EUROPEAN CENTRAL BANK

EUROSYSTEM

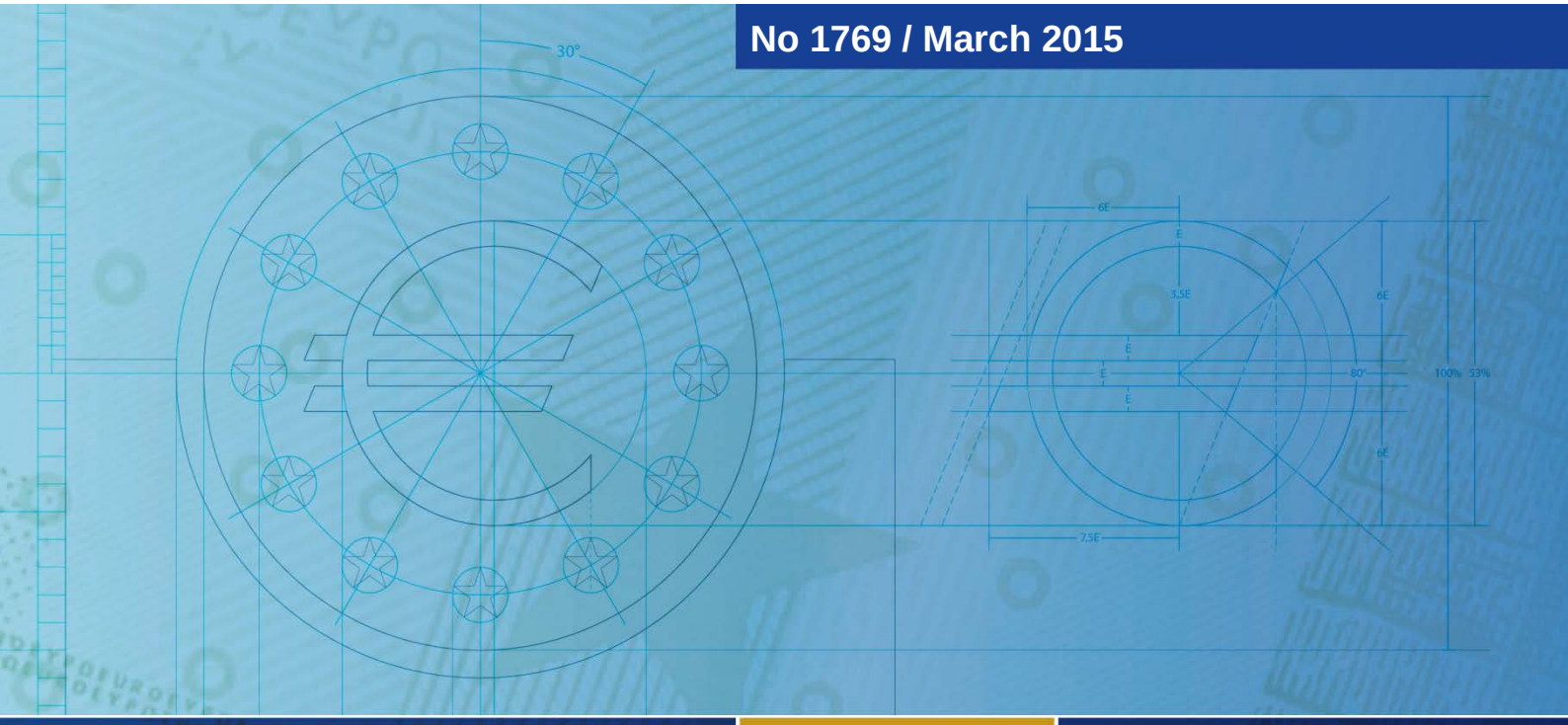
Working Paper Series

Bruce A. Ramsay
and Peter Sarlin

Ending over-lending:

assessing systemic risk with debt to cash flow

Macroprudential Research Network



No 1769 / March 2015

Macroprudential Research Network
This paper presents research conducted within the Macroprudential Research Network (MaRs). The network is composed of economists from the European System of Central Banks (ESCB), i.e. the national central banks of the 27 European Union (EU) Member States and the European Central Bank. The objective of MaRs is to develop core conceptual frameworks, models and/or tools supporting macro-prudential supervision in the EU.
The research is carried out in three work streams: 1) Macro-financial models linking financial stability and the performance of the economy; 2) Early warning systems and systemic risk indicators; 3) Assessing contagion risks.
MaRs is chaired by Philipp Hartmann (ECB). Paolo Angelini (Banca d'Italia), Laurent Clerc (Banque de France), Carsten Detken (ECB), Simone Manganelli (ECB) and Katerina Šmídková (Czech National Bank) are workstream coordinators. Javier Suarez (Center for Monetary and Financial Studies) and Hans Degryse (Katholieke Universiteit Leuven and Tilburg University) act as external consultants. Fiorella De Fiore (ECB) and Kalin Nikolov (ECB) share responsibility for the MaRs Secretariat.
The refereeing process of this paper has been coordinated by a team composed of Gerhard Rünstler, Kalin Nikolov and Bernd Schwaab (all ECB).
The paper is released in order to make the research of MaRs generally available, in preliminary form, to encourage comments and suggestions prior to final publication. The views expressed in the paper are the ones of the author(s) and do not necessarily reflect those of the ECB or of the ESCB.

Acknowledgements
The paper is an extended version of a working paper titled "Ending over-lending: Applying debt to cash flow ratios to nations as a means of avoiding financial calamities." The experiments in this paper come with a supplementary interactive dashboard: http://vis.risklab.fi/#/EOL (for a further discussion of the VisRisk platform see Sarlin (2014)). The paper and previous versions of it have gained useful input from Carol Alexander, Tuomas Peltonen and Torsten Wezel, as well as seminar and conference participants at the 17th International Business Research Conference: Research for Re-thinking at Ryerson University, Toronto, Canada held June 7-8, 2012; the 'Credit where due' conference at the University of Cambridge, UK held September 4-5, 2012; the 3rd International Workshop on Managing Financial Instability in Capitalist Economies (MAFIN) at University of Genoa, Italy held September 19-21, 2012; the Macrotheme Conference – Policy Maker Session in Paris, France held October 16-17, 2012; the 3rd International Conference of the Turkish Economic Association – Debt Dynamics, Fiscal Instability and The Great Recession at Izmir, Turkey held November 1-3, 2012; the 6th Mendel University International Conference – Political Economy of Eurozone Crisis: Is Fiscal Union Feasible? at Mendel University, Brno, Czech Republic held November 22-23, 2012; the 6th Dijon Conference – Sovereign Debts, Economic Policies, and Bank Reforms at University of Bourgogne, Dijon, France held December 6-8, 2012; the 21st International Conference on Money, Banking, and Finance in Rome, Italy held December 10-11, 2012; the Impact of global crises on EU and CEECs governance and financial markets workshop, at Corvinus University of Budapest, Hungary, held May 9-10, 2013; a seminar at The University of Calgary School of Public Policy held June 11, 2013; and the 48th Annual Conference of the Canadian Economics Association at Simon Fraser University held May 29-30, 2014.

Bruce A. Ramsay (corresponding author)
Cascadia Monetary Research, Canada, RiskLab Finland; e-mail: bruce@endingoverlending.com

Peter Sarlin
Goethe University Frankfurt, RiskLab Finland, Hanken School of Economics; e-mail: peter@risklab.fi

Postal address	60640 Frankfurt am Main, Germany
Telephone	+49 69 1344 0
Internet	www.ecb.europa.eu

ISSN	1725-2806 (online)
ISBN	978-92-899-1582-3
DOI	10.2866/641928
EU catalogue number	QB-AR-15-009-EN-N

Abstract

This paper introduces the ratio of debt to cash flow (D/CF) of nations and their economic sectors to macroprudential analysis, particularly as an indicator of systemic risk and vulnerabilities. While leverage is oftentimes linked to the vulnerability of a nation, the stock of total debt and the flow of gross savings is a less explored measure. Cash flows certainly have a well-known connection to corporations' ability to service debt. This paper investigates whether the D/CF provides a means for understanding systemic risks. For a panel of 33 nations, we explore historic D/CF trends, and apply the same procedure to economic sectors. In terms of an early-warning indicator, we show that the D/CF ratio provides a useful additional measure of vulnerability to systemic banking and sovereign crises, relative to more conventional indicators. As a conceptual framework, the assessment of financial stability is arranged for presentation within four vulnerability zones, and exemplified with a number of illustrative case studies.

Keywords: debt to cash flow, total debt to gross savings, systemic risk, early-warning indicator
JEL codes: E210, F340, G010, H630

Non-technical summary

This paper introduces the relationship between the stock of total debt and the flow of gross savings of nations and their economic sectors to macroprudential analysis, particularly as an indicator of systemic risk and vulnerabilities. We follow early theoretical contributions of Hyman Minsky, in which he introduced the notions of a financial fragility view and 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.

