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Beyond Technological Catch-up: An Empirical Investigation of Further Innovative Capability Accumulation Outcomes in Latecomer Firms with Evidence from Brazil*

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ABSTRACT. This article examines outcomes that are achieved by latecomer firms from the accumulation of innovative capabilities. Drawing on fieldwork evidence from pulp and paper firms in Brazil (1950-2010), it was found that: (1) the firms accumulated innovative capabilities that turned them into world leaders in the segment of the global pulp and paper industry based on eucalyptus forestry; (2) besides this technological catch-up, the accumulation of these innovative capabilities resulted in outcomes that generated benefits within these firms such as (i) implemented inventive and innovative activities; (ii) consistent improvement of several parameters of operational and environment-related performance; (iii) varied patterns of corporate growth; (3) these outcomes were achieved not only by research-based and patent-related capabilities but mainly by a mix of innovative capability *levels*, with differing degrees of novelty and complexity for diverse technological functions. Therefore, the accumulation of a wide range of types and levels of innovative capabilities does pay off for the innovative firms, their industries and, ultimately, their economies. By combining a novel approach to examining firm capabilities with findings from an inductive fieldwork, this article provides new empirical and methodological insights for the long-standing debate on innovative capabilities as the fundamental source of firm competitive performance. The article draws managers' attention to the importance of a multiplicity of types and levels of capabilities to achieve relevant outcomes, and policy makers in developing economies to adopt a comprehensive view on innovative activities and place firm-centred innovation capability accumulation at the centre of industrial innovation policies.

KEYWORDS: innovative capability accumulation; latecomer firms; catch-up; competitive performance; Brazil.

JEL CODES: M16, O32, Q16, Q18

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*The work reported in this paper is part of a broader longitudinal study which investigated the nature, sources and outcomes of the technological capability building process in firms of the pulp and paper industries based on planted forestry in Brazil since their inception in the 1940s up to the 2000s. The study was based on first-hand and long-term empirical evidence gathered on the basis of original and extensive fieldwork from 2005 to 2010. The study has been undertaken within the Research Programme on Technological Learning and Industrial Innovation in Brazil at the Getulio Vargas Foundation. Funding from Brazil's National Research Council (CNPq – grants 477731/2006-6 and 307404/2007-2) and from the Brazilian Pulp and Paper Association (Bracelpa) is gratefully acknowledged. Earlier drafts of this papper were presented at the 6th Globelics Conference (Mexico City, 2008) and the 12th International Schumpeter Society Conference (Rio de Janeiro, 2008). This study would not have been materialised without the invaluable cooperation from the professionals from the firms and from the related organizations who participated in the fieldwork for this study. Research assistance from Saulo Gomes is gratefully acknowledged. All disclaimers apply.

1. Introduction

This article reports an empirical investigation of outcomes achieved by firms in developing and emerging economies, which are known as latecomers, from their accumulation of innovative capabilities. Unlike most studies in the literature, this article explores outcomes in addition to technological catch-up. The accumulation of innovative capabilities has been a central issue in the study of latecomer firms since the early 1970s when Charles Cooper (Cooper, 1970) examined the mechanisms by which international technology transfer influenced the long-term accumulation of these capabilities in technology-importing firms based in developing economies.

Research on the innovative capabilities of latecomer firms moved forward through the work of a Latin American group led by Jorge Katz that initiated the first systematic research programme on these issues in the mid-1970s. Drawing on detailed firm-level studies, they unveiled significant technological capabilities that permitted firms to undertake diverse innovative activities across different industries (for a compilation see Katz, 1987). By doing so, they challenged the then prevailing arguments that technological activities in latecomer firms were lacking in creativity and based merely on the *use* of technology generated in advanced economies. This initiative influenced the emergence of other studies in Asia (e.g., Bell et al., 1982; Lall, 1987), giving rise to a research field devoted to understanding the technological capability accumulation process in latecomer firms and industries (for analytical overviews, see Bell and Pavitt, 1993; Bell, 2006; Bell and Figueiredo, 2012).

Following the rise of some developing economies in the early 1990s, there has been a steadily growing number of studies on innovation capability accumulation in latecomer firms, its sources, the underlying learning mechanisms, and its consequences. However, when studies examine the consequences of innovation capability accumulation, they mostly focus on the ways in which latecomer firms close their innovative capability gaps with their counterparts in advanced economies or technological catch-up. Consequently, there is a paucity of empirical research on the types of outcomes, other than technological catch-up, that are achieved by latecomer firms from the accumulation of innovation capabilities. Although prior research suggests that the manner in which these capabilities are accumulated have positive and/or negative implications for latecomer firms' competitive performance (e.g., Bell et al., 1982; Katz, 1987; Figueiredo, 2002), there is a dearth of empirical studies over the past ten years that help extend our understanding of the consequences of innovation capability accumulation in latecomer firms.

This study is intended to contribute to fill that research gap by exploring some of the outcomes of innovation capability accumulation, beyond technological catch-up, that have been achieved by latecomer firms by drawing on the innovative capabilities that they accumulated during their lifetimes. To that end, this article is based on an inductive multiple-case study of homogenous innovative latecomer firms based on first-hand and long-term empirical evidence gathered from a recursive fieldwork process. At the same time, the study builds on previous related empirical research and combines insights from the literature on innovation in latecomer firms and the strategic management literature. By so doing, this article extends our understanding of the consequences of innovation capability accumulation latecomer firms. It also sheds empirical light on the long-standing debate on the role of innovation capabilities as the sources of firms' competitive performance.

The remainder of this paper is structured as follows. Section 2 presents the study background leading to the article's research question, and Section 3 outlines some conceptual perspectives on innovation capability accumulation and its outcomes in latecomers. Section 4 outlines the research context, followed by the research design and methods in Section 5. These findings are presented in Section 6 and discussed in Section 7.

2. Study Background and Research Question

Several studies have examined the attainment of innovative capabilities near or at the international *innovation* frontier in latecomer firms from different industries, including producers of automobiles and semiconductors in South Korea and Taiwan (e.g., Kim, 1997; Sher and Yang, 2005); glass in Mexico (e.g., Dutrénit, 2000); consumer electronics, telecom and telecom-equipment in South Korea, Taiwan, Malaysia and China (e.g., Lee and Lim, 2001; Amsden and Tschang, 2003; Hobday et al., 2004; Choung et al., 2006; Fan, 2006; Ariffin, 2010); thin-film transistor liquid crystal display (TFT-LCD) panels in Taiwan (Zhang et al., 2008); electronics in Mexico (Iammarino et al., 2008); pharmaceuticals in India (Kale and Little, 2007); ships in South Korea and Taiwan (Sohn et al., 2009); oil and gas in Brazil (Dantas and Bell, 2009; Silvestre and Dalcol, 2009); pulp and paper in Brazil (Figueiredo, 2010), metals, ceramics, composites and polymers in Turkey (Yoruk, 2011), and firms located in clusters (e.g., Giuliani and Bell, 2005). Conversely, latecomer firms may accumulate capabilities at the level of the international *production* frontier but not at the international *innovation* frontier – e.g., the pulp and paper industry in Indonesia (van Dijk and Bell, 2007). Intertwined with the examination of innovation capability accumulation in these studies is the issue of technological catch-up as an immediate outcome of capability accumulation

With respect to factors influencing the accumulation of innovative capabilities, there have been several relevant studies on the role of the underlying learning mechanisms (for a review see Bell, 2006; Bell and Figueiredo, 2012). Other studies have sought to examine the role of factors other than learning in latecomer firms' *current* capabilities (not accumulation), such as firm-specific factors, including age and size (e.g., Romijn, 1999), leadership (e.g., Kim, 1997), ownership (e.g., Bohe, 2007), as well as industry-specific factors (e.g., Jung and Lee, 2010) and economy-wide conditions (e.g., Lall, 1992; Arza, 2005).

However, in relation to the investigation of innovation capability accumulation outcomes, beyond *technological catching-up*, there has been a paucity of empirical studies, although there are exceptions. Firm-level studies found that a firm's *current* capabilities either positively or negatively influenced the achievement of specific performance outcomes such as energy performance (Piccinini, 1993), productivity growth (Tremblay, 1994), and patents (Joo and Lee, 2009) but did not examine its innovation capability accumulation. Moving further in relation to these studies and building on past research (e.g., Bell et al., 1982; Katz, 1987), Figueiredo (2002) found inter-firm differences in competitive performance based on a wide range of performance parameters associated with the manner in which firms accumulated different types and levels of technological (production and innovative) capabilities. Ever since the early 2000s, there has been growing research interest in the effects of innovative capabilities on latecomer firm performance. However, both 'innovative capability' and 'performance' have been defined and measured in different ways in different studies of diverse designs, precluding a systematic cumulative body of evidence and leading to inconclusive results.

For instance, using a definition of technological capability similar to Figueiredo's (2002) but operating on the basis of the firms' current yields, Jonker et al. (2006) found a positive correlation between capabilities and economic performance (measured as value added) in paper machines in West Java. Based on a cross-sectional study of 275 firms in Tanzania, Goedhuys et al. (2008) found a weak association between technological capabilities (proxied as R&D and other innovation activities) and labour productivity. Drawing on observations of 15 firms over 15 years in the worldwide integrated circuit manufacturing industry, Bapuji et al. (2011) found that external knowledge acquisition and innovative activities (measured as patent citations) did not always lead to positive firm performance (measured as sales). In contrast, in a sample of 215 firms in the Chinese information technology (IT) industry, Shan and Jolly (2012) found a positive relationship between innovation capabilities (defined according to the Oslo Manual and substantiated through manager perceptions) and firm performance (number of commercialised products (innovative performance), sales performance and product performance. Drawing on observations from 174 firms in Taiwan's IT industry, Chen and Tsou (2012) found, based on manager perceptions, that customer service mediates the influence of IT capability on firm performance (through financial performance, market performance, and customer satisfaction/loyalty).

In summary, although there has been an abundance of studies on innovation capabilities in latecomer firms, most of them have focused on the different ways in which latecomer firms move from the accumulation of production-based business into progressively higher levels of innovative capabilities and the role of factors, notably learning mechanisms in influencing capability accumulation processes. Studies have given less attention to the outcomes attained by latecomer firms by the accumulation of their innovative capabilities. These existing studies focus on technological catch-up as an immediate outcome. Therefore, by building on existing studies, this paper seeks to contribute to filling this gap by examining the following research question: What outcomes, besides technological catch-up, do latecomer firms achieve from the accumulation of innovative capabilities? This article empirically addresses this research question in pulp and paper production based firms derived from forestry in Brazil during the 1950-2010 period. Prior research and the technical literature suggest that Brazil's forestry-derived pulp and paper industry offers a rich empirical setting from which to investigate this research question (e.g., Scott-Kemmis, 1988; Dalcomuni, 1997; World Resources Institute – WRI, 1999; Evans and Turnbull, 2004).

3. Innovation Capability Accumulation and its Outcomes in Latecomer Firms

3.1 Latecomer firms and innovation capabilities

Unlike typical late entrants, latecomer firms are at an historically determined, rather than a strategically chosen, position of late entrance (Mathews, 2002), and they are normally characterised by a low level or even an absence of innovation capabilities and being 'initially imitative', regardless of how dislocated they may be from markets and technology sources. However, they may move from positions of technology-use or imitation, based on very limited innovative capability, to deeper levels of capability that enable them to undertake different types of innovative activities (Bell and Figueiredo, 2012). A firm's technological capability refers to a stock of knowledge-related resources that are accumulated in its 'human capital' (specialist professionals, knowledge bases and skills/talents that are formally and informally allocated within specific organisational units, projects and teams),'organizational' systems (a firm's organizational arrangements such as their routines and procedures, linkages, and managerial systems), techno-physical systems (hardware, software, database, laboratories, equipment) (Katz, 1987; Lall, 1992; Bell and Pavitt, 1993; Leonard-Barton, 1995; Kim, 1997; Dutrénit, 2000).

The literature distinguishes between *production* and *innovation capabilities* (Bell and Pavitt, 1993, 1995). The former refers to those *capabilities* to use existing technologies and production systems with given levels of efficiency, and the latter refers to a firm's abilities to assimilate, use, adapt and change existing technologies and enable firms to create new technologies and develop new products and processes (Kim, 1997; Choung et al., 2000; Dutrénit, 2000). This analytical distinction is important considering that latecomer firms generally start as technology users and/or imitators, this distinction helps determine whether their capabilities grow over time into more innovative levels. Although this paper is concerned with innovation capabilities, the distinction between them is blurred in practice, and production capabilities may even contribute to the accumulation of innovation capabilities (Figueiredo, 2002; Bell and Figueiredo, 2012).

