COMPARATIVE ANALYSIS OF TECHNOLOGICAL CAPABILITY ACCUMULATION ROUTES IN BRAZIL AND INDONESIA: THE CASE OF PULP AND PAPER INDUSTRY

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This paper compares the routes of technological capability accumulation and technology diffusion in the pulp and paper industry in Brazil and Indonesia, and evaluates the evolution of these sectors in international trade of hardwood pulp. The competitiveness of these sectors in Chinese, American and German markets is discussed, based on pulp export data to these countries and on observations made in technical visits carried out to paper mills in China, the United States and Europe in the period 2004-2009, as well as on the testimony of officers and employees of these mills. Through the comparison of routes of technological capability accumulation and technology diffusion in the pulp and paper industry in Brazil and Indonesia, and the assessment of their trends in international trade of hardwood pulp, this study identifies the occurrence of structural change in the pattern of international trade in the global industry and indicates determinants of competitiveness for both Brazil and Indonesia in this industry.

Palavras-chaves: sectoral system of innovation, pulp and paper, technological trajectory, competitiveness, Brazil, Indonesia
1. Introduction

This paper compares the routes of technological capability accumulation and technology diffusion in the pulp and paper industry in Brazil and Indonesia, and evaluates the evolution of these sectors in international trade of hardwood pulp.

According to the Brazilian Association of Pulp and Paper, BRACELPA (2010), in Brazil the taxes paid by companies in this industry exceed $2 billion per year, including city, state and federal taxes. In 2009 the value of exports of the sector was US$ 5 billion with a trade surplus of US$ 3.7 billion, which accounted for 14.4% of the balance of Brazil. Due to its relevance to the economy, the Brazilian pulp industry has been the subject of several previous studies (MONTEBELLO, 2006; ROCHA, 2006; CARVALHO, SILVA, & SOARES, 2009).

Most studies analyze the competitiveness of the Brazilian pulp from endogenous assessments, or by comparison with the historical leaders of this sector in the global market. The foundations for Brazilian competitiveness, as it may emerge from such analyses, are “comparative advantages of location”, according to Dunning’s taxonomy (DUNNING, 1980): low cost of materials, due to the favorable climate for growing trees, with plenty of water, sun and fertile soil; and low cost of labor. Paradoxically, the Brazilian pulp industry was responsible for the development of eucalyptus as raw material for production of hardwood pulp, which has been acknowledged as a disruptive innovation by both the international market (LEHTONEN, 2005) and by the academic community (LINDQVIST, 2005).

Since the “historical leaders” in the international pulp market are in the Northern Hemisphere, the comparative advantages of location favoring Brazil hinder a fair analysis of the potential gains for Brazilian competitiveness on the basis of technological innovation.

More recently, significant investments in the pulp and paper sector have been directed to other Southern Hemisphere countries, specifically for the production of hardwood pulp. The new scenario created by the emergence of these countries in the competitive global market, especially Indonesia, prompts an objective assessment of the Brazilian industry competitiveness in this sector.

Sectoral comparative analysis between Brazil and a country which has the same comparative advantages of location presents an opportunity for learning about other factors that influence the competitiveness of Brazil, in particular regarding the role of technology and innovation capabilities of the Brazilian pulp industry.

By comparing the routes of technological capability accumulation and technology diffusion in the pulp and paper industry in Brazil and Indonesia, and by assessing trends in the performance of these sectors in international trade of hardwood pulp, this paper aims to: (a) identify the occurrence of structural change in the pattern of international trade in the industry, (b) assess the technological trajectory of these sectors and (c) identify determinants of competitiveness.

This paper is organized into five sections that follow this introduction. In the next section, we provide a review of theories and concepts related to innovation as a tool of competitiveness at the aggregate levels. In the third and fourth sections we present the trajectories of the pulp and paper sector in Brazil and Indonesia. The fifth section presents our discussion on the performance of Brazil and Indonesia in international trade of pulp. Finally, we present the conclusions and suggestions for future work.
2. Theoretical framework

Competitiveness is an essential aspect of international trade, and a major concern in an increasingly globalized economy. However, there are different concepts used in the literature on national competitiveness, with no formal consensus on the subject (KRUGMAN, 1996; BUCKLEY et al, 1988).

