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Not all supply chains are created equal: The linkages between soy local trade relations and development outcomes in Brazil

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ABSTRACT

Global agricultural trade is a key driver of socioenvironmental transformations in rural areas, including development dynamics. By creating revenue and wealth opportunities, it influences the economic and social relations in a landscape. However, not all landscapes shaped by a given agricultural sector are the same: one variable is how supply chain actors and their embedded networks (including commodity traders, farmers, and input suppliers) develop, maintain, or shift relationship patterns over time. To explore the connections between development and the nature of such trade relationships, particularly between farmers and commodity traders, we take soy as an emblematic example and compare four different municipalities in Brazil. The contrasting cases are Passo Fundo (RS), an old soy-growing area in Brazil's South, in a consolidated agricultural region with relatively persistent relationships between farmers and commodity traders; Sorriso (MT), in a more recently occupied agricultural region in the country's Center-West, with relatively low persistence of supply-chain relations; Balsas (MA), a place with persistent supply-chain relations in the so-called Matopiba agricultural expansion frontier; and Bom Jesus (PI), also a frontier municipality but having less persistent relations. We build on quantitative assessments of supply-chain stickiness in those four municipalities, which is understood as the persistence of those commercial relationships in contrast to volatility. Analyzing qualitative data collected through over 30 field interviews with local actors, we show how soy supply-chain relations significantly differ across places. We distinguish them particularly in terms of lock-in effects on farmers and level of trust. Crucially, our findings identify supplier cooperatives as key mediating institutions in the supply chain, counterbalancing the power of commodity traders over farmers. Such cooperatives are also associated with more equitable development outcomes. Yet, they require high levels of social trust and distribute wealth primarily within the sector, leaving other farmers excluded.

1. Introduction

Recent growth in agricultural commodity production and international trade has radically shifted landscapes worldwide towards an increasingly globalized agri-food system (Canfield et al., 2021; McMichael, 2009). That has triggered important environmental and socioeconomic changes across the globe (da Silva et al., 2017; Escobar et al., 2020; Green et al., 2019; World Bank, 2019). On the one hand, the increasing production of agricultural commodities – including to supply distant markets (da Silva et al., 2017) – has offered crucial opportunities for rural development and income generation in rural areas (Martinelli et al., 2017; Oliveira & Hecht, 2016; Weinhold et al., 2013). On the other hand, agricultural expansion has also been a critical driver of land-use changes and deforestation, biodiversity loss (Curtis et al., 2018; Green et al., 2019), increased greenhouse gas emissions (Meyfroidt et al., 2014; Pendrill et al., 2019), the displacement of local populations and the erosion of rural livelihoods not involved with the few select agricultural commodities demanded by the global market (Russo Lopes, Bastos, & Reis, 2021). What kinds of outcomes prevail locally, however, vary significantly across contexts.

Not all agricultural supply chains are the same. The socioeconomic and environmental consequences of their setup vary considerably

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depending on some well-known factors (e.g., labor requirements, type of crop) and others that are not yet fully understood. For instance, a common feature of the global agri-food system is market volatility (Clapp, 2009; IPES-Food & ETC Group, 2021). That includes not only commodity price fluctuations but also shifting supply-chain relations, such as changing sourcing regions or corporate reallocation of resources (Bastos Lima et al., 2019; le Polain de Waroux et al., 2016). Another important and understudied aspect that shape these supply-chain relations is the role of local sociocultural dynamics, which encompasses issues of trust, reciprocity, values and reputation (see Wesz, 2019).

Soy is one example of these global agri-food systems that may have different socioeconomic and environmental consequences depending on not yet fully understood factors. Soy is also one of the world's fastest-expanding crops, widely used by the food industry, in animal feed, and increasingly for the bioeconomy (Bastos Lima, 2021a). It has been a boon in some regions, but it can also be a blight for others, depending on who is included and how the supply chain is organized ((de Oliveira & Schneider, 2016; Russo Lopes et al., 2021)).

One of these not fully understood supply chain factors is "stickiness" (Leijten et al., 2022; Reis et al., 2020, 2023). This concept refers to the stability or volatility of supply chain networks and relationships. Reis et al. (2020) define stickiness as "the maintenance and recovery, over time and through shocks, of supply chains' geographic network configurations." Stickiness, therefore, not only characterizes the linkages between specific places of production or consumption and certain actors (e.g., producers, traders, retailers, consumers); but also help identify and assess the geographical embeddedness (Bair, 2008) of given production networks and trade flows – as well as their impacts on development. Even within the same sector, not all supply chain relations are equally (un)stable. Their stickiness varies due to multiple reasons that are only now starting to be understood (Reis et al., 2020, 2023). Likewise, what greater stickiness or volatility entails on the ground – particularly to supply-chain relations between farmers and commodity traders – merits further examination.

Our research question here is: How does the level of stickiness in farmer-trader relation in different regions impact their development outcomes? To answer this question and analyze the relevance of stickiness for supply-chain relations, we focus our qualitative investigation on the relationships between soy farmers and commodity traders, a link sometimes – but not always – mediated by cooperatives, warehouses, and other local intermediaries. We used quantitative measurements of stickiness from Reis et al. (2020) to distinguish patterns in trading relationships between Brazilian soy logistics hubs and export traders, and from these we selected four contrasting municipalities. We then compare the rural development patterns and stickiness levels of those four places that are key soy-supplying regions in Brazil. Our analysis draws from extensive fieldwork and qualitative data from interviews as well as quantified measures of supply-chain stickiness, socio-economic features, and land-use change. It is important to highlight that the relationships taken into consideration in the quantitative measurements by Reis et al. (2020) sum up all trading relations between soy producing and trading municipalities (i.e., any farmer within that municipality, or local traders that serve as aggregators) and export traders. Therefore, in that quantitative measurement, we do not see individual relationships but collective relations aggregated at the municipality level. In the qualitative assessment conducted specifically in this research article, however, we have been able to investigate individual relationships.

This article is structured as the following. First, we elaborate on our analytical framework and particularly on the concept of stickiness as applied to the context of soy supply chains. Second, we present our research methodology and data-collection methods alongside the four case studies in Brazil, explaining why they have been selected, and why they represent key development outcomes that have stickiness as a differentiating factor. Third, we examine the stickiness of farmer-trader relations, notably with respect to power issues and from the farmers' point of view, as they tend to be the weaker stakeholders in that relationship. We expose in detail various outcomes when it comes to farmer-trader relations irrespective of their stickiness or volatility, and discuss how cooperatives have played a key role aiding soy farmers in multiple ways vis-à-vis multinational commodity traders. It is important to highlight that our intention is not to exhaust the reasons why Brazil's multiple soy supply chains have differences – including in their development outcomes. Rather, our contribution lies in presenting and demonstrating how stickiness, among other factors, plays a still understudied role.

2. Stickiness and farmer-trader relations in soy supply chains

2.1. Understanding supply-chain stickiness

Not only agriculture but also the prevailing forms of commercial relations and farmer organizations influence the type of agrarian or socioenvironmental change in a landscape (Reardon et al., 2009). Such outcomes depend significantly on settlement patterns, forms of land use, the level of land tenure security, availability of capital and accessible credit – or the presence of private colonization firms or public-driven colonization enterprises (Jepson, 2006) –, as well as the existence of farmers' associations or cooperatives. Cooperatives are known to be crucial determinants and drivers of rural development (Garrett et al., 2013a; Jepson, 2006; de Sousa & Busch, 1998). However, it remains unclear how elements such as social embeddedness (i.e., how supply-chain relations depend on the social context) and trust – both of which underlie the formation of cooperatives (Ghosh & Fedorowicz, 2008; Granovetter, 1985; Skandrani et al., 2011) – relate to the stickiness or volatility in contemporary supply-chain relations. Likewise, there is a need for a better understanding of how stability or instability in supply chains in turn affects issues of trust, social embeddedness, or the power relations between farmers and traders.

An emerging literature observes that supply-chain stickiness is a product of social and economic relations that consist of three key components: lock-in effects, trust and social relations, and power (Leijten et al., 2022; Reis et al., 2023). First, lock-in effects are forms of path dependency that encompass various factors usually related to the institutional context, local history, or an actor's past decisions constraining their supply chain relationships (see Russo Lopes & Bastos Lima, 2022). Such effects can be (i) infrastructural, such as when physical facilities bind together different supply chain actors (Payo et al., 2016; Vanloqueren & Baret, 2009); (ii) financial, e.g., through biased or preferential credit mechanisms (Bicudo Da Silva et al., 2020); (iii) technological, e.g., when one actor controls – for instance through patents – key technologies upon which others depend (Fares et al., 2012); (iv) institutional, from existing norms or governance mechanisms in place (e.g., the Amazon Soy Moratorium); or (v) lock-in related to consumer preferences, such as for products of a certain origin or quality (Akkermans, 2001; Narasimhan et al., 2009). Lock-in effects are, therefore, supply chain situations in which firms bind certain upstream suppliers (e.g., farmers or other firms) or downstream customers (e.g., end-consumers), preventing them from engaging with other firms and, thus, excluding other actors from accessing certain economic benefits and opportunities (Gereffi et al., 2005).

Second, the social context – i.e., the networks of social relations in which economies are embedded and which influence the market structure (Granovetter, 1985; G. Krippner et al., 2004; Polanyi, 1944) – may also determine the stickiness of subnational supply chain relationships (Beckert, 1996; Uzzi, 1997). Such embeddedness means that commercial decisions may be made for various reasons, not only profit. Those decisions may have to do with trust, family or ethnic relations, and may result from preferences based on social values and norms (Bair, 2008). Trust, in particular, can make commercial relationships more persistent over time (Bair, 2008; Granovetter, 1985; Henderson et al., 2002; Krippner & Alvarez, 2007; Polanyi, 1944; Uzzi, 1997). Such intangible dynamics have been observed in South America's Southern Cone, for

example, where large soy traders are highly de-territorialized and yet base many of their commercial decisions on relations of trust, reciprocity, proximity, as well as family and friendship ties (see Wesz, 2016).

