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Minsky's financial fragility: An empirical analysis of electricity distribution companies in Brazil (2007-15)

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Minsky's Financial Fragility: An Empirical Analysis of Electricity Distribution Companies in Brazil (2007–15)

by

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ABSTRACT

The present paper applies Hyman P. Minsky's insights on financial fragility in order to analyze the behavior of electricity distribution companies in Brazil from 2007 to 2015. More specifically, it builds an analytical framework to classify the firms operating in this sector into Minskyan risk categories and assess how financial fragility evolved over time, in each firm and in the sector as a whole. This work adapts Minsky's financial fragility indicators and taxonomy to the conditions of the electricity distribution sector and applies them to regulatory accounting data for more than 60 firms. This empirical application of Minsky's theory for analyzing firms engaged in the provision of public goods and services is a novelty. The results show an increase in the financial fragility of those firms (as well as the sector) throughout the period, especially between 2008 and 2013, even though the number of firms operating at the highest level of financial risk hardly changed.

KEYWORDS: Minsky; Financial Fragility; Financial Instability Hypothesis; Electricity Distribution Companies

JEL CLASSIFICATIONS: G31; G38; H40; L59; L94

INTRODUCTION

Hyman Minsky's financial instability hypothesis became very popular in the aftermath of the 2008 international crisis. The application of his concept of financial fragility and his evolutionary approach to financial crises, which sees them as the result of a progressive and endogenous increase in the fragilization of economic units, helped in illuminating the causes and operating mechanisms of the meltdown (Kregel 2008; Tymoigne 2010).

Many academic works use Minsky's theoretical insights, though few papers explore financial fragility on empirical grounds. Historically, the few works dedicated to this task focused on macroeconomic issues, treating national economies as a unit (Seccarecia 1988; Paula and Alves 2000; Schroeder 2009). More recently, a group of authors, such as Mulligan (2013), Nishi (2016), and Davis, Souza, and Hernandez (2017), started to develop financial fragility indices at the firm level, aiming to characterize the general behavior of fragility in selected sectors and the economy as a whole, as well as its determinants.

Although we acknowledge the academic relevance of those works, we would like to stress that Minsky's concept of financial fragility has an important microeconomic component, related to each economic unit's (firms, individuals) own financial profile, and industry-level or sectoral financing patterns. Minsky's theoretical framework can also be used to analyze financial fragility at a disaggregated level,[1] with important implications for regulatory and economic policies.

In particular, we propose in this paper to apply Minsky's framework to analyze the financial fragility of firms engaged in the provision of public goods and services. We justify this approach for two reasons. First, the financial soundness of these firms is important for maintaining minimum quality standards in the provision of public goods and services—an increase in financial fragility can have consequences from the viewpoint of operational risks, such as a power outage. Second, regulatory agencies usually have a mandate to assess the financial-economic conditions of regulated companies, thus needing to monitor their financial

[1] As an example, Tymoigne (2010) analyzes Ponzi finance in residential housing in the US household sector.

health. In this context, the Minskyan framework can provide a useful toolkit to regulators for accomplishing this task.

This second reason originated from a specific demand from the Brazilian Electricity Regulatory Agency (ANEEL) for developing a methodology for monitoring electricity distribution companies' financial soundness. In 2012, one of the major financial groups in the industry, the so-called Grupo Rede, collapsed abruptly. At that time, Rede owned 9 out of the 64 electricity distribution firms that existed in Brazil. This case surprised ANEEL and gave rise to research aiming to identify and develop financial indicators that could guide the supervision of concessionary companies. The current paper is a part of this research.[2]

Based on early empirical works, we construct two types of financial fragility indices based on firm-level data: first, a firm-level indicator of hedge, speculative, and Ponzi finance units; and second, an industry-level index of financial fragility based on the frequency of speculative and Ponzi units in our sample. We then apply this framework to a dataset on balance sheets from 64 electricity distribution companies in Brazil, during the period 2007–15. This unprecedented dataset was built by the Study Group on the Electric Energy Sector (GESEL) from the Federal University of Rio de Janeiro (UFRJ), based on regulatory information provided to the public by ANEEL.

Therefore, the aim of this paper is to empirically assess financial fragility in electricity distribution companies in Brazil from 2007 to 2015. More specifically, we aim to classify these firms into Minskyan risk categories and analyze how financial fragility evolved over time in this sector.

The first and second sections of the paper define financial fragility according to Minsky and characterize Minsky's typology of risk categories. The third section reviews the empirical works that use Minsky's framework to analyze financial fragility in the real world. The fourth part proposes a methodology for building financial fragility indices and proposes two indicators in the format indicated above. The fifth section describes our dataset and presents indicators for

[2] ANEEL Research and Development Project PA3009, "Economic and Financial Sustainability Index of Electricity Distribution Companies."

electricity distribution companies in Brazil (2007–15). The final remarks provide a summary of our empirical analysis and discuss possible further research in this area.

1. MINSKY'S FINANCIAL INSTABILITY HYPOTHESIS AND ECONOMIC BEHAVIOR

The American economist Hyman P. Minsky developed the financial instability hypothesis with an aim toward explaining why the United States and other capitalist economies face periodical moments of financial instability and why in some instances these financial problems led to deep macroeconomic crises (Minsky 1972, 1986, 1992).

According to Minsky, the financial instability hypothesis leverages on the work of John Maynard Keynes (1936, 1937) and Irving Fisher's description of the 1929 crisis (Fisher 1933); he also acknowledged the influence of Schumpeter (1934) in the formation of his ideas (Minsky 1992, 1–2).

Minsky (1992, 7–8) defines his financial instability hypothesis in two theorems. First, he acknowledges that an economy can operate under stable or unstable financing regimes. Second, he states that "over periods of prolonged prosperity, the economy transits from financial relations that make for a stable system to financial relations that make for an unstable system" (Minsky 1992, 8).

Minsky's perspective is very different from the mainstream view of neoclassical economists. According the neoclassical strand, markets inexorably tend to reach a position of equilibrium, except when unexpected price shocks or economic policy mistakes take place. Minsky states that "the fundamental proposition of the financial instability theory of a capitalist economy is that the capitalist market mechanism is flawed, in the sense that it does not lead to a stable price–full employment equilibrium" (Minsky 1974, 267).

Once one recognizes that the capitalist market mechanism is flawed, financial instability could be deemed as an essentially endogenous phenomenon, which depends on financial structures and institutional arrangements that are in place in a given economy (Minsky 1972, 49). Therefore, for Minsky (1972, 48), "a financial crisis—used as a generic term—is not an accidental event, and not all financial structures are equally prone to financial instability."

The capital accumulation process takes place through the decision to invest current money based on the expectation of an even greater sum of money in the future. In a modern economy, in which long-term credit and capital markets are already developed, "there is an irreducible speculative element, for the extent of debt-financing of positions and the instruments used in such financing reflect the willingness of businessmen and bankers to speculate on future cash flows and financial market conditions" (Minsky 1986, 198–99).

Economic units are responsible for regularly managing expected, though uncertain, cash revenues obtained in a given period. These cash flows need to be in their hands at the right time and in the right amount in order to cover the following expenses: current and future financial obligations inherited from the past, which are usually foreseeable; operational expenditures; and payment of dividends to business owners.

