Industrial and Corporate Change, 2022, **00**, 1–19
DOI: https://doi.org/10.1093/icc/dtac043
Original Article

OXFORD

Debt-GDP cycles in historical perspective: the case of the USA (1889–2014)

Engelbert Stockhammer[1] and Giorgos Gouzoulis[2,*]

[1]Department of European and International Studies, King's College London, Virginia Woolf Building, 22 Kingsway, London WC2B 6LE, UK. e-mail: engelbert.stockhammer@kcl.ac.uk and [2]Business School, University of Bristol, Howard House, Queen's Avenue, Bristol BS8 1SD, UK.
e-mail: g.gouzoulis@bristol.ac.uk

*Main author for correspondence.

Abstract

Since the Global Financial Crisis, interest in financial cycles has risen significantly. While much of modern macroeconomics conceives financial crises as the results of exogenous shocks, Minsky's financial instability hypothesis posits that financial cycles are endogenous to the economic system. The main contribution of this paper is to use historical macroeconomic data for the United States (1889–2014) to econometrically test for endogenous Minsky cycles: the interaction of procyclical private debt-to-income ratios and a dampening effect of private debt on economic activity. We analyze corporate debt-gross domestic product (GDP) growth cycles, which feature in Minsky's original writings, and mortgage debt-GDP growth cycles as in some recent Minsky-inspired models. We find robust evidence of endogenous corporate debt-GDP cycles over the last 125 years. These results are driven by the pre-World War II (WWII), and post-1973 periods, which had a more liberal economic policy orientation. We find no evidence of mortgage debt-GDP cycles.

JEL classification: E32, E44

1. Introduction

Interest in financial cycles has grown significantly since the Global Financial Crisis (GFC) and with it interest in post-Keynesian monetary theory and the work of Hyman Minsky in particular. Minsky's (1975, 1986, 1992) financial instability hypothesis (FIH) offers a rich analysis of how financial instability arises, which includes changes to what is regarded as an acceptable debt level and resulting changes in financial structures; the role of interest rates that determine the financial viability of firms; and changing portfolio composition from the boom to the bust as investors' risk assessments change (Wray, 2016). One key insight of the FIH is the endogenous emergence of financial instability and financial cycles from the basic mechanisms of market economies. Booms create the conditions for the bust and vice versa—"stability is destabilizing" as Minsky (1986; 218) puts it.

The FIH has been used to develop a rich variety of endogenous cycle models. There is no canonical Minsky model, and a recent survey by Nikolaidi and Stockhammer (2017) identifies no fewer than seven families of Minsky models according to the main mechanisms. These include models that focus on the role of borrowing, debt, and the interest rate on business investment (Asada, 2001; Fazzari *et al.*, 2008), consumption expenditures, and household debt (Kapeller and Schutz, 2014); the role of credit rationing (Nikolaidi, 2014); the role of equity prices and profit expectations (Taylor and O'Connell 1985; Delli Gatti and Gallegatti 1990); and the role of house prices (Ryoo, 2016). Nikolaidi and Stockhammer (2017) show that a Minskyan theory of endogenous cycles needs an overshooting and a stabilizing force and that the different models can be interpreted as offering different explanations of these. We will use these overshooting and dampening forces to identify endogenous cycles empirically.

In contrast to the rich theoretical literature, the empirical Minsky literature is small and limited in what it demonstrates. On the one hand, several papers (e.g., Mulligan, 2013; Davis *et al.*, 2019; Nishi, 2019) estimated the impact of corporate debt on investment or analyzed firms' financial structures using firm-level or sector-level panel data. These studies are limited in which they focus on one specific Minsky mechanism, but, in fact, two mechanisms are needed to generate cycles. On the other hand, Palley (1994) and Kim (2013, 2016) analyzed the effects of consumer and household debt on gross domestic product (GDP) growth in the US economy. They did not analyze corporate debt. Stockhammer *et al.* (2019) are the only ones who try to identify endogenous cycles as such, but they use data for the post-1970 period only.

The main contribution of this paper is to test a Minsky model that allows for an evaluation of the endogenous cycles empirically for long historical macroeconomic data for the United States (1889–2014). The use of long historical data is appropriate because the core assertion of Minsky is that capitalism has long been characterized by financial cycles. While each new boom tends to come with financial innovations and structural change, i.e., has its unique features, there is a basic underlying mechanism of overshooting expectations and growth and a dampening debt burden. Thus, we need long historical data to assess the validity of the FIH. As our sample covers periods with different economic policy regimes, we will report results for subperiods.

We present two minimalistic Minsky models that are boiled down to two-equation systems, which allows us to identify necessary conditions for the emergence of endogenous cycles (operationalized as complex roots of a dynamic system). In such a two-equation system, cycles emerge from the interaction of an overshooting and a dampening force. The paper methodologically follows Stockhammer *et al.* (2019) but analyzes a significantly longer time span. In the first model, the corporate debt-GDP cycle, endogenous fluctuations are generated by the procyclicality of the corporate leverage ratio and the negative effect of debt service payments on investment. Minsky argued that investors' attitudes to risk relax during the euphoria of an investment boom (the overshooting force) leads to rising debt ratios and increased interest payments, which eventually hamper investment and growth (i.e., debt is the dampening force). Compared to the literature that examines the effects of private credit on output and investment (Bezemer *et al.*, 2016; Mian *et al.*, 2017), our approach tests for endogenous cycles, which require both a procyclical leverage ratio and a negative effect of debt on investment and GDP growth.

In the second model, the dynamic system consists of mortgage debt and GDP growth. This corresponds to recent extensions of Minsky to include household debt (Palley, 1994; Kim, 2013, 2016). Compared to Palley (1994) and Kim (2013, 2016), our approach, firstly, covers the interaction between corporate (non-mortgage) debt and investment growth, following Minsky's original writings as well as household (mortgage) debt, and, secondly, it covers a significantly longer historical period.

Also, there is related mainstream literature. A growing empirical literature explores financial cycles through univariate filtering techniques (see, e.g., Drehman *et al.*, 2012; Borio, 2014) and finds that financial cycles are typically longer than the regular business cycle. There is also literature that analyzes the probability of financial crises, some of which uses historical macroeconomic data (see, e.g., Schularick and Taylor, 2012; Jordà *et al.*, 2013, 2015, 2016; Aikman *et al.*, 2015); however, it asks a different question from ours. Schularick and Taylor (2012) and Jordà *et al.* (2013, 2016) use long historical data and show that higher debt levels precede financial crises and impact the depth of the crises. In contrast, our approach focuses on the interaction of debt and growth, i.e., we check for the negative investment and GDP growth effects of debt as well as the procyclical nature of debt ratios, both of which are necessary to generate endogenous oscillations.

The main finding of this study is that the US economy has experienced corporate debt-GDP cycles over the last 125 years. Both the procyclical leverage ratio and the negative growth effect of debt are statistically significant. These cycles (11–12 years) are longer than the regular business cycles. These results are driven by the pre-World War II (WWII) and post-1973 periods but muted in the postwar era. This confirms the basic mechanisms that form the core of Minsky's FIH based on business debt. Our estimations for mortgage debt-GDP cycles fail to find evidence for Minsky cycles. While mortgage debt is procyclical (for the full sample), we do not find a negative effect of mortgage debt on growth. This result may be surprising in the context of the GFC, where household debt indeed played a key role. Only for the pre-WWII period, coefficients have the required signs. This means that either the GFC was not part of the regular Minsky cycles or our model does not adequately capture the mechanisms pertaining to household debt and real estate prices. We cautiously suggest the latter. Our model focuses on simple debt and economic growth interactions. Some Minsky models (Ryoo, 2016; Gusella and Stockhammer, 2021) and momentum trader models of heterogeneous agent models (Dieci and Westerhoff, 2016; Bofinger *et al.*, 2013) highlight speculative asset price dynamics that are not part of our model.

The rest of the paper is structured as follows. Section 2 offers a theoretical discussion of Minsky cycles and presents a simple 2D model to establish necessary and sufficient conditions. Section 3 reviews the existing empirical literature on Minsky models and also relevant parts of the broader literature on financial cycles. Section 4 presents data sources and our econometric modeling approach. Section 5 discusses the estimation results for corporate debt-GDP cycles, corporate debt-investment cycles, and mortgage debt-GDP cycles. Finally, Section 6 concludes by recapitulating the main findings and suggesting future research paths.

