

Characterizing food systems to better understand their vulnerabilities: a case study in Québec and São Paulo

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Research Paper

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Abstract

Characterizing food systems, i.e., describing their organizational features, can help to generate a better understanding of the structural vulnerabilities that constrain transitions towards sustainable food security. However, their characterization across different economic contexts remains challenging. In this paper, by linking key concepts from research on food regimes, food system vulnerabilities and responsible innovation, we aim to characterize food systems in a developing and a developed economy to identify their shared vulnerabilities. We applied a case study design to characterize food production, processing and distribution in the province of Québec (Canada) and in the state of São Paulo (Brazil). In both cases, the processing and distribution stages have higher economic predominance when compared to the agricultural production stage. Furthermore, we observed concentration in a few activities in both food systems, with a shared focus on export-oriented supply chains. Vulnerabilities in both food systems include: (1) increased interdependence because some supply chains are export-oriented or depend on foreign labor and are, therefore, exposed to external risks; (2) concentration in a few activities, which threatens present and future local food diversity and (3) unequal power relations, making small and medium players vulnerable to decisions made by big players. The characterization developed in this study shows that the two food systems are mainly pursuing economic goals, following the institutional logics of the neoliberal food regime, which are not necessarily aligned with food security goals. It also exposes the presence of characteristics of 'responsibility' that may eventually help overcome food systems' vulnerabilities and support transitions toward sustainability.

Introduction

Food systems in most established and emerging economies are highly industrialized (IPES-Food, 2016) because of the globalization of agricultural activities and the many technological advances developed throughout the past few decades. Despite these advances, industrial food systems still fail to fulfill an important societal goal: achieving sustainable food security (FAO, IFAD, UNICEF, WFP and WHO, 2020; von Braun *et al.*, 2021). Several researchers have argued that current industrial food systems are not able to achieve this goal (de Schutter, 2014; IPES-Food, 2016; Touzard, 2016; Bezerra *et al.*, 2019; Willet *et al.*, 2019) and show vulnerabilities that threaten present and future food security (Paloviita *et al.*, 2016; Moragues-Faus *et al.*, 2017). Food systems scholars are indeed called to generate a better understanding of the renewability and resilience of food systems (Swisher *et al.*, 2018). The onset of the COVID-19 pandemic has certainly brought to light the close relationships between food security status and the vulnerabilities of current food provision. For Paloviita *et al.* (2016), vulnerabilities are both environmental and social. Such vulnerabilities include increased interdependencies, power imbalances and low institutional capacities (Moragues-Faus *et al.*, 2017).

Identifying food system vulnerabilities through, for example, characterizing the structure and dynamics of food systems (Rastoin and Ghersi, 2010; Moragues-Faus *et al.*, 2017) is a crucial step towards developing public policies and more responsible food production practices to address these vulnerabilities. To contribute to this emerging literature, we aim to characterize food systems in a developing and a developed economy to identify shared vulnerabilities and to illuminate policy implications of these vulnerabilities. To do so, we establish linkages between research on food regimes, food system vulnerabilities and responsible innovation. In this paper, the term 'characterization' is used to describe how food system activities are organized in a given geographic location (Rastoin and Ghersi, 2010). Characterizing food systems across different economic contexts is challenging but likely to prove very informative since the literature on food regimes indicates that globalized food systems tend to share attributes (Friedmann, 1995). To expose different food systems' shared vulnerabilities, we

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conducted a characterization process using a multiple case study design in the Canadian province of Québec, a developed economy, and in the Brazilian state of São Paulo, a developing economy. The two cases we selected increase the robustness of our study (i.e., its internal validity), as they are ‘information-rich cases’ from which we can learn ‘great deal about the central issues under consideration’ (Patton, 2002, p. 230). Such study design increases the transferability of our findings as it enables the identification of similar patterns across the cases and can thus reveal shared dynamics that are likely to be found in similar contexts. Lastly, because the first author is familiar with both Québec and São Paulo state, fluent in French and Portuguese, the feasibility of conducting high-quality interview-based research on food systems in both contexts is also increased.

Below we clarify the connections between food security, food regimes and responsible innovation and then describe our methodology, which relied on secondary data analyses of governmental and non-governmental reports and a contextual literature review. In the ‘Results’ section, we present our characterization of the Québec and São Paulo food systems, including an across-case summary of their main structure and dynamics. In the ‘Discussion’ section, we analyze three categories of shared vulnerabilities that emerged from the characterization. We conclude with the main contributions of this study: an in-depth understanding of shared vulnerabilities across food systems from different economic contexts and illuminating some elements of ‘responsibility’ that may offer counterpoints to the current neoliberal food regime.

Theoretical background of the study

Food security

A food system is defined as ‘an interdependent network of actors, located in a given geographical area and participating directly or indirectly in the creation of flows of goods and services oriented towards satisfying the food needs of one or more groups of consumers locally or outside the area under consideration’ (Rastoin and Ghersi, 2010, p. 19, own translation). This definition highlights the interdependence between regions and the globalized character of food systems by emphasizing a supply-side perspective. On the demand-side, the Food and Agriculture Organization’s (FAO) definition of food security emphasizes consumers’ perspective (FAO, 2006) and states that food security is met when ‘all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life’ (World Food Summit, 1996). This definition includes four dimensions: food availability, access, utilization and stability (FAO, 2006). In this paper, we focus on the ‘availability’ dimension, which refers to the ability of a food system to provide ‘sufficient quantities of food of appropriate quality, supplied through domestic production or imports’ (FAO, 2006). This dimension is well aligned with the aim of our study and offers a relevant and original lens to characterize food systems, identify their vulnerabilities and discuss ‘societal responsibility’ concerns (which are further defined below).

