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Challenges in building an energy supply chain from urban solid waste: the role of institutional entrepreneurs

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Authors' notes'

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Abstract

Objective: Assess the role of institutional entrepreneurs in building a waste-to-energy supply chain from urban solid waste.

Methodology: The research's units of analysis are the institutional entrepreneurs involved in constructing an energy supply chain at the Western Caucaia Municipal Sanitary Landfill, located in the state of Ceará. The case study, with a qualitative approach, was carried out through semi-structured interviews. The path dependence research technique was adopted to construct the historical pathway and content analysis.

Originality/Relevance: The supply chain investigated was created from a partnership involving the Ceará state government, municipal governments, and companies for the installation of the largest plant in the country capable of injecting biogas, originating from the anaerobic digestion of urban solid waste, in Ceará's natural gas distribution company (CEGÁS).

Results: Institutional entrepreneurs can drive new institutional arrangements through the development of political, social and technical capabilities. Among the strategies identified, partner selection based on pre-existing trust relationships, and the actions of government actors were critical factors for the success of the energy supply chain from urban solid waste.

Contributions: The study contributes to understanding the role of institutional entrepreneurs in rearranging an energy supply chain. The work offers an analysis of political, social and technical capabilities, and contributes to the construction of sustainable cities with efficient waste management and attentiveness to the environmental and social impacts of unruly urban expansion.

Keywords: urban solid waste; waste-to-energy; institutional entrepreneurship

Desafios na construção de uma cadeia de fornecimento de energia a partir de resíduos sólidos urbanos: o papel dos empreendedores institucionais

Resumo

Objetivo: Avaliar o papel dos empreendedores institucionais na construção de uma cadeia de fornecimento de energia a partir de resíduos sólidos urbanos.

Metodologia: As unidades de análise da pesquisa são os empreendedores institucionais envolvidos na construção de uma cadeia de fornecimento de energia no Aterro Sanitário Municipal Oeste de Caucaia, localizado no estado do Ceará. Trata-se de um estudo de caso, com abordagem qualitativa, realizado por meio de entrevistas semiestruturadas. A técnica de pesquisa de *path dependence* foi adotada para a construção da trajetória histórica e análise de conteúdo.

Originalidade/Relevância: A cadeia investigada se constituiu a partir de uma parceria envolvendo o governo do estado do Ceará, prefeituras municipais e empresas privadas, para a instalação da maior usina do país com capacidade de injetar biogás proveniente da digestão anaeróbica de resíduos sólidos urbanos na rede de distribuição de gás natural da Companhia de Gás do Ceará – CEGÁS.

Resultados: Evidenciou-se que empreendedores institucionais podem protagonizar a configuração de um novo arranjo institucional por meio do desenvolvimento de habilidades políticas, sociais e técnicas. Dentre as estratégias identificadas, a seleção de parceiros baseada nas relações de confiança pré-existentes e a atuação dos atores governamentais são fatores críticos para o sucesso da cadeia de fornecimento de energia a partir de resíduos sólidos urbanos.

Contribuições: O estudo contribui para a compreensão da atuação de empreendedores institucionais no rearranjo da cadeia de fornecimento de energia. O trabalho oferece um diagnóstico das habilidades políticas, sociais e técnicas, e contribui para a construção de cidades sustentáveis e eficientes na gestão de resíduos e atentas aos impactos ambientais e sociais do crescimento urbano desordenado.

Palavras-chave: resíduos sólidos urbanos; *waste-to-energy;* empreendedorismo institucional

Desafíos en la construcción de una cadena de suministro de energía a partir de residuos sólidos urbanos: el papel de los emprendedores institucionales

Resumen

Objetivo: Evaluar el papel de los emprendedores institucionales en la construcción de una cadena de suministro de energía a partir de residuos sólidos urbanos.

Metodología: Las unidades de análisis de la investigación son los emprendedores institucionales involucrados en la construcción de una cadena de suministro de energía en el Relleno Sanitario Municipal Oeste de Caucaia, ubicado en el estado de Ceará. Se trata de un estudio de caso, con enfoque cualitativo, realizado a través de entrevistas semiestructuradas. Se adoptó la técnica de investigación de la dependencia de la trayectoria para construir la trayectoria histórica y análisis de contenidos.

Originalidad/Relevancia: La cadena investigada fue creada a partir de una alianza entre el gobierno del estado de Ceará, gobiernos municipales y empresas, para la instalación de la mayor planta del país con capacidad de inyectar biogás, proveniente de la anaerobic digestión de residuos sólidos urbanos en la red de distribución de gas natural de la Companhia de Gás do Ceará – CEGÁS.

Resultados: Fue evidente que los emprendedores institucionales pueden liderar la configuración de un nuevo arreglo institucional a través del desarrollo de habilidades políticas, sociales y técnicas. Entre las estrategias identificadas, la selección de socios, basada en relaciones de confianza preexistentes, y las acciones de los actores gubernamentales son factores críticos para el éxito de la cadena de suministro de energía a partir de residuos sólidos urbanos.