3.2 Technological catch-up and further outcomes from innovation capability accumulation

By accumulating these capabilities, latecomer firms may achieve two types of technological catch-up (Bell and Figueiredo, 2012): (a) when latecomer firms narrow the gap between the technology they *use* in production and those of global industrial leaders at the international production frontier, which is called *catch-up in production*; and (b) when latecomers catch up with global innovation leaders in terms of capabilities to generate and manage *change* in their technologies and they engage directly in innovation activities at the international frontier, which is referred to in this article as *technological catch-up*.

There are different routes by which latecomer firms achieve technological catch-up, such as following the technological paths previously pursued by global leaders (*technology following*), skipping stages along those paths (*stage-skipping*) or even by creating their own paths, or *path creating* (Lee and Lim, 2001). In the latter type of route, with which this article is concerned, latecomer firms accumulate capabilities that enable them to take *different directions* in technological development from those already pursued by the global industry leaders. This accumulation of innovative capabilities does not necessarily stop at pre-determined end-points on existing technological trajectories. Those innovation capabilities may enable firms to develop different technologies, products and processes from those developed by global leaders (Bell and Figueiredo, 2012), reflecting the fluidity of the international technological innovation frontier, which can be explored by any latecomer (Figueiredo, 2010).

When latecomer firms attain the capability level to undertake world-leading innovative activities, that is, they catch up in a technologically fashion with global leaders, their technological behaviour becomes similar to global innovative firms from advanced economies. The latecomers become concerned with how to use, sustain, and expand their innovative capabilities to re-build and re-create new and distinctive positions of strategic competitive advantage, perhaps even by changing, or at least adding to, the areas of technology within which they innovate, which is an issue of concern in strategic management literature (e.g., Pavitt, 1991; Leonard-Barton, 1995; Eisenhardt and Martin, 2000; Teece, 2007a,b). Therefore, it is important to draw on this literature to explore this stage of innovation capability accumulation in latecomer firms. Indeed, the body of literature of capability building and that of strategic management seem to converge meet around a common concern, that is, around outcomes generated by innovative capabilities.

Within the latecomer literature it has been argued that the ability of firms to implement innovative activities and achieve distinctive performances reflects the nature and depth of their technological capabilities (Dosi, 1985; Lall, 1992; Bell and Pavitt, 1993). This argument has been supported by empirical insights that shows that firm capabilities permit the implementation of innovation activities with differing degrees of novelty and complexity (not always R&D-based) with relevant positive operational economic impacts (Enos, 1962; Hollander, 1965). Firm innovation capabilities may generate relevant improvement in operational performance (Patel and Pavitt, 1994; Laestadius, 1998; Piccinini, 1993; Tremblay, 1994; Figueiredo, 2002), but their absence could negatively impact performance (Bell et al., 1982).

Indeed, several studies in the strategic management literature have assumed that innovative capabilities work as a source of competitive performance. Following insights from classical studies (e.g., Penrose, 1959; Chandler, 1962), there has been a steadily growing debate over the past decades on innovation capabilities as the fundamental sources of a firm’s sustainable competitive advantage and superior performance, which has been reflected in different subsets of the literature such as the ‘resource-based view’ (e.g., Peteraf, 1993) or the ‘dynamic capabilities’ (e.g., Hitt et al., 2000; Eisenhardt and Martin, 2000; Teece, 2007a; Helfat et al., 2007). However, existing studies have produced inconclusive, contradictory and inconsistent results (Zahra et al., 2006; Adegbesan and Ricart, 2007; Helfat et al., 2007). Among the reasons for this problem, it has been argued, is the fact most studies within that literature have been dominated by theoretical discussions, relatively weak empirical support (Newbert, 2007; Protogerou et al., 2011) and on a multiplicity of measures for both innovation capability and performance (Coombs and Bierly, 2006). Indeed, it has been argued that there has been an overemphasis on the idiosyncratic nature of these innovative capabilities and that these capabilities are not a guarantee of *sustainable* competitive performance, because firms are subject to unpredictable and uncontrolled influences from within and from outside (Eisenhardt and Martin 2000; Zahra et al., 2006; Costa et al., 2013), although these statements lack firm-level empirical substantiation. The above perspectives constitute an important conceptual basis that helps form the research design, especially the data collection and analysis processes, as outlined below.

4. Research Setting

Pulp and paper firms based on forestry refer to industries classified by the International Standard Industrial Classification of All Economic Activities (ISIC) as silviculture and other forestry activities (ISIC class 0210), which produce feedstock for forest-based manufacturing such as pulp and paper (ISIC class 1701). Pulp-making requires the separation of cellulose fibres from non-cellulose materials and impurities (e.g., lignin) to create wood pulp. Paper-making involves processes such as pulp refining and screening, the mixing of additives, sheet forming and drying. The pulp and paper industry is process-intensive and normally large-scale (Pavitt, 1984). Considering that 90 per cent of paper pulp is currently generated from wood, that pulp is increasingly manufactured in the same country where the plantations are located and that wood represents 55 per cent of the average cost of making pulp, and forestry is considered part of the pulp and paper industry.

Since the 1990s, it has been recognised that trees that yield more cellulose generate gains across the entire production chain in the form of savings from tree harvesting and transportation, minimising the expansion of forests and reducing effluent waste (Grattapaglia, 2004). After realising that the 'pulp factory' is actually the tree (Grattapaglia and Kirst, 2008), pulp and paper firms have shifted their efforts from wood volume to wood quality. The objective is to reduce the cubic meters of wood necessary for the production of one tonne of pulp, that is, to decrease wood-specific consumption (WSC) (Grattapaglia and Kirst, 2008). Through different types of biotechnology these forests have become an important source of biomass and can work as a platform for new products such as fibre cement, biofuels, biochemicals, bio-plastic, bio-materials, and carbon fibres, as well as services such as CO_2 sequestration (Bracelpa, 2012; www.wbcsd.com). To achieve and sustain a global competitive position in this industry and to take advantage of these innovation opportunities, firms must master innovation capabilities near or at a world-leading level, especially in planted forestry research focused on the development of new genetic material.

In 2011, Brazil ranked as the world's fourth-largest pulp producer (all types), the world's largest producer of hardwood pulp ('eucapulp'), and the ninth-largest paper producer. One hundred percent of pulp and paper produced in Brazil is derived from planted forests, which are renewable resources. Brazil has 2.2 million hectares of fully certified planted area for industrial use. In 2011, the revenue from Brazil's pulp and paper industry was close to US$17 billion, yielding exports of US$ 7.2 billion with a trade balance of US$5.1 billion. In 2011, this industry generated 128,000 direct jobs and 575,000 indirect jobs in Brazil, and US$1.75 billion in taxes. From 1970 to 2011, Brazil's output of pulp and paper grew by an average of 6.8 per cent and 5.4 per cent per year. During the same period, Brazil's pulp and paper exports increased by 13.6 per cent and 18.8 per cent annually on average, respectively, and the value of these exports increased by an average of 17.3 per cent (pulp) and 22.7 per cent (paper) annually. Although there are 220 firms in Brazil six large pulp makers responded for 85 per cent of the output pulp in 2010 and they also have their own forests. The six firms represent 55 per cent of the paper output. This high concentration of output from a small number of integrated firms is justified by the high volume of investment involved in forestry and large-scale manufacturing activities (Bracelpa, 2011).

5. Research Design and Methods

This article is based on a broader five-year study about innovation capability accumulation and its causes and consequences in pulp and paper industry firms derived from Brazilian forestry during the 1950-2010 period. Given the paucity of empirical work regarding the relationship between these issues, decision was made (in line with Pettigrew (1990)) to undertake a qualitative inductive study based on multiple case studies and long-term evidence from firms in a similar industrial sector. This methodological approach is appropriate for addressing the relevant gaps in the literature and the general research question and it facilitates a better understanding of what lies behind a subtle and under-researched phenomenon, the details and nuances of which would not be captured by other methods, especially aggregated analysis derived from purely quantitative methods (Eisenhardt, 1989; Yin, 2003). This methodological approach was implemented over three stages of fieldwork, namely exploratory, pilot and main stages, which involved an iterative process of data collection and analysis with constant returns to the literature for conceptual clarification to achieve solid construct and internal validity (Eisenhardt, 1989). Table 1 provides an overview of the field research process. During that process, this author worked closely with two research assistants. All the activities throughout the four major phases were far from linear, but rather recursive and intertwined.

Table 1. Overview of the field research process

Research elements/stages	**Exploratory**	**Pilot**	**Main**	**Post-fieldwork**
Focus and purpose	Test study feasibility. Getting to know the technology, industry, key potential respondents and tips for access negotiation.	Select cases and test of interview protocol.	Collection of bulk of data and implementation of correspondent analysis.	Full operationalization of constructs and data validation
Data sources	Industry experts at business associations and related non-firm organizations and firms.	Firm professionals (e.g., CEOs and industrial directors and managers) Firm archival records and public documents.	Firm professionals (directors, managers, engineers, researchers, technicians, consultants, human resources and engineering departments, R&D units, labs, shop-floor, and retired staff). Non-firm professionals (e.g., universities, research institutes) Firm activities and events Firm archival records	Targeted firm professionals
Data collection techniques (a)	8 informal interviews. Consultation to industry literature.	13 formal interviews and five informal meetings Consultation to firms' archival records and public documents	155 formal interviews and 12 informal meetings. Site observations and tours Consultation of firm archival records	Follow-up questionnaires Double and triple-checks via e-mail and/or phone calls.
Data analysis	Simple description and organization of evidence into short texts related to industry and firms.	Identification of specific construct categories (e.g. 15-20 categories for 'outcomes')	Reduction of overlaps and redundancies in construct categories (to 10-12)	Identification of final construct categories.

Note: A number of data collection activities referred to the entire study.

5.1 Cases selection

The rationale for selecting the cases for this study involved a purposeful choice of firms (Miles and Huberman, 1994) that (i) provided relevant evidence to substantiate the research question and related constructs; (ii) were likely to generate rich information on the issues under study and that were likely to enhance the analytical generalizability of the findings. Therefore, a relatively homogenous sampling (Patton, 2002) was used to provide powerful examples of the phenomenon under study (Siggelkow, 2007), as shown in Table 2.

Table 2. The selected cases

Selected cases	Start-up year	Ownership	Business lines		
			Forestry	Pulp	Paper
Suzano	1941	Brazilian	✓	✓	✓
Klabin	1945	Brazilian	✓	✓	✓
Rigesa	1974	Foreigner	✓	✓	✓
Aracruz	1978	Brazilian	✓	✓	None
VCP-Jacareí	1988	Brazilian	✓	✓	✓
VCP-Luiz Antonio[(a)]	1988	Brazilian	None	✓	✓

(a) Its forestry business is not covered in this study.

5.2 Data collection

This study involved an intense triangulation of data sources and data collection techniques to achieve robust internal validity and reliability (Jick, 1979; Eisenhardt, 1989; Yin, 2003). Data collection involved several stages to identify the necessary data and its sources and decision on techniques to be used for collection. Because the study examines firm capability accumulation and some of its outcomes over time, particular efforts were made to collect data from past years. This collection was undertaken by scrutinising the firms' technological milestones as provided by different interviewees (including retired staff), internal presentations and records, annual reports and independent news reports. The extensive use of triangulation permitted the collection of evidence from a range of sources to substantiate the study; interviews were used intensively. Creating the interview protocol involved a breakdown of the research question and its constructs ('innovation capability' and 'outcomes of innovation capability accumulation') until they were transformed into plain words for the actual interviews. This operation was performed consulting previous studies. Each interview was conducted by two investigators on the basis of a structured but inductive conversation, which encouraged interviewees to talk openly about the research themes (e.g., 'Tell us about the main changes undertaken in your area over the past five years…' 'Who led them?' 'Why?' 'How?' 'Has your company achieved any benefit from these changes?' 'If yes, tell us about them'). Interviews were never recorded. After each interview, the notes were expanded and insights were written down. At the end of each day, there were de-briefing sessions in which the investigators discussed the responses, matched their interpretations and identified the emerging categories (parts of each construct) and plans to reach interviewees for snow-balled interviews were made.

