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Adoption and Diffusion of Green Innovation in Brazil

Eco-Packaging for Consumer Goods and Tracking of Cattle in the Amazon

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Abstract[*]

How do innovative green technologies emerge and diffuse throughout an economy, and how can public policy affect this process? This paper draws from two case studies to reverse engineer how certain firms adopted green technologies in Brazil: (i) eco-packaging to reduce net waste in the consumer goods industry and (ii) the monitoring and tracking of cattle to reduce deforestation in the Amazon. These green products were, as is often the case, more expensive to produce, and consumers were often reluctant to pay more for them just because they were greener—indeed, consumers could even find them to be less attractive than conventional alternatives. Why did the innovations nevertheless emerge? Adoption hinged on the existence of an "innovation space," a combination of factors that allowed firms to ignore market pressures. In some cases, these firms saw an advantage in investing in green products to build brand equity. In other cases, government policies in the form of price controls, subsidies, public investment, and product regulations reduced competitive pressures.

JEL Codes: M19, O25, O33, Q55
Keywords: environment, innovation, eco-packaging, deforestation, Brazil

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INTRODUCTION

How do innovative green technologies emerge and diffuse throughout an economy, and how can public policy affect this process? In contrast to many existing studies that draw from large datasets to estimate the effect of a treatment, such as public regulation or environmental management systems, on a firm's subsequent adoption of green technologies, this paper draws from two case studies to investigate how certain firms adopted green innovation (GI) technologies in Brazil.[1] In particular, this paper examines the adoption of (i) eco-packaging to reduce net waste in the consumer goods industry and (ii) the monitoring and tracking of cattle to reduce deforestation in the Amazon. This research produced several findings. First, it confirmed that green products are often more expensive to produce, at least at first, and that consumers are often reluctant to pay more for a product just because it is green. Making adoption even more difficult, consumers sometimes perceive green products as being less attractive than conventional alternatives. Operating under these circumstances, even large and successful companies that are leaders in their field can find it difficult to adopt green technologies, especially when competitors are plentiful and profit margins are tight.

And yet, the firms we chose to study have adopted green technologies, so adoption was possible after all. An important finding is that, in these cases, adoption hinged on the existence of an "innovation space": a partial or temporary sheltering from cutthroat price competition that allowed for experimentation, learning, coordination, and gradual achievement of scale at important nodes of the supply chain. These spaces can be created by a firm's branding and the brand equity it generates, as well as price controls, subsidies, voluntary standards, public investment, and product regulations. Naturally, well-crafted public policies can contribute to this effort, so governing authorities play an important role in fostering the adoption of GIs.

THEORETICAL FRAMEWORK

GIs are technological, managerial, organizational, or marketing innovations that reduce the environmental impact of production, consumption, and disposal activities (Triebswetter and Wackerbauer, 2008). In some cases, the reduction is the central goal of the innovation. In other cases, the reduction in the environmental impact is a side effect. As the definition implies, GIs do not have to be based on recent scientific or engineering breakthroughs. Rather, a technological, managerial, organizational, or marketing innovation can be termed a GI when (a) it differs from those currently adopted by a firm or industry and (b) "economize[s] on exhaustible resources and emit[s] fewer greenhouse gases" (Rodrik, 2014: 469). This definition is compatible with the OECD's (2009), which highlights the positive-sum outcomes that GI can bring to both the economy and the environment (see also Kemp, 2010). GIs are sometimes called eco-innovation or environmental innovation. This report uses these terms interchangeably.

This focus on GI is associated with a broadened perspective on environmental policies. Historically, environmental policies emphasized the treatment of pollution and waste, and thus on end-of-pipe solutions rather than on production and disposal processes (Parliamentary Office of Science and Technology [UK], 2004). While end-of-pipe solutions have helped reduce the negative environmental impact of economic activities, they have had a relatively limited effect on business innovation, as they segregate environmental concerns from other business activities

[1] The former approach is sometimes summarized as "effect of causes" (EoC) versus the latter's "cause of effects" (CoE). For a recent discussion, see Dawid, Faigman, and Fienberg (2014). For a superb review of existing research on the variables that affect business strategy towards green technology, as well as some associated methodological concerns, see Mazzanti et al. (2016).

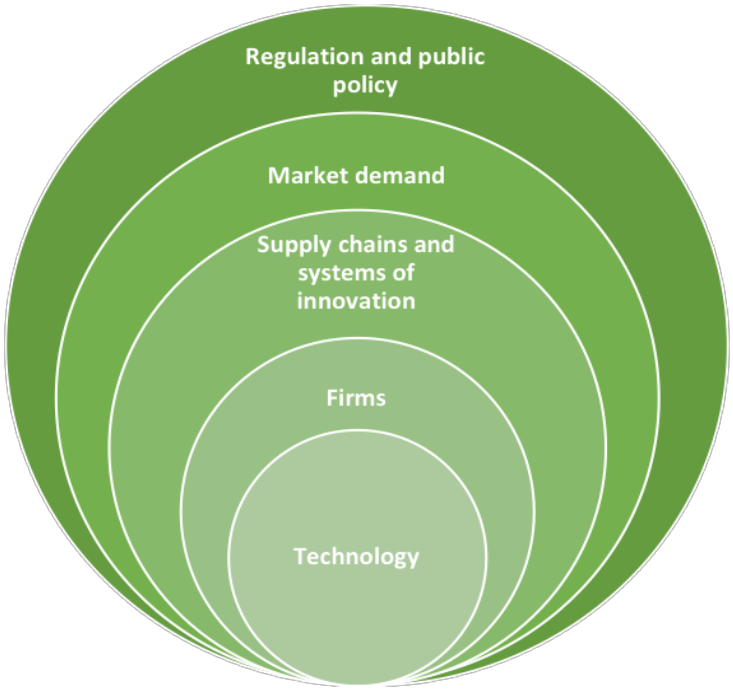
(OECD, 2009). In recent years, however, firms and governments have been shifting away from end-of-pipe interventions and towards integrated environmental strategies and management systems, including closed-loop and circular production systems. This more comprehensive approach tends to erase the boundary between business innovation and environmental protection, which leads to growing attention to GIs.

But what variables affect the adoption and diffusion of GIs across firms and industries? Prevailing answers draw from two main bodies of research, namely research on business innovation and research on the adoption and dissemination of environmental practices. The former examines why some firms or industries invent and adopt new technologies, why some firms refuse to adopt a seemingly better technology long after it has been made available, and why, under some circumstances, firms that have held on to a given technology finally replace it. One important taxonomy in this literature concerns the scope and scale of the innovation. Some innovations are deemed minor or incremental, while others are considered major or even radical. Another related variable concerns the "path," or the sequencing of innovations over time, which leads scholars to discuss concepts such as "path dependency" (Arthur, 1989) and "path creation" (Garud and Karnøe, 2003).

In turn, research on the adoption and dissemination of environmental practices examines those technologies or managerial practices that reduce the negative environmental impact of a product over its life cycle, from sourcing of raw materials, to production, and then disposal. Examples of green technologies include solar panels, wind turbines, and ethanol-powered vehicles, as they can be greener than fossil fuels. This literature highlights that environmental preservation can be conceived as a collective good and thus it is vulnerable to free rider problems, which may decrease the incentives for firms to address such problems and may require government intervention (Kemp, 1997; Rennings, 2000; Rodrik, 2014; Jaffe, Newell, and Stavins, 2002).

Together, the literature on business innovation and GI identify several independent variables that affect innovative activity, including the features of the new technology, internal behavioral and organizational factors of the firm, the presence or absence of complementary inputs in the larger innovation system, other market conditions related to demand and competition, and regulatory mandates. For clarity of exposition, we organize these independent variables as concentric circles of scope, as illustrated in Figure 1. This chart is not meant to suggest a causal model and it does not capture all the different ways that one variable may interact with the others. Rather, it provides a heuristic device to structure the argument. We start by analyzing the intrinsic characteristic of the technology (the innermost circle), then we consider how these interact with internal factors to the firm. We then move on to the immediate environment outside the firm (the supply chain and the system of innovation under which the firms operate), considering also the demands stemming from the market. Finally, we contextualize the analysis by including the broad governing environment that surrounds the firms, including regulatory pressures (outermost circle). As examined by Mazzanti and Zoboli (2006), different policy packages can induce firms in a supply chain to react in different ways and lead them to pursue different techno-organizational outcomes.

Figure 1. Multi-Level Approach to GI



Rogers (1962) provides a starting point for this discussion when he suggests that speed of adoption or diffusion hinges on four **features intrinsic to the technology**: (a) triability, i.e., can the innovation be easily tried?; (b) observability, i.e., can results be observed?; (c) its relative advantage over incumbent technology or other innovations; and (d) its complexity, i.e., how complex is it to learn or use? He also identifies a fifth variable that takes into account both the features of the technology and its broader context, i.e., its compatibility—how does the new technology fit the circumstances into which it will be adopted?

This framework is geared towards explaining why firms seem to prefer incremental change and the continuation of existing innovation paths or trajectories as opposed to more radical innovation. The leading explanation is that many firms have made considerable investments in existing technologies, skills, and people, which create a lock-in effect (Arthur, 1989; Unruh, 2000; Walker, 2000). Similarly, managers often see radical innovations as too risky or disruptive of existing skills and practices (Tushman and Anderson, 1986). As an additional point, this means that shifting industries towards radical innovations might require pressures from consumers, policymakers, civil society, and social movements. The accumulation of such pressures may propel firms to overcome lock-in mechanisms and reorient their efforts towards more radical innovations.

The **intrinsic characteristics of a technology** clearly interact with **internal factors to the firm** in ways that affect the adoption of GI. For example, the availability of in-house knowledge and technical expertise (Ndichu et al., 2015), or a green ethos of environmental responsibility, alongside the necessary skills and capabilities, can all work in favor of improving the environmental performance of the company (Arundel and Kemp, 2009). This literature suggests that human resource practices such as support from senior management, environmental training, environmental teamwork (green teams), and performance evaluation and rewards based on environmental criteria can favor eco-innovation (Jabbour et al., 2015). Environmental

management systems (EMS) such as ISO 14001 can also act as an internal driver by providing an ongoing framework for eco-innovation (Demirel and Kesidou, 2011). Research findings on this theme, however, are equivocal. While one study finds that firms that adopt EMS are more likely to innovate (Rehfeld, Rennings, and Ziegler, 2007), another study (with one overlapping co-author) finds that environmental innovation is not associated with the adoption of EMS (Frondel, Horbach, and Rennings, 2008). Reconciliation might be possible, as another study finds that EMS are associated with process innovations, not product innovations (Wagner, 2008).

Internal competencies may also influence the search patterns and a firm's ability to establish links to external networks and resources to gain the necessary **information and knowledge** on green technologies. The firm's competencies can determine its capability to activate external resources or constrain the establishment of interactive learning relationships with actors who provide information on environmental technologies (Hansen, Sondergaerd, and Meredith, 2002).

Firms may also choose to invest in GIs because they can lead to more **efficient means of production**, creating significant cost savings that can motivate additional investments in GIs ("complementarity effect"). Efficiency in production can be generated by cost savings arising from investments in environmental improvements, which sometimes can also result in equipment upgrades undertaken with the purpose of environmental protection (Demirel and Kesidou, 2011). Cost savings can be a driver for the reduction in energy and material use (Horbach, Rammer, and Rennings, 2012). Reinforcing this point further, Constantini and Mazzanti (2012) find that environmental innovation efforts are compatible with export performance for manufacturing firms. While appealing, the idea that environmental innovation can complement other technological or organizational innovations has faced some challenges. Gilli, Mancinelli, and Mazzanti (2014), for example, find that "complementarity is *not* a low-hanging fruit" (emphasis added). Similarly, Antonioli, Mancinelli, and Mazzanti (2013) find that complementarity is more easily found in the abatement of CO_2 among the more polluting and regulated industries but it is relatively scarce elsewhere.

Internal factors to the firm cannot always explain the development or adoption of a green technology. Some authors highlight the role of **external factors** that may affect the dissemination of GIs. These factors include demand from users (market opportunities), regulations, pollution taxes, subsidies for the adoption of environmentally preferable products or processes, and community pressure (Arundel and Kemp, 2009).

Indeed, **market demand** (or lack thereof) can induce (or hinder) the adoption of environmentally superior processes, goods, and services. Market demand can be encouraged through a well-crafted marketing strategy by manufacturers or service organizations. Direct contact with customers and co-creation can also help suppliers gain ideas for product improvement and find new channels for sales and advertising (Arundel and Kemp, 2009).

Researchers have also noticed that firms may adopt GIs to improve their **corporate image** among customers, employees, and other important constituencies. Corporate Social Responsibility (CSR), which is an element of corporate image, embraces environmental issues as one of its three pillars, the other two being employment/labor practices and human/social rights. However, the effectiveness of environmental actions motivated by CSR has been questioned due to the "voluntary" basis for compliance under CSR (Demirel and Kesidou, 2011).