Third, supply-chain relations are influenced by power asymmetries that go beyond the business constraints discussed earlier. For instance, many farmers are generally subject to the power of large agricultural commodity traders that impose certain production standards, or the utilization of given products or techniques, or who translate consumer-market preferences and restrictions (Clapp, 2021; Coe et al., 2008; Gereffi, 1994, 2014). That power can make supply-chain relations "sticky," for example when downstream actors have incentives to procure specific, unique or specialized commodities. Depending on the abundance of supply and demand, growers who provide such special products may gain market power and even prevent the emergence of competitors – resulting, among others, in higher supply-chain stickiness. Ultimately, issues of power are intertwined with the types of lock-in and issues of trust discussed earlier (Schmitz et al., 2016; Wilson, 2014). Therefore, in the results section we will analytically tease out forms of lock-in, trust and social embeddedness to detail the various elements present in such agricultural supply-chain relations, before discussing how power relations are embedded in these dynamics.

2.2. Soy supply chains in Brazil

Soy has increasingly become South America's flagship crop, particularly in Argentina, Paraguay, and Brazil (Song et al., 2021). Brazil's cultivated area alone leapt from 10 million hectares (Mha) in 1990 to whooping 35.5 Mha in 2020 (Mapbiomas, 2021), as consolidated agricultural regions are joined by expanding frontiers. Substantive land-use change happened throughout Brazil in past decades, replacing smallholder farming, pastures, or native vegetation for soy. Currently, however, that is concentrated in the Amazon and in the Cerrado – the world's most biodiverse savanna and Brazil's second largest ecosystem (Strasburg et al. 2017). Such a boom has been driven by strong global demand for animal feed protein, notably in China and the EU (Kim et al., 2018; Wilkinson et al., 2022). To a lesser extent, Brazil's domestic use of soy for its poultry or pork industries has also played a (minor) role alongside soy's growing appeal for the bioeconomy (e.g., as a biodiesel feedstock) (Lima et al., 2011; Trase 2020a; Bastos Lima, 2021b). Such a rapidly growing sector has been a boon for large-scale agribusiness, yet the social and environmental impacts of soy's unfettered expansion have been notable. Cerrado clearing has been rampant alongside the displacement and resource dispossession of smallholder farmers and traditional communities in the frontiers (Russo Lopes et al., 2021; Schilling-Vacaflor et al., 2021). Those weaker actors and their pleas have been mostly been neglected while soy expands (Bastos Lima & Kmoch, 2021). Still, Brazil's soy supply chain is far from being homogeneous. Its substantive growth hides diversity within the sector as well as tensions between soy suppliers and the commodity traders who arguably dominate the chain. We do not expand on the environmental implications of soy supply-chain linkages as other works have already looked at that through a stickiness lens (see Leijten et al., 2022; Reis et al., 2021, 2023), choosing instead to look at development here.

There are common features across Brazil's entire soy sector, while others vary considerably. For one, throughout the country soy has tended to be intercropped with corn, which also is largely used for animal feed. There is, however, a diversity of supply-chain arrangements and ways through which growers relate to commodity traders. The latter are comparably few; once dominated by the so-called ABCD companies (Archer Daniels Midland, Bunge, Cargill, and Dreyfus), giants such as China's COFCO and numerous smaller traders have joined the sector. That said, commodity traders still work as a bottleneck before soy can reach its global consumers, most of them overseas. Soy farmers can be organized in cooperatives or not; they may sell directly to a commodity trader or first to a local grain aggregator (a "cerealist", in Brazil's parlance); and such sales may take place either through previous contracting (in which traders tend to then finance part of the soy cultivation as well as sell agricultural inputs to the farmer) or under so-called spot trading, whereby farmers negotiate soy supplies "on the spot" after harvesting (see Fig. 1). As we shall see, such patterns vary considerably from region to region, and they may offer lessons for understanding development patterns and the future of places under the growing influence of soy.

3. Case studies and research methodology

3.1. Consolidated regions vs. Agricultural frontiers in Brazil

A first step towards exploring the variety of soy supply-chain relations in Brazil is to note the important distinction between consolidated agricultural areas and the frontier regions where expansion still takes place. The former, located mostly in the country's South and Southeast regions, generally have older, more established rural settlements. They tend to be more industrialized and economically developed. Wealth and land are, on average, also more evenly distributed (Imaflora, 2021). Those farmers are better capitalized and add more value to their production as opposed to frontier farmers, who tend to be less capitalized and more reliant on credit from banks or commodity traders (Garrett et al., 2013a). In consolidated regions, such traders barely engage directly with farmers – they source primarily from small warehouses or cooperatives, who are then the ones engaging with soy growers. Farmer cooperatives are particularly predominant in the southern Brazilian states of Paraná (PR), Rio Grande do Sul (RS), and Santa Catarina (SC) (see Fig. 2), which have been largely populated by German, Italian and other second- or third-generation European immigrants. They have often formed tight-knit ethnic communities that have family-based agriculture and rural cooperatives as an important social and economic institution (Jepson, 2006; Stoffel, 2013). A similar phenomenon is present in neighboring Paraguay, where Mennonite and other German immigrant communities have played a key role in promoting soy agribusiness based on farmer cooperatives (da Costa & Hoff, 2020).

Agricultural frontier regions in turn present a very different socio-economic reality. There, farmers tend to have larger properties and to negotiate directly with commodity traders. That is mainly the case in soy-expansion regions such as Mato Grosso (MT) and in the so-called "Matopiba" states of Maranhão (MA), Tocantins (TO), Piauí (PI), and Bahia (BA). Frontier farmers in Brazil tend to trade greater volumes of soy. Typically, they also commit larger shares of their expected harvests to traders in exchange for advance money (credit) and input supplies. Such a commitment of crop harvests in future contracts is relatively minor in the consolidated regions, where farmers leave more grains for spot deals made after harvesting. In Brazil's South, cooperatives supply virtually all of their members' needs for inputs, credit, technical assistance, agricultural supplies, as well as fuel, clothing, groceries, etc (Bacaltchuk et al., 2015). In a sense, cooperatives make farmers in consolidated regions be closer among themselves than to the traders to which they sell.

Another contrast is that land prices are much higher in Brazil's consolidated southern regions than in the north, due to better access to infrastructure, capital, and larger consumer markets. Therefore, for decades many soy farmers have been selling their southern lands of origin to buy larger tracts in the agricultural frontiers further north (Fearnside, 2008). Growing demand for soy in both the domestic and international markets has made that movement particularly attractive (Cattelan & Dall'Agnol, 2018; Lima, Skutsch, & de Medeiros Costa, 2011). Alternatively, some farmers remain in the south but also invest in northern lands as their secondary properties.

As such, it is important to understand that Brazil's consolidated and frontier regions are intertwined. One could say that the country's South Region is a "producer" of soy farmers, who flow out to other regions of

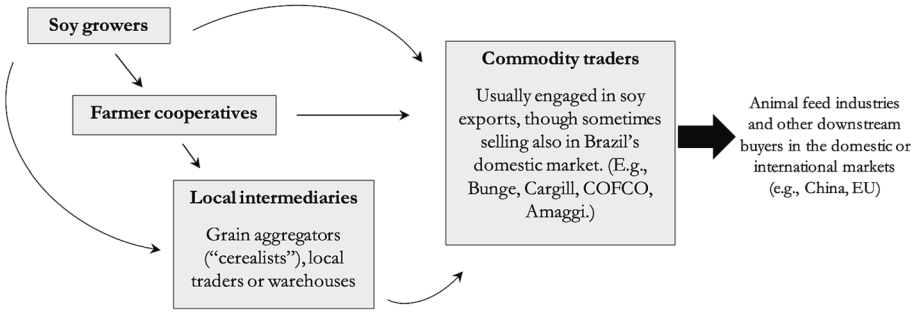

Fig. 1. Usual pathways of the soy supply chain in Brazil. Sales take place either through pre-harvest contracts or through post-harvest "spot trading.".

