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Statistical Analysis of Minsky's Financial Instability Hypothesis for the 1945–2023 Era

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Abstract: Following the 2008 financial crisis, Hyman Minsky's Financial Instability Hypothesis (FIH) emerged as a prominent financial theory to explain the occurrence of business cycles in the U.S. economy. There have been many theoretical, but few empirical studies dedicated to FIH. The current literature also lacks the statistical support to confirm the necessary conditions leading to financial instability and whether FIH concepts remains applicable in the post 1980s periods. This article presents a statistical methodology to analyze the financial debt ratios related to FIH for the 1945–2023 periods through the use of nonparametric statistical analyses of ordered alternatives and a binomial test for meta-analysis. The results indicated that the conditions leading to financial instability such as debt ratios did increase prior to the onset of a recession as prescribed by FIH during the 1945–1980s era. Furthermore, such conditions also repeated prior to some recessions occurred in the 2001–2023 periods. This study provides statistical support for Minsky's FIH theory.

Keywords: Minsky; financial instability hypothesis; financial crisis; financial debt ratios; page test

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1. Introduction

Since World War II (WWII), the United States (U.S.) economy has experienced a series of major economic fluctuations known as business cycles, characterized by the expansion and contraction of the national gross domestic product (GDP) (Madhani 2010). Economists and scholars alike have tried to identify and explain the root cause of this systemic economic problem; among them was the American economist, Hyman Minsky. Minsky discovered that after the Great Depression of 1929 and WWII, the U.S. economic model became highly influenced by Keynesian economic principles where the U.S. government and the central bank intervened with the free market to maintain economic stability (Keynes 1936). This model helped prevent deep prolonged economic depressions but replaced them with many short recessions (Minsky 1986). Minsky explored the financial interactions within the U.S. economy and found that post WWII, business cycles were typically influenced by a combination of Keynesian-like interventions and the prolific use of external debts to finance investments. When the government or central bank intervened with the free market through fiscal or monetary policies, it stabilized the market prices and promoted new investments. On the other hand, the ability to finance investments through external sources allowed new investments to be created beyond the availability of internal funds. This created a delicate environment where external debt must be repaid in the future by the expected profits. However, Minsky found that fiscal and monetary intervention were inflationary in nature. To maintain balance, interest rates were often increased to reduce inflation. This increase in interest rates disrupted the balance between the cost of capital and the expected profits, which led to difficulty in financing investments and repaying debt. Thus, as the economy continued to expand, the financial structure became increasingly

unstable, and this eventually led to an economic contraction. Minsky described these dynamic interactions as the Financial Instability Hypothesis (FIH) (Minsky 1982).

Following the 2008 financial crisis, Minsky's FIH re-emerged as a prominent and insightful theory that explained the events and causes leading up to the crisis in which the Wall Street Journal reported it as the Minsky Moment (Lahart 2007); however, the current literature shows very few empirical studies with statistical support to confirm whether FIH concepts remain applicable to the periods beyond the 1945–1980s era. In one of the early studies, Isenberg (1988) invalidated Minsky's FIH concepts using 1920s firms' financial data. Isenberg hypothesized that if FIH holds true, the firms with the highest growth should increase their debt-to-equity level during the economic expansion cycle. Isenberg found that FIH was not applicable to the 1920s era because the debt-to-equity level of the firms with the highest growth did not rise when the economy fell into the Great Depression of 1929. Isenberg's study is polemic and has continued to be debated. Firstly, Minsky developed FIH from analysis of a post-WWII economic model; thus, whether or not FIH was applicable prior to 1945 periods neither confirmed nor invalidated the theory. Secondly, Isenberg's study lacks statistical evidence to support its finding where insights were primarily drawn from the simple observation of a firm's debt-to-equity values. Another empirical study was carried out by Hannsgen (2005) where he confirmed that the impact from monetary policy (i.e., aggressive changes in interest rate) during the 1960–2002 period indeed had a destabilizing effect on the economy, consistent with Minsky's FIH concepts. However, Hannsgen's study was limited to the impact of interest rate changes only and it is still uncertain whether Hannsgen's methodology can be extended beyond 2002.

There are also a number of other empirical studies that support various elements of FIH. For example, Schroeder (2009) wrote a critical review of how other studies defined financial fragility and extended the work of Foley (2003) by developing her own model to detect financial fragility using New Zealand firms' financial data during the 1990–2007 period. The model looked at the rate of capital accumulation, profit and interest rate then evaluated the empirical data to look for financial fragility when profit rate is below interest rate with increasing capital accumulation, which did occur during the 2004–2007 periods. In a similar fashion, Tymoigne (2014) adapted the FIH framework into financial fragility indices for housing finances in the United States, the United Kingdom, and France. The index was modeled as a sum of all weighted variables such as: home mortgage of households, home price index, mortgage–financial obligation ratio or interest–obligation ratio, etc. Tymoigne found the indices for all three countries rapidly increased as 2008 approached. Nishi (2019) continued the work on the financial fragility index by incorporating the margins of safety in terms of capital values and liquid asset kicker and evaluated his model against Japanese empirical data for the non-financial sector during 1975–2014. He found that small-size and non-manufacturing firms were more financially fragile.

Aside from the financial fragility component, there were a few studies that looked at other essential elements of FIH. For example, Barnes (2011) argued that while Minsky's FIH was applicable to the 2008 financial crisis, it ignored the empirical evidence of financial accounting manipulation and financial fraud that contributed to the crisis. Silipo (2011) found empirical support for FIH through the increases in risk appetite evidence in the financial ratios (e.g., debt to GDP, debt to income, debt to net worth, etc.) and increases in financial innovations. Mulligan (2013) used quarterly financial data from 8707 North American companies between 2002 and 2009 to classify the firms into groups of hedge, speculative, or Ponzi firms, as described by Minsky's FIH. The study found that prior to the 2008 recession, the number of speculative and Ponzi firms did increase, and the firms' debt-to-equity ratio also increased prior to the recession. This study used T-test statistical analysis to support the finding. Although this study analyzed a large amount of empirical data, its findings only reflect the 2008 recession and do not offer insight into prior recessions nor potential future recession.

There is no question that the current literature surrounding Minsky's FIH found convincing empirical evidence to support his theory, and FIH certainly has significant merit to the understanding of the business cycles. The question is: does FIH remain applicable to the current U.S. economic model? This article aims to advance the current literature through systems and a statistical analysis approach to address this question by focusing on the following fundamental questions:

1. What are the critical necessary conditions applicable to FIH?
2. How can these conditions be validated?
3. Do these conditions continue to persist in the U.S. economy?