The idea that the broader environment in which firms operate can affect the creation and adoption of technological, managerial, organizational, or marketing innovations came to be known as the "**systems of innovation**" approach (Lundvall, 1992; Nelson, 1993). It is now a dominant

perspective, and it argues that innovative activity cannot be understood in terms of a firm's decision making alone. Rather, innovative activities depend on the complex interaction between a firm and others in its "system," such as research institutes, suppliers, and users (Smith, 2000).

This shift in perspective brings into play the local and global aspects of value chains and innovation. **Value chains** include input suppliers; producers; processors; buyers; and providers of technical, business, and financial services, as well as the consumer markets into which a product or service is sold, whether local, national, regional, or global. By bringing the value chains framework into the analysis, these theories consider the indigenous and foreign sources of knowledge and technology; the ways in which national policies concerning education, R&D, trade, and investment act as barriers or facilitators; and the need for financial assistance, technology transfer, and technical cooperation to foster innovation. Firms that are more innovative on the environmental front are also more likely to cooperate with external partners (de Marchi, 2012). Indeed, cooperation with suppliers and universities can be the most important driver of environmental innovation (Cainelli, Mazzanti, and Montresor, 2012), and supply chains can act as conduits for the dissemination of green technologies across sectors and countries (Constantini et al., 2017).

An appreciation for the importance of value chains goes hand in hand with an appreciation for other complementary inputs that might bring a green technology within a firm's reach. In some cases, the presence or introduction of relevant **factors of production**, such as credit to acquire the equipment, access to skilled workers to operate it, and managerial expertise to oversee the process, might facilitate adoption of GI.

Finally, GI adoption is likely to depend also on the existence or absence of outside pressure and support on the part of regulators (Horbach, 2008). As analyzed by Kemp and Pontoglio (2011), **regulation** has a better track record in spurring radical innovation than market pressures on their own. However, regulation can also have undesired effects that limit innovation. In some cases, the preference of the regulator for quick results might lead firms to adopt incremental solutions rather than environmentally superior solutions (Nill and Tiessen, 2005; Mazzanti and Zoboli, 2006; Yarime, 2003). In some instances, regulation can act as a barrier to innovation. For instance, regulations may prevent further investments to develop greater control efficiency technology once emissions limits are met. These studies point to the possible conflict between short-term goals of policy and the long-term change needed for sustainability.

Public initiative can come in many guises and produce multiple effects. Arundel and Kemp (2009) provide a list of possible policy tools that can support (or hinder) investment in GI. First, they highlight the importance of **regulations** that create product standards such as housing insulation and energy efficiency standards, vehicle emission standards, recycling requirements, and also rating systems for consumer appliances. A lack of these types of regulations and standards or a lack of enforcement can hinder eco-innovation. Second, they mention **voluntary standards**, which can be part of government initiatives, such as vehicle emission standards, or voluntary industry standards, such as the GSM standards for mobile telephony. Voluntary standards can create large markets that support eco-innovation through scale effects. A lack of standards, as for batteries for electric bicycles, can fracture markets and increase both production and consumer costs, as well as reducing consumer flexibility. Lastly, they mention **financial incentives including for R&D**, both direct and indirect, that can encourage firms to invest in eco-innovation research or infrastructure and encourage firms, government agencies, and households to purchase eco-innovations. Common incentives include grants and subsidies for R&D, investment in eco-innovation infrastructure or power generation, and subsidies for the purchase of eco-innovation products such as electric vehicles.

To sum up, existing research recognizes that there is not a simple unified framework that can predict GI adoption. Indeed, researchers have pointed out that different GIs are likely stimulated by different drivers of adoption (Jaenicke et al., 2000; OECD, 2009). Kemp (1997) argues that there is no single best policy instrument to stimulate clean technology and different instruments may play important roles depending on the context they operate in and the type of clean technology that needs to be stimulated. For example, a combination of policy regulation, market opportunities, and environmental awareness by managers is more likely to influence a firm to invest in an eco-innovation than each of these drivers on its own (Arundel and Kemp, 2009). Likewise, a cluster of barriers, rather than a single barrier, is more likely to influence a firm to defer innovation. Indeed, Jaenicke et al. (2000) find that a combination of instruments performs best in stimulating eco-innovations.

Our Approach

Our research builds on two working hypotheses. First, building on existing frameworks pertaining to the adoption of new technologies (Rogers, 1962; Rennings, 2000; Demirel and Kesidou, 2011; Mazzanti et al., 2016) and our own work (Locke and Romis, 2010; Coslovsky, 2014), we hypothesize that many attributes that seem to be "intrinsic" to a technology actually arise from the interaction of the technology with the business environment in which firms operate. As Gunningham, Kagan, and Thornton (2003) illustrate, company responses can also depend on how the firm interprets its own business environment. That is, some technologies might seem to be clearly profitable on their own, as managers expect them to increase productivity, lower costs, and/or boost revenues. In other cases, the intrinsic characteristics of the technology may make profitability less evident. For example, some GIs may require high upfront investment that would take several years to be recouped. Other technologies, still, will have effects that are more contested, ambiguous, or uncertain, and the effect will in fact depend on the conditions under which the technology is implemented, including the presence (or absence) of other complements or substitutes, such as skilled labor, financing, product demand, intermediate goods, and managerial talent. Thus, if conditions of the business ecosystem or managers' interpretation of the business case change, the relative advantage of one technology over the other also changes.

Second, we hypothesize that political factors, including the existence (or absence) of incentives and opportunities for adequate negotiation of conflicts, might also affect GI adoption. That is, we propose to set aside the rendition of the firm as a cohesive entity to portray it as the product of ongoing negotiations among multiple groups, including people in different hierarchical levels and thematic divisions or possessing different professional training, located both within and outside the enterprise. The existence of processes or "spaces" where they can align their goals facilitates GI. Along similar lines, competitors in an industry and buyers and sellers in a supply chain might also benefit from opportunities to identify areas of common interest, but this can only be done under unusual circumstances.

Our research takes the factors identified in the literature, alongside the two hypotheses outlined above, as its point of departure. Through the analysis of two distinct cases of adoption of GI in Brazil, we hope to contribute to the current debate and identify policies that can foster adoption and diffusion.

RESEARCH DESIGN

The objective of the study is to understand the main forces that promoted, delayed, or even prevented the adoption and diffusion of GI technologies in Brazil, and to identify the role that public policy can play in this process. This type of question is best answered through case studies that draw on open-ended interviews and fieldwork. Case-study logic is particularly effective when asking "how" or "why" questions about processes unknown before the start of the study (Small, 2009). Fieldwork is ideally suited to tracing processes and uncovering mechanisms that were previously unknown to exist (Lamont and White, 2005).

In our case selection, we chose eco-packaging in personal and home care products and the tracking of cattle in the Amazon because both have a relatively long history and the actual technologies have a well-established track record. This means that the central obstacles pertaining to adoption are unlikely to be related to basic science or the viability of the technology per se. Further, the two selected cases are likely to complement each other nicely. For one, they refer to different industries in the same country, so country-level variables such as political, economic, social, or even cultural differences remain constant. Second, they both refer to the production of consumer goods by large corporations (home and personal care products by companies such as Natura and beef by meatpacking conglomerates such as JBS) and entail adjustments throughout their respective supply chains, so we can compare the challenges and strategies deployed in one case to the other. The differences across the cases can be illustrative too. That is, one case covers the decentralized production of cattle in vast rural areas and their subsequent distribution through a multitude of retail channels. The other case covers the centralized production of home and personal care products by a vertically integrated corporation. This variation in industrial structure is likely to strengthen our analysis.

For interviewee selection, we followed a sequential or case-study logic, in which each interview yielded a set of findings and a set of questions that informed both the selection of the next interviewee and the questions that were asked next (Small, 2009). Our goal was not to achieve representativeness or avoid statistical bias but to reach theoretical saturation.

DATA COLLECTION

Data was collected through a two-pronged approach. We began our research with a **desk study** to frame the research and deepen our knowledge about the cases prior to fieldwork. During this phase, we systematically reviewed existing data and literature on the two cases that are the object of this research. This review helped us identify possible factors that have motivated companies to adopt eco-packaging and track cattle in the beef supply chain. It also allowed us to identify some of the barriers that companies and governments faced when adopting or promoting these GI technologies.

The second phase of the research involved in-depth open-ended **interviews with key informants**. These interviews deepened our understanding of the two cases and the underlying mechanisms that have driven GI adoption and/or diffusion. For the eco-packaging case, initial interviews were conducted with two managers at Natura and with the marketing director of another consumer goods company.[2] Even though our eco-packaging case is centered around Natura, we considered it important to complement (and, to some extent, double-check) the data obtained directly from its managers through interviews with representatives from similar

[2] In accordance with conventional research protocols, we strive to maintain the anonymity of informants and their employers. We use names only when drawing from secondary sources that are already in the public domain.

companies and/or related industries. Thanks to these initial interviews, we gained access to additional managers at Natura and at other producers of consumer goods. Going deeper into their supply chain, we also interviewed the manager of a firm that recycles plastics and produces post-consumer resins. For the cattle tracking case, we conducted initial interviews with a cattle rancher, a cattle trader, the manager of a meatpacking plant, and a policy analyst with extensive experience advising government officials on the nexus of cattle ranching and deforestation. Later, we conducted additional interviews with a representative from the Brazilian Association of Meat Exporters (ABIEC, Associação Brasileira das Indústrias Exportadoras de Carnes) and the founders and partners of companies that provide GIS mapping services so meatpackers can track their suppliers.

Throughout the research, we relied on open-ended interviews, with an emphasis on interviewees' recollection of critical events. For example, we asked questions such as: *How did you get the idea for this GI initiative? Which other ideas did you consider but did not implement? Why did you choose this one over the others? Which obstacles did you face during implementation? How did you try to overcome these obstacles? What worked well, and what did not work so well during implementation? Who were your allies in this process? And, how did you know to reach out to them?*

This approach allowed us to retrieve novel information and uncover mechanisms that were hidden or that had not been previously articulated. It also provided us with grounded data to answer more direct questions pertaining to the adoption and dissemination of GI technologies.

CASE STUDY 1: ADOPTION OF ECO-PACKAGING IN HOME AND PERSONAL CARE INDUSTRY: THE CASE OF NATURA IN BRAZIL

In Latin America and the Caribbean, 80 percent of the population lives in cities (World Bank, 2017), and a large proportion of the goods they consume come in bottles, cans, cartons, boxes, or some other container. Packaging creates convenience, but its sourcing, transportation, warehousing, and disposal represent a growing threat to the environment. In recent years, many European countries and some emerging economies such as China have passed environmental laws to encourage the adoption of sustainable packaging. The European Packaging and Packaging Waste Directive (European Parliament and the Council of the European Union, 1994), for example, requires member states to ensure that all packaging placed on the EU market complies with certain essential requirements relating to its manufacturing, composition, and end of life. As a result, producers of consumer goods, including home and personal care products, have been expressing a growing commitment to recycled content, recyclability, and other strategies that decrease the environmental impact of their packaging (D'Angelico and Pujari, 2010).

The Natura Case

Natura is a Brazilian producer and retailer of cosmetics, fragrances, and personal care products. It participates in all main categories of the cosmetics market but it is most prominent in fragrances, perfumes, creams, lotions, and makeup. Natura retails its own products in Argentina, Brazil, Chile, Colombia, France, Mexico, and Peru and distributes them in Bolivia, Guatemala, Honduras, and El Salvador. When selling Natura-branded products, the company relies on almost 1.5 million individual salespeople known as Natura Consultants (Perera, Putt del Pino, and Oliveira, 2013).

Natura has been listed on the São Paulo Stock Exchange since 2004, and in 2011 it accrued approximately US$3 billion in revenue.[3]

Natura is a celebrated leader in eco-packaging (Kelly et al., 2016).[4] To gauge the environmental impact of its activities, it relies on a life-cycle assessment (LCA) tool.[5] LCA is a well-established method to calculate environmental impact across all stages of production, from the extraction of raw materials to the final disposal of the empty package. The method produces a number that allows for the comparison of the environmental impact across products and over time. The methodology was developed by Pre Consultants B.V. through its Eco-Indicators 99 initiative. The LCA tool used by Natura summarizes impact through a standardized unit called a "millipoint" (mpt). The original "point" (Pt) was calculated as the total environmental load observed in Europe in one year, divided by the corresponding population (Ministry of Housing, Spatial Planning and the Environment, The Netherlands, 2000).[6] Natura reports its impact in millipoints (1/1000 of a point) per kilogram of product sold. In 2016, Natura calculated the environmental impact of its packaging as 53 mpt/kg (millipoints per kilo of product content), down from 71.3 mpt/kg in 2008 (see Table 1).