The modern capitalist system is based on a web of financial relations (assets and liabilities), which have multiple interfaces among them, in different manners. These relations can be subject to distinct forms and levels of intermediation, from the debtor firm to the final creditor. This complex capital structure reinforces the relevance of expectations not only in the forecast of future cash flows, but also in the conditions under which liabilities were assumed and in the future market pricing of assets and liabilities of every economic unit. Thus, when the level of current revenues is substantially lower than expected, it is necessary to review the parameters that provided the basis for the calculus behind the operations with third-party resources, be it in the form of debt or in the form of equity.

From this viewpoint, financial institutions and businesspersons are not different. Both of them are enterprises that seek money profits. As in the real economy, innovations in the financial sector create opportunities for financial institutions to earn additional profits. They are, in

practice, new ways of making loans and capital investments that increase the profit margins of the innovator and tend to spread quickly through the markets.

Nevertheless, financial innovations usually bring with them an increase in financial fragility. In practice, they raise the amount of debt that can be issued upon a given amount of collateral and at a given interest rate. The longer the period of economic stability, the greater would be the incentives to financial institutions to introduce financial innovations that reduce the cost of credit to their clients and, at the same time, to investors for assuming greater risks for a given expected profitability. As these financial innovations prove to be profitable, there is a tendency for them to spread across the system, implying a deterioration in the actual risk carried out by enterprises and their creditors.

In Minsky's view, the increase in financial fragility manifests more immediately in the deterioration of margins of safety (collateral) in loans advanced to enterprises. Nevertheless, economic agents only perceive this increase in financial risk at a future moment in time and often abruptly. An unexpected recession might hamper the capacity of indebted firms in renegotiating their liabilities, which before the recession could be seen as something that would be easy to accomplish. Banks retract their balance sheets very quickly, diminishing their appetite for new operations as interest rates increase, and generating a negative shock to the economic system as a whole (Keynes 1972).

Financial fragility can turn into a macroeconomic issue when periods of stability are long lived. In this case, there is a progressive increase of risk implicit in balance sheets that tends to be minimized (Minsky 1992, 8). Economic analysts try to identify elements of current structural change in light of past conditions that might support the robustness of innovations and, therefore, the new characteristics of financial markets. As acknowledged by Reinhardt and Rogoff (2008, 1): "Major default episodes are typically spaced some years (or decades) apart, creating an illusion that 'this time is different' among policymakers and investors."

The greater the financial fragility in a given economic system, the greater the impact of unexpected fluctuations in effective demand in the current level of economic activity will be. This happens because the greater implicit financial risk, which is not priced in the liabilities

structure assumed in the period of macroeconomic stability, will amplify market risks that enterprises are subject to. Financial fragility is therefore a prerequisite for financial instability (Minsky 1986, 280).

2. HEDGE, SPECULATIVE, AND PONZI UNITS: A CHARACTERIZATION OF MINSKY'S TAXONOMY

In his financial instability hypothesis, Minsky has identified that a proper comprehension of financial fragility requires an accurate analysis of economic units. According to him: "One way every economic unit can be characterized is by its portfolio: the set of tangible and financial assets it owns and the financial liabilities on which it owes" (Minsky 1975, 70). Each unit earns money revenues from their assets and incur obligations from their liabilities. The issue is how the combination of revenues and obligations across time affects the current financial conditions of businesspersons, banks, and, as a consequence, the level of economic activity.

In a modern economy, almost all economic units make interest and principal payments on their loans, in amounts and on due dates that are usually foreseeable. To honor these payments, economic actors count on four main different sources: revenues from their operation; interest revenues and rents; revenues from the sale of assets; and cash on hand.

At each moment, economic units manage a cash flow composed of revenues and expenditures to be made in the future. Based on the degree of risk associated with their capacity to discharge financial obligations, Minsky proposed dividing these units into three different categories: hedge, speculative, or Ponzi. According to him, one can apply this taxonomy to every economic unit, from the financial sector or not, without distinction:

> To analyze how financial commitments affect the economy it is necessary to look at economic units in terms of their cash flows. The cash flow approach looks at all units—be they households, corporations, state and municipal governments, or even national governments—as if they were banks. Traditional banking literature emphasized the need for bankers to be liquid and solvent, and this was to be achieved by banks emphasizing self-liquidating commercial loans. In this way, the cash flows from business sales would lead to payments to banks; these payments would guarantee bank liquidity and solvency. In a similar way ordinary business needs to be liquid and solvent; this means that the payment commitments on debts must lie within bounds given by realized and expected cash flows. (Minsky 1986, 221)

Hedge financing units are those that can fulfill by the due date all of their contractual payment obligations (interest and principal) only by their current expected revenues (cash flows). In this case, both the entrepreneur and the banker do not need to worry about changes in financial markets conditions, such as the level of interest rates, loan terms, collateral requirements, etc. All risks associated with the discharge of financial obligations depend on a possible frustration of expected revenues. The lesser the degree of indebtedness of a unit (i.e., the greater the weight of equity financing in the liability structure), the greater the likelihood that it is a hedge financing unit.

Different from hedge units, speculative financing units know beforehand that they will not be able to generate revenues enough to fulfil all of their contractual payment obligations by their due date. Interest payments can be covered, but at least part of the principal of the debt will not be repaid out of current cash flows. Therefore, this unit will need to roll over their liabilities, issuing new debt to meet commitments on maturing debt (i.e., incur in refinancing) before its due date.

This situation means that the decision on these loans is based on the expectation that the speculative unit will need to refinance part of the principal of its debt, both from the perspective of creditors and debtors. This unit poses more risk than a hedge unit as, beyond general market risks (frustration of revenues), it is exposed to an additional financial risk: it might need to renegotiate its liabilities in an adverse moment in debt markets.

Ponzi financial units are similar to speculative units by the fact that they will not be able to fulfill all of their contractual obligations by their due date. Nevertheless, for Ponzi units the

magnitude of the disequilibrium between revenues and obligations is even greater. Expected cash flows are not sufficient to fulfill both the repayment of the principal and the interest due on outstanding debts. In this situation, a firm's indebtedness will increase in the near future unless it renegotiates its liabilities, sells assets, or issues stocks in financial markets. Financial risks of a Ponzi unit are, therefore, very high.

Such units are usually associated with fraudulent financial practices. Nevertheless, as Minsky (1986, 231) highlighted, this is not always the case. An unexpected slowdown in economic activity may affect current revenues, affecting all enterprises negatively. Hedge units can, in the last instance, become speculative units. Speculative units might unwillingly turn to Ponzi units. However, Ponzi units will have no other option than to renegotiate their liabilities or face turbulent market conditions when selling assets or issuing stocks. Therefore, a Ponzi financing structure should be short lived.

A restructuring of debt, diminishing costs and contractual obligations, and enlarging the maturity of debt are normal steps in order to reestablish the financial robustness of economic units' balance sheets. Only with this kind of procedure can Ponzi units turn into speculative units and, occasionally, speculative units can turn to hedge units. According to Vercelli (2009, 7): "a virtually insolvent unit [...] does not need to bankrupt, as it may be rescued by a private or public bail-out, or it may get out of trouble through a prompt adoption of extraordinary measures, such as the sell-out of illiquid and strategic assets to realize a radical downsizing or redirection of activity. […] in any case, even the bankruptcy (in legal sense) of a unit does not fully discontinue its economic and financial consequences."

