard to technological WoO, the literature provided examples of how individual firms managed technological change through capability-building. During a technological WoO, the catching-up trajectories of firms in the same sector were often found to vary significantly. Firms developed capabilities at widely different rates, followed different technological pathways, or remained stuck at a certain level. The capability literature provides insights into the determinants of such varying development paths. For example, in order to identify and adapt to new technology, the literature highlighted the importance of existing capabilities allowing firms to forecast technological trends and internalize new knowledge from external sources. While this raises the issue of path dependence, it does not necessarily imply that firms' choices are limited by their existing resources. This was shown by Dantas and Bell [50], who found that firms could overcome such limitations by

expanding their knowledge-sharing networks. Furthermore, the literature differentiates between R&D and non-R&D based capabilities. Non-R&D capabilities tend to be prioritized less, though they can provide the basis for R&D capabilities and were in some studies shown to be more versatile, serving as a basis for acquiring more advanced capabilities in a range of different sub-fields. Developing non-R&D capabilities may reduce path dependence and allow firms to respond more rapidly to new technology.

The literature also showed how technological WoO may apply to only a few firms within a sector. Furthermore, by providing a framework to assess the types and levels of capabilities and how they relate to specific technologies, the capability literature allows us to explore how firms catch up and thus identify which firms are likely to catch up in a given technological WoO. The literature also demonstrated how firms are more than just passive actors responding to technological change. Indeed, latecomer firms can themselves play a central role in developing new technologies, which may initiate an industry-wide technological shift. As such, a technological WoO may be understood not only as a phenomenon that shapes industrial catching-up, but also as a set of conditions that can be *created by* the actions of individual firms. Similarly, firms' progress in response to technological WoO could in some cases be directly attributed to the decisions and efforts of individuals within the firm. This aligns with Guo et al. [46], who emphasise the importance of firm agency as the primary driver of catching up in the presence of WoO.

With regard to demand-related WoO, the literature again revealed considerable variation among firms in the same sector, in terms of both their levels of capability-building and their responses, during fluctuations in demand. This has important implications for how demand-based WoO are understood. If we consider capability-building to be the main driver of catching up in a demand-based WoO, it is important to consider how opportunities for capability-building, e.g. access to knowledge, may change in line with fluctuations in demand. For example, an increase in domestic demand often brings with it growing investment by foreign firms and thereby opportunities for knowledge-sharing and capability-building by domestic firms and subsidiaries. In other words, it is important to consider how the conditions for knowledge-sharing change as a result of changes in demand. These conditions will depend on whether the demand is domestic or global and also on the nature of the industry. For example, demand in some industries can be more closely linked to policy-making, such as government procurement programmes, than others. In such industries, such as CoPS, demand may be accompanied by knowledge transfer or R&D development programmes, which may implicitly or explicitly target one or two firms. The creation of a large domestic market will increase global market share by domestic firms almost by default, as in China. In the presence of strong domestic demand, the number and size of domestic firms is likely to increase. However, as the literature shows, this does not necessarily correspond to technological catching up. While technological catch-up ultimately results from the capability-building efforts of individual firms, the *conditions* for technological catch-up vary according to the nature of the industry (e.g. natural resource-based and the type of firm (e.g. foreign subsidiary).

With regard to institutional WoO, the literature provided examples from a number of sectors in which industrial development policies were shown to benefit individual or specific groups of firms disproportionately. This suggests that policies aimed at targeting innovation among domestic firms were only relevant for some firms, for instance, those that already possessed the capabilities necessary to take advantage of the WoO. Foreign-owned subsidiaries, for instance, can draw on knowledge from their parent companies, but they may experience difficulties in accessing knowledge embedded in local networks. In some industries—in particular those of national strategic importance—industrial development policies may disproportionately benefit firms that have already established ties or knowledge-sharing relations with government entities. Furthermore, the literature showed that in some cases firms' ability to take advantage of institutional WoO could be traced to the efforts and resources of individuals within the firm. This not only underscores the need for policy-making that caters for technology- and industry-specific learning characteristics, as proposed by Binz et al. [66]; it also suggests, as Hobday and Rush [75] maintain, that policy needs to be adapted to the characteristics of individual firms. If an institutional WoO results in a small group of firms catching up, then it is important to understand why and how. If a policy explicitly targets a few key firms, then an understanding of how these firms are likely to respond based on, for instance, an evaluation of their existing capabilities is important for effective policy-making. Without an in-depth understanding of the underlying capability-building processes, it becomes difficult to evaluate the causal relationship between institutional WoO and catching up. Hence, we argue that integrating the capability-building perspective into WoO research would enable researchers to determine more accurately the link between WoO and catching up by latecomer firms.