Table 1. Environmental Impact of Packaging, by Product Quantity (mpt/kg)—Brazil

2008	2009	2014	2015	2016
71.3	69.5	64	69	53

Source: Adapted from *Natura Annual Report 2016*.

The commitment to develop products with a lower impact throughout their life cycle is explicit in the company's approach to sustainability, which contains both a long-term vision for sustainability across the entire business, which it named "Sustainability Vision 2050," and a set of short-term targets focused on the Natura brand that the company intends to achieve by 2020. In its short-term targets, the company expresses its intention to develop eco-efficient packaging and to increase the use of recyclable and post-consumer recycled materials in packaging.[7] Natura measures performance against these targets every quarter and publicly reports results every year. As the table below illustrates, some progress is being made towards most of the reported targets.

[3] In 2016, Natura acquired Aesop, a luxury skincare company originally from Australia that operates in North America, Europe, and Asia. In 2017, it acquired The Body Shop, a globally known cosmetics, skin care, and perfume company with operations in multiple countries around the world.

[4] Kelly et al. (2016) evaluated companies in terms of their sustainable practices and ranked Natura among the top five performing companies at the "Leading" level of performance (level 3 out of 4). The other leading companies are Henkel and Unilever, closely followed by Beiersdorf and Tesco (Kelly et al., 2016).

[5] The LCA tool that is widely used today can be traced back to unpublished studies conducted in the late 1960s, including one commissioned by The Coca Cola Company to analyze the resource requirements, emissions, and waste flows of different beverage containers (Guinée et al., 2010). By the mid-1990s the tool had acquired methodological consistency thanks to scientific publications, the strengthening of professional networks, and deliberate standardization. Globally, usage has been increasing rapidly over the years. According to one study (Green Research, 2011), LCA tool vendors and consultants have seen demand for their services increase 30–40 percent per year. Natura has been a pioneer in the use of LCA in Brazil. It first adopted the tool in 2001, and in 2013 it joined forces with eight other companies to create the Brazilian Business Network for LCA (Rocha et al., 2015). According to its website (http://cebds.org/empresas/), the network now has 57 members that represent 40 percent of Brazil's GDP.

[6] More details available at https://www.sciencedirect.com/topics/engineering/eco-indicator.

[7] The company defines "eco-efficient packaging" as "Packaging with at least 50 percent of weight reduction in comparison to normal/similar packaging or that is composed of at least 50 percent of post-consumer recycled materials and/or non-cellulose renewable materials, provided they do not increase its mass" (*Natura Annual Report 2016*).

Table 2. Sustainable Vision of Natura Related to Packaging

Area	2017 Performance	2020 Goal
Packaging	A total of 4.6% of all packaging made used post-consumer recycled materials.	At least 10% of all Natura Brazil packaging should be made from post-consumer recycled material.
	In 2017, 50% of all Natura Brazil packaging used recyclable material.	At least 74% of all Natura Brazil packaging should be made from recyclable material.
	21% of the units billed in Brazil were eco-efficient packaging.	Ensure that 40% of Natura Brazil's billed units are eco-efficient packaging.
Waste	29% of post-sale product and packaging retrieved for recycling through partnerships with suppliers and business associations.	Collect and send for recycling 50% of the waste generated by Natura product packaging in Brazil (ton equivalent).

Source: Natura Annual Report 2017, p. 41–42.

The company's achievements can be credited to an expansion in the use of eco-packaging as well as fluctuations in the sales mix. As this document will make clear, this particular set of choices and achievements is conditioned by the broader business environment in which the company operates. That is, the different actions (and inactions) taken by policymakers have elicited different responses from the organization (Mazzanti and Zoboli, 2006). At the time the research was conducted, Natura relies on **four types of eco-packaging**: (a) refillable containers paired with refill packs, (b) green polyethylene made from renewable sources, (c) post-consumer resins, and (d) recyclable materials.

The company offered its first **refillable container paired with refill packs** in 1983 (*Natura Annual Report 2009*). Packaging plays an important role in the cosmetic industry as consumers prefer to buy cosmetic products that look luxurious. For this reason, Natura opted to sell sturdy and nice-looking packaging, comparable to that of its competitors, but pair it with refill packs in order to reduce environmental impact for repeat buyers. Refill packs are lightweight packages that can sit on supermarket shelves and are supposed to hold the product until the consumer has poured it into a sturdier container they already own. Once the product has been transferred from the lightweight package to a permanent container, the empty refill pack can be discarded.[8] Since then, the company has been offering refill packs for an increasing number of products, with multiple benefits: lower average price for the repeat customer, increased consumer loyalty, and decreased environmental impact. Since 1983, Natura has been expanding their offer for product refills and pioneered the use of refills in the perfume category for their line of fragrances, Ekos Frescores (*Natura Annual Report 2016*).

Natura also adopts renewable materials into its packaging, including "**green" polyethylene made of sugarcane (green PE)** and **post-consumption resin (PCR)**. Polyethylene (PE) is one of the most commonly used plastics, and it can be produced from oil or from plants such as sugarcane. The latter is known as "green" PE because it is made from renewable sources. Green PE and conventional PE have similar physical properties, and both can be recycled. The environmental impact of green PE depends on numerous variables, including soil conversion to cultivate its raw

[8] Refill packs are different than bulk stations. Refill packs do not require that retail shops accommodate large equipment or change their shelving units, while bulk stations are relatively large containers that reside in the retail store so consumers can bring their own vessels to fill.

material, and it is not always clear whether it decreases environmental impact when compared to oil-based PE.

PCR is often seen as the gold standard in eco-packaging, as the resin is produced by collecting, sorting, cleaning, shredding, and then reprocessing plastic containers that have already been used by consumers at least once. The production of PCR diverts used containers from landfills and brings their material back into circulation. For example, polyethylene terephthalate (PET) can be produced by recycling previously used PET bottles. Typically, PCRs are used to produce goods for applications with high tolerance for quality variation, including ties for railroad tracks and fence posts for farms, but producers of consumer goods have been trying to adopt PCR in their packaging as well.

The challenges are quite sizeable. First, the exact attributes of the finished container depend on the "raw material" (i.e., used containers) that are used to produce it, so no two batches might end up exactly alike, and the risk of contamination or lingering smell is not trivial. Second, collection and sorting can be labor intensive and thus costly, and the final product often acquires a grayish color that may depart from a brand's image or its consumers' expectations. Third, in many low- and middle-income countries, the collection and sorting of used containers are done by children, older citizens, and self-employed (i.e., informal) workers, and the containers are sometimes washed in rivers or other water streams without due care for the environment, so firms that prize their reputation for social responsibility might be reluctant to buy the resulting material.

If problems can be overcome, the environmental gains can be significant. In 2014, Natura introduced refill packs in their line of perfumes, Ekos Frescores, made of 100 percent post-consumer recycled PET, which—according to company data—generates 72 percent fewer greenhouse gas emissions and 20 percent savings for costumers (*Natura Annual Report 2015*).

The company has a target to use at least 10 percent PCR materials in total packaging mass by 2020. In 2017, about 4 percent of the materials used to make Natura's packaging were of post-consumer recycled origin, a percentage that has grown from 2.9 percent in 2015. The Ekos and TodoDia lines of body care products have greatly contributed towards this goal; their packs are made from 100 percent post-consumer recycled PET or sugarcane-based green PE (*Natura Annual Report 2017*). In 2016, the Ekos line of body products was relaunched, with new formulas and new packaging. The use of recycled PET in the line's plastic packaging rose from 50 percent to 100 percent. Moreover, the Ekos line of body products includes the use of refill packs that are 100 percent made of green PE (interview with head of R&D).

Finally, Natura also relies on **recyclable materials**, i.e., materials that can be reprocessed and reused given existing technology. In essence, "recyclable" indicates a possibility; there is no assurance that a recyclable material will be recycled. In contrast, PCR indicates a fait accompli. Further, most recycling is down-cycling, i.e., the resulting products have low aggregate value. Recycling rates depend on cost differential between recycled and new materials, which in turn depend on the behavior of consumers, available infrastructure, public policy, and other variables.

Preview of Findings

One of our interviewees, the marketing director of a consumer goods company, summarized the challenge of eco-packaging in a succinct way: "[to modify a] product is easy, but [to modify] packaging is hard." This interviewee then explained that changes in packaging involve more stakeholders and more constraints than changes in the product formula. For this reason, "we can

update the product in a year or so, but to revamp the packaging, it might take two or even three years." This assertion helps frame the experience of Natura. On one hand, the company has made significant inroads in adopting eco-packaging thanks to the innovation space created by its branding strategy, its strong internal culture and commitment to sustainability, its investment in research and development, and joint action with suppliers and research centers. On the other hand, Natura still relies quite extensively on conventional packaging. Several factors pertaining to Natura's business ecosystem limit greater adoption of eco-packaging. Specifically, lack of infrastructure and public policies for recycling packaging, lack of coordination with other firms operating in the same market, and lack of consumer awareness that translates into limited willingness to pay a premium for sustainable packaging and limited engagement in recycling used packaging.

The remainder of this case study addresses the main factors that played a role in the adoption of eco-packaging by Natura, and examines some of the reasons why the firm has not gone further.

Branding

For those who are not well-versed in marketing, branding can be an esoteric concept. According to one definition, it is the process through which companies create a worldview around the products they sell (Reed, 2019). When engaged in branding, companies strive to create a worldview that matches or complements the aspirational worldview held by a critical mass of consumers, so these consumers embrace the brand's worldview as part of their own. When a firm deploys a good brand strategy, it does more than create a visual or auditory cue to help consumers distinguish between similar products at the point of sale. Rather, a good brand conveys signals that create utility for consumers beyond the concrete attributes of the product. And if a brand can create utility for consumers, it can appropriate some economic value for itself. Marketing researchers Srinivasan, Park, and Chang (2005) call this source of value "brand equity" and define it as the "incremental contribution ($) per year obtained by the brand in comparison to the underlying product (or service) with no brand-building efforts."

One of the most prominent features of this case study is that Natura invests heavily in creating and maintaining a valuable brand that combines four elements: (a) self-care and self-esteem, (b) use of natural ingredients obtained from the Brazilian biodiversity, (c) sourcing practices that benefit indigenous and traditional communities, and (d) a strong commitment to environmental preservation. Importantly, the company goes to great lengths to portray these elements as inseparable facets of the same identity. As explained on one of its websites: "Natura products […] awaken the senses and improve the relationship of people with themselves, with their bodies, with others, and with the world".[9] In brief, Natura anchors its brand equity on an identity that merges self-care with social and environmental sustainability, and this brand identity allows it to create additional utility for consumers and value for itself.

A firm's branding identity does not have to be perfectly aligned with every one of its productive practices, but a gross mismatch represents a risk to the brand equity and to the company. As the next section shows, Natura goes to great lengths to align its productive practices with its brand identity. As part of this effort, it organizes itself in a way that promotes a continuous search for further alignment. Throughout this process, Natura relies on the financial resources generated by its brand equity while remaining mindful that incremental costs and/or decreased quality could hinder sales.

[9] https://www.naturabrasil.fr/en-us/about-us/cosmetics-leader-in-brazil

Internal Motivations

Natura's effort to align its practices with its brand identity is reflected in its strong internal commitment to environmental sustainability. This commitment manifests itself in multiple forms. Internally, the company maintains a corporate culture that values environmental sustainability through long-term comprehensive goals (Perera, Putt del Pino, and Oliveira, 2013). For instance, senior managers include packaging sustainability commitments and targets in company-wide strategic plans and insist that targets must be monitored and reported publicly (Kelly et al., 2016). These high-level commitments and public goals translate into resources that are available within the company to invest in R&D, seek outside partners, and search for innovative solutions to problems associated with eco-packaging. This kind of corporate culture cannot be taken for granted, but our interviewees say that, in Natura, it has become quite consolidated: "Today, none of our employees ask why we should use PCR PET, no one questions that" (interview with Natura manager).

The beliefs and values that have built the Natura brand also create an internal environment that is conducive to the adoption of eco-packaging. First, innovation and sustainability go hand in hand at Natura. As explained by an interviewee, at the end of 2016, the company integrated the innovation, sustainability, and marketing areas under a single vice president in order to promote innovation through technological development, sustainable use of biodiversity ingredients, and new brand concepts. Second, the company places great emphasis on innovation and continuous improvement, which is pursued by establishing cross-disciplinary teams at the beginning of every new project. Approximately 70 percent of its products are designed in-house. The design department has the mandate to lower the environmental impact of the product: every new design needs to bring a lower impact than the average of the company (interview with Natura R&D manager). Once a design is ready, the packaging development department and supply chain department contact suppliers to discuss the technical aspects of production.