Contribuciones: El estudio contribuye a comprender el papel de los emprendedores institucionales en la reorganización de la cadena de suministro de energía. El trabajo ofrece un diagnóstico de habilidades políticas, sociales y técnicas, y contribuye a la construcción de

ciudades sostenibles y eficientes en la gestión de residuos y atentas a los impactos ambientales y sociales del crecimiento urbano desordenado.

Palabras clave: residuos sólidos urbanos; transformación de residuos en energía; emprendimiento institucional

1 Introduction

Urban solid waste management (USW) is a challenge for governments, companies and civil society (Jacobi & Besen, 2011). Inadequate disposal of USW in landfills proliferates diseases, emits greenhouse gas (GHG) and contaminates soil and groundwater (Matias & Menezes, 2018). Recycling USW into a thermic energy source involves technologies of different scales and complexities (Mutz, Hengevoss, Hugi, & Gross, 2017) and can simultaneously answer USW management and electricity demand (Makarichi, Jutidamrongphan, & Techato, 2018; Pan et al., 2015). Legal conformity with USW management codes comes from a mutual effort among public administration, private companies and civil society (Diniz & Abreu, 2018).

Conceptualized by Eisenstadt (1964), “institutional entrepreneurship” allows for the analysis of relationships between institutions, individuals and organizations. It involves actors’ activities interested in specific institutional arrangements, which are responsible for mobilizing resources to either create institutions or modify existing ones (DiMaggio, 1988). In this sense, institutional entrepreneurs are actors capable of solving problems regarding the creation of an energy supply chain from USW through the adoption of multifaceted strategies, and who can transform the institutional environment. Institutional entrepreneurs can increase waste sorting, recycling and investments in waste treatment technology, as well as aid in the adoption of waste-to-energy transformation chains. Biygautane, Neesham e Al-Yahya (2019) claim that institutional entrepreneurs have different and complementary capacities, which, when combined with strategies, act to drive interests and mobilize resources for implementing new projects. According to Mahzouni (2019), it is necessary to identify institutional entrepreneurs' capacities to execute

changes.

Based on the above, the following research question emerges: *What are the necessary institutional entrepreneurs' capacities for building a waste-to-energy supply chain?* This paper evaluates capacities and strategies of institutional entrepreneurs which favor the building of a waste-to-energy supply chain in west Caucaia municipal landfill (ASMOC), in the state of Ceará, Brazil. The supply chain studied was built from a partnership involving Ceará's state government, municipal governments and private companies, which resulted in Brazil's biggest biogas power plant, capable of injecting biogas from the anaerobic decomposition of USW in Ceará's gas company (CEGÁS) distribution chain. This study contributes to understanding the role of institutional entrepreneurs in promoting changes to the institutional environment and stands out for exploring the need for an efficient USW management, in order to keep up with unruly urban expansion.

To reach the proposed goals, the next section presents the challenges in building the supply chain and the role of institutional entrepreneurs. Followed by the qualitative research methodology, which presents the results and discussions from the interviews with key actors from the waste-to-energy supply chain. Lastly, the study points out the political, social and technical capacities developed by the institutional entrepreneurs in configuring the new institutional arrangement for building sustainable and waste management efficient cities.

2 Theoretical background

2.1 Understanding the urban waste-to-energy supply chain challenges

The waste-to-energy supply chain involves a diverse array of technologies regarding combustion, incineration, pyrolysis, gasification, coprocessing and anaerobic digestion (Pan et al., 2015). Anaerobic digestion is the decomposition of organic matter by microorganisms without the use of oxygen. The anaerobic biodigester offers the necessary conditions for microorganisms to transform organic matter into biogas, which is a mixture of organic gasses that can be burned to generate thermic energy (Mutz et al., 2017). The "landfill gas" is made up of around 45 to 55%

methane (CH4), and is collected by tubulations, which captures the gas and transfers it to a purification system, removing hydrogen sulfide gas (Mutz et al., 2017).

There are regulatory, institutional, financial and technological barriers to implement a waste-to-energy supply chain (Pan et al., 2015). Regulatory barriers are characterized by national goals being too vague for the development of energy technology, public policies being either inadequate or incomprehensible and a general lack of goals or deadlines for policy compliance. Regarding institutional barriers, tackling them requires coordination and cooperation from authorities when creating policies. The main institutional barriers are resistance from local communities and competition with well-established energy generating technologies. The financial barriers are characterized by unclear energy pricing, high cost of capital and long-term investment returns. The technological barriers refer to difficulty accessing technologies, lack of information on the best available option and difficulty choosing economically viable technologies. These barriers cannot be separated, as the mechanisms of public policies usually work on more than one barrier simultaneously (Pan et al., 2015).

Through a social perspective, Ceglia, Abreu and Silva Filho (2017) investigated barriers to be overcome for promoting opportunities in waste exchange. Their findings indicate that values, trust behavior, waste cognitive domain and environmental engagement are necessary for the creation of an eco-industrial park. Social barriers are prerequisites for companies to get involved in establishing technological and logistical solutions. These barriers are deeply ingrained in the context of developing countries.

