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Ending over-lending: Assessing systemic risk with debt to cash flow*

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Abstract

This paper operationalizes early theoretical contributions of Hyman Minsky and applies these in the context of economic sectors and nations. Following the view of boom-bust asset cycles, depicted by the endogenous build-up of risks and their abrupt unraveling, Minsky highlighted the relationship between debt obligations and cash flows. While leverage is oftentimes linked to the vulnerability of a nation, and hence systemic risk, one less explored measure of leverage is the debt-to-cash flow ratio (Debt/CF). Cash flows certainly have a well-known, academically verified connection to the ability of corporations to service and repay corporate debt. This paper investigates whether the relationship between the flow of a nation's savings to its stock of total debt provides a means for understanding systemic risks. For a panel of 33 nations, we explore historic Debt/CF trends, as well as apply the same procedure to individual economic sectors. This assessment of systemic risk is arranged for presentation within a four-zone framework. In terms of an early-warning indicator, we show that the Debt/CF ratio effectively stratifies systemic risks, and offers a useful platform toward macro-financial sustainability.

Keywords: debt-to-cash flow, debt-to-gross saving, systemic risk, four-zone framework
JEL codes: E210, F340, G010, H630

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Ylivelkaantumisen hillitseminen: Velan ja kassavirran suhde systeemiriskien mittana

Tiivistelmä

Tässä työssä tarkastellaan velan ja kassavirran suhdetta systeemiriskien mittana. Työ keskittyy sekä maa- että sektoritasolla karttuvien riskien kartoittamiseen indikaattorilla, joka suhteuttaa velan ja kassavirran. Työn perustana toimii Hyman Minskyn sykliteoria, jonka perusteella rahoitusmarkkinat ovat alttiita euforiaan ja ylikuumenemiseen ja niitä seuraavaan paniikkiin ja romahdukseen. Tässä työssä tarkasteltava indikaattori mittaa kriisiä edeltäviä systeemiriskejä suhteuttamalla maan yhteenlasketun velan bruttosäästöihin, joka kuvastaa maksuvalmiutta ottamalla huomioon maan tulot ja kulutusmenot. Tutkimuksen empiirisessä osassa kuvataan ensiksi indikaattoria maa- ja sektoritasolla kriisien yhteydessä 33 maassa, jonka jälkeen testataan kvantitatiivisesti indikaattorin signalointilaatua. Empiiristen tulosten perusteella indikaattori kuvastaa riskien karttumista ja kasvavia haavoittuvuuksia, ja tukee näin ollen makrovakauden valvontaa.

Avainsanat: velka suhteessa kassavirtaan, velka suhteessa bruttosäästöihin, systeemiriski, indikaattori

Non-technical summary

This paper operationalizes early theoretical contributions of Hyman Minsky and applies these in the context of economic sectors and nations. Minsky (1977; 1982) introduced the notion of a financial fragility view of boom-bust credit or asset cycles. From the viewpoint of systemic risk, the underlying problems relate to an endogenous build-up of widespread imbalances in one or several parts of a financial system, such as high concentrations of lending in certain sectors of the economy or more general credit booms in a nation. Minsky depicted the endogenous build-up of risks and their abrupt unraveling by the relationship between debt obligations and cash flows, cited in terms of three categories of escalating risks. This paper intends to contribute to the literature by relating cash flow and debt to express a specific new measure of financial leverage for nations and their economic sectors in order to operationalize Minsky's hypothesis.

While leverage is oftentimes linked to the vulnerability of a nation, and hence systemic risk, one less explored measure of leverage is the debt-to-cash flow ratio (Debt/CF). Cash flows certainly have a well-known, academically verified connection to the ability of corporations to service and repay corporate debt. The relationship commonly known as the debt-to-cash flow (henceforth Debt/CF) ratio when used in the context of corporate finance, measures the number of years of savings required to retire an entity's outstanding debt. Beyond studies in corporate finance, a closely relevant line of work uses measures of debt relative to income streams as country-level early-warning indicators. While the debt-to-income ratio has commonly been used to illustrate the association between high leverage and losses in credit and output, it misses consumption versus savings decisions. This shortcoming can be illustrated by way of a simple example. Let us say two borrowers each have 100,000 € in income and € 200,000 in debt, and hence a 200% debt-to-income ratio. However, if the borrowers have respective savings rates of 20% and 10%, then the second borrower is twice more levered as measured on a cash flow basis. Further, previous literature has also proposed assessing a debt service ratio which relates interest payments and amortizations to income. These measures proxy financial constraints imposed by debt, and thus the build-up of nations' vulnerabilities. This approach provides an explicit 'coverage' ratio measuring borrowers' carrying capacity, and as such is not a measure of leverage and hence not a substitute to Debt/CF. To the best of our knowledge, other works have not studied the use of Debt/CF or similar ratios relating debt to gross savings for sectors or nations.

This paper investigates whether the relationship between the flow of a nation's savings to its stock of total debt provides a means for understanding systemic risks. For a panel of 33 nations, we explore historic Debt/CF trends, as well as apply the same procedure to individual economic sectors. Starting with a qualitative discussion of the concept and illustrative examples for individual companies, industry groups, economic sectors and nations, we end with a quantitative evaluation of Debt/CF as an early-warning indicator. First, we illustrate patterns of Debt/CF before, during and after distress episodes for a large grouping of utility companies and then move from micro data to an aggregation level to formulate time series of Debt/CF ratios for economic sectors. Second, after discussing the measurement of Debt/CF for nations, we proceed to grouping nation-wide Debt/CF levels into categories − Inefficient, Stable, Warning, and Crisis − providing a four-zone framework for the assessment of risks. Third, we illustrate time series of nations within the four zones and qualitatively analyze the depicted patterns. We then quantitatively measure the early-warning capability of the Debt/CF ratio as a determinant of financial crises, and distinguish differences in performance for banking, debt and currency crises for the Debt/CF and its variants. The signals of early-warning indicators are calibrated according to a policymaker's preferences between type I and II errors, where we assume her to be more concerned about missing a crisis than giving a false alarm. Overall, while the Debt/CF ratio is shown to be a useful early-warning indicator, we show that the ratio performs significantly better on banking and debt crises than on currency crises. To this end, the Debt/CF ratio is shown to effectively stratify systemic risks, and offers thus a useful platform toward macro-financial sustainability.

1. Introduction

This paper investigates the relationship between the stock of total debt and the flow of gross saving of nations and their economic sectors, particularly as an indicator of systemic risks and vulnerabilities. Data series for a sector's or nation's total debt, not only the public debt portion, have become available in recent years. This development, together with recognition that gross saving represents cash flow, opens the door to applying a variety of new metrics to measuring risks in nations and their economic sectors. The relationship commonly known as the debt-to-cash flow (henceforth Debt/CF) ratio when used in the context of corporate finance, measures the number of years of savings required to retire an entity's outstanding debt. The Debt/CF ratio is a direct measure of leverage. The higher the ratio, the more levered the entity. In turn, high leverage is recognized to feed financial instability as it increases the risk of and vulnerability to a crisis in the event of a triggering shock. To the best of our knowledge, other works have not studied the use of Debt/CF or similar ratios relating debt to gross savings for sectors or nations.

Most literature on the Debt/CF ratio relates to corporate finance. Beaver's (1966) early work set the stage for a body of research built on the use of accounting identities. Beaver identified four ratios, including the cash flow to total debt relationship, to be useful in predicting corporate financial failures. More recently, Dichev and Skinner (2002) and Sufi (2009) showed in corporate studies that the Debt/CF ratio is the most and second most common type of covenant used in lines of credit, respectively. Likewise, and among many other studies, Houghton and Woodliff (1987) also concluded that cash flow metrics, including the Debt/CF ratio, are effective predictors of corporate success and failure. In the broader scope of macro-financial instability, early frameworks such as Kindleberger's (1978) book Manias, Panics and Crashes remain as applicable and relevant classics. However, in the past five years, the body of research on financial crises at the country-level has exploded. An accounting based approach, stock-flow consistent modeling, has continued to gain acceptance from earlier leading works, such as Godley and Lavoie (2007) and Taylor (2008). There is also a broad literature on leading, or early-warning, indicators representing macro-financial vulnerabilities. For instance, Alessi and Detken's (2009) work on early-warning indicators extended Borio and Lowe's (2002) prior demonstrated connection between credit growth and financial instability. Likewise, Lo Duca and Peltonen (2013) used a range of macro-financial indicators to assess systemic risks and predict systemic events, whereas Betz et al. (2014) complemented a bank-level model with banking sector and macro-financial conditions. Recent research has also constructed coinciding indexes of financial fragility, such as those by Lee et al. (2013) and Tymoigne (2012). To date, country-level early-warning indicators have not focused on the relationship between debt obligations and cash flows.

A broadly recognized notion providing a theoretical framework to some of the above articles is Hyman Minsky's (1977; 1982) financial fragility view of a boom-bust credit or asset cycle, and particularly the Financial Instability Hypothesis as later outlined in Minsky (1992). Beyond contagion or spillover and exogenous aggregate shocks, these types of build-ups of imbalances are oftentimes referred to as a third type of systemic risk (de Bandt et al., 2009). The underlying problems relate to an endogenous build-up of widespread imbalances in one or several parts of a financial system, such as high concentrations of lending in certain sectors of the economy or more general credit booms in a nation. While these imbalances may in the short term continue with mainly profitable implications, a shock leading to a re-pricing of risk may be triggered by even small events or changes in expectations. Minsky depicted the endogenous build-up of risks and their abrupt unraveling by the relationship between debt obligations and cash flows. Minsky (1992) identifies "three distinct income-debt relations for economic units, which are labeled as hedge, speculative, and Ponzi finance." The three categories outline the relationship between the obligations of liabilities and an entity's underlying cash flows, cited in terms of escalating risks. Minsky does not, however, proceed to provide specific measurements, examples, nor evaluations. Our effort herein intends to contribute to the literature by relating cash flow and debt to express a specific new measure of financial leverage for nations and their economic sectors in order to operationalize Minsky's hypothesis. In that both sector and nation-level leverage represent widespread imbalances, these can be related to the above notion of systemic risk.

The closely related literature is restricted to those applying similar measures but in another context and those applying measures in the same context but with variations in definitions. First, while a few public finance studies using Debt/CF exist, none of these explicitly focus on economic sectors or nations. For instance, Gilbert & Guengant (2002) study the financial conditions of municipalities in France with the debt-to-gross-savings ratio, as one of several metrics. Similarly, the quasi-public finance enquiry by McCue et al. (1990) of risks in hospital finance uses ratios, including cash flow to debt. A second line of work uses measures of debt relative to income streams as country-level early-warning indicators. While the debt-to-income ratio has commonly been used to illustrate the association between high leverage and losses in credit and output (e.g., King, 1994; Mian and Sufi, 2010), it misses consumption versus savings decisions. This shortcoming can be illustrated by way of a simple example. Let us say two borrowers each have 100,000 € in income and € 200,000 in debt, and hence a 200% debt-to-income ratio. However, if the borrowers have respective savings rates of 20% and 10%, then the second borrower is twice more levered as measured on a cash flow basis. Further, Juselius and Kim (2011) and Drehmann and Juselius (2012; 2013) propose the debt service ratio, of interest payments and amortizations to income, as a measure of financial constraints imposed by debt, and thus the build-up of nations' vulnerabilities. This approach provides an explicit 'coverage' ratio measuring borrowers' carrying capacity, and as such is not a measure of leverage and hence not a substitute to Debt/CF. Following the above example, the coverage approach would also benefit from relating carrying costs to cash flow rather than to income. While we consider the previous alternatives to the Debt/CF to be inferior (e.g., debt-to-income) or measures of different dimensions (e.g. coverage versus leverage), a prudent approach of course is to use a panel of indicators measuring a range of different factors.

