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Optimal corporate leverage and speculative cycles: an empirical estimation

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ABSTRACT

This paper develops an empirical model of corporate capital structure, optimal debt, and overleveraging, covering approximately two decades since 2000 across six leading industries: technology, financial, pharmaceutical, auto, airline, and energy. Estimated for each firm (total of 89), the model allows to infer an industry-specific default risk, measuring overleveraging as the difference between actual and optimal debt. The calculated corporate excess debt has largely been moving up, spiking around the global financial crisis and continuing into recovery more recently. The trend is consistent with an increase in the actual debt, with varying average excess debt ratios by sector. These results are informative for more applied ongoing and future outlook studies assessing a range of macroeconomic scenarios. The results also seem to conform to the general Kaleckian–Minskyan analytical framework, suggesting a possibility of endogenously rising speculative borrowing cycles.

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1. Introduction

Following the 2008 Global Financial Crisis (GFC), there has been a rise in academic and policy research on the problems of corporate debt sustainability. The COVID-19 pandemic has reignited the urgency of the topic. While more solid empirical assessments are yet to come, this paper asks a question if the trends in the U.S. corporate debt should raise a concern about a possible speculative borrowing cycle. The paper contributes to recent literature on corporate overleveraging, balance sheets, and the effects of macroeconomic instability shocks on asset prices. Those shocks can be destabilizing, feeding back into the real economy cycles rather than mean-reverting.

Over the past two decades, debt stocks and excessive capital borrowing (leveraging) have grown significantly for both financial and non-financial corporations globally, and specifically in the U.S. In the period after the GFC and before the COVID-19 pandemic, the increase in corporate debt may be partially attributed to the lower borrowing costs prompted by the post-2008 GFC accommodative monetary policy. Such an expansionary policy stance in itself may have led to an asset price inflation, thereby stimulating improvement in corporate financial rankings and, ultimately, leading to an even greater borrowing capacity by non-financial entities (e.g., Stein, 2010, 2012b; Brunnermeier and Sannikov, 2012; Gross et al., 2017). However, learning from the GFC also suggests a tangible risk of prolongation of a scenario of continuously increasing debt obligations, which heightens financial volatility even in expansionary period with a potential for a full-blown debt crisis. The latter sequence of events is well articulated in the contributions in the post-Keynesian literature as discussed later in this paper. The situation is further complicated with the multiple impacts from the pandemic-induced economic downturn and financial pressures that are yet to be fully absorbed.

Adapting a post-GFC theoretical model of firm capital structure advanced by Stein (2010), this paper illustrates empirically that firm's optimal debt is the debt capacity above which borrowing becomes risky. In this model, the optimal capital structure reflects the threshold beyond which firms' net worth declines. The estimation results surpass the traditional leverage calculation, i.e., debt-

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to-equity ratio, a norm thus far, by adding major elements such as risk and return.

Importantly, the model of corporate capital structure developed in this paper focuses on optimal debt analysis, exploring a possibility of excess leverage leading to instability through adverse shocks in asset prices in a sector-specific analysis. The discussion centers on the adverse effects of excessive leverage with subsequent vulnerabilities and credit contractions, i.e., excess debt in Stein (2010). He originally derived an optimal debt ratio for households and identified excess debt as the deviation of this ratio from an actual debt ratio. He built on it to identify an early warning signal of a debt crisis, which is again defined as "excess debt." This paper extends the original model to a corporate optimal and excess debt analysis at a sector-specific level.

At a macro level, this study also raises questions about speculative debt build-up reminiscent of Kalecki's (1937) principle of increasing risk (PIR) and the Minskyan financial instability hypothesis (FIH) and speculative cycles (Minsky, 1986). Working with data on Latin American countries, Gonzalez and Perez-Caldentey (2018) found that FIH held and intensified during expansions as larger numbers of firms were acquiring new debt in contrast to those already engaged in ongoing investment projects. These findings lead our paper to raise a question about macroeconomic stability given the most recent debt build up in the U.S. corporate sector and possible relevance for the speculative economic cycles. Related to the recent debt dynamic, Brunnermeier and Krishnamurthy (2020) offer an initial glimpse into the growing literature on the COVID-19 pandemic's impact on corporate debt and its significance for the broader economy.

This paper adds to the literature by constructing and examining a new dataset comprised of 89 corporations from six industries: technology, financial, pharmaceutical, auto, airline, and energy, with core annual data covering the period from 2000 to 2018. Estimates for the optimal debt ratios are based on data on capital gain/loss, market interest rates, and the productivity of capital. Using these variables, the risk and return components of the model are then calculated, allowing us to estimate the optimal and actual debt ratios. As the excess debt level rises, the probability of a debt crisis increases, which was the case of the 2008 crisis.

As such, the contributions of this paper are manifold, engaging both with applied industry leveraging analysis common across financial markets and literature on economic cycles as well as connecting with the contributions and ongoing debates in post-Keynesian economics. The rest of the paper is structured as follows. Section 2 starts with a brief reference to the works of Hyman Minsky and Michal Kalecki and presents a literature survey in relation to the paper's methodological approach. A theoretical model of optimal leveraging is developed in Section 3. Section 4 presents empirical estimation results with some initial interpretations. The discussion continues in Section 5, connecting with the works of Kalecki and Minsky and the broader picture. The paper also includes a theoretical and technical Appendix.

2. Literature Review

In his *Stabilizing an Unstable Economy*, Hyman Minsky (1986) outlines the macro framework of modern financial economy: the self-induced volatility of financial markets. This inherent financial instability, emanating primarily from speculative funding behavior and adaptations of new financial instruments (i.e., securitization of debt), compounded by what today is known as "asymmetric information" on risk and unregulated competitive behavior, leads to far-reaching conclusions as far as the functioning of today's economy. A critical element of the post-GFC analysis is the observation that lending booms often precede banking system instability as banks and non-financial corporations add more debt in good times with limited foresight into future destabilizing risks.

And while an expansionary period of a cycle may be interpreted as indicating stable economic growth, in Minsky, one reads that "stability is destabilizing." It is also important to remind that either endogenous or exogenous (e.g., policy-driven) lending booms may imply an increasing appetite for risk-taking in a financial market prone to turmoil if the economy is hit by an adverse shock as was, to some extent, the case of the GFC.

In his "Principle of Increasing Risk," Michał Kalecki (1937) discusses a capitalist firm's increasing tendency to add on new debt despite the rising cost of debt service (expressed by the sum of required returns and profit) at the expansionary side of the economic cycle. Thus, the system is characterized by the principle of increasing risk (PIR) as it is framed by the rising probability of emerging crisis due to overleveraging. Shared here in shorthand, these two conceptual reference points seem to be too important to omit from the analysis. But how relevant are either the PIR or FIH to the on–the-ground situation in the U.S. corporate sector? Could these analytical frameworks offer any guidance into the future outlook of corporate (industry-wide) and, more generally, the macroeconomic sustainability of debt?

Before we can answer the above questions, we summarize some of the foundational work on the topic. The literature on corporate debt dynamics is quite broad. Monnin et al. (2010) define instability as the probability of the banking sector becoming insolvent within the next quarter. They state that if at the end of the quarter the market value of the assets owned by all the banks of a certain country is not sufficient to repay its total debt, then the entire banking sector is considered insolvent. Moreover, the distance-to-default is defined as the distance between the banking sector and its default point (in this case, assets are equal to liabilities). The authors argue that there are strong links across banks. Therefore, through distance-to-default, banks may be vulnerable due to the country-specific time-varying covariance matrix. Thus, the entire banking sector of a specific country is considered insolvent (contagion effect). A range of studies have investigated issues related to the asset price channel through which the banking system's instability is triggered.

Brunnermeier and Sannikov (2012) focus specifically on the banking sector. The authors state that a shock to asset prices creates a vicious cycle through banks' balance sheets. Risk-taking and excessive borrowing occur when asset prices are volatile. The authors define a "volatility paradox" as the shock to asset prices that negatively affects banks' balance sheets and subsequently disrupts the real sector. Thus, when the prices of banks' assets decrease, lowering banks' equity value and net worth, the margin loan requirements increase. For financial intermediaries to remain liquid, haircuts and deleveraging would be required. Consequently, a fire sale of assets begins, decreasing the asset price further, and the net worth declines again, triggering an endogenous jump in volatility and a risk for all. A downward spiral is generated.

The main cause for banking sector instability, according to Mittnik and Semmler (2011, 2018) is the unconstrained growth of capital assets through excessive borrowing facilitated by the lack of financial regulations. Large payouts, with no "skin in the game," affect banks' risk-taking behaviors through further equity development and deeper leveraging. The higher the payout the more leveraged the bank becomes, which increases the aggregate risk and risk premia for all. In summary, the increased risk spreads and risk premia, as defaults begin, expose banks to vulnerabilities and financial stress triggered by securities price movements.

Stein (2010, 2012a) argues that the destabilizing mechanism in financial markets also results from a link between asset prices and borrowing patterns. He specifies that overleveraging begins when assets held by banks become overvalued. Above average returns, due to housing prices that increase the owners' equity, induce a greater demand by banks for mortgages and funds; thus, banks enjoy capital gains above the normal returns. At this point, banks start to become overleveraged as opposed to optimally leveraged. Stein's analysis is based on the assumption that the mean interest rate exceeds long-term capital gains, a constraint that he referred to as "no free lunch."