2.2 The concept of institutional entrepreneurship and its strategies

Institutional entrepreneurship highlights the way actors manipulate the structures in which they are inserted to create institutional arrangements and reach their strategic goals. Institutional entrepreneurs are individuals, organizations or coalitions that engage in actions to change their institutional environment (Tracey, Phillips, & Jarvis, 2011). It is a study field focused on changing

existing institutions and creating new ones through entrepreneurs that introduce new business models and social, cultural and environmental practices (Tiberius, Rietz, & Bouncken, 2020). Individuals, organizations, networks and social movements can act as institutional entrepreneurs and use a diverse array of strategies (Hardy & Maguire, 2008). Some of the strategies adopted by institutional entrepreneurs include the articulation of new visions, rationales, awareness, alliances and lobbying. Other strategies employed in shaping regional institutional arrangements are resource mobilization and legitimacy creation (Jolly, 2017).

The process of institutional change is context and objective dependent, however, it generally involves the following steps: emergence, establishment and institutionalization of new rules. At first, institutional entrepreneurs identify an opportunity for institutional change and start to develop a new idea or practice. Secondly, entrepreneurs work on mobilizing resources and building a coalition of supporters to implement institutional changes. Thirdly, the new idea or practice is adopted and becomes part of the institutional routine. Lastly, the institutional change becomes a new rule (Grimm, Hofstetter, & Sarkis, 2023; Linnenluecke, Verreynne, de Villiers Scheepers, & Venter, 2017).

Institutional entrepreneurs' capacities and initiatives perform a crucial role in transforming institutional environments, as changes are often the result of ruptures or crises in institutional arrangements (Heiskanen, Kivimaa, & Lovio, 2019). According to Battilana (2006), the probability of actors being "agents of change" is linked to their position in the institutional field. Institutional entrepreneurs who do not benefit from the current institutional arrangement tend to have less to lose when getting involved with movements attempting institutional changes. On the other hand, entrepreneurs with a higher social status and occupying a more central role, therefore benefiting from the status quo, are less inclined to attempt change.

Li, Feng and Jiang (2006) analyzed the strategies entrepreneurs can use to eliminate institutional barriers and promote market-oriented institutions. They found four main approaches:

a) Open advocacy: publicly acting in defense of altering laws or regulations, done through media interviews, forum participation and accessible conferences, or by conducting public opinion polls.

b) Private persuasion: presenting arguments to relevant decision makers in society, through private encounters or by sponsoring undisclosed research reports.

c) Request an exception: defend the idea that their situation is special, arguing that it should be considered a legislative exception, with the intent of acquiring authorization to operate exceptionally.

d) Ex ante investments with ex post justifications: initially, entrepreneurs either starts or expands their investment avoiding complying with the current regulation. When their investment becomes profitable and generates jobs or social benefits, the entrepreneur leverages this as a way of justifying their previous actions and convincing the government to change rules and regulations, as a way of legitimizing the entrepreneurs' behavior.

Biygautane et al. (2019) identified three cognitive strategies to aid institutional entrepreneurs' efforts in convincing third parties to adopt change: theorization, legitimation and framing. Theorization consists of an abstraction process, in which the current practices' problems or shortcomings are highlighted, while institutional entrepreneurs elucidate why new practices are necessary. Legitimization describes the act of connecting new ideas, forms and practices to a set of values and ideas that the institutional entrepreneurs want to legitimize, as a way of substantiating the relevance of adopting new practices. Lastly, framing is a "cognitive mechanism" in which institutional entrepreneurs use symbolic rhetoric to incite disbelief towards the status quo, as a way of changing institutional arrangements.

2.3 Necessary capacities for institutional entrepreneurs' actions

Cui, Tang, Li and Li (2023) developed a bibliometric analysis of 438 institutional

entrepreneurship studies published and indexed in the Social Science Citation Index (SSCI) between 1994 and 2021. The results show a growing academic interest around the subject, due to a growing number of publications and citations. The research identified areas of application of institutional entrepreneurship, such as healthcare, energy production and transportation, and highlighted the importance of adjusting the concept of institutional entrepreneurship to explain how and why institutions change.

Companies and business associations' participation in institutional change in the Brazilian software and services industry was led by actors who have more resources and are well placed in the organizational field (Jacobus, 2014). Borges and Scherer (2015) researched how the winery Miolo Wine Group used the concept of institutional entrepreneurship to grow the emerging wine hub from Campanha Gaúcha. They found that the winery had actively participated in the creation of Campanha Gaúcha's institutions, acting as a strong leadership for consolidating projects through intangible resources, such as knowledge and experience, which emerged as the main channels of conduct when negotiating with public actors and dialoguing with local communities.

By comparing the institutional strategies that led to the development of wind farms in Finland and India, Jolly, Spodniak and Raven (2016) proposed a typology for the "political", "technical" and "cultural" labor. The political labor in support of wind farms was opposed by the lack of collective action and conflicting interests between different actors, such as the government, industry associations and wind power companies. Finland has a stronger position than India regarding technical labor due to significant research and development in wind power's technological value chain. In terms of cultural labor, the main focus of Indian civil and environmental groups are social justice and equity issues, while in Finland there is an emphasis in planning, environmental concerns and aesthetic issues. With a similar perspective, Jolly (2017) highlighted the state differences between Indian sustainable energy projects, focusing on divergences in the implementation of photovoltaic solar energy connected to the power grid. The study shows that, although pre-existing local conditions were favorable, Eastern Bengal did not

have the necessary support from the involved actors, which shows a lack of institutional entrepreneurship in the region.