This paper demonstrates the usefulness of Debt/CF ratios for measuring financial risks and vulnerabilities in nations and their economic sectors. Starting with a qualitative discussion of the concept and illustrative examples for individual companies, industry groups, economic sectors and nations, we end with a quantitative evaluation of Debt/CF as an early-warning indicator. First, we illustrate patterns of Debt/CF before, during and after distress episodes for a large grouping of utility companies and then move from micro data to an aggregation level to formulate time series of Debt/CF ratios for economic sectors. Second, after discussing the measurement of Debt/CF for nations, we proceed to grouping nation-wide Debt/CF levels into categories – Inefficient, Stable, Warning, and Crisis – providing a four-zone framework for the assessment of risks. Third, we illustrate time series of nations within the four zones and qualitatively analyze the depicted patterns. We then quantitatively measure the early-warning capability of the Debt/CF ratio as a determinant of financial crises, and distinguish differences in performance for banking, debt and currency crises for the Debt/CF and its variants.

The paper is organized as follows. Section 2 describes and applies the Debt/CF to economic sectors. While Section 3 discusses and defines nations' Debt/CF ratio and the four-zone framework for assessing risks, Section 4 applies and analyzes nations' Debt/CF ratios, including an evaluation of performance in determining crises. Finally, Section 5 provides concluding observations of Debt/CF in relation to the transmission of instabilities, macroprudential tools and to bail-in or out. Appendix A.1 provides details of data sources and metrics tested, while Appendices A.2 and A.3 provides technical details of the quantitative testing methodologies, including signal extraction and evaluation. Further, the paper comes with a supplementary interactive dashboard: http://risklab.fi/demo/eol/.

2. The Debt/CF for economic sectors

This section explores the use of Debt/CF ratios to assess risks in economic sectors. We initially describe the common practice of calculating Debt-to-Cash Flow ("Debt/CF") for individual companies and then discuss patterns of Debt/CF before, during and after distress episodes for utility companies. Next the data for similar companies can be aggregated in order to calculate the ratio for industry groups. In turn, when all industries are compiled, the Debt/CF ratio can be calculated for the "non-financial" business sector of the economy. Likewise, we can collect data on households, financial companies and governments to measure the Debt/CF ratio for these economic sectors. In each case,

the Debt/CF ratio provides an indicator of leverage, involving vulnerability to financial instability, which is exemplified with a number of illustrative figures.

2.1. The Debt/CF ratio in corporate and industry group contexts

The Debt/CF ratio measures leverage by expressing the total stock of third party debts owed by an entity, in relation to the amount of cash flow generated (annually) by the entity. The higher the ratio, the more levered the economic unit. Simplistically, the Debt/CF ratio measures the number of years of cash flow required to retire outstanding debt, assuming 100% of cash flow is applied to this purpose. To calculate the Debt/CF ratio for a business, typically short and long-term debts from the balance sheet are totaled for the debt measurement, whereas Cash Flow From Operations from the operating statements is utilized for the cash flow measurement.[1] Cash Flow from Operations is generally expressed as the sum of net after-tax profit plus depreciation and amortization, and other non-cash items. A corporation with $8 million in total debt and $1 million in annual cash flow would have a Debt/CF ratio of 8:1, or 8x. In turn, leverage can be calculated when the debt and cash flow data of all companies from an industry group is aggregated. Table 1 presents the mean Debt/CF leverage for the indicated industries over a 20-year period. The ratio is calculated using two definitions for debt, a narrow approach using only short and long-term debt, and a comprehensive approach using total liabilities.

Table 1: S&P industry group Total Debt/CF and Total Liabilities/CF means (1992–2012).

	Energy	Information Technology	Healthcare	Consumer Staples	Telecom Services	Materials	Consumer Discretionary	Industrials	Utilities
Total Debt/CF	1.53X	1.89X	1.69X	2.63X	3.08X	3.59X	6.26X	5.90X	6.08X
Total Liabs/CF	4.48x	5.92x	5.42x	5.76x	6.69x	8.24x	12.68x	10.58x	11.85x

Notes: Total Debt is modeled to Credit Market Instruments of the Federal Reserve (see Table 3). Total Liabilities is total liabilities of the balance sheet, excluding equity, and is hence pursuant to internationally utilized Flow of Funds definitions (see Table 3), which exclude net worth. **Source**: Standard and Poor's.

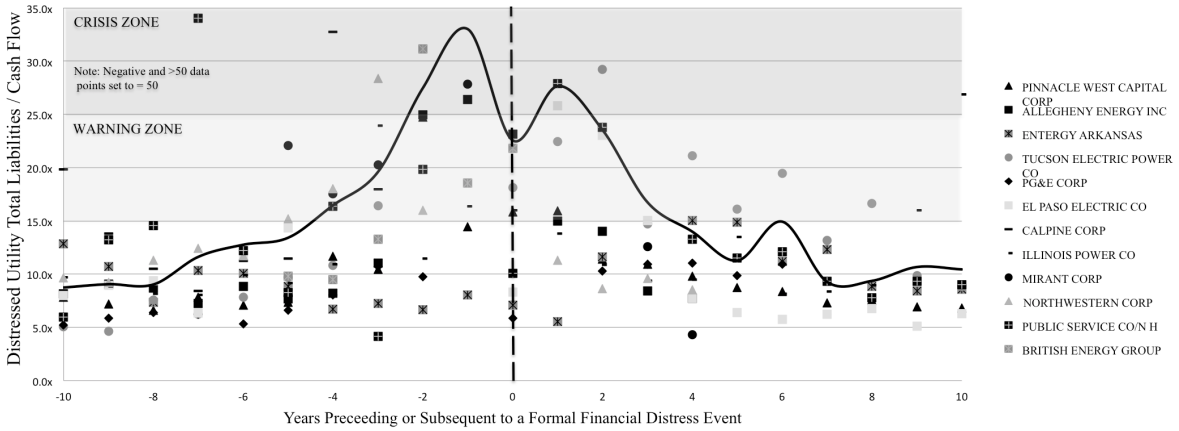
Organizations with steady, predictable cash flow and long-life assets are able to safely support relatively higher leverage. The companies comprising the Utilities group for example sit with among the highest ongoing Debt/CF levels, at 6.08x and 11.85x. On the contrary, organizations that have, or may face, higher volatility of cash flow are significantly less levered. As indicated, companies forming the Energy group operate with significantly lower leverage, with Debt/CF ratios of 1.53x and 4.48x. In this manner appropriate leverage can be seen to vary reflecting the characteristics of the entity. Table 1 presents 20-year mean levels, but of course exceptional years of abnormally high or low leverage will occur. Recessionary periods, poor management decisions, unexpected shocks or other factors will cause volatility in cash flow levels in turn impacting leverage. Alternatively, large sudden incremental debt loads, perhaps connected with an industry-wide acquisition binge, will also affect leverage. Excessive leverage associated with financial distress and instability can be depicted by way of the Debt/CF relationship.

2.2. Utility company distress and Debt/CF

To examine Debt/CF features associated with financial instability, a group of approximately 350 utility companies was examined for incidents of companies entering into formal financial distress, primarily Chapter 11 events. The respective Debt/CF data for these distressed utilities was compiled

[1] Various methods of calculation for the ratio exist, for example netting cash-on-hand against debt, or using Total Liabilities for the debt component. Similarly, different definitions for cash flow can be utilized. Accounting for cash flow and debts can involve differing approaches and comparability can be a material issue.

for the ten years preceding and ten years subsequent to the announcement (i.e. at year 0) of a formal distress event. Figure 1 depicts the state of financial stability by representing the average Debt/CF before, during and after a distress event with a solid line, where the debt component is calculated on a Total Liabilities basis.



Sources: US Energy Information Agency, company press releases and Chapter 11 Library.

Figure 1: Financially distressed utility companies reaching crisis leverage.

Companies with increasing leverage run the risk of continuing in an escalating pattern toward eventual financial instability. Some of these companies will survive by way of management acting quickly and prudently, whereas others will fail. Figure 1 depicts that as part of the conclusion of Chapter 11, the average Debt/CF of the companies recedes. Debt/CF ratio reversions would result from the impositions of lenders and trustees demanding restructured operations to improve cash flows and liability reductions through debt write-offs, asset sales, equity offerings and other rationalizations. These reversions are shown to continue until reaching the Debt/CF ratio stable leverage of their utility peers, as per Table 1.[2] The shading in Figure 1 depicts conceptual zones of escalating financial instability. A range of Debt/CF ratio of 5x to 15x in the case of the utility sector can be considered a "Stable Zone" (in white).[3] A utility company becomes somewhat over-levered at values above 15x Debt/CF and shown as a "Warning Zone" (lightly shaded). Sooner or later, the utility entity may become significantly over-levered and at serious risk with prolonged exposure at Debt/CF values of 25x and above (i.e., a "Crisis Zone" further shaded). To complete the range, an under-levered or "Inefficient Zone" (also in white) is contemplated as less than 5x Debt/CF. In aggregate, these ranges of escalating financial instability could be referred to as a four-zone framework.[4] Rather than crisp levels delimiting between zones, the concept is better conceived as representing overlapping degrees of instability. The zone framework follows guidance from Minsky (1992), Altman (1968) and Fisher (1933) towards scaling leverage to conceive instability, as summarized in Table 2.

[2]The average time period from entering the Warning Zone to crossing into the Crisis Zone is approximately two years. A further two years on average transpires prior to Chapter 11 announcement. The average time period for re-entering the Stable Zone after the collapse event occurs is four years.

[3]In the case of energy companies, the Stable Zone would range with 4.5x as a mid-point using the Total Liabilities definition.

[4]For further details see Ramsay (2011, p. 11).

Table 2: Concepts for stratification of instability.

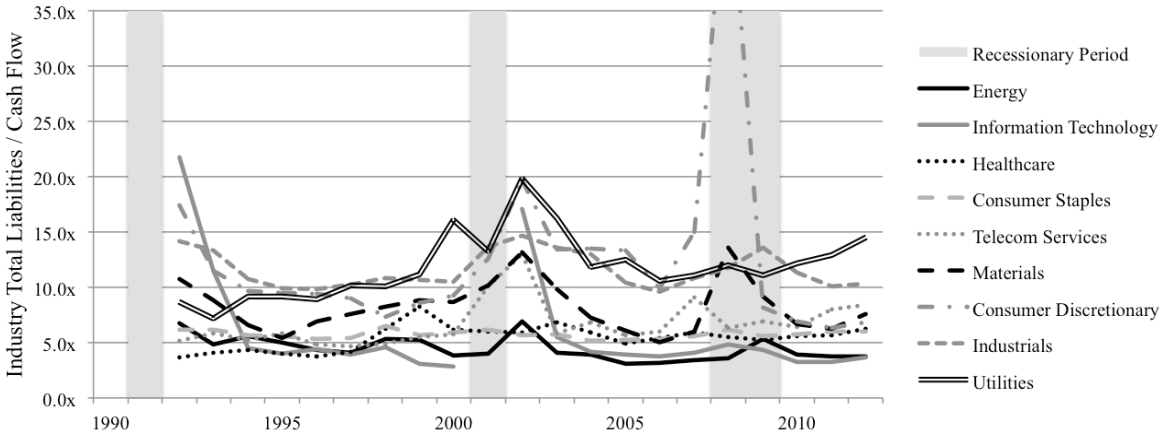
	Stability	→	**Instability**
Minsky's Financial Instability Hypothesis	Hedge units	Speculative units	Ponzi units
Altman's Z-score zones of discrimination	Safe area	Grey area	Distress area
Fisher's Debt-Deflation Theory	Stable boat	Rocking boat	Capsized boat
Four-zone framework	Inefficient zone, Stable zone	Warning zone	Crisis zone

Notes: Total Debt is modeled to Credit Market Instruments of the Federal Reserve (see Table 3). Total Liabilities is total liabilities of the balance sheet, excluding equity, and is hence pursuant to internationally utilized Flow of Funds definitions (see Table 3), which exclude net worth. **Source**: Standard and Poor's.

2.3. Industry groups and the non-financial business sector

These patterns of rising instability and subsequent reversion are also evident in Figure 2, which depicts the Debt/CF results for S&P industry groups 1992–2012.

