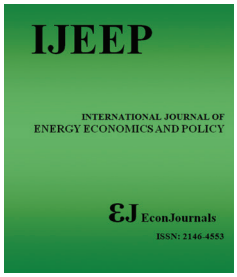
Pavanelli, João Marcos Mott; Igari, Alexandre Toshiro

Article

Institutional reproduction and change : an analytical framework for Brazilian electricity generation choices

Provided in Cooperation with:
International Journal of Energy Economics and Policy (IJEEP)

Reference: Pavanelli, João Marcos Mott/Igari, Alexandre Toshiro (2019). Institutional reproduction and change : an analytical framework for Brazilian electricity generation choices. In: International Journal of Energy Economics and Policy 9 (5), S. 252 - 263. http://econjournals.com/index.php/ijeep/article/download/8056/4517. doi:10.32479/ijeep.8056.



International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2019, 9(5), 252-263.

Institutional Reproduction and Change: An Analytical Framework for Brazilian Electricity Generation Choices

João Marcos Mott Pavanelli*, Alexandre Toshiro Igari

School of Arts, Sciences and Humanities, University of São Paulo (EACH/USP), Brazil. *Email: joaomarcos@usp.br

Received: 18 April 2019 **Accepted:** 05 July 2019 **DOI:** https://doi.org/10.32479/ijeep.8056

ABSTRACT

Energy transitions will be shaped, among other aspects, by their Institutional historical trajectory. Institutions reproduce and change over the time, and these processes have been investigated under different and sometimes confronting approaches. We proposed a framework which articulates different institutionalism approaches to understand the dominance of hydroelectricity in the Brazilian matrix. The framework articulates institutional processes to explain its reproduction and change over time. Findings point out that institutional path dependence and isomorphism have precluded the adoption of other technologies in Brazil. Contrarily, momentary external or internal crisis in the field rapidly fostered the emergence of electricity generation transition from almost fully hydroelectric to a hybrid matrix with thermal (fossil and biomass) and wind power. Crises presented an opportunity to strategic action of social skilled agents on institutional change. This analytical framework improves the integration of complementary theoretical approaches for understanding institutional dynamics in order to guide policymakers.

Keywords: Energy Transitions, Institutional Analysis, Brazilian Electricity Sector
JEL Classifications: B52, P48, Q42

1. INTRODUCTION

Social technical transitions have been explored under hybrid theories (Solomon and Krishna, 2011) (Araújo, 2014) (Kucharski and Unesaki, 2018) (Germán et al., 2016). Neo-institutionalism has articulated politics, economics and sociology to unveil the complexity of social technical transitions (Kucharski and Unesaki, 2018). In the electricity sector social technical transitions usually drives the replacement of fossil fuels by renewable sources. Brazilian case is particular because it shows an empirical and relatively recent case where the electrical transition went backwards: From hydroelectricity to thermoelectric fossil sources.

Brazil always relied on hydroelectric as the main source of electricity generation. Nevertheless, after an offer crisis between 2000 and 2002, the national matrix shifted towards a hybrid source configuration, incorporating fossil thermoelectric, which delivered stability and reliability to national matrix regarding eventual water shortage in rainy seasons.

To unveil and clarify energy transitions in Brazil we undertook an investigation under hybrid institutional theories, in order to understand the emergence, reproduction and change of the generation choices throughout almost 140 years of electricity history in Brazil. For doing so we articulated three main branches of institutional theories: New Institutional Economics and New Organizational Institutionalism to explain institutional emergence and reproduction, and New Economic Sociology to tackle institutional change.

The resulting integrative analytical framework addresses key elements in the process of institutional evolution, and it is confronted to empirical evidences from the history of Brazilian electricity sector. The electricity sector in Brazil, as seen, is a particular clean energy case given its historical reliance

on hydroelectricity, which represents more than 65% of the Brazilian electricity matrix (BEN, 2014). This preference towards hydroelectricity, although obviously explained by the abundance of hydric resources, did not occur in other countries which present as much hydraulic potential as Brazil. (IEA, 2014).

This paper aims to contribute to the research on institutional dynamics, particularly regarding their effects on Brazilian technological choices for electricity generation. The proposed analytical framework unveils the synergic contribution of path dependence and isomorphism on explaining institutions emergence and reproduction, as well as the effects of crises and the role of social skilled agents particularly to explain institutional change.

The next two sections are respectively dedicated to present the theoretical elements incorporated to the integrative analytical framework and to the methods. The latter sections present as results the own analytical framework and the narrative of the historical institutional evolution of the Brazilian electricity sector, and lastly are presented discussion and conclusion.

2. THEORY

The present theoretical synthesis aims to introduce the main concepts from different or even concurrent research fields. Given the epistemological and ontological diversity of theoretical contributions, the reader might incur in some misinterpretations of concepts and assumptions which support the analysis. Furthermore, there is considerable variation on scope and scale in which the research branches undertake institutional analyses. Therefore it is appropriate to clarify in the next sections some key concepts extensively used in the present piece of work.

2.1. Baseline Concepts: Field, Agents and Institutions

The concept of field was introduced by Pierre Bourdieu (1980), and constitutes a broader perspective for understanding the symbolic conflicts among individuals and even organizations. The core idea is that field is the locus where agents struggle for symbolic gains. Ostrom (1990; 2008) adopted an analogue perspective in her investigation on common goods governance. She called arena the field where agents legitimate competing positions while struggling for power domination. Therefore, arena constitutes a field where incumbents and challengers recognize each other positions and stir their dispute.

Bacchiegga and Da Costa Ferreira (2014) stress the difference between the concept of field introduced by Bourdieu (1980) and the concept of arena proposed by Ostrom (2008), by indicating that in the field, differently from the arena, agents may not always be aware of the existence of any symbolic struggle. The present work understands arena as a status of the field where agents recognize and stir their different and frequently confronting positions.

The organizational studies of Dimaggio and Powell (1983) presented the concept as "organizational field," an instance which encompasses the set of relations among organizations. Neil Fligstein (Fligstein, 2001) recognizes the challenge on limiting a field in empirical studies, but he considers a reasonable approach to circumscribe economic sectors, as the electricity sector, as fields.

The definition of agents is very similar among North (1990; 2008), Dimaggio and Powell (1983), Fligstein (2001) and Ostrom (1990; 2008). They converge in the sense that agents can be viewed as players, representing individuals as well as public, private, and non-governmental organizations. In this article agents are presented as individuals, the government, regulatory agencies, investment banks and other public, private and non-governmental organizations.

Institutions are the collectively conceived norms[1] and formal rules responsible for stabilizing the relationships among the agents in a given social field. They guide agents in their strategic social action. The emergence, reproduction and change of the institutions are an outcome of power disputes among agents pursuing their own interests (Fligstein, 2001). When, why, how and by whom institutions rise, reproduce and change are then an important part of the puzzle for understanding their role in social life. The three theoretical approaches addressed in this article present complementary, and sometimes concurrent visions of these phenomena.

2.2. Institutional Theories and Core Analytical Concepts

New economic sociology (NES), when it first appeared in the middle 1980s, had plentiful interactions with New Institutional Economics (NIE), especially regarding the ideas of Douglass North and Elinor Östrom. But some years later the interactions became less frequent and fruitful (Nee and Swedberg, 2008) (Nee, 2005; 2018). This article intends to integrate different theoretical fields, (New Organizational Institutionalism - NOI[2], NES and NIE) for explaining the institutional processes (formation, reproduction and change) which constrained technological choices in the history of the Brazilian electricity sector. We propose that these three theoretical approaches complement each other[3] on understanding the complex process in which institutions evolve in social fields. This article presents a framework which integrates (a) North's concepts of path dependence[4] (1990; 2008) and belief

1 Norms are viewed as "shared prescriptions known and accepted by most of the participants (agents) themselves, involving intrinsic cost and benefits" (Ostrom, 2008).