The activities and strategies that various social actors adopted to build the Saudi Arabia airport, through public-private partnerships, was studied by Biygautane et al. (2019). This project's success involved the close collaboration and interconnectivity between actors. Mahzouni (2019) evaluated how institutional entrepreneurship actions on multiple levels (i.e. individual, organizational and institutional) and development stages (i.e. innovation, mobilization and structuring) interact to enable the construction of an energy production cooperative. The involved social actors combined individual benefits with collective ones, resorting to social positions, experiences and formation of networks to legitimize their actions. Inderberg, Leikanger and Westskog (2023) researched the inclusion of a renewable energy system in a Norwegian middle school, highlighting the importance of entrepreneur politics and the development of organizational culture in the transition to renewable energy. Regional political leadership and organizational culture are crucial factors for a successful transition towards renewable energy.

Institutional enablers to drive the transition to a circular economy (CE) in the European Union were evaluated by Alonso-Almeida et al. (2021). The study used structural equation modeling to analyze the links between institutional entrepreneurship enablers and the impacts on CE strategies. The efficacy of acting as an institutional entrepreneur as essential ability to force transformational and radical change. Through a constructivist approach towards regulation, Larrinaga and Bebbington (2021) came to the conclusion that actors' convergence and structural conditions were crucial for the development of sustainability reports. A case study on institutional entrepreneurship and mega-projects management was performed by Qiu et al. (2022), taking the construction of the Hong Kong-Zhuhai-Macau bridge as an example. The institutional entrepreneurs transformed conventional building practices and reinforced the importance of institutional compatibility and governance in the implementation of new practices. In a different context, Deerfield and Elert (2023) explored the link between regulatory freedom and the

introduction of legislation,taking car-pooling in the United States of America as a case study. Their results suggest that regulatory freedom can be beneficial for institutional entrepreneurship, however the introduction of legislation may be necessary to increase the legitimacy and social acceptance of new forms of entrepreneurship.

Institutional entrepreneurs can influence organizations' decision making regarding sustainability by articulating the need for stakeholders with long term perspectives. Chakhovich and Virtanen (2023) highlighted the importance of collaboration among institutional entrepreneurs and other organizational actors. A refined version of the institutional entrepreneur model was proposed by Pimentel, Major and Cruz (2023), which included collective action as a central element for institutional change. The study highlights the importance of leadership, communication and organizational learning for the success of collective action, as it allows institutional entrepreneurs to mobilize resources and build coalitions to challenge ruling norms.

3 Methodology

The study is qualitative, descriptive and exploratory (Collis & Hussey, 2005), which is more suitable for understanding the dynamics that operate in a single scenario (Eisenhardt, 1989). The strategy adopted in this research is the case study, as it is an empirical investigation that seeks to explore a current phenomenon in depth and in its real circumstances (Yin, 2015). The case study consists of institutional entrepreneurs involved in building a waste-to-energy supply chain in the west Caucaia municipal landfill - ASMOC, in the state of Ceará. This chain was created from a partnership involving the state government, municipal governments and private companies, to install the country's largest waste-to-energy power plant (GNR Fortaleza), which produces biogas that is injected in Ceará's gas company (CEGÁS) distribution network (CicloVivo, 2018). According to data from SNIS (2021), the northeast region of Brazil has the second lowest USW collection coverage index (83,1%). The state of Ceará has the highest USW collection coverage index in the region, but most of this waste ends in dumping grounds (SNIS, 2020).

The data collection was carried out using primary and secondary sources. Primary data was collected through 9 semi structured interviews with 5 actors involved with the construction of the waste-to-energy supply chain. Secondary data was collected from official websites and documents of public institutions and private companies, to build the case's historical pathway. The interviewees were two representants from the public sector and three representants from the private sector. The selection criteria were accessibility and availability (Creswell, 2010; Flick, 2009). The subjects interviewed held strategic positions, such as directors and presidents of companies, and provided a broad understanding of the institutional environment, as listed in figure 1.

Figure 1

Key-actors interviewed

Caracteristics	Organization	Interviewee's position
Mixed Economy Society (public and private sector)	Ceará's Gas Company (CEGÁS)	Director-president
Ceará State Government Secretariat (Public sector)	Environment Secretariat (SEMA)	Environment Secretary
Company (*private sector*)	Ecometano	Director
Company (*private sector*)	Marquise	Director-president
Company (*private sector*)	CERBRAS (project's first client)	Industrial director

Primary data collection took place in two phases: exploratory and confirmatory. During the exploratory phase, three key actors from the private sector and one from the public sector were interviewed, in person, in July 2019. The interviews' script was divided in five sections: project's initial motivation, how the partnership between actors was formed, supply chain's structure, barriers faced during the field's change process and the impacts from building the supply chain. During the confirmatory phase, three key actors from the private sector and two from the public

sector were interviewed, via videoconference, in May 2020. The interview script aimed at understanding institutional entrepreneurship rationale, focusing on evaluating the positioning of actors' social issues in relation to institutional change, strength of government actors, resource mobilization and identification of social actors' capabilities and strategies in overcoming social barriers. The interviews lasted an average of 40 minutes and were recorded and transcribed for content analysis, as proposed by Bardin (2016).