Corporate results can be anticipated to correlate with economic activity (Bernanke, 2000), and Debt/CF results fit this expectation. Recessions typically bring declining cash flows, which in turn cause some industry Debt/CF ratios to rise or spike (as opposed to large run-ups in the stock of debt as the cause). Following a period of instability the Debt/CF for the industry group tends to recover and revert back toward the longer-term mean provided in Table 1.

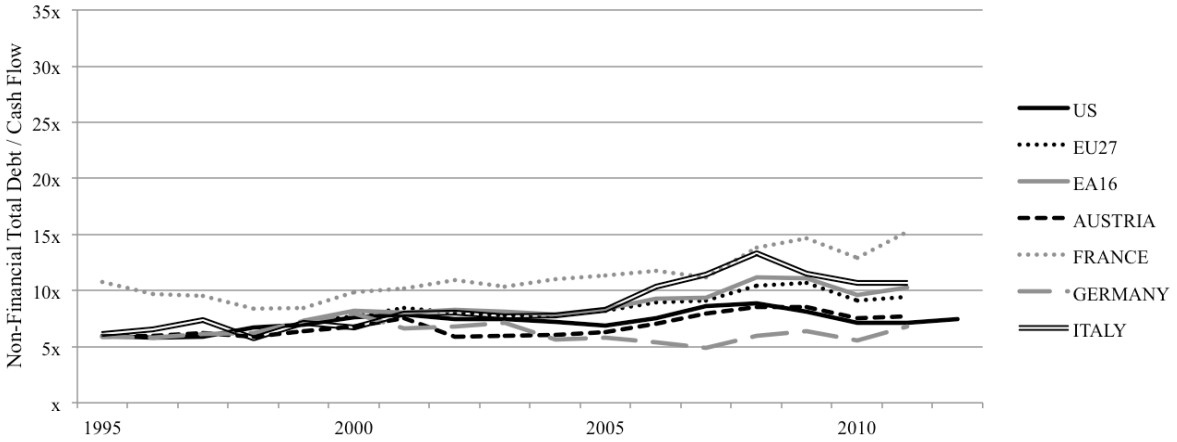


Sources: Standard and Poor's.

Figure 2: Debt/CF of S&P Industrial Groups (1992–2012) and recessionary impacts.

By summation of total debts and total cash flows of all industry groups, the Debt/CF relationship for the entire business sector can be calculated. In order to include un-listed, non-corporate, and other business elements, however, the economic accounts for the "Non-Financial" sector are sourced as time-series data from the System of National Accounts and Flow of Funds. When reported in these economic accounts, the term "Gross Saving" is used to represent cash flow. In Figure 3, the Total Debt of the Non-Financial sector is divided by the sector's Gross Saving to produce the Debt/CF

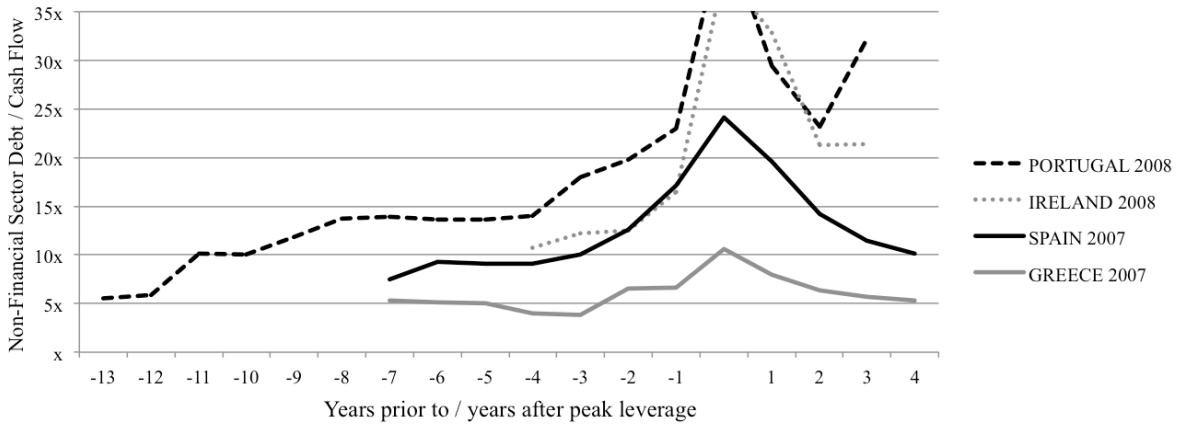
results for the sector.[5] The Debt/CF results for the Non-Financial sector of several major economies are presented, as well as the aggregated sector results for the 16 nation euro area (EA16) and 27 nation European Union (EU27). Some aggregate rising sector leverage is reflected in certain periods, such as Italy and France leading into the 2008–2009 recessionary period, which are shown to diverge following the crisis. Nevertheless, this group of nations' aggregate Non-Financial sector leverage has held reasonably consistent over the time frame displayed.



Sources: Federal Reserve and EuroStat.

Figure 3: Debt/CF of Non-Financial sector for several major nations.

In contrast, the Non-Financial sector Debt/CF results for four crisis-exposed nations are presented in Figure 4. The time series have been aligned to the year the sector reached peak leverage for each nation, depicting the characteristic pattern of financial instability. Of the four nations, Spain's and Greece's Non-Financial sectors appear to have substantially regained control of leverage.



Sources: EuroStat.

Figure 4: Debt/CF of Non-Financial sector for several crisis nations.

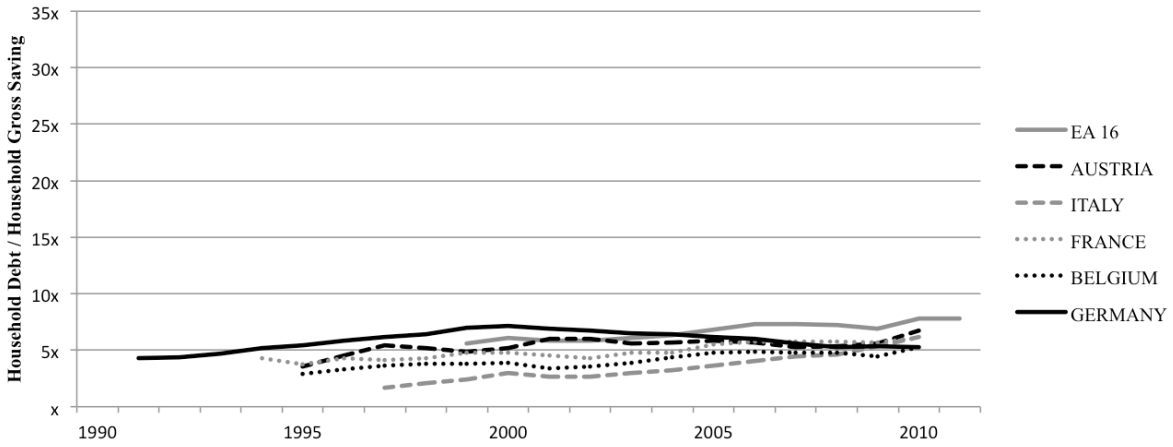
The business sector is expected to be efficient at expunging excess debt. With daily capital markets environments and comprehensive legal impacts on the individual participants, the sector is relatively

[5]Modeled on Federal Reserve definition for Credit Market Instruments (effectively, short and long term debt instruments, see Table 3).

effective in addressing financial instability. Periods of escalating leverage, financial instability, and normalization tend to be less than ten years in duration.

2.4. Debt/CF for the household sector

Minsky's work indicated financial instability would arise in the generic term 'economic units,' hence the Debt/CF metric could be applied in contexts away from typical corporate analysis. Household cash flow data, referred to as Gross Saving, is available as are the total debts of the Household sector, permitting a standard Debt/CF calculation.[6] In Figure 5, a history of Household sector Debt/CF ratios for five EU nations, and the euro area average are depicted. Based on media and central bank press release searches (and an absence of hits), the Household sectors of these individual nations are generally considered financially stable. The results for this stable group are consistent with those of the US Household sector 1946–1985 (see Figure 9), which averaged 5.4x Debt/CF during the four decades with the highest year recorded at 6.9x.



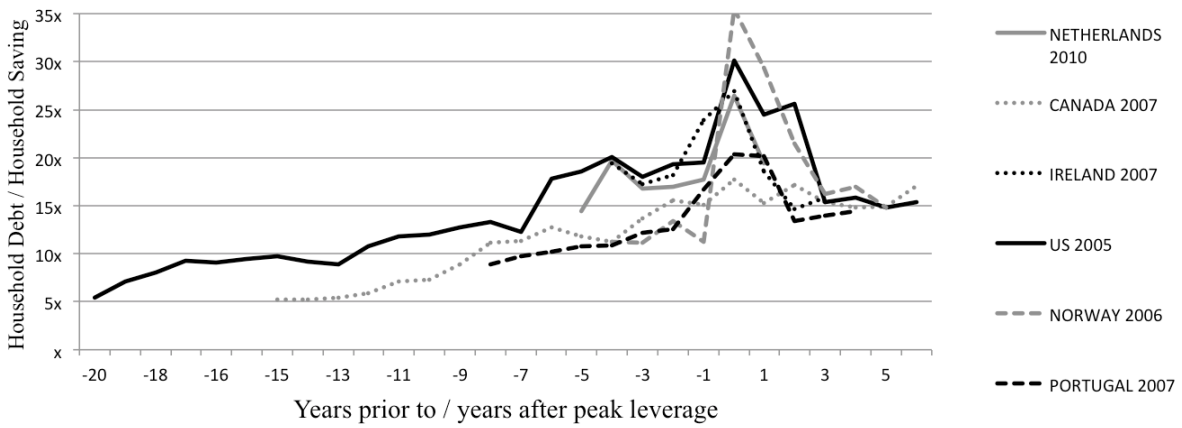
Sources: EuroStat.

Figure 5: Household sector Debt/CF history of various nations and euro area average.

In the mid-1980s, leverage of the US Household sector began to climb, as shown in Figure 6. In the 1990s the US Household sector Debt/CF averaged 11.7x, rising to an average 19.0x during 2000–2004. Peak leverage for the sector was reached in 2005 at 30x, two years prior to the onset of the US financial crisis. The ratio then began a sharp decline to a level of approximately 15x, held for the 2008–2012 period. The EA average in Figure 5 is elevated in recent years as a result of inclusion of the financially distressed Household sectors of several EA nations, as untangled in Figure 6.

The time series in Figure 6 have been aligned to the year the sector reached peak leverage for each nation, as indicated in the legend. Based on media and central bank press release searches, the Debt/CF time series for Household sectors of the individual nations are qualitatively considered to coincide with occurrences of distress. According to Debt/CF, Household leverage has declined in the past 3-5 years for the group, although whether these recent levels will be sustainable requires further research.

[6]Gross Saving for Households is sourced from National Accounts or Integrated Economic & Financial Accounts reporting. Household Credit Market Instruments and international equivalents are used as the debt component (see Table 3). Household Total Liabilities produced an immaterial difference in results. While Household debt / income is a common metric, Debt/CF may be a useful additional indicator as it depicts leverage after accounting for consumption versus saving decisions.



Sources: EuroStat and Federal Reserve.

Figure 6: Demonstrated instability of household sector Debt/CF history of various nations.