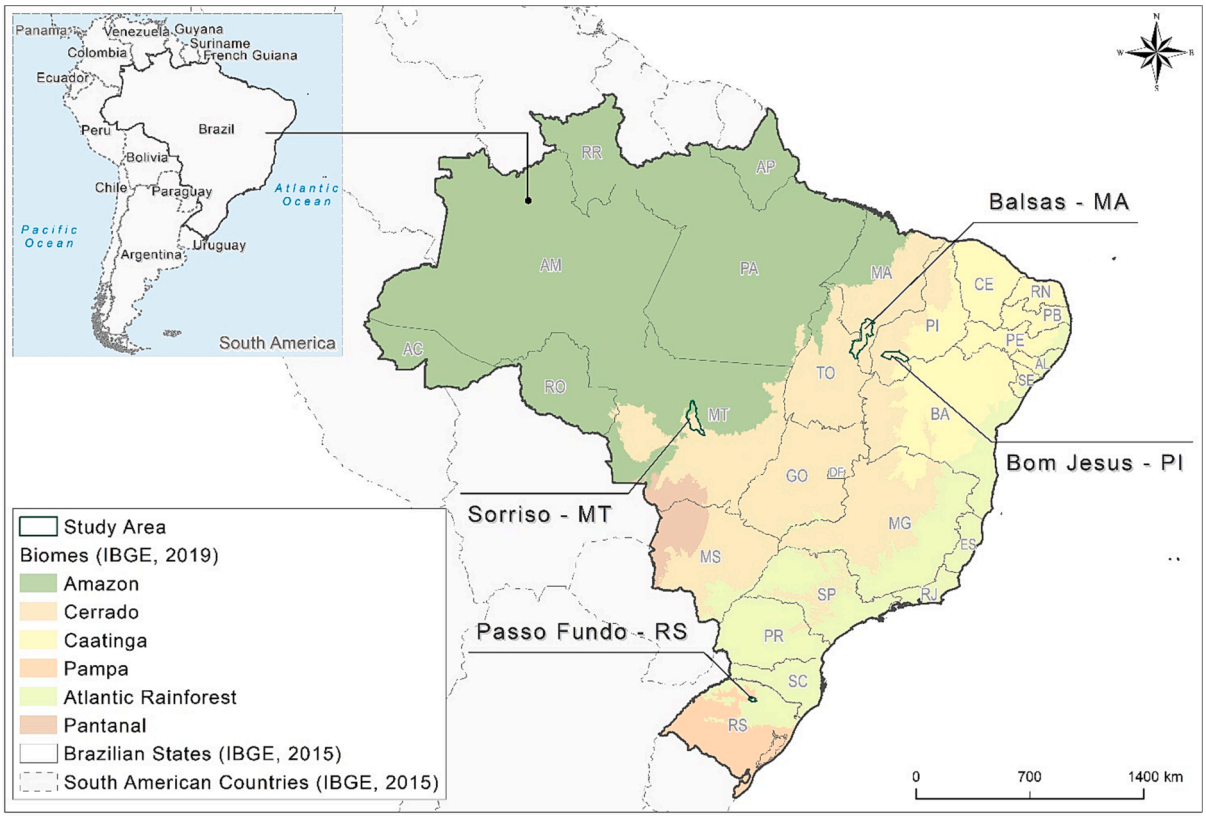

Fig. 2. Map of Brazil showing its biomes, states, and the four municipalities selected as case studies.

the country and internationally in South America (e.g., to Paraguay). In a highly stylized summary, Brazil's agriculturally consolidated regions in the South are more economically equal, with land and income being more evenly distributed. Northern frontiers, in contrast, are more economically unequal, tending to have more a concentrated distribution of land and income (Favareto, 2019; Garrett & Rausch, 2016).

3.2. Data collection and methods

We first used the quantitative measurements provided by Reis et al. (2020) to screen municipalities based on their levels of stickiness (See Supplementary Methods 4 in the Supplementary Material for how stickiness is calculated). Reis et al. (2020) aggregated farmers, traders, cooperatives, small warehouses, and local intermediaries supplying to local traders at the municipality level. For that, Reis et al. (2020) used Trase's (2018) Brazil soy data. The Trase (2018) dataset covers all transactions of soy exported as raw beans, oil, meal or cake. It identifies all producing and exporting municipalities and their export transactions with exporters, importers and destination countries. Therefore, all farmers of a given exporting municipality are bundled in the dataset, as one single row (the existence, and if yes volume, of soy traded between a certain municipality and a certain trader in a certain year). With this dataset, Reis et al. (2020) were able to measure the stickiness between all Brazilian soy exporting municipalities and soy traders annually over the 2003–2017 period by applying network analyses (as explained in the Supplementary Material). Thus, the stickiness index in itself measures the municipality-to-trader relationship, while the fieldwork data (see below) focuses more on farmer-to-trader or cooperative-to-trader relationships.

From that screening of 468 municipalities, where Reis et al. (2020) measured the stickiness between key Brazilian soy producing and trading municipalities considered as logistics hubs, we selected 11 for fieldwork. Then, we explored some contextual factors that could help define whether a municipality is a frontier or consolidated region (See Tables S2 and S3 in the Supplementary Material for the quantitative stickiness measurements and characterization of contextual factors, also in Table 2). We then carried out fieldwork in these 11 municipalities, from which we selected the four case studies used in here. In the 11

Table 1
Four municipalities studied.

	High Stickiness	Low Stickiness
Consolidated Region	Passo Fundo (RS)	Sorriso (MT)
Frontier Region	Balsas (MA)	Bom Jesus (PI)

Table 2
Summary of supply chain stickiness, local rural and socioeconomic contexts, municipalities' profile description, and fieldwork.

Case study	Passo Fundo (RS)	Balsas (MA)	Sorriso (MT)	Bom Jesus (PI)
Stickiness Indicators				
Temporal average stickiness (TCi) (Reis et al., 2020)	0.79	0.79	0.68	0.28
Stickiness position in the 468 soy municipalities in Reis et al (2020) (ranked by decreasing stickiness)	75th	72nd	110th	222nd
2003–2017 stickiness (Reis et al. 2020)	0.00	0.41	0.26	0.00
Farming Indicators				
1985 farming area (%) (Mapbiomas, 2021)	62.38	2.03	22.12	0.79
1985 native vegetation (%) (Mapbiomas, 2021)	34.02	97.81	77.06	98.56
2019 farming area (%) (Mapbiomas, 2021)	71.68	22.53	68.60	21.41
2019 native vegetation (%) (Mapbiomas, 2021)	21.28	76.90	30.00	77.92
Socioeconomic Indicators				
% Working population employed at agriculture (2010) (IBGE, 2020)	3.32	17.51	15.75	24.67
(%) Gross agricultural added value into local GDP (2016) (IBGE, 2020)	2.23	18.49	26.65	11.82
Per capita GDP (2016) (BRL) (IBGE, 2020)	28,000	17,000	45,000	13,900
Monthly *Per capita* income (2010) (BRL) (IBGE, 2020)	1,068.69	531.60	988.74	501.14
Gini index (2010) (IBGE, 2020)	0.53	0.55	0.55	0.63
Information on the data collected				
Number of interviewed actors	10	13	9	13
Participant observation events	1	1	0	1
Fieldwork days	5	7	5	7
Neighboring municipalities visited	2	1	3	1

municipalities where fieldwork and interviews took place, we assessed the qualitative dimension of stickiness between farmers and traders. Therefore, this analysis offers a complementary perspective on the quantitative measurement of stickiness on municipality-traders relationships obtained from Reis et al. (2020).

On the one hand, there is a general and conceptual definition of stickiness, and on the other hand, there are two forms of operationalization of this definition that are used in this paper. First, a quantitative measurement focused on municipality-trader relations based on Reis et al. (2020), and second, a qualitative approach focusing more on farmers, cooperatives, and traders relations, based on qualitative interviews and fieldwork. In the latter, volumes and quantities transacted were not taken into account, but rather the existence of commercial linkages and what were the factors sustaining or disrupting these linkages. Both are consistent with the conceptual definition and provide complementary insights. Although they are different, we expect that they are related to each other, and investigating these relations is part of the underlying goals of the paper.

The first author conducted fieldwork between July and October 2019 in Brazil to inquire about local actors' perceptions on how soy supply-chain relations arise, unfold, stick or break – and the implications thereof. In this paper, we use 32 interviews in the four selected municipalities, from a total of 83 interviews including other municipalities. We also use here one key-expert consultation from a total of 21, and participation in two events in two municipalities from a total of six (see Table S1 in the Supplementary Material). The interviewees were selected using a snowball sampling method (Patton, 2002), starting with gatekeepers and key informants. In places where we had no previous connections, the first author contacted the presidents or leaders of local farmers' unions, rural associations, or academic researchers. The interviewees included soy-and-corn growers, farmer unions or association leaders, agricultural input suppliers, local procurement managers or commodity trader procurers, local warehouse and storage companies, transportation companies, technical assistants, academic researchers, NGO representatives, consultants, and certification companies.

The fieldwork data's qualitative analysis involved a semi-structured guide for the interviews, allowing flexibility for spontaneous topics and subjects (Patton, 2002; Silverman, 2010). The notion of stickiness was explained to interviewees as representing stable, consistent, or loyal relationships between buyers, suppliers, and commercial partners. Acknowledging the central role of situated knowledge in qualitative and geographic research (Nielsen & D'haen, 2014; Simandan, 2019), the first author is Brazilian, originally from the countryside, and therefore conducted all the qualitative analysis in Brazilian Portuguese as his first language. The duration of the interviews ranged from 40 to 150 min. Twenty-eight interviewees allowed audio recording, from which we use some quotations to illustrate our findings in the stakeholders' own voices. Given the tensions and the contentious nature of agri-food politics and supply-chain relations in Brazil, all quotations have been anonymized.

As to the quantitative measurements of stickiness for each case study, we used an index of time-averaged stickiness over 2003–2017 (the "temporal average stickiness (TCi)" in Table 2). At the municipality level, it measures the stickiness between producer municipalities – aggregating farmers, cooperatives, small warehouses, and local intermediaries – and commodity traders (Reis et al., 2020). That index is the arithmetic mean between the successive stickiness indices over successive years (e.g., the stickiness index of 2004 compares the trading relations of a municipality in 2003 vis-à-vis those in 2004). The annual indices, and thus the time average, range between zero and one. Zero means a complete reconfiguration of the supply network around the node (i.e., the producer municipality supplying to traders), while one means complete maintenance of the supply network. In other words, one means absolute stability or stickiness, whereas zero means absolute volatility or total non-stickiness. High stickiness indicates that the supply network has been more stable over time, while low stickiness means it has been more volatile in terms of the traders that sourced soy from that municipality in a given period.

We can consequently assess the stickiness index across municipalities, characterizing each as comparatively high or low (Table 2). Such a comparison is relevant because the index per se is dimensionless, and so its absolute values are not easy to benchmark. We also used here the stickiness index comparing the earliest and latest years available in our data ("2003–2017 stickiness" in Table 2), which is the stickiness calculated across the entire period, by comparing the supply network configuration in 2003 and in 2017 (Reis et al., 2020).