The analysis categories were defined by comparing collected data with concepts of institutional entrepreneurship, which were classified into: social actors' participation; social actors' capabilities and institutional entrepreneurs' strategies. These categories were described and exemplified through quotes and excerpts from interviews. Path dependence research technique was adopted to construct the historical pathway, as proposed by Mahoney (2001). Antecedent conditions, critical situation, structural persistence, reactive sequence and results were identified. Antecedent conditions correspond to the historical factors that define viable options and shape selection processes. Critical juncture is related to the moment when a decision is made, defining the historical pathway's continuation. Structural persistence is the persistent production and reproduction of structural conditions. In the reactive sequence, counter-reactions to existing conditions are identified, and the results are the solutions found for conflicts and counter-reactions (Abreu & Freitas, 2015).

4 Results

4.1 Biogas purification plant path dependence

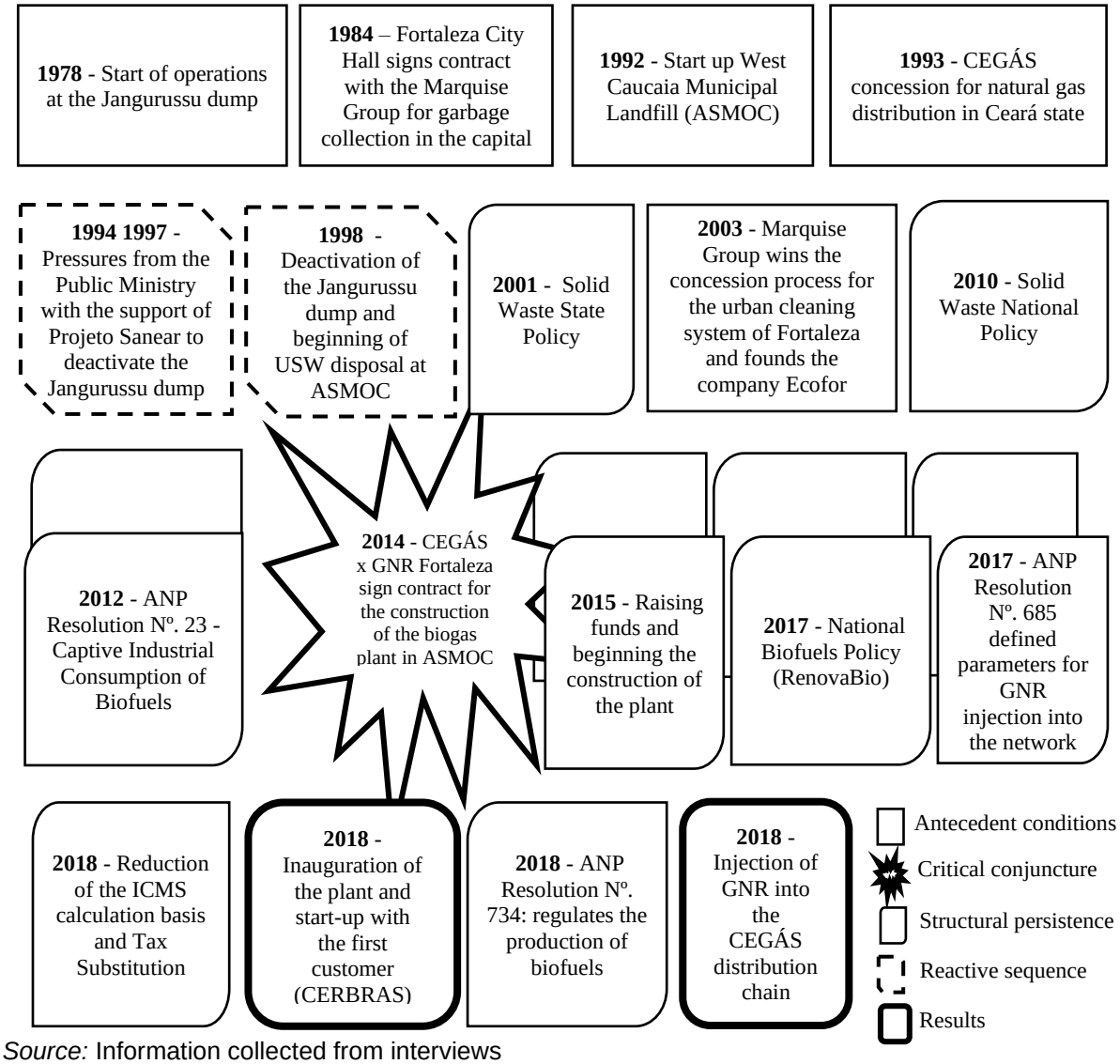
Figure 2 shows the pathway of the biogas purification plant in the ASMOC considering the antecedent conditions, critical junctures, structural persistence, reactive sequences and results. Antecedent conditions involve the beginning of operations of the Jangurussu dumping ground in the city of Fortaleza in 1978. During 20 years of operation, the Jangurussu dump reached 40 meters in height and greatly inconvenienced the local community (Lima, 2013). In 1984, the city

of Fortaleza signed a contract with the Marquise Group, so that the company would become responsible for municipal garbage collection (Marquise, 2020). However, the destination of the collected USW was still the Jangurussu dumping ground. In 1992, in Fortaleza's metropolitan region (FMR), the Caucaia municipality opened up the state's main landfill, west Caucaia municipal landfill (ASMOC) (ACFOR, 2012). In parallel, Ceará's gas company (CEGÁS) is established through a 50 year concession contract for natural gas distribution in the state (CEGÁS, 2020). These events represent historic milestones to the beginning of relations between garbage collection, gas distribution companies and regional public authorities.

