Forest Policy and Economics 64 (2016) 1–14

Contents lists available at ScienceDirect

Forest Policy and Economics

journal homepage: www.elsevier.com/locate/forpol

Evolution of the short-fiber technological trajectory in Brazil's pulp and paper industry: The role of firm-level innovative capability-building and indigenous institutions

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ARTICLE INFO

Article history:
Received 9 October 2014
Received in revised form 18 December 2015
Accepted 18 December 2015
Available online 5 January 2016

Keywords:
Innovative capability-building
Innovation
Institutions
Latecomer firms
Pulp and paper industry, Brazil

ABSTRACT

Despite the growing interest in innovation in the pulp and paper industry (PPI) from strategic management and institutional standpoints, little empirical research exists on the role of firms' technological capabilities and institutions in shaping particular technological trajectories within the industry. The objective of this article is to examine the relationship among firms' technological capability-building process, indigenous institutions, and the evolution of a particular technological trajectory within the PPI. To meet this objective, this article draws on a case study design based on primary and long-term evidence gathered through extensive fieldwork in Brazil. This article shows that (1) Brazil's PPI began by developing technological capabilities in long-fiber technology led by global leaders; instead of moving on a subsequent path-following trajectory, these firms accumulated innovative capabilities that led to the development of the short-fiber trajectory; (2) these capabilities initially permitted the implementation of incremental changes in forestry and process technologies, which evolved into sophisticated R&D; and (3) indigenous institutions shaped this trajectory by providing firms with human capital and research support, funding for production and initial innovative capability development, and IPO and entry into export markets. These capabilities and institutions were effective in developing a technological trajectory that enabled Brazil's PPI to achieve an internationally leading position in this industry; however, new capabilities and institutional arrangements are needed to support Brazil's PPI firms' incipient diversification and to mitigate self-reinforcement. This article shows that innovative capability building combined with effective indigenous institutions enable firms—even those from a late-industrializing country—to create a new technological trajectory. Given the innovation opportunities in the PPI, managers and policy makers should not be satisfied with their achievements; rather, they should be alert to innovative new entrants and explore novel technologically advanced paths.

1. Introduction

The pulp and paper industry (PPI) has conventionally been referred to as a "low-tech" industry with low knowledge intensity (OECD, 2005) that undertakes low-level innovative activities (Diaz-Balteiro et al., 2006) and offers few opportunities for innovation and development (Sachs and Warner, 2001; Cimoli et al., 2009). However, over the past several years, there has been a growing interest by academic researchers (Hansen, 2006; Youtie et al., 2006; Peltoniemi, 2013) and practitioners (Lehtonen, 2005; CEPI, 2013; McCarthy, 2014) to address innovation in the PPI from a strategic management perspective.

There has also been a growing interest in how institutions, e.g., public research institutes or university-industry research cooperatives, have shaped technological advances in the PPI (Stanturf et al., 2003; Thomas and Vaidya, 2009; Ericsson et al., 2011; Sarkki and Ronka, 2012). Recently, increased attention has been given to new opportunities for innovation and diversification in the PPI, e.g., renewable energy (Schwarzbauer and Stern, 2010; Patari et al., 2011; Hurmekoski and Hetemaki, 2013).

Evolution of the PPI has been shaped by technological innovations and institutions (Cohen, 1984; Norberg-Bohm and Rossi, 1998; Baker, 2004; Lamberg et al., 2012). However, there is little empirical research on the role of firms' technological capabilities and indigenous institutions in shaping the evolution of a particular technological trajectory within the PPI. Recent studies have examined the issue of technological capability in the PPI from a strategic management standpoint (van Dijk and Bell, 2007; Lundmark, 2008; Lamberg and Peltoniemi, 2011; Peltoniemi, 2013; Figueiredo, 2010). However, few empirical studies examine, from a strategic management perspective, the relationships between the evolution of a particular technological trajectory within the PPI, firms' technological capability-building processes, and indigenous institutions, and particularly from a late-industrializing standpoint.

The objective of this article is to explore this research gap in a relevant empirical context. Previous studies suggest that Brazil's PPI provides a

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http://dx.doi.org/10.1016/j.forpol.2015.12.008
1389-9341/

useful empirical setting for examining these issues. Despite being a late-industrializing economy, Brazil has achieved a leading technological and commercial position in the global PPI through short-fiber technology (Scott-Kemmis, 1988; Dalcomuni, 1997; World Resources Institute, 1999; Doughty, 2000; Evans and Turnbull, 2004; Toivanen and Toivanen, 2009; Figueiredo, 2010). Therefore, this article seeks to address two research questions: how has the short-fiber technological trajectory evolved in Brazil's PPI since its inception, and what has been the role of firm-level innovative capability-building and indigenous institutions in shaping the evolution of that trajectory?

To address these research questions, this article adopts a qualitative research approach. Such an approach is suitable to address the research questions as it gives greater attention to nuances, idiosyncrasies, and context (Patton, 2002). This approach is operationalized herein through a case study of the short-fiber technological trajectory in Brazil's PPI, from the 1940s to the early 2010s. The case study methodology was chosen because of the following reasons: First, this methodology generates a wealth of detailed evidence and dense description, which can ground research and provide an in-depth examination and understanding of a phenomenon (Eisenhardt, 1989; Yin, 2009). Second, case studies reveal different explanatory paths, or sequences that lead to the same outcome (George and Bennett, 2005). Third, the case study methodology permits the use of multiple sources of first-hand evidence to unveil difficult-to-observe phenomena, such as the one examined herein, and construct a coherent, credible, and innovative story (Dubois and Gadde, 2002).