The globalized nature of contemporary food systems, highlighted in the definition of Rastoin and Ghersi (2010) and in the FAO’s definition of food security (2006), fosters reflection about local food sovereignty vs food systems as a globalized economic activity. However, the role of food systems has only been recently discussed by policy-makers, even though scholars had previously called for sustainable and resilient local food systems

(IPES-Food, 2016; FAO, IFAD, UNICEF, WFP et WHO, 2018; Willet and *et al.*, 2019). The COVID-19 pandemic highlighted how fragile food systems and food security can be (La Presse canadienne, 2020; Fontoura, 2021; Rede PENSSAN, 2021) and reinforced the importance of creating linkages between these two concepts. Therefore, one conceptual premise of this study is that food systems should be more than an economic activity as they play a central role in fulfilling local food security. The dynamics of food systems can be better understood under the light of the food regimes literature.

Food regimes

The literature on food regimes helps situate the Canadian and Brazilian food systems within a historical context and can inform policy directions for fostering the emergence of a new food regime. A food regime is a ‘rule-governed structure of production and consumption on a world scale’ (Friedmann, 1993, p. 30–31). According to Magnan (2012), stable food regimes emerge ‘when key actors—farmers, consumers, states, and capital—agree on implicit rules tying them into predictable relations of food production, consumption and trade’ (p. 3).

So far, the literature on food regimes has described three dominant regimes in history. The first food regime described in the literature is the ‘settler-colonial regime’ (1870–1914), led by Britain ‘with its policy of cheap food’. Second, there was the ‘surplus regime’ (1945–1973), led by the USA which, ‘under the umbrella of food aid programs, invaded their informal empire of postcolonial states with their food surpluses’. Lastly, there is the ‘neoliberal regime’ (1980s–present), also referred to as ‘food from nowhere’ or ‘corporate food regime’, where the ‘hegemonic powers are no longer nation states but large transnational companies controlling the global food chains’ (Sodano, 2019, p. 5).

The main characteristics of the neoliberal food regime are explained by Garnett (2008) and Shiva (2008) and have been aptly summarized by Sodano (2019, p.5): (1) increased corporate power at the manufacturer and retail level; (2) division of labor based on the features of global commodity chains; (3) market differentiation with low-quality mass products alongside high-tech/high-quality rich products; (4) ‘new technologies and intellectual property rights as the new frontiers for profit extraction’ and (5) ‘accelerated depletion of natural resources’.

In the neoliberal food regime, food system activities are means of capital accumulation and domination. However, this has been the case since the first food regime, when the reorganization of agriculture undermined societal goals of food security or the preservation of communities and replaced them with economic goals (Friedmann and McMichael, 1989). Aligned with this perspective, Moragues-Faus *et al.* (2017) identified several structural vulnerabilities of the present European food system: (1) a lack of coordination and integration to achieve long-term food security; (2) an excessive interdependence among food systems; (3) power imbalances among food system actors; (4) the dominance of a non-cooperative, outdated, segmented and incoherent institutional framework leading to ‘low institutional capacity’ to address food security issues in a coordinated way; (5) ‘unequal rights and entitlements in the food system, linked to poverty, inequality, social exclusion and unemployment’ (p. 191), which constrain certain actors’ access to resources and (6) conflicting values and interpretations of food security, which constrain the development of a unified policy vision that ‘ensures and delivers food as a human right’ (Moragues-Faus *et al.*, 2017).

While changes in the balance of power have been the main reason for food regimes' transitions in the past, it is still not clear what might bring the present neoliberal regime to its 'turning point' (Sodano, 2019). One of the possibilities pointed out by Sodano (2019) refers to the rise or re-emergence of alternative and innovative practices in food systems, such as grassroots movements, organic and biodynamic agriculture and short supply-chains. This is where the literature on 'responsible innovation' can be helpful.

Responsible innovation

The literature on responsible innovation can help us observe whether the characterization of the two food systems in our study reveals innovative responsibility-oriented practices and whether the latter can potentially address food system vulnerabilities. The policy-oriented field of research called responsible research and innovation (RRI) was developed to tackle major societal challenges, such as the United Nations' sustainable development goals (Blok and Lemmens, 2015; Inigo and Blok, 2019). RRI entails a forward-looking reflection about the 'ethical acceptability, sustainability and societal desirability' of the processes and outcomes of innovation (von Schomberg, 2011). Responsibility in food systems may take various forms (e.g., organic certification, short supply chains, family farmers, cooperatives), but generally include practices that seek to address societal challenges (Silva *et al.*, 2018). RRI points to the economic, social and environmental impacts of new technologies and, more importantly, frames the very purpose of technological innovation as being serving the greater good. For instance, the responsible innovation in health (RIH) framework draws on the RRI literature, and its proponents seek to make health systems more equitable and sustainable by fostering the development of innovations that offer more value to society. According to Silva *et al.* (2018), RIH 'consists of a collaborative endeavour wherein stakeholders are committed to clarify and meet a set of ethical, economic, social and environmental principles' (p. 5) to address the needs and challenges of health systems in a sustainable way. As indicated above, in the case of food systems, the neoliberal food regime relies heavily on technologies that serve corporate goals, tends to concentrate power in a few large agri-food companies and exacerbates food system vulnerabilities. Hence, inspired by RIH's aim, we posit in this paper that food security should be a societal end (as well as a common good) that food systems should be geared to deliver. Overall, we draw on these linkages between research on food regimes, food system vulnerabilities and responsible innovation to characterize food systems in two different economic contexts.

