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Facilitating international animal welfare standards implementation in national contexts: The role of intermediaries in Brazilian pig production

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ABSTRACT

International agreements have been adopted in recent years to disseminate animal welfare standards worldwide, similar to the situation for environmental and social sustainability standards. Scholars who have analyzed such initiatives argue that this calls for contextualized strategies for a successful implementation of international animal welfare standards in specific settings, also emphasizing the relevance of individuals and institutions who function as intermediaries in these complex situations of change. However, previous studies do not provide empirical insights into how different intermediaries work in relation to international animal welfare standards implementation in national contexts. Focusing empirically on the implementation of EU animal welfare directives in Brazilian pig production, this paper aims to connect the standards implementation and intermediation literatures to deepen the understanding of how a network of intermediaries formed and acted as an 'ecology of intermediaries' to facilitate the implementation process for international animal welfare standards. The paper aims to enrich debates on how to develop contextualized strategies that can translate recognized international regulations into practical animal welfare improvements. Our findings provide evidence that collective intermediation efforts are pivotal in addressing demands (such as translation, adaptation, regulation) that emerge from the complex situation of change provoked by the implementation of international animal welfare standards in national contexts. The main implication of our study for theory on standards implementation is that the operationalization of a contextualized strategy linked to international animal welfare standards implementation is composed of a normative dimension and a technological dimension and that, to achieve their desired outcome, contextualized strategies also rely on connected and complementary intermediation actions.

1. Introduction

The growing societal interest in how food is produced has provoked heated debates in recent decades (Henson and Reardon 2005; Jongwanich 2009; Tomlinson 2013; Darnhofer 2015; Richards et al., 2016; FAO 2018; Burton 2019; Niederle and Schubert 2020; Kassis et al., 2021). One of those debates emerged from scientific findings and civil society anxieties about industrialized farm animal production, prompting a soaring concern on how to establish adequate controls that safeguard animal welfare[1] in livestock industries all over the world (Bennett 1997; Fraser 2008; FAO 2009; Shepherd and Wilson 2013; Buller and Roe 2014; EU 2017; Buddle et al., 2021). Animal welfare within the international industrialized meat system is a multifaceted and interdisciplinary issue with ethical, economic, political, cultural, scientific, and religious implications (Giovanucci and Ponte 2005; Webster 2008; Lever and Miele 2012; Carey et al., 2017; FMO 2018; Suryawan et al., 2019; Fernandes et al., 2021). Increasingly, such complex matters are approached worldwide through bilateral agreements to disseminate international animal welfare standards[2] (Fulponi, 2006; Lundmark et al., 2018, Paschke and Denv, 2021). However, despite their global

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[1] In this study, we follow the World Organization for Animal Health's (OIE) official definition of animal welfare. According to OIE, 'animal welfare is the physical and mental state of an animal concerning the conditions in which it lives and dies.' An animal enjoys good welfare if it is 'healthy, comfortable, well-nourished, safe, able to express innate behavior, and it is not suffering from unpleasant states such as pain, fear, and distress' (OIE 2019).

[2] Scholars stress that five main formats are applied to promote the use of good animal welfare practices worldwide (voluntary welfare codes, corporate programmes, product differentiation, legislated standards, and international agreements) (Fraser 2006). The latter rely on treaties or intergovernmental organizations that establish common standards among countries to prevent different standards from impeding international trade (Grethe 2007).

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acceptance, it is acknowledged that animal welfare standards fostered through treaties or intergovernmental organizations have been insufficiently applied in practice generally (Webster 2005; Zhao et al., 2014; More et al., 2017; Schukat et al., 2020).

The European Union (EU) and the World Organization for Animal Health (OIE) have often been at the forefront of international agreements linked to animal welfare (Ingenbleek et al., 2012; Leone 2020). Since the early 2000s, both organizations have started developing cooperation, particularly with non-EU countries, to promote high animal welfare standards through political and commercial agreements (Maciel et al., 2013). In this endeavour, international cooperation linked to animal welfare tackles various challenges, such as how to build agreed regulations among developed and emergent countries, standards implementation strategies, and assessment and labelling schemes (Bracke 2009). Nonetheless, scholars who have analyzed EU and OIE initiatives stress that the implementation of international animal welfare standards is a very challenging task because it is necessary to motivate diverse actors at distinct levels (e.g., international, national, regional, local) to reshape agri-food production processes in particular contexts (Sinclair 2016; OIE 2019; Khaneghahi Abyaneh et al., 2020). Previous studies have emphasized that active international animal welfare standards implementation relies on developing a contextualized strategy that translates general regulations into practical local measures (Thiermann and Babcock 2005; FAO 2009; Paranhos da Costa et al., 2012; EU 2018).

Building contextualized strategies for animal welfare standards implementation is a complex task that requires the emergence of particular social and technical arrangements for mid- or long-term horizons (Huertas et al., 2014; Gocsik et al., 2016; Carey et al., 2017; Zhou et al., 2019). In such arrangements, individuals and organizations that function as enablers and conducers fulfil a crucial role and operate as what in multiple fields (such as Science and Technology Studies (STS), agricultural innovation studies, and rural sociology) have been defined as intermediaries (e.g., Stafford and Mellor 2009; Yang 2013; Klerkx et al., 2014; Koutsouris 2014; Legun and Bell 2016; Ortega and Wolf 2018). Broadly, intermediaries are individuals or organizations that exert diverse mediating roles to facilitate any aspect of the interplay between two or more actors, acting as connectors, converters and translators both in everyday interactions in agrifood chains (such as traders - Legun and Bell 2016, Grabs and Carodenuto, 2021; Schoonhoven-Speijer and Vellema, 2020) and in change and innovation processes in value chains (such as advisors - Howells, 2006; Snider et al., 2016; Klerkx and Leeuwis 2008, Haigh et al., 2015; Grabs and Carodenuto, 2021). In this article, since we see standards implementation as a systemic innovation process involving combined social, technical, and institutional innovation (following Kilelu et al., 2013; Barrett et al., 2020), we mainly draw on the strand of literature on intermediaries from innovation and transition studies (Howells, 2006; Stewart and Hyysalo, 2008; Kivimaa et al., 2019a).

Recent research on intermediaries increasingly pays attention to how they take part in complex situations of change (Kivimaa et al., 2019a). This strand of literature underlines that multiple intermediaries sometimes function somewhat connectedly and complementarily within a sort of landscape of intermediation (Steyaert et al., 2016). Thus, coming together, they can develop the capacity to coordinate a multitude of actors around challenging tasks (such as global climate change, sustainable food production, and clean energy transition), which would be rather demanding for a single intermediary organization or individual. Such distributed and collective intermediation action was proposed by Stewart and Hyysalo (2008) using the concept of a dynamic ecology of intermediaries. Kivimaa et al. (2017a) further elucidated the concept and described an ecology of intermediaries as intermediaries linked to a change process in a specific context having differing roles that connect and complement one another over time, forming synergies (see also Kivimaa et al., 2019a and 2019b).