4.5 Analysis process

The analysis involved three iterative steps, which reflected a tension between the study's objective (deductive) and the categories and interpretations that emerged from the raw data (inductive). The first occurred during the pilot and main stages. During field interviews, some construct categories began to emerge (e.g., 'outcomes', or types and levels of implemented innovations, operational performance, growth) and were preliminarily labeled (coded) to facilitate their identification and association in field notes and de-briefing sessions.

The second occurred after the pilot and main stages and sought to organise an overwhelmingly and messy amount of field evidence, which were collected from various sources and through diverse techniques, into a manageable amount of evidence to be initially treated in formal analyses. This 'data cleaning' involved separating and organizing different pieces of evidence under relatevely common blocks of observations, which were then organized cronologically into 'within-case display tables', which permitted the grouping of data and emerging categories and exploring relatioships between them, and then in 'cross-case display tables' (Miles and Huberman, 1994). A close examination of these tables was used to code the evidence, identify overlaps and reduce the number categories.

For example, the initial 85-90 categories of 'operational performance', which resulted from innovation capabilities, were reduced into 45-50 categories. Later, these categories were distilled into an 'operational and environment-related performance improvement' for forestry (reduced from 45-50 into 20-25) and pulp and paper (reduced from 50-55 into 25-30), then eventually displayed in Tables 9-13. This procedure was followed by intense discussions about the nature of these categories and their relationships and the writing of storylike narratives (*vignettes*). These vignettes helped in the design of the follow-up questionnaires, which were effective for obtaining more detailed evidence, especially for the outcomes of innovation capabilities. The rows contained a detailed list of major technological activities undertaken by firms over time; the columns referred to the years during which each activity was implemented; the respondents wrote examples of the benefits achieved from those technological activities in the cells. These questionnaires were administered to targeted informants. Because they had already met the investigators during the fieldwork, a 95 per cent response rate was achieved.

The third step involved matching the evidence acquired from the field interviews and other techniques with information from the follow-up questionnaires. The expansion of *vignettes* into short narratives helped to establish causal relationships and strengthen arguments (Dougherty, 2002) and they became a basis for the final reporting. This procedure, together with recursive consultations to the literature, permitted the definition and operationalization of different constructs. For example, 'innovative activities' resulted from firm capabilities involving a combination between skills, knowledge, organizational units and techno-physical systems. However, these capabilities were not confined to R&D or patents, but were related to much wider types and levels of resources spread out to different functional areas. This finding suggested that proxies such as R&D expenditures/facilities or patenting were not appropriate to capture the wide range of firms' innovation capabilities.

5.4 Operationalizing the research constructs

The operationalization of these research constructs required a recursive process, including several rounds of data collection and analysis with consultations of the literature, which permitted the emergence of categories related to the research constructs as follows: innovation capabilities (as scale of innovation capability *levels*) and outcomes of innovation capability accumulation (innovative-related performance; operational and environment-related performance improvement; and patterns of corporate growth).

5.4.1 Innovation capability accumulation

In the operationalization of the innovation capability construct developed over the past few decades in advanced economies, the assessment of innovation capabilities has been heavily based on quantitative measures such as R&D expenditures and/or patent citations (Hagedoorn and Cloodt, 2003). These capabilities may only become useful once firms have built up their innovative capabilities to the point where they involve measurable R&D activities or recorded patenting These capabilities reflect only a fraction of a firm's innovative capability and they reflect none of it in the case of firms that have only non-R&D-based innovative capabilities (Bell and Figueiredo, 2012). The limitation of relying on one aggregated measure of a firm's innovation capability (e.g., R&D expenditures) is to neglect a range of mixed technological activities that are necessary to develop and produce particular products (Patel and Pavitt, 1994) and does not capture the process of technological transformation that involves a spectrum of activities ranging from incremental-types to radical-types, with the significant performance impacts that occur in pulp and paper firms (Laestadius, 1998).

That limitation has been overcome by a comprehensive approach, which has been the primary basis of research in this area since the earliest studies of the innovation capabilities of latecomer firms by using qualitative assessments at the scale of technological capability levels (Katz, 1987; Bell et al, 1982; Lall, 1992; Bell and Pavitt, 1995; Bell and Figueiredo, 2012). Such approach has been operationalized through a typology based on an 'revealed capability' approach. Rather than specifically identifying capability levels in terms of particular quantities and qualities of human resources, skills, knowledge bases and so forth, they have identified levels of increasing novelty and significance of innovative *activity*, and then inferred that different capability levels underlie different types of innovative activity (Bell and Figueiredo, 2012). The use of such a typology captures what firms are able to do, in technological terms, using a nuanced perspective of the 'levels' of capabilities required to undertake innovative activities with different degrees of novelty. In line with the nature of the field evidence, this paper draws on a modified version of the typology developed in Lall (1992) and further refined in Bell and Pavitt (1995). The modified version of this typology identifies 'levels' of innovative capability that range from 'basic' to 'world-leading' and are consistent with the characterisation of innovation in terms of *degrees of novelty* and complexity in technological activities; thus, these levels are consistent with the Oslo Manual (see OECD, 2005).

Such a typology has been used intensively and successfully in studies, with different degrees of capability-level disaggregation that have covered the histories of capability building capability building over considerable time periods (e.g., Dutrénit, 2000; Figueiredo, 2002, 2010; Dantas and Bell, 2009) and in a much larger number of firms, but over shorter periods (e.g., Hobday et al., 2004; Iammarino et al., 2008; Ariffin and Figueiredo, 2004; Ariffin, 2010; Yoruk, 2011; Perally and Cantwell, 2012). Table 3 contains a condensed version of this typology used in this study. The first column shows four levels of innovation capabilities that extend from 'basic' to 'world leading'; the second column provides illustrative examples of these capability levels.

The application of this framework to this study was achieved after approximately six months' work, and involved several consultations with experts in the forestry and pulp and paper industries. These interactive and iterative consultations were used to adapt and validate the taxonomy to the technological specifics of these industries. Although Table 3 condenses the levels of technological capabilities for forestry, pulp and paper, the original framework that was applied during our fieldwork involved the use of a specific matrix for forestry, pulp and paper. Each matrix identified levels of technological capabilities for specific technological functions as follows: forestry (silviculture, harvesting, logistics, and socio-environmental management); pulp and paper (project management, process and production organization, process equipment, product-centred). Project management in our framework was equivalent to Amsden and Hikino's (1994) 'project execution' capabilities.

5.4.2 Outcomes of innovation capability accumulation

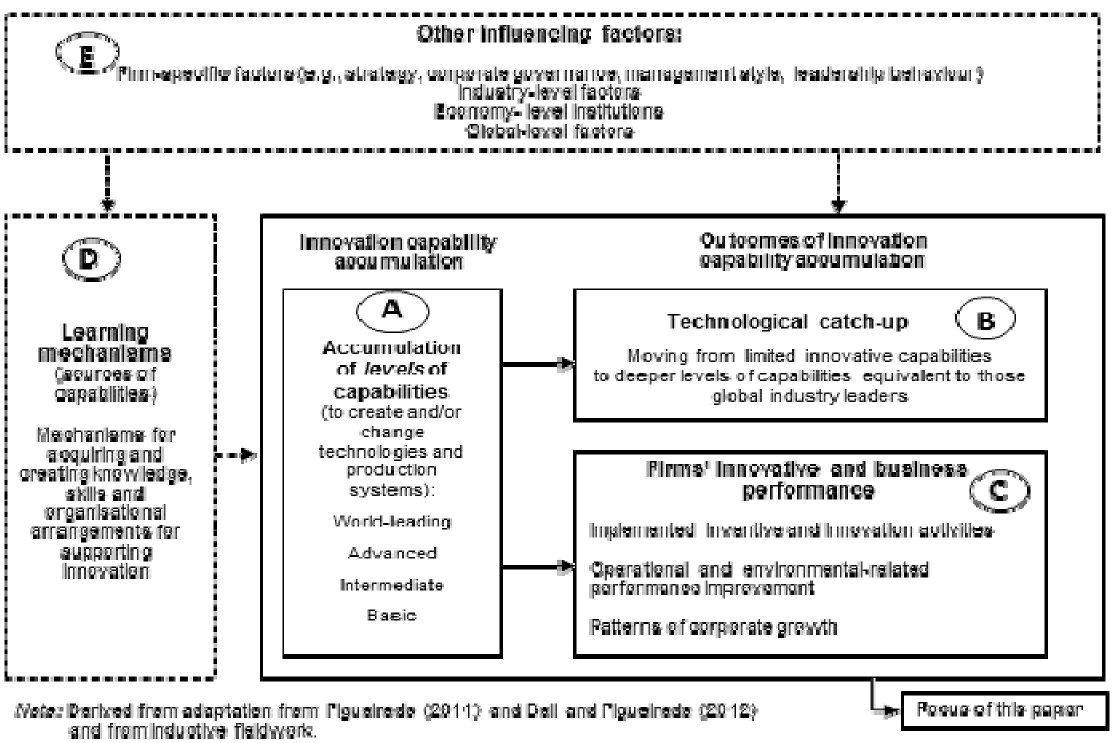
Innovative performance refers to the implementation of creative activities with concrete benefits for firms involving the following: (i) *Implemented inventive activities*, which are measured the quantity and quality of patents; (ii) *Implemented innovative activities* and their benefits as in line with Enos (1962) and Hollander (1965). Creative or innovative activities that may vary in terms of an innovation degree of technological/market 'novelty' or the extent to which it differs from existing technologies, which allows innovations to range from those that are close to being pure imitations to those that are fundamentally different from anything currently in existence (OECD, 1995). This type of differentiation has been widely used, especially for innovation analyses of latecomer firms.

Operational and environmental-related performance improvement refers to technical performance parameters related to the pulp and paper firms derived from forestry. Through the recursive processes of data collection and analysis and in consultation with previous related studies in the pulp and paper industry (e.g., Lasteadeus, 1998; Dalcomuni, 1997; Jonker et al., 2006; Dijk and Bell, 2007), the study identified six parameters for forestry, with 14 for pulp-making and 21 for paper-making.

Patterns of corporate growth. During the data collection and analysis processes, there was a recurrence of categories such as integration 'expansion', 'merger/acquisition', and 'diversification'. A consultation of the literature led these categories to be classified under 'patterns of growth'. Prior studies have pointed to the contribution of innovation capabilitities firms' growth (Penrose, 1959; Chandler, 1962; Amsden and Hikino, 1994; Yang, 2012). By drawing on Torres-Vargas (2006), the firms' growth patterns are measured in terms related to (i) horizontal integration; (ii) vertical integration; and (ii) diversification, which is further disaggregated into 'direct' diversification by the firm and 'indirect' diversification (spin-offs and spill-overs). The latter may take the form of new enterprise creation through the use of more or less formally organised spin-off mechanisms (Bell and Figueiredo, 2012) with positive implications for industrial development (Nelson and Pack, 1999).

The recursive processes of data collection and analysis with constant consultation of the literatures led to the creation of this study's conceptual framework (Figure 1). In the context of this study, the framework identifies at least three types of outcomes (component C) that can be achieved by latecomers from their innovation capability accumulation (component A), beyond technological catch-up (component B). This framework recognises that the achievement of these outcomes may be affected indirectly and/or directly by other factors (components D and E). The other factors are outside the scope of this article.

Figure 1. The article's conceptual framework



6. Findings

This section presents the article’s empirical findings. Section 6.1 presents evidence of innovation capability accumulation and Section 6.2 explores some of the outcomes that were achieved by the cases from the accumulation of innovation capabilities. This study examines these issues over as long a period as possible to capture a large part of these firms’ lifetimes (1950-2000s).

6.1 Innovation capability accumulation

In contrast to prior reports on innovation capability building in latecomer firms, the cases examined here did not follow a trajectory based on the accumulation of progressively higher capabilities from production adaptation to duplicative imitation up to R&D-based innovation or the *imitation to innovation path* (e.g., Kim 1997). As described in Figueiredo (2010), because of several constraints, the firms could not simply copy recognised global leaders, but were instead forced to develop technologies more suited to their own somewhat different operations. This development involved the use of different raw materials (eucapulp), and to develop an effective means to do this, they had to innovate in their downstream pulp and papermaking processes because of the innovations developed upstream in forestry. These firms could not simply *imitate* because they were developing along a different trajectory. The capability accumulation process of these firms can be summarized as moving *from non-imitation to innovation*. In light of the framework in Table 3, Table 4 shows the resulting levels of innovation capability accumulated by these cases for each business line.