Financial instability is directly related to the financial risks incurred by firms on their balance sheets and, subsequently, by financial institutions. The greater the relevance of financial risks in speculative and, principally, Ponzi units, the more prone to crisis that economy is. As Minsky (1986, 232) states: "The mixture of hedge, speculative, and Ponzi finance in an economy is a major determinant of its stability. The existence of a large component of positions financed in a speculative or a Ponzi manner is necessary for financial instability."

In his methodology, Minsky also introduced an element that is, in practice, relevant to financing decisions: the margins or cushions of safety (Minsky 1986; Kregel 2008, 7–10). Three kinds of margins of safety are used as mechanisms to safeguard debts. First is the addition of an excess margin over expected revenues in order to mitigate the risk of abrupt changes in this variable over time. This kind of margin tends to diminish expected cash flows in the face of current obligations to cushion any negative fluctuation of revenues from sales or interests and rents. The second kind is associated with a positive coefficient on the market value of assets in comparison to the market value of liabilities. Alternatively, it has to do with the cushion of net worth or equity relative to indebtedness. Finally, the third kind of margin of safety is the liquid assets held in portfolios, including cash.

3. AN EMPIRICAL ANALYSIS OF FINANCIAL FRAGILITY: A BRIEF REVIEW

Despite the development of Minsky's financial fragility concept on the theoretical front, its empirical applications are still scarce. Some empirical studies employ the terms "financial fragility" or "financial instability," but are based on a theoretical framework that is very distinct from the one we built in the last section (Schroeder 2009; Tymoigne 2010).

Neoclassical and New Keynesian authors use a static notion of financial fragility, usually referring to it as an exogenous phenomenon that occurs because of random shocks, market imperfections, or inappropriate government policies (Tymoigne 2010, 2). For "mainstream economists," fragility is not a process, but a state or event—this result being intimately related to a deterministic treatment of time in this tradition (Schroeder 2009, 293).

Two types of studies follow Minsky's original insights, both of them following the Post-Keynesian strand (Tymoigne 2010, 16–18). First are works that analyze the trends of aggregate variables and elaborate on how they help to explain recessions or crises, such as Estenson (1987). Second are studies that use the Minskyan hedge, speculative, and Ponzi categories and aim at detecting one or more of these categories, such as Schroeder (2009) and Nishi (2016).

The current paper focuses on this second strand of studies, even though works that treat national economies as a unit, such as Seccarecia (1988), Paula and Alves (2000), and Schroeder (2009), are not reviewed herein. We are in line with Tymoigne (2010, 1718), which points out that: "a good analysis of financial fragility cannot be based only on macro data, but also must look in detail at which activities contribute to the fragilization of a sector." Therefore, our particular interest lies with authors that develop financial fragility indices at the firm and sectoral levels.

Tymoigne (2010) proposes a sectoral analysis of Ponzi finance. His work departs from a criticism of a series of early warning indicators of financial crises, based on a static view of financial fragility. He advocates that the possibility of a crisis is endogenous to the economic system (rather than the result of shocks) and, thus the focus of indicators should be the detection of financial fragility during periods of economic stability.

He develops an indicator to detect Ponzi financing patterns and applies it to residential housing in the US household sector (this sector is the unit in Tymoigne's work). According to Tymoigne (2010, 28), a central aspect of Ponzi finance is that "net cash flows from operation are expected to be too low to meet debt commitments." Nevertheless, net cash flows alone are not a good indicator of Ponzi finance, due to methodological issues on actual data: financial obligation ratios are actual instead of expected cash-flow ratios and data on principal payments is not available. In this case, Tymoigne proposes that one should look to three indicators together: cash-flow ratios, liquidity ratios, and refinancing needs. The combination of increasing cash-flow ratios and refinancing needs with declining liquidity ratios is an indicator of Ponzi finance (Tymoigne 2010, 34).

A first index is proposed using three variables, all of them transformed into four-quarter moving averages, in the period 1987–2008: the growth of home prices (g_P), the growth of mortgage debt (g_D), and the growth of the mortgage-financial-obligation ratio (g_{CC}). The index takes a value of one if all the variables together are greater than zero and takes a value of zero otherwise. A second index adds the growth of the ratio of monetary assets to mortgage debts ($g_{M/D}$) to the three variables above. This index takes a value of one if g_P, g_D, and g_{CC} are positive and $g_{M/D}$ is simultaneously negative; it takes a value of zero otherwise. Finally, a third index also includes the effects of refinancing operations, using data about cash-out refinance provided by Freddie

Mac (percentage of refinances resulting in cash-out refinance with loan amounts that are at least 5 percent higher).

The results point out that unsustainable financial practices in home financing marks the periods 1989–90, 1999–2000, and 2003–7. While the first index suggests that Ponzi finance is in place continuously from 2000 to 2007, the second and third indices indicate a break in the period 2001–3, justifying the separation of the periods 1999–2000 and 2003–7.

Mulligan (2013) collects quarterly data from 2002 to 2009 on all publicly traded firms in North American exchanges, a total of 8,707 companies. He proposes the classification of individual firms into hedge, speculative, or Ponzi financing states according to the interest coverage index (*IC*):

$$IC = \frac{(Net\ Income\ +\ Interest\ Expense)}{Interest\ Expense}$$

His classification is defined as follows: "An IC of greater than or equal to 4.00 was selected to identify hedge finance units, between 4.00 and zero for speculative finance units, and less than zero for Ponzi finance units" (Mulligan 2013, 452). One should notice that these thresholds are completely arbitrary and have no theoretical basis in Minsky's works.

After looking at each firm as a unit, Mulligan separates firms into eight industry groups: (1) agriculture, forestry, fishing, and hunting; (2) mining, quarrying, and oil and gas extraction; (3) utilities; (4) manufacturing; (5) transportation and warehousing; (6) information; (7) real estate, rental, and leasing; and (8) professional, scientific, and technical services. From this classification, he is able to analyze the financing patterns on a sector-by-sector basis.

He uses four indicators: (i) the percentage of firms in each category; (ii) the total number of firms listed in each category; (iii) the percentage of firms in each category weighted by each firm's market value; and (iv) the total dollar value for each of the three categories. According to the first indicator, sectors 2, 4, 5, and 8 present the behavior predicted by the financial instability hypothesis, i.e., "the percent of speculative and Ponzi firms […] fall during

the recovery phase, increase over the course of the business expansion between recessions, and rise again during or prior to the next recession" (Mulligan 2013, 452). When he takes the total number of firms listed in each category, stronger evidence in support of Minsky's theory is found: all sectors, except utilities (3), present the expected behavior.

The next two indicators serve to qualify the results of indicator (ii). When using weighted percentages, the market value of speculative and Ponzi firms increases before the crisis for sectors 2, 4, 5, 6, and 7. When looking to the dollar value of the categories, the inverted-u pattern described in the quote above is also observed. The main insight of Mulligan's work is the use of individual or firm-level data to analyze the behavior of single sectors, which can signalize financial fragility in a way macro indicators cannot.