This study deconstructed the FIH framework into a causal loop diagram to define its major components and found that the financial debt ratios were the most critical element of FIH. The critical necessary conditions leading to financial instability were the persistent increases in the financial debt ratios. This article presents a methodology to statistically validate these conditions for the period from 1945 to 2023. The study statistically analyzed the financial ratios related to debt (e.g., liabilities to income ratio, liabilities to savings ratio, short term debt to liquid asset, etc.) for the U.S. economy in four different groups: households, nonfinancial corporates, nonfinancial non-corporates, and financial businesses. A total of seven financial debt ratios were evaluated. This study hypothesized that if FIH concepts (regarding debt) hold true, there should be evidence of persistent increases in the financial debt ratios prior to each recession. The method to statistically confirm whether each financial debt ratio measurement increased prior to a recession was accomplished using the nonparametric Page test for ordered alternatives, also known as Page's trend test, or simply the Page test. This testing method is suitable to detect the existence of a positive growth over a series of measurements. Since the Page test was used in this analysis multiple times (seven tests, one for each financial debt ratio), the risk of having at least one false alarm (Type I error) increased significantly. To address this issue, a nonparametric binomial test was added to determine whether the Page test collective results can be distinguished from the pure randomness or Type I error. It is worth mentioning that it is possible to conceive different approaches for this analysis, such as times series or regression modeling; however, these approaches require individual series modeling, and the incorporation of several series into a single analysis becomes cumbersome and unwieldy, whereas the Page test is both simple and effective. This "simplicity" of the Page test allows for the detection of multiple types of growths: linear, non-linear, or step shifts. This omnibus reduces the power to evaluate a particular type of chance but allows the analysis of variety with enough statistical evidence to be meaningful, as the reader will discover in later sections.

The remainder of this article is organized as follows: The Materials and Methods section briefly discusses Minsky's Financial Instability Hypothesis to establish the fundamental understanding of the primary theory to be analyzed, followed by discussion of the methodology to validate the increases in financial debt ratios. Section 3 discusses the results, and the last section presents the concluding remarks regarding the findings and contributions to the current literature.

2. Materials and Methods

2.1. Minsky's Financial Instability Hypothesis

Before diving into the validation methodology, it is worth reviewing the *Financial Instability Hypothesis* developed by Minsky to understand its critical components and intended application. While some economic theories view the business cycle as an unexpected occurrence caused by external shocks to the economic system (Kydland and Prescott 1982; Drazen 2008), American economist Hyman Minsky investigated the financial interactions within the Keynesian-dominated post-WWII U.S. economic model and discovered that the business cycle is not an economic anomaly but rather it behaves in an expected manner within the model itself. Minsky developed FIH to explain how Keynesian economic principles and the dynamic financial interaction within the same economic system generate both economic expansion and recession.

Minsky discovered that debt-financed investments became more prolific in the post-WWII U.S. capitalist economy. This type of finance implies a commitment to repay, which Minsky referred to as contractual cash flows (Minsky 1986). Minsky categorized these contractual cash flows into three types of finance: *hedge*, *speculative*, and *Ponzi*. A hedge-financed investment typically has cash flows that exceed all debt repayment obligations (principal and interest) in each time period. Speculative-financed investment only has enough cash flows to meet the debt interest commitment but not the principal, this type of finance must continue to roll over mature debts, and the size of the original debt is never reduced. Ponzi-financed investment is one where cash flows cannot meet the debt principal nor the interest repayment obligation. This type of finance must rely on the ability to obtain new debts in order to meet the near-term cash outflow commitment. Thus, these types of finance structures define the level of financial stability or instability within the U.S. economic system. How the U.S. economy progresses from hedge finance to speculative or Ponzi finance is influenced by the Keynesian economic principles that allow the U.S. government and the central bank to intervene with the free market, which can be summarized as follows.

In times of economic stress, the conventional Keynesian response is for the government to intervene with fiscal spending and/or the central bank to exercise expansionary monetary actions. Fiscal spending generally stabilizes employment, and aggregates demands and income, while monetary actions through the Federal Reserve restore the market confidence and stabilizes liquidity flow and asset prices (Minsky 1986). While these interventions help prevent economic turmoil from worsening, most economic agents remain cautious with their investments; thus, the early phase of economic recovery predominantly consists of hedge finance where economic agents typically finance their investments with internal funds and maintain low debt levels. As time slowly erodes memories of recent economic turmoil, investors' confidence and optimism grow. At this point, Minsky identified several factors that contribute to an economic expansion and propel the economy from hedge to speculative or Ponzi finance:

1. Central Bank—expansionary monetary actions often resulted in an abundance of cheap liquidity, thus promoting new investment opportunities.
2. Profit—economic agents' profit-seeking tendency takes advantage of the cheap liquidity opportunities to pursue new investments by accumulating more debts.
3. Economic Euphoria—as economic recovery continues, a prolonged period of consistent profit helps validate past investment forecast and assessment of risk.
4. Risk Reduction—economic euphoria gradually relaxes investment risk. The excessive optimism and confidence in the safety net created by the central bank as the lender of last resort and government intervention led economic agents to accept riskier financial instruments and investments.
5. Financial Innovation—new financial instruments emerge to meet the rising investment demand and to circumvent regulation constraints.

The result is an expanding economy where investment demand exceeds the availability of internal funds, thus creating an environment where economic agents become increasingly reliant on external financing for capital ventures or expansion. This is what Minsky referred to as the upward instability of capitalism (Minsky 1986); that is, as the economy recovers and grows, the internal finance dynamics make it more vulnerable to the following disturbances:

1. Uncertainty—investment decisions are made based on past performance, yet with uncertain future profit expectation. When actual profits miss expectation, cash flows may become insufficient to meet the debt repayment obligation.
2. Labor and Material Cost Increase—as investments grow, so do the cost or demand for labor and raw materials. The increase in cost reduces the profit margin and operating incomes.
3. Reduced Regulations Effectiveness—the advent of new financial instruments is often equipped with mechanisms to circumvent regulation constraints which reduce the effectiveness to maintain financial stability.

4. Inflation—as economic expansion continues, it often puts pressure on inflation. The conventional response to combat rising inflation is for the central bank to raise the interest rate.
5. Rising Cost of Credit—the rise in interest rate increases the cost of borrowing and discourages future investments which reduces profit, income, and economic growth (Minsky 1986).

Together, the combination of government and central bank's interventions and the ability to utilize external debt to finance investments generates both stabilizing and destabilizing effects on the economy.