For analytical purposes, we have maintained a separation between the three types of WoO suggested by Lee and Malerba [2]. However, maintaining this analytical separation may not be straightforward and unproblematic as there can be a significant degree of overlap between the three WoO. For example, Hansen and Hansen [9] argue that changes in institutional framework conditions in the energy sector (an institutional WoO), in the form of feed-in tariffs, directly translate into market demand through economic incentives (a market WoO). Similarly, as argued by Lema et al. [76], a market WoO arising from a growing national or external demand without investments aimed at improving innovation capabilities can result in a situation where latecomers may become market leaders while remaining in a technology follower position. Relatedly, Radosevic and Yoruk [77] argue that it is the nature of the interaction between the three WoO and their mutual complementarities that matters most for creating conducive or unfavorable conditions for firms. These examples point to the importance of understanding the specific interaction patterns emerging between the three types of WoO in a given sector and how this may affect the possibilities for catching up.

5.2. Theoretical implications

Our findings provide relevant insights regarding the usefulness of the WoO perspective in comprehending how catching-up unfolds in developing economies. While WoO research most often involves a sectoral analysis of industries or countries, we argue that WoO offer an appropriate guiding principle for analysis at the firm level, as well when combined with a firm-oriented perspective. As we have shown, the capability literature can enable research on WoO to determine how firms respond differently to certain WoO and the underlying causes of such differences. As such, our paper points to the importance of disaggregating the sectoral perspective, as suggested by Hansen et al. [10]. We therefore recommend closer conceptual integration of the capability approach in future WoO research. Specifically, we propose that the capability approach enhances understanding relating to (i) which and how many firms are influenced by WoO (relevance of WoO); (ii) the learning mechanisms that enable catching up (causal relationship between WoO and catching up); and (iii) the extent to which catching up occurs during a WoO (evaluating outcomes).

The WoO perspective implies that discontinuities in technology, demand or institutions represent an opportunity for *any* latecomer firm to catch up. However, as the review also indicated, WoO may only be relevant to some firms within a sector, for instance, those possessing the capabilities required to take advantage of them. This understanding aligns with Vértesy [73], who emphasises the importance of including in the analysis the preconditions that allow firms to respond to WoO. Hence, we suggest that a closer integration of the capability perspective allows for a more in-depth understanding of the preconditions firms require and of the extent to which these preconditions are present within

the firms that make up a given sector. Disaggregating the analysis to distinguish between firms within sectors based on their attributes, such as pre-existing capabilities and knowledge networks, can go some way to explaining the variation in progress with catching up between firms, as well as to allow certain sub-groups of firms that share common characteristics to be identified. Similarly, the types of capabilities firms possess may have implications for how they are able to respond to future WoO. For instance, several studies in the capability literature emphasise the important role of non-R&D forms of learning [15], which may be better adapted to emerging technologies or applied to different but related industries [24]. This would allow for a more nuanced conceptualization of WoO, one that extends beyond the sectoral innovation-system level of analysis.

In some cases, catching up by a small number of firms within a sector may be explained by firm-level decisions and efforts, which, regardless of the relevance of a WoO, may or may not lead to their catching up. The capability literature can provide a more nuanced understanding of causal factors influencing *how* firms catch up during WoO. While firms' responses are an integral part of the WoO perspective [2], they are rarely explored in depth: few studies, for example, have explicitly examined the causal relationship between WoO and catching up at the firm level [8]. We argue that the capability approach can be applied as a framework to analyse the micro-level processes and learning mechanisms that determine firms' capability-building trajectories and how these evolve and interact with WoO over time. To determine if and to what extent catching up has been enabled by a WoO will require closer attention to the role of firm-level agency, including the agency of individuals within firms. Similarly, through their decisions and efforts to develop capabilities in new directions, individual firms can become the catalysts for industry-wide technological change and thereby play an active role in the *creation* of WoO. As shown in section 4, industry-wide technological change can arise from the capability-building efforts of one or two firms. The decision to build capabilities in a new direction can result in new technology, creating new technological standards, market demand and adaptation of policies. Lee and Malerba [2] recognize that WoO can be created endogenously, but little attention has been paid to how this occurs. We argue that a closer integration of the capability approach will allow for a more in-depth understanding not only of firms' responses to changing external conditions, but also of the interactions between firms' external conditions in shaping WoO.