2 Although authors have classified both DiMaggio and Powell (1983) and Fligstein (Fligstein, 2001) in NES studies, Nee and Swedberg (2008) attributed the term "organizational new institutionalism" to refer the studies from of DiMaggio. Therefore, the present study chose to position NOI as indicated by Nee and Swedberg (Nee and Swedberg, 2008) in order to present a clear distinction between a theory which explains institutional reproduction (NOI) from other selected to address institutional change (NES).

3 In this case, we depart from the arguments of Östrom (Ostrom, 2008) in which she states that the concept of "field" is very synergic among Bourdieu (Bourdieu, 1997), Fligstein (Fligstein, 2001) and DiMaggio and Powell (Dimaggio and Powell, 1983).

4 The first agent to establish the forms of uses and functions of the resource will have the power to guide and influence the subsequent activities. The choice for the initial set of institutions (the early choices for dealing with the resource), as seen, is not necessarily the best or most efficient solution, but it is simply the mostly accepted one (North, 1990).

systems (Denzau and North, 1994) in institutional formation and stabilization[5], (b) the effects of isomorphism on institutional reproduction, addressed by Dimaggio and Powell (1983), and c) the studies on institutional change, derived mainly from Fligstein (2001) and Fligstein and McAdam (2012).

2.2.1. New institutional economics (NIE): Belief systems and path dependence

New institutional economics explains the role of institutions from the perspective of the transactions costs in non-perfect markets[6]. Contrary to neoclassical assumptions, markets under NIE perspective lack relevant information in their transactions and there is remarkable asymmetry on power and information endowments among agents. Improvements in information availability among economic agents would burden markets with transactions costs regarding information prospection, assurance, monitoring and analysis. Institutions play a key role on dealing with information availability and the respective transaction costs, so, the conception, reproduction and change of institutions would be constrained by their ability to deliver information and reduce transaction costs. This perspective, stressed by Williamson (1985), assumes that economic agents are capable of precisely evaluating the economic outcomes of each institutional environment and then selecting the most effective arrangements.

North (1990) expanded this theoretical scope and added psychological and social variables to the instrumental rationality of institutional emergence and selection. Davis and North (1971) and North (2008) theoretical perspective on institutional historical dynamics does not allow to conclude that NIE instrumental rationality necessarily conduces to independent and optimal decisions, since it would be sensible to socially constructed belief systems and to the prior trajectory of choices. Belief systems and historical path dependence on choices would, according to North, constitute key elements to institution formation and reproduction. Belief systems are shared pre-analytical views rooted on accumulated empirical experience and cultural heritage that generate most of the agents` modus operandi (1990; 2008). This symbolic framework shapes and selects the rules and norms responsible for stabilizing the relationship among social agents. The institutional change would then be coherent to changes in belief systems, mostly incremental and bounded to prior choices. Then, the concept of path dependence, predicts that an initial institution, once established in a field, would bound future institutional changes in historically conceived lock-ins. Belief systems and path dependence explanations regarding arise and the reproduction of institutions are consistent to individuals as well as to organizations dynamics (Greenwood et al., 2008).

2.2.2. New organizational institutionalism (NOI): Isomorphism

In meso-level analysis, New Organizational Institutionalism (NOI) assumes organizations as the main agents which struggle for their self-interests in social fields. Specifically, Dimaggio and Powell (1983) stressed the phenomena of homogenization of the structure, processes and institutions concerning strategic actions of organizations in competitive fields. The isomorphism on organizations and institutions would arise from mimetic, coercive or normative driven forces. When the competitive field is under non-diversifiable risks or uncertainties, players are constrained to mimic strategies that are considered the most successful ones. Dominant organizations are frequently imitated by others. Coercive isomorphism occurs when there is a marked power unbalance in the field, as the power of the state or the dominance of oligopolistic agents, which conceive and enforce the rules. In oligopolistic contexts, new players usually conform to present rules and there is little room for change. Finally, according the normative perspective, shared academic background, as well as professional corporate relationships, induce the emergence of similar institutions in independent organizations or fields[7].

NIE and NOI approaches are complementary on the explanation of origin and reproduction of institutions. Regarding institutional change, North attributes it mostly to external crisis phenomena (2008), however, he also acknowledges that long-term change reflects the cumulative effect of internal short-term decisions by political and economic entrepreneurs (1990). Dimaggio and Powell (1983) focused on institutional homogenization process and did not noticeably contribute to clarify institutional change.

2.2.3. New economic sociology (NES): Social skilled agents and crisis

The investigation on social induced institutional dynamics is a core interest of New Economic Sociology (NES). This perspective assumes that emergence, reproduction and change of institutions have roots far beyond the comparative economic results of each possible institutional scenario. Institutions are understood as social-driven and field-endogenous outcomes, which emerge from the recursive relationship between the institutional set in force and the power balance among agents. Coalitions of social agents struggle for their interests, and the incumbents consolidate institutions which stabilize the relationships in the field. This set of institutions in force is favorable to the interests of incumbent coalitions, and does not necessarily represent the optimal institutional arrangement to economic prosperity. Also, stabilization of relationships does not mean that all interests were met, but it just reflects the past and present power balance in the competitive field (Fligstein, 2001; Fligstein and McAdam, 2012).

As well as North, Fligstein and McAdam (2012) claim that prevailing institutions are outcomes of historical and present power disputes in the field. But the NES authors add that short-term disturbs caused by skilled agents or external induced crises can

5 It is important to note the difference between institutional stabilization and institutional reproduction. Institutional stabilization is associated to path dependence and the inertia of belief systems, and it is broadly used under North's approach, while institutional reproduction is associated to institutional homogenization processes, or isomorphism, according DiMaggio and Powell (1983). In this article both (stabilization and reproduction) are assumed as institutional reproduction, and the reason is that both are associated to the process of perpetuating institutions along time.

6 See Coase (1937) and Williamson (1985; 2007).

7 This normative induced isomorphism could be interpreted as a short-term contribution to social belief systems, despite normative isomorphism and belief systems are theoretical constructs from clearly distinct research branches.

disrupt the power balance in the field and foster the emergence of a suitable context for institutional change.

Social skilled agents are those capable of inducing the cooperation among other agents in the field. In the words of Fligstein and McAdam (2012), "social skill is the ability to empathetically understand situations and what others need and want, and to figure out how to use this information to get what you want." Social skilled agents can be positioned in incumbent coalitions and, in this scenario, they struggle to stabilize and reproduce institutions which reinforce their dominant position. On the other hand, these same social abilities can serve challenger coalitions and make emerge favorable conditions to disrupt the power balance and promote institutional change. As incumbents or challengers, social skilled agents tend to amplify their influence on institutional design when internal or external crises emerge in the field. Then, social skilled agents have cognitive, relational and political abilities to establish new coalitions and to conceive innovative institutions which meet emerging interests in the field. However, the institutions in force represent a positive feedback to the present power structure in the competitive field, what contributes to a persistent power and institutional stability.

The key role of social skilled agents is shaping power balance inside fields, however, most events which change the competing context are exogenous (Fligstein and McAdam, 2012). The destabilizing effect of external crises makes institutions lose their role of assuring predictability to strategic action of the agents. In a crisis scenario, incumbent agents attempt to safeguard their status quo and allow incremental changes on current institutions, keeping them suitable to their strategic objectives. On the other hand, challengers rearrange coalitions and try to achieve more favorable competing positions, striving for a new set of institutions, aimed to stabilize the field in this alternative state.