The celebrated “Porter’s diamond” (PORTER, 1990), a model widely used to study the competitiveness of nations, is based on four country-specific determinants and only two external variables to explain nation competitiveness: randomness and the government. According to Dunning (1993) this model underestimates the importance of globalization and markets. Even entities that bring together different nations and engage in economic studies at the global level have different measures and definitions.

The World Economic Forum (WEF, 2003) defines competitiveness of nations as being “the set of institutions and economic policies supportive of high rates of economic growth in the medium term.” According to the OECD, the Organization for Economic Cooperation and Development, the competitiveness of a country is “the degree to which a country can, under free and fair market conditions, produce goods and services which meet the test of international markets, while simultaneously maintaining and expanding the real income of its people over the longer term” (OECD, 1996).

The definitions of these two organizations reveal a closer look at market demand: an approach to nation competitiveness resulting ultimately from the aggregate of their production systems. This aggregate can be decomposed into sectoral systems, whose analysis serves as basis for developing policies to encourage innovation (van HEMERT & NIJKAMP, 2010; OECD, 1999).

A sectoral system, as defined by Malerba (2002), is a set of products and agents who interact for the creation, production and sale of such products, with specific knowledge base, technologies, inputs and demand. Evolutionary economists especially emphasize the sector-specific nature of innovation and highlight the co-evolution of national and sectoral systems of innovation as a critical factor for international competitiveness (DOSI et al, 1995; NELSON & WINTER, 1977; NELSON, 1999).

In this paper we use the concept of technological regime proposed by Malerba & Orsenigo (1997). The authors found sector-specific patterns on innovative activities across countries, with common features to groups of industries and somewhat invariant in respect to the institutional environment. However, they indicate that country differences may emerge “as a result of the working of either specific institutional factors related to a national system of innovation or the presence of a firm or an industry with a peculiar history”. We will investigate if the evolution of Brazilian and Indonesian pulp and paper industries is in line with these findings, while assessing their performance in the international trade of pulp.

3. The evolution of the Brazilian pulp industry: from the formation of a learning network to the second generation of the innovation system

Until World War II, all the raw material used in Brazil for papermaking was imported from traditional suppliers of pulp, such as the United States, Canada and Sweden. In light of the disruptions of war on international trade, Brazil has established self-sufficiency policies, including incentives for the development and production of woodpulp in the country (TOIVANEN, 2004).

The tree species traditionally used in pulpmaking were typical from the Northern Hemisphere. Therefore, domestic production of woodpulp called for the identification of a species with the
right silvicultural characteristics – namely, the ability to develop and grow in Brazilian soil and climate – and also the proper features to meet the requirements for papermaking. The need for development shaped the government import-substitution policies, which included tax incentives for companies that would carry research on new fiber sources and the establishment of sectoral research institutes. Government incentives also comprised a decree, in 1940, to grant low interest financing for the installation of new plants; a new reforestation policy (ABTCP, 2004); and the establishment of large government sponsored forestry plantations in Minas Gerais. (BACHA, 2003).

The eucalyptus, a hardwood species native of Australia, had been introduced in Brazil in 1864 to serve the rail industry. In the early twentieth century, improvements and adaptation led to 12 eucalyptus species particularly appropriate for Brazil, as well as to planting areas. Experiments were carried out with eucalyptus to obtain pulp for paper in the 1920s, but attracted no interest, given the preference for imported pulp made from softwood (long fiber species, such as pine). With the raw material import-substitution policies in place, R&D on eucalyptus pulp intensified, leading to the first paper made exclusively of eucalyptus in 1953 (BACHA, 2003).