2.2. Financial Instability Hypothesis Conceptual Framework

As described above, Minsky's FIH contains many components. This framework is deconstructed into a causal loop diagram (as depicted in Figure 1 below) to summarize the interdependencies and identify the cause and effect of each component on the system as a whole (Phan and Beruvides 2018). This conceptual analysis of Minsky's FIH principles shows many balancing and reinforcing loops (labeled as B and R, respectively) within the system. A balancing loop is when all components within the loop tend to level out over time, whereas a reinforcing loop is when all components with the loop tend to persistently increase or decrease over time. Furthermore, the notation S and O below indicate whether one component exerts the same or opposite effect on the other component. For example, increasing revenue would also cause earnings to increase.

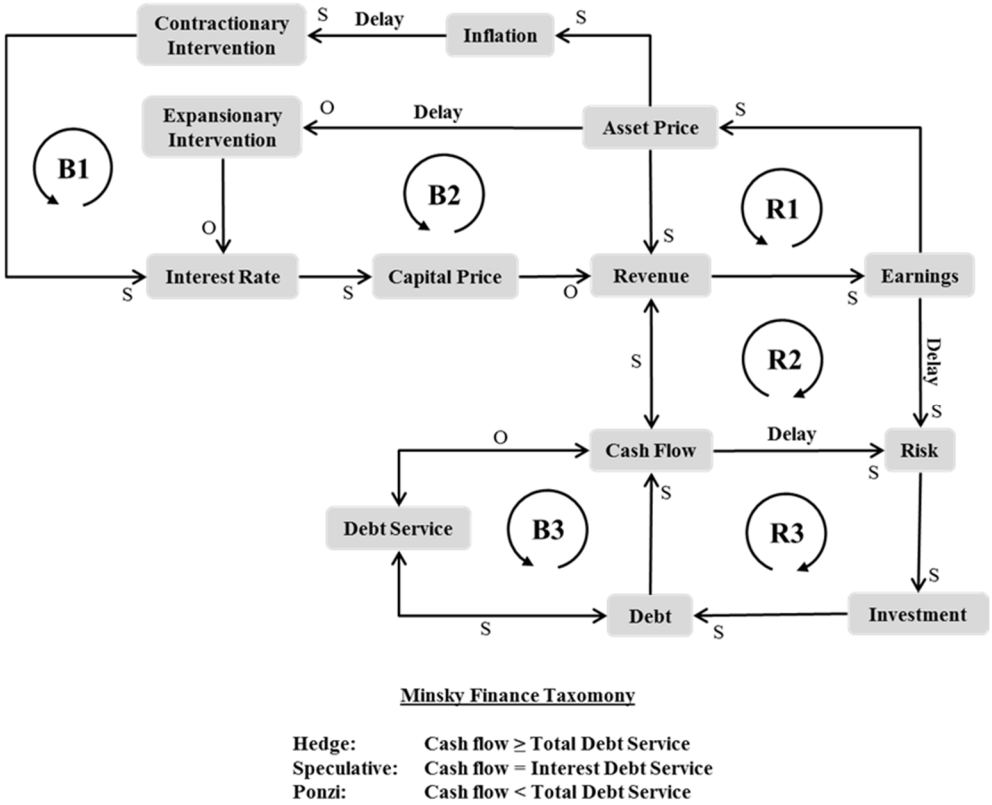

Figure 1. Conceptual framework of Minsky's Financial Instability Hypothesis.

This FIH conceptual model shows how the economic system progresses from a state of stability to instability and vice versa. The starting point may be in the economic expansionary phase where the interest rate is lowered leading to a lower cost of capital; this would tend to increase firms' revenue, earning, and cash flow (and would, in turn, increase households' earning as well). The delay between cash flow and risk or earning and risk represents the behavior during prolonged economic expansion where risk appetite is increased

due to consistent growth. The increase in risk is reflected by an increase in investments and debts. As debt level increases, it also increases the debt service. If economic agents operate within the hedge finance regime, the economic system should be stable where the increasing investments and earnings are sufficient to service the debts. However, economic participants are typically profit-seeking agents; to maintain consistent growth over time, risks, investments, and debts (along with other factors as mentioned in Section 2.1 above) gradually increase leading to an increase in asset price and inflation. Here, it can be marked as a temporary end to this cycle where economic expansion will eventually lead to high inflation. When inflation reaches an excessive level, this economic system would enter a new cycle where either the government or the central bank takes action to reduce inflation (represented by the delay between inflation and contractionary intervention). The typical action to reduce inflation is to increase the interest rate; this would cascade the opposite effect on the whole economic system where capital price increases leading to a reduction in revenue, earning, and cash flow. However, the existing debt service still expects the same level of earning or cash flow. If the debt level is high, there may not be sufficient cash flow to service the debt (speculative or Ponzi finance); thus, investment must be reduced, or assets must be sold to service the debts (also leading to decreases in asset price and inflation). Thus, the critical driver in FIH is debt; the rising accumulation of debt is a particularly necessary condition that contributes to a state change from stable hedge to unstable speculative or Ponzi finance. As mentioned above, the current literature already has many studies dedicated to detecting this state change (e.g., financial fragility index, interest rate change, etc.); however, the current literature lacks the empirical and statistical analysis to confirm this critical element of FIH and whether the debt level did increase before a recession during the periods that FIH was based on (1945–1980s) and whether this behavior continues to persist in the present day (2023), given that the U.S. economic model has remained relatively unchanged since the 1980s.

2.3. Methodology to Confirm the Necessary Conditions for Financial Instability Hypothesis

Minsky's FIH covered a wide range of topics which include the U.S. economic model, the impact of fiscal and monetary policies, financial innovations and regulations, the theoretical framework of profit, investment, prices, and the empirical observation of several other economic parameters such as unemployment and inflation (Minsky 1978, 1982, 1986, 1992). However, the primary focus of FIH was the impact of rising debts over a prolonged period of economic stability. Thus, to simplify the validation process to a manageable scope, this study focuses on the relationships of debt to equity, debt to income, debt to net worth, debt to total asset, and short-term debt to total debt. These ratios shall be henceforth referred to as the financial debt ratios (FDRs). A brief discussion of the FDR data and sources is presented below.

2.3.1. Financial Debt Ratios Data and Sources

To represent as much of the U.S. economic data population as possible, a total of 7 financial debt ratios in 4 different groups (households, nonfinancial corporates, nonfinancial non-corporates, and financial businesses) were chosen for this study. The financial debt ratios are identified in Table 1 below. Some financial debt ratios must be calculated from a composition of other financial series. It is worth noting that the financial series ID is labelled by the Federal Reserve Economic Data (FRED) and may be changed in the future; thus, each individual financial series ID and its description is presented in Table 2 below for reference.

Table 1. Financial debt ratios data.