2.5. Financial sector Debt/CF and instability

Evaluating banks by relating cash flow to debt is not in wide practice, but is advocated in works such as Grier (2012). The Financial sector is very complicated and any conclusions involving Debt/CF should be considered highly tentative. In order to calculate the Debt/CF ratio for the Financial sector of a nation, the expected two components are required, the sector's total debt and the sector's Gross Saving.[7] Figure 7 provides a Debt/CF history for the domestic Financial sector of the US, Canada and the euro area. Canada's Financial sector is admired for its stability and weathered the 2008 financial crisis with relatively few problems.[8] However, the history of the Canadian Financial sector includes a period of instability and apparent reversion, seen as the spike in leverage in the early 1990s and subsequent reversal. During these years, Canada's Financial sector suffered housing and resource related losses and needed restructuring, but was able to settle into manageable leverage afterwards.[9]

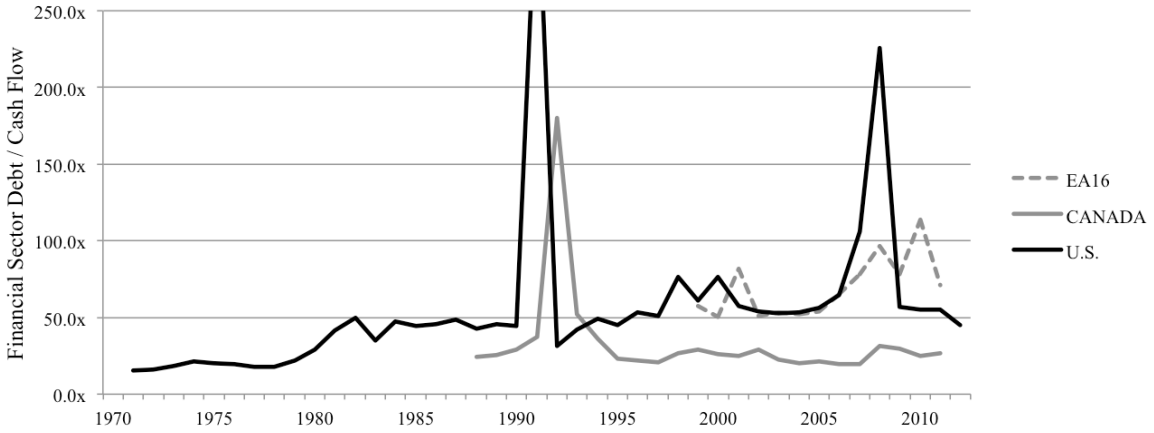
By comparison, a series of US financial mishaps post the 1970s are graphically evident in Figure 7. Periods of significant escalation and volatility in the ratio occurred in the 1980s and early 1990s (S&L crisis) and again in the late 1990s (Long Term Capital Management failure and Asian crisis). The collapse of the US banking system in 2008 is indicated as a spike, and return, but not necessarily a full reversion.[10] Financial entities are expected to be subject to long run Debt/CF ratio ranges related not only to the individual entity, but also collectively as a sector to the sustainability of a nation's financial system. Sovereign risk is in turn directly impacted in so far as governments may be expected to bailout excessive instability of financial systems. Numerous Financial sector crises have morphed into sovereign crises in the past five years, and the vectors of contagion have been flexible in attack, such as housing to financial to sovereign. In this context, in a regulatory framework for financial institutions, the Debt/CF might serve as an additional target or monitor of leverage, as Basel II and III indicate that no cash flow requirements are included or planned to be included.

[7]Debt is sourced as Credit Market Instruments (see Table 3). Total Liabilities of the Financial sector was also tested which produced materially different results. A larger number of formats for the definition of Financial sector liabilities exist compared to those for the household and non-financial sectors. The accounting for opaque financial instruments is still in its infancy, and may cause considerable understatement or comparability issues.

[8]Canada's Financial sector held an average Debt/CF of approximately 25x from 1995 to 2012, with a peak at 41.6x in Q4 2008.

[9]The regulatory regime in Canada includes strong capital ratios, and the Debt/CF results are considered an outcome of such other parameters.

[10]Further research could assess the differential between Financial sector (and hence that of its participants) Debt/CF which are much higher than the Debt/CF of other economic sectors (all considerably lower).



Sources: EuroStat, Federal Reserve and StatsCan.

Figure 7: Debt/CF History of US, Canada, and EA16 domestic financial sectors.

2.6. Debt/CF for the government sector

In recent decades, most governments have run deficits and had negative cash flows, resulting in a negative Debt/CF ratio.[11] Nevertheless, when governments do produce positive cash flow, a Debt/CF can be calculated. The Debt/CF for the US Government sector is included in Figure 9 for the years 1946 to 1974, after which the preponderance of data is negative and not depicted. Certainly, governments themselves may be the cause, even the sole cause, of financial instability and sovereign crises. The factors influencing the financial stability of individual governments or the government sector, however, go considerably beyond their direct leverage as measured by Debt/CF. The varying sequences of instability arising through economic sectors may ultimately become systemic and transmit to the sovereign. In addition, fiscal policies and the interplay of savings transfers through taxation or lack thereof directly impact the relative financial sustainability of private sectors versus government. The aggregate debt of a nation, including government obligations, can thereby be seen to be carried by the aggregate cash flow of the nation. The nation's aggregate Debt/CF in turn reflects back to the sustainability of public debt.

3. Debt/CF for nations: Defining a four-zone framework

This section formulates the Debt/CF ratio for nations. The statistic for a nation can be quantified as Total Economy Debt / National Gross Saving, and hence a nation with $8 Trillion in Total Economy Debt and $1 Trillion in National Gross Saving has a Debt/CF of 8:1 or 8x. While Total Economy Debt is the sum of household, corporate, banking, and government debt and National Gross Savings is GDP less final consumption expenditure, the precise definitions of the measures are not always self-evident. Thus, before describing the four-zone framework for assessing nations' risks and vulnerabilities based upon Debt/CF, this section discusses how to measure the components of the ratio.

3.1. Debt and liability definition table

As suggested by Table 3, various definitions of debt could be tested, depending upon which Flow of Funds components (listed down the left column) are included. In this paper, "Total Economy Debt" was modeled on the US Federal Reserve (2013) definition of Credit Market Instruments, and the equivalent

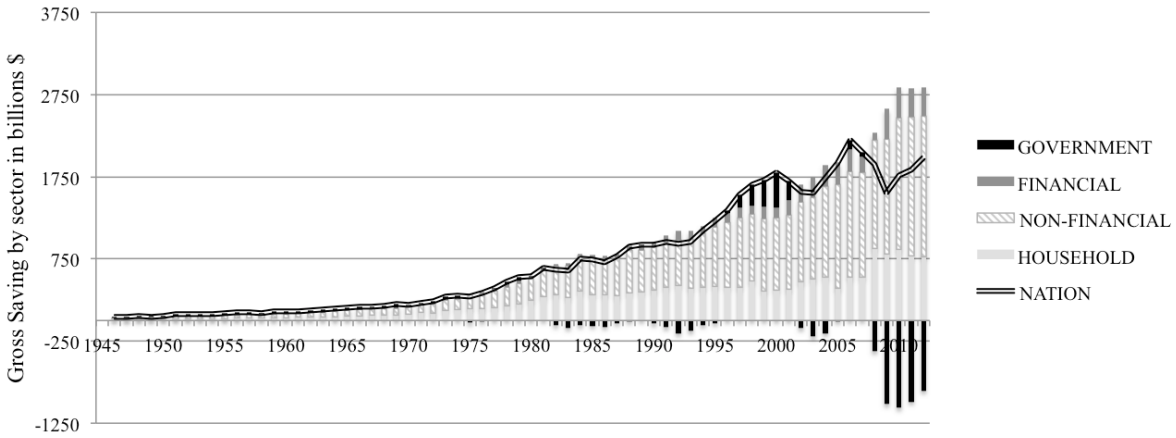
[11] Deficits must be adjusted for the Government Capital Consumption Allowance (CCA) in order to determine Government cash flow. The accounting for public assets and related depreciation may differ relative to private sectors and among nations.

Flow of Funds data for other countries. The two components included in Total Economy Debt are noted with check marks in Table 3 under the Credit Market Instruments definition (second column). For another study that calculated total debt for nations following a similar methodology, see McKinsey Global Institute (2010).

Table 3: Debt and liability definitions applicable to sectors and nations.

	Credit market instruments	Haver Analytics	Total liabilities	Consolidated or Non-Consolidated	External component or Domestic
Currency and deposits			✓		
Securities other than shares	✓	✓	✓		
Loans	✓	✓	✓		
Shares and other equity			✓		
Insurance technical reserves			✓		
Other accounts payable		✓	✓		
Flow Of Funds Total Liabilities (sum of above)			✓		

The definition could be expanded for alternate testing. For example, Haver Analytics publishes sector and total economy debt statistics according to the definition indicated in the second column, where 'Other Accounts Payable' are also included. The definition can be further expanded to the 'Total Liabilities' approach utilized earlier in the paper (see third column), which is structured directly to incorporate all components from Flow of Funds reporting.[12] As per the two right hand columns, each debt definition needs to specify the option of consolidated or non-consolidated data, and select external versus domestic versus total liabilities. Total Economy Debt herein utilizes non-consolidated data for total debt (the sum of domestic and external non-consolidated debts as per the third column).



Sources: Federal Reserve.

Figure 8: Summation of US gross savings by sector with total for nation.

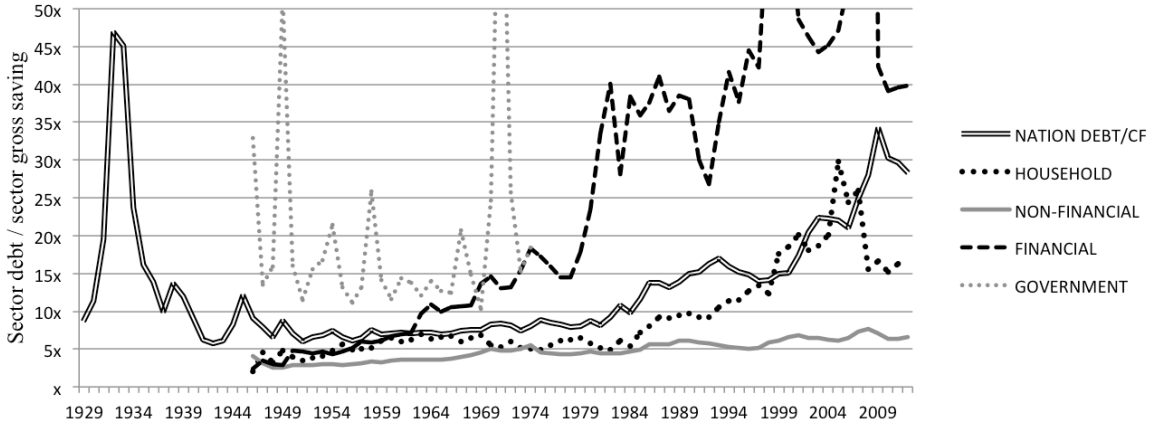
[12] Table 3 itemizes only the components from Flow of Funds statements and thus does not account for off-balance sheet items such as shadow banking, unfunded liabilities or derivatives.

3.2. Gross savings of a nation

A nation's cash flow is measured as National Gross Saving, a standard statistic reported under the System of National Accounts and through the Integrated Macroeconomic Accounts.[13] National Gross Saving can also be calculated by adding the nation's Capital Consumption Allowance to the more commonly cited Net Saving. National Gross Saving represents the aggregate flow of savings generated during a year, and is not a measure of the stock of savings in place. In Figure 8, the aggregation of National Gross Saving for the US is presented. In years of public sector deficits, national cash flow (double black line) is less than the sum of Household, Non-Financial, and Financial cash flows.[14] The majority of US cash flow is currently produced by the Non-Financial sector.

3.3. Comprehensive Debt/CF history of the US

Figure 9 presents a comprehensive history of Debt/CF results for each economic sector of the US and for the nation in aggregate. The financial collapse of the 1930s is depicted, along with an apparent subsequent reversion. The nation's leverage again began to climb in the 1980s, driven by escalating Household and Financial sector leverage, while Non-Financial sector leverage is reasonably stable throughout. Likewise, the swing from Government sector surpluses to deficits also contributes to rising aggregate leverage. Decomposing the Debt/CF results also provides useful information and a basis for further testing. In this regard, from 1946 to 1980 Total Economy Debt grew at a compounded 7.95% annually while National Gross Saving grew at a compounded 8.10%, resulting in stable leverage. From 1980 to 2012 however, Total Economy Debt grew at a compounded 8.05% annually, while National Gross Saving only grew at a compounded 4.13%, resulting in rising leverage through the period. US Gross Saving Margins, defined as Gross Saving to GDP, declined from approximately 20% in the late 1970s to 11.8% in 2012.



Sources: Federal Reserve.

Figure 9: Summation of available Debt/CF history for US sectors and the nation.