Table 4. Levels of innovation capability accumulated in the researched firms

Levels of innovation capability	Business lines and firms		
	Forestry	Pulp	Paper
World leading	VCP-Jacareí	VCP-Jacareí	VCP-Jacareí
	Aracruz	VCP-Luiz Antonio	VCP-Luiz Antonio
	Klabin	Aracruz	Klabin
	Rigesa	Klabin	Suzano
	Suzano	Suzano	
Advanced	All firms	All firms, except Rigesa	Rigesa
Intermediate	All firms	Rigesa	All firms
Basic	All firms	All firms	All firms

Source: Derived from the empirical study.

The findings suggest that these innovative capabilities reflect the firms' proprietary resources that underlie their technological leadership. At the same time, there were features of these capabilities that were common across these firms (e.g., common practices of undertaking research activities; innovative activities in pulp and paper production process, as highlighted in the next section). For example, during the early 2000s these firms sought to deepen their world-leading innovation capabilities by re-organising their research activities. For example, VCP integrated its previously dispersed research activities into the Centre for Pulp Technological Development, Klabin re-configured its research centre based on a review of routine and procedures, documentation and analyses processes and Aracruz merged research on forestry and pulp and paper into a stronger research centre. From 2002 to 2008, these firms engaged in a nation-wide project called, Genolyptus (the Brazilian Network of Eucalyptus Genomics Research) together with other firms and universities under the coordination of the Brazilian Agricultural Corporation (EMBRAPA). This project characterized the complete phenotypes required to study the functions of the genes in question and made use of a multidisciplinary approach involving researchers in genetics, biochemistry, molecular biology, breeding, phyto-pathology, wood technology and industrial process engineering. Their world-leading capabilities permitted these firms to actively collaborate with partners in advanced economies. For example, Suzano collaborated with the genome project led by the Joint Genome Institute (JGI) in the US by donating the a germplasm base, designated as BRASUZ1, for the complete genomic sequencing of eucalyptus (Gratapaglia, 2011).

6.2 Outcomes of innovation capability accumulation

6.2.1 Innovative performance

Inventive activities: quantity and quality of patents

Table 5 shows the evolution of patents in these firms. The quantity increased by 40 per cent in the 2000s relative to the 1990s. During the 1990s, Aracruz scored the highest number of patents in forestry and Suzano did so during the 2000s. Klabin and Suzano had the highest number of paper patents over time. The evidence in Table 5 reflects the tangible outcome of the firms' different types and levels of innovative capabilities and a basis for implementing innovative activities.

Table 5. Evolution of patenting activities in the study firms

Firms and business lines		1990s		2000s	
		Quantity	Qualification	Quantity	Qualification
Aracruz	Forestry	7	Protection of trees against insects and improvement in planting and harvesting equipment. Method for preventing or controlling the occurrence of stains on wood.	3	Control of plant sprouting, seeds and seedling protection and fertilizer formulation.
	Pulp	9	Treatment, bleaching, refining and test of pulp.	1	Formulation of compound applied to pulp production.
Klabin	Forestry	1	Irrigation of seedlings	None	
	Paper	12	Refining process of pulp, packaging designs, displays for packages, devices for stacking packages and towel rack and paper towel.	22	Packaging design; pallet of corrugated cardboard; display packaging design and production process of devices based on corrugated paper. Finish applied to tissue paper.
Rigesa	Paper	5	Packaging design, development of test devices and device for absorbing gases.	24	Changes in design of packaging, pallets and cardboard boxes. Packaging design.
Suzano	Forestry	2	Method for genetic transformation of woody trees. Delignification of wood.	8	Changes in tree characteristics; process of extracting hemicellulose from wood, methods for obtaining hybrids and methods of genetic transformation. Method for genetic modulation of hemicelluloses, cellulose and uronic acid biosynthesis in plant cells using gene expression cassettes.
	Paper	9	Device for pulp washing and production in a closed system, packaging design, production of cardboard for pharmaceutical, chemical input for the production of paper and paperboard and treatment of inputs for paper production.	3	Treatment process of the cooking liquor from the wood, packaging and card design.
VCP	Paper	None		2	Method of assembling large cylindrical structures, device for cutting wires in bales.
Totals		45		63	

Sources: Brazil's National Institute of Industrial Property (INPI) and United States Patent and Trademark Office (USPTO).

Implemented innovation activities in forestry and pulp and paper

With respect to forestry, Table 6 contains 24 observations of implemented innovative activities and their related benefits between the 1970s and the 2000s. The world's first large-scale paper production based on eucalyptus pulp represented an important innovative activity derived from the newly developed innovation capability of Suzano in the 1960s, paving the way for the introduction of the so-called 'new pulp' in the international market. The second major disruptive innovation was implemented by Aracruz (mid 1970s-early 1980s), reflecting its research capabilities on the mass production of clonally propagated planting stock. For this innovation, Aracruz was awarded the prestigious Swedish Marcus Wallenberg Prize in 1984, which recognizes world-leading technological innovations in forestry. During the 1980s, Aracruz and Suzano developed novel eucalyptus varieties that were more productive and more resistant to disease, and adaptable to Brazil's climate conditions. This innovation yielded higher biomass production per unit of planted area and significantly improved the wood quality as industrial raw material and energy input. During the 1990s and 2000s, Aracruz, Suzano, Klabin, Rigesa and VCP expanded their innovation activities in forestry, reflecting a deepening of their related capabilities.

In relation to pulp and paper, Table 7 presents 28 observations from implemented innovative activities in these firms. During the 1960s and 1970s, the firms drew on their engineering and production capabilities to change the existing production processes and process equipment, including chemical processes, to produce pulp and paper based on the new raw material. Process innovations involved the development of modified process technology, which was then installed in a succession of new plants over three decades. These innovative production-based activities might have also contributed to an increase in pulp production (1980-2009) in these case firms by 6.08 per cent annually on average against the 4.8 per cent average of Brazil, while the paper production of the firms grew by an average of 3.9 per cent annually against the 3.6 per cent of Brazil's average during the same period.

Table 6. Implemented innovative activities and related befits in the forestry cases

Firms	Innovative activities ➔	Benefits
1970-1980s		
Aracruz	New process of eucalyptus production by vegetative propagation leading to world's first large-scale eucalyptus clonal forest for pulp and paper.	Achievement of higher biomass production per unit of planted area; significant improvements in wood quality (as industrial raw material or as energy input); and homogenization of wood for industrial purposes. Eucalyptus cuttings produced in intensive clonal systems were 40 per cent higher than those produced through seeds.
	New eucalyptus varieties with reduction of tree maturation time from an average of 15 years to 6-8 years.	Greater adaptability of eucalyptus to local environment and reduced incidence of pests.
Klabin	Implementation of the 'Monte Alegre formula'.	Improved estimation of forest fire risks. Dissemination of this innovation to other firms.
	New genetic materials in pine	Greater disease resistance; higher productivity and better quality in paper making.
Rigesa	Forest biometrics models for forest management	Accurate assessment process of available trees in planting area and greater precision in harvest planning.
1990s		
Aracruz	Genetic improvement of eucalyptus.	Yield increase from 6.4 to 11.8 tonnes of pulp/ha/year (then world's highest) with improved wood quality and lower environmental impacts of planting processes.
	New technologies involving rooting of micro- or mini-cuttings to replace the clonal eucalyptus production with micropropagation.	Improved rooting potential, speed, and quality plus reduction in clonal garden area, reducing costs of transport and shoots collection, improved overall planting efficiency.
Klabin	Production of pine seedlings using the cutting process.	This production process was based on process eucalyptus cutting.
	Somatic embryogenesis process for cloning in pine (later disseminated to Chile).	Uniform plantations with higher forest productivity, lower costs of harvesting and therefore less pressure on native forests.
Suzano	New method for genetic transformation of eucalyptus.	Attainment of first transgenic eucalyptus, creating a basis for potential yield increase.
VCP	Genetic improvement processes through eucalyptus clonal plantations and use of molecular markers.	Achievement of more accurate ways to select varieties of eucalyptus with higher productivity and resistance to pests and diseases.
2000s		
Aracruz	New eucalyptus varieties resistant to drought and cold.	It permitted the planting of eucalyptus in low temperature regions subject to frost.
	Soil conditioner produced from organic wastes and dregs.	Disseminated to other firms, it replaces lime and chemical fertilizer.
	Automation of the production of micro-propagated seedlings in bioreactors.	Reduction in production costs, greater security and cleanliness and purity in obtaining seedlings with lower lignin contents.
	'Aracruz bioindex' (decision-making support tool for forest management).	Integrated and comparative overview of production areas involving the diversity of planted genetic matter, plant ages, type, size and water availability, improving forest stewardship.
	'Aracruz's Pest Assessment Tool'	Better guidance to Aracruz's research projects on forest protection.
	New soil conditioner produced from organic wastes and dregs.	Replacement of lime and chemical fertilizers.
	New eucalyptus varieties resistant to drought and cold (within Genolyptus project).	New opportunities for forestry investments and product diversification.
Klabin	Somatic embryogenesis process to perform cloning in pine.	Achievement of uniformity in plantations, greater forest productivity, lower costs of harvesting.
Rigesa	Clonal planting of *Pinus taeda* on a commercial scale using somatic embryogenesis technique.	
	Indoor garden for recombinant clones of *Eucalyptus dunnii* by using controlled pollination in pots.	Recombination of species to identify the best clones for greenhouse controlled pollination.
Suzano	New eucalyptus varieties to implement "energy forests".	Production of pellets with high power burning and very short planting cycle (2-3 years) in small areas.
VCP	Software to calculate the economic value of a eucalyptus clones.	Identification of most suitable clone for particular plantation sites.
	New genetic materials.	Improvement in wood density, pulping and bleaching processes with positive effects on printing or tissue paper quality.

Source: Derived from empirical study.

Table 7. Implemented innovative activities and related benefits in pulp and paper cases

Firms	Innovative activities ➔	Benefits
	1970s-1980s	
Aracruz	Adaptation and use of cell membrane technology for the hardwood-based pulp making process.	Elimination of the previous mercury-based process that generated hazardous effluents.
	1990s	
Aracruz	Improvements to brownstock washing and oxygen predelignification processes and elimination of molecular chlorine	Reduced volume of polluting effluents.
	New tests of industrial wastewater: completion of sea urchins fertilizations submitted to effluent conditions and assessment of mussels near discharge sites.	Improved accuracy in the assessment of offspring and of toxicity of effluents leading to process and environmental performance improvement.
	Totally chlorine-free (TCF) process technology	Reduction in the load of absorbable organic halogens (AOX) in the effluents leading to improved environmental performance.
	Project control system (PCS)	Improved project management (e.g. Fiberline C was completed in record time creating a worldwide benchmark. Plant erection time was reduced from 36 months (e.g., Fiberline A) to 12 months (e.g., Fiberline C). This project technology led to a benchmarking and was used in other start up plants in Brazil.
	New organizational arrangements for project management based on internal inter-functional interfaces and interfaces with suppliers	
Klabin	Cardboard with a white layer for the Tetra-Pak packaging.	This development allowed the company to position as a provider of the most important international packaging manufacturers.
Suzano	Automation and control system for recovery boiler.	Effective reduction particulate matter and sulphur-based component emissions to the recovery boiler.
	Introduction of elemental chlorine free pulp bleaching process	Meeting of international standards and the reduction of environmental risks at the bleaching stage.
	'Water consumption reduction project'.	Setting of new standards in the industry regarding environmental suitable production processes.
	Alkaline correction in the papermaking process.	Environmentally friendly papermaking process.
	Cut size paper to laser and inkjet printing.	Paper exports packed with the customer brand.
VCP	New variation of ECF (elemental chlorine-free) process.	Reduced use of absorbable organic halogens (AOX) and achievement of environmentally friendly production process.
	New alkaline sizing process.	Achievement of greater brightness, colour stability and body (bulk) in paper-basis for making chemicals papers and coated papers, meeting international quality standards, exports packed with the customer brand and new market share.
	2000s	
Aracruz	New technology to map carbon footprint and optimize cooking additive technologies.	Increased productivity and reduced operating costs in different production units.
	Diffusion of the short-fibre technology to papermakers and development of new types of cellulose through environmentally friendly processes.	Increase in the use of eucalyptus fibres in papermaking processes leading to less waste from electrical and thermal energy and reduction of specific fibre consumption by increasing the retention of mineral fillers.
	Novel operational practices to recycle residues (e.g. limemud, biomass ash, dregs and grits) from chemicals recovery processes.	Reduction of 40 per cent in these residues, with significant economic and environmental benefits.
	Improvement in logistic practices of storage and distribution of chemical residues	
	New organic fertilizer Organomax with the biotechnology firm Organoeste.	Replacement of the conventional NPK fertilizers (nitrogen-phosphorous-potash) and improved physical and micro-biological characteristics in soil. By using 100 per cent ash and limemud in its eucalyptus plantations, Aracruz stopped buying limestone, reduced its purchase of mineral fertilizers, and improved its general recycling index by 20 per cent.
Klabin	Card barrier	Manufacture of packaging resistant to water, grease and steam without using plastic.
	New chemi-thermomechanical pulping process based on hardwood.	More resistant and innovative packaging.
	New production processes using multi-layers cardboard from chemi-thermomechanical pulp.	
Rigesa	Packaging for red fruits made from kraft paper.	High degree of security in the stack with an effective ventilation system with minimum handling of the fruit with perfect exposure at sale point.
	Recyclable container for liquids (200 lt) with corrugated packaging system.	Facilitates the individual handling, high-performance packaging and logistics costs reduction.
Suzano	Special cardboards, such as anti-thermal and anti-freeze, and other distinct characteristics defined by the demands of customers.	These types of roles began to occupy space in the market of specialty papers that were previously only served by imported paper.
	Tissue paper for the pharmaceutical industry.	New market share in Brazil.
VCP	Process and paper machine to produce carbonless paper on-machine.	Achievement of better quality and lower price paper.
	Processes to produce thermal papers	Improved image stability and durability to support new applications (e.g. such credit card and invoice machines).

