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Sustainable Financial Obligations and Crisis Cycles

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Sustainable Financial Obligations and Crisis Cycles

Abstract

What level of indebtedness jeopardizes financial stability? We show that the ratio of financial obligations (interest payments and amortizations) to income, rather than leverage, is crucial for capturing debt sustainability. Estimating regime-shift models on aggregate U.S. credit loss data over the period 1985Q1-2010Q2, we find that credit losses become highly sensitive to adverse shocks when household or business sector financial obligations ratios exceed threshold values of 10%. This occurs in at least one sector 1-2 years prior to each episode of financial distress in the sample. Severe events, e.g., the recent crisis, ensue when debt in both sectors reach unsustainable levels.

JEL classification: E32, E44, G01, G21

Keywords: financial crises, systemic events, credit losses, leverage, financial obligations, sustainable debt burden, STR-model, regime shifts, cointegration.

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1 Introduction

When is financial stability jeopardized by systemic events? Is there a maximum sustainable debt burden? If there is, can it be empirically estimated and will exceeding it necessarily result in a crisis? These are timely and important questions in the wake of the recent financial crisis and its evolution, yet empirical evidence on these issues is rather scarce. Using data on aggregate U.S. credit losses, we show that debt sustainability depends on financial obligations ratios (interest payments and amortizations relative to income) rather than on leverage (debt to income) which has been emphasized in the literature. In particular, we are able to estimate threshold values, interpreted as maximum sustainable debt burdens, for the financial obligations ratios above which financial stability is jeopardized by systemic events.

Recent theories of financial frictions emphasize the interplay between durable asset prices and leverage in generating systemic crisis events.¹ For instance, increases in the price of durable assets raise the value of collaterals available to asset holders, thereby providing them with new borrowing opportunities which may in turn reinforce asset prices (see *e.g.*, Kiyotaki and Moore (1997) and Bernanke et al. (1999)). If agents do not internalize a pecuniary externality associated with fire sales of assets in their demand for credit, this type of interplay is likely to cause asset price bubbles and excessive leverage. Such build-ups in leverage increase the likelihood of a financial crisis in the wake of an adverse shock to the economy (Krishnamurthy (2003), Lorenzoni (2008), Gai et al. (2008), and Miller and Stiglitz (2010)). By reducing their lending standards during booms, banks tend to exacerbate the problem (Ruckes (2004) and Dell’Ariccia and Marquez (2006)).

As much as these theoretical arguments seem compelling, few empirical studies on the relationship between leverage and financial distress exist in the literature. Exceptions are the cross-country study by King (1994) and the recent contributions by Mian and Sufi (2010). The former finds that countries with high degrees of household leverage prior to the recession in the early nineties experienced larger output losses, and the latter that those U.S. counties with high leverage growth prior to the recent crisis experienced the biggest credit and output losses. Related are also studies which construct leading indicators of banking system distress using data on asset prices and leverage (*e.g.*, Borio and Lowe (2002)). But, as pointed out by Jerome Stein (2010), it can be difficult to predict future crisis events based on variables which have experienced growth for longer periods of time, such as leverage and asset prices.² Moreover, simple intertemporal correlations between growing variables do not necessarily imply true relationships, as is well known.

¹In the present paper, we exclusively focus on the role of credit risk in generating financial distress. Analyses of the liquidity risk channel can be found in Smith (2002), Diamond and Rajan (2006), and the references therein.

²Borio and Drehmann (2009) address this criticism by evaluating the out-of-sample predictive performance of several leading indicators of banking system distress, constructed from data on asset price and leverage “gaps” using a signal extraction method. They find that an indicator which incorporates property prices performs quite well with respect to the recent crisis.

More important, Stein (2010) argues that debt sustainability should not be judged by the amount of leverage on its own, but rather by the associated financial obligations as given by interest payments and amortizations. This is not a minor theoretical detail. The fact that U.S. real and nominal interest rates have been declining over the past decades, as pointed out by Caballero et al. (2008) among others, is likely to have a significant impact on debt sustainability. Thus, it is crucial to control for the terms of credit when assessing the effect of debt on financial stability in general, and on the recent crisis in particular.