Finally, a closer integration between the capability approach and the WoO perspective can result in a more comprehensive and precise evaluation of the *extent* of catching up in a given industry. The WoO perspective typically gives primacy to market share as opposed to technological capabilities as the main indicator of catching up. However, as shown in our review, this overlooks which firms and how many of them are actually catching up and, perhaps more importantly, it does not account for the depth, levels, or types of capabilities firms have acquired. As latecomers begin to approach industry leaders, building indigenous innovation capabilities becomes increasingly important [51]. As such, the depth of capability-building has crucial consequences for the sustainability of catching up. In some cases, latecomer firms may expand production capabilities and capture market share without fully internalizing the most advanced innovation capabilities, which often remain with leading firms in industrialized countries. Hence, catching up as a result of WoO can easily be overestimated, particularly when the analysis centres on the sector or country level. Hence, following Lema et al. [76], we argue that, in addition to using market share as an indicator for the existence and extent of catching up, more attention should be paid to the levels, types and depth of capability-building in individual firms as indicators for catching up during WoO using a range of relevant indicators.

In summarizing the above, we are able to put forward the contours of an analytical framework combining insights from the literatures on WoO and capability-building in latecomer firms (Fig. 1). As can be seen in Fig. 1, we posit that the catching up of latecomer firms is conditioned not only by sector-specific characteristics and different types of WoO, but also by firm-specific attributes. We argue that the interaction and relative importance of these factors will determine the responses, level and rate of capability-building by firms that are active in various sectors. The framework can serve as a source of inspiration for future research aimed at further unravelling the relationship between firms' responses to different WoO and the resulting paths of capability-building and catching-up. In this context, it is important to keep in mind the different conditions and factors that influence catching up, both at the sector level and firm level. For example, firms in a given sector will typically be subject to the same economic, regulatory and political framework conditions of a given developing economy, such as tax and trade regulations, economic subsidies and industrial policies. Furthermore, firms in a given sector share some commonalities. For instance, they often draw on the same pool of labour and have access to similar financial resources. Additionally, they may also be geographically concentrated in regional clusters that are closely interconnected through inter-firm linkages and labour mobility. Certain industries may also comprise few large companies or many small and medium-sized companies. These sector-specificities mean that all firms will generally face similar constraints and opportunities to catch up and exploit a WoO. Accordingly, the sectoral perspective, including indicators and causal factors of importance for catching up at the aggregate level, remains relevant and useful. Our paper should therefore not be interpreted as an argument against the usefulness of cross-country comparisons at the sectoral level. Rather, we argue in favour of directing attention to a range of additional factors and conditions when WoO are examined at the micro-level of firms. This complementary approach provides further nuances that can enrich the sectoral perspective.

6. Conclusion

In this paper, we have set out to explore how recent work in the literature on capability-building by latecomer firms may contribute to providing a more nuanced understanding of the WoO concept as put forward by Lee and Malerba [2]. This review represents a first step in synthesising the two approaches using a limited sample of the capability literature. The WoO literature aims to explain catching up based on changes to external conditions that are common to firms in a given sectoral innovation system. However, as we have demonstrated, the capability literature reveals the highly firm-specific nature of how learning occurs in individual firms, which translates into differences in firm-level responses to specific WoO.

In particular, the paper demonstrated how firms' ability to catch up during a WoO is conditioned by their existing capabilities. The relevance of an emerging technology WoO may vary according to firms' individual configurations of capabilities, which may or may not allow them to innovate along the new technological trajectory. The literature also provides examples of firms that were able to overcome an initial lack of capabilities by leveraging expertise embedded in external networks [70]. However, this in itself requires dedicated efforts by the firm and illustrates the centrality of firm agency in the catching-up process. Indeed, the literature demonstrated how firms could play an active role in *creating* technological WoO. In the presence of a demand WoO, catching up in terms of capability-building was also shown to vary considerably between firms in the same sector. In terms of the implications for capability-building, the literature demonstrates the importance of distinguishing between WoO emerging from local and global demand, as well as types of firms that were shown to influence how catching up occurs at the firm level. Similarly, the literature showed that institutional WoO often resulted in catching up by a small group of firms. This could be explained by firm-level characteristics, such as firm ownership, existing capabilities and the decisions of management and even key individuals. As such, the capability literature stresses that, in order to understand *how* and *which* latecomers take advantage of WoO, it is appropriate to begin by exploring capability development processes