A four-zone framework could be devised for each sector and for the US nation based on its specific characteristics. In the same way that Debt/CF mean levels vary according to characteristics of industries, a 'one size fits all' Debt/CF for nations is unlikely. Rather, the diverse fabrics of nations result in different tolerances for leverage and instability. Table 4 presents a rudimentary summary of factors for sector and national financial instability. Intuitively, countries with stable and diversified economies, deep markets and stable regimes may be able to carry higher Debt/CF ratios than countries with narrow, less developed economies and markets.

[13]Note that slight differences in definitions and reporting may occur.

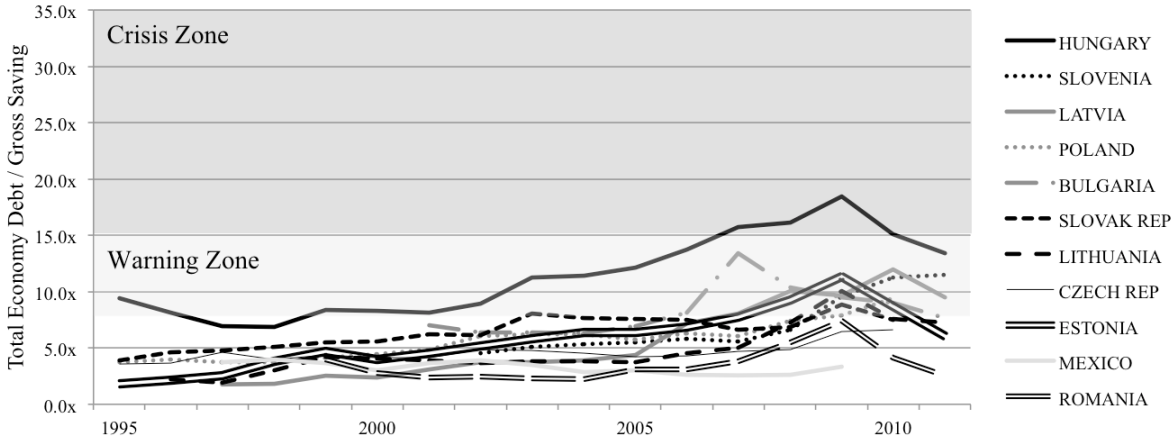
[14]In the SNA, deficits (adjusted for CCA) are accounted for as a reduction in the aggregate cash flow of a nation.

Table 4: Basic contemplation of factors for risks of instability of nations.

Economy	**Markets**	**Regime**
Extent of diversification and volatility of industry composition	Liquidity and sophistication of domestic markets with acceptance internationally	Stability of regime and functionality of public administration
Income and wealth distribution	Strength and effectiveness of regulatory mechanisms	Command of tax base
Savings versus consumption orientation and saving margins	Extent of for-profit banking sector	Risk of monetization

3.4. CEE and Baltic nations

The basic factors of Table 4 can next be applied on a group of somewhat similar nations. In the same manner corporate activity is folded into industry groups, 'peer groups' for nations may be useful to explore an initial application of Debt/CF. Figure 10 presents Debt/CF results for eleven CEE, Baltic and similar nations.



Sources: Eurostat and OECD.

Figure 10: Debt/CF histories for eleven CEE and Baltic nations (and Mexico).

Hungary stands out in the group as materially more levered, and in 2009 entered negotiations with the IMF. The balance of the group is clustered well under 10x, except for periods of instability for certain nations. Five other nations – Slovenia (2010–2011), Latvia (2008–2010), Bulgaria (2008–2009), Lithuania (2009), Estonia (2009) – exceeded 10x Debt/CF prior to 2012. Some characteristics of the nations presented include not being fully industrialized, having less developed financial systems, and regime youth. The nations typically run modest Current Account deficits and require balancing Capital Account inflows. The nations may operate with reasonably strong gross savings margins keeping the need for external capital in check. A suggested risk-adjusted framework for this peer group applied 7.5x< as stable, warning as 15x<, and crisis 15x+.

3.5. Establishing a four-zone framework of financial vulnerability

More advanced and industrialized nations can also be assigned into categories of escalating financial instability – Inefficient, Stable, Warning, and Crisis – according to Debt/CF levels within a four-zone framework. The precise level of Debt/CF demarcation between zones in Table 5 remains qualitative in nature.[15]

[15] Advanced industrialized nations presumably enjoy some diversification of component cash flows, with the attendant benefit of reduced volatility of aggregate Gross Saving. Markets are well developed and regimes are mature. A formula

Table 5: The allocation of advanced industrialized nations into zones of escalating risks.

Debt/CF zone	**Description**	**Categorized countries**
Inefficient Zone; D/CF< 5x	Nations are considered safe but under-levered - debt capital is underplayed and economy may not be operating at potential - upper bound is a level at which a nation crosses from under-levered to appropriately levered	
Stable Zone; D/CF 5x-15x	Nations are appropriately levered - leverage should be distributed among sectors in a balanced manner - debts are rolled over with ease, and excess cash flow may be produced (Hedge or Speculative units) - financial and economic crisis are less likely, will be less severe, occur less often, and can be more easily managed - structural characteristics typically include high Gross Saving Margins, large Current Account surpluses, significant providers of capital internationally, primary international net lenders pursuant to the Net Lending / Borrowing Account - upper bound is a level corresponding with rising financial instability at which a nation crosses from appropriately levered to somewhat over-levered	Austria, Germany, Korea, Norway, Switzerland
Warning Zone; D/CF 15x-25x	Nations are over-levered and exposed to a pattern of escalating instability - national over-leverage may involve a significantly over-levered sector or sectors - unexpected shocks will be more difficult to manage - financial stability is increasingly reliant on the ability to roll over debts and no excess cash flow is produced. - structural characteristics typically include declining Gross Saving Margins, increasing Current Account deficits and Capital Account inflows, increasing Net Borrowing as a portion of GDP (speculative or ponzi units) -upper bound is a level at which a nation becomes exposed to direct and intensifying threats of illiquidity or insolvency	Belgium, Canada, Finland, France, Italy, Spain, Sweden
Crisis Zone; D/CF 25x+	Nations are at significant financial risk of a crisis occurring or have experienced a recent financial or sovereign crisis - leverage is very high and unfavorable circumstances may suddenly drive financial instability to extremes - refinancing and sudden stop risks may become pronounced unexpectedly - structural characteristics typically include high Current Account deficits, significant and escalating Capital Account inflows, steadily deteriorating and low Gross Saving Margins, relatively higher Net Borrowing as a share of GDP	Cyprus, Greece, Iceland, Ireland, Netherlands, Portugal
High Leverage Nations with monetary control	Nations have very high leverage whether or not a crisis has occurred - currency control, and may act as reserve currency - may be internationally important central bank - US and UK Gross Savings Margins have declined from 20% in late 1970s to under 12% recently, and are net borrowers. - Denmark and Japan have high Gross Savings Margins of over 20%, and are net lenders.	Denmark, Japan, United Kingdom, United States

could be constructed to estimate an 'ideal' range for a Stable Zone for a nation through pro-weighting safe and stable sector Debt/CF ranges. Adopting the 5-15x, 15-25x and 25+ zones presents a functional starting point. This base zone framework accounts for leverage only but can be enhanced with other metrics to more comprehensively access systemic risk.

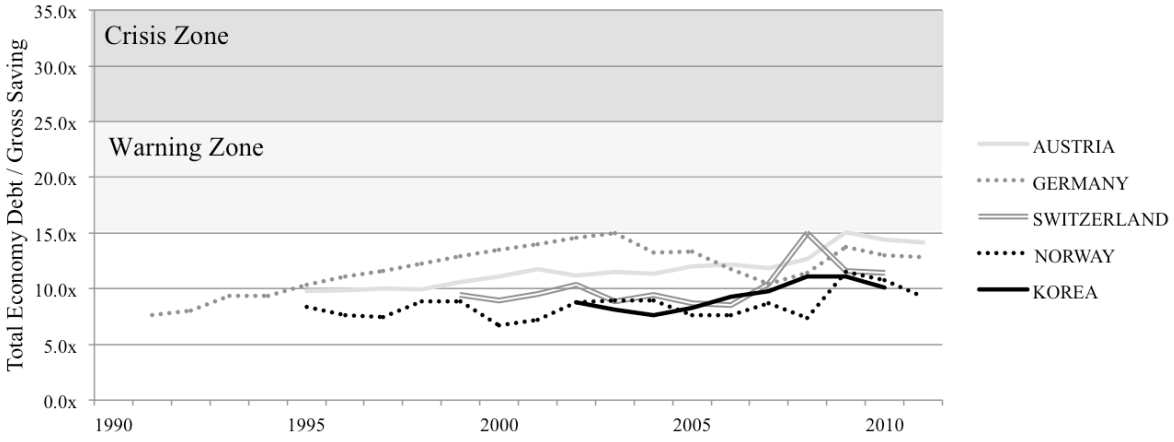
The primary categories and determining parameters are set out in Table 5 below. The table includes sample structural characteristics as determinants of greater or lesser financial stability. Not surprisingly, the current sample does not include economies that are characterized by inefficient Debt/CF levels given ongoing high leverage globally.

4. Exploring Debt/CF histories for nations

This section explores and tests the Debt/CF ratio for the panel of nations over time. First, we apply the criteria set out in Table 5 for the four-zone framework, and discuss the Debt/CF time series for example nations in each category. Next, we discuss alternative uses of the elements of the ratio, and cite potential variations in definitions. Finally, we quantitatively test the performance of Debt/CF, as well as certain variants, as early-warning indicators of banking, debt and currency crises.

4.1. The evolution of nations in the four-zone framework

Applying the zone criteria established in Table 5, Figure 11 presents nations assigned to the stable zone.[16] The group consists mainly of European advanced economies. For Switzerland, the figure depicts increases in leverage prior to the need to bail out the financial sector in 2008−2009. Subsequently, leverage subsided. Hence, an advantage of residence in the stable zone is the ability to absorb shocks and recover quickly. Nations with smaller vulnerabilities are less prone to broader crises, given the occurrence of a shock or other trigger.



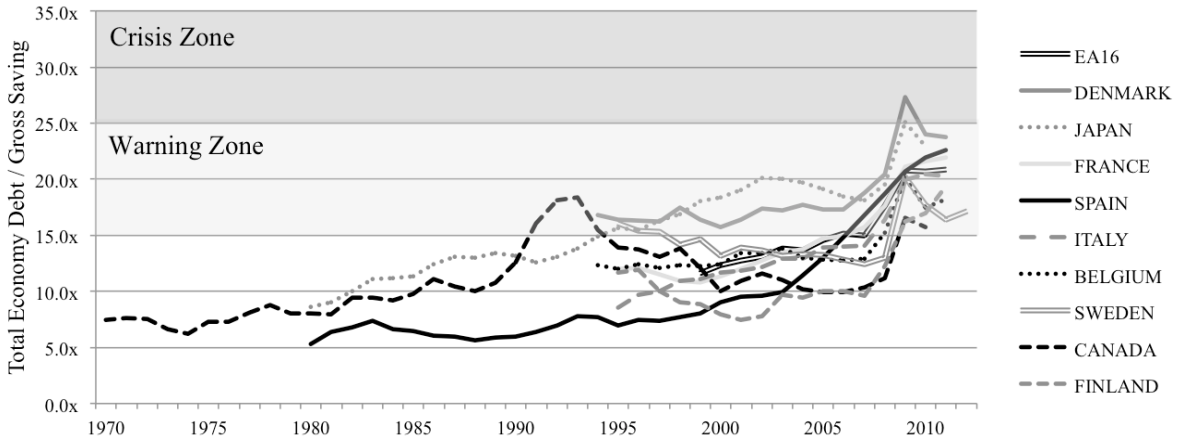
Sources: Eurostat and OECD.

Figure 11: Debt/CF histories for five nations with generic stable leverage.