2. Debt-driven Minsky cycle models

Minsky's (1975, 1986, 1991) writings offer rich insights into financial dynamics, but there is no canonical model. As a result, economists inspired by Minsky have taken his approach in different directions and developed different elements of his analysis into formal models. Nikolaidi and Stockhammer (2017) survey the literature with a focus on models that generate endogenous cycle and distinguish between debt cycle models and asset price models. There are further variations within each of these. In the debt cycle models, the cycle arises from the interaction between financial and real variables (Asada, 2001). The key financial variable is usually the debt-to-income ratio (DEBT), and interest rate movement often plays a key role. The asset price models are based on the nature of expectation formation and often feature the interaction of different valuation strategies. Differences exist on whether interest rates are set by the central bank in response to changes in inflation (Fazzari *et al.*, 2008) or by commercial banks in response to the change in their customers' leverage (e.g., Keen, 1995; Lima and Meirelles, 2007) and on whether they assume stable goods markets (Charles, 2008) or Harrodian instability (Ryoo, 2013). While most models deal with corporate debt, some focus on household debt (Kapeller and Schutz, 2014; Ryoo, 2016). While most models use small-scale macroeconomic models, there are also fully specified stock flow-consistent models (Nikolaidi, 2014; Dafermos, 2018) and heterogeneous agent models (Reissl, 2020).

Some scholars have emphasized the role of institutional change in Minsky's analysis and developed this into a theory of long waves. Palley (2011) discuss Minsky's contribution by distinguishing between shorter finance-driven cycles and long waves of financial expansion. His short waves are close to what we discussed above. Regarding long waves (or super-cycles), Palley highlights that firms and policymakers tend to forget that financial liberalizations in the past have led to major systemic crises and recessions. Policymakers eventually allow the deregulation of institutions and markets, while firms (and households) take on more risk (and debt) taking advantage of this deregulation process. Ultimately, this results in a secular increase in financial fragility, leading to major financial crises like the 2007–2008 crash. While the short cycles operate in a given regulatory environment, the long cycles are about endogenous regulatory change. Similarly, Wray (2009) discusses long Minsky cycles and underlines that a substantial difference between the 1929 financial crisis and the GFC in the United States is that, in the latter case, real estate prices and household finance played a much more important role.

This paper is testing for endogenous cycles arising from the interaction between debt and real expenditures. In Palley's terminology, we focus on the basic (i.e., private sector) Minsky cycle.

We will analyze versions with corporate debt and with mortgage debt. The distinguishing characteristic of Minskyan corporate debt-driven cycle models is that the hypothesized residual source of finance for investment is business debt (Asada, 2001; Lima and Meirelles, 2007; Charles, 2008; Fazzari *et al.*, 2008). The central postulate of the theory is that the desired investment rate rises rapidly during the euphoria of a boom, exceeding retained earnings. The gap between desired investment and actual internal funding resources is then covered by corporate debt, and the DEBT rises as a result.[1] Thus, investment (and GDP) acts as the overshooting force. As the DEBT increases, relevant interest payments rise, and a rising share of retained profits will be devoted to debt service. This makes the balance sheet of the firm increasingly fragile, which eventually leads to a slowdown in investment growth, thus on GDP growth. The leverage ratio thus plays a dampening role. A typical linear reduced-form Minsky corporate debt-driven cycle model can be expressed in the following system of difference equations:

$$\begin{bmatrix} y_t \\ d_t \end{bmatrix} = \begin{bmatrix} J_{11} & J_{12} \\ J_{21} & J_{22} \end{bmatrix} \begin{bmatrix} y_{t-1} \\ d_{t-1} \end{bmatrix} = \begin{bmatrix} \pm & - \\ + & \pm \end{bmatrix} \begin{bmatrix} y_{t-1} \\ d_{t-1} \end{bmatrix} \tag{1}$$

where y is GDP (or investment), and d is a measure of the corporate DEBT.[2] This simple model should be understood as a linear approximation as Minsky models often involve nonlinearities. These matter as nonlinear behavioral equations can give rise to limit cycles, which do not occur in the linear system. As our main interest is in the existence or absence of endogenous oscillations, rather than in the precise nature of oscillations, this is a secondary matter.

A system of difference equations exhibits endogenous oscillations if the eigenvalues of the relevant Jacobian matrix are complex conjugates (see Chiang 1984, pp. 633–645). In a two-dimensional system, the eigenvalues are those λ that satisfy,

$$\lambda^2 - \lambda Tr(J) + \det(J) = 0 \Rightarrow \lambda_{1,\,2} = \pm \frac{Tr(J) \pm \sqrt{Tr(J)^2 - 4\det(J)}}{2}$$

.

The sufficient condition for oscillations is therefore that the discriminant $\Delta = Tr(J)^2 - 4\det(J)$ is negative. The discriminant of a 2D Jacobian matrix can be calculated as a function of its trace and determinant as follows:

$$\Delta = Tr(J)^2 - 4\det(J) < 0 \Leftrightarrow (J_{11} + J_{22})^2 - 4(J_{11}J_{22} - J_{21}J_{12}) < 0$$
$$\Leftrightarrow (J_{11} - J_{22})^2 + 4J_{21}J_{12} < 0.$$

As $(J_{11} - J_{22})^2$ is positive, a necessary condition for oscillations is therefore that the product of the off-diagonal elements of the Jacobian matrix, $J_{21}J_{12}$, is negative. Following Stockhammer *et al.* (2019), necessary conditions for oscillations in equation (1) are debt-burdened investment or GDP growth ($J_{12} < 0$) and a procyclical corporate leverage ratio ($J_{21} > 0$). It is these conditions that we will investigate in the empirical analysis. While our model in principle is closer to Palley's (2011) short cycles within a given institutional structure, there is nothing in our model that restricts the cycle length.

An important simplifying assumption of most Minskyan debt cycle models, implicit in the explanation given above, is that they do not explicitly account for the role of equity markets. There are a few models in which asset prices are procyclical, thus permitting the increase of debt ratios by relaxing firms' collateral constraints, such as Kiyotaki and Moore (1997). However, it is

1 In the post-Keynesian literature, this procyclical debt ratio is not uncontested. In particular, Lavoie and Seccareccia (2001) have argued that in Kaleckian models the paradox of debt will hold, i.e., the investment boom will lead to increased revenues, and thus, realized debt ratios may fall. Theoretically, the assumption of a given marginal saving propensity is critical for their results. The Minskyan model requires a procyclical debt ratio. But for the purposes of this article, the cyclical properties of the debt ratio are an empirical matter.

2 Many theoretical Minsky models use investment over capital stock as the real variable and debt over capital stock as the debt variable. These models often have long time horizons. We prefer this simpler and more intuitive formulation, which corresponds to our shorter time horizons. Moreover, our dataset does not include capital stock.

worth noting that in that model, asset prices are endogenous (but not state variables); therefore, system (1) is fully consistent with its reduced form. Ryoo (2010) also presents a model where asset price expectations along with liquidity preferences generate endogenous instability, building on nonlinear higher-order systems. The incorporation of unobservable variables related to agents' perceived risk makes the estimation of such a system significantly less straightforward than a typical linearized Minsky debt cycle model; thus, it is beyond the scope of this paper to test this model. We leave the empirical estimation of fully specified systems with nonlinear asset price functions to future research.

While Minsky's original emphasis was on business debt-driven cycles, several authors have reformulated Minsky's argument in the context of household debt. Palley (1994) presents a Minskyan model that includes procyclical consumer debt accumulation. Modifying a simple multiplier-accelerator model, Palley shows that initially debt flows increase aggregate demand through consumption, and thus output, but eventually rising debt accumulation decreases aggregate demand. Dutt (2006) and Ryoo and Kim (2014) are related to Kaleckian models that explore the interaction of growth and household debt, but they do not refer to Minsky. Ryoo (2016) develops a real estate price Minsky model, in which momentum traders expect further price increases when house prices rise. Ultimately, households' demand for houses will slow down, curbing house prices and thus the housing cycle. Here, the key variable is expected capital gains, which are not observable. Based on Palley (1994) and Ryoo (2016), we propose a reduced-form Minsky mortgage debt-driven model similar to the 2D corporate debt-GDP model above, i.e., households' confidence during the boom period makes them increase their debt ratio to purchase a house. Eventually, increasing debt payments decrease growth; hence, endogenous fluctuations are generated. Such a Minsky household debt model can be depicted in the following system of difference equations:

$$\begin{bmatrix} y_t \\ h_t \end{bmatrix} = \begin{bmatrix} J_{11} & J_{12} \\ J_{21} & J_{22} \end{bmatrix} \begin{bmatrix} y_{t-1} \\ h_{t-1} \end{bmatrix} = \begin{bmatrix} \pm & - \\ + & \pm \end{bmatrix} \begin{bmatrix} y_{t-1} \\ h_{t-1} \end{bmatrix} \quad (2)$$

where y is GDP, as above, and h is the household DEBT. As in the reduced-form corporate debt-driven model, necessary conditions for oscillations in equation (2) are $J_{12} < 0$ and $J_{21} > 0$.

Stockhammer *et al.* (2019) also analyzed Minsky's GDP-interest cycles. They note that a wide range of models, including standard ISLM, or models with monetary policy rules can generate these cycles, which would be policy-induced rather than endogenous to private sector dynamics.[3] This paper focuses on debt-GDP cycles as these are more clearly Minskyan in character.

The models presented above are pure private sector models. Actual economies are mixed with governments impacting the economy via fiscal and monetary policy and financial regulation. While we do not model these theoretically, in the empirical analysis we present results for periods with different economic policy regimes.