In this paper we show that financial obligations ratios, rather than leverage, have the ability to explain financial fragility. We assess measures of leverage and financial obligations ratios in terms of their explanatory power over credit loss dynamics, using aggregate U.S. data over the period 1985Q1-2010Q2. Contrary to the findings in the existing literature, we find that leverage measures as such cannot adequately account for credit losses during systemic events. Financial obligations ratios, on the other hand, can account for the salient features of credit losses, consistent with the theoretical considerations in Stein (2010). Hence, financial obligations ratios, rather than leverage, are likely to be more informative of impending crises.

Specifically, we are able to estimate a threshold value for the financial obligations ratios, which can be interpreted as measuring a maximum sustainable debt burden (MSDB). When the threshold value is exceeded, interactions between credit losses and the business cycle become pivotal and even small adverse shocks can lead to massive credit losses. We find that the financial obligations ratios typically exceed the estimated thresholds 1-2 years prior to each recession or crisis in the sample period. Moreover, the magnitude of the deviations between the financial obligations ratios and their corresponding MSDB estimates, have explanatory power for the severity and length of the ensuing recessions.

By distinguishing between different loan categories, we also obtain new insights on the relative importance of the business and household sectors in generating financial distress. For example, we find that losses on real estate loans become highly sensitive to adverse shocks when the financial obligations ratio associated with households' real estate debt exceeds a threshold of slightly over 10%. This occurs during two periods in our sample. The first begins in 1989Q2, roughly one year prior to the recession in the early 1990's, and ends at its lowest point. The second begins in 2005Q1, more than two years prior to the recent crisis, and has not yet ended by the last observation in the sample (2010Q2). Hence, armed with this MSDB estimate it might have been possible to detect the problems which led to the recent crisis a full two years before its actual occurrence. We note that these two periods resulted in unusually large numbers of bank failures, suggesting that financial stability was jeopardized on both occasions. Moreover, the magnitude by which the households' financial obligations ratio exceeded the MSDB prior to the recent crisis may explain why only this period developed into what is known as a full-blown financial crisis.

Similarly, we find that large losses on business loans typically ensue when the financial obligations ratio in the business sector exceeds an estimated threshold value.

This occurs between 1-2 years prior to each recession or crisis over the sample period. Credit losses associated with these occasions do not necessarily lead to large scale bank failures, and may therefore be less detrimental to financial stability than the losses connected to real estate. Nevertheless they are likely to significantly affect the business cycle.

Overall, our findings associated with the different loan categories suggest that the compositional dynamics in credit losses, resulting from the business and household sectors, may be of particular importance for understanding financial fragility. For instance, the recent crisis was predominantly caused by too large financial obligations in the household sector, whereas the recession in the early nineties was more related to the business sector.

The rest of the paper is organized as follows: Section 2 introduces the data, whereas Section 3 discusses methodology and statistical models. The results are presented in Section 4 and Section 5 concludes.

2 Data

In this section we introduce our data which consist of quarterly U.S. time-series observations covering the period 1985Q1-2010Q2. We begin by discussing aggregate credit loss rates of commercial banks, which are informative as indicators of the level of distress in the financial system. As mentioned in the introduction, one of the key objectives in this paper is to study the ability of leverage versus financial obligations to explain the variation in the loss rates, specifically during episodes of severe financial distress. Measures of these variables are introduced and discussed in Section 2.2. We also control for a number of variables which are potentially important for understanding credit loss dynamics, such as real house prices, interest rates, monetary policy indicators, and measures of real activity. These variables are introduced in Section 2.3. Detailed descriptions of the variables and their sources are provided in Appendix A.

2.1 Credit losses and financial distress

Almost all serious episodes of financial turmoil in modern history have been associated with massive credit losses (see *e.g.*, Herring (1999)). As a first ocular illustration, Figure 1 shows the association between the rate of commercial bank failures in the U.S. (panel a), and the loss rates on total loans (panel b), real estate loans (panel c), and business loans (panel d). As is apparent, there are only two episodes of major bank failures in our sample. The first occurs between the late 80's and early 90's, and is associated with the savings and loan crisis, whereas the second corresponds to the recent financial crisis. It is notable that the bank failure rate is very low between these two periods, suggesting that the burst of the dot.com bubble had little effect on the incidence of bank failures. In contrast, the rate of losses on total loans displays peaks at each of the three U.S. recessions in the sample, with the most recent one being almost

Figure 1: Indicators of the level of distress in the U.S. banking system.

twice as severe as the previous ones.