Institutional crises make agents more reluctant to perform economic transactions, and are characterized as moments of low flow of assets and information, because agents are no longer able to understand or comply with current institutions, and their actions cannot be well predicted by others.

External-induced institutional crises also emerge in moments of political rearrangement, which involve some relevant ideological change. These moments of change foster institutional reform, and agents are not up to transact while the comprehension of the new institutional order is not clear.

Integrating different institutional theories is a challenging task. We are aware of the methodological, epistemological and even ontological contradictions among the theoretical perspectives which supported the analytical framework proposed in this article. However, each institutional theory contributed to explain a particular aspect of the complex process of institutional emergence, reproduction and change, to the point that complementarities or even synergies incorporated to the framework overcame the latent conflicts among the original institutional theories. This integrative concern is a permanent dilemma for understanding complex phenomena in interdisciplinary research.

3. METHODS

The investigation was conducted under a qualitative approach of nested triangulation (Denzin, 1978) (Krause and Denzin, 1989). Triangulation approach aims to identify convergences and divergences among different sources of information, which are gathered through varied methodological strategies (Denzin, 1978) (Krause and Denzin, 1989) (Flick et al., 2004).

The upper level triangulation (outer dotted line in Figure 1) consolidates the outcomes from the literature review (top circle in Figure 1), empirical evidences from document review (right circle in Figure 1) and from in-depth interviews with specialists (left circle in Figure 1).

The nested lower level triangulation is represented inside each circle. Literature review on NIE, NOI and NES (top circle in Figure 1) identified theoretical complementarities among these concurrent approaches of institutional research, as argued in the theory section. This triangulation of theoretical approaches supported the proposition of the Integrative Analytical Framework (Figure 2). The analytical framework was then confronted to empirical evidences.

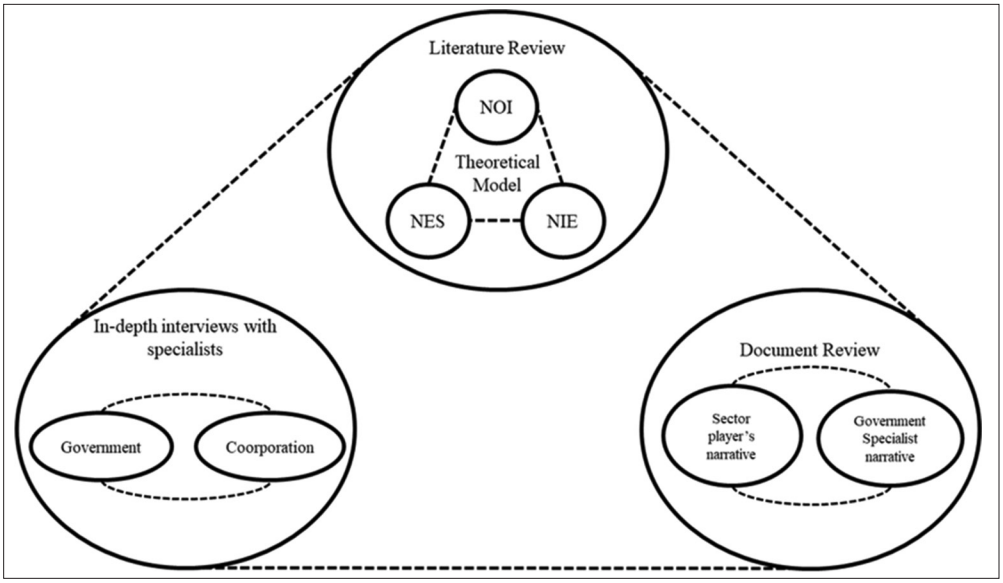
The document review (right circle in Figure 1) consolidated a historical narrative of the Brazilian electricity sector trajectory, regarding the evolution of the institutions, the concentration of political and economic power and the technological changes of the Brazilian electricity matrix. The main documented narratives were achieved from two complementary sources: (1) An organization called "Memória da Eletricidade" (Memory of Electricity), supported by major national players (Eletrobras, Light, CEMIG, Itaipu Binacional), which preserves the history of the electricity sector (Memória da Eletricidade, (Memória da eletricidade, 2015)[8]); (2) two editions of the book "A energia do Brasil"[9] authored by the former-Minister of Mines and Energy Leite (1997; 2014); (3) The book "reconstructing the Brazilian electric sector" from researcher and former Petrobras Director Ildo Sauer (Sauer et al., 2003) and his respective paper (Sauer, 2015). The triangulation of sources (Denzin, 1978), from private funded documents and government specialists books, contributed to retrieve a more complete, consistent, and detailed historical narrative.

In-depth interviews with specialists (left circle in Figure 1) were the last methodological approach inside the upper level triangulation (outer dotted line in Figure 1). The nested triangulation among information sources was conducted between two different perspectives: Government (hereafter specialists Gov1 and Gov2) and private sector corporations (hereafter specialists Corp1 and Corp2). From the government perspective we interviewed one senior acknowledged specialist with attested government background, a former secretary of environment

8 For more information see: http://portal.memoriadaeletricidade.com.br. Further the historical compilation, the site presents a vast collection of pictures and documents (in Portuguese only).

9 The energy of Brazil - translated by the authors of this paper. The minister remained in charge between 1969 and 1974, during the military regime.

Figure 1: Nested triangulation among theories, methods and sources



Source: Authors supported by Creswell (2003), Denzin (1978), Krause and Denzin (1989) and Flick et al. (2004)

(Gov1), and also one specialist (Gov2) from the most relevant Brazilian governmental research organization on energy, EPE – Empresa de Pesquisa Energética (Energy Research Company), which supports the planning and organization of the energy public offers and auctions. From the private sector corporations, we have interviewed one entrepreneur specialist from the photovoltaics distributed market (Corp1), and another specialist from a major multinational of energy distribution in São Paulo.

The nested triangulation process identifies the convergences and divergences among the integrative analytical framework and empirical evidences from diverse information sources, which present a plural set of perspectives regarding the historical phenomena, and are gathered through complementary qualitative research methods.

4. RESULTS

4.1. Integrative Analytical Framework for Institutional Reproduction and Change in the Brazilian Electricity Sector

An initial competitive condition stresses an interest under dispute among social agents, in this particular case, the technological choices for energy generation in Brazil. The dispute establishes the borders for institutional dynamics of a given social field. Agents recognize common and concurrent perspectives, and form coalitions around their strategic objectives. The perspectives, objectives and choices are influenced by present interests, as well as by historically shaped belief systems ("Douglass North" box in Figure 2).

The historical trajectory of choices in a social field reinforces dominant belief systems, which, in turn, foster the reproduction of choices according to a path dependent rationality ("Douglass North" box in Figure 2). Therefore, formal and informal institutions rise and are reproduced through a historical cognitive lock-in ("Technological Reproduction" in Figure 2).