Other important work in this class of studies is Nishi (2016), in which the author analyzes financial fragility and its determinants in nonfinancial sectors in Japan. He uses firm-level data to classify Japanese enterprises into hedge, speculative, or Ponzi units in a large sample and then analyzes the determinants of financial fragility through a panel logit regression model.[3] In this exercise, he uses annual data from 1975 to 2014 and his database includes firms from 32 different sectors, which were split into two groups—manufacturing and nonmanufacturing—and subsets of small, medium, and large enterprises.

Two financial fragility indices were built. First is an index (FFI-1) based on a cash-flow accounting framework, which leverages on Schroeder (2009) but applies to firms and not to the whole economy.[4] To calculate FFI-1 he uses the sources and uses of funds (cash-flow) statement at the level of a (representative) firm, the former composed by the sum of profits and borrowing and the latter composed by new investments, debt service payments, and dividend payments. The introduction of dividend payments is an innovation.

[3] Though Nishi (2016, 7) criticizes previous empirical analyses by focusing only on taxonomy and argues for the benefit of an analysis of the determinants of financial fragility, our interest in this paper is set only on the construction of financial fragility indicators. We believe that, before advancing in an empirical analysis of the determinants, we need to build consistent indicators of financial fragility.

[4] Schroeder (2009) uses a simple cash-flow accounting framework to analyze financial fragility in New Zealand (as a unit) from 1990 to 2007. Her empirical exercise is based on the cash-flow equation proposed by Foley (2003) in a model explaining the analytics of financial fragility: *Profit + Borrowing = Investment + Debt Service*.

$$Profits + Borrowing = New\ investments + Debt\ service\ payments + Dividend\ payments$$

Data on each firm is normalized by capital stock, since values may vary significantly among different firm sizes. From this normalization, four variables are obtained: r, the profit rate; g, the capital accumulation rate; i_D, debt service payments per capita; and d, dividend payments per capita. In this set of variables, Nishi (2016, 9) defines Minskyan categories as follows:

- *Hedge* if $r - g - i_D - d \geq 0$;
- *Speculative* if $r - g - i_D - d < 0$ and $r - i_D - d \geq 0$;
- *Ponzi* if $r - g - i_D - d < 0$ and $r - i_D - d < 0$.

In this definition, hedge economic units do not need to rely on additional borrowing to finance all the new investments and dividend and debt service payments, while a speculative unit does. Ponzi is an extreme case of a speculative unit, in which borrowing is needed to finance dividend and debt service payments (Nishi 2016, 9).

The second index is a measure of margins of safety. Nishi bases his reasoning on Minsky's (1986) "Appendix A: Financing Structures" of the book *Stabilizing an Unstable Economy*. In that appendix, Minsky indicates that financial fragility can be characterized based on three margins of safety: cash-flow margin (τ); capital value margin (μ); and margin provided by the liquid asset kicker (η). Nishi (2016, 9) argues that τ is closely related to μ, and therefore chooses μ to use as a variable to measure financial fragility in terms of flows.

He uses the following expression to denote μ:

$$\mu = \frac{K(\bar{Q} - \lambda.\sigma_Q^2)}{K(CC)}$$

where K is a discount operator used to obtain the present value of variables between the parenthesis; $\bar{Q}$ is average or expected quasi-rents; σ_Q^2 is a quasi-rents variance; λ is a scalar that

expresses the impact of the fluctuation in quasi-rents; and *CC* is cash payment commitments on debts.

Another indicator, the liquid asset kicker, which is denoted by the following expression, complements the capital value margin of safety:

$$\eta = \frac{K(CC) + Eq - P_K K}{K(CC)}$$

where $P_K = \bar{Q} - \lambda.\sigma_Q^2$, represents the capitalized value of expected quasi-rents; and Eq is the equity.

The liquid asset kicker is a measure of the liquid-assets-to-liabilities ratio on the balance sheet of an economic unit. The higher this ratio, the more robust the financial situation of the unit is.

Based on these two indicators, Nishi builds an index of financial fragility, categorizing hedge, speculative, and Ponzi units as follows:

- *Hedge* if $\mu > 1$ and $\eta > 1$;
- *Speculative* if $\mu \geq 1$ and $0 < \eta \leq 1$;
- *Ponzi* if $\mu < 1$, regardless of η.

The index combining these two indicators has two limitations, which Nishi argues are assumptions for the sake of simplicity. First, he bases his calculations on current and realized values, not on expected values (as defined by Minsky [1986]). Second, as this first simplification is made and financial fragility is defined on a yearly basis, margins tend to persist over time. Appendix A presents the database and sources used by Nishi to make his calculations.

His results point out that speculative finance is realized in many sectors of the Japanese economy, though hedge finance increased during expansion, regardless of size and sector, especially from 2002 on. Ponzi finance increases substantially during recessions, as the bursting

of the Japanese bubble in 1991–93 and the 2008 Global Financial Crisis revealed. Besides this general analysis, Nishi (2016, 19) finds that the nonmanufacturing sector is more financially fragile than the manufacturing one in dynamic terms, due to the greater number of records of Ponzi finance.

Nishi's (2016, 20–6) analysis advances to an econometric model to assess the determinants of financial fragility. However, as this is not the focus of our paper, we will suggest the reader consults the original for the results. It is noteworthy, nevertheless, that he finds the determinants of financial fragility differ by sector and size, therefore justifying a disaggregated analysis on this subject.

Finally, Davis, Souza, and Hernandez (2017) apply Minsky's categorization to a panel of nonfinancial corporations in the United States. They propose a discrete classification of economic units based on the following criteria:

- *Hedge* if *[Sources of Cash - Interest Payments - Principal Payments] > 0;*
- *Speculative* if *[Sources of Cash - Interest Payments] > 0* and *[Sources of Cash - Interest Payments - Principal Payments] < 0;*
- *Ponzi* if *[Sources of Cash - Interest Payments] < 0.*

They complement this classification with a measure of interest coverage, which is defined as sources of cash less interest payments, scaled by total assets.

These classifications are applied to data on publicly traded US corporations drawn from Standard & Poor's Compustat Database from 1970 to 2014. They limit their sample to firms incorporated in the United States and exclude financial corporations. In addition, they exclude firms with negative recorded sales, assets, or interest payments from the sample. A complete description of data and sources can be found in appendix B.

Once firms are classified into one of three categories, Davis, Souza, and Hernandez (2017) analyze the general trends in financing patterns of nonfinancial corporations in the United

States, using the percentage shares of each category in the total. A larger portion of firms engage in speculative finance, though Ponzi finance consistently increases in the post-1970 period, from 10.8 percent of the total in 1970 to 31.6 percent in 2014. This indicates a long wave of increasingly fragile financing patterns in the US economy post-1970. However, this pattern is not symmetrical according to a firm's size: the number of small firms that are Ponzi increased a great deal and represent around 70 percent of the total of small firms since the 2000s, though big firms are mostly concentrated in hedge and speculative finance (Davis, Souza, and Hernandez 2017, 10).

Turning to the share of *total assets* under each financial regime, their results show a relatively stable picture, with a small share of Ponzi finance and a predominance of speculative positions (around 70 percent). This result is consistent with the concentration of Ponzi finance in small firms mentioned above and reveals that larger firms tend to be more financially robust.