Decomposing the total loss rate into those belonging to real estate and business loans, as done in panels c and d, reveals a significant difference between the two: the time path of the loss rate on real estate loans (panel c) resembles that of the bank failure rate to a much greater extent than the loss rate on business loans (panel d). This suggests that financial stability is more sensitive to real estate loans than to business loans. The descriptive statistics reported in Table 1 shows the relative importance of these two loan categories in the banks' aggregate loan portfolio. For instance, over the sample the share of real estate loans has increased from 30% to 57%, whereas the share of business loans has declined from 34% to 16%. Table 1 also shows that the household sector share of real estate loans has increased from 48% to 56%, whereas the corresponding business sector share has been fairly constant at slightly below 30%. Thus, the U.S. banking system, as well as the household sector, have become more exposed to real estate loans during the past 25 years.

To get an impression of how real estate losses are distributed between households and businesses, Figure 2 decomposes the loss rate on total real estate loans into these two sectors (available from 1991Q1 onward). The figure shows that the real estate losses associated with the 1990 recession were almost exclusively related to business loans, in line with the results in Peek and Rosengren (1997, 2000), whereas in the recent crisis both sectors experienced similar high loss rates. But as the households' share in real estate loans is almost twice as large as that of the business sector, the recent crisis seems predominately related to the former sector.

For future use, we denote the credit loss rates by cl_t^T , cl_t^R , and cl_t^B , where T , R and B represent total, real estate, and business loans, respectively.

Shares of different loan categories in total loans						
	1985Q1	1990Q1	1995Q1	2000Q1	2005Q1	2010Q1
Share of total loans:						
Real estate loans	30%	41%	46%	47%	57%	57%
Business loans	34%	28%	23%	26%	20%	16%
Other loans [†]	36%	31%	31%	27%	23%	27%
Share of real estate loans:						
Household sector	48%	48%	59%	56%	58%	56%
Business sector	26%	29%	29%	28%	26%	26%
Other loans ^{††}	26%	23%	12%	16%	16%	18%

[†]Includes consumer loans, agricultural loans, loans to depository institutions, lease financing receivables, acceptances of other banks etc..

^{††}Includes loans secured by farmland and loans for construction and land development.

Table 1: Decomposition of aggregate loan portfolios.

(a) Loss rates on total vs. household sector real estate loans.

(b) Loss rates on total vs. business sector real estate loans.

Figure 2: Loan loss rates on total, business sector, and household sector real estate loans.

2.2 Leverage and financial obligations

Panels (a)-(d) in Figure 3 depict debt to income ratios which we use as a measure of leverage. We distinguish between the household (H) and business (B) sector on the one hand, and between total (T) and real estate (R) debt on the other. The corresponding leverage measures are denoted by l_t^{ij} , where $i = H, B$ and $j = T, R$. As seen from the figure, real estate loans constitute a large share of household debt (panels a and b), whereas it is only a small part of business debt (panels c and d). While all these measures are upward trending, household leverage displays the strongest growth rate.

As indicated in the introduction, increasing leverage is not necessarily problematic by itself. This is because higher debt levels can be sustainable with lower levels of interest rates or longer maturity of debt contracts. Since the increasing leverage of the last decades has coincided with declining nominal and real interest rates, this aspect is likely to be relevant. A measure that takes these factors into account is the financial obligations ratio, constructed by the Federal Reserve. It broadly consists of the sum of interest payments and amortization on debt. Since this measure is only available for the household sector, we construct a corresponding measure for the business sector by using the federal funds rates as the relevant interest rate, a fixed maturity of 3 years,³ and applying a linear amortization schedule.

Panels (e)-(h) in Figure 3 depict the financial obligations ratios, denoted f_t^{ij} , where i corresponds to the two sectors and j to the two debt categories. The graphs of these ratios show less growth compared to the leverage variables. In particular, the financial obligations ratio on total business loans (panel g) seems mean reverting, albeit with rather pronounced swings, suggesting that much of the upward trend in business sector leverage is due to declining interest rates.

2.3 Interest rates, monetary policy, and indicators of real activity

The discussion in previous section indicated that declining interest rates may partly be responsible for the increases in leverage. Thus, we control for both real and nominal interest rate movements in the subsequent analysis. The federal funds and government rates are denoted by i_t^M and i_t^G , respectively, and their corresponding real (ex-post) values are defined by $r_t^M = i_t^M - \pi_t$ and $r_t^G = i_t^G - \pi_t$, where π_t is the consumer price inflation rate. These interest rates are depicted in Figure 4 (panels a and b).