For overleveraging to occur, a violation of the "no free lunch" constraint is required as was the case during the GFC. The capital gain should be larger than the financing cost in order to provide banks with excess returns on capital and a high net worth. On the other hand, if capital gains decrease, then the credit spread increases, actual leveraging significantly deviates from optimal leveraging, a rapid deterioration of the balance sheets of banks occurs, and amplified downward effects are triggered. Stein suggested using the trends/drifts in capital gains and interest rates to better measure optimal debt. He also defines "excess debt" as the difference between the actual and optimal debt.

He and Krishnamurthy (2008) look at the role of financial intermediaries in determining asset prices. Through their dynamic general equilibrium framework, the authors find that the need for intermediation arises endogenously. They state that during crises and periods of asset swings, the capacity of risk bearing of the marginal investors, who are the financial intermediaries in their case, is reduced.

Schleer *et al.* (2014) expand beyond the focus on the U.S. banking sector's overleveraged exposure to the real estate market in the GFC to study the spillover effect of leveraging on the broader non-financial sector. The authors start from the theoretical literature assumptions that an overleveraged banking sector leads to constraints in credit supply and delayed recovery. They find that in the few years preceding the GFC, actual and optimal debt deviated from each other and the banking sector began to suffer from overleveraging.

Similarly, Mittnik and Semmler (2011) work in the DSGE tradition to determine the amplifying effect of the financial sector on real economic activity. Empirically, this is often shown in a one-regime VAR (e.g., Gilchrist *et al.*, 2009, 2010; Christensen and Dib, 2008; Del Negro *et al.*, 2010), but the authors employ a multi–regime vector autoregression (MRVAR) approach. They explore the consequences of instabilities arising from regime-dependent shocks by employing data on industrial production and the IMF Financial Stress Index for eight economies (U.S., Canada, Japan, the UK, Germany, France, Italy, and Spain). The authors find a nonlinear positive relationship between the real sector and the financial sector stress, but the individual risk drivers affect economic activity differently across stress regimes and across countries.

Gevorkyan and Semmler (2016) develop a theoretical model and empirically analyze the U.S. shale energy sector, consistent with Stein's optimal debt argument. The authors explore the boom trend in borrowing leading to overleveraging and risks of insolvency. Relying on nonlinear model predictive control (NMPC), the authors advance two mutually exclusive scenarios: oligopoly or extensive competition. The empirical analysis of actual and optimal debt based on a vector error correction model (VECM) suggests that firms with larger market capitalization in the industry are more resilient to oil price volatility than medium and small-sized firms. For the latter, a common trend, following the collapse of the oil price and drying out of revenues to sustain interest on debt, was to be merged with the large firms.

While multi-regime models give a unique approach to the effect of leveraging on the macroeconomy, some one-regime VAR models give significant results and explanations. For instance, Christensen and Dib (2008) use U.S. data post-1979 and estimate two DSGE models, one with and one without a financial accelerator, to analyze the effect of the latter on strengthening of the macroeconomic instability.

The authors' results suggest that a financial accelerator has a significant role in amplifying the effects of demand shocks on investment, reducing those of supply shocks while not affecting much the output fluctuations. Gilchrist *et al.* (2009) also estimate a DSGE model with a financial accelerator to study the link between agents' financial health and the amount of borrowing. They provide empirical evidence that financial frictions have played a crucial role in U.S. cyclical fluctuations.

Singh *et al.* (2005) discuss the impact of corporate debt on long-term investment and firm performance. The authors take a sample of large U.S. manufacturing firms and examine the effect of leverage on R&D expenditure, using corporate performance drivers as intermediate variables. The authors find a strong negative correlation between the degree of financial leverage and the level of R&D expenditure undertaken by the firms. In other words, higher leverage leads to lower R&D expenditure and eventually limits future growth opportunities. In the next section, we spell out our theoretical model.

Elsewhere, Nyambuu and Bernard (2015) employ the Stein (2006) model to calculate optimal debt for developing countries. In contrast to our paper, which calculates the optimal debt at the micro-level, the authors apply the model at a macro-level. In both cases, the optimal debt ratios may be used to define the distance-from-default indicator variable: in this paper it is corporate default and in Nyambuu and Bernard (2015) it is sovereign default. Both models solve the stochastic dynamic decision problem, which maximizes the expected present value of the utility of consumption in order to calculate optimal debt. While both papers calculate optimal debt, each methodology applies different metrics. For instance, our paper uses data on capital gain/loss, market interest rates, and the productivity of capital, whereas Nyambuu and Bernard (2015) use GDP ratio, current account, and actual historical ratios.

Nyambuu and Bernard (2015) show that rising ratios of external debt can make a country vulnerable to shocks and increases the risk of default. Similarly, this paper shows that an increase in excess debt of a certain corporation will increase its risk to default on its debt. In both models, a sudden drop in consumption will result in a drop in the optimal or sustainable debt level. In other words, both models are consistent with Stein (2006) who notes that a debt crisis can occur "if the attempt to service the debt requires a drastic decline in consumption."

3. Theoretical Model

A conventional view held that the 2008 GFC in the U.S. was caused by the excessive financial obligations of households, specifically real estate mortgages. Stein (2012b) starts his discussion about the boom (or even a bubble) in the mortgage market, which he defines as the unsustainable debt-to-income ratios. Stein stated that in contrast to the 2008 crisis, the financial crisis of 1980s related to the business sector, where the financial sector suffered due to the instability of the nation's savings and loan industry, which led to a dramatic rise in inflation and interest rates. So, while debt problems may have originated in either the public or private sectors across different nations, the result was still declining asset values. The mechanisms at work resulted in a contagion effect either from the U.S. to Europe and/or from one European nation to another depending on the debtor-to-creditor relationship. In each scenario, Stein made it clear that the primary source of the problem was not the presence of debt but excess debt within the country or group of countries under analysis.

Stein's early warning signal of a debt crisis is based on the excess debt of households as a difference between the actual debt-to-asset ratio and the optimal debt ratio. Consequently, as the excess debt ratio rises, the probability of a debt crisis increases. This pattern is consistent with the rising house prices since the late 1990s, which has led to above-average capital gains for households and, therefore, increased owner equity. As the supply of mortgages increased, financial obligations as a percentage share of disposable income increased for private households as well. At the same time, the quality of loans declined (i.e., proliferation of subprime mortgages). As the GFC has shown, the trend was not sustainable. As capital gains (initially driven mainly from the cycle of rising housing prices) dropped below the interest payments on debt, the debtors could no longer service their debts and foreclosures led to a collapse in the value of financial derivatives. Applied to individual firms, it may be said that this scenario is well captured in Kalecki's PIR framework.

In what follows, we introduce a model of optimal leverage that helps us define overleveraging. The model is a low-dimensional stochastic variant of a model of banking leveraging. Stochastic modeling forecasts the probability of various outcomes—here, net worth and risk—specifically under different debt conditions.

Based on Stein (2012a), our model is very similar to those of Issa (2020) and Brunnermeier and Sannikov (2014). Both of those models have leveraging and payouts as choice variables, and net worth as a state variable. The models are stochastic. Brunnermeier and Sannikov (2014) focused on the banking sector in a macro setting. There are households that save and financial experts that invest in capital assets owned by households and financial intermediaries. Both have different discount rates.

In our model, preferences in the objective function and Brownian motions are the state variables similar to both studies. The Stein (2012a) model, assuming certain restrictions, uses log utility and allows the exact computation of excess leveraging. Capital return is stochastic due to capital gains as well as the interest rate (both assumptions applied to the model in this paper). This is in contrast with Brunnermeier and Sannikov (2014) where only the capital return is stochastic and the interest rate is a constant. Both Brunnermeier and Sannikov (2014) and Stein (2012a) employ a continuous time version. Adding to the literature, this paper formulates the problem in discrete time variant with a discounted instantaneous payout and an optimal leveraging function.

Consequently, we develop a model with two stochastic variables. A hypothetical investor selects an optimal-debt ratio $f^*(t)$ to maximize the expectation of a concave function of net worth $X(t)$, where t is the terminal date. The model assumes that the optimal debt to net worth ratio significantly depends on the stochastic process concerning the capital gain variable. The expected growth of net worth is also maximal when the actual debt ratio is at the optimal level.

Optimal leverage is given by:

$$f^*(t) = \left[(r-i) + \beta - \alpha y(t) - \frac{\left(\frac{1}{2}\right)\left(o_p^2 - \sigma_i\sigma_p\rho\right)}{o^2} \right] \tag{1}$$

such that

$$Risk = \sigma^2 = \sigma_i + \sigma_p - \left(2\rho_{ip}\sigma_i\sigma_p\right), \tag{2}$$

where r is the bank's capital gain (or loss), i is the credit cost of banks, β is the productivity of capital, $y(t)$ is the deviation of capital gain from its trend, $\alpha y(t)$ is the variance of β (the productivity of capital), σ^2 is the variance, and ρ represents the negative correlation coefficient between interest rate and capital gain.