By combining this methodological approach with insights from literatures regarding strategic management, innovation, and technological capability building, this article contributes to our knowledge of technological development in the global PPI, particularly from a late industrializing perspective. First, the article deepens our understanding of why certain industries from certain countries, and even a late-industrializing country, can achieve a leading technological and commercial position in the global market by taking a novel technological development direction that differs from those previously pursued by global industry leaders. Second, the article contributes to our understanding of how the relationship between firm- and industry-level innovative capabilities and indigenous institutions helps to shape a technological trajectory. Third, the article adopts a novel approach to examining industry-level technological development based on a broad perspective of technological capabilities beyond standard proxies, e.g., research and development (R&D) expenditures and patent statistics, and a comprehensive view of innovation that involves a continuum, from creative imitation to sophisticated R&D. Therefore, the article provides a basis for further investigations of these issues in other types of industries and national contexts. The remainder of the article is organized as follows: Section 2 provides a conceptual framework, and its evidence is examined in the article. Section 3 outlines the study's methods. Section 4 presents the findings, while Section 5 contains the article's discussions.

2. Conceptual framework

By drawing on innovation literature, technological capabilities, and the role of institutions in technological development, this section provides a framework for addressing the article's research questions and evidence. It does so from the perspective of late-industrializing economies, which is the empirical context of this study.

2.1. Technological trajectories: a late-industrializing perspective

Technological trajectory is defined as an evolutionary direction of technological advances that are observable across industries and sectors (Kim, 2003). A technological trajectory involves the progressive refinement and improvement of supply responses to demands and technical requirements (Dosi and Nelson, 2013). The evolution of technological trajectories tends to be shaped by several incremental innovations during the diffusion process (Verspagen, 2005). It is argued that only one technology emerges from this process: a dominant technology that is considered the most suitable for businesses and institutions (Dosi, 1982). However, alternative technological trajectories may emerge and co-exist with outside existing technologies (Kemp et al., 1998).

Nevertheless, firms and industries from late-industrializing economies, also known as latecomers, are expected to follow the same specific technological trajectory previously mapped by global technology leaders. However, by exploring the fluidity of the innovation frontier, latecomer firms may move into qualitatively novel directions that allow them to open up new technological segments and attain global leadership positions (Lee and Lim, 2001; Figueiredo, 2010; Bell and Figueiredo, 2012).

Just as new entrants and incumbents from advanced economies may challenge existing global leaders by engaging in disruptive innovations (Christensen, 1997), latecomer firms may do so by accumulating globally innovative capabilities and creating new technological trajectories (Bell and Figueiredo, 2012). For example, natural resource-related fields, including pulp and paper, are industries in which latecomers must develop new technological trajectories. As developing countries cannot simply copy technology from advanced economies in the international innovation frontier, they must instead develop their own technology, suitable to that country's soil and climate conditions as well as diseases (Mazzoleni and Nelson, 2007). Therefore, latecomers may pursue significantly newer innovation directions that depart from the trajectories previously mapped by earlier innovators (Lee and Lim, 2001; Bell and Figueiredo, 2012).

2.2. Technological capability-building and innovation

2.2.1. A conceptual perspective

As noted by Rush et al. (2007), although it is widely accepted that innovative activities are essential for organizations' survival and growth, "[I]n the long term, however, it is not specific innovations that matter, but rather the capability to generate a stream of products and processes changes that matters" (p. 221). The term "capabilities" reflects what a firm can actually do (Nelson and Winter, 1982; Jacobides and Winter, 2012). As defined by Dosi et al. (2000), "[T]o be *capable* of something is to have a generally reliable capacity to bring that thing about as a result of intended action" (p. 2). In this article, this "reliable capacity" involves a reservoir of knowledge-related assets, which are embodied in interdependent dimensions, such as human capital, e.g., specialist professionals and skills or talents that are formally and informally allocated within specific organizational units, projects, and teams; technophysical systems, such as databases, machinery, or software; and organizational and managerial systems or firms' internal and external organizational arrangements, routines, and procedures (Bell and Pavitt, 1993; Leornard-Barton, 1995; Kim, 1997; Dutrénit, 2000; Teece, 2007).

This reservoir of knowledge-related assets allows organizations to undertake at least two types of activities: operational and innovative. There is a distinction between operational capability, or the use of existing technologies and production systems, and innovative capability, which refers to a firm's ability to assimilate, adapt, and change existing technologies, and to create new technologies (Bell and Pavitt, 1993, 1995; Bell and Figueiredo, 2012). Although this article is concerned with innovative capabilities, the distinction between these two types of capabilities may be blurred in practice; operational capabilities may even contribute to the accumulation of innovative capabilities (Bell and Figueiredo, 2012).

The ability of firms to implement innovative activities reflects the nature and depth of their technological capabilities (Dosi, 1988; Lall, 1992; Bell and Pavitt, 1993). This argument has been supported by empirical insights, which prove that firms' capabilities permit innovative activities. While these activities are not always R&D-based, they may have differing degrees of novelty and complexity, with positive operational economic impacts (Enos, 1962; Hollander, 1965). Firms'