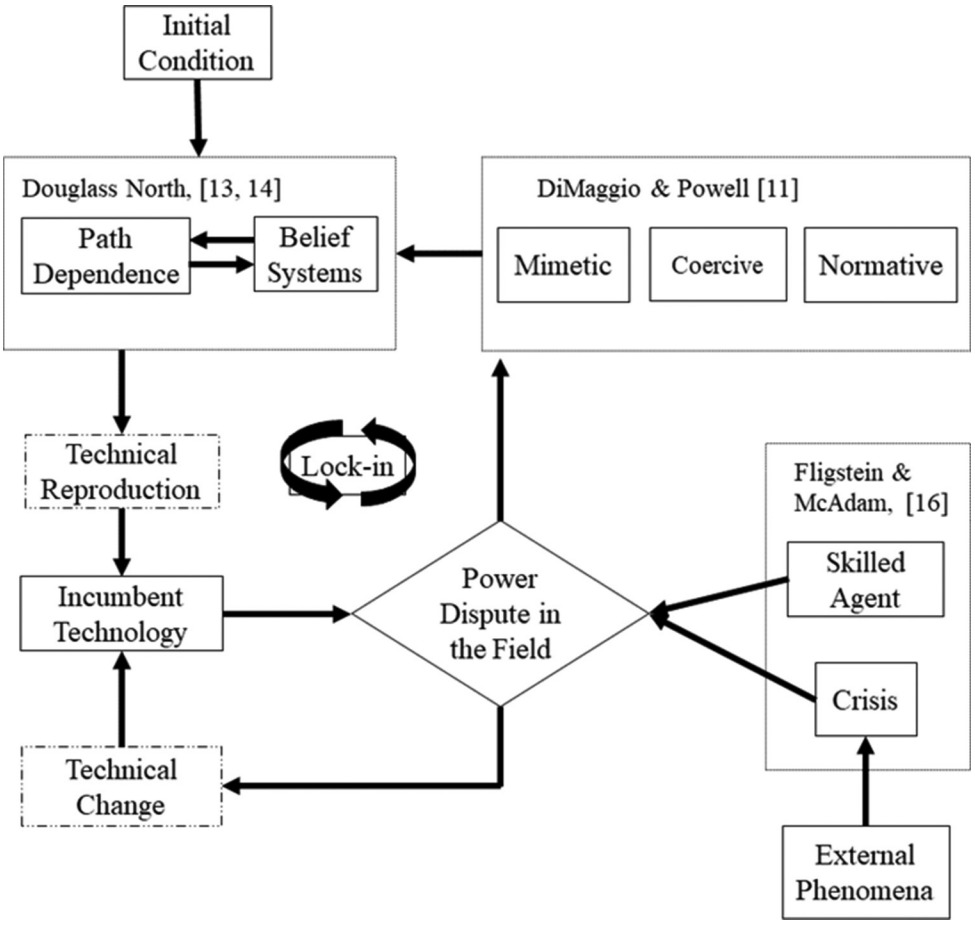
Institutional reproduction, and even homogenization, is reinforced by mimetic, coercive or normative isomorphism drivers ("Dimaggio and Powell" box in Figure 2). Normative isomorphism points out professionalization as a substantial driver for homogenization of decisions among organizational agents. Shared formal education and professional allegiance legitimate belief systems, which, as argued by North (North, 2008), modulate institutional dynamics.

Mimetic isomorphism is the most obvious driver for institutional reproduction. In initial stages of technological development, when uncertainties are dominant, and in markets where firms share the same suppliers or clients, as the electricity sector, organizations tend to take similar decisions, which reinforce path dependence on institutional reproduction. Uncertainties and shared resources foster weaker competitors to mimetize the incumbent decisions.

Government and sector agencies have regulatory power over other economic agents, and constrain strategic actions through formal institutional enactment. The stricter the coercive institutions, the more isomorphic is the organizational behavior in the field. The level of power asymmetry among agents in the field (central diamond in Figure 2) is also a key element for coercive isomorphism ("Dimaggio and Powell" box in Figure 2). Incumbent organizations also impose contractual or informal rules to other firms, what fosters institutional homogenization and reproduction.

Power dispute in the field consolidates incumbent and challenging coalitions around competing interests. Incumbent coalitions maneuver for reproduction of institutions which favor the maintenance and improvement of their position in the field, while challenging coalitions struggle to change the power balance and reformulate institutions according to their own interests. Therefore, incumbent institutions, in this case the technological choice in the electricity sector ("Incumbent Technology" box

Figure 2: Integrative analytical framework for institutional dynamics



in Figure 2), would be reproduced according the lock-in loop established by power dispute among agents (diamond in Figure 2), isomorphic drivers ("Dimaggio and Powell" box in Figure 2) and historical recursive dynamics between path dependence and belief systems ("Douglass North" box in Figure 2). Substantive change on agents' interests and strategic objectives could disrupt coalitions and give rise to new incumbent groups. The emergent power balance could then trigger a process of disruptive institutional change.

Skilled agents ("Fligstein and McAdam" box in Figure 2) present cognitive and empathic abilities which afford them a central role on coalition's emergence, maintenance and change. Skilled agents in incumbent coalitions deal with ongoing institutions, and keep them compatible to coalition shared interests, mainly through incremental institutional changes. On the other hand, skilled agents in challenging coalitions struggle to increase their representativeness in the field, to the point they become incumbent and capable to trigger disruptive institutional change. In this case, institutional change is represented by dashed "Technological Change" box in Figure 2. The internal efforts of Skilled Agents are often catalyzed by field crises driven by external events ("Fligstein and McAdam" box in Figure 2). These crises disrupt the ongoing coalitions, and the following field reorganization is a suitable scenario for Skilled Agent abilities on coalition emergence and change.

4.2. Historical Analysis of Reproduction and Change of Technological Choices in the Brazilian Electricity Sector

The historical narrative identified the shifts of mode (decentralized, centralized or distributed), sources (hydro, thermal - gas, oil, nuclear, biomass - wind, solar) and interconnectivity (locally connected, regionally connected, nationally connected) for Brazilian electrical generation (Table 1). The periods were divided following the previous division made by Electricity Memory (Memória da eletricidade, 2015).

The main events in each historical period (columns in Table 1) were categorized according the rationality of the Integrative Analytical Framework for Institutional Dynamics (Figure 2), and depict the phenomena of institutional emergence: (a) Path dependence; reproduction; (b) belief systems; (c) Isomorphism; and change; (d) external crisis; (e) internal crisis; (f) social skilled agent (Table 1).

4.2.1. 1879-1903: Hydroelectric and thermoelectric decentralized non-connected

Brazil started electricity production in 1879[10], when Pedro II, the last Brazilian emperor, lighted up six lamp bulbs, powered by a small locomotive, for illuminating the central train station in Rio de Janeiro city.

10 Only some months after Edison had invented the electric lamp.

Table 1: Analytical framework theoretical concepts and their empirical evidences in the Brazilian electric sector's history. Rows: Historical trajectory of empirical evidences. Columns: Relationship among events in a given period according the analytical framework