Nations assigned (pursuant to Table 5) to the warning zone are presented in Figure 12. Most of these nations had Debt/CF ratios pushed upwards in concert with the recent global financial crisis. Increased debt funding, bailouts and stimulus programs and/or declines in Gross Savings as a result of the recession have most likely been contributing factors. The significant rise and then fall in Canada's Debt/CF ratio in the early 1990s indicates a period of instability and reversion to long-term mean levels. Canada faced financial distress in the early 1990s. During this period Canada's federal debt was roughly 70% of GDP (excluding provincial and municipal debt) and the budget deficit had peaked at 9.2% of GDP. The nation lost its AAA debt rating with references made to Canada's currency as a 'northern peso'. Pro-active policy counter measures were taken, along with the good fortune of riding

[16] As specified in Table 5, none of the nations in the group have Debt/CF of less than 5x and hence none have been assigned to the inefficient zone.

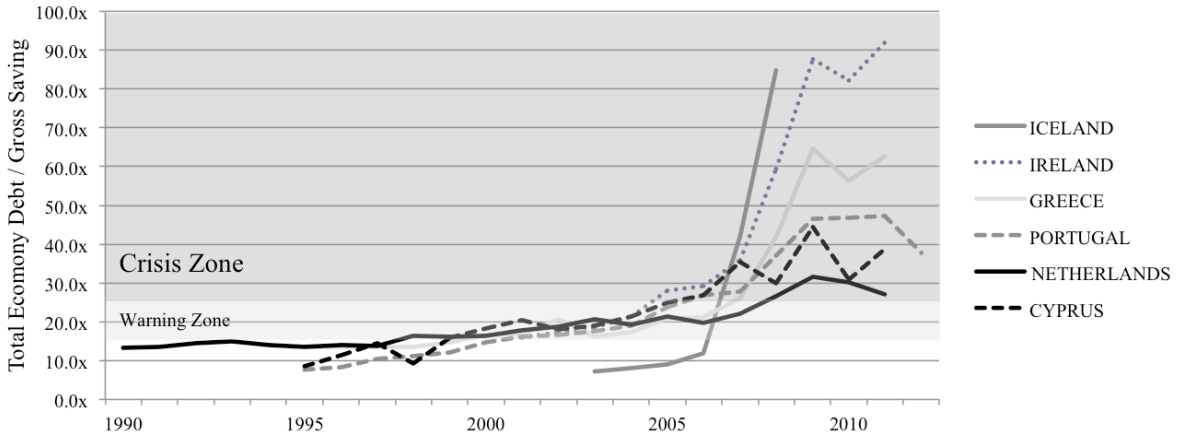
the US expansion of the mid to late 1990s, and Canada's Debt/CF steadied at stable levels for the following 15 years. Canada re-entered warning levels in conjunction with the 2008-9 recession. As a contrast, the relentless deteriorating financial condition of Spain is also evident in Figure 12.



Sources: Eurostat and OECD.

Figure 12: Debt/CF histories for nations with deteriorating financial risks.

Pursuant to Table 5, all nations in Figure 13 (crisis zone) have experienced recent financial and/or sovereign crises (note the change in x-axis scale). The figure portrays paths of escalating leverage since the 1990s when essentially all the nations were positioned in a stable zone. Decomposing the Debt/CF, liabilities have escalated rapidly in the years leading to crises, and the nations commonly have low or falling Gross Saving Margins and ultimately are unable to rollover debts. The Figure 13 nations do not control their own currency, which may influence management scope against crises.[17] In the case of the Netherlands, savings are strong but overall Debt/CF is elevated by a highly levered Household sector, and a proportionately larger financial sector, which was bailed out in 2008.

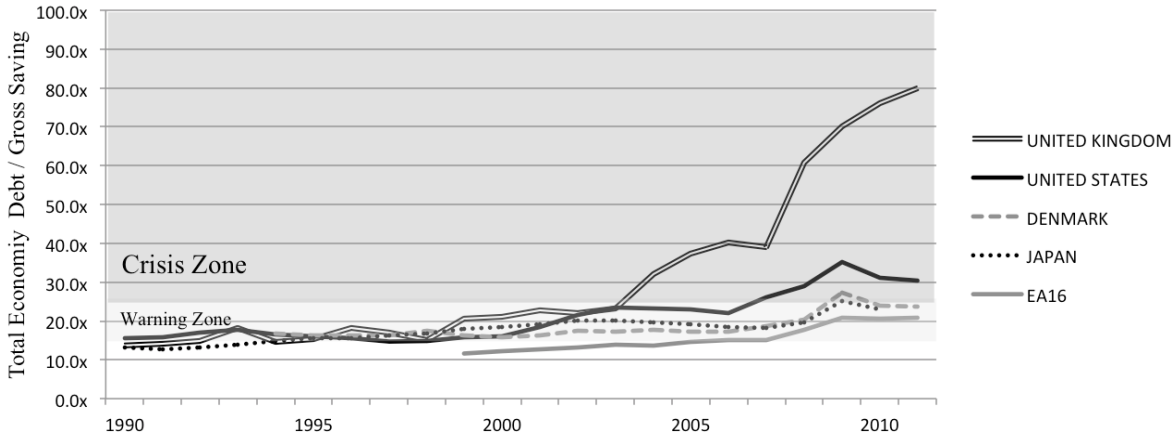


Sources: Eurostat and OECD.

Figure 13: Debt/CF histories for nations with crisis exposure.

[17]Iceland has its own currency but most liabilities were denominated in foreign currency, limiting scope for monetary solutions to its crisis. Debt statistics for Iceland were from local sources.

Figure 14 portrays a group of highly levered advanced nations that have monetary and currency authority. The EA16 group presents a weighted average of stable and unstable euro area nations individually depicted earlier, seen in aggregate to be less levered than the US or UK. The nations in Figure 14 have managed through the recent crises and are experiencing financial market stability in early-2014, despite high Debt/CF. Credit rating agencies deploying panels of statistics, as well as complex models, continue to rate a large number of vulnerable nations AAA in early-2014. The nations continue to attract capital to rollover or increase debts. Leverage is high, but direct financial stress is relatively low. Central bank actions certainly have been instrumental in the return to stability. This short to medium-term stability will be subject to the test of medium to long-term macro-financial sustainability.



Sources: Eurostat, OECD and Federal Reserve.

Figure 14: Debt/CF histories for high leverage nations with monetary authority.

4.2. Variants of Debt/CF

Notably, one leverage metric alone is seldom sufficient to comprehensively assess financial fragility. Additional explanatory power can be found in other flow/flow, stock/stock, and stock/flow comparisons, needed to broadly assess liquidity and solvency risks. Table 6 provides a list of a number of metrics which may complement stock-flow consistent models, financial fragility indexes and early-warning models. Certain of these are variants of Debt/CF and have been subject to preliminary testing. Thus, while Debt/CF primarily reveals solvency risk, metrics such as short term debt / total debt can help flesh out liquidity and refinancing risks. Similarly, the interest expense / gross saving statistic could help explain the manner in which holding interest rates low may extend stability against the risks of high Debt/CF positions.

Table 6: Alternative risk measures based upon elements of the Debt/CF ratio.

Flow/flow	**Stock/stock**	**Stock/flow**
Net lending or borrowing / gross saving	Total debt / net worth	Total debt / (gross saving – net lending or borrowing)
Current account / gross saving	Short term debt / total debt	Alternate debt definitions / gross saving
Interest expense / gross saving	(Foreign currency denominated or external debt) / total debt	Total debt growth rate / gross saving growth rate
Gross saving / GDP	Total debt / total assets	Gross saving / total assets

Metrics involving the net lending / net borrowing accounts could be useful in assessing growing imbalances between economic sectors within a nation, and among nations.[18] Further, deducting the net lending / net borrowing account from gross savings defines a more harsh form of cash flow for testing, netting out the unearned portion. Low or falling gross saving margins and increasing net borrowing accounts are well evident characteristics of the crisis nations of the 2000s (see Ramsay (2011, pp. 19–21)). Although it has been common to assess trend deviations, such as the credit and asset price gaps proposed by Borio and Lowe (2002), we do not consider these types of transformations for the Debt/CF and its variants. The primary reason is that there is little evidence supporting the sustainability of an increasing trend in Debt/CF-related leverage. These and other aspects may be examined to better understand how the vectors of contagion transform sectoral and national high leverage into financial instability.

4.3. Debt/CF and its variants as early-warning indicators

This section tests the performance of Debt/CF and certain of the above noted ratios as early-warning indicators. In short, the aim of such indicators is to issue warning signals during vulnerable states (pre-crisis periods) and to stay quiet otherwise (tranquil periods). The early-warning indicators used herein are created using the signal extraction approach introduced in Kaminsky et al. (1998), and commonly applied thereafter (e.g., Alessi and Detken, 2011). In principle, this turns a univariate variable (e.g., Debt/CF) into country-specific percentiles, and sets a threshold value on the indicator in order to either issue or not issue an early-warning signal. For further information on the signal extraction approach, see Appendix A.2.

The thresholds of early-warning indicators can be set by optimizing policymakers' loss functions and Usefulness measures (see Sarlin, 2013). Usefulness is a measure showing how much better an early-warning indicator or model is than the best guess of a policymaker, given her preferences between issuing false alarms and missing crises and the unconditional probabilities of the classes. Testing Usefulness thus also provides a means for evaluating the performance of an early-warning indicator. In this paper, we focus on relative Usefulness which can be described by the share of available Usefulness that the model captures, given policymakers' preferences μ and a forecast horizon h. For further information on the measures, see Appendix A.3.

We evaluate a number of indicators, including the (*i*) Debt/CF ratio, along with the following variants: (*ii*) net lending / net borrowing to CF, (*iii*) debt to earned CF, (*iv*) gross savings to GDP, (*v*) net lending / net borrowing to GDP, (*vi*) financial sector total liabilities to CF and (*vii*) financial sector debt to CF. Performance of each of the seven indicators as a crisis determinant is tested with respect to how well they are able to classify pre-crisis periods from tranquil times, given a policymaker who is substantially more concerned about missing a crisis ($\mu = 0.9$) and has a forecast horizon of 24 months ($h = 24$). The pre-crisis periods are defined from a set of crisis events, following the database of events specified in Babecky et al. (2013).[19] Further, we assess how the performance of the indicators differs for banking, debt and currency crises, as well as for an aggregate of all three types of crises. Robustness of the results is tested with respect to policymakers' preferences ($\mu = 0.8$ and $\mu = 0.95$) and the forecast horizon ($h = 12$ and $h = 36$). While the details of the evaluation framework are to be found in Appendix A.3, it is important to note that thresholds of 0 or 1 imply that the indicator failed in yielding any Usefulness. In such cases, the optimal choice of a policymaker is to either always or never signal a crisis.

[18] Inter-sectoral imbalances may not be revealed in sector Debt/CF, which indicates the usefulness of disaggregated statistics.

[19] The events in this paper are based upon the initiative by the European System of Central Banks (ESCB) Heads of Research Group, which was reported in Babecky et al. (2013). The database includes banking, currency and debt crisis events for a global set of advanced economies from 1970 to 2012. The database is a compilation of crisis events from a large number of influential papers, which have been further complemented and cross-checked by ESCB Heads of Research. A binary crisis variable takes the value 1 in the case an event occurs, and 0 otherwise. In this paper, we specify the dependent variable to take the value 1 during a specified horizon prior to the crisis events, and 0 otherwise, to identify vulnerable states.