3. Financial cycles: a review of the empirical literature

In contrast to the theoretical literature on Minskyan cycles, the related empirical literature is quite limited. Several studies focus on particular aspects of Minsky's analysis. For example, early studies by Fazzari and Mott (1986) and Fazzari *et al.* (1988) analyze the effect of corporate debt on business investment, while, more recently, Ndikumana (1999), Arza and Español (2008), and Caldentey *et al.* (2019) scrutinize how interest expenses, cash flows, and debt decrease the investment-to-capital ratio using firm-level data. There are also various studies that analyze the financial fragility of non-financial sectors (Isenberg, 1989; Wolfson, 1990; Mulligan, 2013; Davis *et al.*, 2019; Nishi, 2019). All of these studies are consistent with our approach but cover only one of the two mechanisms that are necessary for endogenous cycles: the impact of debt or financial fragility on investment expenditures. Stockhammer *et al.* (2019) are the only ones who attempt to econometrically test for endogenous cycles derived from the interaction of real and financial

3 Interest rate cycles can also arise if banks increase interest rates in response to changes in the DEBT of households or firms, irrespective of the level of the policy rate.

variables. They estimate models with the interest rate, business debt, and household debt as financial variables and real GDP as the real variable. The model is estimated for seven OECD countries for the period 1970–2015. They found robust evidence for corporate debt-growth cycles for some countries and no evidence for mortgage debt-GDP cycles. For the United States, they report weak evidence for corporate debt-GDP cycles.

While there are even fewer Minsky-inspired household debt cycle models, they are closer to what we do as they estimate vector autoregressive (VAR) models. Palley (1994) tests a household debt cycle model using quarterly data for the United States (1975–1991) to evaluate the effects of consumer debt on real GNP per capita. Results from a single-equation distributed lag model and a three-dimensional VAR model indicate that increases in consumer debt produce damped oscillations.[4] Kim (2013) follows Palley's single-equation approach, using quarterly US data (1951–2009) with household net worth and consumer debt as financial variables. He finds a positive effect of a change in household debt but negative level effects, implying an underlying financial accelerator mechanism. Kim (2016) also reports Johansen cointegration tests of vector error correction models of GDP, net worth, consumption, and household, mortgage, or consumer debt and finds that shocks in the debt variables decrease output, while the leverage ratio is procyclical. These results are indeed consistent with our approach on Minsky cycles as the necessary conditions are fulfilled: private indebtedness decreases output, while the leverage ratio is procyclical. However, the lag structure of the specifications is not similar to a typical Minsky debt-capital stock difference equation system; thus, it is not possible to evaluate the sufficient conditions.

In recent years, the wider financial cycle literature has grown, including the field of quantitative macroeconomic history. This research is empirically driven and often refers to New Keynesian theories of credit rationing and the financial accelerator models and, to some extent, to Minsky as motivation. Drehman *et al.* (2012) and Borio (2014) utilize band-pass and Hodrick–Prescott filtering, as well as turning-point analysis, to identify cycles using quarterly and annual data for several countries (1960 to the present). Both papers conclude that financial cycles tend to be longer than real business cycles, while the length and amplitude of the former tend to increase after the mid-1980s. Bezemer *et al.* (2016) examine the effects of financial variables on growth, using a 46-country panel (1970–2011) and an industry-level dataset. Controlling government spending, trade, inflation, and education, they find that credit booms decrease growth. Mian *et al.* (2016) explore the impact of household debt on growth (30 countries, 1960–2012) and show that the household debt-to-GDP ratio is related to future growth; it has a positive short-term but negative long-term effect.

There is a modest literature that uses historical macro data to identify financial cycles or the impact of debt on growth. Aikman *et al.* (2015) utilize band-pass filtering and spectral density analysis, using historical macroeconomic data on total credit (14 countries, 1870–2008). They find that financial cycles are longer than real cycles. Using binary financial crises, variable logit model estimations suggest that credit expansions increase the probability of financial crises. Schularick and Taylor (2012) find negative cumulative output and investment effects of credit and that the impact of credit becomes stronger in the post-WWII era. In logit and probit models predicting financial crises, they report strong effects of credit expansions and stock market booms if the financial sector, measured by credit volumes, is large. Jordà *et al.* (2013) draw similar conclusions about the impact of total credit on the growth rate of real GDP per capita, controlling for excess credit, i.e., the percentage change of the loans-to-output ratio compared to the last expansion period. In more recent work, Jordà *et al.* (2016) disaggregate debt into mortgage debt and non-mortgage debt and estimate probit and logit models to explain banking and financial crises. They find that both categories of debt increase the probability of financial crises and note that the results for mortgage debt are due to the post-WWII period. Five-year cumulated impulse responses for real per capita GDP, real investment per capita, and real lending per capita show that when a crisis follows a credit boom, recessions tend to be longer and recoveries slower. In particular, after WWII, mortgage booms led to deeper recession projections.

4 The paper does not report the coefficient values from which the oscillations are generated, so we cannot draw any conclusion about the signs of the implied Jacobian matrix elements, i.e., whether the oscillations are endogenous as in Minsky.

Table 1. Summary statistics

	Δ(log (GDP))	Δ(log (I))	Δ(BDEBT)	Δ(MDEBT)
Mean	0.031	0.034	0.001	0.002
Median	0.033	0.050	0.001	0.004
Maximum	0.173	0.895	0.037	0.048
Minimum	−0.138	−1.116	−0.072	−0.066
Standard deviation	0.050	0.223	0.015	0.015
Period	1890–2014	1890–2014	1890–2014	1890–2014
Obs.	125	125	125	125

The vast majority of these studies support Minsky's debt-burdened growth hypothesis, as they find that either total, mortgage, and/or non-mortgage debt affect growth negatively (Schularick and Taylor, 2012; Jordà *et al.*, 2013, 2016; Bezemer *et al.*, 2016; Mian *et al.*, 2016). However, that finding alone provides information only about one aspect of Minsky's mechanism of endogenous debt-driven cycles. The other, i.e., the procyclicality of the leverage ratio, remains unexplored in this literature. The empirical literature on finance-driven cycles that uses historical macroeconomic data uses panel data models, often with a binary dependent variable. In contrast, the present study is the first to test for endogenous cycles arising from the interaction of debt and growth using historical macro data.

4. Data and econometric approach

The historical macroeconomic dataset of the present study covers the period from the late 19th century to date for the United States (1889–2014). We obtain data from various sources. The four main variables of interest are real GDP, real investment, the business DEBT, and the mortgage DEBT. Debt refers to bank loans, i.e., it does not include debt to other institutions. Since the business debt is not directly available for the United States before 1960, we approximate it by subtracting mortgage debt from total private credit to the non-financial private sector. While this is a reasonable approximation, it comes with some qualifications: in the postwar era (where better data are available), around 66% of household debt is mortgage debt. Conversely, not all mortgages are to households; some go to business, in particular the non-incorporated business sector. While the pre-1929 mortgage market of the United States has arguably been similar to the pre-2008 experience in that it was driven by households (Galbraith, 1955), in a broader historical picture, we note that a large share of mortgages were agricultural loans that do not resemble modern household debt. On average, the household share in mortgages was about 68% in the postwar era.[5] To derive the two private debt-to-GDP ratios, we divide each nominal debt level series by the nominal GDP (both from Jordà *et al.* (2017)). The source for the real GDP series is Johnston and Williamson (2021). Regarding real investment, the pre-1929 part of the series is derived from Kuznets and Jenks (1961), while the post-1929 part of the series comes from the Bureau of Economic Analysis, National Income and Product Accounts. Investment includes government investment, which likely follows a different pattern, but is of modest size and less volatile than private investment.

Summary statistic for all variables are reported in Table 1. $BDEBT$ is the business (non-mortgage) debt-to-GDP ratio, $MDEBT$ is the mortgage debt-to-GDP ratio, I is the real investment, and GDP is the real gross dometic product. Figure 1 reports the evolution of the private debt ratios over the full period. Both exhibit a cyclical pattern. The results of augmented Dickey–Fuller (ADF) unit root tests can be found in Appendix A1; all variables are stationary in the first differences.

As outlined in Section 2, a simple 2D Minsky cycle model can be specified by a pair of difference equations, which give us the necessary conditions for interaction-driven oscillations derived

5 The relevant data are from the Financial Accounts (https://www.federalreserve.gov/releases/z1/default.htm). The postwar era refers to 1946–2015.