Source: Derived from empirical study.

Since the 1980s, several innovations on the bleaching process became associated with environmentally targeted efforts and involved research on lignin biosynthesis and the patenting of the totally chlorine-free pulp (TCF) process which continued through the 1990s. For example, by augmenting its research capabilities for forestry with pulp and papermaking research, Aracruz intensified research on lignin biosynthesis and pollution control methods based on natural micro-organisms. By 1992, Aracruz had adopted the elementally chlorine-free (ECF) and TCF process, in line with Canada and Scandinavia. However, Aracruz went further by creating a variant in the TCF process, which was characterised by a much lower level of absorbable organic halogens (AOX). This process became known as alpha chlorine-free (ACF) and was patented in 1997. One year later, VCP also created its own versions of the TCF process. Because of these innovations, less chemical products are now needed to whiten the pulp used to make paper.

6.2.2 Operational and environmental-related performance improvement

Table 8 shows some country-level performance parameters related to forestry for pulp and paper. According to the fieldwork and technical literature (WRI, 1999; Evans and Turnbull, 2004), considering the significant technological relevance and scale of Aracruz, VCP, Suzano, Klabin and Rigesa, it is very likely that those leading parameters achieved by Brazil (Table 8) reflect their accumulation of innovative capabilities and related implemented activities. The improvements in forestry performance parameters (Table 9) reflect the case firms' capabilities for genetic manipulation and selective breeding. For instance, the first-generation clonal forestry of eucalyptus during in the 1980s reduced wood-specific consumption (WSC) by 20 per cent. A further 20 per cent reduction was subsequently achieved, based on second-generation clones derived from eucalyptus hybridisation, and leading to the planting of the first large-scale commercial stands of selected clones derived from hardwood cuttings, which in turn resulted in exceptional genetic gains in growth and adaptability to tropical conditions and wood with a higher pulp yield (Grattapaglia and Kirst, 2008).

The evidence in Tables 10 and 11 indicates some significant improvements in the process performance parameters for pulp and paper cases during the 2000-2009 period. For example, specific water consumption of 36.7 m^3 per tonne of pulp and the mean 20.1 m^3 per tonne of paper achieved in the case firms were equivalent to those attained for the Finland and European Union best available technology standards (www.environment.fi). The improvements achieved according to other indicators (e.g. reduction in specific steam and electricity consumption and fibre losses) might have exerted an important impact on cost reduction.

Table 8. Country-level operational performance parameters in forestry for pulp and paper

Types of tree/parameters		Brazil	Chile	Indonesia	Finland	Canada (coastal)	USA
Hardwood	Rotation [(a)] (years)	7 (eucalyptus)	10-12 (eucalyptus)	9 (eucalyptus)	35-40 (birch)	n.a.	n.a.
	Yield (m^3/ha/year)	44	25	24-34	6	n.a.	n.a.
Softwood	Rotation (years)	15 (pinus spp)	25 (pinus radiata)	7 (pinus merkusii)	70-80 (picea abies)	45 (Douglas Fir)	25 (pinus elliottii/ taeda)
	Yield (m^3/ha/year)	38	22	24	4	7	10

Source: Bracelpa (2012) and FAO
Note: (a) Species growth period: from planting to harvest.

Table 9. Evolution of some technical indicators in forestry (1970-2009)

Parameters	Unit	1970	1975	1980	1985	1990	1995	2000	2002	2003	2004	2006	2009	Average annual rate of decrease/increase (%) (1970-2009)
Forest yield	m^3/ha/ year	37	44	47	45	53	52	45	46	45	46	49	49	+0.7
Basic density of wood	Kg/m^3	473	473	473	488	488	488	485	489	494	496	493	506	+0.1
Density	tonne/m^3	0.47	0.47	0.47	0.49	0.49	0.49	0.49	0.49	0.49	0.5	0.49	0.51	+0.2
Cut-off age	years	9.5	9.0	8.5	8.0	7.5	7.4	7.2	7.2	7.1	7.1	7.0	7.0	–0.78
Volume of wood per amount of pulp produced	m^3/tonne pulp	4.2	4.1	3.9	3.8	3.7	3.7	3.8	3.8	3.8	3.9	3.9	3.8	–0.2
Planting density	Trees/ha	1,651	1,651	1,512	1,512	1,486	1,419	1,224	1,259	1,259	1,326	1,326	1,326	–0.5

Table 10. Evolution of process performance in pulp making

Parameters			2000	2001	2002	2003	2004	2006	2009	Average annual rate of reduction/increase (%) (2000-2009)
Specific consumption of:	Steam	Steam tonne/ pulp weight (ton)	4.92	5.4	4.9	4.9	4.5	4.4	3.6	–3.4
	Electricity	KWh/ pulp weight (tonne)	737	730	640.8	646.4	674.2	639.6	571	–2.8
	Water	m^3/ pulp weight (tonne)	41.3	45.6	42.7	39.6	40.9	40.1	36.7	–1.3
Fibre losses		ton/day	13.1	16.7	15.5	11.1	8.8	9.5	10.9	–2

Source: Derived from empirical study. *Notes*: (a) The lower the better

Table 11. Evolution of some process performance in paper making [(a)]

Parameters	Units	2000	2001	2002	2003	2004	2006	2009	Average annual rate of reduction/increase (2000-2009) (%)
Specific steam consumption [(b)]	Steam weight (ton)/ paper weight (ton)								
• Printing and writing		3.1	2.9	2.8	2.7	2.6	2.5	2.4	–2.8
• Packaging, wrapping & boxboard		1.9	2	3.5	3.2	2	1.9	1.9	0.00
• Tissue		1.9	1.7	1.4	1.4	1.4	1.4	1.4	–3.3
Specific electricity consumption[(b)]	KWh/paper weight (ton)								
• Printing and writing		627.5	614.3	591.9	576.1	572	554.5	547	–1.5
• Packaging, wrapping & boxboard		457.5	465.2	655	725.8	486.3	432.8	391.9	–1.7
• Tissue		412	473.5	439.2	458.1	447.1	398.2	229	–6.3
Specific water consumption [(b)]	m^3/ paper weight (ton)								
• Printing and writing		28	26.2	24.6	20.8	19.2	18	17.1	–5.3
• Packaging, wrapping & boxboard		31.6	32.5	32.6	33.5	23.2	19.3	20.1	–4.9
• Tissue		34.8	33.1	31.8	30.6	28.9	25.8	23.3	–4.3

Source: Derived from empirical study. *Notes:* (a) Aggregated by specific paper segments (printing and writing; packaging, wrapping and boxboard; tissue); (b) The lower, the better;

With reference to environment-related indicators in the pulp and paper cases (Tables 12 and 13), the industrial effluent output decreased by 3 per cent annually on average (2000-2009), whereas the SO_2 emission decreased by an average 3.4 per cent annually. In absolute terms, both indicators were below the limits delineated by the Brazilian Environment Authority (Conama) and by the European best available techniques (BAT). Similarly, within the paper mills, the decrease in biochemical oxygen demand (BOD) varied from 2.6 per cent to 9.9 per cent annually which, in absolute terms, were below the limits established by Conama. Consequently, the mills' environmental impact was reduced, particularly in terms of diminished liquid effluents. These performance improvements in Tables 10 to 13 reflect the firms' innovative activities (Table 7) which are very likely to be an outcome from these firms' innovative capabilities.

Table 12 Evolution of environment-related performance in pulp making

Types of effluents and parameters		Units	2000	2003	2006	2009	Average annual rate of reduction/increase (2000-2009)	Limits of CONAMA [c]
Liquid	Industrial effluents output [a]	m^3/pulp weight(ton)	46.7	42.9	38.7	35.3	–3	50-100
	COD (chemical oxygen demand) [a]	Kg/pulp weight (ton)	11.9	10	7.6	6.1	–7.1	10
	BOD (biochemical oxygen demand) [a]		1.8	1.3	1.1	0.8	–8.6	2.5
	Total nitrogen [a]		0.2	0.1	n.a.	n.a.	–20.6	n.a.
Solid	Lime mud/ dregs/grits [b]		33.9	43.5	68	96.2	12.2	n.a.
	Total ashes [b]		11.7	15.5	29.1	38.5	14.1	n.a.
Air	SO_2 (from chemical recovery boiler) [a]	mg/Nm^3	8.8	24	7.1	6.4	–3.4	100
	NOx (nitrogen-oxides, from chemical recovery boiler) [a]		n.a	239.8	187.56	237.91	–0.1	470
	Average TRS (Total reduced sulphur) [a]	ppm	1.64	0.82	2.13	2.42	4.4	n.a.
	Average SO_2 [a]		1.69	2.83	4.4	7.06	17.2	n.a.
	Average TRS (Lime kiln) [a]		17.1	42.9	16.6	17.2	0.03	n.a.

Source: Derived from empirical study.
Notes: (a) the lower, the better; (b) They vary with production output; (c) The National Environment Council of the Brazilian Ministry of Environment; n.a. = not available.

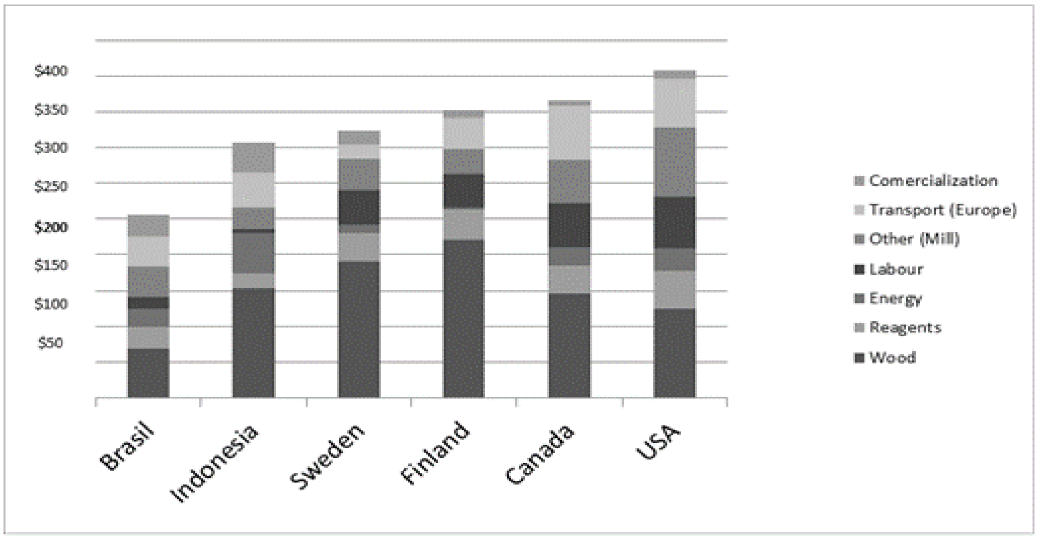
Table 13. Evolution of environment-related performance in paper making

Parameters	Units	2000	2001	2002	2003	2004	2006	2009	Average annual rate of increase/ decrease 2000-2009 (%)	Limits of CONAMA
Industrial effluents output	m^3/ paper weight (ton)									
• Packaging, wrapping & boxboard		28.4	28.4	25.1	37.4	38.8	38.2	39.7	3.7	50-100
• Tissue		90	80	80	46.1	43.4	34.1	31.7	–10.9	50-100
COD (Chemical oxygen demand)	Kg/ paper weight (ton)									
• Packaging, wrapping & boxboard		7.23	6.31	12.7	10.0	10.9	4.9	7.1	–0.2	10
• Tissue		14.5	18.0	13.6	13.6	15.9	9.3	9.2	–4.9	10
BOD (Biochemical oxygen demand)	Kg/ paper weight (ton)									
• Packaging, wrapping & boxboard		n.a.	n.a.	4.3	3.4	4.4	1.5	n.a.	–23.1	5
• Tissue		3.8	5.0	4.32	5.4	5.6	2.4	2.0	–6.8	5

Source: Derived from empirical study.
n.a. = not available

Additionally, field evidence suggests that the firms' capabilities and consequent implemented inventive and innovative activities might have exerted a positive influence on the achievement of highly competitive production and commercialization costs in the international market. For example, the firms (which responded for the majority of Brazil's pulp exports) competitive advantage in relation to international pulp and paper competitors are reflected in their ability to produce high quality bleached eucalyptus kraft pulp (BEKP) for approximately US$225 per tonne (Figure 2).