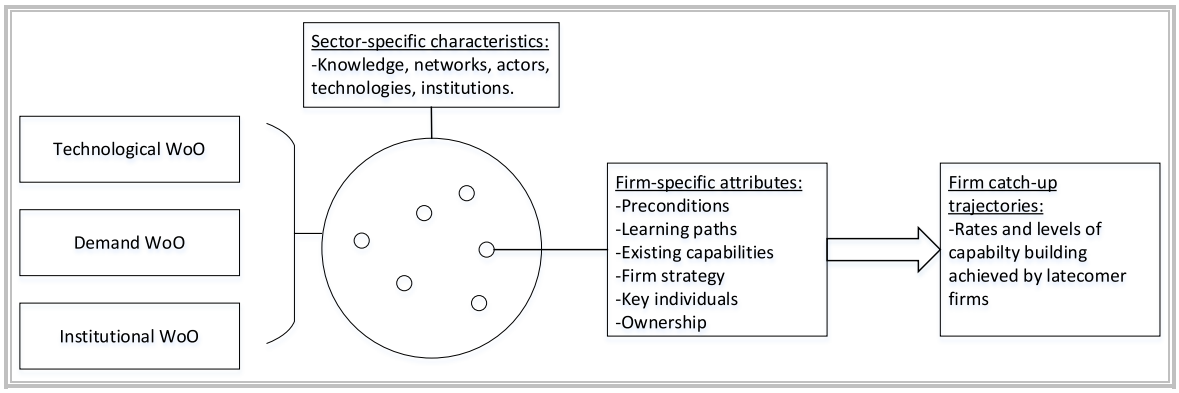

Fig. 1. Integrated conceptual framework.
Source: modified from Vértesy [73], Lema et al. [76], Bell and Figueiredo [60].

and their antecedents at the firm level in depth. Moreover, the individual nature of capability-building emphasises the need to look beyond market share as an indicator for catching up and to explore the underlying learning mechanisms that enable indigenous innovations to take hold.

This paper has attempted to unpack the notion of WoO by using the more granular approach of the capability literature to improve understanding of what it means for individual firms across sectors and industries. Insights from this literature may contribute to a more nuanced and more dynamic understanding of the concept that can be applied to understand the underlying mechanisms of catching up in new industries as they emerge. However, the paper may only be considered a first step in unravelling the importance of WoO in relation to processes of catching up at the micro-level of firms. Accordingly, we see a need for more research addressing the relationship between WoO and the catching-up of firms. Given the increasing speed at which new technological fields are emerging and the shift in the composition of demand towards developing economies,[3] both of which require new approaches to policy-making, research applying the WoO perspective is of the utmost relevance. Nevertheless, as we have shown, the WoO perspective focuses on the sector level of analysis and tends to overlook the micro-dynamics of catching up and the capability-building efforts of individual firms. As such, there is a need for a more nuanced understanding of the causal relationship between WoO and catching-up outcomes. When it comes to achieving a disaggregated view of the underlying causal factors, future studies could, for instance, explicitly focus on tracing the capability-building trajectories of similar firms in the same sector during a WoO. Studies exploring the capability-building trajectories of unsuccessful and successful firms with similar attributes would also provide valuable insights in this respect.

With regard to catching-up outcomes, the WoO perspective gives primacy to market share as an indicator of catching up and industrial leadership. While market share is an important measure, a more accurate understanding of the state of catching up and of how innovation is distributed within a sector could be achieved through an evaluation of the types, levels and speed of capability-building in selected firms. Future WoO studies should apply the capability framework to assess the extent to which latecomer firms have acquired and genuinely internalized core innovation capabilities, rather than simply acting as recipients of innovations developed by firms in industrialized economies.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix. Capability literature sample: 63 articles

Author	Year	Title	Periodical	Country/ region in focus	Sector/industry	Level of analysis	Method	Type of firm ownership
Aeron, Prageet; Jain, Rekha	2015	A study on technological capability among product-based telecom start-ups in India: role of technological learning and bricolage	Int. J. Technol. Learn. Innov. Dev. (International Journal of Technological Learning, Innovation and Development)	India	Telecommunication	Industry level	Qualitative	Domestic

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[3] For instance, in electricity [24].