In their conclusions, Davis, Souza, and Hernandez (2017, 17) highlight that a great number of Ponzi firms go public (i.e., issue stocks), entering the sample despite their apparently fragile financing structure. They conclude then that "this expansion of Ponzi entrants is arguably indicative of changing financial norms and conventions" (Davis, Souza, and Hernandez 2017, 18). The long wave of increasing fragility is therefore a response to the changes in financial norms and conventions, as corroborated by the eruption of the 2008 financial crisis.

We summarize the main characteristics of the empirical works analyzed here in the following table:

Table 1. Summary of Empirical Works on Minsky's Financial Fragility

	Data level	**Flows/Stocks**	**Classification criteria**	**Margins of safety**
Tymoigne (2010)	Sectoral	Flows	Own criteria	No
Mulligan (2013)	Firm	Flows	Ad hoc	No
Nishi (2016)	Firm	Flows (FFI-1) and Stocks (FFI-2)	Based on Minsky (1986)	Yes
Davis, Souza, and Hernandez (2017)	Firm	Flows	Based on Minsky (1986)	No

Source: Authors' elaboration.

Aggregate exercises provide a very broad picture of financial fragility, though they do not properly capture the dynamics of fragility in the economy. Works that use disaggregated data, both at the firm level and at the sectoral level, seem to be more promising for achieving a proper description of fragility and its evolution. Therefore, it is very important to set the focus on the firm.

Nishi's attempt to develop a stock indicator of margins of safety is noteworthy, but his results are very limited due to his assumptions. More specifically, the use of actual instead of expected values of quasi-rents makes his capital value margin and liquid asset kicker indicators imprecise.

Given this background, this paper will develop an empirical analysis based on Minsky's (1986) classification criteria, using firm-level data in a cash-flow approach. Based on this methodology, we will analyze the behavior of financial fragility in a single industry—electricity distribution—in Brazil, during the period 2007–15.

4. FINANCIAL FRAGILITY AT THE FIRM AND SECTORAL LEVELS: PROPOSED INDICATORS

Based on early empirical works reviewed in section 3 and Minsky's original insights, we propose to develop two types of financial fragility indices. First, we will build a firm-level indicator of hedge, speculative, and Ponzi finance units, following the cash-flow approach used in previous studies. This indicator will provide a taxonomy of economic units. Second, we will build an unprecedented index, which we call the "sectoral financial fragility index," based on the frequency of hedge, speculative, and Ponzi units. This indicator will help in analyzing financial fragility on a sectoral basis.

4.1. A Firm-level Index of Financial Fragility

Our empirical approach will characterize Minsky's categories based on a cash-flow approach. We begin from a basic equation proposed by Vercelli (2009, 618), even though we do not follow his approach. He proposes an index of current liquidity, which compares the current

financial inflows (y_{it}) and outflows (e_{it}) from a unit (i) at a given point in time (t). The index (m_{it}) is given by the current excess (or net) financial inflows:

$$m_{it} = y_{it} - e_{it}$$

In line with Davis, Souza, and Hernandez (2017), current financial inflows can be characterized as the diverse *sources of cash* the firm receives from operation, such as income and sales of assets. Current financial outflows, in turn, are the expenditures with financial obligations, especially interest and principal payments:

$$e_{it} = e_{it}^{interest} + e_{it}^{principal}$$

According to this formulation, we characterize a hedge financial unit as the one that presents a positive current liquidity index (or net financial inflows):

$$m_{it} = y_{it} - e_{it} > 0, \text{ or}$$

$$y_{it} > e_{it} \therefore {}^{e_{it}}/_{y_{it}} < 1$$

In this case, all financial obligations of this firm will be discharged without the need to undertake any refinancing, and there are no liquidity problems at any moment. This is equivalent to Davis, Souza, and Hernandez's (2017) terminology that: *[Sources of Cash - Interest Payments - Principal Payments] > 0.*

For a speculative unit, we consider its current liquidity index to be negative, i.e., current financial inflows (y_{it}) are smaller than outflows (e_{it}). As Minsky suggests in his original work, a speculative unit will be able to honor interest payments but not the totality of the principal. Therefore, an additional condition is that interest payments ($e_{it}^{interest}$) are smaller than current inflows (y_{it}). Writing these conditions, we obtain:

$$m_{it} = y_{it} - e_{it} < 0, \text{ or}$$

$$y_{it} < e_{it} \therefore {}^{e_{it}}/_{y_{it}} > 1$$

and

$$e_{it}^{interest} < y_{it}$$

Again, it is just another way to write Davis, Souza, and Hernandez's (2017) conditions: *[Sources of Cash - Interest Payments] > 0* and *[Sources of Cash - Interest Payments - Principal Payments] < 0*.

A Ponzi unit is a special case of a speculative unit. It will present negative net inflows ($m_{it} < 0$), but it will not be able to honor both principal and interest payments. Thus, interest payments ($e_{it}^{interest}$) are greater than current inflows (y_{it}). This unit will need to borrow continuously and, as a consequence, its debt will increase in absolute and relative terms. These conditions can be written as follows:

$$m_{it} = y_{it} - e_{it} < 0, \text{ or}$$

$$y_{it} < e_{it} \therefore {}^{e_{it}}/_{y_{it}} > 1$$

and

$$e_{it}^{interest} > y_{it}$$

Davis, Souza, and Hernandez (2017) write this condition in the following way: *[Sources of Cash - Interest Payments] < 0*.

These conditions give us a very simple and transparent methodology for assessing financial fragility, which is directly based on Minsky's original work. Nevertheless, when applying these equations to real-world data, some issues need to be addressed. In our case, some adaptations to the regulatory accounting of the Brazilian electricity sector are needed.

We consider earnings before interest, taxes, depreciation, and amortization (EBITDA) the most representative indicator of the sources of cash for the firm in a given period *t*. This indicator is, nevertheless, net of operational expenditures (*OE*), which we include in the equation to obtain the gross operating profits of the company in a given period. Financial outflows encompass disbursements with debt service (*DS*) and operational expenditures (*OE*), without investment and tax (income tax) expenditures. Dividends are not included due to data unavailability.

$$y_{it} = EBITDA_{it} + OE_{it}$$

$$e_{it} = DS_{it} + OE_{it}$$

From these two equations, we can obtain the current liquidity index:

$$m_{it} = y_{it} - e_{it}$$

$$m_{it} = (EBITDA_{it} + OE_{it}) - (DS_{it} + OE_{it}) \therefore$$

$$m_{it} = (EBITDA_{it} - DS_{it}) + (OE_{it} - OE_{it}) \therefore$$

$$m_{it} = EBITDA_{it} - DS_{it}$$

A hedge financial unit is characterized by a positive net inflow greater or equal to interest and principal payments, i.e., the debt service. As we defined above, m_{it} should be positive. Nonetheless, we can state that the maximum limit of this condition for a hedge unit is:

$$DS_{it} = EBITDA_{it}$$

or, alternatively,

$$\frac{DS_{it}}{EBITDA_{it}} = 1$$

The closer to zero this ratio is, the greater net cash flows and profits are. In this case, the companies have the ability to use their own resources to honor all financial obligations. In addition, they can use their extra cash flows to finance investments or for the payment of taxes (income tax). Based on this rationale, we define the financial fragility index (FFI) as the ratio of debt service over financial inflows, a type of debt coverage ratio. Adapting this definition to the regulatory accounting standards in the Brazilian electricity sector (given by ANEEL) we have:

$$FFI_{it} = \frac{DS_{it}}{EBITDA_{it}} = \frac{(FO_{it} + STD_{it})}{EBITDA_{it}}$$

where *FO* stands for financial obligations, which represent current interest payments ($e_{it}^{interest}$); and *STD* is the stock of short-term debt, which represents the expected principal payments in the next 12 months ($e_{it}^{principal}$).