3.3. Case-study sites

To select the studied municipalities, we constructed a geographic stratification identifying regions where soy cultivation began at different times, and in different socioeconomic, technological, and biophysical contexts. These regions exhibit different production arrangements, technology or productivity levels, and logistics access (Tables S1 and S2). Four municipalities were chosen to represent cases of low and high stickiness, in frontier and in consolidated regions, to explore and elicit their similarities and differences (Table 1).

3.3.1. Passo Fundo – Rio Grande do Sul (RS)

Passo Fundo is a soy-producing municipality and logistics hub placed in the center of Brazil's southernmost state, Rio Grande do Sul (RS). It is the region where soy was first commercially introduced in the country in the 1960 s (Bacaltchuk et al., 2015). Passo Fundo was selected as a case study because it is located in a consolidated agricultural region and has a high-stickiness profile, meaning it shows stable relations between soy suppliers and commodity traders (see Table 2).

Passo Fundo is also an example of a developed agro-industrial municipality where soy is well-established. In 1985, 62.4 % of its area was used for farming (crop and pasturelands), while 34.0 % of the municipality was covered by native vegetation. In 2019, farming covered 71.7 %, and native vegetation 21.3 % (Mapbiomas, 2021). Fig. 3 shows some of these land-use changes over time alongside the massive growth in soy cultivation as opposed to mixed farming. Socioeconomic indicators reveal that, comparatively, this is a more developed and consolidated agricultural town than the other cases (Table 2).

Passo Fundo's temporal average stickiness annually calculated over 2003–2017 (TC*i*) is 0.79, and the longest 2003–2017 stickiness is 0 (Table 2) (Reis et al., 2020). These figures might appear contradictory, but they are not. They mean that Passo Fundo has been reconfiguring its supply chain network slowly over time. These small yearly changes (reflected in the high stickiness when comparing successive years) resulted in a complete supply network reconfiguration between 2003 and 2017 (reflected in the lowest stickiness comparing 2003 to 2017). This fact implies relative supply chain stability on a year-to-year basis compared to the other municipalities in this study. However, it also means that the Passo Fundo's supply chain was totally different in 2017 in comparison to 2003.

3.3.2. Balsas – Maranhão (MA)

Balsas is a relatively recent soy frontier. Production began only in the 1990s, though it has rapidly expanded since the 2000 s. It is a soy logistics hub located in the south of Maranhão State, part of a region abbreviated as Matopiba – Brazil's latest agricultural frontier, which includes municipalities in the states of Maranhão, Tocantins, Piauí and Bahia (Bastos Lima & Kmoch, 2021). Balsas's stickiness has been relatively high when it comes to municipal-level aggregated relationships between soy farmers and commodity traders. Although both municipalities show high levels of stickiness, Balsas contrasts markedly with Passo Fundo in that the former is ridden by poverty, inequality, and underdevelopment (see a comparison of socioeconomic indicators in Table 2). A few large commodity traders dominate Balsas's soy market, with a clear export orientation, and little value is added to the local economy (Russo Lopes et al., 2021; see also Favareto et al., 2019).

Another contrasting feature in relation to the earlier case study is that, in 1985, Balsas had only 2.0 % of its area occupied by farming (crop and pasturelands), with 97.8 % of the municipality covered by native vegetation. As of 2019, farming already represented 22.5 % of its area vs. 76.9 % of native vegetation (Mapbiomas, 2021) (Table 2). That reveals the speed of agricultural expansion in what still is a resource frontier (Bastos Lima & Kmoch, 2021). Soy cultivation has surged in the region (Fig. 4) to create a cash-crop-based and export-oriented economy, though municipal socioeconomic indicators reveal how poverty remains widespread, with land and wealth being very unevenly distributed.

3.3.3. Sorriso – Mato Grosso (MT)

After soy cultivation began in Mato Grosso State in the 1970 s, the sector boomed in Sorriso and other adjacent municipalities through the 1980 s and 1990s (Garrett et al., 2013b). Once a soy frontier, this is now a consolidated agricultural region. Sorriso is a particularly remarkable case – regarded by some as a "model city" – as it has become a key logistics hub for Mato Grosso's soy-led agribusiness. Observers remark on its wealth and prosperity, with large avenues and relatively good urban planning when compared to most Brazilian cities (Interviews). The soy agroindustry showcases it as an illustrative example of the development it has brought about, while flagging the city's positive socioeconomic indicators (Table 2), including on education and sanitation (Garrett

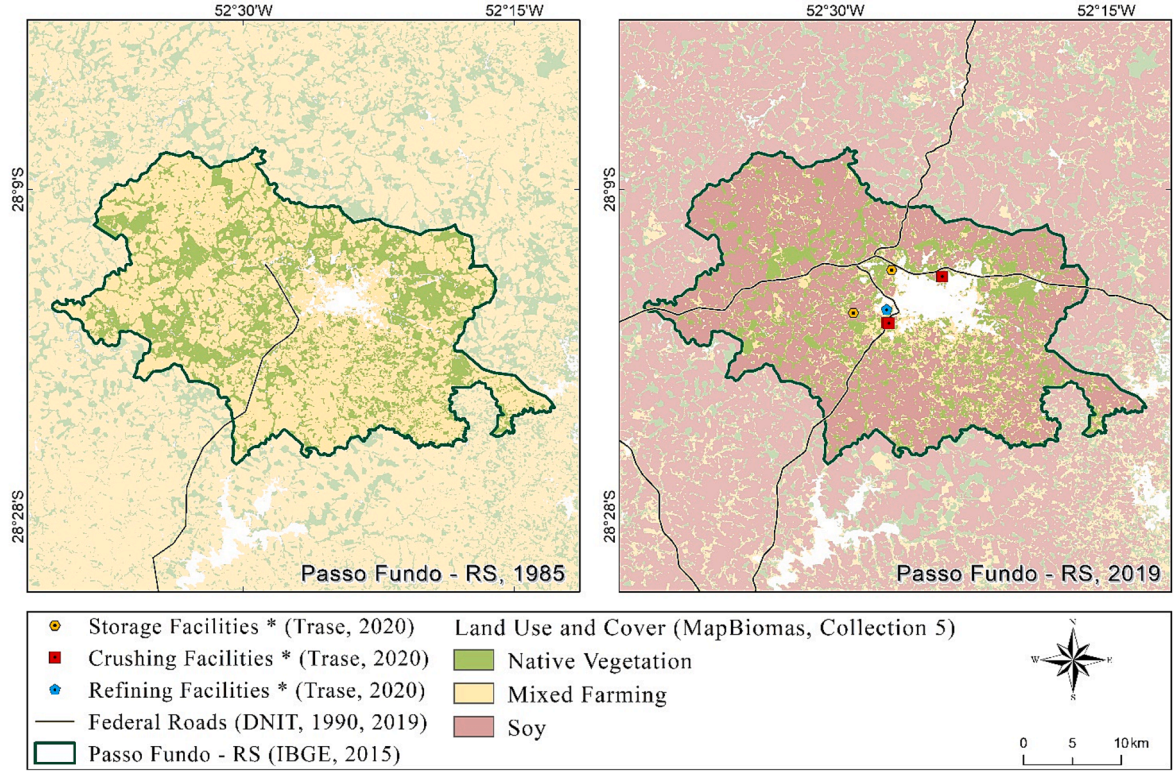

Fig. 3. Map of Passo Fundo (RS) in 1985 and 2019 showing soy and transport infrastructure, land use and cover change. DNIT (1990), IBGE (2015), IBGE (2019), Trase (2020b)

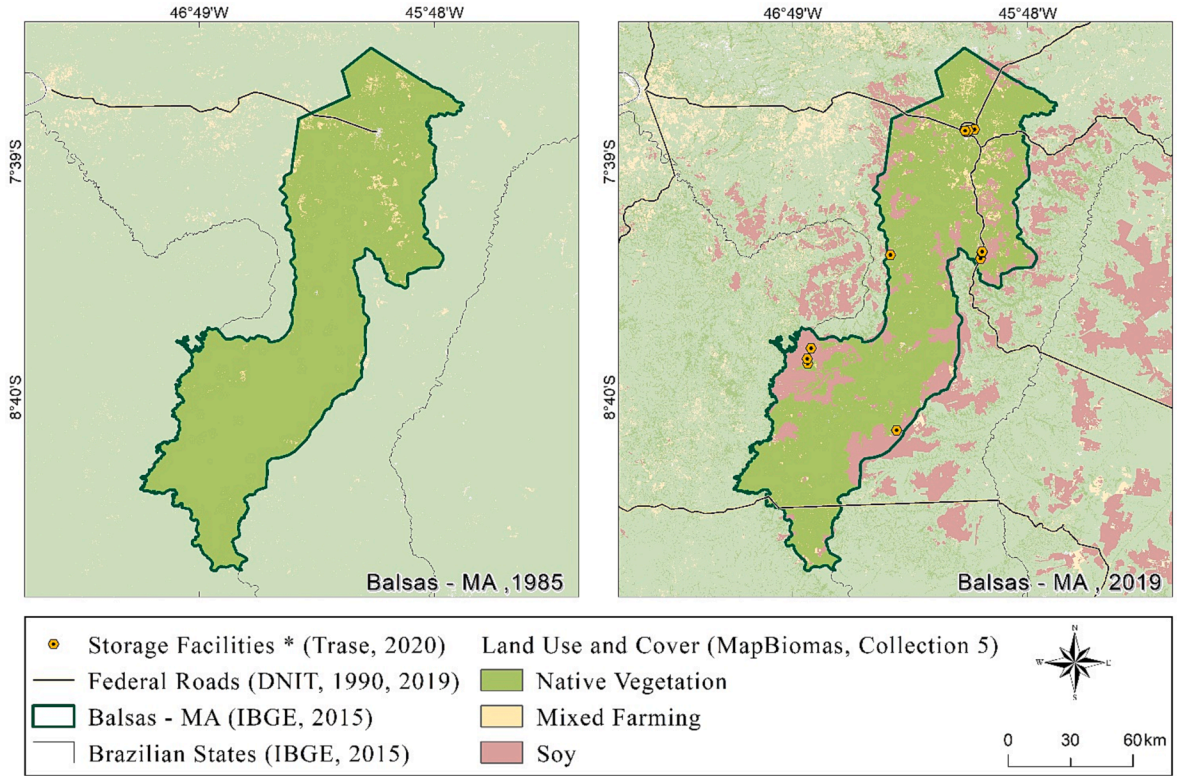

Fig. 4. Map of Balsas (MA) in 1985 and 2019 showing soy and transport infrastructure, land use and cover change. DNIT (1990), IBGE (2015), IBGE (2019), Trase (2020b)

et al., 2013b; Lima, Skutsch, & de Medeiros Costa, 2011).