Stein's model is followed to measure the excess leveraging of corporations. The focus is on the solution of the dynamic version of the model, which allows for using time-series data on corporations. Deviating from Stein's original model, we introduce a novelty in that each firm's productivity of capital is not assumed to be deterministic or constant as in the Stein model. Instead, we calculate individual firm's productivity of capital for the years of 2000–2018 manually. This paper develops and relies on an original theoretical model of corporate capital structure that is not presented or discussed in the Stein papers. Appendix A offers a detailed derivation and explanation of the Stein (2006) model.

There are some limitations to the original layout. First, the Stein model does not look into the non-financial corporate sector. Second, Stein tracks only optimal leveraging, not the actual and excess leveraging as measured in our paper. We argue that such omission is likely to give rise to the actual vulnerability of the banking–corporate macro system. In Stein's model, the rise of actual leverage over and above the optimal leverage is caused by a shock sequence of high capital gains and a shock sequence of low interest rates, both giving rise to excess leveraging. Finally, the Stein model can neatly make the distinction between optimal debt, actual debt and, thus, excess debt. However, it does not specify the more specific mechanisms that build up excess debt. We attempt to address these limitations in our paper.

As such, this paper presents a methodology that can be used to estimate optimal debt ratios in the broader corporate sector, outside of banking. The excess debt is determined by the difference between the actual debt and the optimal debt. The optimal debt level was calculated for the period from 2000 until 2018. That then helped derive excess debt, which, as a reminder, is the measure of overleveraging in this paper. To calculate firms' optimal debt ratios, data on firms' capital gain/loss, market interest rates, and the productivity of capital were collected. Using these variables, we then derived the risk and return components of the model.

Our model computes an economic crisis probability measure or an early warning signal focusing on an excessive credit growth indicator, namely, excessive leverage.[1] Although our theoretical model abstracts from the effect of external shocks and other sectors' returns and debt levels on a certain firm's or sector's leveraging, these play a role—even if perhaps not a primary role—in determining actual leveraging. Therefore, a number of implications emerge from the above discussion that exploit the sources of systemic risk stemming from domestic macro financial disparities, i.e., commodity prices, the interconnectedness (financial, operational, and technological), and external shocks such as COVID-19 or wars.

For instance, increases and decreases in oil prices do affect the banking sector, especially in economies that are highly dependent on oil and gas exports. Moreover, macro financial linkages can amplify the effects of oil price movements over the financial cycle. More specifically, oil price swings, in addition to government spending policies, create feedback loops between asset prices and credit, which can increase the systemic risk in the overall financial sector of a certain economy. An IMF paper by Khandelwal *et al.* (2016) analyzes the effects of oil prices on the banking sector in the Gulf Cooperation Council (GCC). The authors argue that an increase in oil prices leads to higher oil revenues and stronger fiscal and external positions.

In turn, this positively affects equity market returns because investors expect the impact of higher oil prices to be positive on the corporate sector and eventually expect more government spending. Consequently, banks and corporations become more liquid and credit growth increases asset prices. Thus, this places firms' and banks' balance sheets in a much stronger position as asset prices appreciate. Another IMF paper by Eberhardt and Presbitero (2018) states that banking crises are potentially driven by commodity price changes. The authors employ a sample of 60 low-income countries for the years 1981–2015 and show that credit

[1] We are thankful to Reviewer 2 for motivating us to develop the discussion in the remainder of this section.

growth cannot be considered a main driving force of economic distress or financial crisis, as most literature states, because it is mediated through capital inflows, which are also fueled by a booming financial market.

Another externality that needs to be considered is the average leverage level in the market. Suppose, for example, that the firm chooses $f(t)$ to maximize its objective function that depends on $f(t)$ and that the average leverage level $\overline{f(t)}$ in the market, taking $\overline{f(t)}$ as given, is an externality. However, with a single representative firm, in equilibrium it must be the case that $f^*(t) = \overline{f(t)}$. However, this equilibrium would not be "optimal" in the Pareto sense. Depending on whether inter-industry risks are positively or negatively correlated, and depending on the effect of systemic risk on a specific industry risk, the deviations between actual and optimal leveraging, namely, excessive leveraging, may be more or less pronounced.

Future research would need to address the risk factors amplifying leverage and extend the understanding of systemic risks. This paper focuses on the solution of the dynamic version of the Stein (2006) model that allows us to use time-series data on corporations and takes leveraging and payouts as choice variables, and net worth as a state variable. In particular, this paper exploits Stein's insight that the optimal leverage decisions can be done independently over time if using the logarithmic utility function. Still, Stein's work can be extended to include major hazards such as: 1) sudden jumps in domestic stocks and domestic currency; 2) liquidity crunches; 3) news about oil or commodity prices; 4) sanctions and/or trade wars; and 5) interconnectedness at the operational and technological levels.

All these events lead to jumps in investment portfolios, which impacts the debt levels. The magnitude of jumps is random but greater than the portfolio fluctuations right before the jumps. Therefore, all the portfolio fluctuations should not be described with one volatility number. A separate jump component should be added to the equation for dynamics of the investment portfolio price. This must be done in addition to the volatility component, which is already in Stein's equation (e.g., see Semmler *et al.*, 2019).

With that, the model would present a fairly broad framework that lends itself easily to capturing the mechanism between optimal leverage and various commodity-, sector-, and regulation-related events. Highly nonlinear shapes of the mechanism can happen. The jump term may seem like a theoretical extension at first. However, it is hugely important where market changes often occur in sudden jumps rather than in a diffusive manner due to the cross-correlations and covariances between different sectors. Moreover, economic shocks are rarely predictable and they arrive with a suddenness that often outpaces the capacity of bureaucracies to respond in a timely manner (for more on uncertainty and fiscal sustainability, see Gevorkyan *et al.*, 2012).

This future extension to our model should focus on the capital structure of a firm. At time t, the firm has total net worth of $X(t)$. Additionally, the firm borrows $f(t) * X(t)$, where $f(t)$ is known at time t. Thus, $f(t)$ is the leverage ratio and equals debt over equity and $f(t) * X(t)$ are the liabilities, and $(1 + f(t)) * X(t)$ are the assets.

The firm has the following incoming and outgoing cashflows. First, the firm invests its assets into portfolio P. The price of the portfolio fluctuates randomly and equals $P(t)$ at time t. Second, the firm pays interest on liabilities, which is continuously compounded at a rate $i(t)$. The interest rate $i(t)$ is generally treated as a stochastic process. The interest rate is set at the beginning of the accrual period and the front end of the term structure is flat. In other words, at every moment of time t, interest rate $i(t)$ applies to interest paid over the interval $[t,\ t + dt]$ for small values of dt. Third, the firm spends a fraction of its net worth continuously at a rate C. The rate is fixed and deterministic.

The sum of the cashflows implies the following stochastic differential equation (SDE) for $X(t)$:

$$d[X(t)] = X(t) * \left[(1 + f(t)) * \frac{d[P(t)]}{P(t)} - f(t) * i(t) * dt - C * dt \right] \tag{3}$$

Let $Z(t) = (t,\ i(t),\ S(t),\ O(t),\ I(t), C(t))$ be the state process, where t is time, $S(t)$ is the level of S&P 500, $O(t)$ is the price of oil or commodity, $I(t)$ is an indicator of political stability in the region, and $C(t)$ is the cross-correlations and covariances between sectors. The value of $Z(t)$ is completely known at time t. Some of its components may be observed even earlier. In other words, $P(t)$ represents jump diffusion, where the amplitudes of jumps are random; therefore, $P(t)$ may jump due to revisions in the outlook for domestic markets, changes in interest rates, credit levels assumed on average by sectors, or by political events.

Finally, the corporate world ceases to be efficient and corporate default risk increases once the implications of jumps due to firm-specific and non-firm-specific variables are taken into account. Leverage levels do not self-correct; corporations experience market failures and can be a source of systemic risk that can affect an entire economy. As the government has not kept pace with advances in the financialization of corporations, it is ill-equipped to prevent a future crisis (see what happened in COVID-19). For brevity, we proceed with the core Stein model as laid out in Equations (1) and (2), leaving the extension opportunities for separate projects.

4. Estimation of the Optimal Debt

4.1. Dataset

Relying on the foundations laid out above, the optimal and actual debt ratios were calculated for a sample of 89 companies. The primary sources for corporate balance sheets data were Bloomberg terminals and FactSet. We undertake our estimations using the full sample which incorporates firm-specific variables on the leading companies from six largest industries (as per S&P500 ranking). Each industry sub-sample includes up to top twenty publicly traded companies (depending on data availability) based on their market capitalization and total assets compared to others in the respective industry. Table 1B of the Appendix B provides sectors, number of companies, and the ticker symbols of the companies used in the sample.

4.2. Estimation Methodology and Variables

Due to space constraints, Table 1 below provides only a sample table for one company (National Grid). The full dataset for each company is provided in the online Appendix to this paper.