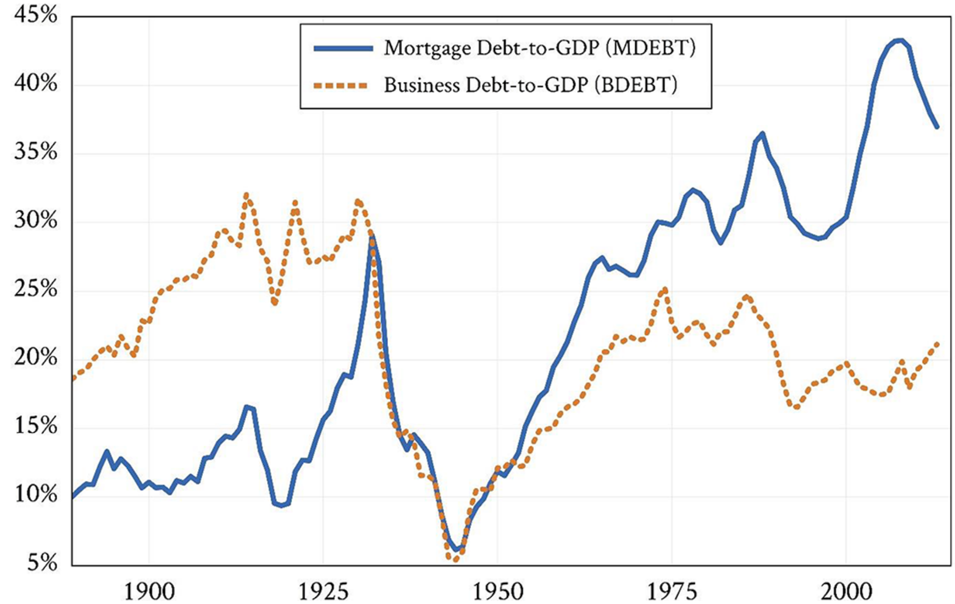

Figure 1. Private debt-to-GDP ratios, 1889–2014. *Note*: Authors' calculation using data from Jordà *et al.* (2017)

from the Jacobian matrix. However, as the lag structure is minimalistic, the reduced form in equations (1) and (2) may well be a poor approximation to the joint distribution of the real variable (GDP or investment) and the debt variable (corporate or mortgage debt). Including more control variables would complex the system of equations, and adding lags would distort the coefficients of interest. Thus, such an approach would not allow estimating the discriminant or the cycle length of the system. We calculate cycle lengths using the VAR coefficients following the approach of Stockhammer *et al.* (2019; 86) (see Appendix A2).

Consequently, in order to derive accurate point estimates for our simple 2D difference equation systems, we estimate them using the Vector Autoregressive Moving Average (VARMA) approach (Dufour and Pelletier, 2011). This empirical strategy allows us to estimate the exact theoretical model presented earlier and derive accurate estimates without altering the original model. As a result, we estimate the following VARMA models on the change in the natural logarithm of investment or GDP and the change in corporate (or mortgage) DEBT, Δ(DEBT):

$$\begin{bmatrix}\Delta(\log(GDP))_t\\ \Delta(BDEBT)_t\end{bmatrix}=\begin{bmatrix}\alpha_1\\ \alpha_2\end{bmatrix}+\begin{bmatrix}\beta_{11} & \beta_{12}\\ \beta_{21} & \beta_{22}\end{bmatrix}\begin{bmatrix}\Delta(\log(GDP))_{t-1}\\ \Delta(BDEBT)_{t-1}\end{bmatrix}+\begin{bmatrix}\theta(L) & 0\\ 0 & \varphi(L)\end{bmatrix}\begin{bmatrix}\epsilon_{1t}\\ \epsilon_{2t}\end{bmatrix} \quad (3)$$

$$\begin{bmatrix}\Delta(\log(INV))_t\\ \Delta(BDEBT)_t\end{bmatrix}=\begin{bmatrix}\alpha_1\\ \alpha_2\end{bmatrix}+\begin{bmatrix}\beta_{11} & \beta_{12}\\ \beta_{11} & \beta_{22}\end{bmatrix}\begin{bmatrix}\Delta(\log(INV))_{t-1}\\ \Delta(BDEBT)_{t-1}\end{bmatrix}+\begin{bmatrix}\theta(L) & 0\\ 0 & \varphi(L)\end{bmatrix}\begin{bmatrix}\epsilon_{1t}\\ \epsilon_{2t}\end{bmatrix} \quad (4)$$

$$\begin{bmatrix}\Delta(\log(GDP))_t\\ \Delta(MDEBT)_t\end{bmatrix}=\begin{bmatrix}\alpha_1\\ \alpha_2\end{bmatrix}+\begin{bmatrix}\beta_{11} & \beta_{12}\\ \beta_{21} & \beta_{22}\end{bmatrix}\begin{bmatrix}\Delta(\log(GDP))_{t-1}\\ \Delta(MDEBT)_{t-1}\end{bmatrix}+\begin{bmatrix}\theta(L) & 0\\ 0 & \varphi(L)\end{bmatrix}\begin{bmatrix}\epsilon_{1t}\\ \epsilon_{2t}\end{bmatrix} \quad (5)$$

where $\theta(L)$ and $\varphi(L)$ are lag polynomials. As the lag length for the Moving Average (MA) terms will be restricted to be 1, given that data are annual, and the resulting models do not suffer from serial correlation, a necessary condition for oscillations in equation (3) is $\beta_{12}\beta_{21} < 0$. To examine the existence of Minsky cycles, we can restrict this necessary condition to the pair of conditions $\beta_{12} < 0$ (debt-burdened growth) and $\beta_{21} > 0$ (procyclical leverage ratio). The sufficient condition for oscillations in equation (3) is the existence of complex conjugate eigenvalues (see Stockhammer *et al.* (2019) and above). So, when the necessary conditions are met, we can also calculate the discriminant to evaluate the sufficient condition (i.e., a negative discriminant).

Two points need to be noted concerning equation (3) before we continue. First, the matrix of MA terms is restricted to be diagonal. As is well known, VARMA models are not identified in the general case and require some form of restriction prior to estimation. Our approach follows Dufour and Pelletier (2011), who point out that the standard approach to imposing identifying restrictions in VARMA models, known as the "echelon form," is considerably more complicated than simply choosing lag orders (as in VAR models), and is a major reason why VARMA models are infrequently used in practice. The "diagonal MA equation form" of equation (3), on the other hand, is extremely simple to specify and can be seen as a straightforward extension of a VAR model. Second, well-behaved estimates require that the roots of $\theta(L)$ and $\varphi(L)$ lie within the unit circle (Brooks, 2014; 267–281). Again, as the MA terms will be of order 1, in practice, the inverted roots are identical to the absolute values of the estimated MA coefficients, which accordingly must be less than one.

The model in equation (3) can be estimated either by maximum likelihood (ML) or generalized least squares (GLS) on an equation-by-equation basis. There are advantages and disadvantages to both methods. As ML using the Kalman filter is a system estimation procedure, any misspecification in one equation will affect the estimates of all other equations when using system estimation. Therefore, in principle, equation-by-equation estimation should be more robust to misspecification. In addition, simulation exercises on ARMA models (Koreisha and Pukkila, 1990; Koreisha and Fang, 2001) suggest that the GLS approach is less sensitive to initial values than the ML approach for small sample sizes (50–200 observations). Thus, we estimate our systems on an equation-by-equation basis using the GLS estimator.

The models estimated are linear. The question thus arises of how empirical findings are if the actual relations are nonlinear and give rise to limit cycles. Kohler and Calvert Jump (2022) provide Monte Carlo evidence on five types of nonlinear business cycle models and conclude that linear models of the type we use in this paper tend to correctly identify endogenous cycle conditions and the approximate cycle length, despite underestimating the cycle mechanisms in many cases.

5. Econometric results and discussion

In this section, we report the econometric results for the real GDP-business debt, real investment-business debt, and real GDP-mortgage debt interaction systems. As our sample covers a long period with substantial institutional change, we will report results for the full period (1890–2014) as well as for three subperiods: the (old liberal) pre-WWII period (1890–1939), the (Keynesian) postwar era (1945–1972), and the (neoliberal) post-1973 era (1973–2014). While the exact cutoff dates may be subject to discussion, the main features of the periods are broadly agreed by different analysts even if they use different labels. For our purpose, differences in financial regulation and the state impact on the economy via fiscal and monetary policy are of interest. The pre-WWII is a relatively liberal period, with a small state and relatively weak financial regulation, which operated under the gold standard. With the Great Depression, the New Deal, and WWII, a new regime with a more interventionist state, tighter financial regulation, and the Bretton Woods System begins, at times called Fordism (Aglietta, 1979), the Bretton Woods System (Eichengreen, 2019), the Golden Age (Marglin and Schor, 1990), or embedded liberalism (Ruggie, 1982). We choose 1973 as the cutoff date between Keynesianism and Neoliberalism, since the Bretton Woods System of fixed exchange rates officially ended in March 1973 (Eichengreen, 2019, Ch. 5), and it is often identified as a year of structural breaks in economic time series. With the end of Bretton Woods, a period of a swing toward more liberal policies, including financial deregulation and flexible exchange rates, often referred to as neoliberalism (Glyn, 2006) or post-Fordism (Amin, 1994), begins.