Sorriso has been selected as a case study because, although it now is a consolidated agricultural region, it has low stickiness in the relationship between soy farmers and commodity traders. Such relatively low stickiness has, however, been gradually increasing over the years. Sorriso is only slightly older than Balsas as a soy-growing region, yet like Passo Fundo it is already considered to be an innovation hub, a cluster of agri-food companies, and to form an important agglomeration economy (Garrett et al., 2013b; Von Dentz & Farias, 2021). While its local economy has an export-oriented cash-crop base, it also includes grain crushers, soy-biodiesel factories, and other agri-food processing facilities that add value to the local production.

In 1985, only 22.1 % of Sorriso's area was directly used for farming (crop and pasturelands), while 77.1 % of it was covered with native vegetation. That shows the recency of its establishment as an agricultural region when compared, for instance, to Passo Fundo. By 2019, that figure had already shifted dramatically as farming occupied 68.6 % of the municipality, leaving only 30.0 % of it with native vegetation (urban area makes 0.4 %) (Mapbiomas, 2021) (Table 2). Fig. 5 also illustrates the speed of soy expansion in Mato Grosso State. The 30.0 % of the municipality left with native vegetation cover is mostly located inside protected areas, indigenous lands, or private reserves, and thus legally off-limits for conversion to agriculture (Arvor et al., 2021). Still, although Sorriso can be considered agriculturally consolidated, neighboring municipalities with larger shares of native vegetation remain susceptible to conversion into soy in a widening regional agribusiness economy that has Sorriso as a hub.

3.3.4. *Bom Jesus – Piauí (PI)*

Bom Jesus, in the Matopiba state of Piauí, is a recent soy frontier – like Balsas (MA). Production only started in the 1990s, before rapidly expanding in the 2000 s and 2010 s. The municipality is a minor logistics hub for the soy agribusiness in the state's far south. It displays low socioeconomic indicators (see Table 2) related to many issues such as food insecurity, poor access to safe drinking water, and inequality (Russo Lopes et al., 2021). As of 1985, Bom Jesus had only 0.8 % of its area used for farming (crop and pasturelands), while 98.6 % of it was covered by native vegetation. By 2019, however, as much as 21.4 % Bom Jesus's area was already composed of farmland, against 77.9 % of native vegetation (Mapbiomas, 2021) (Table 2). Fig. 6 shows how soy quickly expanded there and in neighboring municipalities. The place remains an agricultural frontier, with about 426 thousand hectares of native vegetation that may still be legally converted to farming under various risk levels (Reis et al., 2021).

Supply-chain stickiness has been relatively low in Bom Jesus, even though the last years of the series show relatively high stability. That is because although the municipality started experiencing significant soy production already in the 2000s (Trase, 2020a), only from 2012 – with the arrival of a Cargill soy storage and processing facility – Bom Jesus became an agro-export logistics hub. Before Cargill's arrival, Bom Jesus supplied soy mainly to the domestic market through small and shifting local grain warehouses. These, in turn, would provide soy for feed to poultry or pork producers in the region, or the soy would be exported through other logistics hubs such as Balsas (MA). Bom Jesus has been selected as a case study precisely because it is in an active agricultural frontier and has relatively volatile supply-chain relations, with a low stickiness profile.

Critically, in contrast to Sorriso (MT), most areas of Bom Jesus still covered with native vegetation are unprotected. Brazil's environmental regulations mandate that farms in the Cerrado maintain at least 20 % of their area as "legal reserves," but much remains outside that scope. The municipality has only one public protected area – the ecological station Uruçuí-Una, covering 135 thousand hectares in Bom Jesus (ISA, 2021). Other neighboring municipalities with large native vegetation areas suitable for crop and pasture expansion might, too, foster the consolidation of Bom Jesus as an important agribusiness logistics hub in the future. For now, Bom Jesus has an export-oriented cash-crop economy, but with little value-added through processing. It exports mostly

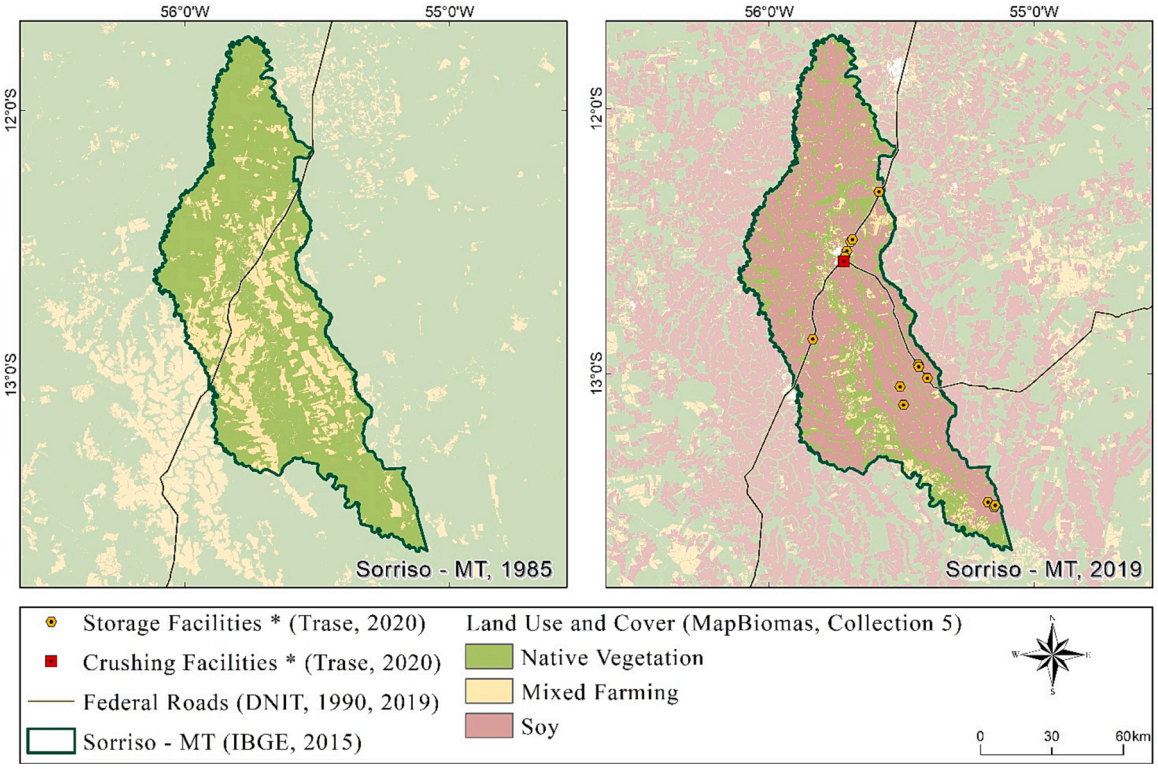

Fig. 5. Map of Sorriso (MT) in 1985 and 2019 showing soy and transport infrastructure, land use and cover change. DNIT (1990), IBGE (2015), IBGE (2019), Trase (2020b)