We also include a measure of the monetary policy stance, calculated as the difference between the federal funds rate and a standard Taylor's rule, $\tilde{i}_t^T$.⁴ As discussed by Rudebusch (2006), this measure captures both innovations to monetary policy and

³This value lies between the average maturities on firms' bank loans reported in Stohs and Mauer (1996) and Berger et al. (2005). We checked robustness of the results below by assuming 2 and 4 year maturities. The results did not change significantly and are available upon request.

⁴The rule is $\tilde{i}_t^T = 3.5 + 1.5(\pi_t - 2) + 0.5\tilde{y}_t$. The coefficient choices are standard in the literature, apart from the constant which is estimated.

(a) Total leverage in the household sector.

(b) Real estate leverage in the household sector.

(c) Total leverage in the business sector.

(d) Real estate leverage in the business sector.

(e) Total financial obligations in the household sector.

(f) Real estate financial obligations in the household sector.

(g) Total financial obligations in the business sector.

(h) Real estate financial obligations in the business sector.

Figure 3: Indicators of leverage and financial obligations in the household and business sectors.

(a) Nominal (solid line) and real (dotted line) federal funds rate.

(b) Nominal (solid line) and real (dotted line) long-term government T-bill rate.

(c) Deviations from Taylor's rule

(d) Interest rate spread

(e) Real house price

(f) Output gap

Figure 4: Various indicators of monetary and real conditions in the United States. The real (ex-post) interest rates are constructed using the 4-quarter moving average inflation rate to facilitate the exposition.

auxiliary information used by the Federal Reserve. In addition, we include the spread between the federal funds rate and the yield on long-term government bonds, $\tilde{i}_t^S$. This measure is strongly associated with the business cycle, and has been viewed as an alternative measure of the monetary policy stance (Bernanke and Blinder (1992)). These two measures are depicted in panels (c) and (d). As a measure of real house prices, p_t^R , we use the Federal Housing Finance Agency (FHFA) house price index divided by the consumer price index. The recent boom in housing is clearly visible from Figure 4 (panel e). As an indicator of business cycle fluctuations we use the output gap, $\tilde{y}_t$, depicted in panel (f).

3 Methodology

In this section, we discuss the dynamic behavior of the credit loss rates during episodes of financial distress and its implications for the choice of estimation strategy that is subsequently applied in Section 4. We conclude the section by discussing the statistical models which are used in the estimations.

3.1 Regime shifts, persistence and the econometric approach

A particularly striking feature of the credit loss rates in Figure 1 are their huge rates of change during episodes of financial distress, especially in the recent crisis period. Such jump behavior may signal heightened sensitivity to aggregate economic conditions due to systemic factors. The reason is that fundamentals affect both households and businesses differently during episodes of severe financial distress, when credit and collateral constraints become binding, compared to normal periods.⁵ Our primary econometric objectives is to uncover the statistically relevant (transition) variable(s) which propagate such regime shifts and to estimate the key parameters associated with them.

From a statistical point of view, regime shift dynamics can induce a degree of persistence in the data which is difficult to distinguish from unit-root dynamics in short samples (Leybourne et al. (1998) and Nelson et al. (2001)). To study this aspect, Figure 5 reports the spectral densities of the credit loss rates. As can be seen from the figure, all credit loss rates show significant variation at frequencies close to zero, consistent with such an interpretation. However, this persistence may of course also originate in some exogenous variable(s) which affects the riskiness of loans, such as the money market interest rate level. Indeed, we find that our leverage variables, financial obligations ratios, real house prices, and interest rates (see figures 3 and 4) all display stochastic trending or, alternatively, cycles of longer duration than the available sample.⁶ Hence, each of these variables may conceivably cause similar dynamics in the

⁵Christiano et al. (2004), for example, study monetary policy during a financial crisis, which is modeled as a period when collateral constraints become binding.

⁶Standard unit-root and stationarity tests indicate that these variables, as well as the credit loss rates, display dynamics consistent with stochastic trends. The only exception is the financial obliga-

Figure 5: Spectral densities of the loan loss rates.

credit loss rates. As such persistence is easily confused with dynamics due to regime shifts, it is crucial to distinguish between the two sources to get unbiased estimates of the latter.