Procedures are in place to ensure that all new packaging is evaluated to optimize its environmental performance and existing packaging is reevaluated regularly. Prototypes for new packaging are only approved after undergoing an environmental assessment (Kelly et al., 2016). Regular benchmarking is applied against competitors' packaging systems.

More recently, the innovation and product development areas have adopted an integrated environmental impact calculator that enables them to estimate the impact of future products during the planning phase. This device permits developers to calculate greenhouse gas emission impact, waste and deject generation impact, and the amount of post-consumer recycled material generated.

In addition, the company created a specific management area to develop post-consumer recycled material, such as PET, glass, and aluminum, in order to form new supply chains, foment waste-picker cooperatives and recycling companies, and build alliances with public authorities and with communities to improve public policies in this area.

Since 2001 the company has been conducting LCA of its products to quantify the environmental impacts of packaging within a complete cycle, from the extraction of raw materials through production and use, to final disposal. The use of LCA requires significant managerial attention and internal commitment. The packaging development team runs the analysis for each packaging, while the sustainability team manages and updates the software and the associated databases. The company uses the available databases from the Eco-Indicator 99 methodology (*Natura Annual Report 2005*). Since the software that the firm uses to calculate packaging LCA has an

international database, Natura has to adapt/group the materials used and the disposal scenarios to Brazilian standards (*Natura Annual Report 2016*).

Natura looks for the best LCA score to produce goods with the lowest possible environmental impact. It's a delicate balance to make with the financial side. At times, the company chooses the best LCA score even if it increases costs. Then, it looks at its entire portfolio of products to find a way to compensate for the higher cost. The company has product committees, and as explained by an interviewee, "each committee is composed of marketing, innovation, sustainability, financial, and other areas. They put everything on the table and make a group decision."

Strong internal commitment does not require that the company reinvent the wheel. When Natura first started looking for renewable materials to use in its packaging, and as explained by an interviewee, the company saw that in countries in Europe and Asia manufacturers were using PCR PET. In Brazil, by law, companies need to guarantee that packaging is safe, but there is no requirement in terms of the material to be used. The best option, then, seemed to try what was already working elsewhere. The fact that the technology already existed and had given positive results for other companies lowered the bar for adoption. Additionally, Natura could test the material with packaging suppliers in Brazil to check for quality and compatibility with its own products.

A challenge that the company faces is to make the use of PCR PET economically viable. At first, PCR PET was more expensive than virgin PET because there were no suppliers of PCR PET in Brazil. Under those conditions, using PCR PET was more difficult, because it could bring up the cost of a product. Today, the cost of PCR PET is about the same as virgin PET. However, the economic pressures of competition are so strong that even today, if the company introduces something new in the packaging (a different percentage of renewable material, or a new material), costs may go up. It is easier to find some room to maneuver when the product's intrinsic market appeal relies on a message of sustainability. An interviewee explained:

> *For each product, managers need to carry out the analysis: What is the story that this product has to tell? Is there a value for consumers for this product? For the Ekos line, for example, consumers buy the products for their sustainability story and values. For this product line, it is more feasible to increase the price because of increased cost in eco-packaging. Similarly for the SOU line, since it has been designed as a line with less impact on the environment.*

(See Table 3 for more details on the different product lines.)

Table 3. Selected Natura Product Lines and Packaging Strategy

Product Line	Description	Target	Packaging
Ekos	A range of body care products and perfumes directly inspired by the ancestral traditions of Brazilian populations	Socially and environmentally conscious consumers	• The new Ekos line launched in 2013 has lessened packaging carbon emissions by 13% (per kg sold). • All Ekos packaging is now 100% recyclable and made out of 50% recycled PET. • Refill packs and conditioner bottles are made out of 100% green plastic coming from sugar cane.
Chronos	A range of skin care products tailored for each age and each skin type using ingredients from the Brazilian biodiversity for anti-aging and moisturizing effects	Anti-aging products, high end of market	• The Chronos line uses eco-design and refillable packaging. • The Flavonoides de Passiflora, a popular line of anti-aging creams, use containers that are refillable and reusable. • The containers use glass polymer (a recyclable material) that offers the clarity, stability, and luxurious feel that Natura wanted for the container. The creams are offered in refill packs that easily snap into the Chronos bottomless pot. • The refill system reduced the amount of resin used and the packaging material required, while also reducing environmental impact of the manufacturing process.
Mamãe e Bebê	A line of products for expecting mothers and infants. All the Mamãe e Bebê products are enriched with passiflora oil. They are paraben free and alcohol free, do not use artificial coloring, and are dermatologist tested.	Expecting and new mothers	• Packaging flasks and tubes are unbreakable and offer refills. • They are made with non-toxic material, and they are soft touch and less slippery than common packaging.
Sou	Body and bath care products designed to reduce impacts along their life cycle and along the supply chain. The product line was developed using eco-design and a life cycle thinking approach, with a dedicated multifunctional team. Formulas were created giving priority to plant-based components and no color pigments.	Market segment with a price point 20–40% lower than other Natura product lines	• Stand-up pouches with a cap are used as primary packaging. • The pouch requires 70% less plastic compared to conventional packaging and CO_2 emissions are reduced by 60%. • The packaging results in three times less waste.

Not all Natura products have 100 percent PCR PET in their packaging. As mentioned earlier, PCR PET has a gray color to it that shows in packaging, and the appearance of packaging plays an important role in the cosmetic industry, so Natura has to constantly search for the right balance between the amount of PCR in the packaging and the look that the packaging needs to have to attract customers. The company analyzes the concept of every sub-brand and tries to use materials that do not impact the aesthetic of the product. If a material does not match the aesthetic of the sub-brand, and if no technology can make this "matching" feasible, then the company refrains from putting PCR PET in the packaging, or uses a smaller percentage of the material so that it is not really noticeable. For example, for the Chronos line, consumers would not expect or accept grayish-colored packaging, and in this case, Natura puts a low percentage of PCR PET so it is not easily perceptible. The Ekos line, on the other hand, is anchored on the idea of sustainability, so it is easier for these products to reach 100 percent PCR PET.

Natura is far from alone in adopting green technologies, as other well-established producers of personal care products have also been on the same pursuit. For example, **Aveda** offers skin care and hair styling products in bottles or jars that are made with 85 percent PCR PET. Likewise, 90 percent of high-density polyethylene (HDPE) bottles in Aveda's product line are made from 80 percent PCR, and several new shampoo and lotion products are packaged in 100 percent PCR HDPE. Accounting for both PET and HDPE, Aveda calculates that its use of PCR reduces the need for virgin resin by 600 tons each year. On a similar note, **L'Oréal** is working to increase its usage of PCR. In 2016, it used more than 7,000 tons of PCR. L'Oréal's Biolage R.A.W., Aura Botanica by Kérastase, and L'Oréal Paris Botanicals Fresh Care shampoo bottles use 100 percent recycled plastic, with the exception of caps and pumps. L'Oréal brand Garnier Fructis has also made significant strides using PET that is 50 percent PCR.

In a different market niche, **Seventh Generation** has been a pioneer in sustainable packaging for household cleaning products, and has publicly committed to manufacturing all packaging from recycled or bio-based materials by 2020. As a strategy, Seventh Generation works to use as much PCR as possible, and then to use bio-based plastics for the remaining portion. For example, in 2016, the company introduced a new 100-ounce laundry detergent bottle made from 80 percent recycled HDPE, 17 percent bio-based PE, and 3 percent colorant. The director of packaging development explained that the 80 percent level of recycled content was derived from extensive testing and acknowledging that at a higher level, stress fractures become possible (Dreizen, 2017).

A likely difference between Aveda and L'Oréal on one side, and Natura (and possibly Seventh Generation) on the other, is that the latter have built their brand, and the story they tell consumers about themselves, around the idea of using natural products with minimal negative impact on the environment. Such a close alignment between brand identity and environmental sustainability should make it easier for these firms to adopt internal practices and processes that allow them to decrease their environmental impact. And yet, in the case of Natura, the battle remains uphill. The company decreases its impact (as measured by the LCA method) millipoint by millipoint, and the effort requires the deliberate recruitment of a network of outside allies.

Supply Chain and Networks

Natura places great emphasis on the quality of its relationships with suppliers because they are an essential component in complying with the values and mission of the company. With this objective, Natura implements initiatives to fine-tune relationship with these stakeholders.[10]

It is not a surprise, then, that long-lasting relationships with packaging suppliers were at the core of the adoption of eco-packaging by Natura. According to Natura manager Flávia Bartholomeu Campos (Braskem, 2016):

> The packaging value chain has supported us a lot. For the adoption of recycled plastic bottles in our Natura Ekos line, collaboration was essential to overcome a challenge in Brazil, which is the regular collection of quality recycled material. Among other examples, the interaction with the supplier market also allowed us to be pioneers in the cosmetics industry in the large-scale use of "I'm green," the green PET produced by Braskem from sugarcane ethanol. The application of the material in packaging and refills of lines such as Natura Ekos and Natura Tododia was a success.

Around 2008, when Natura first started investigating the use of PCR PET, it established a research team, working in partnership with communities and cooperatives to collect plastic. The research team discussed with suppliers ways to test this new type of material. The suppliers were hesitant; they were afraid that the new material could damage their machinery. In the negotiation, Natura agreed to be co-responsible if the equipment broke down during the test. These were their packaging suppliers, and they had long-standing partnerships built on trust. As described by an interviewee, "It was hard at the beginning, especially to have the quantity and quality of the material needed. It took some years for the actual launch."

As explained by another interviewee, Natura does not directly collaborate with industry peers for the development of eco-packaging, but they share the same suppliers. As a result, innovation brought about by Natura (or other firms) can easily be disseminated throughout the industry. When Natura tests and implements something new with a supplier, the company may ask to be the first and only one to use it for a period of time, and then does not object to others using it.[11] For example, for the green PE, after a period of exclusivity with Natura, the supplier later used it with Johnson & Johnson and other companies. Similarly, after Natura started using PCR PET in their packaging, other companies, such as Johnson & Johnson, Unilever, and O Boticário, followed (interview with Natura manager). Also, as mentioned earlier, the company pioneered the use of refills in Brazil, and now it is more widely diffused.

Another example includes the use of plant-based green PE in the packaging of home and personal care products, which is being facilitated by Braskem, a major Brazilian company that

[10] An example is the QLICAR program, whose objective is to boost chain performance through supplier performance management and activities focused on the joint development of processes. The program's acronym in Portuguese stands for each of the aspects that this initiative assesses: (Q)uality, (L)ogistics, (I)nnovation, (C)ompetitiveness, (A) for environmental and social; and (R)elationship. In 2016, 155 companies participated in the QLICAR program.

[11] The manager at another personal care products company that we interviewed explained that contracts that establish exclusivity exist in theory but are not used very often because they are difficult to enforce. Other respondents dismissed the idea outright as impractical and antithetical to their goal of disseminating the use of eco-packaging throughout the industry.

supplies Natura and other firms.[12] The Brazilian company **O Boticário** uses green PE for its flasks and packaging. This company has shifted over 70 percent of their Cuide-se Bem product line to green PE. After adopting the new packaging, O Boticário saved over 90 tons of plastics, preventing the emission of 3,000 tons of carbon dioxide per year. To raise awareness about environment-friendly products, packaging that uses this green PE features a seal that says "With Vegetal Plastic."

Some companies take an even more proactive approach towards dissemination. For example, an interviewee who works for a personal care products company explained that they are not possessive of the green technologies that they develop and are willing to share them with other companies. This interviewee pointed out that they have already shared a technology to reduce the volume of deodorant by compacting it more densely within the package. One of the reasons for sharing is to allow suppliers to reach scale and thus reduce prices. Another reason is to convince customers that a smaller package can pack more product, and that's why it might cost more.

Natura actively engages with suppliers and provides guidelines on packaging sustainability. The company has procedures in place to ensure that all suppliers comply with minimum environmental standards for packaging (Kelly et al., 2016). These standards are applied to suppliers of packaging, packaged materials/components, and packaged products, and suppliers are audited to ensure compliance.

In accordance with its commitment to sustainability, Natura wanted to find a way to drive environmental performance through its supply chain and engage its suppliers in a program aimed at improving their social and environmental contribution. Through this Strategic Sourcing Triple Bottom Line (TBL) program, Natura works with its suppliers to put a price on externalities like carbon dioxide emissions, water use, and waste generation. Specifically, the program aims to account for suppliers':

- economic costs (prices);
- CO_2 emissions;
- waste generation;
- water used;
- employee education (investment in basic and higher education);
- employee training (hours of training);
- work safety (accident rates);
- social inclusion (compensation values and hiring rates of people with disabilities and apprentices);
- direct investment in society (for example, in the communities in which suppliers are based, on health, education, environment, and so on); and
- other social benefits.

This "shadow price" for each environmental (and social) impact helps Natura to select suppliers based on both pricing and environmental impact. This approach is improving the economic, social, and environmental performance of its supply chain while also saving the company money.