The full calculations are presented in 89 tables with 18 columns each. Column 1 (omitting the columns with the years) in Table 2 reports capital gain (loss) that represents the return in percentage to the investors of the bank from capital appreciation or loss in a particular year. This capital gain (loss) is calculated by dividing the change in each bank's stock market capitalization by the beginning market capitalization at each period. The market capitalization series were Hodrick–Prescott (HP)-filtered to eliminate the effects of daily stock market swings. Column 2 represents the market interest rate. The 10-year treasury yield was used to represent the market interest rate and, therefore, is presented in percentage terms. Note, the variables in the first two columns form the uncertainty of the model. The two variables are stochastic in the model and can move in different directions.

In Column 3, beta (β) represents the productivity of capital and is calculated as the firm's annual gross revenue divided by the to-

Table 1
Example of Optimal, Actual, and Excess Debt Calculations for National Grid (NGG), in millions USD.

Year	Market Cap	Net Revenue, Adj	Average Annual SE	Ave Short Term Debt	Average Long Term Debt	Total Capital	Beta (#3)	10-year treasury Bills	Total Assets	Total Debts	Capital Gains	Actual Debt Ratio
2000	13,495.16	5,602.39	4,927.04	1,389.57	4,522.00	7,882.83	0.71	0.03	14,177.76	5,956.07		0.32
2001	9,262.11	6,304.70	4,486.88	1,300.82	9,969.99	10,122.29	0.62	0.02	24,735.31	12,037.50	(0.31)	0.40
2002	22,787.22	14,614.18	1,759.26	1,645.46	19,336.09	12,250.04	1.19	0.02	39,364.51	22,886.23	1.46	0.49
2003	22,213.97	15,130.54	2,229.31	1,600.77	21,212.46	13,635.93	1.11	0.02	43,000.18	24,347.84	(0.03)	0.49
2004	29,408.52	13,664.30	3,988.95	34.01	20,874.41	14,443.16	0.95	0.03	52,077.38	27,036.40	0.32	0.40
2005	26,475.47	15,765.62	6,039.70	5.20	17,843.32	14,963.97	1.05	0.02	44,966.47	22,772.91	(0.10)	0.40
2006	39,207.46	15,770.06	8,090.57	11.77	28,804.39	22,498.65	0.70	0.02	57,693.11	30,826.54	0.48	0.50
2007	42,324.34	22,997.93	10,645.05	1,136.85	34,027.99	28,227.47	0.81	0.03	75,069.86	41,743.46	0.08	0.45
2008	23,880.17	26,590.17	5,690.40	1,122.31	33,741.06	23,122.09	1.15	0.04	63,736.77	38,403.75	(0.44)	0.53
2009	26,982.35	22,350.73	6,369.46	227.53	33,854.18	23,410.32	0.95	0.03	66,065.55	38,110.60	0.13	0.51
2010	30,267.81	22,364.90	14,522.73	799.87	32,453.33	31,149.33	0.72	0.04	77,050.60	37,185.23	0.12	0.42
2011	34,576.84	22,201.74	14,761.61	52.73	32,806.60	31,191.27	0.71	0.05	78,812.21	36,788.20	0.14	0.42
2012	41,574.02	22,690.09	15,532.22	700.01	37,425.24	34,594.84	0.66	0.04	86,364.88	42,660.86	0.20	0.43
2013	48,684.73	23,643.75	19,857.42	445.13	37,409.18	38,784.57	0.61	0.04	90,319.52	43,262.54	0.17	0.41
2014	53,794.24	24,473.67	17,757.59	2,007.04	33,968.33	35,745.28	0.68	0.04	85,648.23	38,463.39	0.11	0.40
2015	51,730.50	19,899.12	19,482.60	5,113.91	35,548.74	39,813.93	0.50	0.04	88,572.17	40,738.83	(0.04)	0.40
2016	44,158.14	19,586.21	25,469.17	6,789.94	28,937.91	43,333.10	0.45	0.05	87,448.97	35,810.39	(0.15)	0.33
2017	39,963.32	20,208.63	26,417.53	3,124.04	31,111.30	43,535.20	0.46	0.05	82,466.41	37,349.55	(0.10)	0.38
2018	33,078.50	19,597.57	25,212.71	3,171.62	31,609.39	42,603.22	0.46	0.07	82,043.94	37,436.63	(0.17)	0.39

Source: authors' calculations based on data from Bloomberg and FactSet
Note: sample company table with optimal debt calculations. Section 4 offers additional details.

Table 2
Example of Optimal, Actual, and Excess Debt Calculations for National Grid (NGG) continued, in millions USD

Year	Capital gains/ (losses), (r)	Interest Rate (i)	Beta (Productivity of Capital, β)	Beta variance (αy(t))	Half Square of capital gain variance	Correlation of interest & capital gain variables	Interest rate variance	Capital gain variance	Correlation and variances of interest and capital gain	Std. deviation of interest rate	Std. deviation of capital gain	2 x (correlation and variances of interest and capital gain)	Risk	Optimal debt ratio, $f^*(t)$	Normalized Optimal Debt ratio	Actual Debt ratio	Normalized Actual Debt	Excess Debt
2001	-0.31367142	0.0243	0.6228528	-0.1438935	0.04919488	-0.3550634	-0.0118	-0.4187023	-0.0017543	0.01343643	0.40365548	-0.0035085	0.42060043	0.898301	-1.5404871	0.40306723	-0.51561	1.02487713
2002	1.460261232	0.0209	1.19299073	0.42624439	1.06618143	-0.3550634	-0.0152	1.35523037	0.00731413	0.01343643	0.40365548	0.01462826	0.40246365	2.8505438	1.73881853	0.49120617	1.11788418	-0.6209343
2003	-0.02515664	0.0188	1.10960859	0.34286225	0.00031643	-0.3550634	-0.0173	-0.1301875	-0.0007997	0.01343643	0.40365548	-0.0015994	0.41869129	1.72364125	-0.1541109	0.49331096	1.15689268	1.31100362
2004	0.323875021	0.0286	0.94607429	0.17932795	0.05244751	-0.3550634	-0.0075	0.21884416	0.00058278	0.01343643	0.40365548	0.00116555	0.41592636	2.42869105	1.03020579	0.40083449	-0.5569899	-1.5871957
2005	-0.0997347	0.0191	1.05357236	0.28682602	0.00497351	-0.3550634	-0.017	-0.2047656	-0.001236	0.01343643	0.40365548	-0.002472	0.41956387	1.52945044	-0.4803055	0.39681389	-0.6315043	-0.1511988
2006	0.480897601	0.0197	0.70093367	-0.0658127	0.11563125	-0.3550634	-0.0164	0.37586674	0.00218869	0.01343643	0.40365548	0.00437737	0.41271454	2.70041706	1.48664115	0.49926915	1.26731689	-0.2193243
2007	0.079497116	0.0339	0.81473579	0.04798945	0.0031599	-0.3550634	-0.0022	-0.0255337	-1.995E-05	0.01343643	0.40365548	-3.989E-05	0.4171318	1.9398272	0.20903027	0.45328431	0.4150719	0.20604163
2008	-0.43578163	0.0373	1.14999013	0.38324379	0.09495282	-0.3550634	0.0012	-0.5408125	0.00023043	0.01343643	0.40365548	0.00046085	0.41663106	0.47750237	-2.2473292	0.52938139	1.82539232	4.07272151
2009	0.12990611	0.0252	0.95473832	0.18799198	0.0084378	-0.3550634	-0.0109	0.02487525	9.6272E-05	0.01343643	0.40365548	0.00019254	0.41689937	2.07030999	0.42821046	0.51243318	1.51128819	1.08307773
2010	0.121763301	0.0374	0.71798974	-0.0487566	0.00741315	-0.3550634	0.0013	0.01673244	-7.723E-06	0.01343643	0.40365548	-1.545E-05	0.41710736	2.0227137	0.34825996	0.42119503	-0.1796444	-0.5279043
2011	0.142363455	0.0476	0.71179333	-0.054953	0.01013368	-0.3550634	0.0115	0.0373326	-0.0001524	0.01343643	0.40365548	-0.0003049	0.41739679	2.03936328	0.37622732	0.41626291	-0.2710522	-0.6472795
2012	0.202366092	0.0442	0.65588071	-0.1108656	0.02047602	-0.3550634	0.0081	0.09733524	-0.0002799	0.01343643	0.40365548	-0.0005599	0.41765179	2.1648572	0.58702739	0.43333864	0.04541532	-0.5416121
2013	0.171037345	0.0422	0.60961736	-0.157129	0.01462689	-0.3550634	0.0061	0.06600649	-0.000143	0.01343643	0.40365548	-0.0002859	0.41737784	2.11035124	0.49547029	0.4141871	-0.3095236	-0.8049939
2014	0.104950977	0.0415	0.68466863	-0.0820777	0.00550735	-0.3550634	0.0054	-7.988E-05	1.5316E-07	0.01343643	0.40365548	3.0631E-07	0.4170916	1.97723979	0.27187456	0.39660283	-0.635416	-0.9072906
2015	-0.03836359	0.0405	0.499803	-0.2669433	0.00073588	-0.3550634	0.0044	-0.1433944	0.00022402	0.01343643	0.40365548	0.00044804	0.41664387	1.64978042	-0.2781796	0.40135338	-0.5473731	-0.2691935
2016	-0.14638096	0.0504	0.45199193	-0.3147544	0.01071369	-0.3550634	0.0143	-0.2514118	0.00127652	0.01343643	0.40365548	0.00255304	0.41453887	1.35217286	-0.7780899	0.33091196	-1.8528763	-1.0747864
2017	-0.0949954	0.0516	0.46419061	-0.3025557	0.00451206	-0.3550634	0.0155	-0.2000263	0.00110084	0.01343643	0.40365548	0.00220168	0.41489023	1.48651301	-0.5524302	0.37726027	-0.993895	-0.4414648
2018	-0.17227848	0.0666	0.46000212	-0.3067442	0.01483994	-0.3550634	0.0305	-0.2773093	0.0030031	0.01343643	0.40365548	0.00600621	0.4110857	1.25528818	-0.9408332	0.38527392	-0.8453767	0.0954565