Table 2 reports the results for the real GDP-business debt system. For the full sample estimations, we find that the impact of business debt on GDP is negative and the effect of GDP on business debt is positive, as expected. The former coefficient is found to be −0.54 while the latter is 0.11. Both are statistically significant at the 5% and 1% levels, respectively. Thus, the necessary conditions for cycles are met, and we calculate the discriminant of the system's matrix, which is −0.24. Since it is negative, the sufficient conditions are also met; hence, we calculate the cycle

Table 2. GDP-business debt cycles

Equations				Adj. R^2	BG LM test	White test	Discriminant	Cycle Length (years)
Full sample (1891–2014)								
$\Delta(log(GDP))_t =$	$0.38 * \Delta(log(GDP))_{t-1}$ [0.122]	$-0.54 * \Delta(BDEBT)_{t-1}$ [0.044]	$-0.26 * MA(1)$ [0.332]	0.26	0.88	0.96	–0.24	10.69
$\Delta(BDEBT)_t =$	$0.11 * \Delta(log(GDP))_{t-1}$ [0.000]	$+0.35 * \Delta(BDEBT)_{t-1}$ [0.025]	$+0.08 * MA(1)$ [0.644]	0.34	0.25	0.32		
Liberal period (1891–1939)								
$\Delta(log(GDP))_t =$	$0.12 * \Delta(log(GDP))_{t-1}$ [0.784]	$-0.84 * \Delta(BDEBT)_{t-1}$ [0.106]	$-0.04 * MA(1)$ [0.922]	0.07	0.90	0.92	–0.42	7.86
$\Delta(BDEBT)_t =$	$0.17 * \Delta(g(GDP))_{t-1}$ [0.000]	$+0.51 * \Delta(BDEBT)_{t-1}$ [0.001]	$-0.02 * MA(1)$ [0.227]	0.43	0.26	0.52		
Keynesian period (1945–1972)								
$\Delta(log(GDP))_t =$	$0.78 * \Delta(log(GDP))_{t-1}$ [0.003]	$+0.61 * \Delta(BDEBT)_{t-1}$ [0.658]	$-1.00 * MA(1)$ [0.999]	0.12	0.08	0.18	2.63	N/A
$\Delta(BDEBT)_t =$	$-0.05 * \Delta(log(GDP))_{t-1}$ [0.076]	$-0.88 * \Delta(BDEBT)_{t-1}$ [0.000]	$+1.00 * MA(1)$ [0.999]	0.09	0.49	0.18		
Neoliberalism period (1973–2014)								
$\Delta(log(GDP))_t =$	$0.37 * \Delta(log(GDP))_{t-1}$ [0.308]	$-0.56 * \Delta(BDEBT)_{t-1}$ [0.082]	$+0.03 * MA(1)$ [0.944]	0.09	0.91	0.30	–0.21	6.34
$\Delta(BDEBT)_t =$	$0.18 * \Delta(log(GDP))_{t-1}$ [0.041]	$-0.07 * \Delta(BDEBT)_{t-1}$ [0.806]	$+0.36 * MA(1)$ [0.227]	0.16	0.53	0.18		

P-values in brackets. Values for specification tests are *P*-values corresponding to nR^2. BG LM test at second lag. Constant terms and dummy variables for the World War years are included but not reported.

length at 10.69 years. The system exhibits damped oscillations (the absolute value of the dominant eigenvalue [0.44] is less than one).[6] Regarding sub-sample estimations, in the pre-WWII period, the results are fairly similar. The coefficient of the impact of business debt on GDP is −0.84, and the one for the effect of GDP on business debt is 0.17. The respective discriminant is −0.42; thus, both the necessary and sufficient conditions for oscillations during this period hold. The cycle length for the pre-WWII era is calculated at 7.86 years. As regards the postwar period, the results do not provide evidence of cycles as the off-diagonal coefficients of the matrix have perverse signs and the discriminant of the system is positive (2.63). As this is the period with relatively tight financial regulation regulated and macroeconomic policies of Keynesian orientation compared to the other periods of our sample, we hypothesize that the economic policy is the cause for the absence of the financial cycle. Finally, regarding post-1973, the results are similar to the full sample and the pre-WWII findings. The coefficients are similar to the full sample results in terms of signs, size, and statistical significance of the coefficients. The same is true for the discriminant of the system, which is −0.21, i.e., sufficient conditions for oscillations are met for this period. Accordingly, the relevant cycle length is 6.34 years. Overall, the post-estimation diagnostics show no evidence of serial correlation or heteroskedasticity issues. Thus, the findings provide solid support that growth has been debt-burdened and business debt ratios have been procyclical in the United States over the last 125 years and in the liberal and neoliberal eras, i.e., corporate debt has been generating endogenous instability.

As the second step in our analysis, we estimate the model using real investment growth instead of GDP. Using investment allows us to better identify Minsky's mechanism as it is closer to the relevant behavioral equation. Table 3 reports the econometric findings for the real investment-business debt systems For the full sample, we find clear evidence of endogenous oscillations. Business debt has been decreasing real investment (−3.99), and real investment is increasing business indebtedness (0.02). Both coefficients are statistically significant at the 1% level. Calculating the discriminant confirms that it is negative (−0.31); thus, the sufficient conditions for endogenous cycles are met. The relevant cycle length is 11.99 years. Results are relatively consistent across subperiods. In the pre-WWII period, real investment is debt-burdened (−6.29), and the business debt ratio is procyclical (0.03). Both coefficients are also statistically significant at the 1% level, and the discriminant of the system is −0.38. Hence, the calculated cycle length is 13.86 years. In the case of the investment-business debt system, we also find evidence for endogenous oscillations for the postwar era. Between 1945 and 1972, business debt exhibited a sizable negative effect on real investment (−5.10), and corporate indebtedness was procyclical with respect to investment (0.01). Yet, only the latter coefficient is statistically significant at the 10% level. The discriminant of the system's matrix in this case is negative but relatively small in size (which results in a longer cycle of 22.52 years). This finding potentially suggests that the macroeconomic policies of this era may have dampened, but not fully eliminated, the endogenous cycle. Finally, with respect to the post-1973 era, the findings are very close to the full sample results. The negative impact of business debt on investment is estimated at −3.46, and the positive effect of investment on the business debt ratio is estimated at 0.04. Accordingly, the discriminant of this system is −0.53, and the cycle length of the neoliberal era is 6.41 years.

Taken together, the econometric findings for the GDP-business debt and the investment-business debt systems provide robust support in favor of Minsky's theory of endogenous corporate debt-driven oscillations for the full sample, the pre-WWII period, and the post-1973 period. Both the liberal and neoliberal eras are the periods of light financial regulation in our sample, which may explain why cycles are more pronounced. The fact that we find some weak evidence for investment-corporate debt cycles, but no GDP-corporate debt cycles for the Keynesian period, suggests that the private sector cycle pattern was still operating, but subdued. Our results suggest that financial regulation and Keynesian demand management seem to have succeeded in dampening Minsky cycles.

6 This would imply that cycles fade out. However, Kohler and Calvert Jump (2022) find that if the actual data-generating process is nonlinear, the linear estimator will understate the actual size of the cycle mechanism. The linear test is better suited to identifying the existence rather than the nature of the endogenous cycles.

Table 3. Investment-business debt cycles

Equations				Adj. R^2	BG LM test	White test	Discriminant	Cycle length (years)
Full sample (1891–2014)								
$\Delta(log(INV))_t =$	$0.52*$ $\Delta(log(INV))_{t-1}$ [0.000]	$-3.99*$ $\Delta(BDEBT)_{t-1}$ [0.000]	$-0.52*$ $MA(1)$ [0.004]	0.25	0.49	0.95	–0.31	11.99
$\Delta(BDEBT)_t =$	$0.02*$ $\Delta(log(INV))_{t-1}$ [0.000]	$+0.45*$ $\Delta(BDEBT)_{t-1}$ [0.002]	$-0.11*$ $MA(1)$ [0.529]	0.34	0.25	0.32		
Liberal period (1891–1939)								
$\Delta(log(INV))_t =$	$0.33*$ $\Delta(log(INV))_{t-1}$ [0.179]	$-6.29*$ $\Delta(BDEBT)_{t-1}$ [0.004]	$-0.33*$ $MA(1)$ [0.257]	0.07	0.90	0.92	–0.38	13.86
$\Delta(BDEBT)_t =$	$0.03*$ $\Delta(log(INV))_{t-1}$ [0.000]	$+0.94*$ $\Delta(BDEBT)_{t-1}$ [0.000]	$-1.00*$ $MA(1)$ [0.999]	0.55	0.00	0.04		
Keynesian period (1945–1972)								
$\Delta(log(INV))_t =$	$0.72*$ $\Delta(log(INV))_{t-1}$ [0.000]	$-5.10*$ $\Delta(BDEBT)_{t-1}$ [0.382]	$-1.00*$ $MA(1)$ [0.999]	0.33	0.19	0.37	–0.08	22.52
$\Delta(BDEBT)_t =$	$0.01*$ $\Delta(log(INV))_{t-1}$ [0.068]	$+0.24*$ $\Delta(BDEBT)_{t-1}$ [0.360]	$-1.00*$ $MA(1)$ [0.999]	0.09	0.49	0.18		
Neoliberal period (1973–2014)								
$\Delta(log(INV))_t =$	$0.32*$ $\Delta(log(INV))_{t-1}$ [0.402]	$-3.46*$ $\Delta(BDEBT)_{t-1}$ [0.027]	$-0.06*$ $MA(1)$ [0.877]	0.07	0.97	0.82	–0.53	6.41
$\Delta(BDEBT)_t =$	$0.04*$ $\Delta(log(INV))_{t-1}$ [0.047]	$+0.17*$ $\Delta(BDEBT)_{t-1}$ [0.574]	$+0.032*$ $MA(1)$ [0.928]	0.15	0.85	0.29		

P-values in brackets. Values for specification tests are *P*-values corresponding to nR^2. BG LM test at second lag. Constant terms and dummy variables for the World War years are included but not reported.