To address this problem we initially restrict attention to the pre-crisis sample 1985Q1-2006Q4, where regime shift dynamics are less likely to have played a dominant role in credit loss determination.⁷ To identify the sources of persistence associated with fundamentals, we model each of the credit loss rates jointly with the other persistent variables (both individually and in selected groups), using the cointegrated vector auto-regressive (VAR) model (see below). We then test whether the latter variables are cointegrated and weakly exogenous with respect to the former. A variable that satisfies both of these criteria can be considered a leading indicator of the long-run movements in the credit loss rates. We use such variables to estimate the stochastic trends, s_t^j for $j = T, R, B$, which generate persistence in the credit loss rates during “normal” periods.

3.2 Statistical models

A convenient way of capturing long-run comovement between the credit loss rates and other persistent variables during the pre-crisis period, is the cointegrated VAR model

$$\Delta \mathbf{y}_t = \sum_{i=1}^{k-1} \Gamma_i \Delta \mathbf{y}_{t-i} + \Pi \mathbf{y}_{t-1} + \Phi \mathbf{d}_t + \boldsymbol{\varepsilon}_t \quad (1)$$

where $\mathbf{y}_t$ consists of the endogenous variables (including a credit loss rate), $\mathbf{d}_t$ is a vector of deterministic terms, $\boldsymbol{\varepsilon}_t \sim N_p(0, \Sigma)$, and k is the lag-length.

Cointegration in (1) can be tested by the likelihood ratio (LR) test for the rank of Π (Johansen (1996)). If the rank, r , is equal to p , then $\mathbf{y}_t$ is stationary, i.e. $\mathbf{y}_t \sim I(0)$. If

tions ratio on total business loans which is found to be stationary. We also note that the leverage measures and the real house price exhibit significant linear trends over the sample. These results are available upon request.

⁷In fact, we do not find any significant non-linearities (at the 5% significance level) in the data for the 1985Q1-2006Q4 sample, using the linearity test in Choi and Saikkonen (2004).

$0 < r < p$, then $\Pi = \alpha\beta'$, where α and β are two $(p \times r)$ matrices of full column rank and $\beta' \mathbf{y}_{t-1}$ describes the cointegration relationships. In this case $\mathbf{y}_t \sim I(1)$ and cointegrated with r cointegration vectors, β , and $p - r$ common stochastic trends, assuming that the “no $I(2)$ trends” condition $\left| \alpha'_{\perp} (I - \sum_{i=1}^{k-1} \Gamma_i) \beta_{\perp} \right| \neq 0$ is met, where $\perp$ denotes orthogonal complements. If $r = 0$, then $\mathbf{y}_t \sim I(1)$ and the process is not cointegrated. A testing sequence that ensures correct power and size starts from the null hypothesis of rank zero and then successively increases the rank by one until the first non-rejection.

When $0 < r < p$, it is possible to test the hypothesis that a variable, $y_{i,t}$ say, precedes the credit loss rate in question in the long-run. The test of this hypothesis is asymptotically χ^2 , and amounts to imposing zero-restrictions on a row of α corresponding to $y_{i,t}$. If the null hypothesis cannot be rejected, $y_{i,t}$ is said to be weakly exogenous with respect to the long-run parameters of the model. An estimate of the stochastic trend, s_t , associated with $y_{i,t}$ can, for example, be obtained from the moving average representation of (1).

Given estimates of s_t^j for $j = T, R, B$, we can estimate the non-linear dynamics associated with systemic events. We model this type of dynamics using a smooth transition regression (STR) model for the credit loss rates over the full sample. This model takes the form

$$\tilde{cl}_t^j = (1 - \varphi(\tau_t))(\mu_1 + \gamma'_1 \mathbf{x}_t) + \varphi(\tau_t)(\mu_2 + \gamma'_2 \mathbf{x}_t) + \boldsymbol{\psi}' \mathbf{d}_t + v_t \quad (2)$$

where $\tilde{cl}_t^j = cl_t^j - s_t^j$, $\mathbf{x}_t$ is a vector of explanatory variables, τ_t is a transition variable, $\mathbf{d}_t$ is a vector of deterministic terms, and v_t is assumed to be a mean zero stationary disturbance term. In the empirical analysis (Section 4), $\mathbf{x}_t$ is selected from the three cyclical indicators $\tilde{i}_t^T$, $\tilde{i}_t^S$, and $\tilde{y}_t$, whereas τ_t is selected from a set which includes the leverage variables, the financial obligations ratios, and several control variables. The transition function $0 \leq \varphi(\tau_t) \leq 1$ determines the relative weights between regimes 1 and 2. We assume that this function takes the form