Source: authors' calculations based on data from Bloomberg and FactSet.
Note: sample company table with optimal debt calculations. Section 4 offers additional details.

tal capital. The total capital here is calculated as shareholder equity plus half of both short-term and total long-term debt.[2] To determine shareholder equity, we obtained the annual value of each bank's shareholder equity from the balance sheet. Short-term debt comprises all of the firm's current liabilities that are usually due within 12 months. Long-term debts, on the other hand, are calculated as the combinations of long-term liabilities and other liabilities in firms' balance sheets. These are basically all bank liabilities due in more than one year's time. Therefore, each firm's productivity of capital is calculated for the years 2000–2018 (recall that this factor is taken as a constant in Stein, 2012a).

Columns 4–9 are the risk elements in the model. Column 4 represents the beta variance calculated as the difference between each year's beta from the mean beta for the years 2000 and 2016, representing the deviation of each period's beta from the mean. Column 5 presents a component of the risk element calculated as one-half of the square of the capital gain variable. Column 6 is the statistical correlation between interest rate and capital gain variables over the period 2000–2018 (the correlation is constant in the calculation). Columns 7 and 8 are the variance for the interest rate and capital gain variables, respectively. Each period's variance is calculated as the deviation of that period's value from the mean. Therefore, interest rate variance is the difference between each year's 10-year treasury yield and the mean interest rate from 2000 to 2018. Similarly, capital gain variance is the difference between each year's capital gain/loss and the mean capital gain from 2000 to 2018.

As an additional component of the risk element, the variable in column 9 is calculated as the product of the correlation factor of the stochastic variables (column 6), interest rate variance (column 7), and capital gain variance (column 8). Note that the optimal debt ratio is positive only if the net return is greater than the risk premium. Columns 10–12 are used to determine the risk investors bear when they decide to hold equity in the firm. This is a key issue for investors' decision making. Columns 10 and 11 represent the standard deviations of the interest rate and capital gains, respectively. Therefore, column 10 is the standard deviation of values in column 2 while column 11 is the standard deviation of values in column 1. Here, standard deviations are constant over the periods, as in the Stein model. Column 12, on the other hand, is calculated as twice the value of the correlation and variances of interest and capital gain . This is, therefore, calculated as 2 multiplied by column 9. Column 13 is the risk of an investor holding the equity of the firm at each time period as in Equation (2). The risk is calculated by adding the standard deviations of the interest rate (column 10) plus the standard deviation of capital gain (column 11), minus the risk component in column 12.

In our model, the optimal debt ratio maximizes the difference between net return and risk term. Therefore, only if the net return exceeds the risk premium does the optimal debt ratio become positive. The optimal debt ratio, therefore, is not a constant, as Stein noted (2012a), but rather varies directly with net return and risk. Designing an effective policy to make optimal debt a fixed ratio based on the net worth of a financial corporation, is a regulatory challenge. High risk implies high return; therefore, decreasing the bank's risk by providing secured lending to corporations will be a challenging task.

In Column 14, we then calculated, using all the above-mentioned variables, Stein's optimal debt ratio $f^*(t)$. Debt ratios were normalized to remove the effects of seasonality. Therefore, normalized $f^*(t)$ measures the deviation of the optimal debt ratio away from the mean. Negative values in Column 14 represent lower optimal debt ratios away from the mean ratio during the applicable periods. The components of the optimal debt ratio are, therefore, primarily the capital gains for equity holders of the firm's stock, the market interest rate, and the risk term. The optimal debt ratio maximizes the difference between mean return and risk term.

The values in the first column are then added to the values in the third and ninth columns; the values in the second, fourth, and fifth columns are subtracted out of the total. Finally, the total is divided by the thirteenth column. In other words, the risk is subtracted out of net worth, which reiterates what has been mentioned above that optimal debt ratio is positive only if the net return is greater than the risk premium and this can intuitively be seen.

In column 15, we calculated normalized optimal debt ratios using column 14 and the mean and standard deviation of the optimal debt values (normalized such that each variable has a mean of zero). In addition to calculating the optimal debt ratio, we calculated the firm's actual debt ratio to calculate the excess debt ratio. The actual debt ratio of the firms was equal to long-term debt divided by total assets, which are given in firms' annual reports as well.

Actual debt ratios are also normalized in the same way as optimal debt ratios (see column 16). After optimal and actual debt ratios are calculated, excess debt is calculated in the last columns as the normalized actual minus the optimal debt. The graphs of the two ratios, namely, actual and optimal debt ratios, are presented for the six industries in Figures 1a–1f in the next section that also offers a summary of our empirical analysis.

5. Empirical Results

Following the methodology from Section 3, we estimate the optimal leverage for our industry sample. The breakdown by sector is included in Table 1B in the Appendix A as discussed above. The analysis was performed using the total long-term debts and total assets. As noted, total long-term debt represents the company's total debt with a maturity date more than one year from the balance sheet date.

The vertical axes of Figures 1a–1f represent the aggregate debt ratios for each industry while the horizontal axes represent the years. Figure 1a shows the optimal debt against the actual debt ratios for the airline industry. Figure 1b shows the optimal debt against the actual debt ratios for the auto industry followed by energy, financial, pharmaceutical, and technology, respectively, in the remaining figures. The debt ratios for each industry are weighted averages of the companies in our sample in each industry.

The optimal and actual debt ratios for most of the firms exhibited similar trends. For several years preceding the 2007–2009 financial crisis, corporations had high optimal debt ratios. For most of the firms, about one or two years prior to 2007 the optimal debt ratios began to drop and the decline was severe in all cases. The trend of actual debt exceeding the optimal debt reversed post-GFC for most industries in the sample.

We also calculate each company's actual debt ratio. Prior to the GFC, the data points to a rising actual debt ratio in the years prior to the GFC. Notably, after 2009, the actual debt levels across the airline, auto, and energy industries remained stable while the trend in the financial, pharmaceutical, and technology industries continued to rise, pushing up leveraging.

For the airline industry, the actual debt level decreased after 2008 and remained at a low level since then even though the optimal level revealed a higher possibility of borrowing. For the auto industry, the actual debt level remained stable after 2009 but with actual debt always increasing beyond optimal debt. This suggests

[2] The reason that total capital is calculated this way is because capital investments in a company comprise equity capital and debt financing; hence, a company has two types of stakeholders: equity and debt holders.

Figure 1. Actual vs. optimal debt by industry estimation results.

that the industry overall had excess debt, which increases the instability risk.

The energy industry exhibited a slightly different behavior. The companies were not excessively leveraged as the graphs show. The optimal debt level was much higher than the actual debt level until 2008. Afterwards, there were some ups and downs with a low debt level between 2012 and 2014.

The financial industry exhibited a continuously increasing level of actual debt, but the levels were still close to the optimal debt level as opposed to the decade before the GFC. The companies in the financial industry decreased excessive risk between 2010 and 2013 to engage in risky borrowing again afterwards. The optimal debt ratio was high during the years prior to the GFC and then decreased around 2006.

For example, Bank of America had a high optimal debt ratio prior to the crisis. However, the ratio began to drop and dropped more dramatically in the years immediately preceding the financial crisis. Between 2002 and early 2005, there were high optimal debt ratios, but a decrease began in mid-2005. The decrease in Bank of America's actual debt around 2002 can be explained by several bank-specific actions.

First, in 2002, recovering from the "dotcom" bubble, the bank's revenue increased by 68% and market stock price increased by 37%. During this year, Bank of America purchased a 24.9% stake in Grupo Financiero Santander Serfin (GFSS), a subsidiary of Santander Central Hispano in Mexico, for $1.6 billion. In 2008, there was a strong decline in the optimal debt of the bank. This is strongly correlated with the bank's acquisitions of both Merrill Lynch and Countrywide Financial in 2008. The bank's financial statements clearly show a strong effect of these acquisitions, which continued over the following several years. This was expected because the acquired firms held significant amounts of risky mortgages and mortgage-backed securities that significantly increased the bank's debt.

On the other hand, Wells Fargo improved significantly after the GFS according to the bank's optimal and actual debt ratios. Further, the optimal debt ratio decreased. More importantly, the actual debt ratio remained very low and debt was well-managed compared to previous years as with other banks. Bank of America's asset prices began to rise at the end of 2010, thus improving the bank's actual debt ratio. Wells Fargo's actual debt ratio declined, which could be related to the constant swings in asset prices.