The sectoral system grew stronger through the following years: in 1960 the first school of forestry science was created at the Federal University of Viçosa, Minas Gerais, giving rise to high level education in the field; in 1968, IPEF – Instituto de Pesquisas e Estudos Florestais, Institute for Forestry Research and Studies – was created, to date a cornerstone for the integration of universities, research centers, private companies and government (IPEF, 2004). The role of the National Bank for Economic and Social Development, Banco Nacional de Desenvolvimento Econômico e Social (BNDES) was also essential for the consolidation of a sectoral system of innovation: since 1968 the Bank promoted the specification of technical standards and established minimum requirements for financing the sector.

From the 1980s, new entrants took advantage of the institutional environment created to multiply pulp capacity in Brazil. Aracruz, in particular, defined the role of environmental and social responsibility to the viability of forest-based industry in Brazil (TOIVANEN & LIMA-TOIVANEN, 2009), and was internationally acknowledged for pioneering the development of clonal plantations of eucalyptus, when its researchers received the Marcus Wallenberg prize, awarded annually by the Swedish company Stora in recognition of achievements in forest science and technology (IPEF, 1984). Sustainable forest management of eucalyptus, which soon became a standard in the forestry activities of all the Brazilian pulp producers, anticipated a trend that only decades later would take place in the rest of the world with the certification of sustainable forests (MANHÃES, VIANNA & GONÇALVES, 2006). The sector’s commitment to environmental issues can also be found in the innovations incorporated into industrial processes. According to CORAZZA (1996), the environmental issue was incorporated into the strategies of the agents of the pulp and paper sector in different aspects: both reducing costs in the use of resources like water and energy, and as an element of building other competitive advantages. The most striking example of the use of capabilities to gain competitive advantage was the speed of adaptation of the bleaching processes, with the replacement of elemental chlorine by other bleaching agents (ECF and TCF bleaching processes). This innovation was adopted and spread rapidly throughout the Brazilian sector, contrary to what was observed in Canada and the United States.

One of the latest advances in the innovation process in this sector concerns research on sequencing the genome of eucalyptus. The “Genolyptus Project” illustrates the coordinated nature of the sectoral innovation system in Brazil, bringing together leading companies,
associations, universities and research institutes related to the forestry sector (GRATTAPAGLIA, 2004).

Toivanen & Lima-Toivanen (2009) classify the current stage of the Brazilian pulp industry as the “second generation of the innovation system” and recognize the development cycle which begun in the second half of last century as a classic process of Schumpeterian innovation. In light of this history, scholars use the Brazilian pulp industry as a paradigm of dynamic innovation system, a sector that endorse capability creation and accumulation (FIGUEIREDO, 2008 and 2009; KATZ, 2000, TOIVANEN & LIMA-TOIVANEN, 2009), in contrast to the classic simplified model suggested by Krugman (1979), which basically argues that the industries of the North have to keep a high rate of innovation, and will eventually decline in the face of low-wage competition from the South.

4. The pulp industry in Indonesia: among giants in just 15 years

Historically, pulp and paper industry in Indonesia began during the Dutch colonial era. The first factories were built in 1923, using rice straw as raw material. With independence from Netherlands in 1945, the Indonesian government built several paper mills, and pulp industry developed slowly until the mid-1970s. By this time, import substitution policies took place, and protectionist rates encouraged the establishment of domestic production, causing a jump in capacity from about 60,000 to about 600,000 tonnes per year (van Dijk & BELL, 2007; Hidayat, 2007).

Government played a significant role for the pulp and paper industry, especially during Suharto dictatorship, from 1967 until 1998. According to Hidayat (2007), the main commitment of the Suharto regime was with political stability. That included the political use of all natural resources, controlled by the government, to the benefit of some groups in the course of stimulating the economy. Granting access to native forests for commercial exploitation was part of the government incentives to the establishment of the pulp and paper industry, along with access to financing and the concession of licenses. In the mid-1980s the industrialization policy was more intense, with heavy investments on technology by new entrants to the pulp and paper industry resulting in another jump in the sector capacity. This capacity elevated Indonesia to a position among the major players in the international market by the 1990s (van DIJK & SZIRMAI, 2006).