Therefore, following earlier findings, this study infers that intermediaries (individuals or formal organizations that assume diverse mediating roles to facilitate the interplay between two or more actors) form an ecology that tends to emerge in support of a given complex situation of change provoked by the implementation of an international standard in a national context. However, previous studies (FAO 2009; EU 2018) lack detailed empirical insights into how such collective intermediation efforts proceed in relation to standards implementation processes and the roles that they play in facilitating standards implementation in practice. Thus, the aim of this study is to connect the strands of literature on standards implementation and on intermediation (Henson and Humphrey 2010; Klerkx et al., 2012; Howells 2006; Steyaert et al., 2016; Kivimaa et al., 2019b) to deepen the understanding of how intermediaries work together to facilitate the implementation process of international animal welfare standards in a particular context. In doing so, we aim to contribute to debates on how to develop contextualized strategies that can translate recognized international regulations into practical animal welfare improvements, following calls for more research into this topic (Maciel et al., 2015; Rahmat et al., 2016; EU 2017; Bayne and Turner 2019). Beyond animal welfare standards, we also aim to contribute to debates on how intermediary actors in value chains facilitate sustainability standards implementation more broadly, as some of these can be considered 'keystone actors' in value chains (Grabs and Carodenuto, 2021; Österblom et al., 2015).

The empirical focus of this study is the national commercial pig production system headed by the four leading Brazilian pig industries,[3] which started pursuing international protocols linked to animal health, animal feeding, animal welfare, and traceability from the mid-2000s due to its commoditization strategy[4] (Talamini and Santos Filho, 2017). Since the mid-2000s, animal welfare issues have provoked specific changes in the national commercial pig production system regarding transportation, slaughter, and piglet handling (Paranhos da Costa et al., 2012). Eventually, in 2013, Brazil signed a technical cooperation agreement with the EU to deploy international animal welfare regulations in its production systems, thereby provoking further changes in Brazilian pig production (Dias et al., 2018b). Two years later, the four leading Brazilian pig industries agreed to comply voluntarily with the EU animal welfare directives by 2026 (Portal, 2017, Suinocultura Industrial, 2020). Both events triggered the effective implementation of international animal welfare standards related to pig production in the Brazilian national context and counted with different organizations and individuals playing a role as intermediaries in this complex change process (Dias et al., 2018b), which suggests this is a suitable context to explore this topic. Therefore, the question that guides this study is: How have different intermediaries worked together to build the different links needed to implement European animal welfare standards in Brazilian pig production?

The remainder of the paper is structured in six sections. The conceptual framework is explained in section 2. Section 3 presents the methodology for applying the conceptual approach in the Brazilian pig production case. Section 4 presents the findings of the case study. Section 5 presents the analysis, a discussion, and lessons learned from the Brazilian case, and conclusions are drawn in section 6.

[3] The four leading Brazilian pig industrias are BRF S.A., JBS S.A., Cooperativa Central Aurora Alimentos, and Frimesa Cooperativa Central, which account for more than 50% of the whole Brazilian commercial pig production (ABPA 2021).

[4] In short, the commoditization strategy adopted by Brazilian pig production meant increasing scale production to produce as much as possible at the lowest possible cost, meeting international food production standards to increase Brazil's presence in the international pork market (Sebrae and ABCS, 2016). Consequently, pig production became more concentrated in fewer pig producers and industries, but those had an international scope (Talamini et al., 2014).

2. Conceptual framework

In this section we will explain the theoretical concepts used in this study. First, we will introduce how the literature conceptualizes the implementation of standards, which has been considered as a step of a wider process. Second, we will explain how intermediation within complex situations of change unfolds, focusing on the ecology of intermediaries concept.

2.1. The implementation step

The literature sees implementation as one of the stages of the process of establishing and operating a standard (Hatanaka et al., 2005; Henson and Humphrey 2010; Klerkx et al., 2012). Henson and Humphrey (2010) split the process of establishing and operating a standard into five steps.[5] The third one is the implementation step, where actors adhere to specific rules and procedures to bring the standard into practice. Additionally, EU and OIE studies on international animal welfare standards dissemination emphasize that a successful implementation process depends on the building of different links at two domains of intervention in local contexts: organizational and technical (Kahn and Varas 2014; EU 2018).

These domains co-evolve, mostly entailing legislation adjustments (measures enacted by actors to adjust local organizational contexts to the scope of international animal welfare standards, such as legislation changes, policy building, and public and private agreements), technological catching-up (technological and practice shifts within the local production process applied by actors to comply with an international animal welfare standard), and actions in education, training, and communication (focused on building actors' capacity to tackle local issues linked to animal welfare standards implementation and operation) (EU 2017; OIE 2017).

2.2. Intermediation within complex situations of change

Scholars attempting to unravel intermediation actions in change processes have made great efforts to explain what individuals or organizations do while aligning two (or more) entities and bringing them into contact to address business information, technological issues, or social matters (Steyaert et al., 2016). Initially, previous studies sought to understand how intermediaries executed specific missions such as support brokering for either problem solving (Hargadon and Sutton 1997) or technology transfer (Bessant and Rush 1995); or how institutional intermediaries helped to address institutional failures in a particular situation (McEvily and Zaheer 1999). Later, scholars broadened the intermediation perspective. They paid attention to intermediaries who act as agents who improve connectivity within and among innovation networks (Stewart and Hyysalo 2008); this is highly important for systemic innovation (Van Lente et al., 2003). Recently, studies have increasingly investigated roles performed by intermediaries in complex situations of change (Steyaert et al., 2016). In this perspective, scholars have introduced an even broader problematization for intermediation actions – e.g., the role of intermediation when the degree of unknown is high (Agogué et al., 2017) and the role of intermediation in the transition to a circular economy (Barrie et al., 2017).

As already mentioned, such studies stress that complex situations of change, given their intrinsic challenging essence, naturally foster the emergence of equally complex intermediation actions, often performed by networks of intermediaries called ecologies of intermediaries (Stewart and Hyysalo 2008; Kivimaa and Martiskainen 2018). A vast array of intermediaries can take part in such networks. Some examples are research or innovation agencies, funding agencies, private consultancy companies, independent technological consultants, innovation platforms, knowledge advisors, non-governmental organizations (NGOs), industries and industry associations, research and technology organizations, producers, and local communities (Howells 2006; Steyaert et al., 2016; Kivimaa et al., 2019b). Some of these organizations and individuals are mandated to act as intermediaries, while some take this up as an informal role (Kivimaa et al., 2019a).

Such different people and organizations when forming an ecology of intermediaries function together as bridges between a range of actors and a range of actions needed to operationalize a complex situation of change (Kivimaa and Martiskainen 2018). In doing so, they play different intermediary roles – e.g., policy building (Shaxson et al., 2012; Kivimaa et al., 2019b), coordination building and network building (Stewart and Hyysalo 2008), knowledge brokering (Klerkx et al., 2014), innovation brokering (Howells 2006), or finance brokering (Polzin et al., 2016), but somehow in a connected and complementary fashion. In practice, they articulate expectations, demands, and visions; build and broker networks; provide knowledge exchange and back learning processes; enable translation between different actors, interests, and contexts; foster capacity building; provide institutional support, such as advocacy or lobbying initiatives; and develop local technological strategies (Van Lente et al., 2003; Stewart and Hyysalo 2008; Klerkx and Leeuwis 2009; Kivimaa et al., 2019b).