Table 4 reports the econometric findings for the real GDP-mortgage debt systems The results for the full period show an explosive interaction between two variables, since mortgage debt increases GDP (0.07) and GDP increases the mortgage debt ratio (0.12). Thus, the necessary conditions for endogenous cycles are not met. In addition, it is worth noting that only the coefficient of the procyclical mortgage leverage ratio is statistically significant at the 1% level. The Minsky cycle does not hold for any of the subperiods, even if the details differ. For the pre-WWII period, the relevant coefficients have the expected signs, i.e., the necessary conditions for endogenous oscillation are met. Mortgage debt decreases GDP (−1.20), while, simultaneously, the mortgage leverage ratio is procyclical (0.16), with only the latter coefficient being statistically significant (at the 1% level). However, the discriminant of the system is positive (0.04), and hence, the sufficient conditions for cycles are not met. The cycle mechanisms are in place, but not sufficiently strong to generate endogenous cycles. For the postwar period, we find that mortgage debt increases GDP (2.95) and that the mortgage leverage ratio is counter-cyclical (−0.02). Thus, both coefficients have "perverse" signs. The discriminant of the system is negative (−0.23), and the calculated cycle length is 10.06 years. The system generates endogenous "anti-Minsky" oscillations. For the post-1973 period, the results are similar to the full sample ones in terms of signs and statistical significance of the main coefficients of interest. Overall, therefore, we fail to find evidence for Minskyan mortgage debt-GDP cycles.

In the light of the GFC, the lack of evidence for mortgage-growth interaction cycles in the United States may be surprising. This might be due to different reasons. First, the findings might suggest that the 2008 financial crisis, in which the US mortgage market clearly played a major role, is the exception rather than the rule and corporate debt that has been driving the medium-term cycles. Second, it is possible that our specification has too simple a dynamic structure to capture the negative effects of mortgage debt on GDP. Mian *et al.* report that effects change with the time horizon. However, it is not obvious why this issue would be more of a problem for mortgage debt than for corporate debt. Third, it is possible that our estimation approach captures the regular medium-term cycle related to business borrowing, but the housing cycle does not follow our simple Minsky debt cycle model but is driven by real estate prices that follow a momentum trader cycle. As our model does incorporate real estate price dynamics, it may not adequately capture the housing cycle.

We note that mortgage debt and (real) house prices are correlated. The differences in the correlation coefficient is 0.18 (statistically significant at the 5% level). Mortgage debt might drive house prices (via housing transactions with slowly adjusting supply) rather than real expenditures. To explore this possibility, we have also estimated a 2D system with house prices and mortgage debt. For a cycle to operate, mortgage debt would have to respond positively to changes in house prices (the overshooting force), and the level of mortgage debt dampens house price growth. However, we failed to find evidence for such a model to work for the full sample and the subsamples.[7] This is consistent with the hypothesis that house prices are driven by momentum trader cycles, where the cyclical mechanism is based on the interaction of different expectation heuristics, with debt playing an amplifying but auxiliary role (Bofinger *et al.*, 2013; De Grauwe and Macchiarelli, 2015). Gusella and Stockhammer (2021) provide evidence for such cycles in house prices without including a role for debt.

Finally, we compare our findings to the extant literature. Our approach is closest to Stockhammer *et al.* (2019), but for a substantially longer period. Their entire sample roughly corresponds to our neoliberal period. Our results are broadly similar, but with some differences. They find weak evidence for corporate debt-GDP cycles in the United States[8] and no evidence for household debt-GDP cycles. Our study covers a different period, but the difference in findings may be due to data used: whereas the present paper uses the long time-span historical macroeconomic of Jordà *et al.* (2017), Stockhammer *et al.* (2019) use short time-span data on the total credit to the corporate sector from the Bank of International Settlements. The Jordà *et al.* (2017) series is spliced from many distinct sources. For example, loans to the non-financial private sector for the

7 Results are available upon request.

8 Stockhammer *et al.* (2019) also report more robust evidence for corporate debt-investment cycles, consistent with our findings.

Table 4. GDP-mortgage debt cycles

Equations				Adj. R^2	BG LM test	White test	Discriminant	Cycle length (years)
Full sample (1891–2014)								
$\Delta(log(GDP))_t =$	$-0.21*$ $\Delta(log(GDP))_{t-1}$ [0.501]	$+0.07*$ $\Delta(MDEBT)_{t-1}$ [0.859]	$+0.42*$ $MA(1)$ [0.144]	0.24	0.49	0.99	N/A	N/A
$\Delta(MDEBT)_t =$	$0.12*$ $\Delta(log(GDP))_{t-1}$ [0.000]	$+0.44*$ $\Delta(MDEBT)_{t-1}$ [0.001]	$+0.49*$ $MA(1)$ [0.000]	0.45	0.32	0.00		
Liberal period (1891–1939)								
$\Delta(log(GDP))_t =$	$-0.35*$ $\Delta(log(GDP))_{t-1}$ [0.490]	$-1.20*$ $\Delta(MDEBT)_{t-1}$ [0.162]	$+0.28*$ $MA(1)$ [0.544]	0.06	0.96	0.87	0.04	N/A
$\Delta(MDEBT)_t =$	$0.16*$ $\Delta(log(GDP))_{t-1}$ [0.003]	$+0.55*$ $\Delta(MDEBT)_{t-1}$ [0.030]	$+0.53*$ $MA(1)$ [0.017]	0.38	0.29	0.13		
Keynesian period (1945–1972)								
$\Delta(log(GDP))_t =$	$0.36*$ $\Delta(log(GDP))_{t-1}$ [0.263]	$+2.95*$ $\Delta(MDEBT)_{t-1}$ [0.014]	$+0.14*$ $MA(1)$ [0.705]	0.19	0.79	0.66	–0.23	10.06
$\Delta(MDEBT)_t =$	$-0.02*$ $\Delta(log(GDP))_{t-1}$ [0.696]	$+0.31*$ $\Delta(MDEBT)_{t-1}$ [0.371]	$+0.04*$ $MA(1)$ [0.923]	0.05	0.65	0.13		
Neoliberal period (1973–2014)								
$\Delta(log(GDP))_t =$	$-0.26*$ $\Delta(log(GDP))_{t-1}$ [0.489]	$+0.68*$ $\Delta(MDEBT)_{t-1}$ [0.051]	$+0.57*$ $MA(1)$ [0.117]	0.13	0.78	0.74	N/A	N/A
$\Delta(MDEBT)_t =$	$0.14*$ $\Delta(log(GDP))_{t-1}$ [0.046]	$+0.35*$ $\Delta(MDEBT)_{t-1}$ [0.047]	$+0.63*$ $MA(1)$ [0.000]	0.54	0.88	0.49		

P-values in brackets. Values for specification tests are *P*-values corresponding to nR^2. BG LM test at second lag. Constant terms and dummy variables for the World War years are included but not reported.

United States are calculated from the information in Federal Reserve archives, work by economic historians, and more recently, Federal Reserve flow of funds tables. These data only cover loans from depository institutions. In comparison, the BIS data are mainly drawn from official flow of funds data and cover loans from all sources. While the latter is a better measure of indebtedness, it is only available for shorter periods, which does not allow us to evaluate Minsky-type cycles in a historical context. The BIS provides data on household debt, whereas we use data on mortgage debt. However, the overall results are similar: the evidence for corporate debt cycles is stronger than for mortgage cycles. We add to this evidence that during the postwar period with Keynesian economic policies, the corporate debt cycle was muted.

Compared to earlier Minskyan contributions, like Palley (1994) and Kim (2013, 2016) who show that consumer debt has driven aggregate demand fluctuations for part of the post-WWII period, our results show that corporate indebtedness might have played a more important role for endogenous growth fluctuations over the last century. Methodologically, our approach has significant advantages over Palley's and Kim's, since we assess both the sufficient and necessary conditions for the emergence of endogenous fluctuations in the context of a system of differential equations. Further, our findings relate directly to the original proposition of Minsky that endogenous cycles emerge from the interaction between corporate indebtedness and real investment.