Table 7: Evaluating early-warning performance of Debt/CF and certain variants.

a) Banking crises

		Benchmark					*Robustness*			
							μ=0.8	*μ=0.95*	*h=12*	*h=36*
Preferences	***λ***	***T 1***	***T 2***	***Accuracy***	***U r (μ)***	**AUC**	***U r (μ)***	***U r (μ)***	***U r (μ)***	***U r (μ)***
Debt to CF	0.74	36.59 %	26.15 %	72.75 %	35.06 %	0.71	12.20 %	25.25 %	31.82 %	28.18 %
Debt to earned CF	0.79	41.46 %	21.26 %	76.61 %	34.77 %	0.67	13.41 %	26.69 %	30.30 %	12.42 %
Gross savings to GDP	0.05	0.00 %	99.75 %	12.47 %	0.25 %	0.55	4.02 %	7.56 %	11.81 %	0.26 %
Net lending/borrowing to CF	0.72	40.74 %	28.14 %	70.35 %	22.11 %	0.64	12.50 %	24.84 %	23.66 %	0.27 %
Net lending/borrowing to GDP	0.69	42.86 %	31.17 %	67.40 %	14.96 %	0.61	12.95 %	17.75 %	19.79 %	0.26 %
Financial sector liabilities to CF	0.09	2.70 %	96.03 %	14.16 %	0.99 %	0.60	0.00 %	0.00 %	0.00 %	1.05 %
Financial sector debt to CF	0.09	2.70 %	96.04 %	14.12 %	0.99 %	0.64	0.00 %	0.00 %	14.04 %	1.05 %

b) Debt crises

		Benchmark					*Robustness*			
							μ=0.8	*μ=0.95*	*h=12*	*h=36*
Preferences	***λ***	***T 1***	***T 2***	***Accuracy***	***U r (μ)***	**AUC**	***U r (μ)***	***U r (μ)***	***U r (μ)***	***U r (μ)***
Debt to CF	0.91	18.75 %	10.60 %	89.13 %	45.83 %	0.85	9.38 %	64.47 %	0.00 %	44.44 %
Debt to earned CF	0.92	50.00 %	11.23 %	87.53 %	12.50 %	0.70	0.00 %	38.82 %	0.00 %	10.53 %
Gross savings to GDP	0.89	64.52 %	12.24 %	85.07 %	10.39 %	0.63	0.00 %	24.65 %	0.00 %	16.81 %
Net lending/borrowing to CF	0.94	61.29 %	8.13 %	89.11 %	22.22 %	0.71	4.84 %	33.92 %	0.00 %	27.92 %
Net lending/borrowing to GDP	0.86	51.61 %	14.83 %	83.28 %	17.92 %	0.69	5.65 %	35.60 %	0.00 %	27.07 %
Financial sector liabilities to CF	1.00	100.00 %	0.00 %	98.12 %	0.00 %	0.63	0.00 %	0.00 %	0.00 %	0.00 %
Financial sector debt to CF	1.00	100.00 %	0.00 %	98.12 %	0.00 %	0.74	0.00 %	6.58 %	0.00 %	0.00 %

c) Currency crises

		Benchmark					*Robustness*			
							μ=0.8	*μ=0.95*	*h=12*	*h=36*
Preferences	***λ***	***T 1***	***T 2***	***Accuracy***	***U r (μ)***	**AUC**	***U r (μ)***	***U r (μ)***	***U r (μ)***	***U r (μ)***
Debt to CF	1.00	100.00 %	0.00 %	98.83 %	0.00 %	0.84	0.00 %	23.68 %	0.00 %	0.00 %
Debt to earned CF	1.00	100.00 %	0.00 %	98.83 %	0.00 %	0.85	0.00 %	37.72 %	0.00 %	0.00 %
Gross savings to GDP	0.96	63.64 %	5.21 %	93.80 %	3.03 %	0.70	0.00 %	27.75 %	5.56 %	2.22 %
Net lending/borrowing to CF	0.93	36.36 %	9.41 %	90.13 %	4.04 %	0.74	0.00 %	35.41 %	0.00 %	3.17 %
Net lending/borrowing to GDP	1.00	100.00 %	0.00 %	98.30 %	0.00 %	0.70	0.00 %	13.40 %	0.00 %	0.00 %
Financial sector liabilities to CF	1.00	100.00 %	0.00 %	98.61 %	0.00 %	0.68	0.00 %	0.00 %	0.00 %	0.00 %
Financial sector debt to CF	1.00	100.00 %	0.00 %	98.62 %	0.00 %	0.72	0.00 %	0.00 %	0.00 %	0.00 %

d) All crises aggregated

		Benchmark					*Robustness*			
							μ=0.8	*μ=0.95*	*h=12*	*h=36*
Preferences	***λ***	***T 1***	***T 2***	***Accuracy***	***U r (μ)***	**AUC**	***U r (μ)***	***U r (μ)***	***U r (μ)***	***U r (μ)***
Debt to CF	0.58	30.43 %	42.73 %	58.78 %	19.09 %	0.63	9.78 %	0.91 %	28.44 %	8.06 %
Debt to earned CF	0.70	36.96 %	30.30 %	68.88 %	23.33 %	0.65	11.41 %	0.30 %	31.56 %	4.19 %
Gross savings to GDP	0.05	0.00 %	99.74 %	13.90 %	0.26 %	0.51	7.08 %	0.26 %	18.41 %	0.28 %
Net lending/borrowing to CF	0.72	38.98 %	27.39 %	71.03 %	17.55 %	0.66	21.19 %	0.27 %	30.72 %	0.28 %
Net lending/borrowing to GDP	0.64	35.00 %	35.88 %	64.24 %	14.25 %	0.63	17.08 %	0.26 %	23.81 %	0.28 %
Financial sector liabilities to CF	0.09	2.50 %	95.89 %	15.36 %	1.03 %	0.57	0.00 %	0.34 %	0.00 %	1.10 %
Financial sector debt to CF	0.09	2.50 %	95.90 %	15.32 %	1.02 %	0.59	0.00 %	0.34 %	13.23 %	1.09 %

The left part of Table 7 summarizes the performance of all seven indicators for different types of crises, whereas the right side provides results of the robustness tests. In terms of $U_r(\mu, h)$, the left part of Table 7 establishes that the indicators generally perform well in signaling banking, debt and aggregate crises, but less so when applied to currency crises, for which we can observe that five indicators are disregarded. This shortcoming follows expectations, as periods reflecting exchange rate pressure or prior to the collapse of a currency is oftentimes described by different types of vulnerabilities (see e.g., Kaminsky et al., 1998). Further, we see that both measures focusing on the financial sector alone show poor performance indicating that the aggregated formats provide a better measure of macro-financial

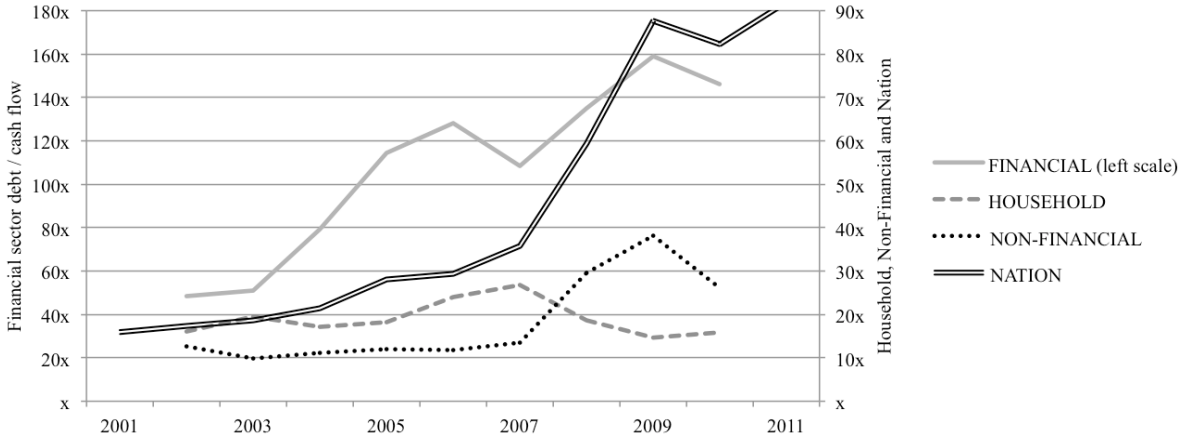
risks. When comparing performance among indicators using $U_r(\mu, h)$, the table indicates that Debt/CF outperforms alternative versions of the indicator, except for aggregated crises in which case debt to earned cash flow is superior by four percentage points.

In assessing robustness on the right side of Table 7, we observe that performance on banking crises is relatively stable for $\mu = 0.95$ and $h = 12$, but diminished for $\mu = 0.80$ and $h = 36$. The table indicates the benchmark specification of the Debt/CF ratio captures a large share of Usefulness on debt crises, which increases to 64.5% for $\mu = 0.95$. Further, each of the variants improved performance at $\mu = 0.95$, again excepting the two banking sector indicators. On the other hand, none of the indicators performs well for $\mu = 0.8$ and $h = 12$ in the context of debt crises. In the context of currency crises, performance is again substantially improved at $\mu = 0.95$, but fails to yield Useful signals for the alternative parameters. Finally, with regard to the aggregate definition of crises, we observe in Table 7 that the indicators, particularly Debt/CF, provide Useful results, but still exhibit poorer performance than for banking and debt crises alone. For the all crises aggregated case, the test with $h = 12$ yields the strongest results.

5. Concluding discussion

This paper has demonstrated the usefulness of Debt/CF ratios for measuring systemic risks and vulnerabilities in nations and their economic sectors. Starting with qualitative discussions of the concept and illustrative examples of cases, the Debt/CF ratio has been shown to indicate increases in risks and vulnerabilities in nations and their economic sectors. We also provided a quantitative evaluation of Debt/CF as a determinant of financial crises, and show the Usefulness of the Debt/CF ratio in terms of an early-warning indicator. Our findings are that the Debt/CF ratio is a Useful indicator in signaling risks. Further, we show that the ratio performs significantly better on banking and debt crises than on currency crises.

This final section concludes the paper by discussing three conceptual issues related to build-ups of systemic risks featured by Debt/CF: assessing the transmission of instabilities, macro-prudential tools and to bail-in or out.



Sources: Eurostat.

Figure 15: Debt/CF histories for Ireland's economic sectors and the nation.

5.1. The transmission of instability sector to sector and sectors to sovereigns

The specific path to instability will be peculiar to each crisis. Figure 15 provides an overview of the way Ireland's leverage builds first in the Financial sector and then the Household sector prior to the crisis. The crisis and recession impact the Non-Financial sector as expected, which then begins to recover. In Ireland's case, the aggregate instabilities transmit to the nation as a whole (double black

line), by way of a Financial sector bailout and a collapse in gross savings, previously puffed up by the leverage boom. The slope of the trajectory and level for each sector within a zone framework may be useful in assessing the potential severity and urgency of escalating risks.

With further testing, the Debt/CF approach is proposed for use by international organizations for monitoring, stratification and reporting of financial vulnerability. In the footsteps of Minsky, the Debt/CF ratio and its variants may provide a coherent grid to assist established institutions dampen build-ups of disruptive macro-financial vulnerabilities. While this work sets a starting point, further research is required to examine the extent to which operationalizing aspects of Minsky's insights in this way can be verified as leading indicators to predict various other types of financial instabilities, as well as how these ought to be implemented in day-to-day policy approaches.

5.2. Macro-prudential aspects and interest rates

Debt/CF is a core accounting connection between the balance sheet of the nation, and the savings generated from the income statement. In effect, the metric measures the strength of the interface between the real economy and the financial system. If Debt/CF ratios revert to mean levels over very long, cyclical time periods, the natural bounds on the feasible range for the relationship should be identifiable. If so, the financial sustainability of sectors and nations is likely subject to limiting medium to long run mathematical relationships between the level of outstanding debt on the balance sheet and the annual flow of savings generated. Operationalizing Minsky's insight by way of Debt/CF may thereby provide elements for economic policy, effective in the stratification of financial instability and useful in the quest for macro-financial sustainability. Each nation could consider establishing a target stable zone. Conceptually, like other prudential macroeconomic tools, the Debt/CF ratio could be influenced using policy levers and central bank mechanics relevant to the nation and each of its four economic component sectors. Nations could learn to lean against the winds of financial instability by pushing Debt/CF within stable levels. A reasonable distribution of leverage among economic sectors would be desirable, along with a proportionately appropriate financial sector. The duration of debt liabilities could be roughly equivalent to a stable level Debt/CF, with maturities distributed evenly, so that cash flow generated approximately equates to obligations due in a particular year. Debt/CF does not answer the question of whether economies work best with stable leverage.