The Strategic Sourcing TBL program was launched by Natura in 2010. Initially as a pilot, it engaged 50 of the largest suppliers in the company's supply chain. These suppliers were trained

[12] Braskem's green plastic has been manufactured since 2007, and the Brazilian company has exported its technology to every continent except Africa. Braskem has since won more than a dozen international sustainability awards, both in Brazil and abroad.

in Natura's methodology and were assisted in data collection. Currently the program includes 110 suppliers that represent approximately 50 percent of total supply chain spending. Each supplier is assessed on specific issues it should focus on, based on its response to the questionnaire used by Natura. Performance is again measured in the following period. The company estimated that the socio-environmental benefits of picking suppliers who are high-sustainability performers was worth more than US$130,000 (over BRL$500,000) in 2011 and US$484,000 (BRL$1.8 million) in 2012, and expected it to be more than US$500,000 (over BRL$1.9 million) per year over the four subsequent years (Perera, Putt del Pino, and Oliveira, 2013).[13]

Engagement with Universities and Research Centers

In the cosmetics industry, Natura stands out for its use of Brazilian biodiversity and for its social and environmental concern. To innovate based on these principles, the company values collaboration. In addition to suppliers, establishing partnerships with research centers is key to identify and test new solutions in eco-packaging. About 60 percent of Natura's innovation projects (over 350 projects) are developed jointly with more than 300 partners, including companies, universities, research institutions, test laboratories, and support organizations (*Natura Annual Report 2013*; UNESCO, 2015). The company maintains close relations, for example, with the Media Lab (digital technologies research laboratory) at MIT (Massachusetts Institute of Technology) in Boston (USA), and with the Cutaneous Biology Research Center at Massachusetts General Hospital (Harvard Medical School's largest teaching hospital), in addition to partnerships in Paris, France, where the company develops collaborative research with the University of Lyon, and in Melbourne, Australia, where the Innovation Center of Aesop, the brand acquired by Natura at the beginning of 2013, is located.

In order to strengthen their work with partners, in 2007 Natura created the Natura Campus Technological Innovation Program, which is supported by the national Council for Scientific and Technological Development (CNPq, Conselho Nacional de Desenvolvimento Científico e Tecnológico), the State of São Paulo Research Foundation (FAPESP), and the Brazilian Innovation Agency (FINEP, Financiadora de Innovação e Pesquisa) (*Natura Annual Report 2009*). These sponsoring institutions contribute to the joint financing of projects and provide equipment, scientific scholarships, and research materials for participants.

An important tool of this strategy is the Natura Campus, a program that since 2003 has sought to establish partnerships and networking in research and development. This program creates a space of collaboration and relationship building with institutions of science and technology, companies, and entrepreneurs. The goal is for everyone to collaborate to generate innovation and shared value. The program periodically publishes calls and challenges, inviting collaborators to present ideas for development in partnership. In addition, external agents have access to Natura's technical teams and propose innovations that are not necessarily related to the calls. These partnerships brought many results in the field of packaging, such as the adoption of renewable resins. As explained by an interviewee (Braskem, 2016):

> The importance of collaboration is evident. We would not have been able to implement several innovations in recent years without the support of partners. In certain cases, it would have taken much longer if we had done it alone. And the high cost could have made us give up projects. This is a clear benefit of open innovation: there is risk-sharing and investment.

[13] All currencies have been converted using the exchange rate of October 10, 2018.

The company established research partnerships consisting of research institutions, suppliers, local producers, and NGOs that helped them to obtain funding (*Natura Annual Report 2012*). Almost every year, the company secures funding from FINEP to support innovation projects to research new natural ingredients, support potential suppliers, and deploy the ingredients in actual products. For example, in 2009, Natura received approximately US$160,000 (BRL$600,000) in financial assistance from FINEP through their Research and Development program. These resources helped fund part of the investments incurred in the drafting of the Technology Platforms for New Cosmetics and Nutritional Supplements project.[14] In 2012 Natura also obtained financing of US$21.6 million (BRL$81.7 million) from the Brazilian National Development Bank (BNDES) intended for investments in information technology and innovation, training of R&D employees, and improvement of industrial facilities and distribution centers, among others.[15] Natura obtained more public sector financing in subsequent years.

Market Demand and Consumer Awareness

A challenge faced by companies is a lack of awareness by customers, who are reluctant to pay a premium price for green product attributes (D'Angelico and Pujari, 2010). As explained by an interviewee, very few consumers in Brazil and around the world are willing to pay more for a product just because it uses eco-packaging. To reach green-minded customers in a competitive marketplace, companies must bundle eco-packaging with other product characteristics related to sustainability, such as ingredients sourced directly from nature, natural aromas, and a compelling narrative. As part of this effort, companies often try to make green products clearly recognizable for customers by using eco-labels with detailed product information, but creating credibility through eco-labels or third-party certification requires stringent scientific and systematic internal processes to integrate and measure a product's environmental impact at each life-cycle stage.

Natura has a documented commitment to engage consumers in sustainability (Kelly et al., 2016). Natura Consultants encourage consumers to consciously consume and recycle: "We encourage new consumption standards, including the use of refills and the proper disposal of packaging" (*Natura Annual Report 2016*). However, even if consumers see value, they do not always change what they do or what they choose; for the most part, consumers always want what is easier for them (interview with Natura manager). As a manager from another consumer goods company put it: "It is hard to change behaviors. Consumers do not want to pay more for green packaging." In response to this challenge, Natura is planning a strategy to mobilize consumers further.[16]

[14] From *Natura Annual Report 2009*: "The subsidiary Natura Inovação e Tecnologia de Produtos ltda. has innovation programs aimed at the development and acquisition of new technologies by means of partnerships with universities and research centers in Brazil and abroad. These innovation programs have the support of research and technological development incentive programs of the FINEP, which facilitates and/or co-finances equipment, scientific grants and research material for the participating universities. These funds were used to partially finance investments incurred in the drafting of the 'Technology Platforms for New Cosmetics and Nutritional Supplements' project."

[15] From *Natura Annual Report 2012*: "The company and its subsidiaries Indústria e Comércio de Cosméticos Natura ltda. and Natura Inovação e Tecnologia de Produtos ltda. have credit facility agreements with the BNDES to facilitate direct investments in the company and its subsidiaries in order to improve certain product lines, train research and development employees, optimize operation product separation lines in the Cajamar, SP industrial facilities, build new distribution centers, and restructure the administration of the Itapecerica da Serra, SP unit and purchase the equipment necessary for these purposes."

[16] Natura Consultants can play an important role in the company's green strategy, as they can encourage (or discourage) consumers from buying refills or returning empty packages. And yet, these are independent contractors who work on commission so the company has limited leverage over them. A proper exploration of the role, perceptions, and motivations of Consultants, however, would require a large-N survey that is beyond the scope of this paper.

Since 2007, the company has been including an environmental table on the packs of all its products, giving consumers information on the origin, processing, and percentage of certified raw materials, in addition to percentages of recycled and recyclable materials and the number of refills. The table has an educational purpose, contributing to customers' awareness of the environmental impact of the products.

Compliance with Regulation

Compliance with environmental regulations allows firms to minimize risk, maintain revenue, and protect their image. Furthermore, regulations can even become an opportunity for new business creation. The so-called "plastic problem" is accelerating and companies expect that governments will at some point impose an environmental tax or fee on companies such as Natura that sell products using plastic packaging. This means that sustainable solutions can soon become a competitive advantage, and then they will become a pre-condition to remain in business. As explained by an interviewee:

> We need to solve this already, because in five years I do not even know if we will be allowed to produce a plastic bottle.

Natura's actions have been informed by public policies and the business environment in which it operates. In Brazil, the disposal of solid waste is regulated by a federal law but implemented by the municipalities. Compliance with the law is low; 80 percent of municipalities in Brazil do not have infrastructure to recycle. Compensating for lack of public infrastructure, an informal network of self-employed waste collectors (*catadores*) and recycling companies have emerged to recycle solid waste. Results are uneven: in Brazil, 70 percent of PET and aluminum is recycled but only 2 percent of compostable solid waste goes to composting stations. Operating under these constraints, Natura has chosen not to invest in compostable packaging and invest instead in materials that can be recycled along with other petrochemicals.[17]

Another challenge for Natura, and other manufacturers, is the post-consumer collection of packaging. The Brazilian National Policy on Solid Waste (PNRS, Federal Law 12,305/2010) posed a challenge to companies because it requires the establishment of logistics chains for the return of post-consumer packaging. Consequently, companies have had to develop ways of connecting with their consumers in order to ensure proper disposal of all packaging after use. In 2016, Natura completed a one-year experimental pilot program devised to promote reverse logistics in the São Paulo metropolitan area (*Natura Annual Report 2016*). Under that program, different means of collecting post-consumer waste were organized, including a commercial partnership with five collection cooperatives. Natura Consultants were also recruited to collect materials. After collection, the waste was sent to recycling centers. The experiment allowed the company to learn more about this chain, as well as reverse logistics operations, and helped the company develop a strategy, procedures, and actions to help it achieve the goal of applying reverse logistics to 50 percent of its products by 2020.

Concluding Remarks

Natura has made important steps towards adopting eco-packaging for its products. Through a combination of employing refills and using both PCR PET and green PE materials, the company

[17] Natura also encountered technical problems with compostable packaging, whose materials can be vulnerable to humidity and heat. Brazil is both hot and humid, and cosmetics contain water, so bioplastic containers might break or leak (interview with Natura R&D manager).

has successfully lowered its impact on the environment over time, as measured by its LCA methodology and calculated on the basis of kilograms of product sold. Perhaps the most striking insight from this analysis concerns the great lengths that the company goes to to search for and gradually find even tiny opportunities to increase its use of eco-packaging in a way that does not threaten (or might contribute to) the bottom line. Some of the key factors that make adoption possible are the resources generated by Natura's brand equity, a company-wide commitment to environmental values embodied in its organizational structure and managerial practices, long-standing partnerships with suppliers, engagement with research centers, and some government support.

Surprisingly, given its commitment to environmental sustainability, the company still employs a considerable amount of non-eco-friendly packaging materials. Why has a company so committed to sustainability not yet achieved 100 percent eco-packaging? An assessment of the obstacles that the company faces—and that it has not been able to remedy on its own—sheds light on initiatives that governing authorities can undertake to promote GI.

The crucial challenge faced by Natura is to reconcile environmental attributes with desirable product qualities at a reasonable cost. The case of PCR is emblematic, as PCR usage would increase significantly if it was cheaper to produce, had more consistent quality attributes across batches, and did not acquire a gray coloration.

These are open-ended problems with no obvious "best" solution. One way to look at it is that the PCR supply chain is still incipient and lacks standardization. There are about six nodes in the PCR supply chain connecting waste generation (consumer) to PCR plastic manufacturer: (a) collection of used plastic, (b) separation/classification of different plastics, (c) cleaning, (d) grinding, (e) consolidation, and (f) sale. As recounted by a manufacturer of PCR plastic, this chain is beset by quality problems caused by incorrect separation between different types of plastic, uneven degrees of cleanliness, and appearance/color. In addition, collectors, cleaners, and separators often employ child labor, allow for unsafe labor conditions, and commit many other infringements of labor regulations. Making matters worse, some workers wash the materials near rivers, which creates pollution. Under these conditions, many firms avoid investing in the manufacturing or use of PCR plastic because the product does not always meet quality requirements, supply is inconsistent, and there is lack of compliance with various labor and environmental laws.

Another challenge relates to cost. One of the reasons the pace of eco-packaging adoption is still slow is not the lack of scientific or engineering knowledge, but the high start-up and manufacturing costs that make the price non-competitive (D'Angelico and Pujari, 2010). In several product categories, without government subsidies to companies or government rebates to customers, companies find it difficult to compete with brands and companies that have not adopted green technologies, at least until economies of scale reduce the price of green alternatives.

Even though technology is available, it might not be efficient enough. Today, plastic separation is not standardized and is done manually. There are about one million people working in the collection and separation of plastic in Brazil; some people do it well and others not so much, which affects quality. Both training and more efficient equipment could help. There are machines that can separate different types of plastic and increase the volume of recyclable plastic that ends up transformed into PCR, but the machines are expensive and have not been properly tested in Brazilian field conditions. Making matters worse, demand for PCR remains incipient, which tampers investment in R&D.

Another important problem concerns consumer habits and behavior. A manager interviewed for this research explained that their company would like to sell a more concentrated product that would require less packaging, but the price per unit of volume would inevitably increase. That is, a small bottle containing a large amount of concentrated product can cost more than a large bottle containing a small amount of watered-down product. Consumers are inevitably skeptical that the product is truly concentrated, and they are not likely to devote a lot of time to figuring things out at the point of sale. According to research done by a consumer goods producer, a person buying detergent usually spends two seconds in the relevant aisle before making a purchasing decision. A person buying shampoo spends from 30 seconds to one minute. This means that producers need to invest considerable resources to get the message across and convince these buyers to try something new within such a short time frame.