Analytical framework concepts	Description	1879-1903	1904-1933	1934-1963	1964-1992	1993-2002	2003-2016
Technological choice	Choices regarding mode (decentralized, centralized and distributed) and source (hydro, thermal - gas, oil, nuclear, biomass - wind, solar) and interconnectivity in the electricity sector	Hydroelectric and thermoelectric decentralized non-connected	Hydroelectric centralized non-connected	Hydroelectric centralized regionally connected	Hydroelectric centralized inter-regionally connected	Hydroelectric centralized nationally connected	Hydroelectric, gas fueled thermal and eolic centralized nationally connected
Social skilled agent	Agent capable of translating different groups interests into widely acceptable institutions that guarantees predictability in strategic social action	Bernardo Marcarenhas, Arthur Thiré and Dom Pedro II	Multinationals Light and Amforp	Getúlio Vargas and CNAEE	MME and Eletrobras	ANEEL, Fernando Henrique Cardoso	ANEEL, EPE, BNDES, Lula
Emergence path dependence	The first experience identified by most agents as successful marks the departing point of a historical trajectory of analogue choices	Early local hydroelectric and thermoelectric experiences	Hydroelectric prevailed over thermoeletric and multinationals outcompeted local companies	Nationalization of electric sector and Hydroelectric growth financed by World Bank	Integration of Hydroelectric generation - frequency standardization in 60 Hz	Privatization of electric sector and generation growth financed by private agents	Gas fueled thermoelectric brought stability to the national grid. Successful experiences with wind in northeast
Reproduction belief system	Aggregated cultural, moral, academic, economic or technological preferences directly or indirectly expressed as organizational or political choices	Reliance on national local private capital for electricity generation	Reliance on large multinational private capital for scaling up electricity generation	Electric sector as strategic and controlled by state	Military government reinforces the perspective of electric sector as strategic and controlled by state	Electric sector as private business under regulation of state agency (ANEEL)	Electric sector expansion through public-private partnerships under regulation of state agency
Reproduction isomorphism	Institutional homogenization driven by coercion, mimicry or shared academic or professional background	Mimetic - local national private companies dominate electricity generation	Coercive - the golden clause favored multinational oligopolies for hidroeletric generation	Coercive -Nationalization and concentration of the electric sector (CHESF, Furnas, Eletrobras)	Normative - Lobby of engeneering and construction companies specialized in dams	Coercive – ANEEL, MME and public energy auctions guide choices for energy generation sources	Coercive - ANEEL, MME, EPE and public energy auctions guide choices for energy generation sources
Change external crisis	Event external to the electric sector that disturbed the ongoing institutional dynamics - agents were no longer able to predict strategic social action		29's crash undermined multinational investments in Brazil	Military coup d'état	New liberal civil government - national program of privatization (PND)		Climate crisis fosters the choices for clean and renewable generation sources
Change internal crisis	Event internal to the electric sector that disturbed the ongoing institutional dynamics - agents were no longer able to predict strategic social action	Lack of national private and public resources for generation expansion	Lack of resources for generation expansion		Insolvency crisis in the electric sector	Offer crisis - national blackouts	

Source: Elaborated by the author with theoretical support from North (1990; 2008), Dimaggio and Powell (1983) and Fligstein (2001)

Early hydroelectric experiences were carried by Arthur Thiré in 1883, and by Bernardo Mascarenhas in 1889 in Minas Gerais state, which have supplied electricity through a two kilometer transmission line (1879-1903 in Table 1). Brazilian private entrepreneurs were the major investors of early electrical expansion, through thermoelectric projects in southern and northern urban areas of Brazil. However, in the southeastern states of Rio de Janeiro, São Paulo and Minas Gerais, the expansion of generation was mostly through hydroelectricity. Southeastern industrialists achieved municipal concessions for exploiting hydraulic potential of rivers, which sometimes were conditioned to provision of public illumination.

Nevertheless, by 1900, the first expressive multinational, Light, established its operations in Brazil with a thermoelectric facility in the city of Sao Paulo. By 1901 Light has launched a hydroelectric mill in the state of Sao Paulo, and by 1904 started another hydroelectric in the state of Rio de Janeiro, mimetizing the successful hydroelectric models from Brazilian entrepreneurs.

Then, decentralized non-connected hydroelectric and thermoelectric production established the initial technological dispute in the Brazilian electric matrix. On the other hand, the power dispute between national and multinational investments would stir up, as described in the next section.

4.2.2. 1904-1933: Hydroelectric centralized non-connected

Abundance of hydric resources (Gov1, Gov2, Corp1, Corp2) was a key reason for early expansion hydroelectricity instead of thermoelectricity (1904-1933 in Table 1). Multinationals as Light and Amforp concentrated the capital for expanding generation and outcompeted sparse national entrepreneurs. As Federal Government and private local entrepreneurs lacked resources for investments in generation expansion (Gov1), those multinationals pressed politicians to implement the Golden Clause in 1904.This norm fixed their returns in American dollars, reducing currency and exchange risks derived by Brazilian inflation fluctuations. The Golden Clause was a coercive institution which resulted from a growing power asymmetry in the field, and favored the incumbent coalition of multinational companies (1904-1933 in Table 1). The electrical expansion was smooth until 1929, when the financial crash committed the global economy. Multinationals then lacked resources for investments in expansion of electricity generation in Brazil (1904-1933 in Table 1).

4.2.3. 1934-1963: Hydroelectric centralized regionally connected

In 1934 the president Getúlio Vargas[11] revoked the Golden Clause and gradually increased state influence in the electric sector, stablishing the beginning of a new belief system: The electric sector as a strategic state issue that might be controlled by the Federal Government (1904-1933 in Table 1). Vargas implemented the Water Code and also a federal secretary for regulating hydroelectric generation (CNAEE)[12], which reflected the Federal Government source preference.

Although multinationals still held significant influence in strategic decision in the electricity sector, the federal power increased substantially. In the mid-fifties, the Federal Government, with World Bank's financing (Gov1), concentrated the sector in two major national companies, CHESF, in the northeast, to explore the São Francisco basin, and Furnas, in the south, to explore the Paraná basin (1904-1933 in Table 1).

Nevertheless, along the expansion of electric generation, both private and state agents reproduced hydroelectric power plants as the main technological option. Projects increased the size of the plants, which allowed electricity supply to larger areas. However, transmission lines remained regionally-connected.

In 1954 the Federal Government created Eletrobras, the largest public company of the Brazilian electricity sector, but it would effectively operate only after 1962. Eletrobras acquired assets from Light and Amforp with World Bank financing (Gov1), and it would hold most of the investments until 1990[13]. The Ministry of Mines and Energy (MME) was also created in 1962, and it would become responsible for regulating the national electricity production, centralizing regulation and becoming the federal organization for reinforcing coercive isomorphism to the field.

4.2.4. 1964-1992: Hydroelectric centralized inter-regionally connected

Both Eletrobras and the MME were social skilled agents responsible for implementing, in 1964, the frequency standardization in 60 Hz (1964-1992 in Table 1). Frequency standardization was an unavoidable technical condition for integration of the electric national grid and eventual connection of all centralized hydroelectric facilities in the national territory.

Brazilian military coup d'état (1964-1985) represented an external crisis on Brazilian electricity sector. Nationalization took impulse, and was not restricted to electricity sector, it was rather a state policy for the named "strategic sectors" (e.g., oil, mining, energy). Nationalization has not changed the technological choices for electricity generation, remaining mostly hydroelectric[14]. However, both the centrality of the Federal Government in the electricity sector decision making and the national security (aimed under political military belief system) supported the investments towards grid standardization and integration. Eletrobras and MME were

11 Getúlio Vargas had taken office in 1930 by a coup d'état. He was a populist politician who had enough social skill to politically influence many economic and social fields.

12 In 1940 the first regulation for thermoelectric was implemented under the dispositions of the CNAEE and the Water Code. However, it did not launch expressive thermoelectric projects, exception made for Light's first centralized thermoelectric in 1954, with an expressive installed capacity (200 MW), in São Paulo.

13 Eletrobras still holds more than thirty percent of Brazilian generation assets (Eletrobras, 2015).

14 Only in 1985 Brazil has built its first nuclear power plant, with 657 MW installed capacity, which is owned, controlled and operated by Eletrobras. However, it did not threat the dominant technological choice for central hydroelectric, remaining as a minor challenger technology until present days.

pivotal agents in the process of changing the model towards centralized connected hydroelectric plants (1964-1992 in Table 1).