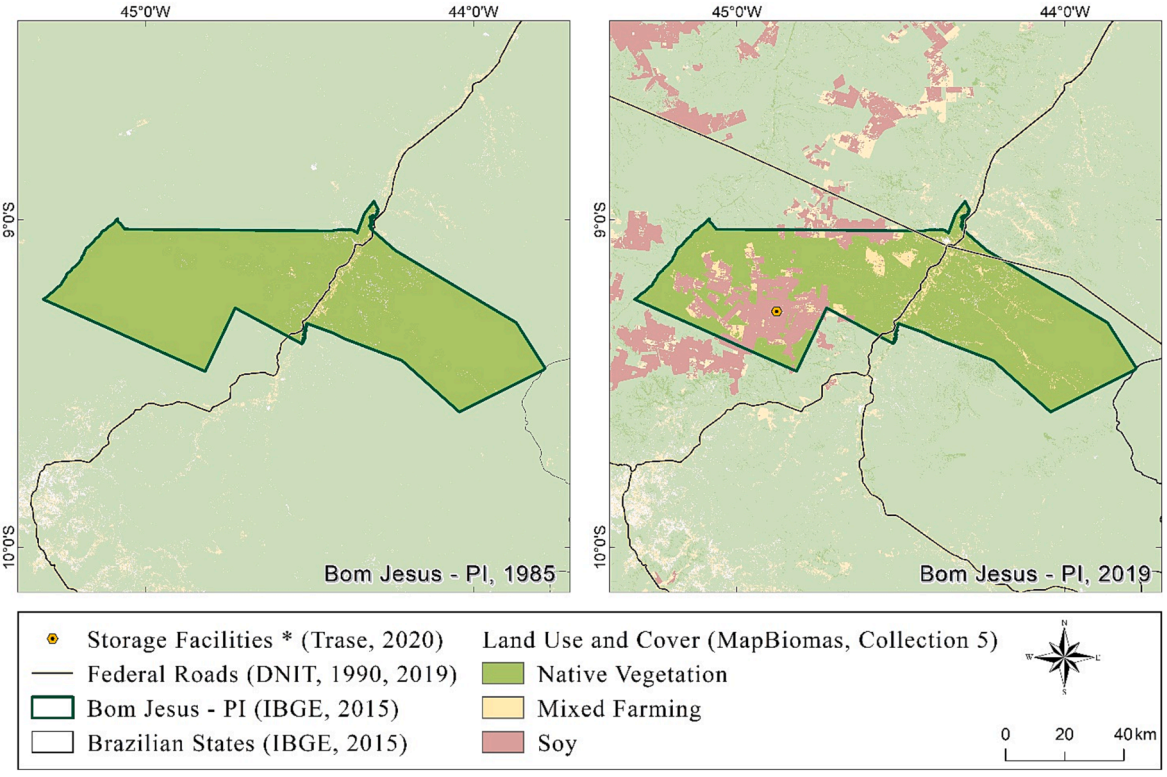

Fig. 6. Map of Bom Jesus (PI) in 1985 and 2019 showing soy and transport infrastructure, land use and cover change. DNIT (1990), IBGE (2015), IBGE (2019), Trase (2020b)

unprocessed soybeans. Moreover, substantive rural conflicts remain due to the exclusion of local communities from the emerging soy-based economy, done primarily by southern Brazilian migrants (Bastos Lima & Kmoch, 2021; Mondardo & de Azevedo, 2019). Resource dispossession has been rampant in the forms of land and water grabbing, alongside the disruption of traditional small-scale farming systems and livelihoods (Russo Lopes et al., 2021; Schilling-Vacaflor et al., 2021).

4. Results: Varieties of soy supply-chain relations

4.1. Tense relationships in Brazil's soy supply chains

Grain growers and traders both have profited from the surge in global demand for soy (Garrett & Rausch, 2016; Russo Lopes et al., 2021). However, underneath what may at first seem like a seamless and collaborative supply chain, soy agroindustry stakeholders speak of continuous tensions. As traders constantly seek to expand on their power and control over suppliers while these suppliers try to outsmart or group together to resist and get the upper hand vis-à-vis commodity traders, there is a widespread perception of the soy supply chain as one characterized by struggle.

There is a longstanding literature on corporate dominance in the industrial agri-food system, and much of that is power exerted over supplier farmers (Kneen, 1995; McMichael, 2009; Clapp & Purugganan, 2020). Yet, as we detail below, soy farmers gather in cooperatives, buying pools or clubs to challenge commodity traders' power and break, for example, infrastructural and financial forms of lock-in. There are also features pertaining to Brazil's specific social history of farmer migration and its geography of rain-fed soy that influence supply-chain relations.

4.1.1. Broad trader geographic strategies in Brazil

Grain traders in Brazil seek to diversify their geographic sourcing patterns as much as possible to mitigate the climatic risk of crop failures. There was a consensus among our interviewees that the business success of grain crushers and commodity traders depend on stability of supply and accurate logistics planning, tailoring operations to the availability of trucks, access to shipping for exports, etc. Traders also try to secure future harvests from soy farmers ahead of time. Therefore, if a trader concentrates its sourcing excessively in one geographic region, it may be exposed to climatic shocks and harvest losses. Conversely, the more geographically widespread trader operations are, the less climate risk of crop failure it bears. Therefore, traders seek to be in as many locations as possible, favoring especially those known for their climate stability and predictability. That is why the consolidated region of Sorriso (MT), for example, is a crucial hub for traders.

In Sorriso, rainfall patterns are regular and rather stable in comparison to other soy-producing regions of Brazil. It counts on a long rainy season that allows for two or sometimes even three crops a year. Soy cultivated in the agricultural frontiers, in contrast, tends to attract only the largest traders, which can bear the associated risks. In bumper-crop years, smaller and spot-market traders may come to reap the benefits, but they will only source directly from large farmers that have storage facilities. In years of poor harvests, only large traders will source – and potentially absorb losses from the elevated costs of maintaining idle storage capacity.

4.1.2. Grouping together and growing big: Soy farmer resistance towards traders

Large grain traders monitor crop growth, climate conditions, and use market intelligence instruments to gauge how much of the expected soy harvest each farmer has already committed to other traders. As the harvest period approaches, they know which farmers lack access to silos and those who left certain amounts of grain to deal in spot markets. In addition, traders generally know the consumer markets more than farmers do. Therefore, there is a general perception that these knowledge and information asymmetries influence the stickiness of trade relations (decreasing or increasing stickiness depending on the combination of various other factors).

Soy farmers, however, have increasingly banded together to try to counterbalance those knowledge and information asymmetries. For instance, they often group to share market insights. As one farmer revealed,

> *"We have a WhatsApp group only amongst friends, reliable and trustworthy people where we share our trade deals and information, so that at least within the group we know when someone is making a bad or good deal. The traders share their prices with each other; why shouldn't we do the same? We also have regular meetings, we gather to buy inputs as well, so that we can negotiate better prices."*

Farmer cooperatives, in particular, have been a bulwark against excessive trader dominance in Brazil's soy sector. Their principal advantage over traders is capillarity, i.e., their capacity to reach out to many relatively small suppliers. Consolidated agricultural regions, particularly in Brazil's South, include many small soy farmers whose properties range between 20 and 100 ha, in contrast with the northern frontiers where farmers own on average 1,000–2,000 ha (Imaflora, 2021). While commodity traders would face high transaction costs engaging with all those numerous suppliers, such farmer cooperatives tend to be socially embedded and count on established access. They benefit from networks of trust, information, knowledge sharing, and ample communication among their members. Consequently, the power dynamics at play between soy farmers and large traders in the northern frontiers is different from what happens in consolidated areas. In the latter, commodity traders source primarily from cooperatives rather than from individual farmers. Some cooperatives have grown so large that they can source from multiple states. In such contexts, traders have gradually lost power as some large soy-farmer cooperatives increasingly venture even into exporting without having traders as intermediaries.

4.2. Lock-in effects

There are key lock-in effects – including infrastructural, financial, technological, and institutional constraints – that broadly define soy supply-chain relationships in Brazil. They are generally the issues around which farmer-trader tensions coalesce, and they largely explain the variety of supply-chain arrangements one can find in the sector.

4.2.1. Infrastructural constraints

Soybean is a perishable crop after harvest. Therefore, owning a grain silo on the farm is a crucial factor to the stickiness of trade relations in this supply chain. All interviewed actors perceive farmers with silos as having greater bargaining power vis-à-vis commodity traders. By having a silo, farmers can adequately store their production, split it, and negotiate partial amounts with as many traders as they want. That allows soy farmers to look for multiple deals at different times as well as to wait and sell when grain prices are higher. In contrast, when traders control such facilities, they retain more power, especially in frontier regions with few economic opportunities.

Farmers who do not own a facility to receive, clean, process, dry, and safely store soy grains after harvest – especially in regions where the harvest time coincides with the wet or rainy season – consequently lose negotiating power. These farmers need to harvest and deliver their soy quickly somewhere, something that commodity traders know and use as a bargaining chip. As the harvest period approaches, a trader usually knows which farmers lack access to a silo and who left specific amounts to deal in spot markets (i.e., soy not previously committed in future contracts). These commodity traders then reap the benefits of having the facilities ready to receive those grains.

As one frontier farmer explains it,

> "*I don't have a silo, but I wish I had because then I would have more time to think and trade my grains. I would gain up to six months after harvest*

to find better prices, and I would be able to sell to those opportunistic traders who appear out of nothing paying great sums because they have an empty ship waiting at the port. You know, sometimes it is costlier for a trader to keep a ship waiting at the port than paying whatever price here."[1]

A quote from another farmer reveals how determinant a trader's grain-reception capacity is:

"After price, the first thing I consider when dealing with a trader is its reception capacity, whether the trucks' queue is long, how fair they normally are in classifying and qualifying my grain. If the queue is too long, I may consider selling for a lower price to a nearby small warehouse that will mix my bad grains with good grains to classify them as good quality, pay a fair price and receive my trucks speedily."

Such infrastructural constraints amount to an advantage that traders typically have had over most soy farmers in Brazil. Cooperatives, as seen, somewhat counterbalance that in consolidated agricultural regions, as they often own storage capacity for their members' collective use. More recently, an increase in large and well-capitalized soy farmers that have their own silos has been challenging traders' infrastructural dominance in agricultural frontiers, too. Lately, entrepreneurial farmers or farming companies have been arriving already with access to large volumes of capital, something that was uncommon in the 1990s and 2000s. As such, traders' power – based on control over infrastructure and easier access to capital – has been gradually waning vis-à-vis Brazilian soy farmers since the 2010s.

That has taken place alongside the entrance of a new type of "lightweight" commodity trader in Brazil's soy market. These actors rely on little structure for their business operations and deploy strategies that have much lower costs. While large traders make big investments in physical facilities as well as provide inputs and credit to farmers – including technical assistance and monitoring teams to ensure that farmers are producing correctly and will deliver on their future contracts –, lightweight traders operate primarily in spot markets. They source soy primarily from larger farmers that have individual silos, from cooperatives, or local warehouses. They exploit market opportunities, pay higher prices than large traders do, and thus have gained important market share by engaging with farmers that are free from big-trader lock-in and that have their own sources of input, credit, and technical assistance.