Methodology

Study design

We adopted a multiple case study design in the province of Québec (Canada) and in the state of São Paulo (Brazil). Both regions are comparable from a policy standpoint as they are influenced by federal government-level policies but have considerable autonomy over food and agricultural issues. Québec has a globalized food supply, but its population is increasingly interested in understanding and improving food autonomy in the province (Mundler, 2020). São Paulo is a major food producer, playing an important role in the international supply for certain food products. More detailed information about the food systems of the

two cases is provided in the 'Results' section and in the Supplementary material.

A case study of two different contexts is likely to increase the robustness of the results because it can reveal structural elements and dynamics that are shared across them and thus likely to be found elsewhere (Gioia *et al.*, 2013). We followed the classification of the World Economic Situation and Prospects, which classifies countries according to their economic conditions. In this classification, Canada is described as a developed economy and Brazil as a developing economy (World Economic Situation and Prospects, 2021). Likewise, the classification of the United Nations Conference on Trade and Development defines Canada as a developed region and Brazil as a developing region (United Nations Conference on Trade and Development, 2021). These regions face different food security challenges and possess different innovation capacities, offering empirical variations that can enrich our findings. Québec is the second largest Canadian province and accounts for about 20% of the country's gross domestic product (GDP) (Statistics Canada, 2023). In 2020, the prevalence of moderate or severe food insecurity among Quebec households was 8.6% (Statistics Canada, 2022; Tarasuk *et al.*, 2022). São Paulo is the most economically developed Brazilian state, accounting for about 30% of its GDP (Fundação Seade, 2020; IBGE Contas Nacionais Anuais, 2020). While the economic growth of São Paulo in the past few decades has contributed to the reduction of food access problems, there are large social inequalities, with areas of high living standards and others of extreme poverty (Munhoz, 2010).

Data collection

We focused our data collection on food production, processing and distribution, as described by Rastoin and Ghersi (2010). Using the province/state as our unit of analysis, we sought data from governmental and non-governmental sources. Our search yielded data on food production, processing and distribution, including international exchange. The variables we aimed to systematically document included the production value and the portion of GDP generated by each activity, the number of jobs and the number of agricultural establishments and companies. In Québec, the main source of data was the Ministry of Agriculture, Fisheries, and Food (MAPAQ is the French acronym). In São Paulo, we relied on statistics from the Brazilian Institute of Geography and Statistics, the Institute of Agricultural Economics, as well as reports elaborated by the Center for Advanced Studies on Applied Economics.

We used the year 2017 as our baseline because it offered the most recent and complete information for both cases. When specific data were not available for 2017, we used data for the closest year. To identify each region's specificities, we complemented the secondary data collection with contextual narrative findings. To this end, we conducted a literature review on the two food systems.

Data analysis

The analytical strategy involved performing a detailed within-case analysis, followed by an across-case summary. The documents were analyzed following a 'narrative review' methodology, which is 'a form of storytelling' (Popay *et al.*, 2006, p. 5) that relies on the use of text to interpret, summarize and explain the evidence (Dixon-Woods *et al.*, 2004). We analyzed data pertaining to each case to identify the overall structure and dynamics of each

Table 1. GDP (%) and job distribution (%) at each stage of the food systems of Quebec and São Paulo in 2017

Food system stage		PCT of food system GDP		PCT on the number of jobs generated	
		QC (%)	SP (%)	QC (%)	SP (%)
Production	Crop and livestock farming	16	11	12	18
	Agricultural support activities	1	5		
	Total	17	16		
Processing	Total	33	41	14	35
Distribution	Total	51	43	74	47

Adapted from: Gouvernement du Québec (2019), CEPEA (2017), Barros *et al.* (2019).

food system. This characterization is showed in the results, but more detailed information can be found in the Supplementary material. Based on the characterization, we analyzed the vulnerabilities documented in the two food systems. Vulnerabilities are defined as food system characteristics that pose a potential negative impact if challenges arise (Paloviita *et al.*, 2016; Moragues-Faus *et al.*, 2017). To inform our empirical analyses, we used the work of Moragues-Faus *et al.* (2017) who adopted a holistic perspective and identified a series of food system vulnerabilities. As food systems worldwide have been following similar paths (IPES-Food, 2016), it was likely that similar vulnerabilities were also present in the Québec and São Paulo food systems. In the final step of our data analysis, we identified indicators of responsible innovation by drawing from the RIH framework (Silva *et al.*, 2018). A description of its nine responsibility attributes is available in the Supplementary material (Health relevance; Ethical, legal, and social issues; Health inequalities; Inclusiveness; Responsiveness; Level and intensity of care; Frugality; Business model; Eco-responsibility). Because the literature specific to responsible innovation in food systems still lacks a clear framework, we relied on the RIH attributes that were more pertinent to our study to identify signs of responsible innovation in food systems. For instance, we qualified organic production as a sign of responsibility because it meets the RIH attribute of eco-responsibility, which ‘refers to a product, process or method that reduces the negative environmental impacts of an innovation’ (Silva *et al.*, 2021, p. 185). Likewise, family farms reflect the business model attribute, which refers to the components through which an organization creates, delivers and captures social and economic value for society (Silva *et al.*, 2021).

Results

An overview of the two food systems

The two food systems under study manifested key characteristics of a neoliberal food regime, which are summarized in Table 1. Altogether, food production, processing and distribution accounted for almost 8% of the GDP and 12% of all jobs in Québec (Gouvernement du Québec, 2019). The economic distribution of these three components followed the logic of industrialized food systems (Table 1). This means that the stage of distribution was the most economically preponderant component of the food system, followed by processing and, lastly, by the stage of production (Gouvernement du Québec, 2019).