$$\varphi(\tau_t) = \frac{1}{1 + e^{-\kappa_1(\tau_t - \kappa_2)}}$$

giving symmetric weights around the threshold parameter, κ_2 , where e is the natural exponent and $\varphi(\kappa_2) = 1/2$.⁸ Both the explanatory variables and the transition variable are allowed to exhibit stochastic trends. This is convenient as all of the leverage measures and most of financial obligations ratios display dynamics consistent with unit-roots. We note that the stationarity assumption on the disturbance term implies that $\tilde{cl}_t^j$ and $\mathbf{x}_t$ are either linearly or non-linearly cointegrated. Thus, verifying this assumption ensures model consistency, as well as safeguards against spurious results, for example due to growth correlations over time.

We apply a linearity test by Choi and Saikkonen (2004) to identify the statistically significant transition variables. The test is based on a Taylor series approximation of

⁸The signal extraction method outlined in Kaminsky and Reinhart (1999) also involves estimating critical thresholds and is, in this particular respect, similar in spirit to our approach.

Linear cointegration results								
$\mathbf{y}'_t$	1985Q1-2006Q4				1985Q1-2010Q2			
	$r = 0$	$r \leq 1$	$\alpha_{cl} = 0$	$\alpha_{iM} = 0$	$r = 0$	$r \leq 1$	$\alpha_{cl} = 0$	$\alpha_{iM} = 0$
$(cl_t^T, i_t^M)'$	0.00	0.38	0.00	0.42	0.96	0.98	–	–
$(cl_t^R, i_t^M)'$	0.01	0.79	0.00	0.13	0.95	0.94	–	–
$(cl_t^B, i_t^M)'$	0.00	0.19	0.00	0.54	0.27	0.29	–	–

Table 2: Linear cointegration results. Notes: The rows labeled “ $r = 0$ ” and “ $r \leq 1$ ” report the p -values of the LR tests for the rank of Π . The last two rows report the p -values from testing weak exogeneity for each of the variables in $\mathbf{x}_t$. Boldface values indicate significance at the 5% level.

(2), which under the null hypothesis of linearity will not contain any significant second (or higher) order polynomial terms. However, under the STR alternative, all significant higher order terms will involve the transition variable, τ_t . Hence, statistically valid transition variables can be detected by applying the test successively to each variable from the set of potential transition variables. As discussed in the introduction, such information may be helpful in distinguishing between competing explanations for the recent crisis, such as lax monetary policy or excessive debt.

4 Results

This section reports the main empirical findings. Section 4.1 first investigates whether the persistence in the credit loss rates is primarily due to exogenous factors or related to regime shifts (or both). Next, Section 4.2 compares the aptitude of leverage and financial obligations for explaining credit loss dynamics. Finally, Section 4.3 reports the estimates associated with regime shift dynamics, and shows that they are informative about debt sustainability.

4.1 Linearity vs. regime shifts

To identify the sources of persistent movements in the credit loss rates over the pre-crisis sample 1985Q1-2006Q4, we estimate (1) for each of the three credit loss rates combined with groups of variables consisting of at least one of the variables introduced in sections 2.2 and 2.3.

The left hand side of Table 2 reports the results of the LR test for the rank of Π and tests of weak exogeneity (conditional on $r = 1$) in estimates of (1) with $\mathbf{y}_t = (cl_t^j, i_t^M)'$, $j = T, B, R$, $k = 2$, a restricted constant, three centered seasonal dummies, and transitory impulse dummies to account for a few additive outliers in the credit loss rates (reported in Appendix A). As can be seen from the table $r = 0$ is rejected, whereas $r \leq 1$ cannot be rejected, in all three models. Furthermore, weak exogeneity is always rejected for the credit loss rates, but never rejected for the federal funds rate. This suggests that the declining interest rates during the past decades have reduced credit

risks associated with the existing stock of loans in banks' loan portfolios, consistent with Altunbas et al. (2010). We also find that none of the other variables, including the leverage and financial obligations ratios, satisfy both of these criteria.⁹