Previous literature focusing on broadening the intermediation perspective also hints that ecologies of intermediaries evolve as dynamic networks (Stewart and Hyysalo 2008; Kivimaa et al., 2019a; Manders et al., 2020). This means that intermediary roles and intermediation actions, and the need for them, may vary as a complex situation of change unfolds (Kivimaa and Martiskainen 2018). Such dynamics imply that the ecology of intermediaries' composition tends to fluctuate over time (Manders et al., 2020). Furthermore, ecologies of intermediaries are orchestrated to some extent. Although often they cannot be understood as a designed or seamlessly functioning assemblage, the connectivity and complementarity of their elements demonstrate that they are mobilized by shared influences (Stewart and Hyysalo 2008; Kivimaa et al., 2019a). However, their components may struggle (for funding, relevance, technological paradigms) and overlap (different intermediaries playing similar roles, intentionally or not) (Kivimaa et al., 2017a).

In what follows, we will analyze how intermediaries have worked together to implement European animal welfare standards in Brazil by unravelling: 1) which different links in organizational and technical domains of intervention have been built in the Brazilian national commercial pig production system; and 2) how organizations and individuals who play formal and informal roles as intermediaries have worked together to facilitate the building of these different links in the operationalization of a contextualized strategy in the Brazilian national commercial pig production system.

3. Research methods

Studies focusing on intermediaries often take a qualitative approach based on an exploratory case study design to answer how and why individuals and organizations perform intermediary roles and activities in change processes (Maningas 2006; Kilelu et al., 2011; Yang 2013; Klerkx et al., 2014; Kivimaa et al., 2017a). This methodological construction has been associated mainly with intermediation research, as it allows enough freedom to explore insights that emerge during the empirical data collection that were not anticipated during the research design and also not identified from the literature review (Bryman 2012). Moreover,

[5] Henson and Humphrey's (2010) five steps for establishing and operating a standard are: 1) standard setting (formulation of written rules and procedures); 2) adoption (a decision by an entity to adopt the standard); 3) implementation (the application of rules and procedures); 4) conformity assessment (documented evidence that the standard was implemented effectively); and 5) enforcement (procedures to respond to non-compliance and sanctions to withdraw recognition if corrective action is not taken). In this study, we focus on further unravelling the third step (implementation).

exploratory case studies are suitable to approach phenomena that are not well known, have many facets, and require an in-depth perspective (Gray 2004; Eisenhardt and Graebner 2007) – circumstances that fit in our study.

The empirical case analyzed in this study comes from the Brazilian agricultural context, a world leader in meat production, and because of that, a country where animal welfare issues became crucial recently (Molento 2005; Chaddad 2016). Animal welfare has been a sensitive issue in the Brazilian national commercial pig production system. This socio-technical setting is highly industrialized, accounts for 80% of all pig meat produced in Brazil, and concentrates in eight of the 26 Brazilian states (Santa Catarina, Rio Grande do Sul, Paraná, Mato Grosso, Mato Grosso do Sul, Goiás, São Paulo, and Minas Gerais) (ABPA 2021). Different pressures ended up forcing Brazil to increasingly deploy changes in its national commercial pig production system until the most prominent Brazilian pig industries agreed to apply the EU animal welfare standards (Dias et al., 2018a). This compromise, taken in 2015, triggered an interesting case of implementation of international animal welfare rules in a national context, which is the focus of this study. Furthermore, Brazilian pig production has reliable databases (in private and public institutions, such as the Brazilian Animal Protein Association and the Brazilian Agricultural Research Corporation) showing how animal welfare issues have evolved countrywide.

The primary data sources for this study were 27 in-depth interviews with influential actors involved with animal welfare issues in Brazilian pig production. They are representatives from varied interests, such as industries, producers, governmental institutions, NGOs, science institutions, and advisory services (see Appendix 1). Relying on previous knowledge about Brazilian pig production and additional information available in publications and on websites of industries, associations, public organs, NGOs, and science institutions, we compiled a list of 18 interviewees. We also applied the snowballing method (Kumar 2011), and, from the initial round of interviews, we added another nine influential interviewees.

The interviews, conducted between July and December 2017 and March and April 2019, lasted between half an hour and 2 h and were tape-recorded and transcribed verbatim. They followed an interview guide based on our literature review of international animal welfare standards, standards implementation processes, and animal welfare implementation in Brazilian pig production. The interview guide listed the high-level topics regarding our research, of which there are four main ones: 1) overall information about the animal welfare trajectory in Brazilian pig production; 2) implementation strategies linked to the EU standards in Brazil; 3) the actors that have taken part in the implementation process, the kinds of roles that they have played, and the kinds of activities that they have performed; and 4) how actors have interacted to implement the EU standards in Brazil. Core and additional secondary data were also collected. The core secondary data consisted of books, scientific papers, and policy briefs (see Appendix 2). Additional secondary data came from official public reports and media articles published in newspapers and magazines.

The interview content was interpreted in a twofold way: 1) from a historical perspective, connecting the storyline told by interviewees in a single trajectory of the implementation of international animal welfare standards in Brazilian pig production; 2) from an intermediation perspective, looking at the kinds of intermediation roles played in the implementation of international animal welfare standards in Brazilian pig production and who performed them. As suggested by Olsen (2004) and often applied in previous studies about intermediaries (Al-Sobhi et al., 2010; Yang 2013, Schröter et al., 2015; Agogué et al., 2017), after interpreting the interview content, we triangulated it with secondary data. Thus, we could sharpen our understanding of the animal welfare trajectory in Brazilian pig production. Most importantly, this data triangulation allowed us to identify more precisely the actors who acted as intermediaries in the implementation process. Afterwards, the interview content and secondary data were interpreted using the theoretical framework as an analytical lens. In terms of possible biases, as regards internal validity, the findings rely on actors' representatives holding high positions (usually CEO or senior consultants). They were able to provide a broad view of animal welfare evolvement and functioning in the Brazilian context. In terms of external validity, a researcher specialized in animal welfare issues in the Brazilian context reviewed our findings. He validated the roles and activities performed by intermediaries and their interactions throughout the implementation process.

4. Findings

4.1. EU animal welfare standards within the Brazilian context

Economic and diplomatic relations between Brazil and the EU started in the 1960s and were strengthened politically and in terms of cooperation in the 1980s (Farina et al., 2005; Saraiva 2017). This led to the establishment of a first framework cooperation agreement in 1992 (Afionis and Stringer 2014). This agreement encompassed different areas and fostered sector dialogues between Brazil and the EU (van Loon 2015). In 2007, the cooperation agreement evolved into a strategic partnership, formalized at the 1st EU–Brazil Summit held in Lisbon (4 July 2007). The objective of the strategic partnership between the EU and Brazil was to promote cooperation initiatives and a wider policy dialogue, with the overall aim of tackling global challenges such as sustainable development, climate change, human rights, poverty, and food security (EU 2007). Within the strategic partnership, an EU–Brazil sector dialogue support facility was created, focused on agriculture and rural development, introducing a joint action plan composed of several projects that started to achieve practical results from 2008 onwards (Silva 2011). However, it was only in 2013, during the 6th EU–Brazil Summit held in Brasilia, that animal welfare became one of the priority areas supported by the strategic partnership (Maciel et al., 2015). As a result, a Memorandum of Understanding (henceforth MoU 48) on technical cooperation in animal welfare was formalized between the Brazilian Ministry of Agriculture, Livestock, and Food Supply (MAPA) and DG SANTE.[6]