Figure 2. Production and commercialization costs of short fibre pulp (US$)



6.2.3 Patterns of corporate growth

As indicated in Table 14, growth patterns based on horizontal and vertical integration were prevalent from the 1950s-2000s, which seem to have been enabled by the accumulation of innovative project management capabilities that permitted these firms to design and execute plans, with partners and to coordinate those expansion projects. For example, Aracruz developed novel techniques for project engineering that permitted the firm to expand its fibre lines in world record time. These capabilities seem to have paid off by allowing Aracruz and VCP to set up large logistic projects with positive impacts on their competitiveness.

Table 14. Patterns of corporate growth in the researched firms

Patterns of corporate growth			1950-1980s	1990s	2000s
Horizontal integration	*Enlargement of existing facilities and set up of new ones*		Klabin: 12 new facilities Aracruz: Fiberline A	Klabin: two new facilities in Brazil and one in Argentina. Enlargement of Monte Alegre Mill in Telêmaco Borba Aracruz: Fiberline B and C	Enlargement of Monte Alegre Mill in Telêmaco Borba through Project MA1100. Suzano: Start-up of Line 2 of Mucuri (Bahia) Aracruz and VCP: start-up of Eldorado Brasil
	Merger/acquisition to increase production of existing products		Suzano: Acquisition of Papel Rio Verde	Klabin with Kimberly (50 per cent) = Tissue	Aracruz and VCP (26 per cent) Aracruz and VCP (100 per cent, forming Fibria, 2009) Suzano: acquisition of Ripasa (50 per cent) and Bahia Sul VCP: joint venture with Ahlstrom in paper business
Vertical integration	*Upstream*	Production of own feedstock	All firms: production of eucalyptus pulp		
	Dowstream	International distribution channels of final product	Aracruz, VCP, Suzano: international distribution channels		
		Logistic services for final product	Aracruz: operation of Portocel, a specialized forestry terminal;	Aracruz: Operation of three docks for wood and pulp VCP: Operation of two terminals at Porto of Santos with capacity to ship 2million tonnes pulp	Aracruz: Operation of a terminal to load 6million tonnes of pulp/year. VCP: Operation of railways to transport pulp from Western Brazil to Porto of Santos.
Diversification	*'Directly' (diversification by the firm)*		None	Aracruz, VCP, Klabin: electricity and steam power	Aracruz: • organic fertilizer (with Organoeste, Brazil) • renewable energy (with Ensyn, USA) Suzano: • bioenergy (by creating Suzano Energia Renovável) • biotechnology (by acquiring FuturaGene) Klabin: • biorefinery (embryonic) • fitoterapics
	'Indirectly' (spin-offs/spill-overs)		All firms: Programme of forest partnerships		
			Aracruz: Imetame Metalworking	Klabin: Wood cluster	Aracruz: Inflor Consulting and Systems

Source: Derived from empirical study.

'Direct' firm diversification only began to become significant during the 2000s. These firms were created under the ISI regime and their businesses evolved around the pulp and paper industry, with a low degree of diversification. One exception is VCP, which is part of a large Brazilian business group diversified into relatively related areas (e.g, chemicals, cement, metals, agro-industry, pulp and paper and banking). However, during the 2000s, they began to draw on their world-leading innovative capability in forestry to diversify into new activities from their stock of innovative capability in that area, giving rise to *new* 'high tech' activities in the pulp and paper industry in Brazil.

For example, by acquiring FuturaGene (with operations in the US, Israel, China and Southeast Asia), Suzano was able to firmly engage in the international commercialisation of modified genes and develop trees that will need require less land, less water consumption, less fertilizers, produce less lignin (requiring less chemicals during the pulping processes), and higher carbon sequestration, contributing to stronger competitiveness in its forestry and pulp and paper businesses. The creation of Suzano Renewable Energy may allow Suzano to move into the new forestry segment of planted 'energy forests' by producing genetically modified trees with very short cut-off times and calorific properties. By drawing on its world-leading forestry capabilities, Klabin intensified its business in medicinal plants, phytotherapy and phytocosmetics. In relation 'indirect' firm diversification (spin-offs and spill overs), the evidence suggests that as these firms accumulated innovative capabilities, they also seem to have stimulated the emergence of some spin-offs and spill overs (see four outstanding examples in Table 15).

Table 15. Examples of spin-offs and spill-overs generated by these cases

Examples of spin-offs/spill-overs	Start-up year	Origin	Description
Imetame Metalworking	1980	Aracruz	After spinning off, Imetame deepened its capabilities in engineering services (engineering projects; maintenance services in pulp and paper, metallurgy and mining; industrial erection and structure and logistics). With approximately 4,000 employees, Imetame has a large portfolio of clients including large local and multinational firms in the pulp and paper, oil and gas, steel, and capital goods industries and has been awarded several prizes from these firms (www.imetame.com.br).
Inflor Consulting and Systems	2001	Aracruz	After spinning off, Inflor deepened its capabilities to create original information technology (IT) systems for integrated and sustainable forestry management and by 2007 they expanded their services to sectors such as sugarcane ethanol and agriculture-related firms. Since 2008, Inflor has been providing its services to customers in Chile, Uruguay, Europe and China, which appears to constitute firm steps into the internationalisation of its activities. (www.inflor.com.br).
Wood cluster at Telêmaco Borba, a municipality in the southern state of Paraná	Mid-1990s	Klabin	The partnerships led by Klabin with the municipality's council, the National Service for Industrial Apprenticeship (SENAI), the FATEB, a local technical university and the Wood Technological Centre (CETMAN), stimulated the emergence of 50 small and medium-sized firms in Telêmaco Borba, generating approximately 1,500 jobs and the Centre of Residues Utilisation. By the mid-2000s, Klabin led new efforts to expand this wood cluster to another 14 municipalities in the region.
Forest partnerships programme	Early 1980s	Aracruz, Klabin, Suzano and VCP	Based on their innovation capability development for large-scale cloned eucalyptus plantations, these firms created a programme to transfer some elements of this technology to independent land owners to plant eucalyptus and become wood suppliers. By purchasing wood from these producers the firms encourages the development of profitable agricultural activities with forest planting, reconciling economic gains with environmental preservation. The programme benefits thousands of small rural owners in 539 towns in Brazil and supplies 20 per cent of the wood used in pulp production.

7. Discussion

Building on a research tradition in technological capability accumulation and its performance implications in latecomer firms (e.g., Bell et al., 1982; Katz, 1987; Figueiredo, 2002), the purpose of the reported study was to empirically investigate the types of outcomes that are achieved by latecomer firms from the accumulation of innovation capabilities, up to the world-leading level, besides technological catch-up. In contrast to most existing studies, this article has proxied innovation capability drawing on a comprehensive taxonomy based on a scale of *capability levels* for a wide range technological activities. Based on an inductive multiple-case study involving first-hand and long-term evidence derived from extensive field investigations of a relatively homogenous set of pulp and paper firms derived from Brazilian, this study scrutinized a number of outcomes related to innovative performance and business performance as outcomes achieved by these firms from their innovation capabilities accumulated over their lifetime. The recursive fieldwork process in combination with insights from literature of innovation in latecomer firms and the strategic management literature, permitted the achievement of the framework in Figure 1, especially exploration of the relationships between components A, B, and C the findings of which respond to the article's general research question and generate further implications as outlined below.

7.1 Discussion of findings

7.1.1 Innovation capability accumulation

The researched firms accumulated innovation capabilities that eventually turned them into world leaders in a particular segment of the world pulp and paper industry, namely that based on short-fibre (eucalyptus). This finding is consistent with previous studies that have reported the attainment by latecomer firms from other industries of leading technological positions at the international innovation frontier (Section 2). However, instead of starting from the accumulation of production capability and then moving into the progressive accumulation of innovative capabilities (from adaptation to R&D-based innovation), as usually documented in the literature, these firms accumulated innovative capabilities that permitted them to take a *direction* of technological development that was different from those already pursued by global industry leaders. Their innovative capability accumulation process involved a *qualitative discontinuity* from the established technological trajectory at an *early stage* in the development of their capabilities, which is rare in the related literature. Additionally, different from most studies of technological capability accumulation studies, that focus on the so-called 'high-tech' industries (e.g., electronics), this study has examined this issue in natural resource-related firms, which are scantly investigated in the literature, despite their importance for national economies, although there are exceptions (e.g., Dantas and Bell, 2009; Silvestre and Dalcol, 2009). Elsewhere (Figueiredo, 2010) additional details are provided of this capability accumulation process so the following section discusses findings related to outcomes.

7.1.2 Outcomes of innovation capability accumulation

As the firms accumulated these innovative capabilities, they drew on the resources to change and or create technologies and components of production systems besides achieving a technological catch-up, thereby achieving concrete benefits from the accumulation of these capabilities in terms of innovative and business performance, which could guarantee their international competitiveness. Thus, the study found the following outcomes resulted from the accumulation of these innovative capabilities: (i) *Innovative performance (implemented inventive and innovative activities)*, which involved evidence from 108 accumulated patents (Table 5) and 24 examples of significant innovative activities in forestry and 28 in pulp and paper (Tables 6 and 7) of different types and with varying degrees of complexity and novelty; (iii) *Operational and environment-related performance improvement*, involving county-level and firm-level (six types) performance parameters in forestry, 14 types of performance parameters for pulp making and 21 in paper making, plus country level product and commercialisation cost (Tables 8 to 13 and Figure 2); (iii) *corporate growth patterns*, involving more than 30 examples of these patterns in the form of horizontal integration and upstream and downstream vertical integration, and ‘direct’ diversification and indirect’ diversification (spin-offs and spill-overs). This study indicates that these outcomes were achieved by accumulating a wide range of innovative capability levels (from basic to advanced) for diverse technological functions (e.g., silviculture, harvesting, project management, process and production organization, product-centred and related engineering-based capabilities) and varied implemented inventive and innovative activities with differing levels of novelty and complexity.

Specifically, in relation to the nature of these capabilities and the outcomes that they generate beyond technological catch-up, the study found that, first, this wide range of innovative activities, several of which were engineering-based and incremental-type of capabilities which have intermediated the achievement of several improvements in operational and environmental-related performance parameters that are vital for the international competeiveness of these firms. Although this result of not really ‘new’, as the importance of these types of innovative activities for firm performance has been examined in previous research (e.g., Enos, 1962; Hollander, 1965; Bell et al., 1982; Katz, 1987; Figueiredo, 2002), studies in the strategic management literature (Section 3) and even studies focusing on latecomer firms (Section 2), since the 1990s, have been addressing innovative capabilities narrowly mainly as R&D expenditures, patent citations or product innovation. Second, although these innovative capabilities were strategic for these firms, especially the high-level ones, there were features of these capabilities that were common across these firms. This result seems to contradict well accepted assumptions that these high-level capabilities are highly idiosyncratic resources. This does not imply absence of distinctiveness across these firms. However, such distinctiveness should not be attributable only to innovative capabilities but probably to an interaction between these capabilities and other factors as represented in Figure 1.