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 (henceforth Debt/CF or D/CF). Cash flows certainly have a well-known, academically verified connection to the ability of corporations to service and repay corporate debt. In the context of corporate finance, the D/CF relationship 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, consumption versus savings decisions are over-looked. This shortcoming can be illustrated by way of a simple example. Say two borrowers each have € 100,000 in income and € 200,000 in debt, and hence both have a 200% debt-to-income ratio. If the borrowers have respective savings rates of 20% and 10%, however, the second borrower is twice more levered as measured on a cash flow basis, at 20x D/CF, versus 10x for the first borrower. Further, previous literature has also proposed assessing a debt service ratio which relates interest payments and amortizations to income. These measures proxy ongoing financial constraints imposed by debt, and thus the build-up of nations' vulnerabilities. This approach provides an explicit 'coverage' ratio measuring borrowers' carrying capacity. Coverage ratios and leverage ratios are complimentary approaches, rather than substitutes, and D/CF intends to shed addtional light on the leverage aspect. To the best of our knowledge, other works have not studied the use of D/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 D/CF trends, and apply the same procedure to individual economic sectors. First, we illustrate the use of D/CF for firms and industry groups, and then move from micro data to an aggregation level to formulate time series of D/CF ratios for economic sectors and nations. Next, we quantitatively measure the performance of the D/CF ratio as a determinant of financial crises. 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. We show that the D/CF ratio performs better or on par with more conventional measures, such as public debt to GDP and the credit-to-GDP gap. We also distinguish differences in signalling performance of D/CF and its variants on banking, debt and currency crises, showing that while the D/CF ratio is a useful early-warning indicator, the ratio performs significantly better on banking and debt crises than on currency crises. Finally, we proceed to group nation-wide D/CF levels into four categories — Inefficient, Stable, Warning, and Crisis — providing a four-zone framework for the assessment of risks. We illustrate time series of nations within the four zones and qualitatively analyze the depicted patterns. Overall, the D/CF ratio is shown to effectively stratify systemic risks, and offers a useful platform toward macro-financial sustainability.

1. Introduction

This paper introduces the relationship between the stock of total debt and the flow of gross saving of nations and their economic sectors to macroprudential analysis, particularly as an indicator of systemic risk and vulnerabilities. Data series for sectors' and nations' total debt, not only the public debt portion, have become available in recent years. This development, together with the proposition that gross saving represents an equivalent to cash flow generated from operations, 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 or D/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 D/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 D/CF or similar ratios relating debt to gross savings for sectors or nations.

Most literature on the D/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 D/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) and Sufi (2009) concluded that cash flow metrics, including the D/CF ratio, are effective predictors of corporate success and failure. In the broader scope of macro-financial instability, early frameworks such as Kindleberger (1978) 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, the work on early-warning indicators by Alessi and Detken (2009) extended prior demonstrated connection between credit growth and financial instability by Borio and Lowe (2002). 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. In particular, 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 that both sector and nation-level leverage represent widespread

imbalances, these can be related to the above notion of systemic risk.

This paper demonstrates the usefulness of D/CF ratios for measuring financial risks and vulnerabilities in nations and their economic sectors. First, we illustrate the use of D/CF for firms and industry groups, and then move from micro data to an aggregation level to formulate time series of D/CF ratios for economic sectors and nations. Second, we quantitatively measure the performance of the D/CF ratio as a determinant of financial crises. 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. We show that the D/CF ratio performs better or on par with more conventional measures, such as public debt to GDP and the credit-to-GDP gap. We also distinguish differences in signalling performance of D/CF and its variants on banking, debt and currency crises, showing that the D/CF ratio is a useful early-warning indicator that performs significantly better on banking and debt crises than on currency crises. Third, we proceed to group nation-wide D/CF levels into four categories − Inefficient, Stable, Warning, and Crisis − providing a four-zone framework for the assessment of risks. We illustrate time series of nations within the four zones and qualitatively analyze the depicted patterns.

The paper is organized as follows. While Section 2 reviews the related literatre, Section 3 describes the data used for computing the D/CF and applies this to various entities, ranging from firms to nations. Section 4 analyzes the D/CF ratio for nations as an early-warning indicator, including an evaluation of performance in signal extraction. Section 5 discusses and defines the four-zone framework for assessing risk, and provides a number of illustrative case studies. Appendices A.1 and A.2 provide details of data sources and metrics tested and supply additional exemplifying graphics. Further, the paper comes with a supplementary interactive dashboard, accessed at: http://vis.risklab.fi/#/EOL (for a further discussion of the VisRisk platform see Sarlin (2014)).

2. Related literature

This section places the concept of D/CF within the literature on country-level indicators. First, we relate the use of debt-based measures to those based upon credit aggregate misalignments. Second, we connect the D/CF to other studies on the ratio of debt to cash flows, which mainly involve corporate finance, and then to debt-based measures of systemic risk.

The first part of the related literature focuses on systemic risk indicators, which have largely been based upon credit-based measures. A significant number of studies and a share of policy discussion alike have concerned aggregates of credit provided by the banking sector to the private sector (e.g., Borio and Lowe, 2002; Alessi and Detken, 2011; Lo Duca and Peltonen, 2013). These types of credit aggregates are usually measured in relation to GDP, such as bank credit to the private sector in relation to GDP. As these relationships have been increasing ratios for past decades (with varying slopes in different economies), the measures have oftentimes been related to their long-term trend. More formally, these are measured as the absolute or relative gap between credit in the current period and a real-time long-term trend computed with one-sided Hodrick-Prescott filtering (i.e., with a large λ parameter, e.g. 400 000). Yet, as might be expected from a measure to steer policy (e.g., through Basel III), there has been wide criticism of the use of the credit-to-GDP gap (e.g., Edge and Meisenzahl, 2011; Farrell, 2013). The concerns relate to policy suitability, quality as an early-warning indicator, and measurement problems, among other aspects. Although Drehmann and Tsatsaronis (2014) provide a thorough reply to the criticism, we feel certain concerns with respect to measurement are still untackled. In particular, calculating a long-term trend is challenging in itself, but also might lead to varying slopes which in an extreme case may have a steep slope of credit increases embedded into the trend component. For instance, prior to the crises, Spain had a steeply increasing, Germany a close to constant, and Japan a decreasing trend. Accordingly, in extreme cases a constant credit stock might trigger signals of vulnerability. While not undermining the use of credit gaps, these issues point to challenges which suggest the importance of assessing risk utilizing a range of different indicators and transformations. When assessing credit-based measures, it is worth noting that these are from-whom-to-whom measures of indebtedness. In fact, Drehmann (2013) recently introduced a new BIS

database of total credit, rather than only bank credit, and showed that developments of total credit yield better signals of systemic banking crises. The new database measures borrowing by combining the non-financial and household sectors, which highlights the potential preference to account for broader measures of obligations denoted as debt or credit aggregates. While credit and debt aggregates are from time to time associated with different implications, such as measures of financial development versus burdens on growth, the D/CF in this paper brings these concepts together and relates these to gross saving, which imposes no direct need to estimate equilibrium trends.

The second part of related literature are those applying D/CF or equivalent measures but in contexts other than sectors and nations, as well as literature which applies measures in the context of nations but with variations in definitions. First, while a few public finance studies using D/CF exist, none of these 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 publicly owned healthcare firms 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, consumption versus savings decisions are over-looked. This shortcoming can be illustrated by way of a simple example. Say two borrowers each have € 100,000 in income and € 200,000 in debt, and hence both have a 200% debt-to-income ratio. If the borrowers have respective savings rates of 20% and 10%, however, the second borrower is twice more levered as measured on a cash flow basis, at 20x D/CF, versus 10x for the first borrower. Further, Juselius and Kim (2011) and Drehmann and Juselius (2012; 2013) propose the Debt Service Ratio (DSR), of interest payments and amortizations to income, as a measure of financial constraints imposed by debt. Even though the DSR increases with debt, one could question to what extent it measures early build-up of risk, as borrowing costs may be low in good times and increase in times of crisis (cf. European debt crisis). On the other hand, this approach provides an explicit and useful 'coverage' ratio measuring borrowers' carrying capacity. Coverage ratios and leverage ratios are complimentary approaches, rather than substitutes, and D/CF intends to shed addtional light on the leverage aspect. Following the above example, the coverage approach could also benefit from relating carrying costs to cash flow, in addition to income.

While we believe the previous alternatives to the D/CF to potentially exhibit measurement problems (e.g., debt-to-income and credit gap) or be measures of different dimensions (e.g. coverage versus leverage), the prudent and prefered approach of course is to assess risks using a panel of indicators measuring a range of different factors.

3. Debt to Cash Flows: From firms to nations

This section provides a background discussion of the D/CF ratio, ranging from firms to economic sectors to nations. We initially describe the common practice of calculating the D/CF ratio for individual companies and then discuss patterns of D/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 D/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 D/CF ratio for these economic sectors, as well as for the nation as a whole. In each case, the D/CF ratio provides an indicator of leverage, involving vulnerability to financial instability, which is herein exemplified with a number of illustrative figures.