Financial Ratio	Type	Formula by Source ID
Total liabilities to assets	HH	TLBSHNO/TFAABSHNO
Liability to net worth	HH	CMDEBT/TNWBSHNO
Short-term debt to liquid asset	NFC	(BLNECLBSNNCB + OLALBSNNCB + CPLBSNNCB + TPLBSNNCB + TXLBSNNB)/(FDABSNNCB + NCBCDCA + TSDABSNNCB + MMFSABSNNCB + SRPSABSNNCB + NCBDSTQ027S/1000 + NCBMFSA)
Debt to equity	NFC	NCBCMDPMVCE
Total liabilities to deposit	NFC	TLBSNNCB/(NCBCDCA + FDABSNNCB + TSDABSNNCB)
Total liabilities to deposit	NFNC	TLBSNNB/(NNBCDCA + TSDABSNNB)
Short-term debt to total debt	FB	FBSTLRQ027S/FBDSTSQ027S

Type: HH = household, NFC = nonfinancial corporate, NFNC = nonfinancial non-corporate, FB = financial business. Data source: https://fred.stlouisfed.org/ (accessed on 24 September 2023).

Table 2. Financial series identification.

ID	Type	Financial Series
CMDEBT	HH	Credit market instruments; liability, level
TFAABSHNO	HH	Total financial assets, level
TNWBSHNO	HH	Net worth, level
TLBSHNO	HH	Total liabilities, level
BLNECLBSNNCB	NFC	Depository institution loans not elsewhere classified; liability, level
NCBCDCA	NFC	Checkable deposits and currency; asset
CPLBSNNCB	NFC	Commercial paper; liability, level
NCBCMDPMVCE	NFC	Credit market debt as a percentage of the market value of corporate equities
NCBDSTQ027S	NFC	Debt securities; asset, level
MMFSABSNNCB	NFC	Money market mutual fund shares; asset, level
NCBMFSA	NFC	Mutual fund shares; asset
OLALBSNNCB	NFC	Other loans and advances; liability
FDABSNNCB	NFC	Private foreign deposits; asset
SRPSABSNNCB	NFC	Security repurchase agreements; asset, level
TLBSNNCB	NFC	Total liabilities, level
TSDABSNNCB	NFC	Total time and savings deposits; asset, level
TPLBSNNCB	NFC	Trade payables; liability, level
NNBCDCA	NFNC	Checkable deposits and currency; asset
TXLBSNNB	NFNC	Taxes payable; liability, level
TLBSNNB	NFNC	Total liabilities, level
TSDABSNNB	NFNC	Total time and savings deposits; asset, level
FBDSTSQ027S	FB	Debt securities; asset, level
FBSTLRQ027S	FB	Short-term loans including repurchase agreements; asset, level

Type: HH = household, NFC = nonfinancial corporate business, NFNC = nonfinancial non-corporate business, FB = financial business. Data source: https://fred.stlouisfed.org/ (accessed on 24 September 2023). The data were chosen based on the following criteria: (1) they closely reflect FIH concepts, (2) the data are available from credible sources for the 1945–2023 period, and (3) the data frequency (quarterly data) and data structure (number of quarters between recessions) are consistent so that they can be analyzed by the statistical methods. The data for this study were obtained directly from the Federal Reserve Economic Data (https://fred.stlouisfed.org/ accessed on 24 September 2023). These financial debt ratios were evaluated against the following general hypotheses.

Note that the public debt was not included in this analysis because it is not a major component of FIH. The core of FIH is based on the financial relationship between the financial institutions (banks) and the economic agents (firms or households). In other words, the bank lends money to the firm to finance its investment in exchange for an interest payment. This interest payment is presumably supported by the expected profit (or cash flow) from such investment. Financial instability is primarily the result of insufficient cash flow to service debt leading to the economic agent reducing its investment or liquidating its assets, etc., to service debt (Minsky 1986). This relationship is not well understood in FIH in terms of public debt. It would require a different study to analyze this FIH concept by evaluating federal, state, and local debt (bonds, treasury bills, etc.) and the mechanism to repay public debt (taxes, new issuance of bonds, etc.) and determine if this relationship exhibits the same speculative or Ponzi finance that contributes to a kind of financial instability (e.g., government, state, local bankruptcy? Bond holders' loss of confidence? etc.). It is uncertain whether the financial instability from public debt has the same characteristics as those generated by firms and households; thus, public debt was excluded from this study.

2.3.2. General Hypothesis

In accordance with FIH concepts, the general hypothesis is that over a prolonged period of economic expansion, the financial debt ratio will increase prior to each economic recession. The null (H_0) and alternative (H_1) hypotheses are:

H_0. *Financial debt ratio does not increase prior to economic recession.*

H_1. *Financial debt ratio increased prior to economic recession.*

Mathematically, hypotheses (H_0) and (H_1) can be expressed as:

$$H_0: X_1 = X_2 = X_3 \cdots = X_n, \tag{1}$$

$$H_1: X_1 < X_2 < X_3 \cdots < X_n, \tag{2}$$

where X_i represents the debt-related financial debt ratio for each financial period i. This hypothesis was evaluated by the nonparametric statistical method, the Page test (to be discussed in subsequence section); thus, this generated many results that must be analyzed collectively to confirm the alternate hypothesis. The process analyzing the collective results from the Page test followed the binomial test to determine whether they were due to actually detected growths or random occurrences. Since each Page test was subjected to a 5% significance level, on average, 1 out of 20 tests will reject the null hypothesis when the null hypothesis is true. To confirm that the Page test results did not come from this random chance of Type I errors, a binomial test was configured to measure if the number of significant Page tests was bigger than the expected number of false alarms. The binomial test is used for meta-analysis. As the probability of a Type I error in the Page test was 5%, the meta hypotheses are defined as:

H_2. *The number of significant increments in financial debt ratios are due to random chance.*

H_3. *The number of significant increments in financial debt ratios are not due to random chance.*

The expressions (H_2) and (H_3) are rewritten as:

$$H_2: \pi = 0.05, \tag{3}$$

$$H_3: \pi > 0.05. \tag{4}$$

where π represents the probability of Type I error.

2.3.3. Validation Process

The first step in validating the hypotheses above evaluated the chosen financial debt ratios against the post-WWII periods (1945–1980s); then the test was repeated for the 1990–2023 periods. The main objective of the validation was to determine whether the chosen financial debt ratio measurement increased prior to a recession. This type of test followed the design of the test for ordered alternatives developed by Ellis B. Page (2021), for its ability to detect a monotonic growth (or decay) within a set of different series.