A unit will be classified as hedge if its FFI is less than or equal to one. If the FFI is greater than one, there are two possibilities of classification: speculative, if current interest payments (*FO*) are smaller than current cash inflows (*EBITDA*); or Ponzi if, as in speculative finance, current interest payments (*FO*) are smaller than current cash inflows (*EBITDA*), and principal payments (*STD*) are greater than current cash inflows (*EBITDA*). In addition, companies with negative cash inflows (i.e., *EBITDA < 0*) were also considered Ponzi, despite the behavior of the other variables.

In sum, our classification will reflect the following conditions:

- *Hedge* if $FFI \leq 1$;
- *Speculative* if $FFI > 1$ and $FO < EBITDA$;
- *Ponzi* if $EBITDA < 0$ or $FFI > 1$, $FO < EBITDA$ and $STD > EBITDA$.

This classification results from a concern about assessing companies' balance sheets from a strictly financial viewpoint, gathering in a hierarchized way the information on the ability of firms to discharge their financial obligations with resources from current activities.

4.2. Regulatory Considerations on the Firm-level FFI

We should take into account that the electricity distribution sector provides an essential service that is directly regulated by the government. In this case, the regulator should not only be concerned with the exposure of companies to financial risks but also with the possible impacts of financial fragilization in the provision of services to the public. An increase in financial fragility might hamper the ability of concessionaries to finance current investments and maintain a high level of quality in the provision of services before they need to restructure their liabilities.

Due to these reasons, we propose the elaboration of a second FFI that addresses those regulatory concerns. We call it the "regulatory financial fragility index" (RFFI). The difference between the FFI and the RFFI lies in the addition of a "cushion of safety," as suggested by Minsky, which addresses the needs of the regulator.

The original plan was to incorporate current investments and dividend payments into the FFI. However, the lack of data demanded an alternative, which is the use of an accounting depreciation (AD) variable. This variable is a proxy for the minimum investment that a distribution company should make in the long term in order to maintain the capacity of their (physical) assets, and thus maintaining the quality in the provision of their services. Therefore, the RFFI differs from the FFI due to the presence of an additional term, AD, in the numerator:

$$FFI_{it} = \frac{(FO_{it} + STD_{it} + AD_{it})}{EBITDA_{it}}$$

Based on the RFFI, we renamed the three original risk categories proposed by Minsky, aiming to reflect the precautionary perspective inherent in the supervision conducted by the regulator. In this context, companies in a sound financial situation (i.e., with an RFFI greater or equal to one) were classified as "robust," as they do not represent an immediate risk to the system.

A company that presents an RFFI equal to one has the ability to pay its financial obligations with its own resources and, at the same time, maintain an investment level that keeps its capital base without increasing indebtedness. The lower the RFFI, the greater will be the ability of a

firm to use internal resources for financing net investments, paying income taxes, and distributing dividends.

Companies that are more subject to financial risks than that of robust companies form our second risk category, which we call "exposed" firms. These companies will need to roll over their debt at some point in the future to keep their financial obligations and investments current. Their financial situation is worse in comparison to robust firms, but it is manageable: the quality in the provision of services is at risk, but a controlled degree of risk. In numbers, RFFI is greater than one, though $FO + AD < EBITDA$.

The remainder of the companies, deemed as "fragilized," are included in the highest risk category from the viewpoint of the regulator. In this case, besides an RFFI that is greater than one, interest payments plus accounting depreciation is greater than net cash flows (EBITDA). Firms with negative net cash flows are also included in this category, independent of other criteria.

In sum, our classification will reflect the following conditions:

- *Robust* if $RFFI \leq 1$;
- *Exposed* if $RFFI > 1$ and $FO + AD < EBITDA$;
- *Fragilized* if $EBITDA < 0$ or $RFFI > 1$, $FO + AD < EBITDA$ and $STD + AD > EBITDA$.

4.3. A Sectoral-level FFI

The outcomes of the application of the FFI and RFFI allow another type of quantitative analysis of financial fragility, based on an FFI that encompasses all the companies in the sector, treating it at the industry level. We will develop the methodology of this approach in the following paragraphs, detailing the construction of the sectoral financial fragility index (SFFI) and the sectoral regulatory financial fragility index (SRFFI).

Both the SFFI and SRFFI vary in scale, ranging from a minimum of zero to a maximum of 100. The level zero indicates that all companies are engaged in hedge (FFI) or robust (RFFI) finance. The level 100 indicates that all companies are engaged in Ponzi or fragilized finance. If the index assumes the level 50, the mixture of companies in the sector reveals, on average, a speculative or exposed finance structure.

To build these indices we used two approaches. First, we calculated the index based on a simple frequency (*f*) of companies in each risk category on a year-by-year basis. Hedge units are multiplied by a factor equal to zero, speculative units by 0.5, and Ponzi units by 1.0. The sum of these values was normalized for the total of companies (i.e., divided by x_t, where x_t is the total number of firms in each year) and multiplied by 100, resulting in an index that ranges from zero to 100:

$$SFFI_t^{Simple} = \frac{(0 \times f_t^{Hedge} + 0.5 \times f_t^{Speculative} + 1.0 \times f_t^{Ponzi})}{x_t} \times 100$$

The differences in size among companies in the electricity distribution sector, whatever the criteria used to assess it (number of clients, assets, earnings, depreciation), is massive. Firms in the top 10 for total revenues represented more than 60 percent of all regulatory depreciation in 2015. In the second approach, we try to address this characteristic by taking into account the relative size of each company.

Due to the availability of data, the statistic used to measure the size of each company is the accounting depreciation, which represents the minimum investment needed to maintain the quality of physical assets of the distribution companies. The weighted index sums the value of the accounting depreciation of companies by categories in each year, multiplying it by zero, 0.5, and 1.0 for hedge, speculative, and Ponzi, respectively, and then dividing by the average accounting depreciation. Again, we multiply this number by 100 to achieve the 0–100 scale:

$$SFFI_t^{Weighted} = \frac{(0 \times \sum_{i=1}^{j} AD_{it}^{Hedge} + 0.5 \times \sum_{i=j+1}^{k} AD_{it}^{Speculative} + 1.0 \times \sum_{i=k+1}^{n} AD_{it}^{Ponzi})}{\sum_{i=1}^{n} AD_i / x_t} \times 100$$

The same rationale applies to the SRFFI, though we use data from the RFFI instead of the FFI as an input.

5. APPLYING FINANCIAL FRAGILITY INDICATORS TO BRAZILIAN ELECTRICITY DISTRIBUTION COMPANIES IN THE PERIOD 2007–15

In this section, we apply the methodology proposed in section 4 to the dataset on electricity distribution companies developed by the GESEL at the UFRJ. This database was built based on regulatory information provided to the public by ANEEL, covering balance sheets of distribution companies and following the regulatory accounting standard from ANEEL in the period 2007–15.