In face of social and environmental problems caused by the improper management of USW in the Jangurussu dumping ground, the Ceará state public prosecutor, with support from the Sanear project, pressured the state government to close the dumping ground in 1998. Consequently, the final destination of Fortaleza collected USW became the ASMOC (ACFOR, 2012). On January 24, 2001, the state government created Law No. 13,103, providing integrated action planning with regionalized goals. In 2003, the Marquise group founded the Ecofor Ambiental company due to getting the concession for Fortaleza's USW services. For 20 years, the company has held exclusive rights to UWS management services, including waste collection, sweeping and ASMOC landfill operation (Marquise, 2020).

Figure 2

Path dependence of the Waste-to-Energy supply chain in ASMOC



Source: Information collected from interviews

Despite states taking some actions towards USW management, the impacts from Brazil's growing waste production were becoming more dire. In this context, the National Solid Waste Policy (NSWP) was created through law nº 12.305 in August 2, 2010, providing the principles, objectives, instruments and guidelines for solid waste management, as well as assigning responsibilities for waste generators and public authorities. In accordance with the NSWP, in 2012

the national agency for petroleum, natural gas and biofuel (ANP) established resolution nº 23, authorizing industrial consumption of biofuel. From this moment on, unspecified gaseous biofuel (such as the ones produced from solid waste decomposition) could be used for pilot projects for use in industrial contexts. This resolution was an important incentive for entrepreneurs to invest in waste-to-energy projects.

In 2014 the historical pathway reached a critical juncture, when the Marquise group made the strategic decision of establishing a partnership with Ecometano. The company captures and refines biogas from renewable sources and identifies an opportunity for building a waste-to-energy system in the ASMOC. By the end of 2014, Ecometano and the Marquise group created the GNR Fortaleza company and established a contract to supply biogas from ASMOC to CEGÁS (ABIOGÁS, 2019). In 2015, entrepreneurs started taking necessary actions to enable the construction of a power plant in the ASMOC. During the next two years, financial resources were raised for the project and to create a regulatory framework to authorize the sale of landfill gas to a diverse set of clients. The supply contract was signed before the existence of specific legislation. In 2017, the National Policy for Biofuel (RenovaBio), instituted by law nº 13.576, established annual national goals for decarbonization for the fuel sector, as a way of incentivizing an increase in biofuel's production and participation in the country 's transport energy matrix. In the same year, the ANP, through Resolution No. 685, established quality control rules and specified biomethane from landfills and sewage treatment plants, which was intended for vehicular, residential, industrial and commercial uses, and to be sold throughout national territory (ABIOGÁS, 2019).

The power plant's construction was finished in February 2018. In the same year, the state government, influenced by entrepreneurs, gave it tax subsidies through decree No. 32,600/2018, which equated the price of biogas to that of natural gas (ABIOGÁS, 2019). The power plant started operation in April 2018, having CERBRAS, a manufacturer of ceramics as its main client, which operated with a daily production of 100 thousand meters. In the following month, through resolution Nº 734/2018, ANP regulated biofuel production, including landfill biomethane

(ABIOGÁS, 2019). This led to GNR's first injection of purified biogas in Brazil's natural gas supply chain, which represents the first Brazilian waste-to-energy initiative.

4.2 Social actors' participation in institutional change process

Structuring the waste-to-energy supply chain changed the institutional environment. The interviewees were unanimous in pointing it out that they could not identify actors who were against the project. Regarding hierarchical positions, it became evident that institutional entrepreneurs, specially private sector representatives, drove this change as marginalized actors, meaning they did not act through the existing institutional arrangement and attempted to acquire financial resources to kickstart/enable the project. However, the entrepreneurs gained central actors' acceptance, such as companies involved with ASMOC and local public representatives, to propose new institutional arrangements, as highlighted by the quotes in figure 3.

In regard to the most influential government actors, Ceará's state government was the most cited by interviewees. The states' decision-making power as the major shareholder of CEGÁS was a defining factor. Ecometano had attempted to establish a similar supply chain in Rio de Janeiro, however it did not receive the same governmental support. The representative from CEGÁS highlighted that implementing an innovative project such as this has several financial risks. In line with that statement, the interviewee from Ceará's environmental secretariat claimed Fortaleza's city hall and the state government had studied the possibility of making use of landfill gas, and when the company pitched the proposal government actors had faith in the project, trusting the credibility of the companies involved.