The expansion of the centralized connected hydroelectric plants in this period would culminate, in 1984, in two of the largest hydroelectric facilities in the world: Itaipu and Tucurui, with respectively 14 and 11 GW installed capacity. Nationalization of private assets and investments in new projects were largely financed by the World Bank (Gov1), which legitimated and reinforced the power balance and the institutions in the electricity sector. Furthermore, the legitimation of hydroelectric generation as main national electricity source has consolidated specialized engineering and construction companies, which, in turn, constituted an important political lobby towards hydroelectricity expansion (Gov1). This reproduction lock-in around hydroelectric technological path is also reinforced by consolidation of engineering specialization in the Brazilian universities, fostering a normative isomorphism (1964-1992 in Table 1).

By 1985, an internal crisis arose: Public and also private companies in the sector went through an insolvency crisis, mostly because the unfavorable contractual financial returns imposed by the Federal Government at the moment (Gov1). Then, in 1990, another external crisis broke out from the political sphere and impacted the electricity sector. The first elected Federal Government after the military period sanctioned the National Program of Privatization (PND), aiming to achieve investments from private actors (1964-1992 in Table 1). In the electricity sector, the necessity of investments for expansion of the national grid made the liberal oriented Federal Government consider privatization as a promising solution.

4.2.5. 1993-2002: Hydroelectric centralized nationally connected

Between 1994 and 1998 the privatization of the electricity sector gained momentum, mainly under the presidential term of Fernando Henrique Cardoso, from 1995 to 2002. Public electrical companies were divided into generation, transmission and distribution categories, facilitating and accelerating the privatization program. Aiming to regulate and coordinate operations of public and private companies, by 1997 the Federal Government conceived its first regulatory agency in the electricity sector: The National Agency of Electricity (ANEEL). ANEEL would be independent from the state and less sensible to political pressure[15]. The regulatory agency shared with the MME all the regulation issues, consolidating itself as a major source for coercive isomorphism (1993-2002 in Table 1).

By the end of 1990's, despite most of Brazilian electric grid was interconnected, an energy supply crisis loomed at the horizon. In 2000, trying to anticipate an offer crisis, the president Fernando Henrique Cardoso launched the priority program of thermoelectric (PPT), fueled by natural gas supplied by Bolivia through recent pipelines infrastructures (Sauer et al., 2003). Nevertheless PPT did not achieved its objectives in time and, between 2001 and 2002, Brazil suffered a series of blackouts in major cities[16]. After the blackouts, gas fueled thermoelectric brought stability to the national grid, supplying electricity in dry periods when the levels of hydroelectric dams are lower. No other major internal crisis as the 2002 offer crisis has risen since then, and this internal crisis is held responsible for triggering the first disruptive change in terms of electricity generation source (1993-2002 in Table 1).

The offer crisis of 2002 consolidated thermoelectric incumbent role in the Brazilian electrical grid, and also opened room for centralized connected renewables, as wind power, and distributed connected small hydroelectric and biomass generation, as the bagasse cogeneration in sugarcane mills in São Paulo (Gov1)[17]. These interconnected generation sources gained relevance in public auctions and assumed challenging positions in the sector. The system then started to operate mainly as centralized connected hydroelectric with centralized connected thermoelectric as a complement[18].

4.2.6. 2003-2016: Hydroelectric, Gas fueled thermoelectric and eolic centralized connected and also biomass thermoelectric distributed[19] connected (sugarcane cogeneration)

In 2004, for financing the strategic planning of the electricity sector, the Federal Government enacted that one percent of the net profit from every company of the electricity sector might be destined to the energy research company (EPE). EPE publishes yearly, since then, annual reports and 10 year outlooks and assessments for the electricity sector, and it got also responsible for the public auctions coordination. EPE aimed to be a reliable source of information and forecasting for electricity sector policy makers (Gov1). EPE and ANEEL are identified as social skilled agents capable to modulate the prices for generation for each source in order to foster competitiveness. Together, EPE and ANEEL would be responsible for most of the proposals and are therefore organizations capable of conceiving relevant institutions and promoting coercive isomorphism (2003-2016 in Table 1).

The expansion of gas fueled thermoelectric centralized connected generation was consolidated as an incumbent technological choice. Thermoelectric is the second most representative source in the Brazilian electric matrix, with 27% (included central gas fueled power plants and distributed biomass) of total installed capacity in 2016 (EPE, 2017). The main purpose of thermoelectric plants is supplying electricity when the water level in hydroelectric dams is more critical, reducing the risk of a new offer crisis. Despite

15 Although the executive power indicates its board composition, and the nomination must be assessed and approved by the national congress.

16 A series of public measures was taken under Fernando Henrique Cardoso administration for stabilizing future supply crises derived from drought periods and empty reservoirs. Among them was short term energy rationing (throughout programmed shutdowns) and the creation of agencies for managing new inputs of electricity from thermoelectric.

17 The incentives for renewables from small hydroelectric, biomass generation and wind power plants are part of a Federal program called Proinfa (Program of Incentive for Alternative Sources) (Eletrobras, 2015).

18 In present days, centralized thermoelectric takes around thirty percent of share in the total national matrix source composition (EPE, 2017).

19 Centralized generation and decentralized generation are differentiated, in general terms, by the size of the power plants and the geographical area supplied. When the national or regional grid is integrated, centralized Generation becomes the dominant option due its scale gains. There is also distributed generation, which usually relies on small scale plants that generate electric energy for *in-loco* consumption. They can be connected or disconnected from the grid (Ackermann et al., 2001).

the substantial operational costs, gas fueled thermoelectric are accomplishing their strategic supplying role.

On the other hand, the expansion of fossil thermoelectric faces environmental contestation. Greenhouse gases from energy sector are in the core of global concerns on climate governance. Brazilian emissions are mainly derived from land use change, and the hydroelectric-based matrix was historically an environmental global reference. However, the exhaustion of the hydraulic potential (Gov2, Corp1, Corp2) and the growing relevance of thermoelectric in the national electric matrix increased the projections of the electricity sector greenhouse emissions. In this scenario, Brazilian commitments on reduction of energy greenhouse gases represent a new external-driven crisis on the electricity sector which might change power disputes and technological choices in the field. Brazil was among more than 190 countries in COP21, held in Paris, to pledge expansion in renewable and clean energy sources (2003-2016 in Table 1).

Centralized wind power plants assumed a relevant position in the national matrix since then, mainly in the northeast of Brazil, where it represents up to one third of the total electricity generation (EPE, 2017). Eolic represented more than 10 GW, around 7% of total installed capacity in Brazil (EPE, 2017). Furthermore, almost one century after the pioneer experiences on electricity generation in the state of Minas Gerais, the private investments in distributed small power plants (up to 5 MW of installed capacity) are relevant again in the national matrix, manly from small hydroelectric and thermoelectric fueled with biomass from sugarcane bagasse (Gov1). Biomass from sugarcane bagasse represented 6.09% of the total electric Brazilian generation in 2016 with 35.236 GWh[20] (EPE, 2017).

Other small scaled distributed sources are incipient yet, and demand economic and technological support to consolidate as viable challenging technologies. Connected individual solar panels are expanding in the cities and are a promising complementary source. However, scaling up these distributed sources demands technological improvements in the distribution grid and close control of scale diseconomies regarding transaction and maintenance costs (Gov2, Corp1, Corp2).