Our characterization of the São Paulo food system revealed a strong presence of agri-food complexes, represented by

coordinated chains composed of ‘large processing companies’, the most predominant being the industries of sugar, orange juice and coffee (Saes *et al.*, 2019). About 12% of the São Paulo state’s GDP resulted from the activities of food production, processing and distribution (CEPEA, 2019). São Paulo’s food system was centered on processing and distribution compared to production, reflecting the industrial profile of the state’s food system and differing from other Brazilian states (Sachs, 2017; Seade, 2019).¹ The food system provided close to 15% of the formal jobs in the state (Barros *et al.*, *s/d*).

Production

In Québec, the production stage was characterized by a loosely coordinated balance between the internal and external demand. While some products were governed by internal demand (as was the case for milk, eggs and poultry) and produced under supply management policies that match production to domestic demand (Heminthavong, 2018), others followed the external demand. For instance, pork production was four times bigger than the internal demand and oriented toward exports (Mundler, 2020). Even though the production of cereals and pulses was significant (represented 15% of the total production value), most of it was intended for animal feed and ethanol production. Consequently, the province met less than 10% of its domestic demand for cereals and pulses for human consumption (Mundler, 2020). Another characteristic of this food system component was the dependence on foreign labor. From the total of jobs generated in the agricultural sector more than 20% were fulfilled by foreign workers, mostly from Mexico and Guatemala (Statistics Canada, 2018a, 2018b). Finally, we found that Québec had the largest number of farms with organic certification in Canada. Keable (2018), who developed a general portrait of organic farming in Canada using the Agricultural Census, found that about 4% of Québec farms were certified for organic production, while only 2% of farms in other Canadian provinces had such certification.

¹São Paulo has played a leadership role in the evolution of food production in Brazil. It was only after the 1960s that agricultural production spread throughout the country. Before that, it was mainly concentrated in São Paulo. The expansion of coffee production in the state in the latter part of the 19th century transformed the state ‘from a cattle-raising area to one of the wealthiest and most dynamic areas of the country’ (Missiaen and Ruff, 1975, p. 60). Later, the 1929 economic crisis followed by a coffee crisis in 1930 had a negative impact on coffee production, so farmers started to diversify to produce commodities such as sugarcane and beef, currently two of the most important productions in the state.

Production in *São Paulo* was concentrated on sugarcane (41% of the agricultural production value), produced for the alcohol and sugar industries and for domestic and international markets. Using data from the Brazilian Institute of Geography and Statistics, Silva *et al.* (2015) analyzed the size and composition of agribusiness in *São Paulo* and found that the production of sugarcane covered close to 67% of the cultivated area in the state. Drawing on complementary data from the Institute of Agricultural Economics, we found that cattle breeding and the production of oranges for the beverage industry were also important activities (12 and 6% of the production value, respectively). About 70% of Brazil's orange production was concentrated in *São Paulo*, which presently remains the main world producer of this fruit² (Neves *et al.*, 2010; Buainain *et al.*, 2019). Another characteristic of the production stage was the important participation of family farms,³ which represented 65% of all the agricultural establishments⁴ in *São Paulo*. However, they contributed only 13% of the agricultural production value in the state, highlighting the state's agrarian structure, i.e., the way in which agricultural properties are distributed and organized in a territory. According to data from the Agricultural Census, properties larger than 100 hectares represented only 13% of the total number of agricultural establishments in *São Paulo* but used 80% of the farming area, underscoring the concentration of large properties in the state. Organic production represented 2.6% of all agricultural establishments,⁵ which was higher than the Brazilian average of 1.3% (IBGE, 2019).

Processing

Food processing⁶ was one of the *Québec's* main economic activities and the leading employer in the province's manufacturing sector (Lacharité, 2017). We found that food processing was concentrated around the meat and dairy industries, which represented more than 40% of the income generated at this stage. Food processing in *Québec* was characterized by a strong presence of small- and medium-sized companies (Gouvernement du Québec, 2016), including cooperatives, differing from the other Canadian provinces, where the presence of foreign multinationals was stronger (Gouvernement du Québec, 2016). Nonetheless, we found that approximately 70% of processed food sales in *Québec* were made by the 30 largest companies present in the province—including local, national, as well as European and American multinationals (Gouvernement du Québec, 2016).

²Oranges are grown on farms of independent growers as well as large-sized farms that belong to companies that produce and export orange juice (Boteon *et al.*, 2013).

³A family farmer or rural entrepreneur is defined as 'someone who engages in activities in the rural environment while meeting the following requirements: I—he does not hold, for any reason, an area larger than four (4) tax modules; II—he relies predominantly on family members for labour in the economic activities of his establishment or enterprise; III—he has a minimum percentage of family income generated from the economic activities of his establishment or enterprise, as defined by the Executive Branch; IV—he manages his establishment or enterprise with his family' (DelGrossi, 2019, p. 4, own translation).

⁴Every production/exploitation unit dedicated, totally or partially, to agricultural, forestry and aquaculture activities, regardless of its size, legal form (if it belongs to a producer, several producers, a company, a group of companies, etc.), or location (urban or rural area), with the objective of production, either for sale (marketing the production) or for subsistence (sustenance of the producer or his family)' (IBGE, 2017, p. 38, own translation).

⁵According to 2006 data, only 6% of agricultural establishments involved in organic agriculture had a certification for organic production. Thus, we can infer that in 2017 just a small percentage of agricultural establishments that rely on organic agriculture have certification.

⁶The analysis of food processing in *Québec* includes the beverage and tobacco industries, following the same methodology of the MAPAQ reports.