3.1. D/CF for firms and industry groups

In a corporate finance context, the D/CF ratio measures leverage by expressing the total stock of third party debts owed by a firm, in relation to the amount of annually generated cash flow from operations. The higher the ratio, the more levered the firm. Accordingly, the D/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. Typical calculations of the D/CF ratio involve totalling short and long-term debts from the balance sheet for the debt measurement. 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. The importance of operational cash flow goes beyond a simple netting of inflows and outflows, as the measure speaks to the inherent ability of the entity to generate positive cash flow. A corporation with $8 million in total debt and $1 million in annual cash flow would have a D/CF ratio of 8:1, or 8x. In turn, leverage can be calculated for an industry group when the debt and cash flow data of all companies from that industry group is aggregated. Table 1 presents the mean D/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).

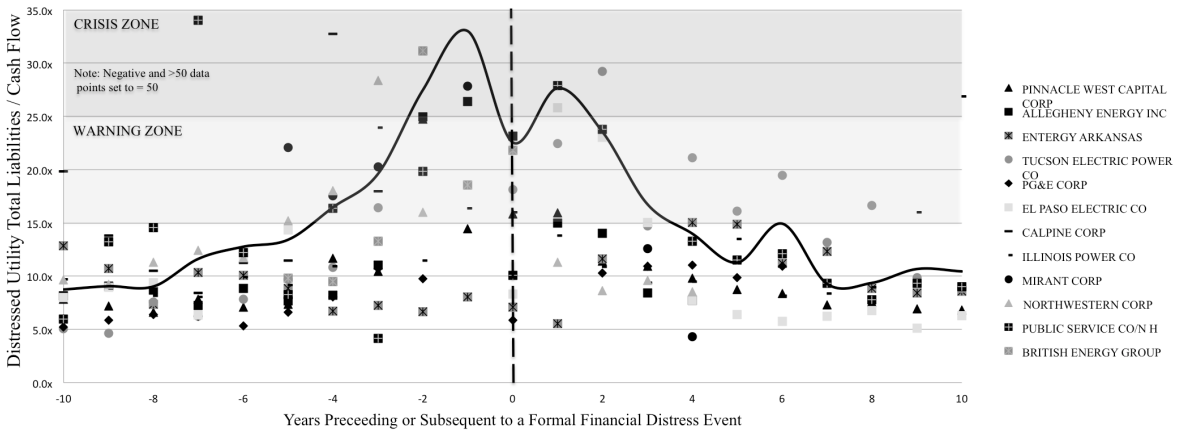
	Energy	Information technology	Healthcare	Consumer staples	Telecom services	Materials	Consumer discretionary	Industrials	Utilities
Total debt/CF	1.53x	1.89x	1.69x	2.63x	3.08x	3.59x	6.26x	5.90x	6.08x
Total liabs/CF	4.48x	5.92x	5.42x	5.76x	6.69x	8.24x	12.68x	10.58x	11.85x

Notes: Total debt is modeled to credit market instruments of the Federal Reserve (see Table 2 in Section 3.3). Total liabilities is total liabilities of the balance sheet, excluding equity, and is hence pursuant to internationally utilized flow-of-funds definitions (see Table 2), 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 D/CF levels, at 6.08x and 11.85x. On the contrary, organizations that have, or may face, higher volatility of cash flow manage financial affairs to maintain significantly less leverage. As indicated, companies forming the Energy group operate with significantly lower leverage, with D/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 will also affect leverage. Excessive leverage associated with financial distress and instability can be depicted by way of the D/CF relationship.

To illustrate D/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 D/CF data for these distressed utilities was compiled 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 D/CF before, during and after a distress event with a solid line, where the debt component is calculated on a total liabilities basis. Companies with high leverage run the risk of financial instability. Figure 1 also depicts that as part of the conclusion of Chapter 11, the average D/CF of the companies recedes. D/CF ratio reversions could result, for instance, 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 D/CF ratio stable leverage of their utility peers, as per Table 1. Accordingly, Figure 1 is divided into conceptual zones which are labeled stable (white), warning (light gray) and crisis (gray).

[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.

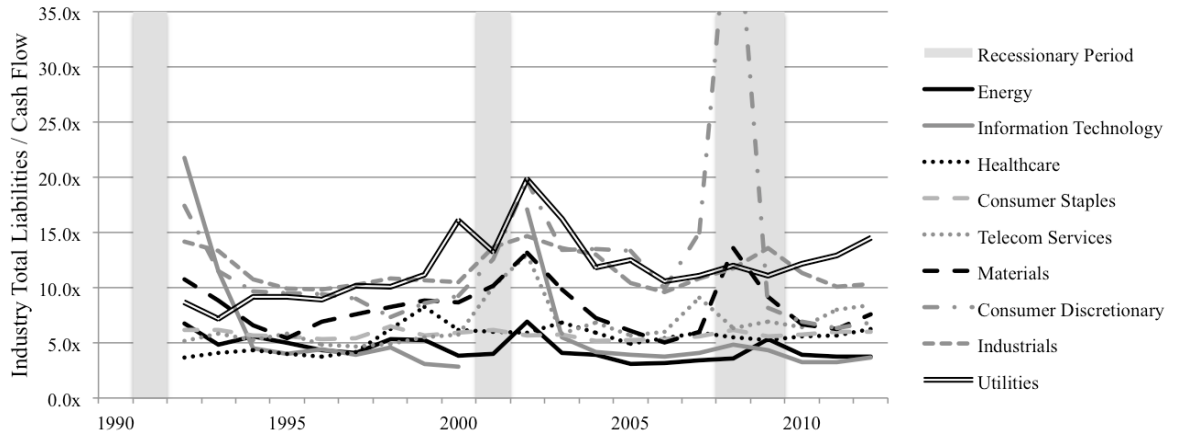


Sources: US Energy Information Agency, company press releases and Chapter 11 Library.

Figure 1: Financially distressed utility companies reaching crisis leverage.

3.2. D/CF for economic sectors

Corporate results can be anticipated to correlate with economic activity (Bernanke, 2000), and D/CF results fit this expectation. Recessions typically bring declining cash flows, which in turn cause some industry D/CF ratios to rise or spike (as opposed to large run-ups in the stock of debt as the typical cause). Following a period of instability, the D/CF for the industry group tends to recover and revert back toward the longer-term mean (cf. Table 1). Patterns of rising instability and subsequent reversion are evident in Figure 2, which depicts the D/CF results for S&P industry groups 1992–2012. Discerning the effect of numerator versus denominator, the Consumer Discretionary group for instance faced a cash flow decline of 49.8% leading into the 2001 recession, and 78.6% decline into the 2008 recession, set against only minor changes in debt levels.

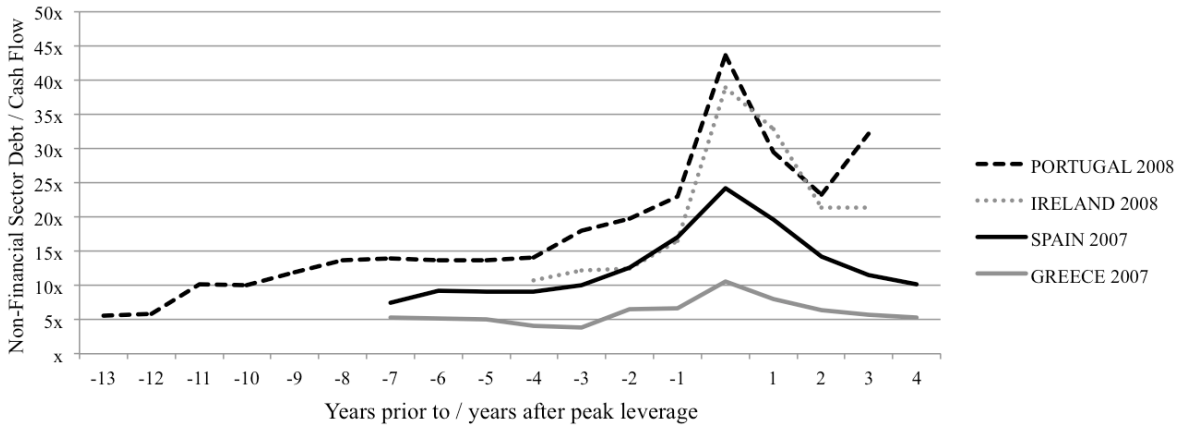


Sources: Standard and Poor's.

Figure 2: D/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 D/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.[2] In Figure 3, the total debt of the non-financial sector is divided by the sector's gross savings to produce the D/CF results for four crisis-exposed nations.[3] 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, despite all showing increased values prior to distress, Spain's and Greece's non-financial sectors appear to have substantially regained control of leverage. As an indication of the impacts of the numerators versus denominators on the D/CF result, Portugal's debt balances rise steadily over the period but gross savings undertakes a 52.8% drop in the 2004-2008 period. In contrast to these economies, we show in Figure B.1 in the Appendix D/CF results for a large number of advanced economies with less elevated D/CF values.