As regards the financial cycles and macroeconomic financial history literature, our approach analyses both legs of the cycle mechanism. Schularick and Taylor (2012) and Jordà *et al.* (2013) show that total credit hampers growth and investment over the long run, which is only one of the necessary mechanisms for endogenous cycles. Moreover, our allows identifying corporate debt as the main driving force behind endogenous cycles. Compared to Jordà *et al.* (2016), who demonstrate that both mortgage and non-mortgage debt increase the probability of financial crises in a wide range of countries, in the long run, our results clarify that (in the United States) financial cycles are driven by corporate debt rather than mortgages.

6. Conclusion

Most of the recent contributions to the analysis of financial cycles either focus on univariate cycles in financial variables (Borio, 2014; Aikman *et al.*, 2015) or on the negative growth effects of indebtedness (Jordà *et al.*, 2013; Mian *et al.*, 2017). Similarly, much of the empirical Minsky literature focuses on the negative effect of corporate debt on investment (Fazzari *et al.*, 1988; Davis *et al.*, 2019; Nishi, 2019). This paper provides an empirical examination of Minsky's theory of endogenous cycles resulting from the interaction of procyclical DEBTs and the negative effect of debt on growth. It thereby pinpoints the endogenous nature of financial cycles (Stockhammer *et al.*, 2019). We estimate simple VARMA models in debt and output, in which the conditions for oscillations driven by the interaction between debt and GDP growth can be easily evaluated. We use historical macroeconomic data for the United States covering the period between 1889 and 2014. The paper thus goes beyond the existing econometric studies in the Minsky tradition (Palley, 1994; Kim, 2013, 2016; Stockhammer *et al.*, 2019) in that it considers corporate debt as well as mortgage debt as debt variables and covers a much longer time horizon.

Our results provide robust evidence for Minskyan cycles driven by the interaction of corporate debt and real investment growth or real GDP growth for the United States. These results are driven by the more liberal pre-WWII and post-1973 periods. We find that increases in the corporate debt–income ratio decrease investment and GDP growth, while increases in real investment or GDP growth lead to increases in the debt–income ratio. The implied cycle length (for the full sample) is 11 and 12 years for GDP and investment, respectively. Thus, the interaction cycles are substantially longer than the regular business cycle. In contrast, our results for mortgage debt-GDP interaction cycles offer no evidence for the existence of a Minskyan cycle driven by the interaction of mortgage debt and real GDP growth for the United States.

Our approach sheds light on the endogeneity of a debt-driven cycle mechanism, which is consistent with Hyman Minsky's theory of endogenous crises.[9] This has been the case for the past century and is not only valid for the period of neoliberalism. It suggests that corporate debt plays a key role in the medium-term cycle. However, economic policy matters: cycles are subdued during the Keynesian period. Perhaps surprisingly, given the prominence that household debt has gained debates on financial instability since the GFC, our results for mortgage debt are weaker than those for corporate debt. However, the fact that we find no evidence for mortgage debt-driven cycles does not necessarily imply that mortgage debt is not important. In particular, our results are not inconsistent with findings that household debt led to deeper recessions. A possible way to reconcile our findings with the Minskyan literature on household debt is to interpret changes in mortgage debt as driven by speculative real estate prices (e.g., Ryoo, 2016; Gusella and Stockhammer, 2021). This suggests that integration of asset prices (and possibly monetary policy) and the estimation of higher-order, fully specified finance-driven models would be a useful next step.

Acknowledgments

This paper is part of the research project "*Income Distribution, Asset Prices and Aggregate Demand Formation, 1850-2010: A post-Keynesian Approach to Historical Macroeconomic Data*" (INO16-00008) with financial support from the *Institute for New Economic Thinking*. We are grateful to Rob Calvert Jump for extensive discussions and advice on the econometric methodology used in the paper. We would also like to thank Erik Bengtsson, Karsten Köhler, Maria Nikolaidi, Ron Smith, and two anonymous referees for helpful comments and suggestions on earlier versions of this paper. All the remaining errors are ours.

References

Aglietta, M. (1979), 'A theory of capitalist regulation,' in *The US Experience*. Verso: London.

Aikman, D., A. G. Haldane and B. D. Nelson (2015), 'Curbing the credit cycle,' *The Economic Journal*, **125**(585), 1072–1109.

Amin, A. (ed.), (1994), *Post-Fordism. A Reader*. Blackwell Publishers: Oxford.

Arza, V. and P. Español (2008), 'Les liaisons dangereuses: a Minskyan approach to the relation of credit and investment in Argentina during the 1990's,' *Cambridge Journal of Economics*, **32**(5), 5.

Asada, T. (2001), 'Nonlinear dynamics of debt and capital: a post-Keynesian analysis,' in Y. Aruka (ed.), *Evolutionary Controversies in Economics*. Springer: Japan, pp. 73–87.

Bezemer, D., M. Grydaki and L. Zhang (2016), 'More mortgages, lower growth?,' *Economic Inquiry*, **54**(1), 652–674.

Bofinger, P., S. Debes, J. Gareis and E. Mayer (2013), 'Monetary policy transmission in a model with animal spirits and house price booms and busts,' *Journal of Economic Dynamics & Control*, **37**(12), 2862–2881.

Borio, C. (2014), 'The financial cycle and macroeconomics: what have we learnt?' *Journal of Banking & Finance*, **45**, 182–198.

Brooks, C. (2014), 'Introductory Econometrics for Finance (3rd ed.)'. Cambridge University Press: Cambridge.

Caldentey, E. P., N. Favreau Negront and L. Méndez Lobos (2019), 'Corporate debt in Latin America and its macroeconomic implications,' *Journal of Post Keynesian Economics*, **42**(3), 335–362.

Charles, S. (2008), 'Teaching Minsky's financial instability hypothesis: a manageable suggestion,' *Journal of Post Keynesian Economics*, **31**(1), 125–138.

Dafermos, Y. (2018), 'Debt cycles, instability and fiscal rules: a Godley–Minsky synthesis,' *Cambridge Journal of Economics*, **42**(5), 1277–1313.

Davis, L., P. de Souza and G. Hernandez (2019), 'An empirical analysis of Minsky regimes in the US economy,' *Cambridge Journal of Economics*, **43**(3), 541–583.

De Grauwe, P. and C. Macchiarelli (2015), 'Animal spirits and credit cycles,' *Journal of Economic Dynamics & Control*, **59**, 95–117.

9 Our results are arguable, but also consistent with New Keynesian theories of the financial accelerator. See Stockhammer *et al*. (2019) for a more detailed discussion.

Dieci, R. and F. Westerhoff (2016), 'Heterogeneous expectations, boom-bust housing cycles, and supply conditions: A nonlinear economic dynamics approach,' *Journal of Economic Dynamics and Control*, **71**, 21–44.

Drehman, M., C. Borio and K. Tsatsaronis (2012). 'Characterising the financial cycle: don't lose sight of the medium term!' *BIS Working Papers*, No 380, 1–43.

Dufour, J. and D. Pelletier (2011), 'Practical methods for modelling weak VARMA processes: identification, estimation and specification with a macroeconomic application,' *Discussion Paper, Department of Economics, McGill University, CIREQ & CIRANO*.

Dutt, A. K. (2006), 'Maturity, stagnation and consumer debt: a Steindlian approach,' *Metroeconomica*, **57**(3), 339–364.

Eichengreen, B. (2019), *Globalizing Capital*. Princeton University Press: New Jersey.

Fazzari, S., P. Ferri and E. Greenberg (2008), 'Cash flow, investment, and Keynes–Minsky cycles,' *Journal of Economic Behavior & Organization*, **65**(3–4), 555–572.

Fazzari, S. M., R. G. Hubbard and B. C. Petersen (1988), 'Financing constraints and corporate investment,' *Brookings Papers on Economic Activity*. pp. 141–195.

Fazzari, S. M. and T. L. Mott (1986), 'The investment theories of Kalecki and Keynes: an empirical study of firm data, 1970–1982,' *Journal of Post Keynesian Economics*, **9**(2), 171–187.

Galbraith, J. K. (1955), *The Great Crash, 1929*. Pelican: London.

Gatti, D. D. and M. Gallegati (1990), 'Financial instability, income distribution, and the stock market,' *Journal of Post Keynesian Economics*, **12**(3), 356–374.

Glyn, A. (2006), *Capitalism Unleashed: Finance, Globalization and Welfare*. Oxford University Press: Oxford.

Gusella, F. and E. Stockhammer (2021), 'Testing fundamentalist–momentum trader financial cycles: an empirical analysis via the Kalman filter,' *Metroeconomica*, **72**(4), 758–797.

Isenberg, D. (1989), 'The financially fragile firm: is there a case for it in the 1920s?' *Jerome Levy Economics Institute*. *Working Paper No. 15*.

Johnston, L. and S. H. Williamson (2021). What Was the U.S. GDP Then? *Measuring Worth Foundation*. https://www.measuringworth.com/datasets/usgdp/.