Despite its transformative ambitions, the animal welfare agreement between the EU and Brazil assumed a purely advisory nature (Maciel and Bock 2013). It did not include, for instance, any further consequences for political or economic relations between the two parties in the event of insufficient achievements. Mostly, MoU 48 provided a regular exchange of information and technical cooperation related to several animal welfare issues (e.g., horse welfare, asinine welfare, sheep farming, dairy cattle, pig and poultry transport handling, and laying hens) (EU 2017). Despite its predominantly advisory character, MoU 48 had a relevant impact on the Brazilian pig sector (Dias et al., 2018a). For instance, it reinforced previous pressures coming from the scientific community, international buyers, and non-governmental animal rights organizations, stimulating further changes in production practices (Yunes et al., 2018). Moreover, as already mentioned, it influenced the four leading Brazilian pig industries to announce in 2015 that they would comply voluntarily with the EU animal welfare legislative standards by 2026 (Dias et al., 2018b). Those pig industries took this decision as they realized that adhering to the European animal welfare standards could open new commercial opportunities in more stringent markets, such as the European, Japanese, and North American (Albernaz-Gonçalves et al., 2021). Additionally, the implementation of an animal welfare standard, even partially, would help to anticipate the Brazilian pig production sector to avoiding possible future international

[6] DG SANTE is the acronym of the Commission's Directorate-General for Health and Food Safety, which is responsible for EU policy on food safety and health and for monitoring the implementation of related laws. Animal welfare issues are also included in the DG SANTE duties (EU 2018).

commercial barriers (Maciel et al., 2015).

In practice, the decision taken by the four leading Brazilian pig industries reinforced the introduction of two EU animal welfare regulations in the Brazilian context: 1) Council Directive 98/58/EC (concerning the protection of animals kept for farming purposes); and 2) Council Directive 2008/120/EC (concerning laying down minimum standards for the protection of pigs) (Dias et al., 2018a). An assessment carried out by independent researchers on the implementation feasibility of both animal welfare directives showed that some characteristics of the Brazilian pig production would facilitate EU model adoption (Dias et al., 2015). They quoted the favourable climate and the abundance of natural resources, the availability of suitable feed for pigs (such as maize and soya), and the high level of human resources linked to the pig industry, research institutions, and governmental organs (Dias et al., 2015). They also listed 36 items that should be changed in Brazilian pig production (Dias et al., 2015). These were split into four levels of complexity in the application of EU regulations in Brazil (low, light, moderate, and high). Only four items were labelled as high complexity. Eight were labelled as moderate complexity, 11 as light complexity, and 13 as low complexity – Appendix 3 describes all 36 items and their levels of complexity (Dias et al., 2015).

The levels of complexity relating to the application of EU regulations in Brazil and influential actors' evaluations collected from the 27 in-depth interviews conducted in our fieldwork were used in this study as the basis on which to uncover the different links that should be built in the organizational and technical intervention domains to implement Council Directive 98/58/EC and Council Directive 2008/120/EC in Brazilian pig production - these links are presented in the second column of Table 1.

4.2. *Intermediation for adjusting Brazilian regulations to the EU directives*

According to the gaps (organizational, legal, technological, and capacity building) in the Brazilian context to comply with the EU directives described in Table 1, there was an imperative demand for adjusting Brazilian animal welfare regulations. Thus, the link needed to be built in the organizational domain of intervention was to establish national animal welfare legislation for pig production according to the EU directives. Brazil had enacted a legal framework relating to animal welfare before starting the technical cooperation with the EU in 2013 (EU 2017). In the case of farm animals, the Brazilian legal system established provisions on animal welfare within a comprehensive set of rules for animal health.

Then, and more specifically between 2000 and 2011, three subject-specific regulations (in Brazil called Normative Instructions – IN) were released to set out in more detail local animal welfare standards also linked to pig production (Dias et al., 2018a). These regulations are IN nº 03/2000 (technical regulation for stunning methods and humane slaughter procedures) (MAPA 2000); IN nº 56/2008 (recommendations on good welfare practices in various stages of an animal's life) (MAPA 2008); and IN nº 46/2011 (technical regulation for organic animal and plant production systems) (MAPA 2011). Despite these moves forward, EU directives kept becoming more encompassing than Brazilian animal welfare regulations.

However, MAPA did not take coercive measures to adjust the Brazilian regulations to the EU animal welfare standards (EU 2017). According to the narratives from the interviews with the Brazilian pig production representatives, at first the technical cooperation with the EU performed more as a tool to involve particularly pig industries in policy discussions on animal welfare. In practice, MAPA decided to postpone normative changes until the broadest possible consensus was reached. That position slowed down the EU directives implementation process. On the other hand, it ensured that the alignment of Brazilian animal welfare regulations with the EU directives would be underpinned by a public/private coalition. Moreover, setting the broadest possible consensus reinforced the importance of intermediaries, as intermediation actions were crucial to mediate the understanding between rather diverse actors and interests (e.g., MAPA and the EU were more interested in applying international regulations; industries mostly wanted to keep their international business; producers were worried about how much they would need to spend to adjust their pig production facilities).

Two committees undertook most of the intermediation actions to establish national animal welfare legislation for pig production according to the EU directives. One of them is the Permanent Technical Committee on Animal Welfare (henceforth CTBEA). It was formally nominated by the Brazilian government to mediate the translation of the EU directives to the local context, to coordinate how they would be deployed, and to build local animal welfare legislation aligned with the European rules. In practice, CTBEA performed as an intermediary focused on policy building. It performed this role through an extensive dialogue with actors linked to animal production, becoming a crucial

Table 1
Gaps and links needed in relation to the implementation of EU animal directives in the Brazilian commercial pig production system (based on Dias et al., 2015 and fieldwork interviews)

Brazilian gaps (organizational, legal, technological, and capacity building) concerning EU animal welfare pig production requirements	Links needed to be built to tackle gaps and fulfil EU animal welfare pig production requirements	Domain of intervention
1) Absence of a specific regulation to establish animal welfare requirements in pig production	*Establish national animal welfare legislation for pig production according to the EU directives*	**Organizational**
2) Most facilities in pig farms do not meet EU rules in terms of minimum spaces for different types of pigs (boars, sows, piglets), minimum width between joists on slatted floors, and rest areas	*Develop a strategy to adapt existing facilities to the EU directives; set rules to orient the building of new facilities according to the EU directives*	**Technical**
3) Group housing of sows; Provision of materials for sows to build the nest before giving birth; 4) Provision of handling materials for pigs of all ages; 5) Use of fibre in the diet of pregnant sows; 6) Abolish practices of tooth tip reduction, partial tail cutting, and males castration prior to the seventh day in piglet management; 7) Adopt a minimum age of 21 days to wean piglets; 8) Reduce the mix of pigs coming from different properties in the nursery, growing, and finishing stages	*Set up a public/private strategy to develop a Brazilian proposal to review technologies and practices linked to animal welfare issues*	**Technical**
4) Proper euthanasia procedures	*Establish national animal welfare legislation for pig production according to the EU directives*	**Organizational**
5) Keep records of veterinary treatments and mortality for at least three years	*Establish national animal welfare legislation for pig production according to the EU directives*	**Organizational**
6) Promotion of official animal welfare capacitation initiatives for farmers, extension technicians, animal transporters, and slaughterhouse workers	*Establish a public/private action to provide animal welfare capacity building linked to the EU directives*	**Technical**
7) Development of research projects to endorse international animal welfare rules according to the Brazilian context	*Set up a public/private strategy to foster research about animal welfare in the Brazilian context*	**Technical**

intermediary in terms of articulation of expectations, demands, and visions, and policy building. CTBEA mobilized actors mainly by means of workgroups focused on specific subjects (e.g., pet animal welfare, animal welfare applied to pig production, welfare standards for live animal transportation). These workgroups were composed of representatives from actors that became involved in each subject in the local context and whose main assignment was to design normative instructions adjusted to EU directives.