Based on the obtained results, it may be argued that the financial industry is the second most vulnerable industry. The financial industry in general is seen as the driving force behind the GFC actual debt spike in 2008, but some had a smooth behavior afterwards. What we can see from individual banks is that the larger the bank the higher the excess debt.

Our analysis also suggests that the pharmaceutical industry is the most vulnerable in our industry sample. In contrast to the financial industry, the pharmaceutical industry had low debt levels up until 2006. However, the leveraging has been steadily increasing with higher levels since 2014. Large firms such as Merck and Pfizer were vulnerable in 2008 due to their financial structure, and still seem to have excess debt levels.

The technology industry shows the highest level of actual debt in 2018 and is continuously increasing its excess leverage. However, this does not mean that the industry is vulnerable though some companies are. The actual debt levels are close to the optimal levels except for the period 2013–2015. Technology firms, with the exception of a few firms, seem to be more stable and less leveraged. Also, the largest technology firms are hoarding cash (e.g., Faulkender *et al.*, 2019).

Firms like Dell, HP, and IBM are more vulnerable than firms like Apple, Amazon, Facebook, and Twitter. The former group's leverage has been increasing exponentially and this could be due to the fact that they needed capital to change their business model and innovate in order to include more services and less products. Facebook and Twitter are the least leveraged, but Apple started to increase leverage in 2012.

6. A bigger picture? Connecting with the work of Kalecki and Minsky: a brief comment

The results from the above estimations suggest that estimated corporate excess debt has largely been moving up, spiking around the GFC and then declining only to resume the rise later (Figure 2). This trend is consistent with an increase in actual debt across industries though the average excess debt ratios vary by sector. Leveraging was much higher in some real sectors prior to the GFC relative to the financial sector, e.g., airline and auto industries. Post crisis, and especially since 2010, leverage jumps are observed in the technology and pharmaceutical sectors.

At the same time, individual company idiosyncrasies aside, all industries seem to be following a common trend, which, in turn, appears to be led by the energy industry, especially in the post-GFC period. Figure 2 also reports that overleveraging has continued long after the 2008 peak of the GFC. The financial sector in our sample consists mostly of advanced economies' large banks. The GFC and subsequent proactive central bank interventions, along with restrained banking sector activity and broader technological change, weakened the financial sector, transferring the default risk to the non-banking sector.

That may partially explain declining leverage immediately after the GFC, as banks reduced risk-taking following the crisis. The situation reversed in 2012 after market concerns about low profitability deprived banks of an important source of fresh capital, which encouraged renewed risk-taking and leveraging by banks. Bank lending to non-bank financial institutions rose after the crisis, which again increased the vulnerability of the sector. It would be interesting to investigate large banks in emerging markets where, in contrast to advanced economies, bank lending expanded strongly post-GFC and onwards, raising sustainability concerns, especially that the risk-taking is not supported by sufficient capital and liquidity buffers.

It is also important to keep in mind the dynamics of large firms within each industry. This point is also raised in the analysis of macroeconomic effects of debt by Brunnermeier and Krishnamurthy (2020), and in a recent report from Vandevelde (2020). Much would depend on the firm's significance as far as market power and share of financial obligation in relation to the competitors in the sector. Due to the changing nature of the relevant factors (e.g., market capitalization), we leave such estimation out of the purview of this paper but call attention to the large-firm effect's significance as the COVID-19 pandemic forced economic downturn takes an unpredictable turn.

Leverage varies across industries due to several reasons. First, the fact that some are more capital-intensive than others may be playing a role. For instance, the financial sector, by nature of the business and not necessarily by volatility indicators, has one of the highest excess debt ratios. The energy sector is also capital-intensive by nature, requiring substantial financial resources for production.

Second, the nature of the actual work may define the level of debt that a certain industry can manage. For example, the technology sector has high productivity of capital, which provides space for more leveraging. The assumption here, following from Equation (1) in the theoretical part of this paper, is that the productivity of capital is positively correlated with the amount of debt used. High profitability creates stability regardless of the economic conditions, which allows for higher risk.

More broadly, Figure 3 adds to our discussion with recent observations on the actual debt evolutions in the U.S. non-financial corporate sector. There are signs that overleveraging across industries is likely on the rise again (e.g., Vandevelde, 2020). At first, it might be tempting to view the evidence in this paper as industry-specific with relevance to the isolated debt risk assessments. In fact, the identification of specific risk factors in each industry is informative for more concrete regional policy decisions and macroeconomic pressures. For example, the airline industry may have been affected by a sudden drop in business and leisure travel. The financial sector is caught in the unpredictability of risk valuations and future cash flows. Similar rationalizations may be advanced for other industries.

However, as has been mentioned, the COVID-19 pandemic delivered a structurally different impact, layering upon subdued en-

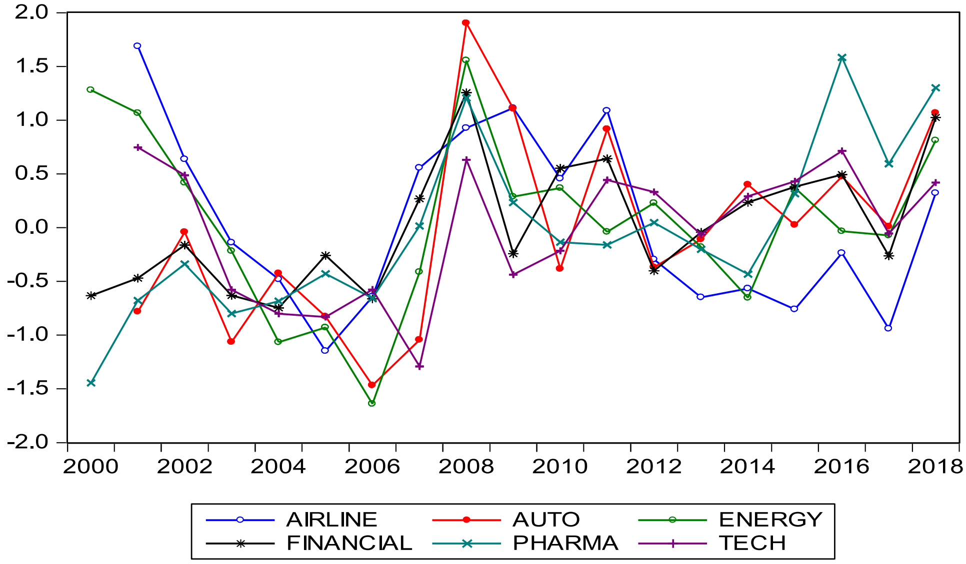

Figure 2. Selected industries' average excess debt
Source: authors' calculation.

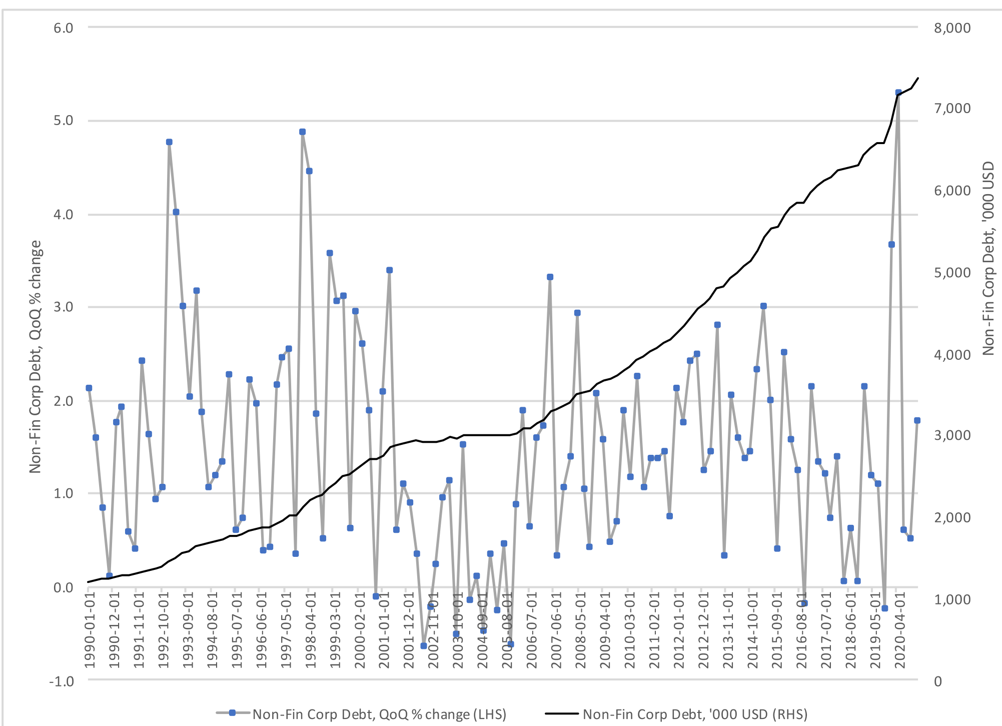

Figure 3. Actual debt evolution in the U.S. non-financial sector
Source: FRED (2021).

dogenous fragilities. The challenge is in the wide-scale uncertainty of the global pandemic and the subsequent economic volatility. Here, Figure 3 seems to be revealing a broader trend, which is somewhat consistent with our reading of the Kaleckian–Minskyan framework of macroeconomic cycles. There are two immediate points that help analytically sum up the results of this paper in the context of a rapidly changing environment.