As a grain broker explains,

"The big trading companies, overall, are trying to reduce their costs with physical facilities. These new start-up traders are threatening them. Take this trader X, for example, they come here paying 0.5 or 1 real (BRL) above the big traders' prices, and they buy everything that is left, without a binding contract, in our region's silos. They take everything to the port and without all those costs that the big traders have. They are opportunistic, and they are shaking the market. I don't know how long these big traders will continue ruling things here."

Large traders that retain a more traditional business strategy have responded by shedding infrastructure seen as redundant while making larger investments for the control of entire regions, through private ports and cargo transport facilities. Silos and other such storage facilities have sometimes been regarded as costly liabilities that can be sold and outsourced, notably in consolidated regions where farmer cooperatives thrive. Increasingly this has been happening also in frontiers such as Matopiba, as soy farmers consolidate large cropland areas and gather in pool clubs (*ad hoc* gatherings of farmers, in contrast to the institutionalized cooperatives). They then buy larger amounts of inputs for lower prices, while bargaining higher prices when selling grains as a group to commodity traders. These clubs have started to build their own facilities to undermine large traders' infrastructural dominance, thus allowing also for the entrance of the lightweight traders in this market.

Large traders have therefore gradually turned their attention to larger logistics infrastructure. For example, Amaggi (Brazil's largest domestic trader) owns the grain terminal at the strategically located river port of Itacoatiara (AM). As a consequence, it trades most of the soy produced in the west of Mato Grosso State and in Rondônia State. When Amaggi does not obtain soy from its own, vertically integrated farms, it still operates a *de facto* monopsony in the region (that is, practically only one buyer available), because sending the soy elsewhere would make it more expensive for the farmers due to transport costs. As the manager of another trader spells out,

"All this production from the west of Mato Grosso and from Rondônia is dominated by Amaggi. If Amaggi does not buy this soy, it has to go through the Port of Santos, much further away and costlier than Itacoatiara."

Large traders have thus raced to dominate the so-called "export corridors," controlling cargo railroads and grain terminals at key ports that can give them an advantage when supplying soy to foreign markets. As a grain broker puts it,

"Whoever has the investment in the port becomes fixed in the region. Those who do not have that investment are obliged to subcontract idle capacity from the ones who own terminals in order to export."

One final observation is that large farmers with silos of their own tend to be found in municipalities with lower stickiness in supply-chain relations between suppliers and traders. Those soy farmers amass sufficient land and capital to acquire economies of scale and avoid being subject to most infrastructural constraints from commodity traders. That contrasts with sticky farmers in agricultural frontiers, who own smaller plots, do not themselves have storage facilities, and therefore are much more vulnerable. In frontiers, farmers either have silos or they have to rely on traders – for infrastructure and more.

4.2.2. Financial and technological lock-in

In agricultural frontiers, production risks are higher due to uncertain biophysical conditions and less reliable infrastructure. As such, farmers in those regions tend not to have a good credit assessment. Bank loans from either public or private institutions become much more challenging to obtain than in consolidated agricultural regions. Commodity traders, therefore, have played a key role in financing soy cultivation in Brazil's agricultural frontiers. They, however, typically charge much higher interest rates than banks. Their lending also generally involves barter deals whereby they provide chemical inputs, technical assistance, and some advance money in exchange for future soy harvests purchased at an advantageous price (to the trader). Farmers then pay back their loans with bags of soybean delivered immediately after harvesting. If traders perceive a given farmer as too risky, few will be willing to finance that individual, and his or her interest rate will be higher. The farmer who ventures into production, in turn, will become bound to a given trader that provides agricultural inputs and credit. Bicudo da Silva et al. (2020) describe such an arrangement as the "soybean trap," as traders bind their suppliers while embedding relatively high interest rates in those transactions. Supply-chain stickiness then emerges from the creation of farmer dependence upon a trader.

Interviewed actors call those inputs and assistance that come along with finance the "technological package." It usually includes genetically modified seeds, pesticides, fertilizers, and technical assistance to use these inputs, supplied all together in "take it or leave it" deals. Such forms of financial and technological lock-in have become common issues in large-scale industrial agriculture (Clapp & Ruder, 2020), and they appeared explicitly in our field interviews, especially in frontier regions. That kind of lock-in has tended to accentuate land and income concentration in agricultural frontiers because farmers then become divided

[1] The first author as native speaker of Brazilian Portuguese translated literally all the direct quotes shown in this study.

between well-capitalized ones (usually with access to regular banks) and those who rely only on credit from traders and, thus, become bound to the latter. This second group loses all capacity to negotiate better prices or alternative deals. As a local procurement manager of a large trader explains,

> *"We have a financing system that we call 70–30. This 70–30 means that for a farmer to obtain credit from us, he has to use 70 % of this credit to buy our agrochemicals and fertilizers, and only 30 % we advance to him in cash. Whatever the total amount of credit we give to him is quantified and put in the contract in bags of soy. So when he harvests, let's say, six months later, he pays us by giving the amount of soybean bags that was agreed, regardless of the current soy price."*

Cooperatives, in this regard, play a fundamental role helping farmers avoid such financial lock-in, as they generally provide flexible and cheap credit to their members through collective funding systems. Moreover, although Brazilian soy-farmer cooperatives usually do not own patents or control specific technologies, they still make larger purchases and therefore reduce the costs for individual farmers. In frontiers, however, soy cooperatives are scarce. When they do exist, they are frequently minor and nearly irrelevant from a market perspective – or they consist only of informal buying pools or temporary voluntary associations. These flimsier associations help diminish information asymmetries for farmers, and they somewhat reduce power imbalances in supply chains. However, they are not as solid and all-encompassing as the cooperatives found in consolidated agricultural regions, which typically have more stable membership, greater socio-cultural significance, and higher economic relevance.

4.2.3. Institutional lock-out

A final related element in this category of factors influencing supply-chain relations are institutional conditions, notably the Amazon Soy Moratorium – a voluntary agreement signed by major commodity traders and environmental NGOs committing to sourcing soy from the Amazon region only from areas that were already deforested before 2008 (Heilmayr et al., 2020). Soy farmers, however, resent what they regard as an undue, extra-legal institutional "lock-out" that blocks certain trading relations. The moratorium may not prevent soy grown in more recently deforested lands from being sold, but it still decreases the price offered to blacklisted farmers and restricts the options of traders to which they can sell. As one farmer puts it,

> *"This soy moratorium is a thing created by European companies to lower our prices. It only benefits some. It is effective only to make my soy costlier because I have to issue an invoice with my brother's name or sell the beans at a lower price to a non-signatory company. Then this smaller company will mix all soy and sell to any of these large signatory traders when they need. So I say this is a hypocritical law."*

As such, the moratorium has inadvertently helped create a niche market for smaller (and sometimes shadier) traders that source from non-compliant soy growers "locked out" of the mainstream market.

4.3. Trust and the social embeddedness of supply-chain relations

Interviewed actors reported an important role for social relatedness and cultural factors in shaping Brazil's soy sector and influencing supply-chain relationships. Cooperatives usually assemble growers that share the same origin and cultural background, and thus association becomes also a form of manifesting social identity (Chase, 2003). Places such as Passo Fundo (RS) have farmer cooperatives going back several generations – sometimes from when those German or Italian immigrants, most with rural backgrounds, moved to Brazil in the late 19th or early 20th century. But more recently consolidated areas such as Sorriso and the remainder of Brazil's Center-West Region also have got strong soy-grower cooperatives from farmers who migrated there from the South in the 1970 s and 1980 s (de Souza et al., 2018; de Sowa & Busch, 1998; Jepson, 2006). Such cooperatives promote cultural celebrations, social gatherings, distribute profits, and often secure everything to their members – from chemical input supplies to fuel, clothing, and even groceries. In the agricultural towns of Brazil's South Region, such cooperatives are well-respected and admired institutions that greatly influence the local economy and social life in general. In contrast, such social embeddedness is mostly absent in soy-expansion frontiers in the north.

Interviewed soy-sector stakeholders highlight that such cooperatives are particularly strong when they carry a sense of belonging, shared values, and frequently origin. They point out that associated soy farmers hardly default (i.e., fail to deliver grains) on the cooperatives to which they belong, and that benefit-sharing mechanisms within such institutions help promote social equity among members. For example, if individual farmers sell grains cheaply to the cooperative and later the cooperative succeeds in selling those grains for a much higher price to commodity traders, this profit will be equally distributed and revert to those farmers anyway. By solidifying trust and strong social embeddedness, cooperatives thus can be said to increase the stickiness among participant farmers, as between them and those institutions. Meanwhile, they also decrease the stickiness between soy farmers and commodity traders as cooperatives make such suppliers better positioned to negotiate with different buyers.