Sources: EuroStat.

Figure 3: D/CF of non-financial sector for several crisis nations.

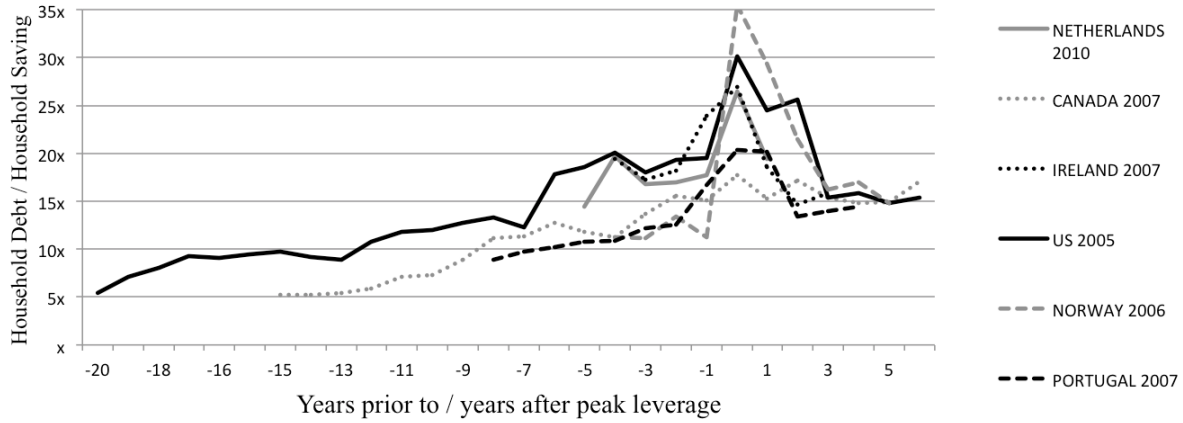
Minsky's work indicated financial instability would arise in the generic term 'economic units,' hence the D/CF metric could be applied in contexts away from typical corporate analysis. Household cash flow data, referred to as gross savings, is available as are the total debts of the household sector, permitting a standard D/CF calculation.[4] Figure 4 presents a history of household sector D/CF ratios for six nations, including the US. The US household sector 1946–1985 exhibits an average D/CF of 5.4x during the four decades with the highest year recorded at 6.9x. In the mid-1980s, leverage of the US household sector began to climb, as shown in Figure 4. In the 1990s the US household sector D/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 time series in Figure 4 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, as well as the later used banking crisis databases (Babecky et al., 2013), the D/CF time series for household sectors of the individual nations are qualitatively considered to coincide with occurrences of distress. According to D/CF, Household

[2]In corporate accounting:
corporate revenue - cash costs including taxes = profit + depreciation and amortization = cash flow from operations.
Equivalently, in the SNA:
GDP - consumption including taxes = net saving + consumption of fixed capital = Gross Saving.
Similar adjustments are made such as including changes in working capital, and accounting for capital transfers.

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

[4]Gross savings 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. Utilizing Household total liabilities as the debt component produced an immaterial difference in results.

leverage has declined in the past 3–5 years for the group. In contrast, Figure B.2 in the Appendix shows household sector D/CF of six individual economies that do not exhibit elevated D/CF values, and are also generally considered financially stable. The EA average in Figure A.2 is elevated in recent years as a result of inclusion of the financially distressed household sectors of several EA nations, as untangled in Figure 4. Once again we find that the emergence of sharp spikes in D/CF tend to relate to high volatility in the denominator, as for example Norway's Household gross saving falls 64.5% from prior to 2006 into the ensuing years.



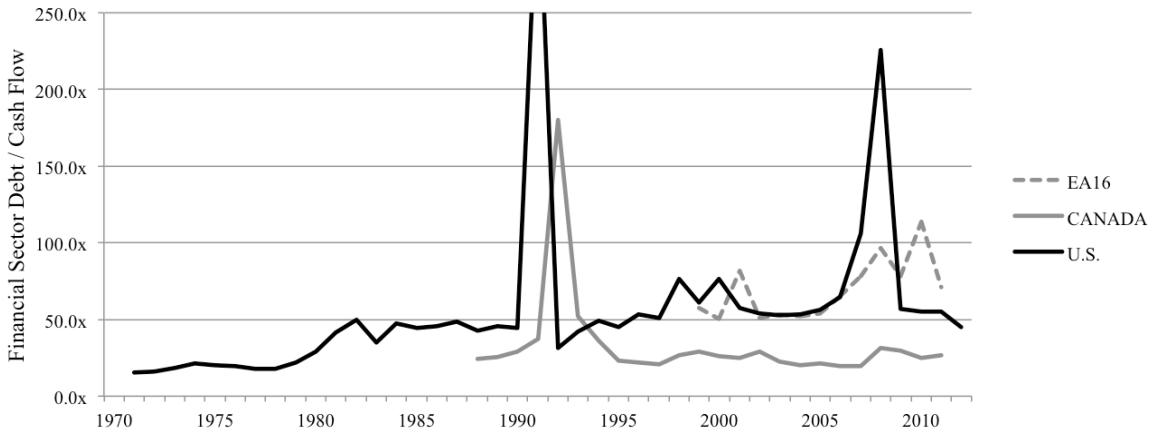
Sources: EuroStat and Federal Reserve.

Figure 4: Demonstrated instability of household sector D/CF history of various nations.

Evaluating banks by relating cash flow to debt is not in wide practice, but is advocated in works such as Gross (2007) and Grier (2012). Financial entities are expected to be subject to long run D/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. Due to the complex nature of the financial sector, conclusions involving D/CF, and most other individual accounting-based measures, should be considered somewhat tentative. In order to calculate the D/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 savings.[5] Figure 5 provides a D/CF history for the domestic financial sector of the US, Canada and the euro area. Canada's average D/CF of approximately 25x from 1995 to 2012, with a peak at 41.6x in Q4 2008, coincides well with the relatively few problems in the financial sector. However, the Canadian financial sector includes a period of instability and reversion during the early 1990s. At this time, Canada's financial sector suffered housing and resource related losses and needed restructuring, but was able to settle into manageable leverage afterwards.[6] For the US, 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 (LTCM failure and Asian crisis). The collapse of the US banking system in 2008 is indicated as a spike, and return, but not a full reversion. Beyond financial sector fragility, 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 years. In this context, in a regulatory framework for financial institutions, the D/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.

[5]Debt is sourced as credit market instruments (see Table 2 in Section 3.3). Total liabilities of the financial sector 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.

[6]The regulatory regime in Canada includes strong capital ratios, and the D/CF results may be considered an outcome of such other parameters.



Sources: EuroStat, Federal Reserve and StatsCan.

Figure 5: D/CF History of US, Canada, and EA16 domestic financial sectors.

In recent decades, most governments have run deficits and had negative cash flows, resulting in a negative D/CF ratio.[7] Nevertheless, when governments do produce positive cash flow, the interpretation of a D/CF calculation is more meaningful. The D/CF for the US government sector is included in Figure 7 for the years 1946–1974, after which the preponderance of data is negative and not depicted. Certainly, despite that governments themselves may contribute to the causes of financial distress, the factors influencing the financial stability of individual governments or the government sector go beyond a single measure of leverage (e.g., D/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 the 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 D/CF in turn reflects back to the sustainability of public debt. For these reasons, and given ongoing government deficits, the D/CF of the nation in aggregate may be a more useful indicator than government D/CF on a stand alone basis.

3.3. D/CF for nations

This section formulates the D/CF ratio for nations. Although the more granular view of sectoral D/CF ratios provides relevant detail, the overall leverage of a nation should also be considered. This complimentary view is not only important from the perspective of viewing the broad metric for a nation, but also as indebtedness and savings need not be distributed evenly between economic sectors. An exemplifying case could be that debt might be concentrated in the household sector, whereas savings could be concentrated in other sectors. This highlights the importance of jointly assessing D/CF at both the level of sectors and nations. The statistic for a nation can be quantified as total economy debt to national gross savings. While total economy debt is the sum of indebtedness in the household, corporate, banking, and government sectors, national gross savings is GDP less final consumption expenditure. Yet, the precise definitions of the measures are not always self-evident. Before illustrating the case of D/CF for the US, this section discusses how to measure the components of the ratio.