By the end of the twentieth century, the raw material used by the mills was at large supplied by exploitation of native tropical forests, often obtained by illegal logging (BARR apud van DIJK & BELL, 2007). According to Sonnenfeld (1998), some exploited areas were gradually replanted, preferably with acacia, a native hardwood species.

On one hand, the use of a single species (such as planted acacia) favors machine runnability and product quality, thus supporting pulp acceptance by international papermakers; on the other hand, the use of native forest keeps wood costs at a minimum. Although the leading pulp companies in Indonesia state their commitment to the development of sustainable forest management, according to Hidayat (2007), the use of native forests in conjunction with the planted timber was a common practice in the 2000s, and Pirard & Irland indicated that up to 65% of the wood used by two units of a leading Indonesian pulp company was supplied by clearcutting natural forests up to the end of 2005.

In stark contrast to the predatory forestry practices, the technologies adopted in the pulpmaking process are in line with the best practices in regard to low environmental impact. Sonnenfeld (1998) highlights that the adoption of these technologies, including ECF bleaching, is by no means a matter of principle or strategy of the pulp and paper executives, but rather due to the articulation of the minister of Indonesia’s Environmental Impact
Management Agency, who attracted investments to the sector in the 1990s, while under society pressure motivated by a major environmental accident at a pulp mill site. Regarding the industrial technology, van Dijk and Bell (2007) show that the largest pulp companies reached high levels of operational efficiency, but heavily dependent on expatriates, rather than local capabilities. Moreover, the levels of excellence are observed only in a few groups, with no coordination of sector activities. According to the authors, these characteristics, combined with the lack of infrastructure for education and R&D, limit and fragment the assimilation of technology in the Indonesian pulp and paper industry.

5. Economic performance of the pulp sectors from Brazil and Indonesia

In order to understand the performance of specific pulp sectors, one should understand the behavior of this industry as a whole. The following figures illustrate the evolution of the main players in the pulp market.

Figure 1 presents the historical production capacity of chemical pulp by country since 1961. “Chemical pulp” comprehends all pulp produced by means of a chemical process, either sulfite or kraft (sulfate). Over the years, the kraft process prevailed, thus, to more recent historical analysis, the data presented refer only to bleached kraft pulp (BKP).

![Chemical pulp production by country](image1.png)

**Figure 1 - Historical evolution of production capacity of chemical pulp by country. Source: FAO, 2010**

Figure 2 illustrates the main markets for bleached kraft pulp, indicating a significant concentration of its importers. It is noted also that the importance of Asia as import market has been growing since the 1980s, and China is currently the main market for kraft pulp.
Among the major pulp producers, there are countries that also have a high domestic demand. This is the case for the United States, which leads the world production, but ranked third in pulp exports (Figura 3).

In Figures 2 and 3 we observed a change in the pattern of international trade, with increasing participation of Brazil, Chile and Indonesia among the exporting countries and larger partaking from Asia, particularly China and Korea, among the main markets. This evolution is consistent with the structural change in trade flow of fiber - woodpulp and waste paper - indicated by the Conference on Trade and Development United Nations (UNCTAD, 2009).
Following Wignajara and Ikiara, the analysis of economic performance is based on increasing exports (JONKER et al, 2006). For the analysis, we selected the top three importers of wood pulp: China, U.S. and Germany. It may seem odd that the US is a major exporter and also a major importer of pulp, but that is due to technical differences in pulps. This interesting discussion, however, will be explored elsewhere due to space limitations.

Figures 5, 6 and 7 present the evolution of pulp exports from Indonesia and Brazil, compared to exports from all other countries, showing, respectively, imports made by China, U.S. and Germany. Prices were calculated by dividing the total exports value in U.S. dollars by the total exports quantity in tonnes of pulp. Both sets of data, value and quantity, are from FAO (2010).