Hydroelectric expansion through larger dams face social and environmental constraints (Fearnside, 1999; 2006) (Gov1). The hydric resources are seen as almost completely exploited (Gov2, Corp1, Corp2). However, hydroelectric dominance is predicted to resist for several decades more (Gov1). The Federal Government and private companies continue to prioritize centralized hydroelectric power plants for expanding the national installed capacity. Belo Monte power plant was launched in 2016, with more than 11 GW of installed capacity[21], figuring among the largest in the world. The role of EPE and ANEEL on planning and structuring public auctions for energy supply remains crucial for institutional and technological changes towards generation matrix' expansion.

From 2003 on, under the presidential term of Lula, state control over the expansion of the electricity sector had again a change of direction, marking a new belief system. Public auctions were still the major instance for hiring electricity to the national grid. The auctions, though, were divided in new power plants and old power plants, with specific hiring conditions for each one. The most expressive change was that state and private corporations could establish partnerships in order to expand the electricity sector (2003-2016 in Table 1). The National Bank of Development (BNDES) represented a key actor for emerging public-private partnerships, since it controls substantial financial resources under low interest rates, to finance long term and low return assets, as power plants and transmission lines. This arrangement relieves the direct public budget and keeps state control over the sector[22].

Brazilian electricity sector then currently relies on hydroelectric centralized and connected; gas fueled thermoelectric centralized connected; distributed connected thermoelectric (the latter fueled with sugarcane bagasse); and centralized connected wind power plants.

5. DISCUSSION

The historical narrative for technological choices in the Brazilian electricity sector was developed with emphasis on institutional perspective. We pointed out three institutional aspects as determinants for the technological path which locked Brazilian matrix in centralized hydroelectric generation: (1) The formal institutions that constrained the agent's choices (2) the internal and external crises and (3) the strategic action of social skilled agents.

The centrality of the macro and meso scale social drivers on institutional emergence, reproduction and change, supported by NIE and NOI, is modulated by micro scale individual action of social skilled agents, who present cognitive and relational abilities to change (or halt) path dependence institutional trajectories during internal or external crises.

The historical evidences demonstrate that disruptive technological change in the Brazilian electricity sector demands more than technological development, economic payoffs and political will. Breakthroughs which overcame tenacious institutional lock-in - here identified as result of synergic interactions among path dependence, belief system and isomorphism - occurred mainly as result of the interaction between crises and strategic action of social skilled agents.

Energy transitions have usually taken long periods, even centuries, for arising and consolidating innovative patterns. From the discovery of petrol to its broad usage, it has taken more than a hundred years to surpass biomass as the dominant energy source (Solomon and Krishna, 2011). Brazil had a fast moving transition from hydro to thermal electricity generation. However, the lock-ins on technological trajectories in electricity generation are

20 From the total 27% of thermal participation this represents a bit more than 20% of total thermal national production.

21 But only 4.6 GW operating due environmental and social pressures.

22 However, given the central role of the public bank BNDES in the expansion projects, there is a substantial indirect public expenditure on subsidized interest rates.

beyond single theory analysis, they demand multidisciplinary approaches to enlarge the theoretical comprehension on such complex phenomena.

Single theory efforts on explaining the historical trajectory of technological choices in the Brazilian electricity sector stressed path dependence as the main driven force which constrained agents toward hydroelectric choice, as shown in studies by Araújo (2014) and also by Césaris (2009) has also relied on path dependence approach, and pointed out the importance of refining an analytical frameworks which addresses the institutional reproduction and change.

Ince et al. (2015), also under a single theory approach, applied NOI theories to analyze the Norway's renewable expansion. They pointed out isomorphism influence on institutional reproduction in the Norwegian electricity sector. The authors observed that introduction of renewable sources in Norwegian electricity sector was undertaken under coercive and mimetic isomorphism fostered by incumbent Europeans countries. On the other hand, applying hybrid theories to conceive a theoretical model, a study tackling energy transitions in Japan concluded that political, social and economic aspects must be integrated in an interdisciplinary approach towards institutional analysis (Kucharski and Unesaki, 2018).

The recognized work of Hoffman (1999) also laid on Dimaggio and Powell (1983) isomorphism theoretical approach, but relied on complementary theoretical contributions for explaining the inertia in the USA chemical industry during 1960-1993 period. Hoffman expressed concerns regarding the suitability of isomorphism theoretical approach on explaining institutional change process. He aimed to introduce "(…) the "old" institutional concept of change into the neoinstitutional literature." Hoffman (1999), as well as the present study, sees organizational fields as arenas of political confrontations and proposes three institutional categories of analysis: Organizational field, situated institutions[23] and disruptive events. Those categories carry on similarities to some categories we articulated in this work, respectively power dispute in the field, dominant institutions (incumbent technology) and internal/external crises. The main advance in the analytical framework presented in our work is the recognition of the micro level role of social skilled agents in the process of institutional change. Our work, as well as Hoffman´s, presents a proposal of an analytical framework which incorporates and integrates contributions of different and even conflicting academic fields in the assessment of historical institutional change process.

6. CONCLUSIONS

The evolution of institutions in the history of the Brazilian electricity sector is understood more comprehensively when theories which explicitly address institutional change and the role of strategic skilled agents, from New Economic Sociology, are articulated to traditional institutional models of path dependence and isomorphism, respectively from New Institutional Economics and New Organization Institutionalism.

The findings showed evidences that the major changes which took place in the Brazilian electricity sector, concerning its technological choices along the last century were driven by: (1) Formal and informal constraints (institutions), (2) internal and external crises and (3) strategic action of social skilled agents.

The choice for hydroelectric generation in Brazil is not only due abundance of hydric resources and the technological set available at the beginning of the 20th century. This paper has shown that institutional constraints, crises and social skill drove the configuration of the Brazilian electric matrix toward dominance of large dams and hydroelectric facilities. Institutional reproduction of the electricity generation pattern was only placed in check when external or internal crises broke out, as respectively the 1929's crash and the national offer crisis of 2002.

The replication of the analytical framework in further studies should incorporate specific social and cultural aspects which influence strategic action in the organizational and individual level, as well as shaping the power balance in the field. Considering context premises, the framework can also be applied to assess institutional change in other economic sectors. Future applications are promising for natural monopolies[24], as utilities sectors, and other cases with expressive sunk investments associated to assets specificity[25]. The analytical framework could contribute to elucidate why countries as Canada, Norway or New Zealand, which present different social and political characteristics compared to Brazil, ended up presenting central hydroelectric as the dominant generation option.

Limitations are associated to methodological choices: The qualitative methods are not exhaustive, the respondents were chosen by availability and not randomly, ontology shapes researchers view and the analytical model is not falsifiable and was not conceived to deliver predictions.

Research results contribute to elucidate the phenomena of institutional constraints over Brazilian electric generation choices, and the study overcomes single-theory explanations for why Brazil adopted hydroelectric since the beginning of the historical trajectory, and why technological changes occurred.

7. ACKNOWLEDGMENTS

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001. Also, both authors would like to thank

23 We interpreted Hoffman (1999) "situated institutions" much as what North (1990) and Ostrom (2008) call norms and informal constraints: "Institutional beliefs and perceptions are influenced by this field-level competition but are situated within individual organizations or populations of organizations. Therefore, to fully appreciate the complexity of institutional dynamics, one must analyze both the specific institutions that lie at the center of an issue-based field and the competing institutions that may lie within the individual populations" (Hoffman, 1999).

24 A natural monopolies arise because a single firm can supply a good or service to an entire market at a smaller cost than could two or more firms (Mankiw, 2017).