Brazil's most important food processing companies were part of the *São Paulo's* food system: 30% of the country's gross value of food industries was concentrated in the state. A significant part of the food processed in *São Paulo* came from other parts of the country and were then consumed locally or in other parts of Brazil, or still exported to other countries (Silva *et al.*, 2015). Food processing in *São Paulo* was characterized by 'strictly coordinated chains' (Saes *et al.*, 2019) composed of large companies, especially the sugar, meat products, starch and animal feed and orange juice (Chaddad, 2016; IBGE, 2019).

Distribution

Our findings showed that 45% of the food produced in *Québec* was sold to consumers within the province, 23% was sold to other Canadian provinces and 32% was sold to other countries, mainly the USA (Gouvernement du Québec, 2016). This food system reflected the logic of integrated markets, where both exports and imports of food play an important role (Riopel, 2020). As for the distribution channels, two-thirds of food sales (almost \$26 billion) went through retail outlets and almost one-third (\$14 billion) through food services (Gouvernement du Québec, 2016). An increasing part of food sales was made through alternative distribution channels which included short-circuit markets and 'zero waste' food stores (Gouvernement du Québec, 2016). Commercialization of food products in short circuit means that no more than one intermediary intervenes between the production or processing company and the consumer (Gouvernement du Québec, 2023). The concept of 'zero waste' refers to the conservation of resources through 'responsible production, consumption, reuse, and recovery of products, packaging, and materials without burning and with no discharges to land, water, or air that threaten the environment or human health' (ZWIA, 2018).

For instance, using data from the Agricultural Census, Boudreau (2018) concluded that close to one in five farms sold directly (in part or entirely) to the consumer in the province, especially for products such as vegetables, fruits or maple products. However, these alternative distribution channels were still limited, representing 2.5% of the food distributed across the province.

When it comes to food distribution in *São Paulo*, our results showed that food products that dominated production and processing were clearly export-oriented chains, such as sugar and orange juice. We did not find enough information about the origin of the food distributed across the state for local consumption. Yet, the types of food imported and the lower volumes of imports when compared to exports (exports are four times bigger than imports) suggest that food available in this region originated mostly from inside the state as well as from other Brazilian states (Ministry of Industry, Foreign Trade and Service, 2019). Furthermore, some narrative findings supported this hypothesis. For instance, researchers from the Instituto Escolhas (2020) who used secondary data to analyze the food system of the *São Paulo* metropolitan region found that 42% of the fruits, 73% of the vegetables and 96% of the greens sold at the largest supply center for fresh food in Latin America (Entrepósito Terminal *São Paulo*) originated from the state of *São Paulo*.

Across case summary of the food systems of Québec and São Paulo

Figure 1 presents an across case summary of the *Québec* and *São Paulo* food systems. First, our characterization of these food

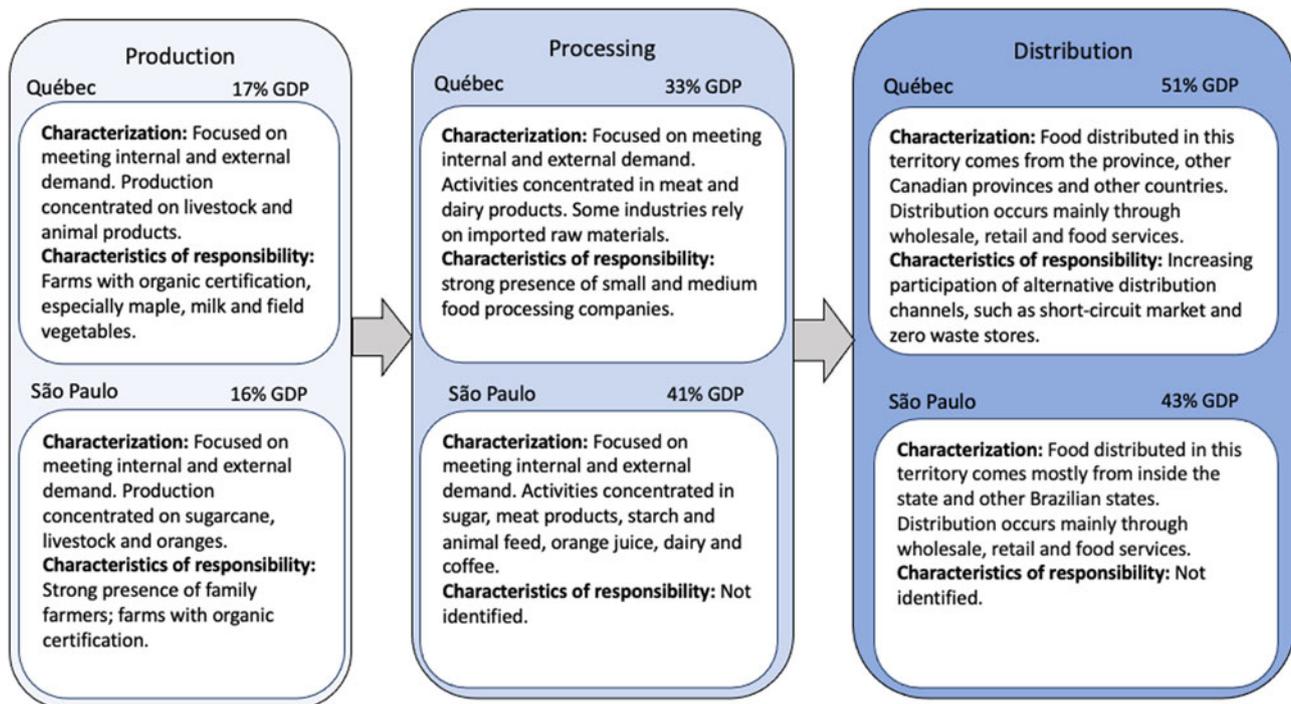


Figure 1. Characterization of the food systems of Québec and São Paulo (prepared by the authors).

systems highlighted common aspects of a neoliberal food regime. In both cases, we observed a higher economic preponderance of the processing and distribution stages when compared to the agricultural production stage, a typical pattern of industrialized food systems. Furthermore, both food systems focused on a few activities, with a particular focus on export-oriented supply chains. Each of these food systems also had particularities. While the food system of Québec reflected the logic of globally integrated markets, relying on both exports and imports, the available data did not allow us to conclude the same about São Paulo. Based on the available information, the food system of São Paulo was structured as an international food supplier because it exported much more than it imported. As we explain below, our characterization of both food systems points to shared vulnerabilities that deserve policy attention because they affect food security.