According to our methodology, we classified distribution companies in hedge, speculative, or Ponzi finance categories on a yearly basis to identify the evolution of financial risks at the firm level. For this purpose, we used the FFI and RFFI. After this exercise, we looked into the frequency with which companies appear in each category (number and percentage) to characterize the evolution of financial fragility in the sector. Then we estimated the industry-level indices of fragility (SFFI and SRFFI, on simple and weighted versions) to better characterize how financing patterns evolved over time in this sector.

5.1. The Evolution of the FFI

Table 2 presents the results of the FFI for electricity distribution companies in Brazil in the period from 2007 to 2015. The number of companies in our sample varied between 62 and 64 in each year.[5] Data shows that distribution companies were in a very comfortable financial situation in 2007. In this year, the general picture was characterized by a very low level of financial fragility, as 48 companies (75 percent of the total) were in a hedge financing pattern. The remainder of the companies were divided almost equally between speculative and Ponzi structures.

[5] This behavior is due to mergers and acquisitions, and the lack of data, which nonetheless does not hamper the results in the sample as it refers to very small companies in specific years.

Table 2. Electricity Distribution Companies by Category (FFI)

Year	Number				Percentage			
	Hedge	Speculative	Ponzi	Total	Hedge	Speculative	Ponzi	Total
2007	48	7	9	64	75%	11%	14%	100%
2008	49	7	7	63	78%	11%	11%	100%
2009	41	11	11	63	65%	17%	17%	100%
2010	40	13	10	63	63%	21%	16%	100%
2011	44	8	11	63	70%	13%	17%	100%
2012	37	13	12	62	60%	21%	19%	100%
2013	32	17	13	62	52%	27%	21%	100%
2014	32	24	6	62	52%	39%	10%	100%
2015	25	27	10	62	40%	44%	16%	100%

Source: Authors' elaboration, based on data from ANEEL.

The number of companies engaged in Ponzi finance remained relatively stable in the period: there were nine companies in 2007 and in 2015 there were ten companies. However, between 2008 and 2013 the number of companies engaged in Ponzi finance grew. The decrease in the number of companies engaged in Ponzi finance in 2013 and 2014 was due to the financial restructuring of private enterprises that were formerly owned by the Grupo Rede; these enterprises left this financial category after the restructuring process. The private company AES-Sul joined the group of companies engaged in Ponzi finance in 2015 and was acquired by other controllers in the following year. This pattern reveals that companies remain in an extremely fragile situation for a limited period, as expected by the Minskyan theory.

However, from a Minskyan point of view, the existence of a significant number of companies engaged in Ponzi finance (some of them large in size) for a relatively long period (nine years) represents a quandary. This can be explained by the fact that the government controls all of them, which is a particularity of this sector. The federal government, through its holding of Eletrobrás, owns the seven largest Ponzi companies.[6] In the remainder of our sample, there are some small companies owned by municipalities and one under state government control, the Central Elétrica de Brasília.

[6] Eletrobrás controls the following companies: CEAL, CELG, CEPISA, CEA, CERON, ELETROACRE, and AMAZONAS.

The regular flow of public subsidies to these companies explains why they were able to keep in such a fragile financial situation during this long period. In practice, it is the capital injection of public resources that keeps these companies running. Otherwise, as exemplified by companies of the former Grupo Rede, they would be restructured right after becoming financially fragile.

The continuous decrease in hedge financing was followed by the increase in speculative financing, pointing to the gradual increase in financial fragility in the electricity distribution sector. In 2007, 48 out of 64 companies were classified as hedge (75 percent from the total). However, year by year, this number has decreased until reaching its lowest point at 25 companies in 2015 (40 percent from the total). Simultaneously, the number of speculative distribution companies increased fourfold in nine years: in 2007 there were 7 companies (11 percent) engaged in speculative finance, while in 2015 this number increased to 27 companies (44 percent of the total). In 2015, speculative overcame hedge financing in the number and the overall proportion of companies. The main reasons for that seem to be related to changes in the tariff policy set by the regulatory agency and the impacts of a sharp exchange rate devaluation in 2015.

5.2. The Evolution of the RFFI

The use of the RFFI on the same sample shows a very similar picture to the one revealed by the FFI. As shown in table 3, financial fragility increased among electricity distribution companies from 2007 to 2015. The number of companies classified in the best financial situation (i.e., financially robust companies) decreased from 39 to 15 during the same period. On the other hand, firms classified as financially exposed increased from 10 to 30.

Financially robust companies have a net cash inflow that is high enough to discharge all financial obligations and to cover capital depreciation expenditures. Exposed firms have cash flows that are sufficient to honor principal payments and depreciation expenditures, but they need to refinance part of their interest payments by borrowing in the market. These firms are therefore more vulnerable to potentially adverse conditions in financial markets.

As observed in the FFI, the number of financially fragile companies does not increase too much from 2007 to 2015. In the former year, there were 15 financially fragile companies, while in the latter there were 17 companies fitting in such a financial profile. Between 2007 and 2015 this number varied between a low point of 13 and a high point of 20 firms.

Table 3. Electricity Distribution Companies by Category (RFFI)

Year	Number				Percentage			
	Robust	Exposed	Fragilized	Total	Robust	Exposed	Fragilized	Total
2007	39	10	15	64	61%	16%	23%	100%
2008	43	9	11	63	68%	14%	17%	100%
2009	31	15	17	63	49%	24%	27%	100%
2010	34	16	13	63	54%	25%	21%	100%
2011	37	11	15	63	59%	17%	24%	100%
2012	28	19	15	62	45%	31%	24%	100%
2013	25	17	20	62	40%	27%	32%	100%
2014	27	23	12	62	44%	37%	19%	100%
2015	15	30	17	62	24%	48%	27%	100%

Source: Authors' elaboration, based on data from ANEEL.

The main difference between the results of the FFI and RFFI is, as expected, the higher number of companies engaged in more fragile financing patterns. Three reasons are behind this outcome. First is that a higher number of companies from Grupo Rede, extinct in 2013, are identified as fragilized companies. Simultaneously, some companies engaged in Ponzi finance according to the FFI appear as fragilized companies over a longer period when RFFI is applied.

The second difference is the higher number of companies controlled by the state government that are classified as fragilized, particularly in 2015. Besides Central Elétrica de Brasília, CEMIG, Light, and CEEE joined this category in the last year of our sample.

A study from CEMEC (2016) showed that exchange rate depreciation had an enormous negative impact on the financial situation of publicly traded companies. In the electricity distribution sector, this effect was even greater for companies that depend on the Itaipu Binacional hydro plant, where energy provision contracts are set in US dollars. Beyond this, due to weather reasons, the use of thermoelectric power plants substantially increased in 2015. These two factors had immediate impacts on the current costs of the concessionaries, but they were not compensated for by a proportional increase in tariffs on the annual readjustment dates. In that

scenario, distribution companies needed to decapitalize at the moment that market interest rates were increasing.

5.3. A "Systemic View" of Financial Fragility: SFFI and SRFFI

The SFFI uses the outcomes of the FFI and RFFI to form a sectoral indicator of financial fragility on a scale from zero (minimum) to 100 (maximum). The level zero indicates that all companies are engaged in hedge (or robust) finance. The level 100 indicates that all companies are engaged in Ponzi (or fragilized) finance. If the index assumes the level 50, the mixture of companies in the sector reveals a speculative (or exposed) financing structure.