One critical question was how many financial periods prior to a recession must be tested to properly evaluate if the financial debt ratios did increase prior to the recession? This question had not been addressed before; thus, there was no known or fixed number of financial periods to indicate the best result. Therefore, to provide insight into this inquiry, the validation process performed 5 iterations of the Page test for each financial debt ratio. The first iteration tested each FDR for 3 financial periods (quarters) prior to the recession. Each subsequent iteration increased the financial periods count by 1, such that the second iteration tests each FDR for 4 financial periods and so on until the last iteration tested for 7 financial periods prior to the recession. Starting the test at 3 financial periods was recommended by Page (2021) to obtain the minimum amount of data to yield meaningful results, and the reason for stopping the test at 7 financial periods was due to the data limitation that the shortest expansionary cycle between any 2 recessions lasted only 7 financial periods. Thus, expansionary cycles with fewer than 7 financial periods were excluded from this study because the Page test cannot be applied to an incongruent dataset. A brief overview of the Page test is discussed in the following section to help illustrate how the data were analyzed.

It is worth noting that the Page test had received some criticism due to the misuses by practitioners and the broad concept that represents a monotonic trend (Stadler 2021); however, it was exactly this ability to detect any type of growth or decay within a series that made the Page test attractive for the purpose of this specific study. Furthermore, since the Page test evaluates ordered alternatives, it uses the ranks of the data instead of the data itself. Information is lost in this process; however, flexibility is gained in exchange. The Page test can evaluate a wide range of increments that can help address Minsky's hypothesis. However, when the number of series used is small, or the number of periods is small, the Page test might fail to detect increments in favor of Minsky's hypothesis. For these periods, a model-based approach might be required; however, the task of doing that for each period and each series is monumental as a model might be required for each situation. For instance, a test for a linear trend can be used for each series, and the p-values combined in a single meta-analysis. This is possible as p-values under the null distribution behave as a uniform distribution, and p-values can be combined by adding them together. A new p-value from the combined results is obtained from the distribution of a sum of independent uniform distributions. This approach is feasible in many situations; however, it only holds for normal data. While the analysis can be adjusted to deal with other distributions using transformations or developing a new theory, assuming a distribution when dealing with small samples is a risky approach. To prove normality, for instance, a goodness of fit test is usually performed; nevertheless, goodness of fit tests are known to lack power and often fail to reject the normality hypothesis when they should. See (Khakifirooz et al. 2021) for a situation where parametric approaches assuming normality can be problematic, and goodness of fit tests are one of the root causes of the problem. The Page test can avoid the requirement of a specified distribution, and the analysis covers a wide range of monotonic increments in the evaluated series, not limited to linear situations. By using a nonparametric approach, power might be lost when compared with a situation where a parametric alternative is available and assumptions hold; however, the nonparametric approach has more power when the ideal conditions of the parametric alternatives do not hold. Since small samples do not provide strong evidence for a parametric test, the Page test is a more reliable alternative with a controlled degree of confidence. A third option is

the use of data-driven approaches, but there are insufficient data for rigorous training and validation for the rigorous assessment this study intended to carry out.

2.3.4. Page Test

Originally developed by Page (2021), this test for ordered alternatives utilized a randomized block design for the data which is a two-dimensional matrix consisting of m number of blocks where each block has n number of observations. In term of this study's data, the block represented the number of recessions, and the observation n represented the number of financial periods to be tested. The design model of the randomized block design and calculation of the trend value (L) is illustrated in Tables 3 and 4 below.

Table 3. Randomized block design model.

	Observations (*n*)				
Blocks (*m*)	**1**	**2**	**3**	. . .	***n***
1	X_{11}	X_{12}	X_{13}	...	X_{1n}
2	X_{21}	X_{22}	X_{23}	...	X_{2n}
3	X_{31}	X_{32}	X_{33}	...	X_{3n}
. . .	...	...	...	...	...
m	X_{m1}	X_{m2}	X_{m3}	...	X_{mn}

Table 4. Ordered rank matrix for the Page test.

	Ordered Rank (*n*)				
Blocks (*m*)	**1**	**2**	**3**	. . .	***n***
1	R_{11}	R_{12}	R_{13}	...	R_{1n}
2	R_{21}	R_{22}	R_{23}	...	R_{2n}
3	R_{31}	R_{32}	R_{33}	...	R_{3n}
. . .	...	...	...	...	...
m	R_{m1}	R_{m2}	R_{m3}	...	R_{mn}
$Y_j = \sum_{i=1}^{m} R_{ij}$	Y_1	Y_2	Y_3	...	Y_n
$L = \sum_{j=1}^{n} j * Y_j$	$1 * Y_1$	$2 * Y_2$	$3 * Y_3$	...	$n * Y_n$

The term X_{ij} represented the financial debt ratio measurement for recession number i in financial period j. Once the observed data were assembled into a randomized block design, each datum within a block or recession was then ranked from 1 to n (where n was the highest rank) into an ordered rank matrix as shown in Table 3.

The term R_{ij} represented the numerical rank (between 1 and n). Once all the data for all recessions were properly ranked, the sum for each rank (Y) was calculated based on the following formula:

$$Y_j = \sum_{i=1}^{m} R_{ij}, \tag{5}$$

where Y_j represented the sum of all rank j. The trend value (L) was calculated as

$$L = \sum_{j=1}^{n} j * Y_j \tag{6}$$

To determine whether the null hypothesis (1) should be rejected, the trend value (L) was evaluated against the critical value (L_c) where the null hypothesis should be rejected if $L > L_c$. The L_c value was calculated as

$$L_c = \frac{m(n^3 - n)}{12}\left[\frac{Z_c}{\sqrt{m(n-1)}} + \frac{3(n+1)}{n-1}\right], \tag{7}$$

where the value Z_c stands for the critical value of a standard normal. The statistical significance level for the Page test in this study was 5%; thus, Z_c = 1.645.

Since 7 financial debt ratios were evaluated in five iterations, there were 7 Page test results for each iteration. Each result indicated whether the observations from each financial debt ratio confirmed the alternative hypothesis (2). The collective results could show that none, some, or all 7 financial debt ratios confirm the existence of a positive growth. In the case of no confirmation, it would suggest that there is no evidence to support that a rising debt level is a necessary condition leading to financial instability. On the other hand, if all 7 results confirmed the alternative hypothesis (2), it would suggest that a rising debt level is indeed a necessary condition leading to financial instability. However, in the case that there were only a few confirmations out of 7, there must be an appropriate method to determine whether the few significant Page test results were not due to random chance. This meta-analysis was addressed with the nonparametric binomial test. A brief overview of the binomial test is discussed in the following section.