Secondly, in both food systems, we observed characteristics of ‘responsible innovation’. As defined previously, responsibility refers to the presence of alternative or new practices or organizations intended to tackle societal challenges, such as climate change, poverty and food security. In the province of Québec, we found indicators of responsibility, including: farms with organic certification in an average that is higher than the Canadian average; a strong presence of small- and medium-sized companies in the processing stage and, finally, increasing food sales through alternative distribution channels or directly from farmers to consumers. In São Paulo, the most relevant signs of ‘responsibility’ that we found included: the strong presence of family farmers, as well as the existence of farms with organic certification in an average higher than the country’s average. Although these elements of responsibility may remain marginal within a neoliberal food regime, they offer potential avenues to support transitions to more sustainable and resilient food systems. Nevertheless, it is important to point out that even though these elements may indicate the presence of responsible innovation, our

data cannot ascertain whether the actors leading such practices were following responsibility principles.

Discussion

Food systems vulnerabilities and their likely consequences on food security

The characterization developed in this study showed two food systems from different economic contexts ruled by the neoliberal food regime, as indicated by power being held by a few key actors. The analysis also exposed the presence of vulnerabilities that potentially constrain the ability to transition towards sustainable food security (Paloviita *et al.*, 2016; Moragues-Faus *et al.*, 2017). We found three main categories of vulnerabilities that are summarized in Table 2.

The first category is *increased interdependencies*, and it refers to structural vulnerabilities that arise when food systems rely heavily on their external context. In both food systems, we observed a strong presence of export-oriented supply chains. These activities were among the most economically important for the food systems of these cases. In São Paulo, the supply chains of sugar, orange juice, soybeans, beef and coffee were notable examples that relied heavily on international demand. In Québec, the pork industry was devoted to the international market. For instance, Québec produced four times its domestic demand for hogs but only 10% of its demand for cereals and pulses for human consumption (Mundler, 2020). International food trade is mostly based on an economic logic that does not take into consideration food security issues. Because these market dynamics affect food production practices, they can negatively impact the availability of food (Gerbet, 2019; Coalition for agriculture and food exception, 2020). According to Kummu *et al.* (2020), the diversity of food production seems to have decreased

Table 2. GDP and job distribution at each stage of the Québec's food system in 2017

Indications of vulnerability	Supporting data	Examples	Likely consequences for food availability
<i>Increased interdependencies</i>	Trade agreements in both territories based on economic logics	<ul style="list-style-type: none"> • Québec: The province produces four times more hogs than it needs and the entire pork industry is organized around the international market • São Paulo: Focus on supply chains that are export-oriented: sugar, orange juice, soybeans, beef and coffee 	The diversity of food production decreased in major exporting countries, creating vulnerabilities and dependencies 'for both exporters and importers' (Kummu <i>et al.</i> , 2020).
	Strong participation of foreign workers in agricultural activities	<ul style="list-style-type: none"> • Québec: Each year, more than 8000 seasonal workers come mostly from Mexico and Guatemala to work in the farms of Québec 	Border closures caused by the COVID-19 pandemic directly affected fruit and vegetable producers in the province of Québec (Lavoie, 2020).
<i>Low diversity in economic importance</i>	Concentration in a few supply chains	<ul style="list-style-type: none"> • Québec: Livestock, poultry and animal products (milk, eggs) represent more than 60% of the agricultural production value • São Paulo: Sugarcane represents 41% of the agricultural production value and occupies 67% of the cultivated area 	A high degree of diversity in the food system can facilitate 'greater dietary diversity and better nutrition' (Gómez <i>et al.</i> , 2013). The concentration of activities can limit local capacity to produce other food products. It also puts stress on local ecosystems (Aguiar and Souza, 2014).
<i>Unequal power relations</i>	Low economic importance of small growers and companies	<ul style="list-style-type: none"> • Québec: Strong presence of small- and medium-sized enterprises in the processing stage, but 70% of food sales are made by the 30 largest companies • São Paulo: Family farms represent 65% of all the agricultural establishments, but only 13% of the agricultural production value 	'Family farmers provide healthy, diversified and culturally appropriate foods' (FAO, 2019). Small farms and food businesses contribute to the alleviation of rural poverty, whilst delivering environmental and social benefits (Galli <i>et al.</i> , 2020). Unequal power relations can constrain the ability of these actors to fulfill these goals.

Source: Québec (2019).

in 'major exporting countries' in recent years, creating vulnerabilities and dependencies 'for both exporters and importers alike' (p. 9). We also observed the presence of this vulnerability in the reliance on foreign workers for the production of fruits and vegetables in Québec, which makes this food system vulnerable to external context risks. This was clearly observed in 2020 at the onset of the COVID-19 pandemic when Canadian border closures destabilized growers in Québec, resulting in production losses because of the lack of workers (Cameron, 2020; Lauzon, 2020; Riopel, 2020).