Taking into account the differences in scale among the companies in our sample, we will present the results of the SFFI in two versions: one based on the frequency of companies in each risk category (simple) and other that weighs each company by its accounting depreciation (weighted). Therefore, the SFFI reflects Minsky's concern with the mixture of different economic units in the different risk categories.

Figure 1 plots the evolution of the SFFI, which uses data from the FFI. As expected, there is a progressive and continuous increase in SFFI in the period 2007–15. The simple SFFI increases from 20 in the beginning of our sample to 38 in the last year, while the weighted SFFI increases from 8 to 29.

Figure 1. Evolution of the SFFI

Source: Authors' elaboration, based on data from ANEEL.

Despite the trajectory of increasing financial fragility in the sector—the SFFI almost doubles between 2007 and 2015—the absolute levels of fragility in the end of the period are not particularly worrying. There is an evolution in the direction of speculative finance, but the general index remained lower than 50. This means that hedge and speculative financing patterns are predominant. The weighing by depreciation shows that smaller companies were the ones that are responsible for the fragilization on a sectoral basis. Nevertheless, the contribution to the increase in the SFFI in 2015 by CEMIG and Light, the two biggest distribution companies, was remarkable.

Figure 2 shows the evolution of the SRFFI. The broad picture showed by the SRFFI is similar to the SFFI; however, the degree of financial fragility revealed by the SRFFI is more acute, as depreciation is taken into account. Between 2007 and 2015, the simple index evolved from 31 to 52, while the weighted index increased from 16 to 46. The former shows that in the end of the period the mixture among risk categories suggests the sector could be classified as financially exposed.

Figure 2. Evolution of the SRFFI

Source: Authors' elaboration, based on data from ANEEL.

Another important difference between the SFFI and SRFFI is the role of big companies in sectoral fragility. When depreciation is taken into account, the biggest companies played a more relevant role in the fragilization of the electricity distribution sector across the whole period. From this viewpoint, the sector becomes homogeneous in terms of financial fragility along the time period, with the predominance of firms engaged in speculative finance.

FINAL REMARKS

Minsky's financial instability hypothesis and his concept of financial fragility were traditionally used to explain macroeconomic phenomena. However, the financial instability hypothesis is based on the financial behavior of economic units, which is characterized by the increasing proclivity to assume risks as economic stability holds. In order to capture these microeconomic elements, Minsky proposed the classification of economic units in three different risk categories—hedge, speculative, and Ponzi—according to the degree of financial risk to which their balance sheets are exposed.

Empirical works that rely on this microeconomic view of financial fragility are scarce. The few papers dedicated to this theme (Mulligan 2013; Nishi 2016; Davis, Souza, and Hernandez 2017) are restricted to analyzing different sectors simultaneously to identify the macroeconomic impact of financial fragility (and its determinants). The use of Minsky's theory to analyze firms engaged in the provision of public goods and services is a novelty.

In this work, we proposed to analyze the evolution of financial fragility in the electricity distribution sector in Brazil between 2007 and 2015. The application of a Minskyan methodology to data regarding electricity distribution companies in Brazil in this period showed that financial fragility increased during this time, especially between 2008 and 2013. These results are reinforced when regulatory issues are considered (RFFI and SRFFI), and they support the financial instability hypothesis: the macroeconomic stability of the Brazilian economy at that time led distribution companies to engage in more fragile financing practices. More recently, when macroeconomic performance worsened, the proportion of Ponzi or fragilized firms became significant and the sector was characterized by a generalized speculative behavior.

Our results reveal that the Minskyan framework is a powerful instrument for making a diagnosis of the evolution of financial fragility in a specific sector. This methodology has the capacity to classify a heterogeneous set of companies into different risk categories and monitor the evolution of fragility on a sectoral basis. Firms' financial risks were hierarchized and thus provide a useful picture for reorienting regulatory efforts. Therefore, we believe the use of this type of methodology could have helped ANEEL in monitoring distribution companies and signaling the problems like the Grupo Rede bankruptcy in 2012–13.

Financial fragility is not an indicator for predicting disruptive corporate situations, such as special administration, recovery, and bankruptcies. The role it plays is rather in the signaling of fundamental vulnerabilities in firms' balance sheets, therefore making it possible to prevent, in some manner, such events. Simultaneously, it is different from traditional accounting instruments for the assessment of financial soundness because of its simplicity and transparency.

Besides the classification of companies in risk categories and the monitoring of financial soundness on a sectoral basis, financial fragility indices can also be used to identify managerial, sectoral, and macroeconomic determinants that are responsible for the fragilization of economic units, both at the firm and sectoral levels. This line of research, first suggested by Nishi (2016), could be promising and should be developed in future works in this field.

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APPENDICIES

Appendix A. Definition of the Variables and Data Source from Nishi (2016)

(A) FFI-1 based on a cash flow accounting framework

Variable	Definition in sec. 3.1	Data item in the *Financial Statements Statistics of Corporations*
r	Profit rate	Operating profits (48) divided by capital stock
g	Capital accumulation rate	Investment divided by capital stock
i_D	Debt service per capital	Interest expense (68) divided by capital stock
d	Dividends payments per capital	Cash dividends divided by capital stock

(B) FFI-2 based on the margins of safety

Variable	Definition in sec. 3.1	Data item in the *Financial Statements Statistics of Corporations*
$\bar{Q}$	Quasi-rents	Operating profits (48)
σ_Q^2	Variance of quasi-rents	Variance of operating profits during 1975–2014 in each sector
CC	Contractual cash payment	Interest expense (68) plus cash dividends (60)
P_kK	Capital assets	Fixed assets (147) (205)
$K(CC)$	Debt service per capital	Liabilities (224) (230)
Eq	Equity	Net assets (157) (215)

Source: Nishi (2016, 36).

Note: In part (A), capital stock is defined as the average value of tangible fixed assets (148) (206) minus land (12) (169). Investment is defined as the sum of the increase in capital stock and depreciation expenses (221). In part (B), the values of capital stock, capital assets, debt, and equity are the average of the beginning and the end of the period.

Appendix B. Definition of the Variables and Data Source from Davis, Souza, and Hernandez (2017)

	Compustat #
Sources of funds	
Funds from operations	
Income before extraordinary items[1]	18+15
Depreciation and amortization	14
Extraordinary items and discontinued operations	48
Deferred taxes	126
Equity in net loss	106
Sale of property, plant, and equipment, and sale of investments (loss)[2]	213
Funds from investment activities	
Sale of property, plant, and equipment[2]	107
Sale of investments[2]	109
Other funds from current activities[2]	218
Cash commitments	
Interest and related expenses	15
Debt in current liabilities - total[3]	34
Notes payable	
Long-term debt due in one year	
Trade accounts payable[3]	70
Current liabilities - other[3]	72

Source: Davis, Souza, and Hernandez (2017, 6).
Notes: [1] Income before extraordinary items is reported net of interest expense; we therefore add interest payments back into this income category to measure sources of cash available to meet financial obligations. [2] Items with zero imputed for missing observations. [3] Items evaluated at the end of the previous year.