As suggested by the columns in Table 2, various definitions of debt or credit could be tested, depending upon the included flow-of-funds components. In this paper, total economy debt is modeled

[7]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. An obvious approach to tackle short-term deficits would be to compute cash flows as moving averages.

on the US Federal Reserve (2013) definition of credit market instruments, and the equivalent flow-of-funds data for other countries. The definition of credit market instruments (first column) includes both securities other than shares and loans, as noted with check marks in Table 2. In this paper, the term 'debt' is preferred to the term 'credit' as the providers of these obligations are not narrowly the banking sector, but rather include all capital markets participants. For another study that calculated total debt for nations following a similar methodology, see McKinsey Global Institute (2010). The definition could be expanded for alternate testing. For instance, Haver Analytics publishes sector and total economy debt statistics (second column), where other accounts payable are also included. The definition can be further expanded to total liabilities (third column), which is structured directly to incorporate all components from flow-of-funds reporting.[8] 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 (i.e., sum of domestic and external non-consolidated debts), which matches the definition used by BIS in private sector credit aggregates.

Table 2: 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		✓	✓		

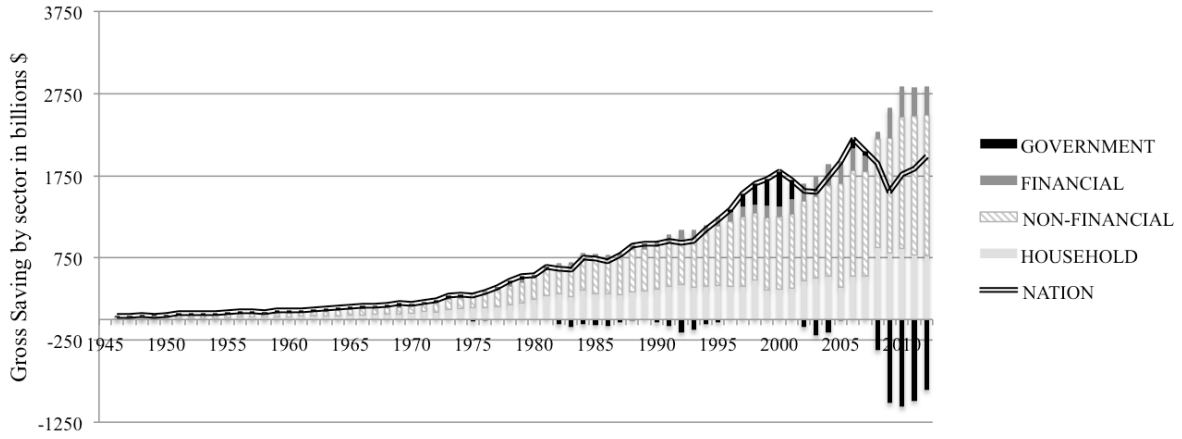
Despite minor variations in definitions, a nation's cash flow is generally measured as national gross savings, a standard statistic reported under the System of National Accounts and through the Integrated Macroeconomic Accounts. National gross savings can also be calculated by adding the nation's capital consumption allowance to the more commonly cited net saving. This statistic represents the aggregate flow of savings generated during a year, and is hence not a measure of the stock of savings in place. Although cash flow is sometimes narrowly considered as a simple netting of inflow and outflow of cash, this contemplation misses the critical importance of an entitity's comparative operational ability to generate positive cash flows. In Figure 6, the aggregation of national gross savings 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.[9] The majority of US cash flow is currently produced by the non-financial sector.

For the US, Figure 7 presents long time-series of the D/CF for each economic sector and the nation as a whole. 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 D/CF into its two components also provides useful information regarding the numerator and

[8] Table 2 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.

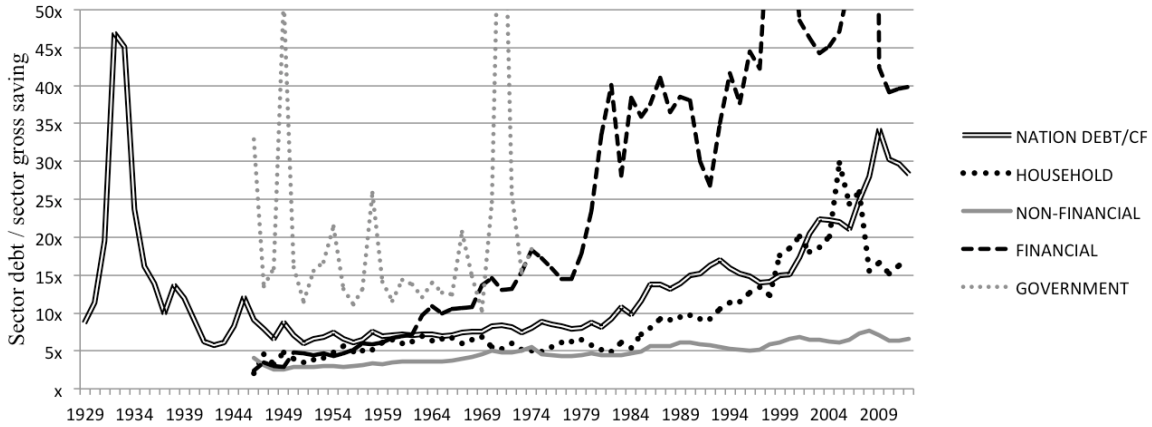
[9] In the SNA, deficits adjusted for CCA are accounted for as a reduction in the nation's aggregate cash flow.

denominator. In this regard, from 1946 to 1980 total economy debt grew at a compounded 7.95% annually, while national gross savings 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 savings only grew at a compounded 4.13%, resulting in rising leverage through the period. US gross saving margins, defined as gross savings to GDP, declined from approximately 20% in the late 1970s to 11.8% in 2012.



Sources: Federal Reserve.

Figure 6: Summation of US gross savings by sector with total for nation.



Sources: Federal Reserve.

Figure 7: Summation of available D/CF history for US sectors and the nation.

4. Debt/CF as a measure of systemic risk

This section proposes and tests the performance of the D/CF as a measure of systemic risk. We perform quantitative tests of the signalling performance of the D/CF with respect to financial crises, particularly the vulnerability to systemic repercussions at the country level. The D/CF and its variants are used as early-warning indicators for banking, sovereign debt and currency crises. After presenting the signaling methodology, we first test performance of the D/CF versus conventional measures, and then test variants of the D/CF.

4.1. Signal extraction and evaluation

This section 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. 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 in the following.

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 resembles 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. 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 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 in Table 3 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) are also common measures 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.

4.2. D/CF versus conventional measures

This section tests the performance of D/CF against certain more conventional measures as early-warning indicators. As described in the previous section, the early-warning indicators used herein are created using the signal extraction approach. In principle, this turns a univariate variable (e.g., D/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. The thresholds of early-warning indicators are set by optimizing a policymaker's loss function and Usefulness measure (see Sarlin, 2013). Testing Usefulness thus provides a means for evaluating the performance of an early-warning indicator. In this paper, we focus on relative Usefulness, given policymakers' preferences $\mu = 0.9$ and a forecast horizon $h = 24$ months in the benchmark case.

In order to relate the performance of the D/CF to conventional indicators, we perform a signaling exercise with three other variables: public debt to GDP, bank credit to GDP gap and total credit to the GDP gap.[10] For comparable results, we reduce the sample to similar for all variables, and

[10]The credit measures relate bank credit to the private sector and total credit to the private sector with GDP. As Lainá et al. (2014) find minor differences between performance of absolute and relative gaps, we use the absolute difference

hence drop any observation that has a missing value for any of the variables. The pre-crisis periods are defined from a set of crisis events, following the database of events specified in Babecky et al. (2013).[11] Further, we assess how the performance of the indicators differs for banking, debt, currency and aggregate 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 the previous section, 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.

The left part of Table 4 summarizes the performance of the five indicators for Banking crises and then Debt crises, whereas the right side provides results of the robustness tests. Table 4a shows that D/CF and debt to earned CF perform well in signaling Banking crises, in comparison to the conventional indicators. With the benchmark preferences of $\mu = 0.90$ and horizon of $h = 24$, the D/CF measures clearly outperform the three alternative measures in terms of $U_r(\mu, h)$, which is also confirmed by higher AUC measures. For $\mu = 0.8$, all indicators except public debt to GDP perform well, whereas the D/CF-based measures yield more Usefulness for $\mu = 0.95$. While all indicators perform well for forecast horizons of $h = 12$, D/CF yields around 10 percentage points more Usefulness than all other indicators for $h = 36$. These results suggest that D/CF may have merit to be considered along with existing systemic risk indicators for macroprudential analysis.