In November 2018, a second committee linked to the implementation of EU directives in Brazilian pig production, called Workgroup Pig Production (henceforth GT Pigs), started working – it was composed of representatives from industries, producers, international animal welfare NGOs, research institutions, and the Brazilian government. Essentially, GT Pigs functioned as an intermediary with two objectives: 1) to stimulate collaboration between pig production actors to translate EU animal welfare directives to the Brazilian pig production context; and 2) to build with pig production actors a proposal to harmonize Brazilian animal welfare standards with the EU directives. Accordingly, GT Pigs performed as an intermediary focused on translation between different actors, interests, and contexts (policy translation and policy building roles).

In 2019, GT Pigs released a draft for public consultation on animal welfare regulations applied to pig production. After receiving further suggestions from any actors interested in contributing to the draft, GT Pigs presented to CTBEA a proposal for an animal welfare normative instruction focused on pig production, which was issued in December 2020 officially (MAPA 2020). The IN nº 113/2020 adjusted the Brazilian animal welfare legal framework to international requirements by introducing minimum spaces for different types of pigs (boars, sows, piglets), proper euthanasia procedures, rules for group housing of sows, and many other regulations.

As both CTBEA and GT Pigs received official mandates from the Brazilian government to mediate how local animal welfare legislation would absorb EU directives, the synergy between them developed effortlessly. However, they also experienced struggles due to their different objectives in terms of policy building to some extent. CTBEA had as its crucial aim to establish animal welfare regulations adapted to the EU directives. GT Pigs assumed a pivotal role to translate the EU directives to the Brazilian context and negotiate how to bring such understanding to practice through feasible regulations. These different objectives brought to the fore some struggles. CTBEA and GT Pigs disagreed on how much time producers and industries would have to adapt themselves to the new animal welfare rules. Moreover, they initially disagreed on the extent to which the normative instruction would contain mandatory changes for all pig producers and industries. The following quote of a GT Pigs member further clarifies struggles linked to intermediation for adjusting Brazilian regulations to the EU directives.

These difficulties arose because the CTBEA also had to be concerned with more political and institutional aspects. On the other hand, GT Pigs looked at the interests of those represented on the committee and how to reflect the harmonization of these interests in the regulation of animal welfare. Nevertheless, despite some difficulties, we have reached a satisfactory result. (An animal welfare specialist who works for a non-governmental organization).

4.3. Intermediaries and intermediation actions to fill technological gaps

The direction assumed in the technical intervention domain has to do whit the IN nº 113/2020, which established that Brazilian pig production actors must comply with all new animal welfare regulations by 2045. Thus, short-term technological changes are not mandatory (Table 1 list all technical changes in facilities and other aspects are required by the EU directives). However, the transition from keeping pregnant sows in cages (one of the most significant criticisms of European animal welfare authorities) to group housing of sows by 2026 is part of the voluntary commitment of the four leading pig industries to the EU directives' implementation. As such change means a huge technological challenge for Brazilian pig production, developing a Brazilian model for group housing of sows became a shared demand.

According to the narratives from the interviews with the Brazilian pig production representatives, independent consultants have mostly mediated interactions between industries, producers, suppliers, and research institutions to find the best technological choice to deploy the group housing of sows in Brazilian pig production – three different technological routes have been trialled so far.[7] They create ties with national and international equipment suppliers or offer advisory services for industries and independent producers. In both cases, these independent consultants organize meetings to discuss technologies (such as electronic sow feeding), play a role as bridges to bring together researchers and industry technical teams, and help producers and industries to identify the most affordable manner to adapt pig facilities to the group housing of sows. Thus, independent consultants have performed as innovation brokers in the development of local technological strategies.

The Brazilian Agricultural Research Corporation (Embrapa) also can be seen as an innovation broker that has connected actors interested in building a Brazilian model for group housing of sows. Embrapa has an acknowledged trajectory as a research institution in the animal welfare debate in the Brazilian context. However, as a further result of its research efforts, Embrapa has intermediated actors' collaboration to assess the technical and economic impact of group housing of sows in the Brazilian context. Embrapa has also fostered the interplay between actors in particular circumstances. In the case of pre-slaughter management practices, Embrapa headed intermediation actions to bring together pig producers and equipment suppliers regarding improvements in pig transportation especially. From Embrapa's mediation, actors developed new designs for truck-trailers, as well as pig loading and unloading equipment.

Intermediation was also not without struggle in the technological realm. Independent consultants and Embrapa presented low synergy while intermediating interactions between different actors to deploy the group housing of sows in Brazilian pig production. They struggled for relevance and funding, and their intermediation actions often overlapped. Such struggles arose due to the different intermediation purposes independent consultants and Embrapa had as regards solving technological gaps in the group housing of sows. The former mainly wanted to facilitate the group housing of sows deployment by selling equipment or services to the Brazilian pig industries, so acting more as an economic intermediary. The latter focused on intermediating the building of alliances to develop local technologies or adapt imported solutions. Though unfolding in parallel, both intermediation initiatives have interacted somewhat by exchanging knowledge and data (consultants and Embrapa shared results they achieved while experimenting methods and equipment to establish a Brazilian model for group housing of sows).

[7] Pig production actors in Brazil have discussed and applied three different methods of group housing of sows. However, none of them has become hegemonic so far (Dias et al., 2018a). The first is the traditional model, where sows live in small numbers housed in a collective stall, with manual or automatic feed supply. The second is the minibox model, where sows share a collective stall with small boxes in its walls. These boxes have linear feeders or food is thrown directly on the floor, using manual or automatic equipment. The third model is electronic sow feeding, or a station with electronic power control. This system has an electronic chip applied to the sows' ear. This chip is read by the sensor present at the feed station entrance, which thus provides an amount of feed determined by the operator of the integrated farm system and adjusted to the needs of each matrix (MAPA 2018).