These perceived problems can be remedied through many different solutions, or combinations of solutions. One option is to train and reward the individuals who collect and sort used plastic prior to processing. Another option is to replace or complement human judgment with automated technologies or techniques that sort the used plastics more efficiently, accurately, and consistently. Yet another option is to pursue new chemical technologies that obviate the problem by "resetting" the polymers. Or the relevant firms could coordinate their efforts to make it easier to produce better and cheaper PCR, or reduce the cost of packaging. For example, they could foster an industry-wide agreement to move towards more concentrated products, or agree to certain standards and certification schemes for eco-packaging that assure consumers that they are not paying dearly for a watered-down product.

Other initiatives are more effective if adopted by the government. For example, the government could adopt product regulations that prevent companies from mixing certain types of materials in the same packaging, or using certain types of plastics in certain products, as specific pairings make sorting difficult and also have high stakes: one mistake can condemn an entire batch.[18] Or the government could require that consumers pay a "deposit" for each plastic bottle they buy. This type of price regulation is likely to increase the supply of post-consumer materials as users and their surrogates will prefer to return the bottle to a recycling station to redeem the deposit instead of sending the container to a landfill. Alternatively, the government could simply subsidize the use of eco-packaging, or at least subsidize the research that might lead to better green technologies.

In the end, there is no obvious "best" course ahead so finding an acceptable way forward requires exploration. The problem, as noted by Hausmann and Rodrik (2003), is that the costs of exploration tend to be private while the knowledge and value that it generates are likely to be public. This gap between private costs and public benefits constitutes a market failure of its own, and it can also be solved through government intervention.

In brief, Natura strives to enhance its market performance through branding and other conventional business techniques, and then it uses some of these resources to adopt green technologies so its practices remain aligned with its branding. So far, and in general terms, progress has required extensive investment and commitment by a large multinational that embeds

[18] This problem was made vivid by one interviewee, who explained how minimal amounts of silicone residue can drastically reduce the value of a batch of recycled plastic, as the silicone creates tiny holes in the finished product that prevent it from being used for bottles or other vessels that contain liquid. A coordination problem arises because the companies that manufacture silicone sealants use plastic packaging that can be recycled, so the sorting machines and techniques used by the recycling plants channel them towards the recycling pile. To avoid commingling, the recyclers must be extremely vigilant to visually identify these near-empty bottles of silicone and discard them before they are ground up and contaminate an entire batch of PCR. An obvious solution would be for manufacturers of silicone sealants to use materials that can be more easily distinguished from plastic intended for PCR.

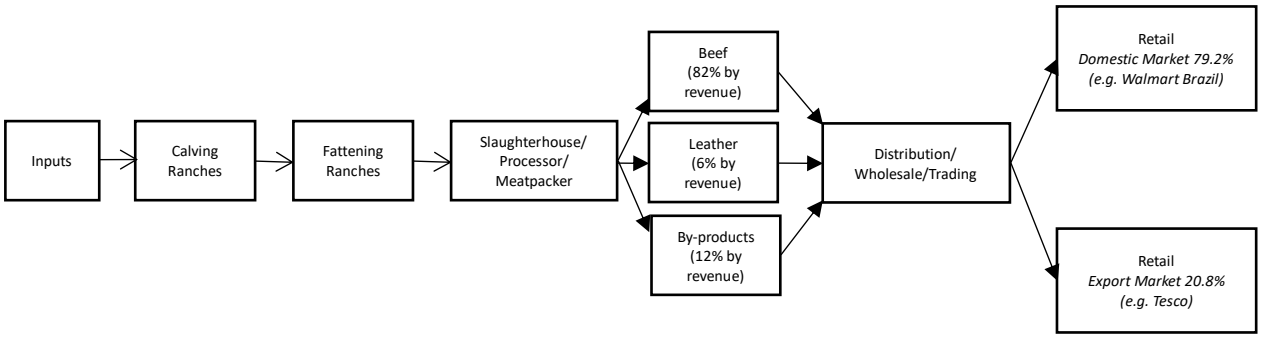
sustainability into its business model and has the scale to obtain financing, recruit suppliers, and receive some government support. Even though Natura is often celebrated as a champion of sustainable business, this case shows how difficult it must be for other firms to follow suit.

CASE STUDY 2: TRACKING OF CATTLE TO PREVENT DEFORESTATION IN THE AMAZON

Cattle has been raised in the Amazon since the early days of European colonization. In recent decades, however, the local herd has increased at a staggering pace, from 26.6 million animals in 1990 to 64 million in 2003 (Arima, Barreto, and Brito, 2005). The average growth rate for this period—6.9 percent per year—is 10 times larger than the equivalent figure for the rest of the country, and it was driven primarily by easy access to cheap land. Most of this land, however, used to be covered with tropical forests, and thus cattle ranching became the "real motivating force behind the deforestation process in Brazilian Amazonia" (Margulis, 2004).

During those years of steep growth, the industry could be characterized as entrepreneurial or free-wheeling, i.e., ranchers and meatpackers had latitude to act as they pleased, without much regard for environmental or labor regulations. Instead of maintaining or improving existing pastures, ranchers routinely allowed their animals to overgraze until the pasture had degraded, and then they moved their herds to fresh pastures established in newly deforested land. For the most part, the meatpacking sector was fragmented, and populated by many small and medium enterprises. As part of this laissez-faire atmosphere, commercial relations within the supply chain remained at arms' length; that is, meatpackers relied on middlemen to buy cattle sight unseen, no questions asked. Many meatpackers did not even know where their animals had been raised. Figure 2 illustrates the relationships in the Brazilian cattle value chain.

Figure 2. The Brazilian Cattle Value Chain



Source: Lee and Rammohan (2017).

By 2010 or so, the situation had changed quite dramatically. The meatpacking sector experienced enormous growth and consolidation. Further, and as shown by Gibbs et al. (2015), slaughterhouses such as JBS (the largest meat-processing conglomerate in the world) started to exclude ranches with deforestation from their supply chain, which led deforestation rates among their first-tier suppliers to decline by 50 to 75 percent. To achieve this outcome, cattle producers have been relying on a GI that enables meatpackers to monitor their suppliers' environmental status through GIS maps, GIS-indexed databases, and satellite imagery. Thanks to this technology, which is offered by vendors such as AgroTools and Terras, a large number of

meatpackers can tell with reasonable precision where most of their animals originate and whether the seller complies with applicable regulations.

Preview of Findings

This case study produced three main insights. First, the Brazilian Amazon is home to approximately 400,000 cattle ranches and a relatively small number—approximately 100—meatpacking firms (Barreto et al., 2017), so it made sense for regulators to target meatpackers as central nodes in this supply chain.[19] Second, even though meatpackers occupy a commanding position, they are still constrained by competition. On the input side, meatpackers cannot be too picky when buying animals otherwise they might fail to secure a steady supply of cheap livestock. On the output side, they cannot let their own production costs escalate, otherwise they might be unable to sell the meat and other bovine products that they produce. And third, this particular GI—the monitoring of suppliers and tracking of cattle by meatpackers and retailers—was only adopted after the Brazilian government and other actors had changed the competitive environment in which cattle ranchers and meatpackers operate.

In this case, adoption was driven by extensive and forceful regulatory and extra-regulatory pressure that was exerted by government authorities and environmental activists. This pressure was twofold. On one side, regulatory agents used Brazilian law to target producers, processors, and retailers directly and threaten them with fines, forced closure, and even criminal sanctions. On the other side, activists engaged in name-and-shame campaigns around the world to threaten the reputation of global brands that rely on animal products. In turn, these brands—particularly those located in the EU, and to a lesser extent the US—exerted pressure on their suppliers in Brazil.[20]

But relentless legal action and consumer pressure would not have generated results on their own. As a counterfactual, they might have caused the Brazilian industry to shrink or to hide in informality. To avoid this fate, pressure was complemented by the creation of a space for negotiation and exploration so meatpackers and ranchers could find an acceptable solution to the regulatory demands that they faced. Naturally, the technology was important, and the exact form that it took hinged on the features of the supply chain and the nature of competition among meatpackers.

Understanding GI Adoption: Regulatory and Extra-Regulatory Pressure

The process that culminated with the adoption of technology for the monitoring and tracking of cattle can be traced back to 2009, when environmental activists and government authorities launched two matched interventions that forced meatpackers to reassess their business practices.

The first intervention was spearheaded by environmental activists, in particular Greenpeace and Friends of the Earth. In two separate reports, they demonstrated that cattle ranching was a driving force behind the deforestation of the Amazon. The reports further charged that meatpackers were deliberately ignorant of environmental variables when buying cattle, and that well-known

[19] The two largest Brazilian meatpackers, JBS and Marfrig Group, have a global presence and are the first- and third-largest animal protein producers in the world respectively.
[20] Municipal and state governments can play an important role in shaping land use and deforestation in the Amazon so it would be reasonable to assume that they could also affect adoption and dissemination of this technology. That said, we did not find evidence supporting this possibility.

companies such as Adidas, Nike, Ford Motors, Honda, Toyota, and BMW were "silent partners to crime."[21]

In 2010, the Consumer Goods Forum (CGF), a global network of manufacturers of consumer goods and retailers focused on sustainability, announced its commitment to zero net deforestation related to beef, soy, palm oil, and paper in member supply chains by 2020. This commitment reinforced the demand signal for deforestation-free beef from companies like Walmart, Carrefour, Unilever, and others.

Retailers found support from the various working groups focused on sustainable beef. Global retailer Tesco had begun working closely with CGF in 2010 on efforts to reduce deforestation related to cattle, palm, soy, and timber, partly due to Greenpeace's accusations that Tesco's corned beef was linked to deforestation because it was sourced from JBS. Similarly, in the spring of 2014, McDonald's announced its commitment to global deforestation-free commodity sourcing for beef, poultry, palm oil, and packaging. This move was the result of work with many groups, including the World Wildlife Fund (WWF), and was poised to affect 3,100 of the company's global direct suppliers and countless indirect suppliers.

The second set of complementary interventions was directed by Brazilian prosecutors associated with the Ministério Público Federal (MPF). In 2009, and after an extensive investigation, they filed 20 indictments against 34 defendants, including cattle ranches and meatpacking plants, for illegally deforesting 157,000 hectares in the state of Pará (Mesquita, n.d.). As part of this effort, the same prosecutors sent cease-and-desist letters to dozens of supermarkets and other retailers of animal products informing them that they might be criminally liable if they continued purchasing animal products without checking their origin.[22] This initial effort by prosecutors in Pará was emulated by federal prosecutors in other Amazonian states, who indicted cattle ranches and meatpackers in their respective states for violations of environmental laws, violations of indigenous people's rights, and for engaging in modern-day slavery, either directly or indirectly.[23] These laws were not new, but they had not been enforced with diligence against these powerful and scattered defendants before.[24]

In an unusual move, the MPF complemented their eminently legal approach with a series of online videos that taught consumers to care about the source of the meat they eat. The videos argued that anyone who bought meat from unknown sources contributed to illegal deforestation, money laundering, and slave-like labor conditions.

The lawsuits launched by the prosecutors and the name-and-shame campaign led by the environmental activists had an immediate impact. Within two weeks of Greenpeace's report being issued, targeted meatpackers lost 7–11 percent in share value (Lee and Rammohan, 2017: 8). Some of the largest food retailers in Brazil, including Pão de Açúcar, Carrefour, and Walmart, suspended contracts with the targeted meatpackers. Buyers of animal products such as Nike and Timberland formally committed to stop buying leather from the Amazon unless proper tracking and assurance systems were in place. Walmart declared its intention to require independent

[21] The activists had sharpened their tools during an earlier campaign, targeted at producers and buyers of soy that contributed to deforestation.
[22] This effort was the culmination of a long learning curve, in which different government agencies had tried for several years to regulate cattle ranching in the Amazon.
[23] For details, see https://reporterbrasil.org.br/2013/04/producao-de-carne-na-amazonia-entra-na-mira-do-ministerio-publico/.
[24] An introduction to the MPF's approach to law enforcement in general and environmental law in particular can be found in McAllister (2008). An examination of the modus operandi of the MPF can be found in Coslovsky (2014).

audits on the meat supply chain. And the BNDES, a major funder of cattle industry growth, revised its environmental guidelines for loans, requiring the adoption of traceability by the slaughterhouses so they could avoid purchasing cattle produced in areas of illegal deforestation or from ranches with forced labor, as well as requiring independent audits (Walker, Patel, and Kalif, 2013). Other banks active in the agricultural sector also adopted policies against lending to producers with recent deforestation on their properties.