2.3.5. Binomial Test for Meta-Analysis

The purpose of employing the binomial test was to statistically determine whether the collective results generated from the Page test indeed validated the general hypotheses or whether they simply results from random chances. This was carried out by treating each calculated trend value (L) as a random variable where L could result in a higher or lower value than L_c. When $L > L_c$, this was considered as a successful or significant outcome. The binomial test then calculated the probability of obtaining at least (s) number of successful outcomes out of 7 tests as

$$P(S \geq s) = \sum_{k=s}^{m} p_k, \tag{8}$$

where p_k represented the probability of obtaining exactly k number of successes. This probability (p_k) was based on the following binomial probability mass function

$$p_k = \left(\frac{N!}{k!(N-k)!} \right) \pi^k (1-\pi)^{(N-k)} \tag{9}$$

where N represented the number of financial debt ratios and the value (π) represented the probability of obtaining a successful outcome from the Page test (where $L > L_c$) due to a random chance. This probability is the same as the significance level for the Page test which was 5%; thus, for the binomial test, this study defined π = 0.05. The significance level for this binomial test was also 5%; thus, the decision rule to reject the null hypothesis (3) was when the probability of obtaining at least s number of successes ($P(S \geq s)$) was less than 5%. Such a result would indicate that the collective results from the Page test provided the statistical evidence to support the validity of the FIH concept regarding rising debt as a necessary condition leading to financial instability.

The combination of the Page and binomial tests described above served as a standard method to confirm evidence of rising debt levels against the historical recessions of the 1945–1980s era. This same process was repeated for the 1990, 2001, and 2008 recessions to determine whether this behavior still persisted in the post 1980s era. Finally, the same process was applied to the COVID-19 and 2023 periods to determine the potential for the next recession. The results for this analysis are discussed in the following section.

3. Results and Discussion

From 1945 to 2023, the U.S. economy has experienced 11 recessions. Figure 2 below shows the unemployment rate and recession (indicated by the vertical gray bar). This information was used to identify the starting period for each recession where data prior to each recession were collected and analyzed for the following results.

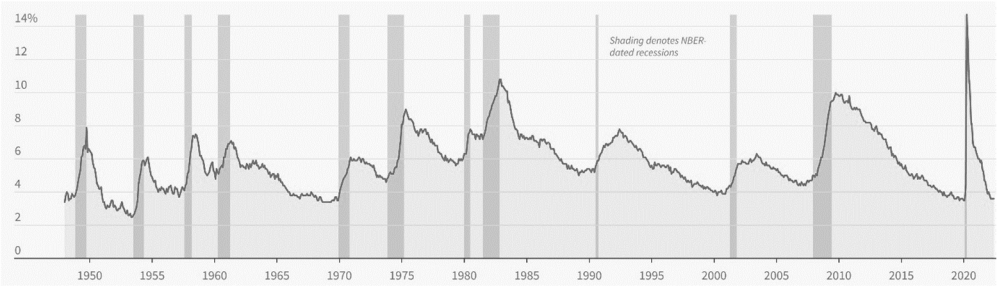

Figure 2. Unemployment rate and recessions during 1945–2023 (source: https://www.nber.org/research/business-cycle-dating accessed on 24 September 2023).

3.1. 1945–1980s Era

This first set of results analyzed data for the 1945–1980s period where FIH was based on. This era experienced eight recessions, as shown in Figure 2 above. A total of six of these recessions had sufficient data to be tested by the methodology described. These recessions had a minimum of seven quarters during the economic expansionary cycle which allowed all five iterations of the Page test to be conducted. Thus, the recessions of 1948 and 1980 were excluded from this analysis.

Overall, the seven financial debt ratios chosen for this study indicated a positive growth of increasing debts prior to the onset of a recession. To illustrate how the data were analyzed, the first iteration of the Page test for one of the financial debt ratios (household total liabilities to assets) is presented in Table 5.

Table 5. First iteration of Page test randomized block design for household total liabilities to assets ratio.

	Financial Ratio at Quarter Prior to Recession		
Recession Start (DDMMYY)	**3rd**	**2nd**	**1st**
01/07/1953	0.10070	0.10268	0.10754
01/10/1957	0.12707	0.12797	0.13112
01/04/1960	0.13465	0.13631	0.13739
01/01/1970	0.15900	0.16057	0.16473
01/01/1974	0.16434	0.16377	0.17113
01/01/1980	0.20246	0.20388	0.20435

Data source: https://fred.stlouisfed.org/ accessed on 24 September 2023.

In this first iteration of the Page test, the randomized block design in Table 5 consisted of six recessions and three financial periods for each recession. The financial periods were arranged in the order prior to the start of the recession (e.g., the first period represented the data for the quarter immediately before the start of the recession). Within each recession, the data were compared and ranked. The ordered rank matrix for the household total liabilities to assets ratio is presented in Table 6.

Table 6. Ordered rank matrix for household total liabilities to assets ratio.

	Ordered Rank		
Recession (DDMMYY)	**1**	**2**	**3**
01/07/1953	1	2	3
01/10/1957	1	2	3
01/04/1960	1	2	3
01/01/1970	1	2	3
01/01/1974	2	1	3
01/01/1980	1	2	3
Y =	7	11	18
L = 83	7	22	54

The sum (Y) for each rank was then calculated according to Equation (5); thus, the calculated (L) value per Equation (6) was 83. This (L) value was then compared against the critical value (L_c = 77.7) per Equation (7). Since $L > L_c$, this Page test result suggested a positive growth indeed existed for the household total liabilities to assets ratio where the ratio increased as the economy approached each of the six historical recessions. This test was repeated for all remaining six financial debt ratios. The results for all seven FDRs in all five iterations are shown in Table 7.

Table 7. Page test result for all financial debt ratios and iterations.

Iteration	1st	2nd	3rd	4th	5th
Number of Periods	**3**	**4**	**5**	**6**	**7**
L_c =	77.7	161.6	290.1	472.5	718.1
financial ratio	L	L	L	L	L
HH: total liabilities to assets	83	179	328	540	826
HH: liability to net worth	83	179	328	537	818
NFC: short-term debt to liquid asset	78	171	313	516	787
NFC: debt to equity	77	166	298	488	731
NFC: total liabilities to deposit	71	154	298	475	712
NFNC: total liabilities to deposit	80	171	307	503	769
FB: short-term debt to total debt	82	178	327	543	834
Count of $L > L_c$	5	6	7	7	6

HH = household, NFC = nonfinancial corporate business, NFNC = nonfinancial non-corporate business, FB = financial business.

Page tests showed a mixture of results when each financial debt ratio was evaluated at a different number of financial periods (iterations). However, most of the FDRs exhibited evidence of positive growth in the level of debt. To conclusively determine if any of the test iterations confirmed a rise in debt, the collective results above were then evaluated by the binomial test.