Jordà, Ò., M. Schularick and A. M. Taylor (2013), 'When credit bites back,' *Journal of Money, Credit, and Banking*, **45**(s2), 3–28.

Jordà, Ò., M. Schularick and A. M. Taylor (2015), 'Leveraged bubbles,' *Journal of Monetary Economics*, **76**, S1–S20.

Jordà, Ò., M. Schularick and A. M. Taylor (2016), 'The great mortgaging: housing finance, crises and business cycles,' *Economic Policy*, **31**(85), 107–152.

Jordà, Ò., M. Schularick and A. M. Taylor (2017), 'Macrofinancial history and the new business cycle facts,' in M. Eichenbaum and J. A. Parker (eds), *NBER Macroeconomics Annual 2016*. Vol. 31 University of Chicago Press: Chicago, IL, pp. 213–263.

Kapeller, J. and B. Schutz (2014), 'Debt, boom, bust: a theory of Minsky–Veblen cycles,' *Journal of Post Keynesian Economics*, **36**(4), 781–814.

Keen, S. (1995), 'Finance and economic breakdown: modeling Minsky's "financial instability hypothesis",' *Journal of Post Keynesian Economics*, **17**(4), 607–635.

Kim, Y. K. (2013), 'Household debt, financialization, and macroeconomic performance in the United States, 1951-2009,' *Journal of Post Keynesian Economics*, **35**(4), 675–694.

Kim, Y. K. (2016), 'Macroeconomic effects of household debt: an empirical analysis,' *Review of Keynesian Economics*, **4**(2), 127–150.

Kiyotaki, N. and J. Moore (1997), 'Credit cycles,' *Journal of Political Economy*, **105**(2), 211–248.

Kohler, K. and R. Calvert Jump (2022), 'Estimating nonlinear business cycle mechanisms with linear vector autoregressions: a Monte Carlo study,' *Oxford Bulletin of Economics and Statistics*.

Koreisha, S. G. and Y. Fang (2001), 'Generalized least squares with misspecified serial correlation structures,' *Journal of the Royal Statistical Society. Series B, Statistical Methodology*, **63**(3), 515–531.

Koreisha, S. G. and T. Pukkila (1990), 'A generalized least-squares approach for estimating autoregressive moving-average models,' *Journal of Time Series Analysis*, **11**(2), 139–151.

Kuznets, S. and E. Jenks (1961), 'Appendices and Index to "Capital in the American Economy: Its Formation and Financing",' In *Capital in the American Economy: Its Formation and Financing*. Princeton University Press, pp. 465–664.

Lavoie, M. and M. Seccareccia (2001), 'Minsky's financial fragility hypothesis: a missing macroeconomic link,' *Financial Fragility and Investment in the Capitalist Economy: The Economic Legacy of Hyman Minsky*, **2**, 76–96.

Lima, G. T. and A. J. A. Meirelles (2007), 'Macrodynamics of debt regimes, financial instability and growth,' *Cambridge Journal of Economics*, **31**(4), 563–580.

Marglin, S. and J. Schor (eds), (1990), *The Golden Age of Capitalism. Reinterpreting the Postwar Experience*. Clarendon: Oxford.
Mian, A. R., A. Sufi and E. Verner (2017), 'Household Debt and Business Cycles Worldwide,' *The Quarterly Journal of Economics*, **132**(4),1755–1817.
Minsky, H. P. (1975), *John Maynard Keynes*. Palgrave Macmillan: London, UK.
Minsky, H. P. (1986), *Stabilizing an Unstable Economy*. 2nd edn. McGraw-Hill: New York, NY, p. 2008.
Minsky, H. P. (1991), 'Financial crises: Systemic or idiosyncratic,' *Levy Economics Institute. Working Paper No. 51*.
Minsky, H. P. (1992), 'The financial instability hypothesis,' *Levy Economics Institute. Working Paper No. 74*.
Mulligan, R. F. (2013), 'A sectoral analysis of the financial instability hypothesis,' *The Quarterly Review of Economics and Finance*, **53**(4), 450–459.
Ndikumana, L. (1999), 'Debt service, financing constraints, and fixed investment: evidence from panel data,' *Journal of Post Keynesian Economics*, **21**(3), 455–478.
Nikolaidi, M. (2014), 'Margins of safety and instability in a macrodynamic model with Minskyan insights,' *Structural Change and Economic Dynamics*, **31**, 1–16.
Nikolaidi, M. and E. Stockhammer (2017), 'Minsky models: a structured survey,' *Journal of Economic Surveys*, **31**(5), 1304–1331.
Nishi, H. (2019), 'An empirical contribution to Minsky's financial fragility: evidence from non-financial sectors in Japan,' *Cambridge Journal of Economics*, **43**(3), 585–622.
Palley, T. I. (1994), 'Debt, aggregate demand, and the business cycle: an analysis in the spirit of Kaldor and Minsky,' *Journal of Post Keynesian Economics*, **16**(3), 371–390.
Palley, T. I. (2011), 'A theory of Minsky super-cycles and financial crises,' *Contributions to Political Economy*, **30**(1), 31–46.
Reissl, S. (2020), 'Minsky from the bottom up – formalising the two-price model of investment in a simple agent-based framework,' *Journal of Economic Behavior & Organization*, **177**, 109–142.
Ruggie, J. G. (1982), 'International regimes, transactions, and change: embedded liberalism in the postwar economic order,' *International Organization*, **36**(2), 379–415.
Ryoo, S. (2010), 'Long waves and short cycles in a model of endogenous financial fragility,' *Journal of Economic Behavior & Organization*, **74**(3), 163–186.
Ryoo, S. (2013), 'Bank profitability, leverage and financial instability: a Minsky–Harrod model,' *Cambridge Journal of Economics*, **37**(5), 1127–1160.
Ryoo, S. (2016), 'Household debt and housing bubble: a Minskian approach to boom-bust cycles,' *Journal of Evolutionary Economics*, **26**(5), 971–1006.
Ryoo, S. and Y. K. Kim (2014), 'Income distribution, consumer debt and keeping up with the Joneses,' *Metroeconomica*, **65**(4), 585–618.
Schularick, M. and A. M. Taylor (2012), 'Credit booms gone bust: monetary policy, leverage cycles, and financial crises, 1870–2008,' *The American Economic Review*, **102**(2), 1029–1061.
Stockhammer, E., R. C. Jump, K. Kohler and J. Cavallero (2019), 'Short and medium term financial-real cycles: an empirical assessment,' *Journal of International Money and Finance*, **94**, 81–96.
Taylor, L., S. A. O'Connell (1985), 'A Minsky crisis,' *The Quarterly Journal of Economics*, **100**(Supplement), 871–885.
Wolfson, M. H. (1990), 'The causes of financial instability,' *Journal of Post Keynesian Economics*, **12**(3), 333–355.
Wray, L. R. (2009), 'The rise and fall of money manager capitalism: a Minskian approach,' *Cambridge Journal of Economics*, **33**(4), 807–828.
Wray, R. (2016), 'Why Minsky matters,' in G. Jones (ed), *An Introduction to the Work of a Maverick Economist*. Princeton University Press: Princeton, pp. 230–240.

Appendix

A1. ADF unit root tests

A2. Calculating Cycle Length for VAR Models

As suggested by Stockhammer *et al.* (2019), if the Jacobian matrix of a system estimated as a VAR model contains at least one pair of complex conjugate eigenvalues (λ), then the cycle length can be calculated as follows.

The polar form of a pair of complex conjugate eigenvalues ($\lambda = h \pm \Omega i$) is given as:

$$\lambda = R(cos\theta \pm i.sin\theta)$$

Table A1. ADF unit root tests

	ADF test		
Variable	**Levels**	**First differences**	**Conclusion**
Log (GDP)	(1.000)	(0.000)	I(1)
Log (INV)	(0.995)	(0.000)	I(1)
BDEBT	(0.515)	(0.000)	I(1)
MDEBT	(0.692)	(0.000)	I(1)

Values corresponding to ADF tests are *P*-values.

where $R = \sqrt{h^2 + \Omega^2}$ is the modulus, θ is an angle measured in radians, h (real part) is $\frac{Tr}{2}$, and Ω is $\frac{\sqrt{\Delta}}{2}$. In the context of the 2D system (1), the matrix's trace is $Tr = J_{11} + J_{22}$, and the matrix's discriminant is $\Delta = (J_{11} - J_{22})^2 + (4 * J_{21} * J_{12})$. Transforming the eigenvalues (λ^t) into their polar form based on De Moivre's theorem, we get the form of the following trigonometric expression:

$$\lambda^t = [R(cos\theta \pm i.sin\theta)]^t = R^t (cos\theta t \pm i.sin\theta t)$$

Accordingly, a distinct cycle frequency can be derived from each pair of complex eigenvalues of a VAR system, and the implied cycle length can be calculated as follows:

$$\text{Cycle Length} = \frac{2\pi}{\theta} = \frac{2\pi}{\arccos\left(\frac{h}{R}\right)}$$