Third, the findings do not imply that the accumulation of these innovative capabilities is any guarantee of 'sustained' innovative and business performance because firms may go through severe difficulties despite the accumulation of innovative capabilities. For example, during the 1970s and 1990s, the global paper industry experienced serious down cycles that kept prices at historically low levels, severely impacting earnings (Lamberg et al., 2005) and during the 1980s, Brazil's economy went through a combination of recession and uncontrolled hyperinflation. During the early 1990s, there was an abrupt change from the import substitution industrialization (ISI) regime in Brazil to trade liberalization and an open economy, which swept many firms from the market. These events generated significant negative impacts on the competitive and economic performance of firms such as Klabin, VCP, Suzano and Aracruz. In 2008, Aracruz experienced a deep financial crisis involving losses of US$2.1 billion as a consequence of rapid exchange rates movements following the international financial crisis as a result of its hedging policies based on derivatives (Zeidan and Rodrigues, 2013), putting Aracruz on the verge of bankruptcy despite its innovative capabilities. Indeed, as firms operate in increasingly inter-connected and ever-changing environments, their performance is more susceptible to external influences (Zahra et al., 2006) including macro-economic conditions (Lall, 1992; Arza, 2005), changes in institutional frameworks and firm's decisions. Nevertheless, the accumulation of innovative capabilities permits firms to mitigate the negative impacts of external factors on its competitiveness, and also permits firms to cross certain discontinuities in their environments and overcome certain crises (Figueiredo, 2002). Therefore, the findings show that by accumulating significant levels of innovative capabilities, firms achieve not only technological catch-up, but also significant outcomes related to innovative and business performance.

Fourth, outcomes such as o*perational and environment-related performance improvement*, could have been achieved through the firms' acquisition of new production systems embodying ‘advanced’ technology by contracting an array of external consultant designers, process engineers, and project managers to define and bring a new set of products, processes, and equipment-related technologies into operational use on its behalf (see Bell and Figueiredo, 2012), delegating these duties third parties or even using governments subsidies to provide inputs. The firms could have achieved similar types of outcomes through perhaps different means and different ways. Thus, it is interesting to bring in the notion of equifinality (Zahra et al., 2006) to interpret these performance improvements. On the other hand, it seems unlikely that these firms could have achieved consistent and continuous improvement in a wide range of operational and environment-related performance parameters across different business lines over time, without the accumulation of a wide range of levels and types of innovative capabilities. In other words, in the absence of significant innovative capabilities, it would most likely that these firms keep achieving further levels of competitive operational and environment-related performance in the face of fierce competition against highly innovative competitors in the global market. Additionally, even if the same performance is achieved, the differences in the underlying capabilities do matter. Therefore, these findings offer en empirical substantiation to the position presented in Zahra et al. (2006) about the *means* (in this case, innovation capabilities) used by firms to achieve competitive performance. Therefore, even if some of those outcomes could have been achieved by other means, the accumulation of innovation capability does matter.

7.2 Implications of these findings for the related literature and theoretical contributions

Although these findings are consistent with some of literature, they also move further in relation to existing studies and approaches in the literature on innovation capability building in latecomer firms and the strategic management literature concerned with the role of innovation capability as sources of competitive performance, in several ways.

First, by capturing a wide variety of qualitative outcomes over time, and based on a comprehensive framework for different capability levels, this study advances research addressing latecomer firms and the impacts of their *current* technological capabilities on specific performance indicators (e.g., Piccinini, 1993; Tremblay, 1994; Joo and Lee, 2009) and studies that have examined the impacts of innovation capabilities (proxied in different ways from R&D efforts to patenting) on firm performance (proxied in different manners) based on large data samples (e.g., Jonker, 2006; Goedhuys et al., 2008; Bapuji et al., 2011; Shan and Jolly, 2012; Chen and Tsou, 2012). Therefore, this study adds important nuanced qualitative evidence to improve the debate. Although corporate growth is explored here in a incipient manner, it furthers recent studies that have addressed the impact of innovation capabilites on corporate growth based on large data samples and perceptual evidence (Yang, 2012), the different types of growth patterns that may be supported by a wide range of types and levels of innovation capabilities, not only R&D, and probably even production capabilities. Diversification into related areas is consistent with Torres-Vargas (2006) and not with Amsden and Hikino (1994). Some of these growth patterns, e.g., upstream diversification leading to a new business line or involuntary spill-overs led by individuals who create new businesses for the country, may play an important role in changing a country's industrial structure, which is consistent with Nelson and Pack (1999).

Second, the findings are consistent with the long-standing arguments that the ability of firms to implement innovative activities and achieve distinctive performance reflect the nature and depth of their technological capabilities (Dosi, 1988; Lall, 1992; Bell and Pavitt, 1993) and a tradition of empirical research on the performance implications of innovation capabilitiy (Bell et al., 1982; Katz, 1987) and that the accumulation does pay off in terms of achievement of wide performance benefits (Figueiredo, 2002). The finding related to the role of wide range of innovation capabilities in the attainment of these outcomes gives to support to Bell and Pavitt (1995, Patel and Pavitt (1994) and Lasteadius (2006) on the importance of non-R&D capabilities for the achievement of innovative performance, based on the implementation of innovative activities with differing degrees of novelty and complexity (not always R&D-based) with relevant positive operational economic impacts for firms (Enos, 1962; Hollander, 1965).

Third, this study provides an empirical response to the call for empirical substantiation about the implications of innovative capabilities for firm competitive performance (e.g., Helfat et al., 2007; Newbert, 2007; Protogerou et al., 2011). By providing empirical substantiation for this relationship, this study may move the debate forward and pave the way for further empirical analysis to generate a cumulative body of evidence. However, this study suggests that the nature of these capabilities is much wider, involving a wide range of levels and types related to diverse technological functions and corresponding to different types and degrees of novelty relating innovative activities. This narrative contradicts the prevailing notion of innovation capability as a mere reflection of R&D and patenting. This also calls for more comprehensive types of measurement. Therefore, these findings line up with Eisenhardt and Martin (2000) and Newbert (2007), but move a bit further by empirically exploring some of the outcomes achieved by firms from their accumulated innovative capabilities. Thus, it might be that firms' distinctiveness and capacity to achieve long-term competitiveness lies beyond these innovative capabilities to involve a combination of factors that may directly and indirectly influence the achievement of firm innovative and business performance, as highlighted in Figure 1, although that broad perspective was beyond the scope of this article.

7.3 Implications for corporate managers and government policy

To achieve the types of outcomes reported herein managers need to manage a multiplicity of levels and types of innovative capabilities for diverse technological functions. These capabilities are spread across different corporate functional areas and involve a wide range of professionals. Consequently, managers should develop a more comprehensive view on innovation capabilities beyond the R&D units and praise the importance of engineering-based and non-R&D types of capabilities that are highly relevant for the achievement of competitive performance. Second, managers and especially policy makers should reduce their infatuation for radical innovations. Consequently, especially in developing economies, where government policy tends to play a major role in industrial innovation, policies should give more emphasis to the development of engineering-based capabilities within firms as they may work as a pre-condition for the accumulation of higher capability levels and have significant impacts on the competitive performance of firms, industries and, ultimately, the economy.

Therefore, corporate and government policies should *converge* on incentives to stimulate the firms' engagement in new technological trajectories to achieve world-leading innovative performance. Upstream diversification based on accumulated innovation capabilities, such as the experience of the forestry firms examined herein, appears to be an interesting focus for policy efforts. In addition, the findings suggest that the establishment of development goals such as the improvement of environmental performance may not lead to concrete positive results, understanding and tackling the issue of firm-level innovative capability building, particularly with regard to the nature, direction and speed of innovative capability-building within firms. Additionally, the accumulation of innovative capabilities may contribute to output diversification either within the firm or externally via spill-overs. Again, policy makers should reduce their emphasis on creation of science parks and similar initiatives and create mechanisms to stimulate spill overs and spin-offs that are generated from within firms.

7.4 Limitations, future research and conclusion

The reported study, like all studies, has limitations that create opportunities for future research. Some of these opportunities refer the exploration of factors highlighted in Figure 1 that may affect the relationship of innovation capability accumulation and its outcomes. First, the article did not examine the role of the underlying learning mechanisms in creating the capabilities that were examined herein, which would explain how each firm arrived at its current capability levels. Second, the article lacked detailed evidence of individual firms, especially in terms of operational and environment-related performance improvement. This evidence would be important for sharpening the analysis and capturing nuanced differences across them. Third, the article lacked comparison with firms that did not attain those high capability levels. A fourth limitation, posing a major opportunity for future inquiry, is to compare the outcomes achieved by firms that have accumulated technological capabilities (production and innovative) with firms that have attained basic to intermediate levels of these capabilities. This comparative design would permit a more nuanced view of the consequences of innovation capabilities. Finally, future studies could examine the role of intermediate variables (e.g., firm strategies and leadership) as well as the role of policy context in influencing the accumulation of innovation capabilities and outcomes.

In conclusion, this study has shown that by accumulating innovative capabilities the firms attained importance performance outcomes. Therefore, although these performance outcomes are likely to be affected by a number of factors, the firms would be unlikely to reach them without these capability levels. Therefore, if latecomer firms make efforts to accumulate these levels of innovation capabilities, they will achieve not only technological catch-up but they are also likely to generate different types of outcomes that may benefit the innovative firms themselves as well as their industries and, ultimately, economies. By adopting a comprehensive and nuanced view and measuring innovative capabilities and outcomes, this study stimulates further understanding of that intricate relationship, especially in latecomer firms. Indeed, the relationship between innovative capabilities and outcomes is nuanced and intricate and hard to capture by limited proxies.

References

Amsden, A. H., Tschang, F.T., 2003. A new approach to assessing the technological complexity of different categories of R&D (with examples from Singapore). *Research Policy* 32, 553-572.

Adegbesan, T., Ricart, J. E. , 2007. What do we really know about when technological innovation improves performance (and when it does not)? *IESE Working Paper* 668, January, Navarra.

Amsden, A.H. and Hikino, T., 1994. Project execution capability, organizational know- how, and conglomerate corporate growth in late industrialization. *Industrial and Corporate Change* 3 (1),111–147.

Arza, V., 2005. Technological performance, economic performance and behavior: A study of Argentinean firms during the 1990s. *Innovation: Management, Policy and Practice* 7 (2-3), 131-51.

Ariffin, N., 2010. Internationalisation of technological innovative capabilities: levels, types and speed (learning rates) in the electronics industry in Malaysia, *Int. J. of Technological Learning, Innovation and Development* 3 (4), 347-391.

Ariffin, N., Figueiredo, P.N., 2004. Internationalisation of innovative capabilities:counter evidence from the electronics industry in Malaysia and Brazil, *Oxford Development Studies* 32 (4), 559-583.

Bapuji, H., Loree, D., Crossan, M. 2011. Connecting external knowledge usage and firm performance: an empirical analysis, *J. of Engineering and Technology Management* 28, 215-231.

Bell, M., Pavitt, K., 1993. Technological accumulation and industrial growth: contrasts between developed and developing countries, *Industrial and Corporate Change* 2 (2),157 211.

Bell, M., Pavitt, K., 1995. The development of technological capabilities, in Haque, I.(ed.), *Trade,Technology and International Competitiveness, 69-101.* Washington:The World Bank.

Bell, M., Scott-Kemmis, D., Satyarakwit, W., 1982. Limited learning in infant industry:a case study, in F. Stewart and F. James (eds.), *The Economics of New Technology in Developing Countries*, 138-156. London: Frances Pinter.

Bell, M., 2006. Time and technological learning in industrialising countries: how long does it take? Howfast is it moving (if at all)? *Int. J. of Technology Management* 36 (1-3), 25-42.

Bell, M., Figueiredo, P.N., 2012. Building Innovative Capabilities in Latecomer Emerging Market Firms: Some Key Issues, In: J. Cantwell and Ed Amann (eds.), *Innovative Firms in Emerging Market Countries*, Oxford: Oxford University Press.

Boehe, D.M., 2007. Product development in MNC subsidiaries: local linkages and global in terdependencies. *J. of International Management* 13 (4), 488–512.

Chandler, A.D, Jr., 1962. *Strategy and Structure: Chapters in the History of the American Industrial Enterprise* (MIT Press, Cambridge, MA).