The second category of vulnerabilities is *low diversity in terms of economic importance*, which refers to the economic concentration of food systems activities on a few products that encourages producers, processors and distributors to increasingly concentrate their activities. In both food systems we observed a concentration of activities in a few products in the production and processing stages. This concentration was notable in the export-oriented chains. While in Québec the production of livestock and animal products contributed to more than 50% of the agricultural production value, sugarcane represented 41% of the agricultural production value in São Paulo and occupied 67% of the cultivated area. According to Gómez *et al.* (2013), a high degree of diversity in the food system can facilitate 'increased dietary diversity and better nutrition' (p. 16). Fraser *et al.* (2005) argued that food systems relying on highly productive monocultures are considered vulnerable because future disturbances in such food systems 'may cause significant collapses' (p. 473). For Aguiar and Souza (2014), the concentration of food production in a few supply chains negatively affects local food systems, for instance, by reducing their capacity to produce other varieties of food as well as

increasing stress on ecosystems. Therefore, even though a variety of other products was found in both regions, the economic concentration on a few supply chains is a vulnerability that may threaten local food production and diversity.

The third category refers to *unequal power relations*. This structural vulnerability concerns the differences of power between small and big players in the food system. It is considered a vulnerability because the ability of small growers and companies to participate in decision-making is overshadowed by the decisions of bigger and more influential players (IPES-Food, 2016). The way big players influence the food system occurs in various ways. For instance, multinational food companies are taking a central role in research, where they are increasingly shaping the research problems and developing innovations that are favorable to their own interests rather than developing technologies that could also benefit small players (IPES-Food, 2016; Clapp, 2021). Also, big players in the food system are constantly lobbying policy-makers to 'ensure favourable policy frameworks' (IPES-Food, 2016, p. 58). Differences in power relations can create vulnerabilities for small- and medium-sized actors in both food systems, reducing the likelihood that their interests are fully considered in decision-making and, therefore, constraining their capacity to contribute to food security. For instance, even though the US Department of Agriculture (USDA) had asked for recommendations from a health and nutrition expert Committee to develop the 2015 dietary guidelines, the final document did not reflect many of their recommendations because of the lobbying efforts made by food companies (Watson, 2015). We found evidence of this vulnerability in both food systems. In Québec, even though there was an important number of small- and medium-sized food

enterprises, the majority of food sales were made by the largest companies in the province. In São Paulo, family farms represented the majority of agricultural establishments, but contributed only a small portion of the gross agricultural value (13%). Thus, even though small farms play a key role in ‘food self-provisioning and income provision’ both of which contribute to improve ‘food availability and access’, these discrepancies in economic participation are translated into unequal power relations in the food supply chain (Galli *et al.*, 2020, p. 49).

Contributions of the study and policy implications

Recognizing the highly globalized world in which food systems operate, we were motivated to examine whether and how it is possible to characterize food systems using the meso-level of the state/province as the unit of analysis. Our first contribution with this study is, therefore, to confirm that food systems anchored in different contexts—that are shaped by broader macro-level dynamics (Magnan, 2012)—can be rigorously and systematically characterized at this level of analysis. This empirical validation is important because meso-level analyses can foster the development of local initiatives and policies that contribute to food security (FAO, 2022).

Second, the study results generate a better understanding of the relations between food systems characteristics and the shared vulnerabilities that constrain transitions toward sustainable food security. Our analysis showed the existence of three categories of vulnerabilities across the two food systems. The vulnerabilities summarized in Figure 2 are likely to be transferable to other contexts, notably in emergent and established economies.

The third contribution of our study is to show how food systems are approached by public authorities in their own jurisdictions. The information sources we used reflect the extent to which food systems are governed as an economic activity among many others. The literature on food regimes helps to understand why food systems are approached this way. According to Friedmann and McMichael (1989), since the 19th century, when agriculture became oriented towards capital accumulation, societal goals such as ‘food security’ and the

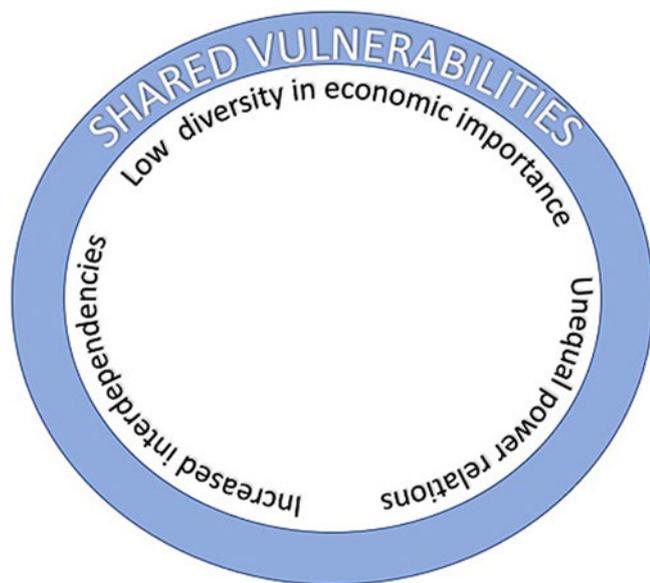


Figure 2. Shared vulnerabilities in the food systems of Québec and São Paulo.