4.4. Intermediation in relation to shared actions in education, training, and communication

Among the gaps in the Brazilian context to comply with the EU directives described in Table 1, there was also a demand for fostering animal welfare capacity building initiatives for farmers, extension technicians, animal transporters, and slaughterhouse workers. This gap relates to a second link that needed to be established in the technical domain, i.e., establishing public/private actions to provide animal welfare capacity building linked to the EU directives. Indeed, animal welfare became a usual subject of scientific events, and learning activities focused on pig production actors and the development of technical learning materials (such as brief guides and videos on pig pre-slaughter management on farms, animal transportation, and ethical slaughter) from the mid-2000s (Silva et al. 2018b). Even animal welfare teaching in agrarian science colleges and universities strengthened in the same period, according to a survey in 130 faculties of veterinary medicine and animal husbandry registered at the Brazilian Federal Council of Veterinary Medicine (Borges et al., 2013).

However, after MoU 48 was signed and after the decision of the four leading industries to comply voluntarily with the EU directives by 2026, animal welfare-specific actions in education, training, and communication became a mutual aim in Brazilian pig production. Thus, intermediaries interested in taking part in establishing a public/private partnership to build capacity in animal welfare issues were mobilized, especially from 2015 onwards. From our interviews with pig production representatives, we found that some actors performed as knowledge brokers in a threefold way: 1) they brought together pig production actors at scientific events to discuss how to implement international animal welfare standards in the Brazilian context; 2) they elaborated consensually new and more focused technical learning materials on animal welfare (taking into account the EU perspective); and 3) they mobilized pig production actors to organize short-term courses and training on the content of new technical learning materials. CTBEA, the World Animal Protection (henceforth WAP), and the Brazilian Pig Producers' Association (henceforth ABCS) were the intermediaries that performed together as knowledge brokers.

They raised public and private funds and applied them in capacity building projects. For example, they mobilized actors from science and practice (national and international researchers, producers' representatives, consultants, international NGOs, industry representatives, and national and international supplier representatives) in 2015 to compile four handbooks to translate the European view on animal welfare – Animal welfare in pig production: slaughterhouse (ABCS 2016a); Animal welfare in pig production: transportation (ABCS 2016b); Animal welfare in pig production: the whole farm (ABCS 2016c); and Housing pregnant sows in a group: good practices for welfare in pig farming (MAPA 2018). They also mediated the production of three videos about animal welfare, supported diversified scientific events (such as the Workshop on Animal Welfare in Pig Farming – 2015 and the Animal Welfare International Symposium: a Sustainable Business Strategy – 2019), and in recent years intermediated the organization of practical courses on animal welfare regulations, involving thousands of people (technicians, producers, and slaughterhouse employees) linked to pig production.

5. Analysis and discussion

The findings presented in this study provide evidence that the implementation of the EU animal welfare directives in the Brazilian commercial pig production system has unfolded as a complex situation of change and influenced the emergence of an ecology of intermediaries attached to it, as expected according to previous literature on standards implementation (EU 2018; OIE 2019) and intermediation (Stewart and Hyysalo 2008; Kivimaa et al. 2017b, 2019a). From the Brazilian case, we have learned three contributions that shed light on different aspects of implementing global food production standards in local contexts. First, the interplay between intermediaries within ecologies of intermediaries is greater than the sum of their separate efforts and plays a pivotal role in operationalizing contextualized strategies aimed to fill gaps between the local context and the international standards. Second, the interplay between intermediaries builds interfaces that allowed actors involved with implementing international standards to extrapolate their often horizontal relationships. And third, our study deepens the understanding of in which dimensions contextualized strategies to implement animal welfare international standards unfold. We now further discuss these main findings and distil implications for theory and practice.

5.1. Intermediaries interplay: greater than the sum of their separate efforts in implementing international standards

Previous literature emphasized that the building of contextualized strategies for animal welfare standards implementation relies on the emergence of particular socio-technical arrangements for mid- or long-term horizons (Huertas et al., 2014; Gocsik et al., 2016; Carey et al., 2017; Zhou et al., 2019). Scholars also highlighted that individuals and organizations that play a role as enablers within these arrangements are crucial to operationalize contextualized strategies (Stafford and Mellor 2009; Yang 2013; Klerkx et al., 2014; Koutsouris 2014; Ortega and Wolf 2018). This study adds to extant work by paying attention to how formal and informal individuals and organizations gathered as an ecology of intermediaries performed collective intermediation efforts to facilitate the implementation of an international standard. The findings presented in section 4 showed that the interplay between them achieved an effect greater than the sum of their separate efforts and provided essential support (such as policy building, knowledge translation, knowledge brokering, innovation brokering) to enable the filling of organizational and technical gaps related to the implementation of the EU animal welfare directives in the Brazilian commercial pig production system.

The interplay between intermediaries went beyond the sum of their separate efforts in the Brazilian case because it unfolded as an alliance in which diverse intermediation roles were played with a certain degree of orchestration to fulfill tasks related to the international standards implementation process. Thus, connections and complementarities between intermediaries became decisive to enable actors' mobilization in building organizational and technical solutions required by EU directives. For instance, CTBEA and GT Pigs performed as pivotal intermediaries in establishing national animal welfare legislation for pig production fitted to the EU directives. Both intermediated policy building by exerting connected and complementary intermediation tasks. CTBEA assumed the network building demand mainly by mobilizing representatives from actors (industries, producers, international animal welfare NGOs, research institutions, and the Brazilian government) involved with the Brazilian commercial pig production system to make up GT Pigs. It also articulated which expectations, demands, and visions would guide the building of normative instructions adjusted to the EU directives by GT Pigs. In its turn, GT Pigs intermediated the translation of the EU directives to the Brazilian context and coordinated the network assembled by CTBEA to build the new Brazilian animal welfare regulations applied to pig production. As a result, the IN nº 113/2020, the legal framework that adjusted Brazilian regulations to international animal welfare requirements, was issued counting with broad acceptance.

Even when intermediaries presented a low synergy within the ecology of intermediaries linked to the EU directives implementation in the Brazilian commercial pig production system, they complemented each other somehow. This could be seen in the case of independent consultants and Embrapa while intermediating interactions between different actors to deploy the group housing of sows in Brazilian pig production. Although guided by different objectives - i.e., independent consultants focused on selling imported equipment and Embrapa on developing a Brazilian solution, their different intermediation purposes have allowed

simultaneously experiencing multi-technological routes, which improved intermediation efforts to refine which alternative best fits the Brazilian context. Altogether, intermediaries attached to the complex situation of change provoked by the EU directives implementation created increasing connections and complementarities among them over time, thus confirming earlier findings presented by Kivimaa et al. (2017b) on why intermediaries that have not planned to work together sometimes end up working as an ecology of intermediaries.

Moreover, looking at the interplay between intermediaries also allowed identifying gaps in operationalizing the contextualized strategy to implement the EU directives in the Brazilian commercial pig production system. For example, the interplay between intermediaries could improve the implementation process in Brazil if it had enhanced initiatives related to innovation brokering (to speed up needed changes in facilities and practices such as tooth tip reduction, partial tail cutting, and males castration), network building, and finance brokering (to improve the development of research projects to endorse international animal welfare rules according to the Brazilian context). In other words, looking at individuals and organizations involved with collective intermediation efforts may reveal more clearly the strengths and weaknesses of contextualized strategies attached to standards implementation processes, facilitating interventions to make them more efficient.