As shown in Table 8, the calculated p-value for each binomial test represented the probability that such binomial result was due to a Type I error. These values were significantly small (0.00%). These results suggested that all iterations of the Page test found statistical evidence to support the validity of FIH concepts regarding rising debt levels for the 1945–1980s era.

Table 8. Binomial test result for each Page test iteration.

Iteration (Periods)	Success	Failure	Total	Binomial Test (p-Value)	Result
1st (3)	5	2	7	0.000	Reject H_2 (3), confirmed FIH conditions
2nd (4)	6	1	7	0.000	Reject H_2 (3), confirmed FIH conditions
3rd (5)	7	0	7	0.000	Reject H_2 (3), confirmed FIH conditions
4th (6)	7	0	7	0.000	Reject H_2 (3), confirmed FIH conditions
5th (7)	6	1	7	0.000	Reject H_2 (3), confirmed FIH conditions

This finding confirmed that the chosen financial debt ratios along with the validation process had established a methodology (with statistical support) to evaluate Minsky's FIH concepts regarding the impact of debt on financial stability. This methodology was then extended to the 1990, 2001, and 2008 recessions to determine whether FIH concepts remained applicable to post-1980s periods.

3.2. Post-1980s Era Results

Defining the precise causes for each recession can be quite difficult; however, the specific causes for each recession can often be found in the media. For instance, the 2001

recession was said to be associated the Y2K fear, the dot-com bubble, the 9/11 terrorist attack (Amadeo 2021); the 2008 recession was linked the subprime mortgage failure (Suttmeier 2011) and the deregulation of the banking industries (Weissman and Donahue 2009). These causes were quite different from each other, yet they resulted in a recession regardless. When this validation methodology was applied to the post-1980s periods, it revealed that the 2001 and 2008 recessions both exhibited similar financial behavior that was consistent with prior recessions. As shown in Tables 9–11, at four to seven quarters prior to the recession, there was sufficient statistical evidence to suggest that the financial debt ratios indeed increased. However, the study did not find any evidence to conclude that the financial debt ratios increased prior to the 1990 recession. This is because recessions vary in severity (amplitude, duration, investment demand, etc.). Minsky explained that although financial distress, prescribed in FIH, is biased toward severe recession, the lack of evidence of such financial distress should not imply the economic contraction that a variable degree of severity cannot occur, or that a severe recession can only occur as a result of such evidence (Minsky et al. 1960). Since the analysis of recession severity is outside the scope of this study, it is possible that some recessions, such as that of 1990, are not severe recessions, or evidence of financial instability may indicate severe recessions but not the causation for all recessions.

Table 9. 1990 recession test results.

Iteration (Periods)	Success	Failure	Total	Binomial Test (p-Value)	Result
1st (3)	0	7	7	1.00	Failed to reject H_2 (3)
2nd (4)	1	6	7	0.30	Failed to reject H_2 (3)
3rd (5)	0	7	7	1.00	Failed to reject H_2 (3)
4th (6)	0	7	7	1.00	Failed to reject H_2 (3)
5th (7)	1	6	7	0.30	Failed to reject H_2 (3)

Table 10. 2001 recession test results.

Iteration (Periods)	Success	Failure	Total	Binomial Test (p-Value)	Result
1st (3)	0	7	7	1.00	Failed to reject H_2 (3)
2nd (4)	3	4	7	0.00	Reject H_2 (3), FIH applicable
3rd (5)	3	4	7	0.00	Reject H_2 (3), FIH applicable
4th (6)	4	3	7	0.00	Reject H_2 (3), FIH applicable
5th (7)	2	5	7	0.04	Reject H_2 (3), FIH applicable

Table 11. 2008 recession test results.

Iteration (Periods)	Success	Failure	Total	Binomial Test (p-Value)	Result
1st (3)	0	7	7	1.00	Failed to reject H_2 (3)
2nd (4)	4	3	7	0.00	Reject H_2 (3), FIH applicable
3rd (5)	5	2	7	0.00	Reject H_2 (3), FIH applicable
4th (6)	5	2	7	0.00	Reject H_2 (3), FIH applicable
5th (7)	5	2	7	0.00	Reject H_2 (3), FIH applicable

The results for the post-1980s periods (except for the 1990 recession) showed that after a prolonged period of economic stability, there were evidence of a persistent rise in the level of debt that contributed to overall financial instability, as described by FIH. This result suggested that overall, Minsky's FIH concepts remained applicable to post-1980s periods; this validation process was then applied to the COVID-19 and 2023 periods to determine whether the current economic environment is vulnerable to any recession risk.

3.3. COVID-19 Pandemic Result

During the 2019 to 2020 periods, the world experienced a significant health crisis known as the COVID-19 pandemic. This pandemic started in 2019 where a new and deadly respiratory virus spread around world, killing millions of people, and led to the shutdown of travel and many businesses. As a result, unemployment and economic turmoil spread across many countries around the world (Belitski et al. 2022). The U.S. real gross domestic product (GDP) decreased from USD 19,202 billion in the fourth quarter of 2019 to USD 18,951 billion and USD 17,258 billion in the first and second quarter of 2020, respectively (U.S. Bureau of Economic Analysis et al. 2022), as shown in Figure 3 below.