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Author	Year	Title	Periodical	Country/ region in focus	Sector/industry	Level of analysis	Method	Type of firm ownership
Ariffin, N.	2010	Internationalization of technological innovative capabilities: levels, types and speed (learning rates) in the electronics industry in Malaysia	Int. J. Technol. Learn. Innov. Dev. (International Journal of Technological Learning, Innovation and Development)	Malaysia	electronics	Industry level	Mixed methods	Domestic, MNC subsidiaries
Bell, Martin; Figueiredo, Paulo N.	2012	Innovation capability building and learning mechanisms in latecomer firms: recent empirical contributions and implications for research	Canadian Journal of Development Studies/Revue canadienne d'études du développement	Developing/ emerging markets	General	n/a	n/a	n/a
Bernat, Stefan; Karabag, Solmaz Filiz	2019	Strategic alignment of technology: Organising for technology upgrading in emerging economy firms	Technol. Forecast. Soc. Change (Technological Forecasting and Social Change)	Brazil	Industrial engineering/ petroleum	Country level	Qualitative	Domestic, State-owned
Binz, Christian; Gosens, Jorrit; Hansen, Teis; Hansen, Ulrich E.	2017	Toward Technology-Sensitive Catching-Up Policies: Insights from Renewable Energy in China	World Dev. (World Development)	China	Renewables	Industry level	Qualitative	n/a
Chandran, V. G. R.; Rasiah, Rajah	2013	Firm Size, Technological Capability, Exports and Economic Performance: The Case of Electronics Industry in Malaysia	Journal of Business Economics and Management	Malaysia	electronics	Industry level	Quantitative	n/a
Choung, Jae-Yong; Hwang, Hye-Ran; Choi, Jun Kyun	2016	Post catch-up system transition failure: the case of ICT technology development in Korea	Asian J. Technol. Innov. (Asian Journal of Technology Innovation)	Korea	Information and communication technology (ICT)	Industry level	Qualitative	n/a
Chuang, Y.-S.; Hobday, Michael	2013	Technological upgrading in Taiwan's TFT-LCD industry: Signs of a deeper absorptive capacity?	Technol. Anal. Strateg. Manage. (Technology Analysis and Strategic Management)	Taiwan	Thin film transister liquid crystal display (TFT-LCD)	Industry level	Qualitative	Domestic
Collinson, Simon C.; Wang, Rowena	2012	The evolution of innovation capability in multinational enterprise subsidiaries: Dual network embeddedness and the divergence of subsidiary specialisation in Taiwan	Res Policy (Research Policy)	Taiwan	Semiconductor	Firm level	Qualitative	MNC Subsidiary
Dantas, E.; Bell, M.	2011	The Co-Evolution of Firm-Centered Knowledge Networks and Capabilities in Late Industrializing Countries: The Case of Petrobras in the Offshore Oil Innovation System in Brazil	World Dev. (World Development)	Brazil	Oil	Firm level	Qualitative	State owned enterprise (SOE)
Doranova, Asel; Costa, Ionara; Duysters, Geert	2011	The role of absorptive capacity in technological learning in CDM projects: evidences from survey in Brazil, China, India and Mexico	Int. J. Technol. Globalisation (International Journal of Technology and Globalisation)	India, Brazil, Mexico, China	CDM project firms	Project level	Quantitative	n/a
Dutrénit, Gabriela; Natera, José Miguel; Puchet Anyul, Martín; Vera-Cruz, Alexandre O.	2019	Development profiles and accumulation of technological capabilities in Latin America	Technol. Forecast. Soc. Change (Technological Forecasting and Social Change)	Latin America	General	Regional	Quantitative	n/a
Egbetokun, A. A.	2015	Interactive learning and firm-level capabilities in latecomer settings: The Nigerian manufacturing industry	Technol. Forecast. Soc. Change (Technological Forecasting and Social Change)	Nigeria	Manufacturing	Industry level	Quantitative	Domestic
Figueiredo, Paulo N.	2010	Discontinuous innovation capability accumulation in latecomer natural resource-processing firms	Technol. Forecast. Soc. Change (Technological Forecasting and Social Change)	Brazil	Forestry and pulp	Industry level	Qualitative	Domestic, foreign
Figueiredo, Paulo N.	2013	Embedding with multiple knowledge sources to improve innovation	Knowledge Management Research & Practice	Brazil	Information and communication technology (ICT)	Firm level	Qualitative	MNC Subsidiary