First, it is important to differentiate between the nature of the external COVID-19 shock and the 2008 crisis. The former is a purely exogenous shock while the latter is a result of a vulnerable state of the financial system. COVID-19 provides a shock that is not connected to business or financial cycles and, as such, behavior can be analyzed empirically with less concern for the usual endogeneity issues. Second, despite the principal difference in the nature of the crisis, the new spike in indebtedness is building upon the fragilities of the past decade's growth trend in corporate over-leveraging. Importantly, the latter trends have been uniform across all industries and business types (i.e., financial and non-financial corporations).

These two factors can then be reviewed in the Kaleckian–Minskyan cycles. As mentioned earlier, González and Pérez-Caldentey (2018) offer a substantive analysis of Minsky's FIH in the Latin American context, finding evidence supporting the hypothesis. The authors also engage substantively with the post-Keynesian literature that argues that debt levels may be counter-cyclical (e.g., Lavoie and Seccareccia, 2001). Hence, we omit this part of the discussion and defer the reader to the informative contribution of González and Pérez-Caldentey (2018).

An interpretation of Kalecki's (1937) principle of increasing risk suggests that the larger a new investment project funded by a firm the greater the risk of lower returns in case of inability to generate sufficient required revenues. The volume of the latter is "required" to cover the costs of borrowing and add to the profit pool with plans for future scale-expanding investment. One might argue that the accommodative monetary policy since the GFC and sustained through the COVID-19 pandemic has ensured the longest period of low interest rates, effectively nullifying the interest rate risk. Yet, at the same time, and this is evident from Kalecki's argument, such environment only emboldens a greater increase in firms' liabilities; such a rising trend is clear from our excess leverage analysis above. The observations from our estimation then offer additional support to the endogeneity of the speculative cyclical trends in the modern financialized economy.

Still, a counter-argument would be to sustain increased leverage as long as the interest service costs are low and liquidity is available. So, firms continue raising new external funds (on top of self-funding) to invest in expanding productive activities. Kalecki's main intuition is the firm's capitalist motive, i.e., growth and maximization of profits, hence, the assumed efficient use of new funds. In other words, one might assume productive, business growth-oriented use of both own and borrowed funds. As the firm grows and contributes to its capital, the need for additional leveraging declines, and with that the PIR fades. Firms with larger capital are likely to be commanding a larger market share and grow in their ability to attract additional funds. The system remains dynamic until there is either a breakdown in the capital flows (endogenous as in the GFC or exogenous in the case of the pandemic) or the firm's loses competitiveness and the ability to generate the required return. Depending on the severity of the crisis, the cycle repeats, with wide-spread social impacts on the macroeconomy and labor markets.[3]

Minsky, in turn, advances a financial instability hypothesis, arguing famously that "stability is destabilizing" and stating instability to be a fundamental feature of a contemporary economy (Minsky, 1986). Without delving too much into details already well summarized elsewhere (e.g., Bernard *et al.*, 2013), the Minskyan cycle comprises three phases. The first is "hedging," when borrowers can meet their interest and principal debt liabilities out of revenues. Second is "speculative" financing, when the firm's revenues are just sufficient to cover the interest payments but not the principal, requiring refinancing and adding on new debt. The third form of financing in this system is the "Ponzi," which indicates that the borrowing firm's internal revenue flows are lacking to sustain interest payments, locking the firm into a continuous debt cycle. As with the Kaleckian system, this continues until the firm is no longer able to raise sufficient funds externally (it is, in fact, irrelevant whether that is done via the banking system or other proxy markets at this stage), all ending with a bust cycle. This is the essence of the FIH, which intensifies during the expansionary period of the economic cycle as risk perceptions fade and memories (and lessons) of previous crises dissipate (Minsky, 1992).

Both PIR and FIH then suggest an endogenous cycle of repeating instability. The only sensible benign remedy to such outcome is to curtail firms' leveraging appetites. However, there is an explicit detrimental impact on competitiveness if firms are considerably limited by regulation in their borrowing and risk-taking capacity. Still, lacking sensible balance between regulative and competitive factors, there remains a scenario of severe economic crisis, in response to preceding speculative (i.e., debt-driven) expansion (e.g., Bernard *et al.*, 2014; Gevorkyan, 2015).

It is the position of this paper, based on the evidence on excess debt uncovered in the empirical exercises discussed above, that the endogeneity of the speculative embedded uncertainties of the principle of increasing risk and financial instability hypothesis are found in contemporary leveraging trends. We raise these concerns in connection with the discussion in Section 3 on the effects of systemic risk on corporate (industry-wide) debt sustainability at first and, second, in connection with broader macroeconomic resilience in a financialized economy.

As such, the problems of macroeconomic stability and corporate debt management should be high on policymakers' radars, and PIR and FIH add to researchers' analytical policy kits. This proposition is in contrast to a range of market clearing models that internalize individual bankruptcies as efficiency gaining episodes (e.g., for a good summary of popular analytical models on corporate debt, see Brunnermeier and Krishnamurthy, 2020).

As seen above, the excess leverage taken by the corporate sector poses serious threats. The unprecedented policy response to the COVID-19 pandemic has helped prevent a meltdown and maintain the flow of credit to the economy. However, the outlook remains highly uncertain and vulnerabilities are rising, representing a potential early warning signal.

While both the financial and real sectors increased their debt in the years preceding the GFC, the financial sector seems to have deleveraged after the GFC. Increased regulation has forced financial institutions to hold more capital and reduce their risk exposures, contributing to lower leverage, but this is not the case with the real sector. Policymakers and investors must remain aware about the risks that rising interest rates and increased market volatility pose to the overall macroeconomic stability, and their potential to trigger another large scale meltdown.

7. Conclusion

The optimal debt ratio estimation presented in this paper is an important measure that can help corporations detect a sustainable debt level above which it becomes risky to leverage. This is a key financial metric in that it allows firms to avoid the risk of insolvency when they take this metric seriously.

This paper relied on estimated excess debt—the difference between actual and optimal debt—as the measure of overleveraging. The estimated excess debt of each company was averaged at the industry level. While the excess debt ratios for most of the firms exhibited similar trends, the trends for some industries were more pronounced than for others. In most cases, when the optimal debt moves down, excess leverage increases for a given level of actual leverage. Our results indicate that seeing rising excess debt pressures, operational medium-term stability instead of short-term high profit should be the driving force for the corporations. Firms can take corrective measures by keeping cash flowing and increasing capital requirements, and banks can limit lending to high-risk borrowers. Here, too, firms' vulnerability and exposure to insolvency risk can become an important threat to macroeconomic stability.

The results of the paper lead to some policy implications helpful to improving the performance of the modern financialized industries. A possible approach may be setting a stricter requirement on the borrower's collateral that keeps the balance between the default risk and intended use of the funds. A nuanced collateral clause can be a powerful tool of stability despite the repossession costs for the borrowers significantly exposed to financial shocks. Our model's empirical application suggests an opportunity to re-

[3] For a much more in-depth description of Kalecki's first-hand analysis of capitalist cycles, see his work in Kalecki (1954, 1970) and Mott (2009).

duce overall risky debt by developing an optimal debt structure that helps minimize financial instability and default within possible combinations of policy framework.

Overall, our results confirm the observations of the classical writers Michal Kalecki and Hyman Minsky about the endogeneity of the speculative cyclical transformations of the modern financialized economy. There are certainly regulatory and technical challenges in designing an effective policy of optimal debt estimated as a fixed ratio on the basis of net worth. In many ways, however, our empirical estimations have led us to and confirmed the concerns and earlier policy variations advanced by Kalecki and Minsky. There is a clear benefit in reading the classics.

Given our results for the optimal and excess debt component built into the Stein model, we could also spell out some further policy implications with a further look at firm-specific behavior or regional debt accumulation.

Appendix A

Mathematical Derivation of Stein's Optimal Debt Model

Here, Stein (2012) shows how the optimal debt ratio is derived in the logarithm case. The stochastic differential equation is (1):

$$dX(t) = X(t)\left[(1+f(t))\left(\frac{dP(t)}{P(t)} + \beta(t)dt\right) - i(t)f(t) - cdt\right] \tag{1}$$

where the Debt Ratio is $f(t) = \frac{L(t)}{X(t)} = \frac{Debt}{Net\ Worth}$; Capital Gain or Loss is $\frac{dP(t)}{P(t)}$; Productivity of Capital is $\beta(t) = \frac{Income}{Assets}$; Interest Rate is $i(t)$; $(1+f(t)) = \frac{Assets}{Net\ Worth}$; Ratio of Consumption is: $c = \frac{(Consumption\ or\ Dividends)}{Net\ Worth}$ and is taken as given.