We next investigate whether a linear combination between the federal funds rate and the credit loss rates continue to be cointegrated in the full sample, 1985Q1-2010Q2. As the results in the right hand side of Table 2 show, cointegration between the variables breaks down in this case suggesting that the credit loss rates follow a different parameter regime in the crisis period. This is consistent with the nonlinear hypothesis in (2). We investigate this possibility using the linearity test of Choi and Saikkonen (2004). Prior to the estimations, we remove the persistent (stochastic) trend associated with the interest rate decline, s_t , from the credit loss rates, where the former is estimated by the Hodric-Prescott filtered federal funds rate.¹⁰ The filtered loss rates are denoted by $\tilde{cl}_t^j$, for $j = T, R, B$ and depicted in Figure 6.

We test the null hypothesis of linearity against the STR model alternative in (2) and try different alternatives for $\mathbf{x}_t$ and τ_t . In particular, we use the interest rate spread, $\tilde{i}_t^S$, and the output gap, $\tilde{y}_t$,¹¹ both individually and jointly, as explanatory variable(s), and successively try each of $\tilde{i}_t^T$, $\tilde{i}_t^S$, p_t^R , l_t^{ij} , and f_t^{ij} ($i = H, B$ and $j = T, R$) as transition variable. Initial results show that output gap movements, $\tilde{y}$, is neither significant in the first nor in the second regime in the model for the loss rate on business loans, $\tilde{cl}_t^B$, and was hence excluded from $\mathbf{x}_t$ in this equation. Both $\tilde{y}_t$ and $\tilde{i}_t^S$ produced significant results in the remaining models. Hence, we use $\mathbf{x}_t = (\tilde{i}_t^S, \tilde{y}_t)'$ in the models for the loss rate on total loans and real estate loans, $\tilde{cl}_t^T$ and $\tilde{cl}_t^R$, as well as $\mathbf{x}_t = \tilde{i}_t^S$ in the model of $\tilde{cl}_t^B$.

Given the indicated choices of $\mathbf{x}_t$, Table 3 reports the results of the linearity tests corresponding to each potential transition variable. For the pre-crisis period, the results in the upper part of the table show that the null hypothesis of linearity cannot be rejected in any of the models. However, turning to the lower part of Table 3, we see that the null hypothesis of linearity is rejected for several potential transition variables in the full sample. For instance, in the model for the loss rate on real estate loans, $\tilde{cl}_t^R$, there seems to be significant non-linearities associated with the interest rate spread, the household and business sector real estate debt to income ratios, and the household

⁹These results are omitted for brevity, but are available upon request. We also tried per capita GDP, the inflation rate, the unemployment rate, and the real exchange rate. None of these were found to be both cointegrated and weakly exogenous with respect to the credit loss rates.

¹⁰This is statistically justified if the federal funds rate is strongly exogenous. Exclusion restrictions on the Δcl_t^j terms in the equation for Δi_t^M in (1) produced marginal significance levels of 0.26, 0.03 and 0.37 for $j = T, R, B$, respectively. Hence, in conjunction with results on weak exogeneity, these results imply that the federal funds rate is strongly exogenous with respect to the credit loss rates (or close to in the case of cl_t^R). We also checked robustness with respect to this estimate of s_t , by estimating (2) with cl_t^j on the left hand side and i_t^M added to the right hand side. This did not change the results below to any significant degree.

¹¹We also tried the deviations from Taylor's rule, $\tilde{i}_t^T$, in $\mathbf{x}_t$, but this variable was not significant in any of the estimated regimes, and hence excluded from the analysis.

(a) Filtered Loss rate on total loans.

(b) Filtered loss rate on business loans.

(c) Filtered loss rate on real estate loans.

Figure 6: Indicators of financial distress with stochastic trend component removed.