‘preservation of communities’ were replaced by the ‘power of capital’. This was intensified during the second and third food regimes, with the increasing separation between agriculture and industrial activities (Friedmann and McMichael, 1989; Sodano, 2019). As agricultural products became ‘raw materials’ for the industry, food systems became ‘a statistical artifact’ highly integrated into an international market dominated by ‘large industrial capitals’ (Friedmann and McMichael, 1989, p. 112). The food systems of Québec and São Paulo are examples of this ‘path-dependency’ (Vanloqueren and Baret, 2009) where agricultural production follows the demand of ‘transnational agro-food corporations’ for inputs that are then processed into food products and distributed globally (Friedmann and McMichael, 1989). As put by Friedmann and McMichael (1989), ‘not only is agriculture no longer a coherent sector, but even food is not. It is linked, for instance, to the chemical industry at all phases, from fertilizers to preservatives’ (p. 112). As we observed, the neoliberal food regime relies heavily on technologies that serve corporate goals, tends to concentrate power in a few large agri-food companies and exacerbates the vulnerabilities identified in our study.

Considering the findings of our study and the present context of food security challenges and climate change, we argue that food systems need to be approached by policy-makers no longer as only an economic activity, but through a careful consideration of food systems’ social, environmental and economic roles in the tackling of today’s societal challenges.

The fourth contribution of our study reinforces the above argument as it concerns the indicators of responsibility identified in both food systems. Friedmann and McMichael (1989) suggest that a ‘re-localization’ of the food system can help to redirect food systems towards ‘comprehensive goals’ such as proper land use and ecological practices. According to Sodano (2019), an ‘agroecology food regime’ would respect sustainability and food sovereignty principles. Inspired by RIH’s aim, which is to steer innovation towards equitable and sustainable health systems, in our characterization we sought to emphasize that food security is an end that food systems should be geared to deliver (Schot and Steinmueller, 2018; Swisher *et al.*, 2018; Rastoin, 2020; Sabio and Lehoux, 2022). Our findings indicate the presence of practices with potential for fostering responsible food system innovation in Québec and São Paulo, for instance: the predominance of family farmers in São Paulo, the high number of small- and medium-sized processing local companies in Québec, the considerable participation of organic food production in both regions and the increasing food sales through alternative distribution channels in Québec. Nevertheless, these practices currently have a modest economic presence in the dominant food system and would require policy-makers to build a favorable institutional environment for their emergence and consolidation (Sodano, 2019; Sabio and Lehoux, 2022). Such initiatives need to be leveraged by public policies that promote structural changes across all stages of the food system towards food security.

Lastly, even though the literature on food regimes provided a rich theoretical lens for situating the food systems of Québec and São Paulo within an evolutionary historical context and thus generate a better understanding of their current dominant dynamics, our findings suggest that food systems cannot be conceptualized or empirically examined as monolithic entities. By searching for indicators of responsibility, we observed an emerging diversity within food systems that we would not have captured without using the RIH framework. Therefore, our study contributes to overcoming a conceptual and empirical limitation in the food regimes literature.

Limitations of the study and further research

The data we found reflect contemporary governments' approach to food systems as mainly economic activity. Such data were well suited to highlight systemic vulnerabilities because they reflect a globalized market logic that is disconnected from what resilient food systems should be organized to achieve (Branca *et al.*, 2020; Sellberg *et al.*, 2020). Data pertaining to the food distribution stage were, however, less abundant even though it represents the biggest share of the food system's GDP in both regions. Specifically in the case of São Paulo, there were limited data regarding the origin of the food available for the population. Our study also lacks consumer-centered data, which could have highlighted additional systemic vulnerabilities and trends. This gap could be addressed by further research. Our study signaled the presence of responsibility-oriented practices and organizations in food systems, but further research is needed to define in greater detail currently extant practices and to assess how responsible organizations in the different stages of the food systems could contribute to food systems transition. Future research could also contribute by characterizing food systems using longitudinal data rather than a cross-sectional study design like ours. Lastly, because the way food systems in both emerging and mature economies may transition remains globally interconnected, further research could examine how different regions achieve food security through responsible food system-level innovation and how such innovation could be scaled or adapted to other contexts.

Conclusion

'Climate change and sudden system shocks' as well as 'pandemics such as the one caused by COVID-19' have shown 'how fragile food provision can be' (Jensen and Orfila, 2021, p. 2). Current food systems transformation is indeed 'key to increasing food security' and 'strengthening the sustainable management of natural resources in the face of climate change' (Dupouy and Gurinovic, 2020, p. 2). By characterizing two food systems from different economic contexts, our study highlighted shared vulnerabilities that are driven by similar interconnected dynamics that have been established and reinforced over the years. For instance, Brazilian economic history is linked to commodity exports after a period of diversification (Toni, 2015). In the Canadian context, food supply management has existed since the 1970s and has been criticized because of the institutional barriers it creates for local and regional food system development and for food diversity in Canada (Heminthavong, 2018; Mundler *et al.*, 2020; Mundler and Ubertino, 2022). This institutional structure is embedded to varying degrees in the structure and dynamics of the neoliberal food regime.

The shared vulnerabilities identified in our study reinforce the need for food systems transition. Furthermore, the additional challenges imposed by the COVID-19 pandemic exposed and amplified many societal vulnerabilities, including those in the two food systems examined in this paper. The need to tackle vulnerabilities that hinder a transition towards sustainable food systems is now much more visible. While 20th century scientists and innovators helped to shape a major transition in food systems, a renewed contribution to a 21st century transition will be necessary to achieve food security through more responsible food systems. One of the ways to constructively promote such a transition—as pointed out in our study—is through research and policies that foster the development and consolidation of responsible innovation in food systems in order to integrate their social,

economic and environmental impacts. This concept is increasingly being applied in food studies (Khan *et al.*, 2016; Long *et al.*, 2018; Purwins and Schulze-Ehlers, 2018; Gremmen *et al.*, 2019), but still lacks an agreed upon definition and a common vision of the structural systemic vulnerabilities embedded in the present food regime.

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