Let the price evolve as:

$$dP(t) = P(t)(\alpha(t)dt + o_p dw_p(t)) \tag{2b}$$

where $\alpha(t)$ represents the asset's drift component and the interest rate is represented by the sum of i and a Brownian Motion term as follows:

$$i(t) = idt + o_i dw_i(t) \tag{1}$$

Substitute (2) and (3) in (1) and derive (4):

$$dX(t) = X(t)[(1+f(t))((\alpha(t)dt + o_p dw_p(t)) + \beta(t)dt) - i(t)f(t)dt - cdt]$$

$$dX(t) = X(t)(\mathrm{M}f(t))dt + X(t)\beta f(t) \tag{2}$$

$$\mathrm{M}f(t) = [(1+f(t))((\alpha(t)dt) + \beta(t)dt) - i(t)f(t)dt - cdt]$$

$$\beta(t) = [(1+f(t))o_p dw_p - o_i f(t)dw_i(t)]$$

$$\beta^2 f(t) = \left[\left(1+f(t)^2\right)o^2{}_p\, dt + f(t)^2 o^2{}_i\, dt - 2f(t)(1+f(t))o_i o_p dw_p dw_i\right]$$

$$\text{Risk} = \mathrm{R}f(t) = \left(\frac{1}{2}\right)\left[\left(1+f(t)^2\right)o^2{}_p\, dt + f(t)^2 o^2{}_i\, dt - 2f(t)(1+f(t))o_i o_p\right]$$

$\mathrm{M}f(t)$ contains the deterministic terms and $\beta(t)$ contains the stochastic terms. To solve for $X(t)$, consider the change in $\ln X(t)$ in (5). This is based on the Ito equation of the stochastic calculus. A great virtue of using the logarithm criterion is that one does not need to use dynamic programming. The expectation of $dlnX(t)$ is (6):

$$dlnX(t) = \left(\frac{1}{X(t)}\right)dXt - \left(\frac{1}{2}X(t)^2\right)\left(dx(t)^2\right) \tag{3}$$

$$E[d(lnX(t))] = [\mathrm{M}f(t)] - \mathrm{R}[f(t)]dt \tag{4}$$

The correlation $\rho dt = E(dw_p dw_i)$ is negative, which increases risk: $(dt)^2 = 0,\ dwdt = 0.$

The optimal debt ratio f^* maximizes the difference between the mean and risk:

$$f^* = argmax_f[M(f(t)) - R(f(t))] = [\alpha(t) + \beta(t) - i] - \left[\left(\frac{(\sigma_p^2 - \rho\sigma_i\sigma_{p)})}{\sigma^2}\right)\right] f^* = argmax_f[M(f(t)) - R(f(t))]$$

$$= f^*(t) = \left\{(r-i) + \beta - \alpha y(t) - \left(\frac{1/2(\sigma_p^2 - \rho_{ip}\sigma_i\sigma_{p)})}{\sigma^2}\right)\right\} \tag{5}$$

s.t.

$$Risk = \sigma^2 = \sigma_i{}^2 + \sigma_p{}^2 - \left(2\rho_{ip}\sigma_i\sigma_p\right)$$

Model I:

Model I assumes that price $P(t)$ has a trend rt and a deviation $Y(t)$ from it (8). The deviation $Y(t)$ follows an Ornstein–Uhlenbeck ergodic mean-reverting process (9). Coefficient α is positive and finite. The interest rate is the same as in Model II:

$$P(t) = Pexp(rt + y(t)) \tag{8}$$

The deviation from the trend is demonstrated through:

$$y(t) \ = \ ln\, P(t) \ - - ln\, P \ - - rt$$

The mean-reversion aspect characterized by a convergence of α is defined as:

$$dy(t) = -\alpha(t)dt + o_p dw_p(t) \tag{9}$$

In this model, Stein defines E(dw) = 0; $E(dw)^2 = dt$

$$limy(t) \sim N\left(0,\ \frac{o^2}{2\alpha}\right)$$

Stein constrains the solution such that r $\leq i$ and calls this the "No free lunch constraint." Therefore, the stochastic calculus in Model I is the first term in (10):

$$dP(t) = P(t)(\alpha(t)dt + o_p dw_p(t))$$

$$dP(t)/P(t) = (r - \alpha y(t)) + \frac{1}{2}o_p{}^2\Big)dt + o_p dw_p \tag{10}$$

where $\alpha(t)$ represents the asset's drift component and the interest rate is represented by the sum of i and a Brownian Motion term as follows:

$$i(t) = idt + o_i dw_i(t)$$

Substitute (10) in (7) and derive (11); the optimal debt ratio in Model I is as follows:

$$f^*(t) = \left[(r-i) + \beta - \alpha y(t) - \frac{\left(\frac{1}{2}\right)\left(o_p^2 - o_i o_p \rho\right)}{o^2}\right] \tag{11}$$

Consider $\beta(t)$ as deterministic.

Model II:

In Model II, the price equation is (12). The drift is $\alpha(t)dt = \pi\,\mathrm{d}t$ and the diffusion is $o_p dw_p$:

$$dP(t)/P(t) = \pi\,\mathrm{d}t + o_p dw_p \tag{12}$$

The optimal debt ratio $f^*(t)$ is (13). Consider $\beta(t)$ as deterministic:

$$f^*(t) = \left[(\pi + \beta(t) - i) - \frac{\left(o_p^2 - o_i o_p \rho\right)}{o^2}\right] \tag{13}$$

s.t.

$$\sigma^2 = \sigma_i{}^2 + \sigma_p{}^2 - \left(2\rho_{ip}\sigma_i\sigma_p\right)$$

In terms of a maximization portfolio decision, we have:

$$\max_{\alpha_t}\left[\alpha_t(E(R_{t+1}) - R_{F,\,t+1}) - \frac{k}{2}\alpha_t^2\sigma_t^2\right] \tag{14}$$

Appendix B

Table 1B
List of Companies Included in the Sample, by Industry (ticker symbol in parenthesis)

Technology Industry	Financial Industry	Pharmaceutical Industry
1. Apple (AAPL)	1. Berkshire Hathaway (BRK/B)	1. Abbott Laboratories (ABT)
2. Samsung (SSNLF)	2. Fannie Mae (FNMA	2. Allergan, Inc. (AGN)
3. Microsoft (MSFT)	3. BNP Paribas BNP	3. AmerisourceBergen Corporation (ABC)
4. Alphabet (GOOGL)	4. JP Morgan Chase (JPM	4. Cardinal Health, Inc. (CAH)m
5. Intel (INTC)	5. Société Générale GLE	5. Eli Lilly and Company (LLY)
6. IBM(IBM)	6. HSBC(HSBC)	6. GlaxoSmithKline Plc. (GSK)
7. Facebook (FB)	7. Bank of America BAC	7. Johnson & Johnson (JNJ)
8. Tencent (TCEHY)	8. Bank of BACHF	8. McKesson Corporation (MCK)
9. Oracle (ORCL)	9. Wells Fargo WFC	9. Merck & Company, Inc. (MRK)
10. Amazon (AMZN)	10. Citigroup C	10. Mylan Inc. (MYL)
11. Twitter, Inc. (TWTR)	11. Freddie Mac FMCC	11. Novartis AG (NVS)
12. Cisco (CSCO)	12. Goldman Sachs GS	12. Novo Nordisk (NVO)
13. Sony (SNE)	13. Lloyds Banking Group LYG	13. Perrigo Company (PRGO)
14. Nintendo (NTDOY)	14. Banco do Brasil BBAS3	14. Pfizer, Inc. (PFE
15. Ebay (EBAY)	15. Barclays (BCS)	15. Sanofi (SNY)
16. Alibaba (BABA)	16. Deutsche Bank (DB)	16. Zoetis Inc. (ZTS
17. Dell (DELL)	17. National Australia Bank (NAB)	17. Akorn, Inc. (AKRX)
18. Toshiba (TOSBF)	18. UBS (UBS)	18. Dr. Reddy's Laboratories Ltd. (RDY)
19. HP (HPQ)	19. Sumitomo Mitsui Financial Group (SMFG)	19. Endo International Plc. (ENDP)
20. Adobe (ADBE)	20. Credit Suisse Group (CS)	

Auto Industry	Energy Industry	Airline Industry
1. Bayerische Motoren Werke AG - BMW (BMWYY)	1. Duke Energy Corp (Duk)	1. AAL(American Airlines)
2. Daimler AG (DMLRY)	2. Engie SA (ENGI) France	2. Air China Limited (AICAF)
3. Ford (F)	3. National Grid (NGG) England	3. ANA Holdings Inc. (ALNPY)
4. Fiat Chrysler Automobiles (FCAU)	4. Nextera (NEE)	4. Eastern Airlines (CEA)
5. Toyota JP (TM 7203 JP)	5. EDF (EDF) England	5. Delta (DAL)
6. General Motors Co (GM)	6. Enel (ENLAY) Italy	6. Lufthansa (DLAKY)
7. Tesla Inc (TSLA)	7. Dominium (D)	7. JAPSY (Japan Airlines Co. Ltd.)
8. Honda Motor Co Ltd (HMC)	8. Iberdrola (IBDRY) Spain	8. Southwest (LUV)
9. Nissan Motor Co Ltd (NSANY)	9. Southern Company (SO)	9. United (UAL)
10. Volkswagen AG (VWAGY)	10. EXelon (EXC)	10. Souhtern Airlines (ZNH)

Source: Bloomberg
Note: Each industry sub-sample includes up to top twenty publicly traded companies (depending on data availability) based on their market capitalization and total assets compared to others in the respective industry. Section 4 offers additional details.

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