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Author	Year	Title	Periodical	Country/ region in focus	Sector/industry	Level of analysis	Method	Type of firm ownership
		performance: the learning experience of Motorola in Brazil						
Figueiredo, Paulo N.	2014	Beyond technological catch-up: An empirical investigation of further innovative capability accumulation outcomes in latecomer firms with evidence from Brazil	J Eng Technol Manage JET M (Journal of Engineering and Technology Management - JET-M)	Brazil	Pulp and paper	Industry level	Qualitative	Domestic, foreign
Figueiredo, Paulo N.	2016	Evolution of the short-fiber technological trajectory in Brazil's pulp and paper industry: The role of firm-level innovative capability-building and indigenous institutions	For. Policy Econ. (Forest Policy and Economics)	Brazil	Pulp and paper	Industry level	Qualitative	Domestic
Figueiredo, Paulo N.	2016	New challenges for public research organizations in agricultural innovation in developing economies: Evidence from Embrapa in Brazil's soybean industry	The Quarterly Review of Economics and Finance	Brazil	Soybean	Industry level	Qualitative	n/a
Figueiredo, Paulo N.	2017	Micro-level technological capability accumulation in developing economies: Insights from the Brazilian sugarcane ethanol industry	J. Clean. Prod. (Journal of Cleaner Production)	Brazil	Ethanol	Industry level	Qualitative	Domestic, foreign
Figueiredo, Paulo N.; Brito, K.	2011	The innovation performance of MNE subsidiaries and local embeddedness: Evidence from an emerging economy	J. Evol. Econ. (Journal of Evolutionary Economics)	Brazil	electronics	Industry level	Qualitative	MNC Subsidiary
Figueiredo, Paulo N.; Cohen, Marcela	2019	Explaining early entry into path-creation technological catch-up in the forestry and pulp industry: Evidence from Brazil	Res Policy (Research Policy)	Brazil	Forestry and pulp	Industry level	Mixed methods	MNC
Figueiredo, Paulo N.; Larsen, Henrik; Hansen, Ulrich E.	2020	The role of interactive learning in innovation capability building in multinational subsidiaries: A micro-level study of biotechnology in Brazil	Res Policy (Research Policy)	Brazil	Biotechnology	Firm level	Qualitative	MNC Subsidiary
Figueiredo, Paulo N.; Piana, Janaina	2018	Innovative capability building and learning linkages in knowledge-intensive service SMEs in Brazil's mining industry	Resources Policy	Brazil	Mining	Industry level	Qualitative	Domestic, foreign
Figueiredo, Paulo N.; Piana, J.	2020	Technological learning strategies and technology upgrading intensity in the mining industry: evidence from Brazil	J. Technol. Transf. (Journal of Technology Transfer)	Brazil	Mining	Industry level	Qualitative	Domestic
Francelino, Josiane de Araújo; Urbina, Ligia Maria Soto; Furtado, André Tosi; Chagas, Milton de Freitas	2019	How public policies have shaped the technological progress in the Brazilian aeronautics industry: Embraer case	Sci. and Pub. Pol. (Science and Public Policy)	Brazil	Aeronautics	Industry level	Qualitative	Domestic
Fujita, M.	2012	How sectoral systems of production promote capability building: Insights from the Vietnamese motorcycle industry	Asian J. Technol. Innov. (Asian Journal of Technology Innovation)	Vietnam	Motorcycle	Industry level	Qualitative	Domestic, State-owned
Guo, Bin; Chen, Xiaoling	2013	Learning by decomposition and recombination in technological catching-up: a case study of a Chinese leading air separator system manufacturer, 1978–2008	IJPD (International Journal of Product Development)	China	Air separator system	Firm level	Qualitative	Domestic
Guo, L.; Zhang, M. Y.; Dodgson, M.; Gann, D.	2019	Huawei's catch-up in the global telecommunication industry: innovation	Technol. Anal. Strateg. Manage. (Technology Analysis	China	Telecommunication	Firm level	Quantitative	Domestic