It is important to note that unit price estimation by this method is subject to deviation, depending on actual month-to-month variation in price and quantity. If the imports quantity is evenly distributed along the year, the average price estimate is expected to be consistent with real unit price values. That is the situation observed for the Chinese market, for both Brazilian and Indonesian pulp. As a result, price trends are similar to both products, as expected for commodities (Figure 5). Year 2007 is an exception. Along that year, pulp prices have risen considerably, peaking in December; Indonesian imports also peaked in December, while Brazilian imports fell short that month (HAWKINS WRIGHT, 2010) which caused the distortion observed for the year.

As for the US and Germany (Figures 6 and 7), Indonesian wood pulp imports have been insignificant and erratic, eventually taking place in a single month for the whole year or not taking place at all, as observed for several years in the American market. Thus, deviation in price estimates for Indonesian pulp is significant.

The following discussion about the competitiveness of the sectors studied in each market is based on observations made in technical visits to paper mills in China, the United States and Europe, carried out in the period 2004-2009, as well as on the testimony of officers and employees of these mills.
Figure 5 - Evolution of pulp imports to China from Indonesia, Brazil and other countries. Source: FAO, 2010

Despite being the birthplace of paper, until the end of last century China had a structure of old mills, labor-intensive, that used virtually any type of fiber as raw material, resulting in low operating efficiency and seriously compromising the quality of the final product. At the turn of the century, large investments were made in the paper industry, and mills from “old China” and “new China” began to coexist. The paper and paperboard mills from “new China” are technology intensive, with state of the art machines and top level laboratories and systems for quality and process control. The purchase of raw materials at these mills became selective not only in price but also in quality. Although environmental criteria are not yet part of the procurement process for raw material, according to chief executives of some modern plants, “it is a trend in the context of a series of measures for environmental improvements planned by President Hu Jintao”.

Since 2003, the Brazilian share in the Chinese pulp market has become more important, disturbing a steady increase in Indonesia exports to this market, as can be seen in Figure 5.
In the United States and Germany, the presence of the Indonesian pulp is negligible (Figures 6 and 7). In the case of the United States, the logistical complexity is a major factor. With a big supply of domestic and Canadian pulp that can benefit from the proximity, the usual sales terms for woodpulp in the U.S. include delivery to the paper mill. Since most American paper mills are not close to seaports, this implies that overseas pulp suppliers must afford not only to the shipping, but to managing warehouses and ground transportation. To cope with these logistics requirements, supply contracts usually include the provision of large volumes in long-term horizon. Some paper manufacturers attributes to Indonesia a “high institutional instability”, which impairs long-term agreements. Moreover, the environmental component - although not as critical as in Europe - imposes constraints on the use of pulp from Indonesia.

For Germany, the environmental component is the major limiting factor. A good illustration of this is the question about the use of chlorine in pulp bleaching process, the subject of a heated debate in the 1990s. Much discussion went on about the environmental effects of processes ECF (Elemental Chlorine-Free), ie pulp bleached with chlorine dioxide (ClO₂) but free of elemental chlorine (Cl₂), and the processes TCF (Totally Chlorine-Free), based on peroxide, oxygen or ozone. Eventually there was a convergence towards the efficiency of the ECF process (Folk, Renberg, & McCubbin, 1996). In Germany, however, the preference for the more “extreme” environmental approach, TCF, still prevails. For this reason, the main pulp suppliers to Germany are Sweden and Finland, which maintain the production of TCF pulp largely to serve this market, strategic for the proximity and high demand. And even these suppliers have to face increased competition from recycled fiber. All environment issues taken in consideration, the really restrictive factor in the case of Indonesia is the sustainability of forests. Despite efforts made by major Indonesian pulp exporters to demonstrate commitment to sustainable practices, years of tropical forests exploitation left a strong image to repair. To this fact adds the perception of Indonesia as a country with weak institutions, high levels of corruption and government collusion with illegal or unsustainable exploitation of timber.
6. Final remarks and suggestion for future work