The interest rate implications under a Debt/CF model are noteworthy. If financial sustainability favors residence in the Stable Zone, the components of the ratio must react accordingly. If Debt/CF is in the Stable Zone, interest rates ought to be in a normal range consistent with long-term expected returns. As the upper bound of stable leverage is breached, interest rates need to rise. Higher rates would discourage borrowing and encourage saving. The numerator is invited to decline, the denominator to increase. When Debt/CF is near the Inefficient Zone, interest rates would be set below normal levels to encourage borrowing and discourage saving.

5.3. Bail-out to grow out or Bail-in?

The various theoretical debates, such as austerity versus stimulus, are questions about the best formula to achieve GDP growth. Growth is expected to resolve instabilities, along with near every economic ill known. The status of existing leverage of nations and their economic sectors is relevant to these debates. Global leverage, as measured by Debt/CF, has increased significantly in recent decades. The 2008 and subsequent crises' policy response, to bail-out (rather than bail-in) financial sector creditors of the major and crisis economies, has served to stabilize, but continue, a highly levered environment. Will any growth-centric approach be effective against a tide of leverage? Beyond the ability to grow out of excessive leverage, two policy choices are forefront. For those nations with monetary control, the possibility to monetize liabilities theoretically exists. As a remaining alternative in a highly levered circumstance, Debt/CF could be deployed to determine the portion of credit to be rationalized (down to a particular Debt/CF level) in a currency and credit consolidation. Perhaps it will be different this time, and leverage may not revert, or at least not as an abruptly unraveling shock. Perhaps sophisticated nations have entered a new, manageable paradigm of on-going high

Debt/CF leverage, where strategic central bank actions and intelligent fiscal elements can achieve healthy economies yet contain financial instability. Or, perhaps the leverage cycle is simply extending, and Minsky's principle that stability begets instability is in fact operating.

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Appendix A.1. Data, metrics and sources

Table A.1: Definitions and sources of data.

Level	Variable	Definition and transformation	Timespan	Source	Figure/Table/Section
Firm	Debt to Cash Flow	Total liabilities to CF	1951-2007	U.S. Energy Inform. Adm.	Figure 1 in Section 2.2
Sector	Total Debt to Cash Flow for S&P Industry Groups	(Total current liabilities + long-term debt) / CF	1992-2012	Standard & Poor's	Table 1, Section 2.1
	Total Liabilities to Cash Flow for S&P Industry Groups	(Total debt + deferred taxes & inv. tax credits + minority intr. + other liab.) / CF	1992-2012	Standard & Poor's	Table 1, Section 2.1; Figure 2, Section 2.3
	Total Debt to Cash Flow of the Non-Financial Sector	Total debt / gross saving	1995-2012	EUROSTAT, OECD	Figures 3 & 4, Section 2.3
	Total Debt to Cash Flow of the Household Sector	Total debt / gross saving	1985-2012	EUROSTAT, OECD	Figures 5 & 6, Section 2.4
	Total Debt to Cash Flow of the Financial Sector	Total debt / gross saving	1952-2012	EUROSTAT, U.S. BEA, Stats Canada	Figure 7, Section 2.5; Signal extraction, Section 4.3
	Total Liabilities to Cash Flow of the Financial Sector	Total Liabilities / gross saving	1952-2012	EUROSTAT, U.S. BEA, Stats Canada	Figure 7, Section 2.5; Signal extraction, Section 4.3
	Total Debt to Cash Flow of US Sectors	Total debt / gross saving	1946-2012	US Federal Reserve	Figure 8 & 9, Section 3.2
Country	Total Debt to Cash Flow of US Total Economy	Total debt / gross saving	1946-2012	US Federal Reserve	Figure 8 & 9, Section 3.2
	Total Debt to Cash Flow of Nations	Total debt / gross saving	1995-2012	EUROSTAT; OECD	Figures 10-14, Sections 3.4, 4.1; Signal extraction, Section 4.3
	Total Debt to Earned Cash Flow of Nations	Total debt / (gross saving - net lendingnet borrowing)	1970-2011	EUROSTAT; OECD	Signal extraction, Section 4.3
	Net Lending/Net Borrowing to Cash Flow of Nations	Net lending or borrowing / gross saving (= % unearned cash flow)	1970-2011	EUROSTAT; OECD	Signal extraction, Section 4.3
	Net Lending/Net Borrowing to GDP of Nations	Net lending or borrowing / GDP (= % unearned GDP)	1970-2011	EUROSTAT; OECD	Signal extraction, Section 4.3
	Gross Saving Margin of Nations	Gross saving / GDP	1970-2011	EUROSTAT; OECD	Signal extraction, Section 4.3

Table A.2: Summary statistics.

Level	Variable	Obs	Min	Max	Mean	Std. Dev.	Skew	Kurt
Firm	Debt to Cash Flow	246	4.17	50.00	16.70	13.48	1.66	1.52
Sector	Total Debt to Cash Flow for S&P Industry Groups	189	0.00	23.05	3.77	2.49	2.85	18.20
	Total Liabilities to Cash Flow for S&P Industry Groups	208	2.84	48.98	9.15	5.79	2.52	11.50
	Total Debt to Cash Flow of the Non-Financial Sector	204	3.48	43.61	9.02	5.69	3.16	12.77
	Total Debt to Cash Flow of the Household Sector	235	1.68	35.49	9.10	5.92	1.51	2.32
	Total Debt to Cash Flow of the Financial Sector	482	0.00	2200.09	78.41	173.26	7.11	64.20
	Total Liabilities to Cash Flow of the Financial Sector	481	0.00	8132.94	430.89	948.29	5.28	31.10
	Total Debt to Cash Flow of US Sectors	268	-1118.62	396.82	6.79	83.27	-9.43	129.45
Country	Total Debt to Cash Flow of US Total Economy	84	5.75	46.91	13.14	8.35	2.02	4.67
	Total Debt to Cash Flow of Nations	570	0.00	98.68	13.14	11.01	3.80	20.94
	Total Debt to Earned Cash Flow of Nations	570	-89.09	14402.30	41.18	603.00	23.82	568.40
	Net Lending/Borrowing to Cash Flow of Nations	1073	-16897.70	189.80	-25.39	518.89	-32.14	1045.67
	Net Lending/Borrowing to GDP of Nations	1081	-164.00	65.70	-1.26	11.39	-7.32	86.46
	Gross Saving Margin of Nations	1083	0.00	40.70	20.10	8.95	-0.77	0.46

Appendix A.2. Signal extraction

This appendix describes the functioning of the signal extraction approach, as well as other details related to the design of the empirical experiments used in this paper. We make use of the signal extraction approach introduced by Kaminsky et al. (1998). Typically, the literature has preferred the use of pooled indicators (e.g., Fuertes and Kalotychou, 2007; Sarlin and Peltonen, 2013). A reasonable rationale for this is the relatively small number of crises in individual countries and the aim to capture a wide variety of crises. In order to account for country-specific differences, we transform each indicator into country-specific percentiles. Rather than using lagged explanatory variables, the benchmark dependent variable is defined as a specified number of years prior to the crises (2 years in the benchmark case). To issue binary signals, we need to specify a threshold value on the indicators, which is set as to optimize performance (Usefulness, as outlined in Appendix B). As proposed by Bussiere and Fratzscher (2006), the signal extraction accounts for post-crisis and crisis bias by not including periods when a crisis occurs or the 2 years thereafter. The excluded observations are not informative regarding the transition from tranquil times to distress events, as they can neither be considered "normal" periods nor vulnerabilities prior to distress. After signal extraction, an essential part is to evaluate the "quality of the signals" by measuring the classification performance of the indicator. The measures used are described in Appendix B.

Appendix A.3. Policymakers' loss functions and Usefulness measures

Early-warning models require evaluation criteria that account for the nature of the underlying problem, which relates to low-probability, high-impact events. Of central importance is that the evaluation framework resemble the decision problem faced by a policymaker. Following Sarlin (2013), the signal evaluation framework focuses on a policymaker with relative preferences between type I and II errors, and the usefulness that she derives by using a model, in relation to not using it.

To mimic an ideal leading indicator, we build a binary state variable $C_j(h) \in \{0, 1\}$ for observation j (where $j = 1, 2, \ldots, N$) given a specified forecast horizon h. Let $C_j(h)$ be a binary indicator that is one during pre-crisis periods and zero otherwise. For detecting events C_j using information from indicators, we need to estimate the probability of a crisis occurrence $p_j \in [0, 1]$, for which herein we use the signal extraction approach discussed in Appendix A. The probability p_j is turned into a binary prediction P_j, which takes the value one if p_j exceeds a specified threshold $\lambda \in [0, 1]$ and zero otherwise. The correspondence between the prediction P_j and the ideal leading indicator C_j can then be summarized into a so-called contingency matrix.

Table A.3: A contingency matrix.

		Actual class C_j	
		Crisis	No crisis
Predicted class P_j	Signal	Correct call *True positive (TP)*	False alarm *False positive (FP)*
	No signal	Missed crisis *False negative (FN)*	Correct silence *True negative (TN)*

The frequencies of prediction-realization combinations in the contingency matrix are used for computing a wide range of quantitative measures of classification performance. Some of the commonly used evaluation measures include: Recall positives (or TP rate) = TP/(TP+FN), Recall negatives (or TN rate) = TN/(TN+FP), Precision positives = TP/(TP+FP), Precision negatives = TN/(TN+FN), Accuracy = (TP+TN)/(TP+TN+FP+FN), FP rate = FP/(FP+TN), and FN rate = FN/(FN+TP). Receiver operating characteristics (ROC) curves and the area under the ROC curve (AUC) have also been used for comparing performance of early-warning models and indicators. The ROC curve plots, for the complete range of measures, the conditional probability of positives to the conditional probability of negatives:

$$ROC = \frac{P(P = 1 \mid C = 1)}{1 - P(P = 0 \mid C = 0)}.$$

Beyond the above measures, a policymaker can be thought to be primarily concerned with two types of errors: issuing a false alarm and missing a crisis. The evaluation framework described below is based upon that in Sarlin (2013) for turning policymakers' preferences into a loss function, where the policymaker has relative preferences between type I and II errors. While type I errors represent the share of missed crises to the frequency of crises $T_1 \in [0, 1]$ =FN/(TP+FN), type II errors represent the share of issued false alarms to the frequency of tranquil periods $T_2 \in [0, 1]$ =FP/(FP+TN). Given probabilities p_j of a model, the policymaker then optimizes the threshold λ such that her loss is minimized. The loss of a policymaker includes T_1 and T_2, weighted by relative preferences between missing crises (μ) and issuing false alarms ($1 - \mu$). By accounting for unconditional probabilities of crises $P_1 = P(C = 1)$ and tranquil periods $P_2 = P(C = 0) = 1 - P_1$, the loss function can be written as follows:

$$L(\mu) = \mu T_1 P_1 + (1 - \mu) T_2 P_2 \tag{1}$$

where $\mu \in [0, 1]$ represents the relative preferences of missing crises and $1 - \mu$ of giving false alarms, T_1 the type I errors, and T_2 the type II errors. P_1 refers to the size of the crisis class and P_2 to the size of the tranquil class. Further, the Usefulness of a model can be defined in a more intuitive manner. First, the absolute Usefulness (U_a) is given by:

$$U_a(\mu) = \min(\mu P_1, (1 - \mu)\, P_2) - L(\mu), \tag{2}$$

which computes the superiority of a model in relation to not using any model. As the unconditional probabilities are commonly unbalanced and the policymaker may be more concerned about the rare class, a policymaker could achieve a loss of $\min(\mu P_1, (1 - \mu)\, P_2)$ by either always or never signalling a crisis. This predicament highlights the challenge in building a Useful early-warning model: With a non-perfect model, it would otherwise easily pay-off for the policymaker to always signal the high-frequency class.

Second, we can compute the relative Usefulness U_r as follows:

$$U_r(\mu) = \frac{U_a(\mu)}{\min(\mu P_1, (1 - \mu)\, P_2)}, \tag{3}$$

where U_a of the model is compared with the maximum possible usefulness of the model. That is, the loss of disregarding the model is the maximum available Usefulness. Hence, U_r reports U_a as a share of the Usefulness that a policymaker would gain with a perfectly-performing model, which supports interpretation of the measure.

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