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Author	Year	Title	Periodical	Country/ region in focus	Sector/industry	Level of analysis	Method	Type of firm ownership
		capability and transition to leadership	and Strategic Management)					
Guo, L.; Zhang, M. Y.; Dodgson, M.; Gann, D.; Cai, H.	2019	Seizing windows of opportunity by using technology-building and market-seeking strategies in tandem: Huawei's sustained catch-up in the global market	Asia Pac. J. Manage. (Asia Pacific Journal of Management)	China	Telecommunication	Firm level	Qualitative	Domestic
Haakonsson, S.; Kirkegaard, J. K.; Lema, R.	2020	The decomposition of innovation in Europe and China's catch-up in wind power technology: the role of KIBS	Eur. Plann. Stud. (European Planning Studies)	China	Wind turbines	Industry level	Qualitative	Domestic
Hansen, Ulrich E.; Fold, Niels; Hansen, Teis	2016	Upgrading to lead firm position via international acquisition: learning from the global biomass power plant industry	J Econ Geogr (Journal of Economic Geography)	China	Biomass	Firm level	Qualitative	Domestic
Hansen, Ulrich E.; Larsen, T. H.; Bhasin, S.; Burgers, R.; Larsen, H.	2020	Innovation capability building in subsidiaries of multinational companies in emerging economies: Insights from the wind turbine industry	J. Clean. Prod. (Journal of Cleaner Production)	India	Wind turbines	Firm level	Qualitative	MNC Subsidiary
Hansen, Ulrich E.; Lema, R.	2019	The co-evolution of learning mechanisms and technological capabilities: Lessons from energy technologies in emerging economies	Technol. Forecast. Soc. Change (Technological Forecasting and Social Change)	Malaysia, China	Biomass, wind	Industry level	Qualitative	Domestic
Hansen, Ulrich E.; Ockwell, David	2014	Learning and technological capability building in emerging economies: The case of the biomass power equipment industry in Malaysia	Technovation (Technovation)	Malaysia	Biomass	Firm level	Qualitative	Domestic
Hayashi, Daisuke	2018	Knowledge flow in low-carbon technology transfer: A case of India's wind power industry	Energy Policy	India	Wind turbines	Industry level	Qualitative	Domestic, foreign
Huenteler, Joern; Niebuhr, Christian; Schmidt, Tobias S.	2016	The effect of local and global learning on the cost of renewable energy in developing countries	J. Clean. Prod. (Journal of Cleaner Production)	Thailand	Electricity	Industry level	Quantitative	n/a
Kale, Dinar	2019	From small molecule generics to biosimilars: Technological upgrading and patterns of distinctive learning processes in the Indian pharmaceutical industry	Technol. Forecast. Soc. Change (Technological Forecasting and Social Change)	India	Pharmaceutical	Industry level	Qualitative	Domestic
Karabag, Solmaz Filiz; Bernat, Stefan	2018	Accumulating technological capabilities through R&D projects: studies on the Brazilian defence industry	Int. J. Technol. Learn. Innov. Dev. (International Journal of Technological Learning, Innovation and Development)	Brazil	Defence	Industry level	Qualitative	n/a
Kiamehr, M.	2017	Paths of technological capability building in complex capital goods: The case of hydro electricity generation systems in Iran	Technol. Forecast. Soc. Change (Technological Forecasting and Social Change)	Iran	Hydro electricity	Firm level	Qualitative	Domestic
Kiamehr, M.; Hobday, Michael; Kermanshah, A.	2014	Latecomer systems integration capability in complex capital goods: the case of Iran's electricity generation systems	Industrial and Corporate Change	Iran	Electricity	Firm level	Qualitative	Domestic
Kiamehr, M.; Hobday, Michael; Hamedi, M.	2015	Latecomer firm strategies in complex product systems (CoPS): The case of Iran's thermal electricity generation systems	Res Policy (Research Policy)	Iran	Thermal electricity	Firm level	Qualitative	Domestic
Kim, Y.; Ha, S.	2010	Innovation activities and innovation performances of	Asian J. Technol. Innov. (Asian Journal	Korea	electronics	Industry level	Quantitative	Domestic, foreign

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Author	Year	Title	Periodical	Country/ region in focus	Sector/industry	Level of analysis	Method	Type of firm ownership
		SMEs: The Korean electronic parts industry 1990-19951	of Technology Innovation)					
Kuramoto Gonzalez, Rafael; Kindl da Cunha, Sieglinde	2012	Internationalization Process and Technological Capability Trajectory of Iguaçu	Journal of Technology Management & Innovation (Journal of technology management & innovation)	Brazil	Coffee	Firm level	Qualitative	Domestic
Landini, Fabio; Malerba, Franco	2017	Public policy and catching up by developing countries in global industries: a simulation model	Cambridge Journal of Economics	Global	n/a	Macro	Quantitative	n/a
Lema, Rasmus	2012	Outsourcing and supplier learning: insights from the Indian software industry	Int. J. Technol. Globalisation (International Journal of Technology and Globalisation)	India	Software	Industry level	Qualitative	Domestic
Lema, Rasmus	2014	Offshore outsourcing and innovation capabilities in the supply base: evidence from software firms in Bangalore	Int. J. Technol. Learn. Innov. Dev. (International Journal of Technological Learning, Innovation and Development)	India	Software	Industry level	Qualitative	Domestic
Lema, A.; Lema, R.	2016	Low-carbon innovation and technology transfer in latecomer countries: Insights from solar PV in the clean development mechanism	Technol. Forecast. Soc. Change (Technological Forecasting and Social Change)	China, India, Thailand	Solar PV	Macro	Qualitative	n/a
Lema, Rasmus; Quadros, Ruy; Schmitz, Hubert	2015	Reorganising global value chains and building innovation capabilities in Brazil and India	Res Policy (Research Policy)	Brazil, India	Automobile, software	Industry level	Qualitative	Domestic, foreign
Li, Huiping; Cantwell, John	2010	Autonomy and technological capability in joint ventures in China	Int. J. Technol. Learn. Innov. Dev. (International Journal of Technological Learning, Innovation and Development)	China	Manufacturing	Firm level	Quantitative	Domestic, foreign
Majidpour, Mehdi	2017	International technology transfer and the dynamics of complementarity: A new approach	Technol. Forecast. Soc. Change (Technological Forecasting and Social Change)	Iran	Gas turbine	Firm level	Qualitative	State owned enterprise (SOE)
Mbula, Erika Kraemer; Lorenz, Edward; Greenish, Lotta Takala; Jegede, Oluseye Oladayo; Garba, Tukur; Mutambala, Musambya; Esemu, Timothy	2019	Are African micro- and small enterprises misunderstood Unpacking the relationship between work organisation, capability development and innovation	Int. J. Technol. Learn. Innov. Dev. (International Journal of Technological Learning, Innovation and Development)	Africa	Multiple	Regional	Qualitative	n/a
Melo, José Maria Gonçalves Nunes de	2017	The role of public policy in the development of technological capabilities of companies in the wind energy sector and the impact on social and environmental performance	International Journal of Energy Economics and Policy	Brazil	Wind energy	Industry level	Qualitative	n/a
Ocheni, Joel; Ilori, Matthew Olugbemiga; Oluwale, Billy Adegbola; Adelowo, Caleb Muyiwa	2017	Technological capability building in Nigerian cashew nut processing industry	Int. J. Technol. Learn. Innov. Dev. (International Journal of Technological Learning, Innovation and Development)	Nigeria	Cashew nut processing	Industry level	Quantitative	Domestic, foreign
Rasiah, Rajah	2010	Are electronics firms in Malaysia catching up in the technology ladder?	J. Asia Pac. Econ. (Journal of the Asia Pacific Economy)	Malaysia	electronics	Industry level	Quantitative	Domestic, foreign