The results presented indicate a structural change in the pattern of international trade of pulp, both in demand and in supply. On the demand side, the shift in Chinese imports reflects the trend observed also for other commodities (such as steel, for instance). On the supply side, there was a shift from the historical axis to the Southern Hemisphere, reflecting a trend started in earlier decades by Brazil and Chile, and more recently by Indonesia. While this observation is consistent with the simplified model of Krugman (1979), which argues that the industries of the North have to keep constantly innovative as they will eventually migrate to the South seeking cheaper labor, the technological trajectory of the sector in Brazil does not support this argument.

In both countries the government was instrumental in establishing the pulp and paper industry. The mechanisms of incentive used, however, affected differently the technological trajectory of these sectors. While in Indonesia the entrepreneurs were granted access to factors of production, the native forest included, in Brazil there was a stimulus to the development of forestry technology in order to gain access to sustainable wood supply. The role of private groups also influenced differently the sectors of each country. Companies in both countries have as strategy “to continuously pursue low production costs”, but in Brazil the unfolding of this strategy comprehends: development of forestry technology, by means of silvicultural techniques, genetic improvement and sustainable forest management; and use of industrial technology in the state of the art for pulp production with minimal environmental impact, acquired and adapted. In Indonesia, the main groups also use technology in state of the art for the industrial process, but have not yet accumulated capabilities to innovate or adapt technologies, and forestry technology is not in place.

We can conclude that in the case of the Brazilian pulp and paper industry, a sectoral system of innovation was established, that affected its technological regime. This led to the creation of competitive advantages for Brazil in the traditional markets, as compared to the Indonesian counterpart. Further investigation is suggested on how the Brazilian sector compares to other emerging players, such as Chile.

Although not a specific object of study, it was observed that the strategy for business expansion also differs between Brazilian and Indonesian pulp companies, and may be related to the technological route. The leading pulp producers in Indonesia, APRIL and APP, internationalized their activities with production units out of Indonesia - especially in China, currently the largest consumer market for pulp. As these companies have not developed their own forestry technologies (which are usually specific to a given region), we can infer that the operation in other regions with the same locational comparative advantages will yield at least similar (and profitable) results among the production units.

In Brazil, the main pulp producers expand their operations with new mills within the country, despite the fact that a pulp mill in China might offer significant logistical advantages. We can infer that the technological advantages gained in the forestry outweigh such logistics opportunities. It is worth noting that Brazil has a much bigger area than Indonesia, and one could easily get to the conclusion that Brazil does not internationalize its operations for having enough available area for planting. However, one should take into account that the Brazilian industry as a whole is also more diversified than the Indonesian industry, and eucalyptus trees compete for space with agribusiness and biofuels. The deepening of this issue is beyond the scope of this work, but it certainly stands as a major issue for future research.

Finally, evaluating market barriers, we observe that currently the main material disadvantage of the Indonesian pulp in comparison to Brazilian pulp in the international market is related to
the unsustainability of the wood supply, and the image of depleting native forests. Around 30 years ago, that was the international market perception about Brazilian pulp, whose industry was accused of destroying the Amazon forest - although 95% of Brazilian pulp production take place in Bahia and in the South and Southeast states.

In an article on radical innovations on pulp, Lehtonen (2005) included a provocative subtitle: “Why pulp producers cannot rest on their laurels”. The author then describes, from the viewpoint of a Nordic paper manufacturer, how the eucalyptus pulp was elevated from a “low cost/low quality” perception to an acknowledged position of “high value/high quality”, bypassing the traditional birch pulp in less than fifteen years.

The history of the Brazilian pulp industry has so far proven that it is a legitimate sectoral system of innovation. The recent history of this sector in Indonesia indicates that the solidness of the Brazilian system and its role in the country’s competitiveness in the international arena is about to be tested over the coming decades.

References