Table 4: Early-warning performance of D/CF in comparison to alternative measures.

a) Banking crises

	Benchmark						*Robustness*			
							μ=0.8	*μ=0.95*	*h=12*	*h=36*
Indicator	*λ*	T_1	T_2	*Accuracy*	$U_r(\mu)$	AUC	$U_r(\mu)$	$U_r(\mu)$	$U_r(\mu)$	$U_r(\mu)$
Debt to CF	0.78	37.78 %	21.77 %	76.50 %	37.10 %	0.70	19.22 %	22.47 %	25.12 %	17.38 %
Debt to earned CF	0.79	37.78 %	20.70 %	77.46 %	38.17 %	0.67	19.54 %	21.14 %	28.50 %	4.56 %
Public debt to GDP	0.83	60.87 %	19.01 %	76.03 %	7.31 %	0.57	5.43 %	5.26 %	21.30 %	5.61 %
Bank credit to GDP gap	0.91	63.53 %	7.73 %	86.02 %	20.06 %	0.62	22.06 %	5.94 %	25.68 %	3.62 %
Total credit to GDP gap	0.91	65.88 %	7.82 %	85.60 %	16.39 %	0.62	19.12 %	6.02 %	23.21 %	4.34 %

b) Debt crises

	Benchmark						*Robustness*			
							μ=0.8	*μ=0.95*	*h=12*	*h=36*
Indicator	*λ*	T_1	T_2	*Accuracy*	$U_r(\mu)$	AUC	$U_r(\mu)$	$U_r(\mu)$	$U_r(\mu)$	$U_r(\mu)$
Debt to CF	0.9	56.25 %	12.69 %	84.78 %	20.83 %	0.68	11.29 %	10.29 %	24.31 %	31.32 %
Debt to earned CF	0.91	56.25 %	10.77 %	86.59 %	24.31 %	0.70	13.71 %	8.16 %	29.58 %	23.36 %
Public debt to GDP	0.84	54.84 %	17.55 %	78.26 %	20.00 %	0.59	7.26 %	4.90 %	20.83 %	10.60 %
Bank credit to GDP gap	1	100.00 %	0.00 %	94.20 %	0.00 %	0.14	1.52 %	0.00 %	9.03 %	4.62 %
Total credit to GDP gap	1	100.00 %	0.00 %	94.20 %	0.00 %	0.15	1.52 %	1.22 %	9.03 %	2.33 %

When comparing the conventional indicators with respect to Debt crises (see Table 4b), we observe significant differences within the alternative measures. While debt to GDP performs fairly well, both credit-to-GDP gaps totally fail in terms of performance. For the benchmark, the credit-to-GDP gaps do not signal at all and otherwise only yield little Usefulness. The public debt measure performs almost

between the credit-to-GDP ratio and its long-term trend. The trend is computed with one-sided Hodrick-Prescott filtering with a λ parameter of 400 000, in order to mimic the financial cycle.

[11] 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.

on par with the D/CF measures on the benchmark specification. In all robustness checks, the D/CF measures outperform the Public debt to GDP measure. Similarly, the AUC measures of D/CF-based indicators outperform the public debt-based measures. To sum up, this section has shown the notable performance of D/CF vis a vis the more conventional measures, with respect to both banking and debt crises.

4.3. D/CF and its variants

This section tests the performance of D/CF and certain variants as early-warning indicators. Beyond the conventional indicators reviewed in Section 2 and tested in Section 4.2, additional explanatory power can be found in a large number of other flow/flow, stock/stock, and stock/flow comparisons for broadly assessing indebtedness, liquidity and solvency risks. Metrics involving the net lending / net borrowing accounts may be useful in assessing growing imbalances between economic sectors within a nation, and among nations.[12] Further, deducting the net lending / net borrowing account from gross savings defines a more harsh form of cash flow for testing, by netting out the unearned portion (cited as Debt to earned CF in the tables). Low or falling gross saving margins and increasing net borrowing accounts are oftentimes evident characteristics of crisis nations of the 2000s. 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 D/CF and its variants. The primary reason is that there is little evidence supporting the sustainability of an increasing trend in D/CF-related leverage. Moreover, to better cope with variation in gross savings over time, one could measure cash flows as moving averages or use an estimated trend component.

In this section, we evaluate a number of D/CF related indicators, including the (*i*) D/CF ratio itself, and 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. We use the same definition of pre-crisis periods (i.e., Babecky et al., 2013), but 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 is again tested with respect to policymakers' preferences ($\mu = 0.8$ and $\mu = 0.95$) and the forecast horizon ($h = 12$ and $h = 36$). As above, the left part of Table 5 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 5 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 entirely disregarded. This shortcoming follows expectations, as periods reflecting exchange-rate pressure prior to the collapse of a currency are most often described by other 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, rather than a sector alone.[13] When comparing performance among indicators using $U_r(\mu, h)$, the table indicates that D/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 5, 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 D/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 perform 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

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

[13] Further investigation in this regard is still required, as the treatement of the financial sector is not trivial.

alternative parameters. Finally, with regard to the Aggregate definition of crises, we observe in Table 5 that the indicators, particularly D/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.

Table 5: Evaluating early-warning performance of D/CF and certain variants.

a) Banking crises

		Benchmark					*Robustness*			
							μ=0.8	*μ=0.95*	*h=12*	*h=36*
Indicator	*λ*	T_1	T_2	*Accuracy*	$U_r(\mu)$	AUC	$U_r(\mu)$	$U_r(\mu)$	$U_r(\mu)$	$U_r(\mu)$
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*
Indicator	*λ*	T_1	T_2	*Accuracy*	$U_r(\mu)$	AUC	$U_r(\mu)$	$U_r(\mu)$	$U_r(\mu)$	$U_r(\mu)$
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*
Indicator	*λ*	T_1	T_2	*Accuracy*	$U_r(\mu)$	AUC	$U_r(\mu)$	$U_r(\mu)$	$U_r(\mu)$	$U_r(\mu)$
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*
Indicator	*λ*	T_1	T_2	*Accuracy*	$U_r(\mu)$	AUC	$U_r(\mu)$	$U_r(\mu)$	$U_r(\mu)$	$U_r(\mu)$
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 %

5. A conceptual framework with illustrative cases

This section describes a four-zone framework for assessing nations' risks and vulnerabilities based upon the D/CF.

5.1. A conceptual four-zone framework

In the same way D/CF mean levels vary according to characteristics of industries as noted in Table 1, a 'one size fits all' D/CF for nations is unlikely. Rather, the diverse fabrics of nations result in different tolerances for leverage and instability. Intuitively, countries with diversified economies, deep markets and stable regimes, amongst many other impacting factors, may be able to carry higher D/CF ratios than countries with narrow, less developed economies and markets. While cross-country differences are important to contemplate, this section moves towards a D/CF framework with conceptual zones of escalating financial instability.

Tapping into the first exercise of this paper in Figure 1, a D/CF ratio of approximately 5–15x was considered a Stable Zone (in white). At D/CF values above 15x, a utility company becomes somewhat over-levered, denoted as a Warning Zone (light gray). The companies may ultimately enter a so-called Crisis Zone when they become significantly over-levered with prolonged exposure at D/CF values above 25x (gray). To complete the range, there would also exist an under-levered state, or Inefficient Zone (also in white), wherein D/CF is less than 5x. These ranges of escalating financial instability could be referred to as a conceptual four-zone framework. Rather than crisp levels delimiting between zones, the concept is better conceived as representing overlapping degrees of instability. As summarized in Table 6, the zone framework follows guidance from Minsky (1992), Altman (1968) and Fisher (1933) toward scaling leverage to conceive instability.

Table 6: 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
The D/CF framework	Inefficient zone, Stable zone	Warning zone	Crisis zone

Table 7 presents advanced economies in categories of escalating financial instability according to D/CF levels within the four-zone framework. It is important to acknowledge that at this juncture, the level of D/CF demarcation between zones remains qualitative in nature.[14] The primary categories and determining parameters are set out in Table 7, which also includes sample structural characteristics as determinants of greater or lesser financial stability. Not surprisingly, the current sample does not include under-levered economies characterized by inefficient D/CF levels given ongoing high leverage globally.

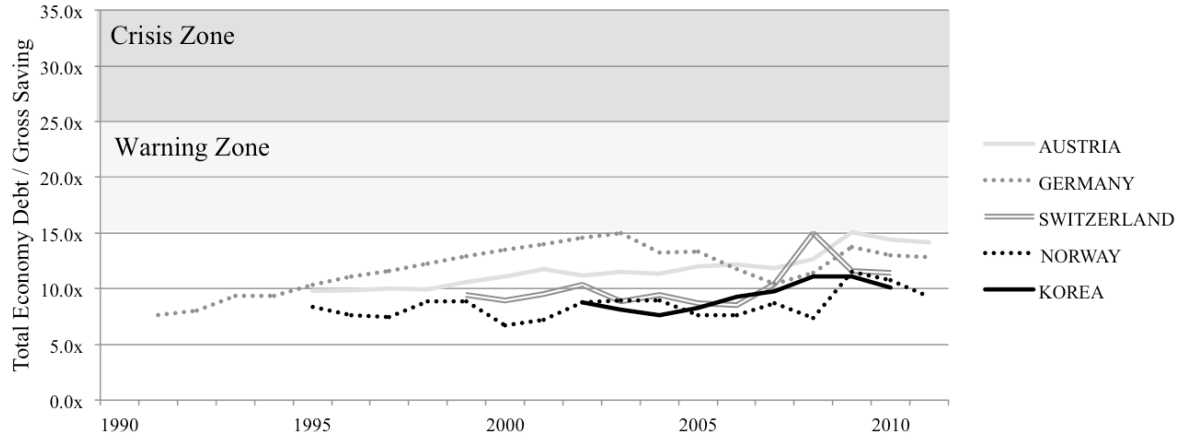
[14] Advanced economies presumably enjoy some diversification of component cash flows, with the attendant benefit of reduced volatility of aggregate gross savings. Markets are well developed and regimes are mature. A formula could be constructed to estimate an 'ideal' range for a Stable Zone for a nation through pro-weighting safe and stable sector D/CF ranges. Adopting the 5-15x, 15-25x and 25+ zones presents a functional starting point.