Figure 3

Main quotes regarding social actors' participation in change processes

ANALYSIS CATEGORY	CONTEXT UNIT	QUOTES
Social actors' participations	Actors positions regarding changes	"I don't know of any reasonable or worthwhile critique for this particular project, at least not one that would require the project to be redone, on the contrary, I believe the project was well accepted by environmentalists and NGOs who oversaw it." (Environment secretary)
	Governmental actors' strength	"[...] Ceará's state government had a very important vote, it validated a political position "This is an important project, there are uncertainties and risks, but it is important for the government and we vote for signing this contract" [...]" (Ecometano)

Source: Information collected from interviews

4.3 Institutional entrepreneurs capacities and strategies

The capacity to mobilize interests and acquire scarce resources were highlighted by interviewees as examples of critical skills in this process of institutional change, as quoted in figure 4 categorized in three categories involving some actors' capacity to mobilize allies and acquire resources through political, social and technical aptitude. .

Figure 4

Main quotes regarding actors' capabilities

ANALYSIS CATEGORY	CONTEXT UNIT	QUOTES
Social actors' capabilities	Political	"I think CEGÁS showed a lot of competence and capability/skill, the sector's entrepreneurs also showed a lot of skill, and I believe this is evident, it really helped the whole process" (Environment Secretary)
	Social	"Ecometano has an investment project and when it decides to implement a project in a landfill, we always partner with the landfill's owner, we always see the owner as a very important partner, as they have to commit to supplying the basic input, which is biogas" (Ecometano)
	Technical	"Have no doubt that Marquise and Ecometano's technical crew is made of extremely competent people, there were never any doubts about their abilities/competence" (Marquise)

Source: Information collected from interviews

Regarding the strategies adopted by social actors through the lens of institutional entrepreneurship to achieving changes at the organizational field, the emergence of the following strategies were observed, as presented in figure 5: theorization; legitimation; adaptation of solutions from other institutional contexts; private persuasion; creation of new alliances; open advocacy; lobbying; and selection of partners based on pre-existing relationships of trust.

Figure 5

Main quotes on the adopted strategies

ANALYSIS CATEGORY	UNIDADE DE CONTEXTO/CONTEXT UNIT	QUOTES
Institutional entrepreneurs' strategies	Theorization	"At the moment, hydroelectric plants are facing a lot of environmental difficulties, supply difficulties, they are very overloaded... fossil fuels are also being questioned a lot, at this moment we are living under global warming, climate change..." (Environment Secretary)
	Legitimation	"Therefore, when we capture the landfill methane, we enhance the environmental benefit" (CEGÁS)
	Adapting solutions from other institutional contexts	"They came here and we sought out the United States landfills' prospecting technology, we approve of the american technology and brought this technology for prospecting and purifying gas" (Marquise)
	Private persuasion	"There were many interventions with these people, from the president, company directors, technicians and engineers talking to the entire chain to point out shortcomings" (Ecometano)
	Creation of new alliances	"So there was a confluence of interests and strong acceptance from everyone" (Marquise)
	Open advocacy	"There is this participation more within the scope of federal regulation. Ecometano had to put a lot of work into it, as, at the time, Brazil did not have legislation for using biomethane like it has now. This regulation was driven by Ecometano" (Ecometano)
	Lobbying	"I think there was an alignment and knowledge of the entrepreneurs in dealing with the state government, because here in Ceará the partnership was with the company that already managed the landfill [...] It was used to dealing with the state government, with city hall" (CEGÁS)
	Selecting partners from pre-existing trust-based relationships	"We have this relationship with CEGÁS, I emphasize that it because it is mostly based on trust" (CERBRAS)

Source: Information collected from interviews

5 Discussion

The determining factors for institutional change in structuring the waste-to-energy supply chain were partner selection, based on pre-existing relationships of trust and actions of governmental actors. Considering the high risks identified during the creation of the waste-to-energy supply chain, institutional entrepreneurs sought the necessary safety to invest, through partnerships with the organizational field central actors, who had relationships of trust with each

other and with local government.

Institutional entrepreneurs' capabilities and strategies promoted collective action, allowing them to overcome barriers. Social actors' capabilities of promoting institutional change were divided in three categories: political, social and technical (Ometto & Lemos, 2010; Perkmann & Spicer, 2007). Political capabilities are associated with discursive interventions for institutional change, involving creativity, the spread of new ideas and actors' reputations, as highlighted by Ometto and Lemos (2010). Actors used their political capabilities to propose solutions, disseminate their ideas and attract new influential actors capable of investing (Svejenova, Mazza, & Planellas, 2007). This study's findings corroborate Battilana (2006) claims that the actors' field position determines their probability of being agents of change.

Social capabilities were also highlighted, such as actors' aptitude for mobilizing allies and acquiring financial resources. According to the interviewees, institutional entrepreneurs also used empathy to select the most adequate strategy to articulate a diverse array of interests (Heiskanen et al., 2019). Technical capabilities were considered crucial for successfully building the waste-to-energy supply chain, as the companies' technological experience was a determining factor for the project's economic viability. In the same vein, Borges and Scherer (2015) highlight actors' knowledge and experience as intangible resources in consolidating institutional entrepreneurs' projects, such as that of Miolo Wine Group.