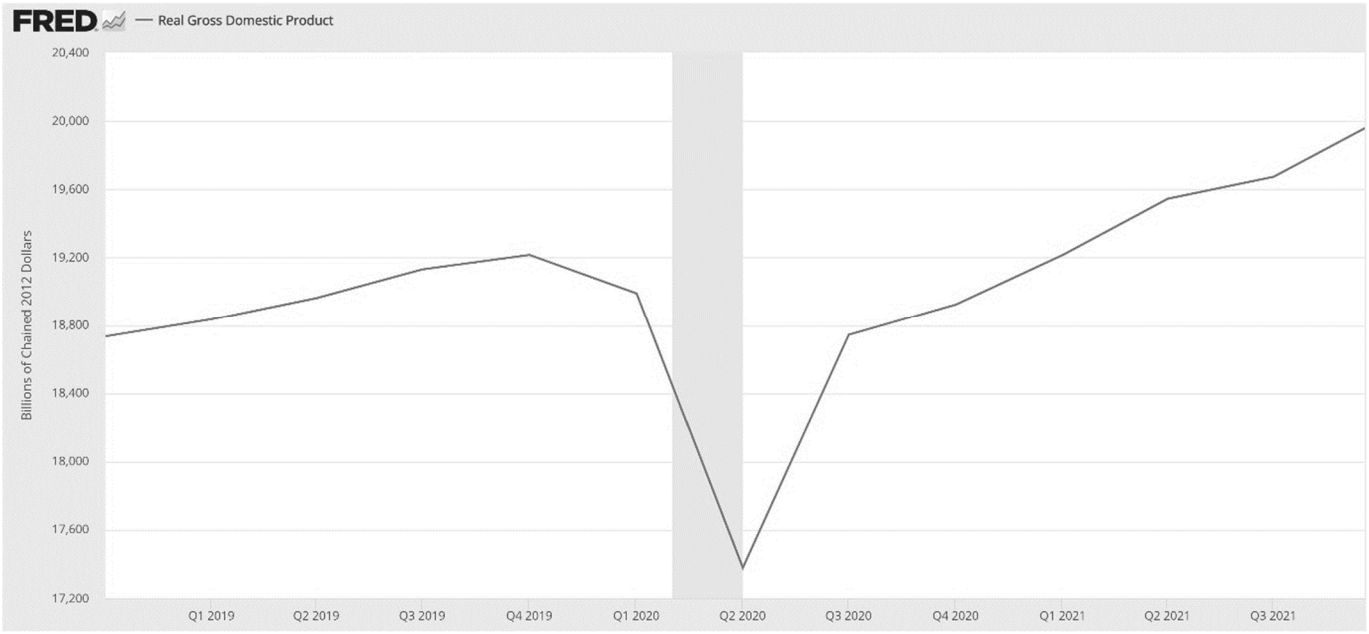

Figure 3. U.S. real gross domestic product during COVID-19 pandemic (source: U.S. Bureau of Economic Analysis).

This event provided an opportunity to evaluate the FIH validation above against a known external stimulant like this COVID-19 pandemic; thus, the same FIH validation process was applied to seven quarterly datasets before 2020 (from July 2018 to Jan 2020). The result of the Page test iterations found no evidence of increasing financial debt ratios (see Table 12 below).

Table 12. COVID-19 pandemic test results.

Iteration (Periods)	Success	Failure	Total	Binomial Test (p-Value)	Result
1st (3)	0	7	7	1.00	Failed to reject H_2 (3)
2nd (4)	0	7	7	1.00	Failed to reject H_2 (3)
3rd (5)	0	7	7	1.00	Failed to reject H_2 (3)
4th (6)	0	7	7	1.00	Failed to reject H_2 (3)
5th (7)	0	7	7	1.00	Failed to reject H_2 (3)

These results suggested that the recession was not caused by instability in the U.S. financial system. As expected, the rise in unemployment and business contractions was primarily due to the government mandate to shutdown businesses to slow the spread of COVID-19 (Belitski et al. 2022). This led to a sudden decline in real GDP rather than businesses becoming overly indebted and destabilizing the financial system. This result is

consistent with FIH where Minsky applied such a theory to the internal dynamics of the financial system.

3.4. Post COVID-19 Pandemic to 2023 Result

Since the FIH validation process had been applied to many historical recessions and the results were quite consistent, it was then used to evaluate the current financial environment to detect any potential risk of a new recession. When the FIH validation process was applied to seven quarterly datasets from October 2021 to April 2023, all Page test iterations showed that the majority of the financial debt ratios were not increasing (as shown in Table 13). The binomial test results also found no statistical evidence to confirm a recession threat.

Table 13. Post COVID-19 pandemic to 2023 test result.

Iteration (Periods)	Success	Failure	Total	Binomial Test (p-Value)	Result
1st (3)	0	7	7	1.00	Failed to reject H_2 (3)
2nd (4)	0	7	7	1.00	Failed to reject H_2 (3)
3rd (5)	1	6	7	0.30	Failed to reject H_2 (3)
4th (6)	1	6	7	0.30	Failed to reject H_2 (3)
5th (7)	0	7	7	1.00	Failed to reject H_2 (3)

These results suggested two possibilities: (1) Minsky's FIH is no longer applicable to the current period, or (2) since Minsky's FIH theory continued to hold true for the last eight recessions, it is possible that FIH is still applicable; however, the current economic conditions simply do not exhibit persistent increases in debt. Thus, no such evidence was found. These results indicated that the null hypothesis (5) for the binomial test cannot be rejected; thus, the inference from such results was subjected to the limitation of classical statistics that failed to reject the null hypothesis that does not suggest Minsky's FIH concepts regarding financial debt are inapplicable to the current period. This result was also supported by the evidence of the real GDP which has been steadily increasing since the second quarter of 2020 (see Figure 3 above).

4. Conclusions

Since World War II, the U.S. economy has been dominated by Keynesian economic principles. Such economic doctrines helped prevent major depression like the Great Depression of 1929; however, American economist Hyman Minsky found that the Keynesian economic model replaced deep depression with short periods of recession. This article presents a statistical methodology to confirm an important aspect of Minsky's Financial Instability Hypothesis to determine whether the financial structure of U.S. households, nonfinancial corporates, nonfinancial non-corporates, and financial businesses deteriorated prior to the onset of a recession. The empirical data from seven financial debt ratios were analyzed for the period from 1945 to 2023. Using non-parametric statistical analyses of the Page test for ordered alternatives and binomial tests revealed statistical evidence that the financial debt ratios indeed increased prior to each of the last eight recessions (excluding the 1990 recession). The validation process also found no evidence of financial instability during the COVID-19 pandemic in which the real GDP briefly declined for three consecutive quarters. Additionally, analysis of the period between 2021 and 2023 found no evidence to suggest a near term recession. It is possible that Minsky's FIH is no longer applicable (due to a significant shift in the economy that has occurred, yet is unobserved by this study) or that Minsky's FIH is still applicable, but the current economic conditions have yet worsened.

This article presents a novel contribution to the current literature by establishing a reliable methodology to confirm critical components of Minsky's Financial Instability Hypothesis. The methodology addressed two primary gaps in the current literature: (1) a

lack of empirical confirmation of rising financial debt level for the time periods intended by Minsky (1945–1980s), (2) a lack of confirmation of whether Minsky's FIH concepts remain relevant and applicable to time periods beyond the 1980s. In addition, the validation methodology was designed to use financial data readily available from the Federal Reserve Economic Data; thus, this methodology can be applied to future financial data to monitor economic conditions for the potential threat of recession, especially in the current financial climate where the central bank has recently decided to raise interest rates and implement quantitative tightening to combat inflation. If this methodological approach continues to show relevance, then it lends strength to the economic voices that call for governmental focus on debt reduction, the monitoring of debt to assure economic well-being, and perhaps policies and laws to better control and regulate the potential adverse effects of uncontrolled financial debt.

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