Table 7: 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

5.2. Exploring D/CF histories for nations

This section provides illustrative time-series of the application of the D/CF ratio to various nations, primarily the advanced economies.[15] That is, we apply the criteria set out in Table 7 for the four-zone framework, and discuss the D/CF time series for example nations in each category. Applying the zone criteria established in Table 7, Figure 8 presents nations assigned to the stable zone.[16] The group consists mainly of European economies. For Switzerland, the figure depicts increases in leverage prior to the need to provide state aid to 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 severe crises, given the occurrence of a shock or other trigger.



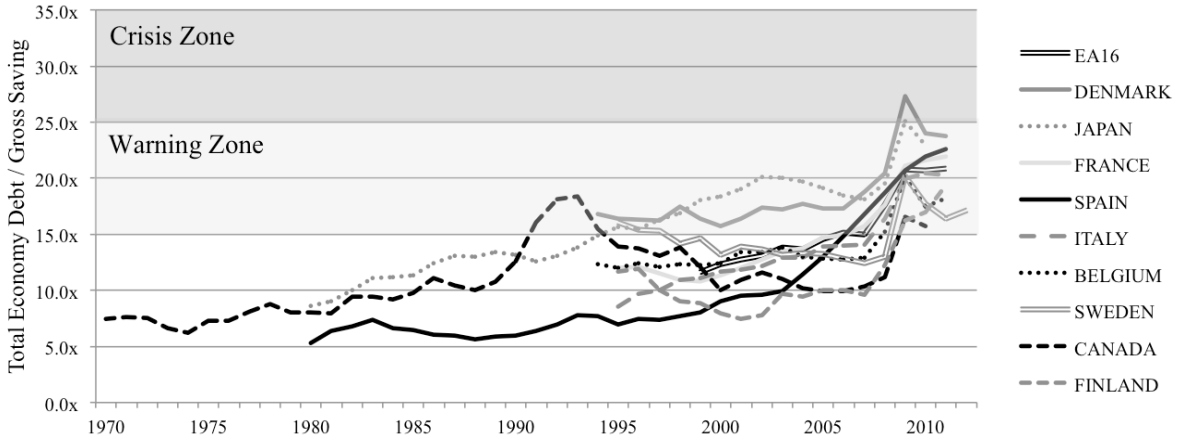
Sources: Eurostat and OECD.

Figure 8: D/CF histories for five nations with generic stable leverage.

Nations assigned (pursuant to Table 7) to the warning zone are presented in Figure 9. Most of these nations have had D/CF ratios pushed upwards in concert with the recent global financial crisis. Increased debt funding, state aid 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 D/CF ratio in the early 1990s indicates a period of instability and reversion to long-term mean levels, as Canada faced financial distress in the early 1990s. Canada's D/CF steadied at stable levels for the following 15 years, but re-entered warning levels in conjunction with the 2008–2009 recession. As a contrast, the relentless deteriorating financial condition of Spain is also evident in Figure 9.

[15] In contrast to the analysis of advanced economies in this section, we also present in Figure B.3 in the Appendix illustrative time-series for Mexico and a number of Central and Eastern European countries.

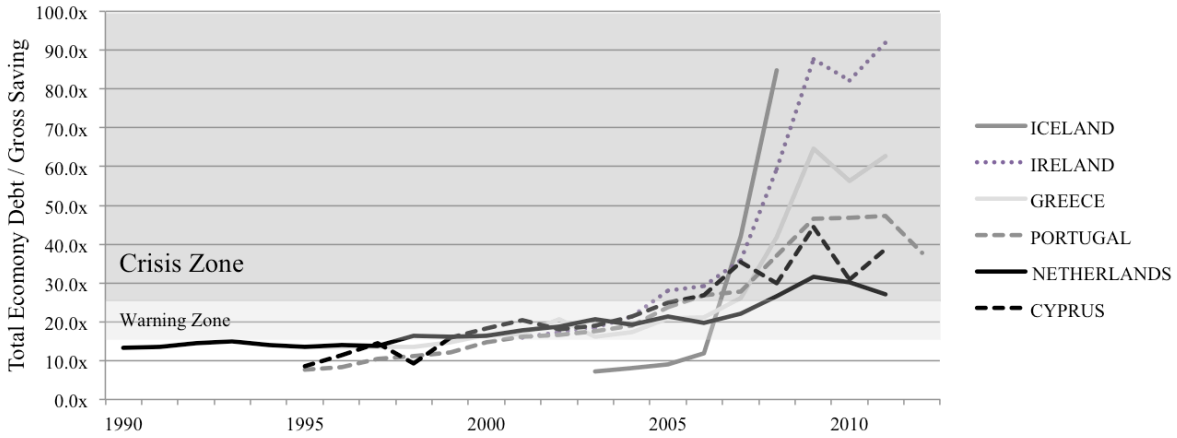
[16] As specified in Table 5, none of the nations in the group have D/CF of less than 5x and hence none have been assigned to the inefficient zone.



Sources: Eurostat and OECD.

Figure 9: D/CF histories for nations with deteriorating financial risks.

Pursuant to Table 7, all nations in Figure 10 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 D/CF, liabilities have escalated rapidly in the years leading to crises, and the nations commonly have low or falling gross saving margins, and are ultimately unable to rollover debts. Nations in Figure 10 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 D/CF is elevated by a highly levered household sector, and a proportionately larger financial sector, which received state aid in 2008.



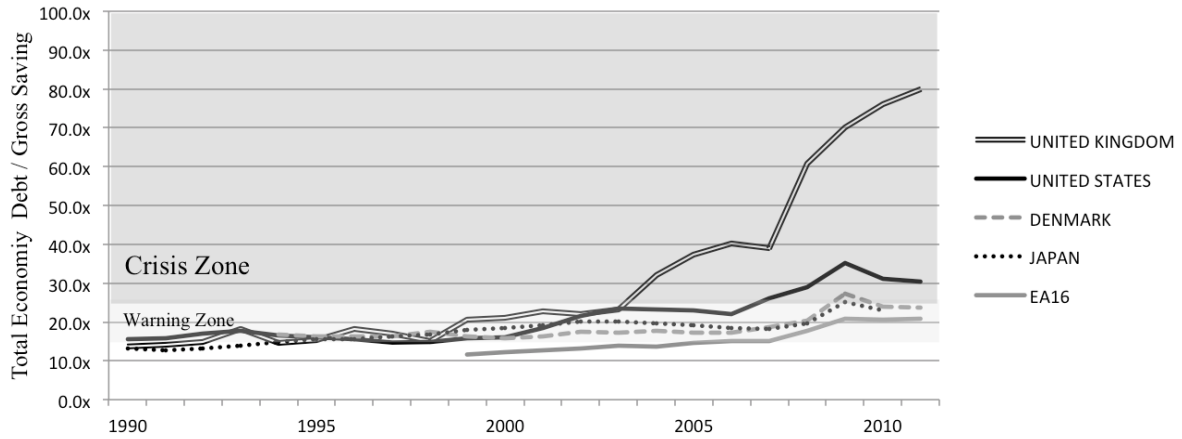
Sources: Eurostat and OECD.

Figure 10: D/CF histories for nations with crisis exposure.

Figure 11 portrays again a group of highly levered advanced nations, but in this case each is a nation with monetary and currency authority. The EA16 group presents a weighted average of stable and unstable euro area nations individually depicted earlier. In aggregate, the EA16 group appears to be less levered than the US or UK. Despite instabilities during the global crisis of 2007–2008, the individual

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

nations in Figure 11 have since managed reasonably well. Overall, the nations have experienced both sovereign and financial market stability. The nations continue to attract capital to rollover or increase debts, despite high D/CF. 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.