5.2. *Intermediaries collective actions provide interfaces that take actors from horizontal to vertical relationships*

Previous literature has emphasized that the interaction needed between diverse actors dispersed over different levels is one of the major issues for implementing international animal welfare standards in specific contexts (Sinclair 2016; OIE 2019; Khaneghahi Abyaneh et al., 2020). Analyzing the interplay between individuals and organizations within intermediaries' ecologies deepens understanding of how such interactions unfold in practice. In the Brazilian case analyzed in this study, the ecology of intermediaries attached to the EU directives implementation in the Brazilian commercial pig production system contributed to facilitating collaboration between actors from international and national levels. It played this role by building shared interfaces (e.g., multi-stakeholder committees, capacity building projects, technology development partnerships) where actors negotiated, exchanged knowledge, and built agreed solutions to tackle demands raised by the EU directives implementation process – e.g., changes in the Brazilian legislation; adaptation of technologies, practices, and facilities; development of national research in animal welfare issues. These interfaces bridged actors vertically, making them extrapolate their – often horizontal – relationships, i.e., within the level to which they belong.

Two examples described in our findings illustrate how the ecology of intermediaries related to the EU directives implementation process in the Brazilian commercial production system provided interfaces where actors went beyond their usual relationships. First, CTBEA functioned as the principal policy building intermediary in the EU directives implementation process. It deployed a committee (GT Pigs) composed of representatives from international (international animal welfare NGOs) and national (research institutions, the Brazilian government, industries, and producers) levels. GT Pigs became a shared interface where actors collaborated to adjust Brazilian animal welfare legal regulations to European standards, a link that needed to be built in the organizational intervention domain. Second, CTBEA, WAP, and ABCS performed as intermediaries that mobilized national and international researchers, producer representatives, consultants, international NGOs, industry representatives, and national and international supplier representatives through capacity-building projects. As a result, these diverse actors compiled learning materials on animal welfare standards implementation in Brazilian pig production, creating a link that needed to be built in the technical intervention domain.

5.3. *Normative and technological: dimensions where contextualized strategies unfold*

Our study also deepens the understanding of what a contextualized strategy to implement international animal welfare standards is. Mainly, our study extends the understanding of contextualized strategies by arguing that they unfold through two dimensions. The first is the normative dimension, which refers to building local capacity to translate, adapt, and implement regulations according to the international standard chosen. The second is the technological dimension, which has to do with building local capacity to innovate via adaptation or creation of technologies and practices to apply the chosen international standard to the production process. Therefore, our study increases the comprehension of how to operationalize contextualized strategies to foster the co-evolution of the two intervention domains (organizational and technical) of an international animal welfare standards implementation process. This refines earlier work (Kahn and Varas 2014, EU 2017, OIE 2017, EU 2018) that looks at several components of animal welfare standards implementation and support strategies for their contextualization but tends to see those more in isolation.

Furthermore, our study sheds light on how intermediaries work to operationalize contextualized strategies aimed at implementing international animal welfare standards. Our study emphasizes the importance of individuals and organizations interested in intermediating the adaptation of technologies in a national context to comply with international regulations, confirming earlier findings by other authors (Mol and Oosterveer 2015; Rahmat et al., 2016; EU 2017; Eastwood et al., 2017; Dias et al., 2018b; Bayne and Turner, 2019; Grabs and Carodenuto, 2021). Furthermore, we demonstrated that to come to contextualized strategies this relies on connected and complementary intermediation actions. This highlights the importance of a holistic analysis of intermediaries within the whole system, as opposed to compartmentalized analysis of how particular individuals and organizations play intermediary roles on particular elements of such interventions. This implies that, in contextualized strategies, more proactive consideration should be given to enabling intermediary actions aimed at facilitating the collaboration needed between multiple actors at different levels of the international animal welfare standards implementation process.

6. Conclusion

This study connected strands of literature on standards implementation and intermediation to deepen the understanding of implementing global food production standards in local contexts. We have shown that collective intermediation efforts are pivotal in addressing the demands (such as translation, adaptation, regulation) emerging from the complex situation of change provoked by international animal welfare standards implementation processes. Additionally, we demonstrated that a network of individuals and organizations that formed an ecology of intermediaries played connected and complementary intermediary roles (such as innovation brokering, knowledge brokering, policy building) to bridge actors from different levels (international, national, and local) in the building of the links needed to effectively introduce in the Brazilian commercial pig production system internationally recognized sets of animal welfare tenets and rules.

The main implication of our study for theory on international standards implementation (focused on animal welfare, but also on other environmental and social sustainability issues) is that, instead of the scattered support actions currently described by the literature, we should see the different intermediaries involved in standards implementation processes as a support system enacted by an alliance between them. This gives a more integrated view on the fact that standards implementation is a layered process of linking, translating, and feeding back information between international standards setters and national adopters of these standards. Furthermore, we highlight a key policy

implication from our study. Supporting international agreements as a strategy to improve animal welfare worldwide implies also fostering planning and funding mechanisms that allow a co-evolution of standards implementation processes and ecologies of intermediaries attached to them in national contexts. Furthermore, international animal welfare standards setters (such as the EU and OIE) could help national industries to better map ecologies of intermediaries associated with implementation processes and see where the gaps are.

Given the generalizability limitations of our explorative case, future work would be needed to substantiate our findings regarding how intermediation efforts facilitate international animal welfare standards implementation processes in other contexts. Such work would need to focus at a lower level of aggregation (the level of regions, territories, individual farms) to see how actors such as farmers or other local actors (traders, input providers – see Legun and Bell, 2016; Schoonhoven-Speijer and Vellema, 2020) may act as intermediaries for the translation of international welfare standards in everyday practice and to more local settings than national. Moreover, future studies should also look at how international standards are translated to or influence other sorts of production systems, such as the artisanal small scale pig production. Thus, such studies may investigate whether there are parallel networks of intermediaries, next to those identified in this paper, playing a role as connected facilitators of animal welfare international standards implementation in other Brazilian contexts. Also, future work could take the lens of ecologies of intermediaries to assess distributed change agency and support for implementation of other international agrifood sustainability standards (e.g. environmental and social) in national contexts (see also for example Klerkx et al., 2012; Grabs and Caradenuto, 2021).

In this study, we have mainly focused on the role of humans as intermediaries, justified by our choice of applying the ecology of intermediaries concept to frame how individuals and organizations worked together in the Brazilian case. However, it is presumable that there are also non-human components that may somehow intermediate international standards implementation processes. Further studies could therefore apply perspectives drawing on assemblage theory (Deleuze and Guatari 1987, Muller 2016) or actor-network theory (Latour 2002, Aka 2019) to look at how all entities (humans and non-humans, such as animals, things, and matter) involved with implementing international animal welfare standards in local contexts constitute an order that emerges in particular ways, holds together, and moulds local contexts (see for example Contesse et al., 2021; Darnhofer, 2016; Higgins et al., 2017, Legun and Sautier 2018, Comi, 2020).

Given that the analysis points at importance of coordination in the ecology of intermediaries, it would also be interesting to investigate to what extent it is feasible to purposefully introduce collective intermediation efforts related to complex situations of change. Thus, one could analyze, for example, to what extent human or non-human components in alliances can be orchestrated to fill gaps in intermediation roles focused on creating contextualized strategies to implement international animal welfare standards.