Our research, in convergence with Biygautane et al. (2019), also indicates that the interviewed institutional entrepreneurs have different and complementary capabilities. The results corroborate the assumption that successful institutional entrepreneurship is not a linear process dominated by the actions of few actors, but rather a result of close collaboration and interconnectedness between several actors from different institutional fields. Actors involved in the creating the waste-to-energy supply chain adopted a diverse array of strategies in the argumentation, convincing and legitimization steps of institutional change.

In line with an empirical study by Biygautane et al. (2019), theorization and legitimation

were the first cognitive strategies adopted, when institutional entrepreneurs pointed out flaws in the way USW was being managed in the ASMOC, focusing on the environmental impacts caused by greenhouse gas emission. Once the problem was identified, entrepreneurs found an opportunity of solving it through repurposing for biogas production in the landfill. To realize the change, entrepreneurs argued in favor of its environmental, social and economic benefits for the government.

Another strategy observed was adapting solutions from other institutional contexts, as suggested by Tracey and Phillips (2011). The technicians visited several biogas purification plants in the United States and Europe. The creation of the waste-to-energy supply chain in the state of Ceará was adapted for the particularities of the ASMOC. Institutional entrepreneurs also adopted private persuasion and open advocacy strategies, confirming Li, Feng and Jiang (2006) approaches for overcoming barriers. Private persuasion was adopted when arguments with society's relevant actors and public agents. Open advocacy was adopted in public defense to changes in national and state legislation, due to the absence of regulations pertaining to the injection of biogas into the natural gas distribution chain.

In consonance with Jolly (2017) and Mahzouni (2019), actors made alliances and lobbied to influence governmental decisions, with the intent to achieve institutional change. Alliances established between actors were a key element for the project's approval. Adopting lobbying as a strategy promoted the establishment of significant alliances and helped gather political support. Diverging from Jolly, Spodniak and Raven (2016), there was no resistance to the political support for ASMOC biogas production, which shows that these different actors had aligned interests.

5.1 Theoretical implications

This study highlights the importance of entrepreneurs in promoting institutional changes, as it offers insights on the necessary political, social and technical capabilities for overcoming barriers and structuring innovative chains, in accordance with the approach proposed by Ometto and Lemos (2010) and Perkmann and Spicer (2007). The success of institutional

entrepreneurship is not only the result of individual actions, but of collaboration and interconnectedness between a diverse set of actors. The waste-to-energy supply chain can enrich discussions regarding collaborative dynamics in the global south's institutional context, as well as emphasize the importance of interactions and pre-existing trust-based relationships. Identifying cognitive strategies, such as theorization and legitimization, highlight how institutional entrepreneurs shape perception and understandings to favor change acceptance (Biygautane et al., 2019). Analysis of private persuasion and open advocacy contributes to our understanding of how institutional actors influence political decisions (Li et al., 2006). Also, this research highlights that alliance formation and lobbying are key elements for influencing political decisions (Jolly, 2017).

5.2 Practical implications

This study offers practical guidelines for institutional entrepreneurs and can guide managers who seek to promote institutional changes in challenging contexts. The identified strategies, such as theorization, legitimization, private persuasion and open advocacy, can be used as reference for managers involved with institutional change processes. This can be particularly useful in sectors dealing with regulatory challenges. The strategy of selecting partners based on pre-existing relationships of trust highlights the importance of building and maintaining long-term relationships. This can guide institutional entrepreneurs to form strategic partnerships to mitigate risks and ensure innovative projects' success. Adapting technological solutions from different institutional contexts is indicative of the relevance of learning from outside experiences. This encourages the pursuit for good practices from different sectors and regions, promoting innovation and efficacy when implementing institutional changes. The emphasis in achieving economic and operational viability for the waste-to-energy supply chain highlights the need for a joint company action in search of mitigation solutions for greenhouse gas emissions.

6 Conclusion

This paper presents the historical pathway of Ceará's waste-to-energy supply chain. It identified capabilities and strategies adopted by institutional entrepreneurs in building/creating the waste-to-energy supply chain. Institutional entrepreneurs were the drivers of change as marginalized actors, gaining the approval of central actors, such as large companies and state governments officials. Previous relationships between the field's actors, economic and operational viability and state government decision making power, as it was the gas company's main shareholder, were key factors for the projects' approval. Lobbying made a difference for the waste-to-energy project's approval, as Ceará was a pioneer on the national scene.

Actors' political, social and technical capabilities were necessary for overcoming barriers.The capacity to articulate interests and mobilize resources were essential for promoting institutional change. Social and technical capabilities were of great importance in convincing other actors of the project's financial and technological viability. Many strategies were adopted to accomplish institutional change, of which the main ones are theorization, legitimization, adapting solutions from other institutional contexts, private persuasion, open advocacy, alliance formation and lobbying. The selection of partners based on pre-existing trust relationships promoted the engagement of central actors in the field and generated collective action in favor of the desired change.

Regarding this research's limitations, its main one is the amount of interviewed actors, specially government representatives. A suggestion for future studies is to interview more government actors and to get the opinion of actors who are contrary to institutional change. This research reinforces the importance of solutions to minimize the impacts from USW and contributes to building sustainable and efficient cities in regard to managing the harmful social and environmental impacts of unruly urban expansion.

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