Trial and Error

At first, meatpackers tried to fight the charges or deflect responsibility, but they soon relented and signed a deferred prosecution agreement (TAC, Termo de Ajuste de Conduta) as proposed by the prosecutor's office, in which meatpackers agreed to monitor their suppliers and avoid those who infringed environmental laws. The first agreement was signed in the state of Pará. Later a similar agreement was signed in Mato Grosso state, the largest cattle-producing state in the Amazon (Walker, Patel, and Kalif, 2013), and then in other states in the Brazilian Amazon. A few months later, some of the largest meatpackers signed an additional and more stringent public agreement with Greenpeace—the so-called Cattle Agreement—in which they agreed to avoid suppliers that engaged in *any* deforestation, independent of legality.

But even if meatpackers had agreed to monitor their suppliers, they lacked a detailed plan of action. They considered several alternatives, along three main tracks: first, they kept on negotiating with prosecutors to revise the TACs along more reasonable lines. For example, meatpackers asked for longer deadlines and less stringent demands. Instead of requiring that suppliers had land titles and environmental licenses, compliance with the TACs would require that ranchers obtain a CAR (Cadastro Ambiental Rural), which is a simpler document and the first step in the often long process that can lead to environmental licenses. The CAR ended up being a pillar of subsequent monitoring activities. The CARs are property-level records in a GIS-enabled database maintained by state-level Secretaries of Environment. An individual CAR entry contains the external boundaries of the rural property (in GIS terms, the "polygon") as well as the internal polygons of pasture, forest, and other environmentally protected areas such as riparian zones and steep inclines that the property contains.

Second, meatpackers started to reconsider their own managerial practices and internal business processes to better understand how they could comply with the monitoring requirements without compromising their market performance and with minimal disruption to their established routines and procedures. Many meatpackers bought cattle through middlemen, mostly on spot transactions, and did not retain reliable information or access to ranchers. As described by an interviewee, "[meatpackers] had no idea of how their suppliers were disposed geographically" (Lee and Rammohan, 2017: 15).

And third, meatpackers and their representatives searched for a proper tracking and monitoring system that would both satisfy the Brazilian regulators and transnational activists and be within reach given their capabilities and market constraints. The largest meatpackers recruited the Brazilian Association of Meat Exporters (ABIEC, Associação Brasileira das Indústrias Exportadoras de Carnes) to help explore alternatives. Their initial instinct was to use available data to identify viable suppliers. IBAMA, the Federal Environmental Enforcement Agency, had a deforestation list, but meatpackers soon learned that the list was incomplete and inaccurate. Some of the people involved in these negotiations suggested that the industry should adopt a system of private certification. Meatpackers viewed this option with skepticism; they believed certification would increase costs without a corresponding increase in revenue because customers would not pay extra for animal products with certified origin.

ABIEC favored monitoring as opposed to private certification, and its executive director suggested that meatpackers join forces to create a shared database of suppliers. This proposal was based on the fact that ranchers often sold cattle to more than one meatpacker in the same region, so it would be more efficient if meatpackers shared the burden of identifying and monitoring their suppliers. To ensure that sensitive information would remain private, the database would only show meatpackers data on their own suppliers. Still, meatpackers considered information about suppliers as trade secrets and refused to feed this information into a system that they did not fully control. Given this obstacle, ABIEC abandoned this plan (Lee and Rammohan, 2017: 9). ABIEC also considered proposing animal-level tracking, akin to the system that was being designed by Brazilian food safety authorities to comply with EU demands. Once again, this option was abandoned, for two reasons. First, the costs would be relatively high and not offset by higher prices and thus they would decrease profit margins. And second, some of our interviewees suggested that meatpackers and ranchers were afraid of providing regulators with the detailed information that animal-level tracking would generate.

Industry Collaboration

Coordination of efforts and collaboration across the industry played a significant role in the adoption of the tracking and monitoring system in the cattle supply chain. The enormous pressure put on retailers and meatpackers by environmental activists and the lawsuits triggered a number of multi-stakeholder initiatives that brought together the cattle supply chain and civil society to address concerns about deforestation. In addition to the aforementioned Cattle Agreement orchestrated by Greenpeace, other initiatives included the Leather Working Group and the Brazilian Working Group on Sustainable Beef (Grupo de Trabalho da Pecuária Sustentável). The latter is a working group committed to zero deforestation and sustainable beef that comprised environmental organizations and beef supply chain representatives including input suppliers, farmers, banks, research centers, retailers, and others. Eventually ABIEC became the leader of this working group.

Additionally, ABIEC established partnerships with NGOs, government organizations, and agribusiness consultancies to reduce deforestation, combat child labor, protect indigenous communities, intensify cattle production, reduce greenhouse gas emissions, and promote compliance with environmental regulations in the beef supply chain. Moreover, the organization signed Technical Cooperation Agreements (ACTs in Portuguese, Acordos de Cooperação Técnica) with the MPF and the Ministry of the Environment to support the implementation of the Forest Code (Lee and Rammohan, 2017).

A Multi-Pronged Approach to Green Innovation

As these efforts progressed, the largest meatpackers started to experiment on their own. For example, meatpackers such as JBS, Marfrig, and Minerva started by obtaining one geo-referenced location point from each of their direct suppliers and overlaying these points on maps of recent deforestation, protected areas, and indigenous lands (Walker, Patel, and Kalif, 2013). Suppliers located near a protected area or an area of new deforestation had to provide some assurance that the new deforestation was not on their property, otherwise they would be suspended from selling cattle to the slaughterhouse. In July 2010, as a result of this process, the slaughterhouses announced that they had suspended purchases from 221 ranches—a small proportion of the tens of thousands of ranches in their supply chain, but still an indicator that meatpackers could decrease, or even eliminate, deforestation from their direct suppliers in a relatively short period of time.

On a parallel track, ABIEC developed the protocol for a more sophisticated geographic monitoring system that was eventually adopted by meatpackers (Lee and Rammohan, 2017: 5). This system stood on three pillars: (a) the CAR; (b) public GIS-enabled databases of protected areas, newly deforested areas, and indigenous lands maintained by the Brazilian government; and (c) software applications and new managerial routines to combine these data and inform decision making. We examine each of these pillars below.

Cadastro Ambiental Rural (CAR)

The CAR was created by the federal government in the mid-2000s, but for several years it had almost no data. In June 2009, and thus immediately before the indictments and the name-and-shame campaigns, only 0.19 percent of fattening farms in the Amazon had a CAR (Gibbs et al., 2015). By early 2010—soon after the original TACs had been signed—60 percent of the cattle sold to meatpacking plants originated in a property with a CAR. In 2013, coverage reached close to 100 percent.

To a large extent, this change was caused by regulatory enforcement, as the deferred prosecution agreements (TACs) that meatpackers had signed with the prosecutors' office stipulated that meatpackers would only buy animals from ranchers that had registered their properties in the CAR. Instead of monitoring their suppliers through a single geolocated data point, meatpackers could gain access to the coordinates for the entire perimeter (i.e., the polygon) of their suppliers, as well as other topographical details.

But regulatory pressure alone was not enough. According to an interviewee, CARs are not complicated to produce, and many individuals in the Amazon have the skills to use handheld GPS devices to collect the coordinates of a rural property and map them in GIS-enabled software. Still, many ranchers found CARs expensive and hard to do, so meatpackers often helped them obtain their CAR.

Government Monitoring and Production of GIS-Enabled Databases

In addition to maintaining the CAR, the Brazilian public sector produces and disseminates important GIS-enabled datasets that allow for the monitoring and tracking of cattle in the Amazon. Perhaps the most important of these datasets is produced by the National Institute for Space Research (INPE, Instituto Nacional de Pesquisas Espaciais), a federal agency under the Brazilian Ministry of Science and Technology. Among its many activities, INPE runs the Project to Estimate Deforestation in the Amazon (PRODES, Programa de Cálculo do Desflorestamento da Amazônia). PRODES was instituted in 1988, and it relies on satellite data to estimate forest clear cutting in the Amazon.[25] The data is collected on an ongoing basis from multiple satellites to overcome problems associated with cloud cover; the result is a resolution of 6.25 hectares. PRODES publishes the final consolidated data annually, at the beginning of the calendar year for the preceding year. The entire dataset can be downloaded by anyone at no cost.

To promote adoption and usage even further, INPE has supported the development of a free open-source multi-user GIS software tool called TerraAmazon. This tool was specially designed by INPE and its partners for the analysis of vector-based geographical data over time, including changes in soil coverage. TerraAmazon can be enhanced by various plug-ins, and it relies on a

[25] See http://www.obt.inpe.br/OBT/assuntos/programas/amazonia/prodes.

dataset and library that are also free and open source.[26] These resources provide meatpackers with crucial information as they strive to monitor their supply chain.

Software Applications for GIS Cross-Referencing of Databases

To cross-reference the CAR, PRODES, and other relevant data, meatpackers have been relying on the services provided by technology firms such as AgroTools and Terras. AgroTools calls itself an AgTech company, "a world leader in agricultural intelligence." Most startups dedicated to the agricultural sector focus on the operations within the farm, including better seeds, fertilizer, irrigation, and monitoring of crops by sensors or drones. In contrast, AgroTools focuses on improving the business ecosystem where farms operate. As described by one of its senior managers, "The ranches and farms are not our client. We operate outside the farm's gate." In practical terms, the firm develops and sells software applications that convert "big data" into actionable insights for firms in the broader agricultural supply chain, including processors, retailers, banks, credit bureaus, traders, and insurers.

AgroTools offers multiple products, and its exact business model has evolved over the years. It was founded around 2008 to decrease information asymmetry in the market for agricultural-based financial bonds, which was done by using satellite imagery to check whether a given farm had indeed planted a given crop, when the crop would likely be harvested, and when it would be sold. Thanks to this assurance, issuers could charge more for their bonds.

According to its CEO, the expansion into monitoring for compliance was fairly straightforward:

> Around that time, those involved with cattle faced a serious challenge: all animals raised in the Amazon region were seen as causing deforestation. The large corporations that rely on animal products stopped buying from ranchers in the region, despite not really knowing if any given farm was promoting deforestation or not. How could we help solve this problem? The solution was to use satellite imagery to identify the pasture area for each ranch, and thus show buyers of animal products whether the originating ranch had engaged in illegal activities, including deforestation and slave labor.[27]

The product was designed to be simple to use. At any time, the meatpacker employee responsible for buying cattle can type the name of the ranch into a search field, and the software responds with a summarized assessment indicating overall compliance (green), alert (yellow), or non-compliance (red), as well as a more detailed list of important indicators (e.g., deforestation in 2017, deforestation in 2018, overlap with protected areas, etc.), and a symbol next to each one indicating compliance, alert, or non-compliance for that particular item. The user can also request to see the information on a map, and the software will display the farm and the areas within the farm that triggered the alert or the non-compliance warning.

To produce these reports, the software relies on more than 1,000 separate datasets (in GIS terms, "layers"). Some of these datasets are public, while others are private. The company has also developed a proprietary algorithm to identify the perimeter of each farm. As mentioned earlier, many farms have CARs, but the data are not always accurate or reliable. To fix this problem, AgroTools complements the data from the CARs with other datasets such as rural land registries to try to identify the most likely perimeter of each farm.

In case of disagreement, for instance when the manager of a ranch disputes that it engaged in proscribed activities, the company sends an auditor to verify the situation *in loco*.

[26] See http://www.terraamazon.dpi.inpe.br/sobre.
[27] See http://revistapesquisa.fapesp.br/2018/07/12/fernando-martins-agricultura-digital/.

As an added bonus, the software was designed so meatpackers could adopt it with minimal changes to their existing business practices. In essence, the software provided by AgroTools replaces the cattle buyers' old Rolodex with an electronic record that includes contact details as well as up-to-date information on whether the ranch is in compliance with environmental and other relevant regulations.[28]

In addition to providing services to meatpackers, AgroTools sells its software to downstream firms such as McDonald's and Walmart that also rely on animal products. The services that it offers are basically the same, but at a higher-level of aggregation. That is, the individuals within Walmart or McDonald's who are responsible for buying a shipment of meat can check whether the meatpacker selling it can provide assurances that the product is not associated with deforestation, slave labor, or other proscribed conducts.

In 2014, a group of researchers, environmentalists, and social entrepreneurs based in the Brazilian Amazon launched a startup called Terras App Solutions, a private company whose mission is to promote zero-deforestation agriculture and cattle ranching in the region. To fulfill this mission, Terras develops mobile and desktop applications that combine satellite imagery with other datasets to promote better land management practices, improve traceability of supply chains, and eliminate some of the monitoring obstacles that limit farmers' and ranchers' access to credit.