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Author	Year	Title	Periodical	Country/ region in focus	Sector/industry	Level of analysis	Method	Type of firm ownership
Rasiah, Rajah; Amin, Abdusy Syakur	2010	Ownership and technological capabilities in Indonesia's automotive parts firms	J. Asia Pac. Econ. (Journal of the Asia Pacific Economy)	Indonesia	Automotive parts	Industry level	Quantitative	Domestic, foreign
Rasiah, Rajah; Gopal Krishna, Vignes; Ratnavelu, Kurunathan	2015	Do contractors undertake more learning and innovation than multinational subsidiaries at least developed host-sites? A study of clothing firms in Cambodia	Asian J. Technol. Innov. (Asian Journal of Technology Innovation)	Cambodia	Clothing	Industry level	Quantitative	Domestic, foreign
Rasiah, Rajah; Shahrivar, Rafat Beigpoor; Yap, Xiao-Shan	2016	Institutional support, innovation capabilities and exports: Evidence from the semiconductor industry in Taiwan	Technol. Forecast. Soc. Change (Technological Forecasting and Social Change)	Taiwan	Semiconductor	Industry level	Quantitative	Domestic
Ribeiro, Cássio Garcia; Furtado, André Tosi	2014	Government Procurement Policy in Developing Countries: The Case of Petrobras	Science, Technology and Society	Brazil	Oil	Firm level	Qualitative	State owned enterprise (SOE)
Sadoi, Y.	2010	Technological capability of automobile parts suppliers in Thailand	J. Asia Pac. Econ. (Journal of the Asia Pacific Economy)	Thailand	Automotive parts	Industry level	Qualitative	Domestic, foreign
Silvestre, Bruno S.; Neto, Romeu e. Silva	2014	Capability accumulation, innovation, and technology diffusion: Lessons from a Base of the Pyramid cluster	Technovation (Technovation)	Brazil	Mining	Industry level	Qualitative	Domestic, foreign
Torres, Arturo; Dutrénit, Gabriela; Sampedro, Jose L.; Becerra, Noé	2011	What are the factors driving university–industry linkages in latecomer firms: evidence from Mexico	Sci. and Pub. Pol. (Science and Public Policy)	Mexico	Manufacturing	Industry level	Quantitative	Domestic, foreign
Torres, Ricardo L.; Hasenclever, Lia	2016	Technological Capability Building in the Brazilian Pharmaceutical Industry	Latin American Business Review	Brazil	Pharmaceutical	Industry level	Quantitative	Domestic, State-owned
Yu, Jiang; Liu, Rui; Chen, Feng	2020	Linking institutional environment with technological change: The rise of China's flat panel display industry	Technol. Forecast. Soc. Change (Technological Forecasting and Social Change)	China	Flat panel display (FPD)	Industry level	Qualitative	Domestic

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