Author statement

Jean Vilas-Boas: Conceptualization, Formal analysis, Investigation, Methodology, Writing – original draft. **Laurens Klerkx**: Supervision, Writing – review & editing. **Rico Lie**: Supervision, Writing – review & editing.

Appendix

Appendix 1

List of interviewees, 2017 and 2019

Groups of influential actors	Interviewees	Position or Expertise	Total
Industries	BRF SA representative	sustainability, process management	7
	Aurora Alimentos Central Cooperative representative	president	
	JBS Foods	corporate director of livestock	
	Pamplona Food SA	president	
	Frimesa Central Cooperative	executive director	
	Master Agriculture and Livestock	executive director	
	Pig Production Industries Association	president	
Producers	Brazilian Pig Producers Association	executive director	2
	Santa Catarina Pig Producers Association	president	
Advisory services	BRF SA representative	executive director	5
	Aurora Alimentos Central Cooperative representative	executive director	
	Advisory service consultant	innovation and animal welfare	
	Advisory service consultant	communication and animal welfare	
	Advisory service consultant	animal welfare	
Science	Research governmental company	animal welfare	4
	Research governmental company	animal health	
	Research governmental company	Environment and sociology	
	University	animal welfare	
	University	education and animal welfare	
Non-governmental organizations	Humane Society International	animal welfare specialist	4
	World Animal Protection Brazil	executive director	
	Santa Catarina Animal Health Institute	animal health, environment, and education	
	Santa Catarina Agriculture Association	president	
Government/policymakers	Brazilian Ministry of Agriculture, Livestock, and Supply	pig production director	3
	Brazilian Ministry of Agriculture, Livestock, and Supply	animal welfare department director	
	Santa Catarina Agriculture, Livestock, and Fishery Department	animal health and animal welfare	
Suppliers	GSI Brazil Industry and Equipment	Director	2
	Schauer Brazil	business representative	
Total			27

Appendix 2

List of core and additional secondary data, 2017 and 2019

Type of secondary data	Core secondary data	Additional secondary data	Total
Books	The economics and organization of Brazilian agriculture – Fábio Chaddad (2016) Mapping of Brazilian Pork Chain – SEBRAE and ABCS (2016) Pig production: theory and practice – ABCS (2014) Swine cooking in Brazil: quality from the field to the table – Arthur Bosísio, Raul Lody, Jean Vilas-Boas, Márcia Leitão, Humberto Medeiros (2003) Sonho, desafio e tecnologia: 35 anos de contribuições da Embrapa Suínos e Aves – Jean Vilas-Boas, Dirceu Talamini, Gerson Scheuermann, Gilberto Schimidt (2011) Bem-estar dos suínos – Cleandro Pazinato Dias (2016)		6
Scientific papers	Como as normas de bem-estar animal podem impactar na produção de suínos no Brasil – Cleandro Pazinato Dias (2018) Pork consumption in Brazil: challenges and opportunities for the Brazilian pork production chain – Marcia Dutra de Barcellos (2011) Bem-estar Animal na Produção de Suínos (Transporte) – Charli Ludtke, Osmar Dalla Costa, Stefan Rohr, Dalla Costa and Dalla Costa, 2015		3
Policy briefs	Decree on Pig Production Animal Welfare Best Practices – Brazilian Ministry of Agriculture (final version, which will be issued in 2020)		1
Guides and official technical material in animal welfare	Animal Welfare in Brazil – Brazilian Ministry of Agriculture (2016) STEPS Project: Guide to humane slaughter of pigs – WSPA (2010)		2
Official public reports		Censo Agropecuário Brasileiro – IBGE (2006)	1
Media articles published in newspapers and magazines		Guia Gessulli da Suinocultura Industrial – Revista Suinocultura Industrial (2015)	1
Annual reports		ABPA Annual Report 2019 – ABPA (2020) ABPA Annual Report 2020 – ABPA (2021) Pig Production Magazine Nº 14 – ABCS (2015) Pig Production Magazine Nº 15 – ABCS (2015)	4
Total			18

Appendix 3

Theoretical level of complexity of implementing EU directives in the Brazilian pig industry (Dias et al., 2015, p. 1082).

Requirements of animal welfare	Level
•Unobstructed floor area available to each weaner or rearing pig in a group (m2/animal)	+
•Total unobstructed floor area available to each gilt and sow kept in a group after service (m2/animal)	+
•Minimum area of continuous solid floor in a gestation group (m2/animal)	+
•Maximum width of the openings and minimum slat width when concrete slatted floors are used for pigs kept in groups	+++
•Freedom of movement: gilts and sows, tethered	↓
•Freedom of movement: housing pregnant sows in a group	+++
•Access to manipulable material to build a nest during the week before the expected farrowing time	+++
•Permanent access to sufficient stimulation and enrichment activities for all pigs	+++
•Supply of wholesome food appropriate to their age and in sufficient quantity	↓
•Conception and use of feeders and drinkers to reduce the risk of contamination and negative effects of competition between animals	+
•Use high-fibre materials in the diet of gestation sows	++
•All pigs fed at least once a day	↓
•Simultaneous access to feed for all pigs fed in groups and not fed *ad libitum*	+
•Fresh water for all pigs over two weeks of age	↓
•Segregation of sick animals (hospital pens) with immediate and appropriate treatment	↓
•Appropriate euthanasia procedures when necessary to prevent needless suffering	++
•Sufficient number of trained people to take care of the animals	↓
•Staff training (training courses/certificates)	↓
•Low level of continuous noise (<85 dBA), constant or sudden noise shall be avoided	↓
•Light with an intensity of at least 40 lux during a minimum period of 8 h/dia	↓
•Lying area: physically and thermally comfortable, drained, clean and with space for all animals to lie down at the same time	++
•Floors smooth, not slippery, and stable	+
•Air circulation, dust level, temperature, relative air humidity and gas concentrations within limits not harmful to animals	↓
•Daily inspection of equipment essential to animal health and welfare and correction of damage	↓
•Provide emergency and alarm systems, when animal health and welfare depend on artificial ventilation systems	+
•Procedures with piglets: avoid routine reduction of corner teeth	+
•Procedures with piglets: avoid routine tail docking	++
•Procedures with piglets: castration of males until 7 days (without anaesthesia and analgesia)	+
•Procedures with boars: reduce the length of the tusks	↓
•Housing of boars in pens (minimum 6 m2)	++
•Farrowing pens should allow free movement of females and protection for piglets (farrowing rails). The area behind of the farrowing pen should allow natural or assisted farrow	++
•Facilities for piglets: allow all piglets to lie down at the same time, floor solid or covered with bedding	++
•Weaning at age 28 days or 21 days (nursery: all in/all out, separated from sows)	+
•Minimum possible mixing of pigs in the nursery and growing and finishing	++
•Daily inspection of animals	↓
•Maintain records of veterinary treatments and mortality rates for at least 3 years	+

Levels of complexity for implementation in Brazil.

↓ (Reduced): Natural Brazilian advantage due to climate, space, or availability of human resources and raw materials for food.

+ (Minor): Minor changes to management and/or low investment.

+ + (Moderate) Moderate changes to management and/or moderate investment.
+ + + (Major): Major changes to management and/or high investment.

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