For example, the Terras app dedicated to rural credit allows small farmers to record data about their properties, cross-reference the data against existing databases to demonstrate compliance with applicable laws and regulations, and connect directly to banks that provide rural credit for small farmers. In turn, the banks can use the software to monitor their borrowers for compliance with environmental and other applicable laws over time. Among its various capabilities, this software checks whether rural properties overlap with areas designated as national protected areas, indigenous land, illegal deforestation, resettlement for land reform, areas with occurrence of slave-like labor, and more. It is already being used by the Banco da Amazonia, a regional development bank, to monitor environmental compliance among small farmers that apply for credit. As part of its products and services, Terras offers buyers of agricultural commodities the opportunity to monitor compliance and changes in land use among their suppliers. The tracking system is offered under a freemium business model, largely driven by the demand of small- and medium-sized meatpackers that lacked the resources for monitoring their supply chains.

Terras is a spinoff of Imazon, a renowned nonprofit working on deforestation monitoring in the Amazon. Even though Terras is a private company, it is best understood as a social venture that raises capital (and grants) from social investment funds such as those established by the Skoll Foundation, the Good Energies Foundation, the Nature Conservancy, and the Mulago Foundation.

As mentioned earlier, the adoption of monitoring technology has proceeded apace, as confirmed by independent research (see Gibbs et al., 2015) and also by third-party audits conducted by PricewaterhouseCoopers, BDO International, and other global accounting firms with experience verifying compliance with certification and monitoring systems in a variety of fields.

[28] As one would have expected, it is easier for larger meatpacking operations to adopt this software because they have dedicated teams of in-house cattle buyers. As mentioned earlier, the smaller meatpackers tend to rely on middlemen. In this sense, the growing tendency towards market concentration in the Brazilian meatpacking sector (with few, larger meatpacking companies) favored adoption of this particular GI.

In addition, as part of monitoring efforts cited in the Cattle Agreement, JBS, Marfrig, and Minerva agreed to auditing of their efforts to remove direct suppliers who are involved in deforestation. In April 2014, Greenpeace declared that it found Brazilian processors had systems in place to block the purchase of cattle from farms operating on cleared forest land, farms linked to slave-like working conditions, or farms located on indigenous lands or conservation areas. This was based on company audits covering operations in 2013. The audits detailed the companies' thorough geo-referencing systems that checked a sample of the property boundaries of their suppliers. The level of non-compliance by these three companies, based on the Cattle Agreement, was less than 1 percent for all criteria. Audits in 2015 told a similar story.

Corporate Image Benefits

This GI was not only shaped by a change in the business environment triggered by regulation and activists' campaigns, but it has also reshaped the business environment in return. In particular, the GI provided adopters with an unexpected commercial benefit. For example, in 2013, JBS launched an ad campaign to teach consumers to care about the source of the meat that they consume. This campaign was focused on one of its brands, Friboi. Broadcast repeatedly during prime time on TV, the campaign's tagline was "safe and trustworthy meat has a name" ("carne confiavel tem nome").[29] While meat was historically retailed as a generic commodity, JBS was trying to create a brand for Friboi, build consumer loyalty, and consequently capture higher profit margins when retailing unprocessed meat. This effort caused enormous controversy among numerous constituencies, including competitors (who viewed it as an attempt to downgrade their own products), consumer rights groups (who claimed that the company was simply complying with Brazilian law), vegetarians, animal rights advocates, and others. Some deemed the campaign successful, but it was soon derailed by a large corruption scandal that engulfed the company and its founders.

Other companies sought to leverage deforestation-free cattle to grow revenue. For example, Gucci, owned by apparel and accessories company Kering, introduced a new handbag line in 2013 that used sustainably produced leather sourced from ranches in the Brazilian Amazon that had earned the Rainforest Alliance certified seal of approval (Lee and Rammohan, 2017). Certification ensures the ranches curb deforestation, protect wildlife habitat, provide ethical treatment to livestock, and promote the labor rights of ranch workers. This initiative provides an illustrative example in the fashion industry, demonstrating that "leather can be produced in a way that benefits the environment and farming communities, while promoting the humane treatment of livestock" (Rainforest Alliance, 2013).

Persisting Challenges and Concluding Remarks

Even though the current environmental tracking procedures seem to have helped reduce deforestation overall, including deforestation caused by cattle ranches that supply animals to the participating meatpackers, the overall achievement should not be overstated. At present, the bulk of tracking activity is done at the **property level for first-tier suppliers**. This means that meatpackers and retailers monitor the farms that sell them livestock, not the animals themselves.

[29] See https://exame.abril.com.br/marketing/lewlara-tbwa-cria-nova-campanha-para-a-friboi/. Other efforts have been territory-based instead of supply-chain based. Similarly, the mayor of Paragominas, a municipality that used to be an epicenter of deforestation in the Amazon, launched an effort to overhaul the local economy, encouraging local firms to rely on sustainable practices instead of deforestation. See also http://www.meioemensagem.com.br/home/comunicacao/2017/03/22/carne-fraca-credibilidade-foi-alicerce-das-campanhas.html.

Further, they have no direct knowledge of what happens at the second- or third-tier ranches that sell animals to the first-tier suppliers.

This approach allows for two problems, or loopholes. The first big problem with property-level monitoring of first-tier suppliers is that it allows for "laundering," i.e., animals that have been raised on a farm that engaged in illegal deforestation can be sold to a farm that complies with regulation, and then sold to a meatpacker. This animal will be counted as "legal" since the farm that sold it to the meatpacker has not engaged in deforestation, but the calf might have been born and raised on a ranch that would not have passed muster.[30]

Second, incomplete coverage of the monitoring system allows for "leakage," i.e., animals that are raised on farms that infringe environmental laws can be sold to meatpackers that do not monitor their suppliers. In essence, it allows for a two-tiered system, where a compliant supply chain coexists with a black market for animals raised in a way that damages the environment.

Together, these two problems might cancel the benefits of the technology. As explained by an interviewee:

> Those who signed the TAC have deforested less, but farms that operate outside the system have been deforesting more than expected. So the final result might have been a wash; the decrease in deforestation in some farms was negated by an increase in other farms.

The first problem—laundering—could be solved with tracking and monitoring at the **animal level** (instead of the property level).[31] Animal-level tracking requires that each calf receives a unique tag at birth, and a system that records the exact ranch where this particular animal is raised over time. The technology for animal-level tracking exists, and it varies from simple plastic numbered ear tags to ear tags with RFID-activated chips or RFID implants that can be retrieved after the animal has been slaughtered. The problem, however, is that animal-level tracking can be expensive, cumbersome, and often inaccurate. Worse, the extra costs are not offset by a corresponding increase in revenue, so cattle ranchers are reluctant to adopt it. And even if adopted, animal-level tracking might increase the incentive for leakage, or the creation of a two-tiered system in which "legal" animals coexist with "illegal" ones.

Consumer demand played an important role in bringing about the Cattle Agreement through international media attention and greater demand for deforestation-free products. But at the moment, only one half of registered slaughterhouses in the Amazon have export licenses and two-thirds of these have zero-deforestation policies (Walker, Patel, and Kalif, 2013). However, if exports rise as predicted, the slaughterhouses with zero-deforestation policies may gain an even larger share of the market, or if other slaughterhouse facilities increase exports, international market pressure could encourage these companies to adopt similar tracking practices.

The bottom line is that illegal deforestation caused by cattle ranching in the Amazon is far from over (Greenpeace devoted a full report titled "Broken Promises" to these problems). While the meatpackers that signed the Cattle Agreement have taken important steps to ensure that they

[30] The *New York Times* published an article in 2019 explaining how this loophole might be hollowing out the entire initiative; see https://www.nytimes.com/2019/10/10/world/americas/amazon-fires-brazil-cattle.html.
[31] As explained by an interviewee, Brazilian food safety authorities already track the flow of animals through farms, from birth to slaughter, so the herd can be certified as free of foot-and-mouth disease, but the environmental authorities do not have access to the data.

buy from direct suppliers complying with zero-deforestation goals, the complexity of the pre-slaughterhouse supply chain and the large number of ranches that can supply each direct supplier make full monitoring and tracking more difficult (Walker, Patel, and Kalif, 2013). Moreover, meatpackers that signed the Cattle Agreement control only about one-third of Amazon exports and national slaughter. The remaining two-thirds of the industry includes legal and illegal slaughterhouses, which similarly service both national and international markets. Consumer concerns for the environment may eventually put pressure on these industry actors as well.

DISCUSSION OF THE TWO CASES

The two case studies presented in this paper offer several insights. First, they illustrate that even large and successful companies that are leaders in their field often face multiple constraints to the adoption of green technologies. One of the most important obstacles is that green products can be costlier to produce, but neither firms nor consumers are willing to pay more for a product just because it is green. Making adoption more difficult, consumers sometimes perceive greener products as being less attractive than conventional products with similar attributes (e.g., PCR containers might have a grayish color while containers made from virgin plastic can be bright and colorful). Given these circumstances, it is no surprise that firms are often reluctant to adopt green technologies.

Yet, even in the face of these obstacles, the firms we studied have adopted green technologies, so adoption was possible after all. In the eco-packaging case, the main driver seems to have been the company's desire to align its practices with its brand identity. In the cattle case, adoption of GI was driven by regulatory action paired with strong market incentives favoring monitoring practices.[32]

Second, the GIs studied were not only technological innovations but also included managerial, organizational, and marketing innovations. In the two cases, the adoption of a green technology relied on changes inside the firms both in their managerial practices (i.e., use of the LCA tool in eco-packaging and the change of buying practices in the cattle industry) and in their organizational structures (i.e., the establishment of multidisciplinary product committees in eco-packaging and the establishment of sustainability departments in meatpacking plants). Innovations in their marketing strategies are also part of this suite of GIs (i.e., differentiated marketing strategies for green products in eco-packaging and the attempted "legal meat" branding in the cattle industry).

Third, these cases allowed us to study GI from different perspectives, with one case (eco-packaging) where the government played a relatively minor role and the other (cattle industry) where the government action was crucial to trigger the diffusion of the GI. The eco-packaging case is about a company whose brand equity is wrapped around its strong commitment to sustainability. Thanks to this branding, Natura captures an economic rent, and it uses part of this rent to reassess its existing portfolio, consider new products that match its identity, and engage other parties to join eco-packaging initiatives. Strong and long-standing relationships with suppliers, direct engagement with consumers, and collaboration with public funding agencies are some of the factors that facilitated adoption of the GI in eco-packaging.

[32] In a less charitable interpretation, it is possible that leading firms adopted the GI because they knew they could count on loopholes to remain competitive.

The adoption of the monitoring technology by meatpackers to sever the causal link between cattle ranching and deforestation in the Amazon illustrates the flip side of the eco-packaging case. In this case, the forceful intervention of regulators and activists, as well as more awareness on the part of consumers in Europe, the US, and other advanced industrial nations that import animal products from Brazil, pushed hesitant companies into revamping their procurement practices. The case also illustrates the critical role of activist NGOs in setting the stage for active policies.

In contrast to Natura, meatpackers were not used to having long-standing partnerships with suppliers to solve problems related to sustainability. And yet, meatpackers had to look more closely at their supply chain. Again, technology was mostly available and no groundbreaking research was needed to allow for monitoring, but it was hard for meatpackers to find the best way to use the technology given the configuration and practices of their supply chain. An added obstacle was competition among meatpackers, as they hesitated to collaborate with competitors to solve shared problems. However, notwithstanding initial reluctance, companies in this case joined several working groups and multi-stakeholder initiatives that helped them experiment and eventually find acceptable solutions.

This latter point takes us to our final insight. In both instances, adoption was conditioned on the existence of an "innovation space," i.e., a partial or temporary sheltering from cutthroat price competition that allowed for experimentation, investment, coordination, and gradual achievement of scale in relevant nodes of the supply chain. In the Natura case, the space was created by the company itself, as it proactively used its resources and influence to promote its identity as a purveyor of sustainability. In turn, this identity created additional resources that supported the effort. The space was inevitably small. Lacking more room for maneuver to increase the use of sustainable materials in its packaging, Natura has to search far and wide for all opportunities, for example by slightly increasing the percentage of PCR PET in their packaging without altering appearance and functionality, or agreeing to incur a small loss on one green product as long as this loss can be subsidized by additional revenue obtained elsewhere in its portfolio.

In the cattle case, the space was represented by an adjustment period created under the TACs, when meatpacking companies were able to test various solutions. This metaphorical space gave them some margin for trial and error, and thanks to the experimentation the firms eventually found a viable way to comply with regulation.

These innovation spaces can be created or maintained by multiple means, including a firm's branding, private voluntary initiatives, product regulation, price controls, or even subsidies. Depending on the circumstances, industry-wide coordination could be beneficial, as it would allow for increased scale for eco-products and would also raise awareness among consumers. Independent of the exact instrument, public policies can help, and that is why governing authorities have an important role to play in fostering the adoption of GIs.

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