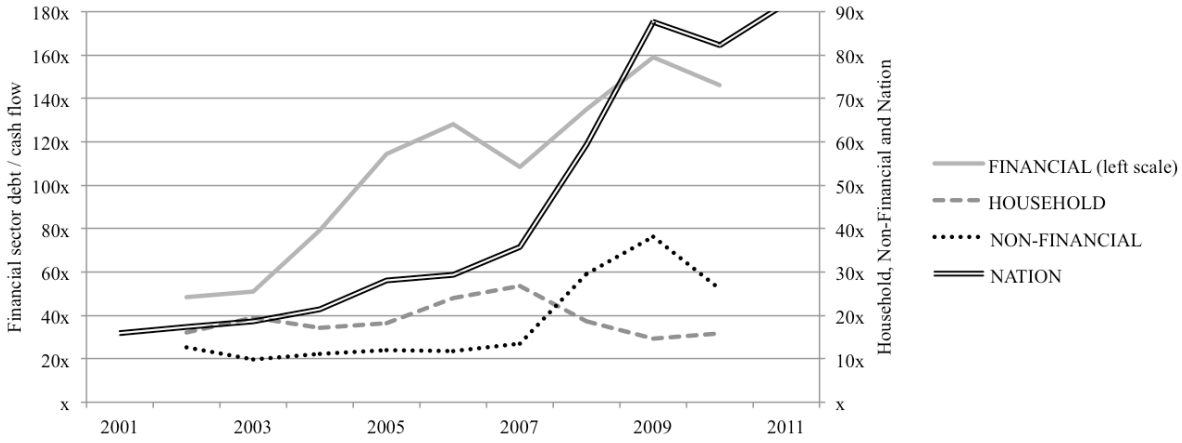


Sources: Eurostat, OECD and Federal Reserve.

Figure 11: D/CF histories for high leverage nations with monetary authority.

5.3. Discussion

The specific path to instability is peculiar to each crisis, and it is important to understand the transmission of instability from sector to sector and from sectors to sovereigns. We do not tackle this question herein, but rather illustrate the need for further work on transmissions among sectors. Figure 12 provides an overview of the way Ireland's leverage builds up 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 are useful ingredients in the assesssment of the potential severity and urgency of escalating risks.



Sources: Eurostat.

Figure 12: D/CF histories for Ireland's economic sectors and the nation.

With further testing, the D/CF approach is proposed for use in monitoring, stratification and reporting of financial vulnerability. In the footsteps of Minsky, the D/CF ratio and its variants may provide a coherent grid to assist established supervisory institutions dampen build-ups of disruptive macro-financial vulnerabilities.

6. Conclusion

This paper has demonstrated the usefulness of D/CF ratios for measuring systemic risks and overall vulnerabilities in nations and their economic sectors. Starting with qualitative discussions of the concept and illustrative examples of cases, the D/CF ratio was shown to indicate increases in risks and vulnerabilities in individual companies, industry groups, economic sectors and nations. Beyond this qualitative setting, we next provided a quantitative evaluation of D/CF as a determinant of financial crises, particularly banking, debt and currency crises. We showed that the D/CF ratio performs better or on par with more conventional measures, such as public debt to GDP and the credit-to-GDP gap. We also showed that while the D/CF ratio yields positive Usefulness in terms of an early-warning indicator, the ratio performs significantly better on banking and debt crises than on currency crises. At a more conceptual level, we then related the D/CF to four conceptual zones of escalating financial instability: inefficient, stable, warning and crisis zones. Despite the qualitative nature of this paricular analysis, this context may offer a wider platform toward macro-financial sustainability than a simple stand-alone early-warning exercise. We hope this paper sparks further research on the use of the relationship between the stock of total debt and the flow of gross savings of nations and their economic sectors in macroprudential analysis.

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Appendix A.1. Data, metrics and sources

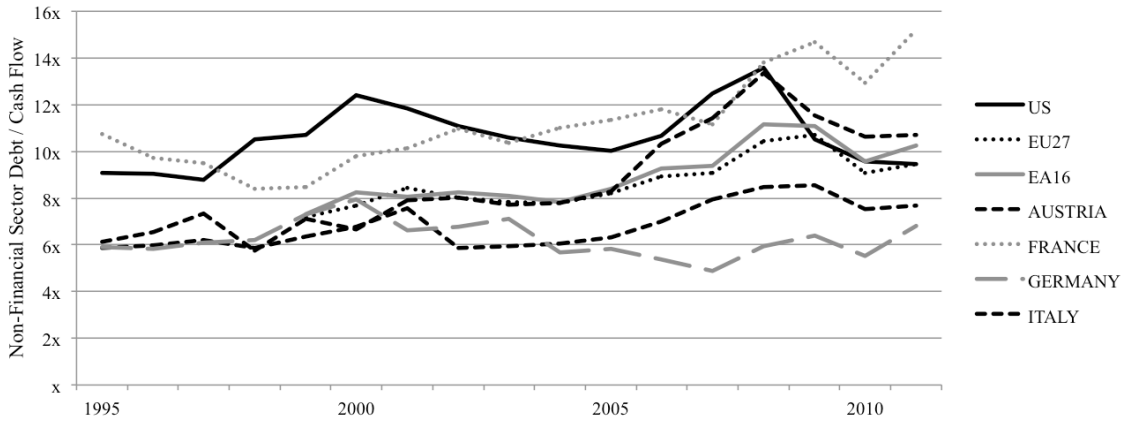
Table A.1: Definitions and sources of data.

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 lending:net 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.

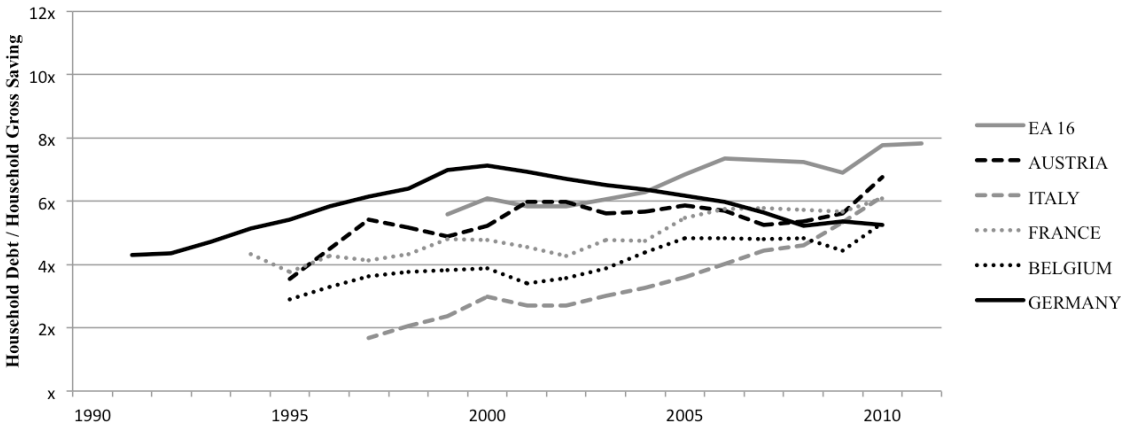
Level	Variable	Obs	Min	Max	Mean	Std. Dev.	Skew	Kurt
Firm	Debt to Cash Flow	246	4.17	50.00	16.70	13.48	1.66	1.52
Sector	Total Debt to Cash Flow for S&P Industry Groups	189	0.00	23.05	3.77	2.49	2.85	18.20
	Total Liabilities to Cash Flow for S&P Industry Groups	208	2.84	48.98	9.15	5.79	2.52	11.50
	Total 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 B.1. Patterns of D/CF



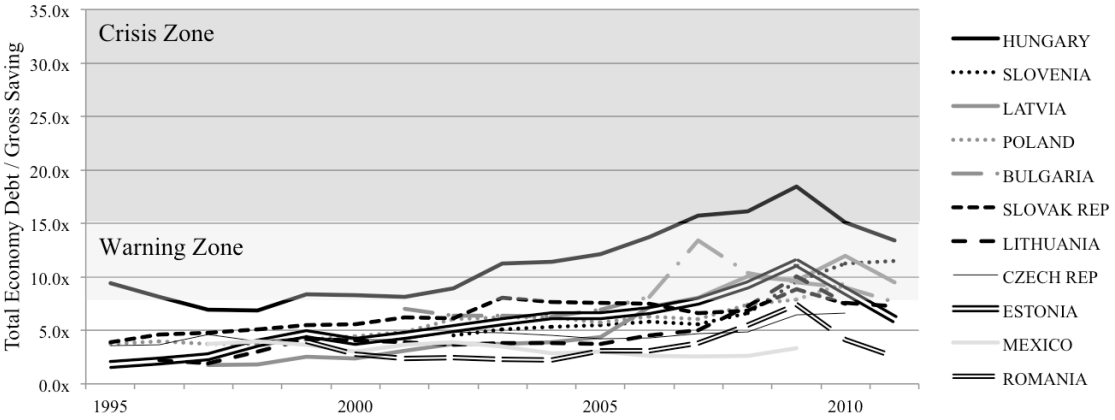
Sources: Federal Reserve and EuroStat.

Figure B.1: D/CF of non-financial sector for several major nations.



Sources: EuroStat.

Figure B.2: Household sector D/CF history of various nations and the euro area.



Sources: Eurostat and OECD.

Figure B.3: D/CF histories for eleven Central and Eastern European nations and Mexico.