Chen, J.S, Tsou, H.T., 2012. Performance effects of IT capability, service process innovation, and the mediating role of customer service. *J. of Engineering and Technology Management* 29, 71-94.

Choung, J.Y, Hwang, H.R., Yang, H., 2006. The co-evolution of technology and institution in the Korean information and communications industry, *Int. J. of Technology Management* 36 (1-3),249-266.

Coombs, J., E., Bierly., P., E., 2006. Measuring technological capability and performance. *R&DManagement* 36 (4), 421-438.

Cooper, C. 1970. The transfer of industrial technology to the under-developed countries, *IDS Bulletin* 3.1, Institute of Development Studies, Falmer

Costa, L.A, Cool, K., Dierickx, I., 2013. The competitive implications of the development of unique resources, *Strategic Management Journal* 34 (4), 445-463.

Dalcomuni, S.M., 1997. Dynamic capabilities for cleaner production innovation: thecase of the market pulp export industry in Brazil. D.Phil. Thesis, SPRU/Sussex University, Brighton.

Dantas, E., Bell, M., 2009. Latecomer firms and the emergence and development of knowledge networks: The case of Petrobras in Brazil, *Research Policy* 38 (5), 829- 844.

Dijk, M.V, Bell, M., 2007. Rapid growth with limited learning: industrial policy and Indonesia's pulp and paper industry, *Oxford Development Studies* 35 (2), 149-169.

Dosi, G., 1988. Sources, procedures, and microeconomic effects of innovation, *J. of Economic Literature* 26 (3), 1120-71.

Dougherty, D., 2002. Grounded theory research methods, in: J. A. C. Baum (Ed.), *The Blackwell Companion to Organisations*, Padstow, UK: Blackwell, 849-866.

Dutrénit, G., 2000. *Learning and Knowledge Management in the Firm. From Knowledge Accumulation to Strategic Capabilities*, Edward Elgar, Cheltenham, UK.

Eisenhardt, K. M., 1989. Building theories from case study research, *Academy of Management Review* 14 (4), 532-550.

Eisenhardt, K.M., Martin, J.A., 2000. Dynamic capabilities: what are they? *Strategic Management Journal* 21, 1105– 21.

Enos, J. L., 1962.Invention and Innovation in the Refining Industry, in R. R. Nelson (ed) *The Rate and Direction of Inventive Activity: Economic and Social Factors*. Princeton: Princeton University Press.

Evans, J. and Turnbull, J. W. 2004. *Plantation Forestry in the Tropics.* 3rd ed. Oxford University Press, Oxford.

Fan, P., 2006. Catching up through developing innovation capability: evidence from China's telecom equipment industry. *Technovation* 26, 359-368.

Figueiredo, P. N., 2002. Does technological learning pay off? Implications for inter firm differences in operational performance improvement, *Research Policy* 31 (1),73-94.

Figueiredo, P.N., 2010. Discontinuous innovation capability accumulation in latecomer natural resource-processing firms, *Technological Forecasting and Social Change* 77 (7), 1090-1108

Grattapaglia, D., 2004. Integrating genomics into eucalyptus breeding, *Genetic and Molecular Research* 30 (3), 356-368.

Gratttapaglia, D., Kirst, M., 2008. Eucalyptus applied genomics: From genes sequences to breeding tool. *New Phytol*, 179 (4), 911-929.

Gratapaglia, D. (ed). (2011). IUFRO Tree Biotechnology Conference 2011: From Genomes to Integration and Delivery, *BMC Proceedings*, Bahia, Brazil. 26 June-2 July

Giuliani, E., Bell, M., 2005. The micro-determinants of meso-level learning and innovation: evidence from a Chilean wine cluster. *Research Policy* 34, 47–68

Goedhuys, M., Janz, N., Mohnen, P., 2008. What drives productivity in Tanzania manufacturing firms. *European J. of Development Research* 20 (2), 199-208

Hagedoorn, J., Cloodt, M., 2003. Measuring innovative performance: is there an advantage in using multiple indicators?, *Research Policy* 32 (8), 1365-79.

Helfat, C. E., Finkelstein,S., Mitchell, W., Peteraf, M.A., Singh, H., Teece, D.J., Winter, S.G., 2007. *Dynamic Capabilities: Understanding Strategic Change in Organization*. Blackwell:Malden

Hitt, M.A., Ireland, R.D., Lee, H. 2000. Technological learning, knowledge management, firm growth and performance: an introductory essay. *J. of Engineering Technology and Management* 17, 231-46

Hobday, M., Rush,H., Bessant, J., 2004. Approaching the innovation frontier in Korea:the transition phase to leadership. *Research Policy* 33 (10), 1433-1457.

Hollander, S., 1965. *The Sources of Increased Efficiency: A Study of Du Pont Rayon Plants*, Cambridge,MA: MIT Press.

Iammarino, S., Padilla, R., von Tunzelmann, N., 2008. Technological capabilities and global-local interactions: the electronics industry in two Mexican regions, *World Development* 36 (10), 1980-2003.

Jick, T. D., 1979. Mixing qualitative and quantitative methods: Triangulation in action, *Administrative Science Quarterly* 24(4), 602-611.

Jonker, M., Romijn, H.,Szirmai. E., 2006. Building technological capabilities to improve performance - A case study of the paper industry in West Java, Indonesia,*Technovation* 26 (1), 121-134.

Joo, S. and Lee, K. 2010. Samsung's Catch-up with Sony: analysis with patent data, *Journal of Asia-Pacific Economy* 15(3): 271-87

Jung, M., Lee, K., 2010. Sectoral systems of innovation and productivity catch-up:determinants of the productivity gap between Korean and Japanese firms, *Industrial and Corporate Change* 19 (4), 1037–1069.

Katz, J., 1987.*Technology Generation in Latin American Manufacturing Industries,* London:Macmillan.

Kale, D., Little, S., 2007. From imitation to innovation: The evolution of R&D capabilities and learning processes in the Indian pharmaceutical industry. *Technology Analysis and Strategic Management* 19 (5), 589-609.

Kim, L., 1997. *Imitation to Innovation: The Dynamics of Korea's Technological Learning*. Boston, MA: Harvard Business School Press.

Laestadius, S,. 1998. The relevance of science and technology indicators: the case of pulp and paper. *Research Policy* 27, 385-395.

Lall, S., 1987. *Learning to Industrialize: The Acquisition of Technological Capability by India.* London:Macmillan.

Lall, S., 1992. Technological Capabilities and Industrialisation, *World Development,* 20 (2), 165-186.

Laestadius, S., 1998. The relevance of science and technology indicators: the case of pulp and paper.*Research Policy* 27, 385-395.

Lamberg, J.A., Ojala, J., Satado, P., 2005. The Evolution of Competitive Strategies in Global Forestry Industries: Comparative Perspectives. Springer 29.

Lee, K., Lim, C., 2001. Technological regimes, catching-up and leapfrogging: findings from the Korean industries. *Research Policy* 30 (3), 459-483.

Leornard-Barton, D. 1995. *Wellsprings of Knowledge: Building and Sustaining the Sources of Innovation,* Harvard Business School Press: Boston, MA.

Mathews, J.A., 2002. Competitive advantages of the latecomer firm: a resource based account of industrial catch-up strategies. *Asia Pacific Journal of Management* 19 (4),467-488.

Miles, M. B., Huberman, A. M., 1994. *Qualitative Data Analysis: An Expanded Sourcebook* (2nd ed.). Sage: Thousand Oaks

Nelson, R. & H. Pack (1999). The Asia miracle and modern growth theory. *The Economic Journal* 109 (457), 457-478.

Newbert, S.L, 2007. Empirical research on the resource-based view of the firm: an assessment and sggestions for future research. *Strategic Management Journal* 28, 121-146.

OECD. 2005. *Oslo Manual*. EU/Eurostat, Paris.

Patton, M. 2002. *Qualitative Evaluation and Research Methods*. (3rd ed.). Sage: London

Patel, P., Pavitt, K., 1994. The continuing, widespread (and neglected) importance of improvements in mechanical technologies. *Research Policy* 23, 533-545.

Pavitt, K., 1991. Key characteristics of the large innovating firm, *British Journal of Management* 2 (1), 41-50.

Pavitt, K., 1984. Sectorial patterns of technical change: towards a taxonomy and a theory, *Research Policy* 13 (6), 343-73.

Peerally, J.A, Cantwell, J., 2012. Changes in trade policies and the heterogeneity of domestic and multinational firms' strategic response: The effects on firm-level capabilities, *World Development* 40 (3), 469–485.

Penrose, E. T., 1959. *The Theory of the Growth of the Firm*, Basil Blackwell: Oxford.

Peteraf ,M.A., 1993. The cornerstones of competitive advantage. *Strategic Management Journal* 14 (3) 179–191.

Pettigrew, A.M., 1990. Longitudinal field research on change: theory and practice, *Organization Science* 1 (3), 267-292.

Piccinini, M., 1993. Technical change and energy efficiency: a case study in the iron and steel industry in Brazil. D. Phil Thesis, SPRU, University of Sussex.

Protogerou, A., Caloghirou, Y., Lioukas, S., 2011. Dynamic capabilities and their indirect impact on firm performance. *Industrial and Corporate Change* 21 (3), 615-647.

Romijn H.,1999. *Acquisition of Technological Capability in Small Firms in Developing Countries*.London: Macmillan.

OECD. (2005). *Oslo Manual*. European Commission/Eurostat, Paris.

Shan, J., Jolly, D. 2012. Accumulation of technological innovation capability and competitive performance: A quantitive study in Chinese electronic information industry. *Int. J. of Innovation and Technology Management* 9 (5).

Sher, P.J., Yang, P.Y., 2005. The effects of innovative capabilities and R&D clustering on firm performance: the evidence of Taiwan's semiconductor industry. *Technovation* 25, 33–43.

Siggelkow, N. , 2007. Persuasion with case studies, *Academy of Management Journal* 5(1), 20 24.

Silvestre, B.S., Dalcol, P.R.T., 2009. Geographical proximity and innovation: Evidences from the Campos Basin oil & gas industrial agglomeration – Brasil. *Technovation* 29, 546–561.

Scott-Kemmis, D., 1988. Learning and the Accumulation of Technological Capacity in Brazilian Pulp and Paper Firms', Working Paper, 187, World Employment Programme Research (2-22).

Sohn, E., Chang, S. Y., Song, J., 2009. Technological catching-up and latecomer strategy: A case study of the Asian shipbuilding industry. *Seoul Journal of Business*, 15 (2), 26-57.

Teece, D. 2007a. Explicating dynamic cabalities: The nature and microfoundation of (sustainable) enterprise performance. *Strategic Management Journal* 28, 1319 – 135.

Teece, D., 2007b. The role of managers, entrepreneurs and the literati in enterprise performance and economic growth, *Int. J. of Technological Learning, Innovation and Development* 1 (1), 43-64.

Torres-Vargas, A. 2006. Product-makert and technological direction in the evolution of large business groups in Mexico. *DRUID Summer Conference*, Copenhagen.

Tremblay, P.J., 1994. Comparative Analysis of Technological Capability and Productivity Grotwh in the pulp and paper Industry in Industrialised Countries.,DPhil Thesis, SPRU, Sussex University.

Yang, J., 2012. Innovation capability and corporate growth: An empirical investigation in China. *J. of Engineering and Technology Management* 29, 34-46.

Yin, R., 2003. *Case Study Research: Design and Methods*. Sage: London.

Yoruk, E., 2011. The influence of technological capabilities on the knowledge network component of innovation systems: evidence from advanced materials in Turkey. *Int. J. Technological Learning, Innovation and Development* 4(4), 330- 362

World Resources Institute (1999). *Aracruz Celulose S. A. And Riocell S. A: Efficiency and Sustainability on Brazilian Pulp Plantations*. The Macarthur Foundation: Chicago

Zhang, W., Shi, Y., Wu, X., Teng, Y., 2008. Enterpreneurship and innovation Organizations, Institutions, systems and Regions. *DRUID Conference, Copenhagen*.

Zahra, S. A., Sapienza, H.J., 2006. Entrepreneurship and dynamic capabilities: A review, model and research agenda. *Journal of Management Studies* 43 (4), 917-955.

Zeidan, R., Rodrigues, B., 2013. The failure of risk management for nonfinancial companies in the context of the financial crisis: lessons from Aracruz Celulose and hedging with derivatives. *Applied Financial Economics* 23 (3), 241-250.

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