Without such social embeddedness that cooperatives provide, Brazilian soy farmers generally fear defaults and prefer to dilute their deals with as many different intermediaries as possible. Interviewed actors reported on routine cases of small traders, warehouses or grain aggregators that bankrupted and left suppliers unattended. As a rule of thumb, Brazilian soy farmers will thus seek to diversify their market relations. Generally, they commit large shares of their expected harvests to a single buyer only when they are bound to a major trader through a contract or to a cooperative they are part of. As a grain broker puts it,

> *"[Bankruptcy] is a real risk. There is a mechanism in the Brazilian legal system called judicial recovery, which regulates bankruptcy and allows legally declared failing companies to postpone the payment of their suppliers. Therefore, farmers are becoming ever more scared of committing in future contracts or even of depositing harvested soybeans in these small warehouses or traders, fearing a default of payments."*

Particularly in frontier regions, trust then becomes key when engaging in business relations – and here socio-cultural factors reveal to be of paramount importance. There was a consensus amongst interviewed soy farmers that factors such a common origin not only "oils the wheels" of supply-chain relations but also influences behavioral expectations and business decisions. The detailed testimonial of a Southern farmer who owns lands in Tocantins State (Matopiba frontier) is illustrative,

> *"In Tocantins [State], if I find a 'gaúcho'* [broad label for people originally from Rio Grande do Sul, Brazil's southernmost state], *I try to find out from where in 'Rio Grande' he came. Those people from Missões, for example, are indigenous mixed with Portuguese and Africans. They have a way to deal. Those from here (Passo Fundo), a mixture of indigenous, Germans, and Italians, deal differently. It is very different the way one or another pays you. With some of those, you can only accept upfront payment. With the others, they are more opportunistic. They will deal with you this year if it is good for them. The next year they drop you for cents and deal with someone else. If they sign a contract with you today, considering soy at a given price, and in six months - when he needs to deliver - the contract prices are much higher, they will disappear from here with all the soy to sell it somewhere else. There is no loyalty with some kinds of guys, but with others there is."*

Immaterial factors such as trust, therefore, can also underpin supply-chain stickiness. Business engagement based on cultural relatedness or shared backgrounds reportedly lead to higher levels of trust and last

longer. Such an intra-community form of solidarity is common, particularly in the more consolidated agricultural regions. It contrasts with a perception of generally low levels of trust in agricultural frontiers. In the latter, in line with the frontiers literature (see Bastos Lima & Kmoch, 2021), farmers and traders see supply-chain relationships as dodgier and riskier as many actors are regarded as rootless, adventurous entrepreneurs just looking for ways to make money quickly and without constraints. There is reportedly little sense of benefit sharing even among soy farmers in frontier regions. Established cooperatives are much scarcer, and therefore trust based on shared background or identities become all the more relevant.

5. Discussion: Cooperatives and soy supply-chain relations in the context of rural development

Brazil's soy-sector landscape comprises a diversity of farmer-trader arrangements. As we have seen, some of those supply-chain relations are more volatile and some are "stickier," for different reasons. Stickiness in consolidated agricultural regions generally means stable commercial relationships, notably between supplier farmers and their cooperatives but often also between such cooperatives and some traders. Meanwhile, sticky supply-chain relations in agricultural frontiers tend to reflect the binding of less-empowered soy farmers to a given trader. The growing presence of larger and more capitalized soy farmers in Brazil's agricultural frontiers has somewhat countered trader dominance, leading to more volatile supply-chain relations that include "lightweight" enterprises trading soy primarily on spot markets. Still, the power of major traders persists further down in the supply chain as they increasingly control key shipping facilities and other infrastructure used for grain exports.

In examining the relations between such a diversity of soy supply-chain arrangements and development, we identify in farmer cooperatives a pivotal role. Cooperatives aggregate upstream farmers and "stick" them not through imbalanced power relations as major commodity traders do but by socially embedded commercial relationships (see (Ghosh & Fedorowicz, 2008; Skandrani et al., 2011; de Sousa & Busch, 1998). Cooperatives generally require a certain level of trust, which soy farmers frequently obtain from a shared origin or cultural background, and those institutions in turn help solidify such a sense of relatedness and of community through joint cultural activities and economic benefit sharing. As seen, it generally is "good business" for soy farmers to be part of such cooperatives, which act as forms of socially-embedded traders, distributing profits while also securing a strong sense of farmer identity. Facilitated access to credit, inputs and technical assistance puts such soy farmers in an advantageous position compared to non-members (Bacaltchuk et al., 2015; de Sousa & Busch, 1998).

Our analysis shows that cooperatives also influence the relations between cooperated farmers and commodity traders. Building on the argument by Bicudo da Silva et al. (2020) that traders normally set a binding trap for soy farmers whereby these become dependent and indebted, we demonstrate how cooperatives help farmers avoid that trap and negotiate better deals (see also De Maria et al., 2020; de Oliveira & Schneider, 2016; Turzi, 2017). Cooperatives may thus be described as a solution to reduce commodity trader dominance in agricultural supply chains. By increasing farmers' leverage, they alter the very governance structure of supply chains (see Gereffi et al., 2005; Neilson et al., 2014). We thus add to the knowledge produced by Garrett et al., (2013a), who found that cooperatives are associated with higher soy yields, by showing how they also influence stickiness and supply-chain arrangements.

It is important, however, not to idealize such cooperatives. Cooperatives in Brazil's rural areas have a longstanding history of social struggles, and their emergence and development vary widely depending on their region of origin, members' composition, external partners, and agricultural production (see Brondizio et al., 2021). In this sense, it is key to place soy supply chains within a broader rural development context. As seen, Brazil's soy-farmer cooperatives have become sizeable commercial endeavors that sometimes even bypass export traders altogether. They tend to be beneficial in promoting benefit-sharing among members and thus promote equitable development for their communities, but that says little – if anything – about the relations between such soy-farmer groups and their environs.

In consolidated agricultural regions, Chase (2003), Brannstrom and Brandão (2012), and Ioris (2017) all show that social and economic exclusion is prevalent for those who do not grow soy and who do not fit into the model of export-oriented commodity agriculture. Soy expansion, indeed, has become a concern for Brazilian food security as staple crops such as rice get replaced, as for deforestation (Aguiar, 2021; Rausch et al., 2019). Chase (2003) shows that cooperatives have been no less engaged in such expansion – including via the promotion of speculative land acquisitions at agricultural frontiers. There, Russo Lopes et al. (2021) argue that "maldevelopment" has become prevalent as many migrant soy farmers accumulate profits and resources at the cost of dispossessing local populations while compromising alternative agricultures and local agri-food systems. Growing soy-farmer strength – through cooperatives as well as umbrella organizations such as Brazil's Soy Producers Association (Aprosoja) – has indeed meant more powerful rejection of sustainability regulations that international commodity traders sometimes embrace, such as the Amazon Soy Moratorium (Rausch & Gibbs, 2021). Most soy growers – as overall agribusiness – were staunch supporters of President Bolsonaro and a key political force behind Brazil's recent governmental dismantling of environmental protections, Indigenous rights, support to smallholder agriculture, and the encouragement to unfettered cash-crop expansion (Forlini, 2020; Lapper, 2021).

As Bastos Lima & Kmoch (2021) warn, neglecting such broader landscape dynamics usually is a starting point for letting dispossession go unnoticed, therefore it is vital to place our findings within Brazil's larger development context. We here show that the structure of (soy) supply chains vary, yet the limit of that diversity is in the allegiance to a commodity-based agriculture connected to a global agri-food system that differs from more localized alternatives receiving less attention. Our findings would suggest that establishing strength through cooperatives could conversely be beneficial also to such other, local farmers. However, as we have seen, the establishment of such farmer groupings rely on having a strong socio-economic basis, high levels of trust, and organizational capacity that are not always present among poorer communities of more diverse cultural backgrounds. Our analysis, at any rate, shows that multinational corporations are not supreme forces even in a globalized agri-food sector such as soy. Farmers can and do take on them, though so far primarily for their own benefit, and in contradiction with broader societal interests in environmental conservation or more diverse and inclusive agri-food systems in Brazil.

6. Conclusion

This study has put forth stickiness as a novel analytical lens in the assessment of supply-chain relations. It has exposed the different relationships that exist among farmers as between farmers and traders in Brazil's soy sector. We elicited the perceptions of soy supply chain actors about the processes that underpin stickiness and uncovered various influencing factors, such as the key role of infrastructure, financial traps, and issues of trust. Cooperatives, in particular, have revealed to be pivotal mediators in such farmer-trader relations. We have found that in regions where cooperatives exist and are strongly organized, they challenge the infrastructural, financial, and technological lock-ins created by the large export traders, effectively rebalancing power relations. Such cooperatives solidify trust among soy farmers and usually also correlate with less concentrated land and capital distribution than in frontier regions, where they generally are absent. That said, the exclusion of those who are outside such communities of trust (who frequently share a similar sociocultural background) and outside of the

soy business remains an issue for rural development. Although Brazil has witnessed the rebalancing of power relations *within* its soy sector, its relationship with other land uses (such as conservation) and other forms of agriculture remains broadly conflictive.

Supply-chain stickiness, in the end, reveals to be an ambivalent indicator – by itself neither necessarily good nor bad. It emerges in different contexts and may signify either relationships of domination (usually of major commodity traders vis-à-vis divided farmers) or more balanced ones, usually involving soy-farmer cooperatives. As our case studies show, there is a variety of supply-chain relations to learn from, even within the same sector. The sector conserves some common features such as the kind of agriculture practiced or its export orientation, yet it does also reveal that various arrangements exist and can be promoted for more balanced relations between suppliers and traders – be it with soy or other crops. The concept of stickiness, ultimately, helps us understand the diversity and specificities of local (material and immaterial) relations even within transnational supply-chain dynamics. Rather than seeking to determine or predict development outcomes, the concept contributes to more nuanced analyses and elicits insights on the interaction between local dynamics and global trade flows.

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CRediT authorship contribution statement

Tiago N.P. dos Reis: Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Writing – original draft, Writing – review & editing. **Mairon G. Bastos Lima:** Formal analysis, Writing – original draft, Writing – review & editing. **Gabriela Russo Lopes:** Formal analysis, Writing – original draft, Writing – review & editing. **Patrick Meyfroidt:** Conceptualization, Formal analysis, Writing – original draft, Writing – review & editing, Supervision, Project administration, Funding acquisition.

Declaration of competing interest

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

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.worlddev.2023.106475.

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