25 Assets specificity is the difficulty to liquidate a specific asset in case of bad business bias (Williamson, 1985; 2007).

grant 2015/03804-9, São Paulo Research Foundation (FAPESP). Annelise Vendramini Felsberg, Sylmara Lopes Francelino Gonçalves-Dias and, Oswaldo dos Santos Lucon also contributed with valuable institutional insights for modeling theoretical concepts into operational variables. Respondents from in-depth interviews also elucidated the narrative with shreds of evidence that otherwise would not be enlightened, for that the authors show appreciation to José Goldemberg from the Institute of Energy and Environment from the University of São Paulo (IEE-USP), Gabriel Kozen from EPE, and the engineers Luciano Pelegrina, entrepreneur from mc2 solar, and Elio Vicentini, from AES Eletropaulo.

REFERENCES

Ackermann, T., Andersson, G., Söder, L. (2001), Distributed generation: A definition. Electric Power Systems Research, 57(3), 195-204.

Araújo, K. (2014), The emerging field of energy transitions: Progress, challenges, and opportunities. Energy Research and Social Science, 1, 112-121.

Bacchiegga, F., Da Costa Ferreira, L. (2014). Uma análise das aproximações e distanciamentos epistemológicos das noções de campo em P. Bourdieu e de arena em E. Ostrom. Dialogos, 18, 49-66.

BEN. (2014), Balanço Energético Nacional 2014. Rio de Janeiro: Empresa de Pesquisa Energética.

Bourdieu, P. (1980), Questions de sociologie. In: Revue Française de Sociologie. Vol. 22. Paris: Sciences Po University Press.

Bourdieu, P. (1997), Le champ économique. Actes de La Recherche En Sciences Sociales, 119, 48-66.

Césaris, L.E.U. (2009), Reconceitualizando o Institucionalismo Histórico: Path Dependence, Agência e Mudança Institucional. São Paulo: Universidade de São Paulo.

Coase, R.H. (1937), The nature of the firm. Economica, 4(16), 386-405.

Creswell, J. (2003), Qualitative, quantitative, and mixed methods approaches. In: Creswell, J.W., editor. Research Design. 2nd ed. California, Thousand Oaks: Sage.

Davis, L.E., North, D. (1971), Insitutional Change and American Economic Growth. New York: CUP Archive.

Denzau, A.T., North, D.C. (1994), Shared mental models: Ideologies and institutions. Kyklos, 47, 3-31.

Denzin, N.K. (1978), The Research Act: Symbolic Interaction: A Reader in Social Psychology. Vol. 1. New York: Routledge.

Dimaggio, P.J., Powell, W.W. (1983), The iron cage revisited: Isomorphism and collective rationality in organizational fields. American Sociological Review, 48(2), 147-160.

Eletrobras. (2015), Relatório Anual e de Sustentabilidade. Available from: http://www.eletrobras.com/pt/SobreaEletrobras/Relatorio_Anual_Sustentabilidade/2015/Relatorio-Anual-e-de-Sustentabilidade-Eletrobras-2015.pdf.

EPE. (2017), BEN EPE Empresa de Pesquisa Energética. Rio de Janeiro: EPE.

Fearnside, P.M. (1999), Social Impacts of Brazil Tucuruí Dam. Environmental Management, 24(4), 483-495.

Fearnside, P.M. (2006), Dams in the Amazon: Belo Monte and Brazil's hydroelectric development of the xingu river basin. Environmental Management, 38(1), 16-27.

Flick, U., von Kardorff, E., Steinke, I. (2004), A Companion to Qualitative Research. 1st ed. London: S. Publications.

Fligstein, N. (2001), Social skill and the theory of fields. Social Skill and the Theory of Fields, 19(2), 105-125.

Fligstein, N., McAdam, D. (2012), A Theory of Field. New York: Oxford University Press.

Germán, C., González, M., Amado, N.B., Sauer, I.L. (2016), Desenvolvimento Sustentável, Transição Energética Mundial Pós-combustíveis Fósseis e o Pensamento Político da Esquerda Latino-americana. Anais do II Simpósio Internacional Pensar e Repensar a América Latina.

Greenwood, R., Oliver, C., Lawrence, T.B., Meyer, R.E. (2008), Organizational institutionalism. In: The SAGE Handbook of Organizational Institutionalism. Thousand Oaks: SAGE.

Hoffman, A.J. (1999), Institutional evolution and change: Environmentalism and the U.S. chemical industry. The Academy of Management Journal, 42(4), 351-371.

IEA. (2014), Key World Energy Statistics. 2014. Paris: International Energy Agency.

Ince, D., Vredenburg, H., Liu, X. (2015), Drivers and inhibitors of renewable energy: A qualitative and quantitative study of the Caribbean. Energy Policy, 98, 700-712.

Krause, D., Denzin, N.K. (1989), The research act: A theoretical introduction to sociological methods. Teaching Sociology, 17(4), 500.

Kucharski, J.B., Unesaki, H. (2018), An institutional analysis of the Japanese energy transition. Environmental Innovation and Societal Transitions, 29, 126-143.

Leite, A.D. (1997), A Energia do Brasil. Rio de Janeiro: Editora Nova Fronteira.

Leite, A.D. (2014), A Energia do Brasil. 3rd ed. Rio de Janeiro: Lexicon.

Mankiw, N.G. (2017), Mankiw Principles of Economics. Vol. 53. Mason, OH: South-Western College Publishing Group.

Memória da Eletricidade. (2015), Memória da Eletricidade. Avaialble from: http://www.memoriadaeletricidade.com.br/Default.asp?pagina=destaques/linha&menu=368&iEmpresa=Menu#368. [Last accessed on 2015 Dec 15].

Nee, V. (2005), In: Smelser, N., Swedberg, R., editors. The New Institutionalism in Economics and Sociology. Forthcoming: Handbook for Economic Sociology. CSES Working Paper Series. p1-71.

Nee, V. (2018), Middle-range theories of institutional change. Sociological Forum, 33(4), 845-854.

Nee, V., Swedberg, R. (2008), Economic sociology and new institutional economics. In: Ménard, C., Shirley, M.M., editors. Handbook of New Institutional Economics. 1st ed. United States: Springer. p884.

North, D. (1990), In: Alt, J., North, D., editors. Institutions, Institutional Change and Economic Performance. 1st ed. Washington, DC: Cambrige University Press.

North, D.C. (1990), Institutions, Institutional Change and Economic Performance. Washington, DC: Cambrige University Press.

North, D.C. (2008), Institutions and the performance of economies over time. In: Handbook of New Institutional Economics. New York: Springer. p21-40.

Ostrom, E. (1990), Reflections on the commons. In: Governing the Commons. Cambridge: Cambridge University Press. p1-28.

Ostrom, E. (2008), Doing institutional analysis: Digging deeper than markets and hierarchies. In: Handbook of New Institutional Economics. 1st ed. Dordrecht: Springer. p819-848.

Sauer, I.L. (2015), A Gênese e a Permanência da Crise do Setor Elétrico no Brasil. Brasil: Revista USP.

Sauer, I.L., Rosa, L.P., Carvalho, J.F. de Terry, L.A., Prado, L.T.S., Lopes, J.E.G. (2003), A Reconstrução do Setor Elétrico Brasileiro. 1st ed. São Paulo: Paz e Terra.

Solomon, B.D., Krishna, K. (2011), The coming sustainable energy transition: History, strategies, and outlook. Energy Policy, 39(11), 7422-7431.

Williamson, O.E. (1985), The Economics Institutions of Capitalism. 1st ed. New York: The Free Press.

Williamson, O.E. (2007), Transaction Cost Economics : An Introduction. Economics Discussion Papers, No. 3. p33.