Tests of linearity vs. regime shifts											
1985Q1-2006Q2											
$\tilde{cl}_t^j \setminus \tau_t$	$\tilde{i}_t^T$	$\tilde{i}_t^S$	p_t^R	l_t^H	l_t^{HR}	l_t^B	l_t^{BR}	λ_t^H	λ_t^{HR}	λ_t^B	λ_t^{BR}
$\tilde{cl}_t^T$	0.244	0.170	0.918	0.828	0.719	0.535	0.419	0.963	0.406	0.780	0.570
$\tilde{cl}_t^R$	0.330	0.085	0.187	0.363	0.597	0.489	0.688	0.108	0.085	0.221	0.583
$\tilde{cl}_t^B$	0.559	0.582	0.249	0.370	0.408	0.072	0.256	0.132	0.929	0.141	0.420
1985Q1-2010Q2											
$\tilde{cl}_t^j \setminus \tau_t$	$\tilde{i}_t^T$	$\tilde{i}_t^S$	p_t^R	l_t^H	l_t^{HR}	l_t^B	l_t^{BR}	λ_t^H	λ_t^{HR}	λ_t^B	λ_t^{BR}
$\tilde{cl}_t^T$	0.819	0.021	0.034	0.016	0.013	0.011	0.012	0.181	0.041	0.411	0.037
$\tilde{cl}_t^R$	0.617	0.015	0.168	0.059	0.042	0.052	0.021	0.738	0.018	0.940	0.054
$\tilde{cl}_t^B$	0.784	0.338	0.068	0.048	0.049	0.006	0.029	0.058	0.151	0.021	0.064

Table 3: Tests of linearity against a STR alternative. Bold values indicate rejection of the null hypothesis at the 5% significance level.

sector's real estate financial obligations ratios. In the model for the loss rate on business loans, $\tilde{cl}_t^B$ on the other hand, all debt to income ratios and the financial obligations ratio in the business sector, are significant. The results of the model for the loss rate on total loans, $\tilde{cl}_t^T$ are, by and large, a combination of the results from the models of $\tilde{cl}_t^R$ and $\tilde{cl}_t^B$.

Summarizing, we find that the federal funds rate can be considered a leading indicator of long-run movements in the credit loss rates. While regime shifts do not play a very dominant role in the pre-crisis period, they are crucial for describing credit loss dynamics in the full sample, and in particular during the recent financial crisis.

4.2 Leverage vs. financial obligations

Next we estimate (2) for each the three credit loss rates, $\tilde{cl}_t^j$, with $\mathbf{x}_t$ as above, and τ_t successively equal to one of the transition variable candidates that has a significant entry in Table 3. When τ_t equals the interest rate spread, $\tilde{i}_t^S$, the real house price, p_t^R , or any of the leverage variables, l_t^{ij} , we find that either the estimate of the threshold parameter, κ_2 , lies outside the range of the relevant transition variable or that the statistical fit of the model is poor, or both. More important, unit-roots cannot be rejected in the residuals of these models, implying that the underlying assumptions of the cointegrated STR-model are not satisfied. Hence, these variables, and leverage in particular, cannot adequately account for the large and persistent fluctuations in the credit loss rates associated with the regime-shift dynamics.

In contrast, when any of the significant financial obligations ratios in Table 3 are used, we get stationary residuals, a good statistical fit, and a threshold parameter estimate which is in the range of the relevant transition variable. It is also notable from the table, that the financial obligations ratios related to household real estate debt and

STR estimates							
Transition parameters				Regime 1		Regime 2	
$\tilde{cl}_t^i$	τ_t	κ_1	κ_2	γ_{is}	$\gamma_{\tilde{y}}$	γ_{is}	$\gamma_{\tilde{y}}$
$\tilde{cl}_t^T$	f_t^{HR}	12.678 (5.630)	10.192 (0.056)	-0.063 (0.034)	0.002 (0.045)	-0.276 (0.094)	-0.224 (0.051)
$\tilde{cl}_t^R$	f_t^{HR}	3.609 (1.128)	10.079 (0.106)	-0.023 (0.041)	-0.051 (0.038)	-0.267 (0.099)	-0.243 (0.049)
$\tilde{cl}_t^B$	f_t^{BT}	2.318 (0.968)	10.44 (0.199)	-0.249 (0.085)	—	-0.619 (0.119)	—

Table 4: Estimated transition parameters and regime coefficients from STR-models of the adjusted credit loss rates.

total business debt, f_t^{HR} and f_t^{BT} , are the only statistically valid transition variables in the models for the loss rate on real estate loans and business loans $\tilde{cl}_t^R$ and $\tilde{cl}_t^B$, respectively. Finally, we note that the financial obligations ratios associated with real estate debt in both the household and business sector, f_t^{HR} and f_t^{BR} , produce sensible results in the model for the loss rate on total loans, $\tilde{cl}_t^T$. We choose the former financial obligations ratio as it produces a somewhat better fit and higher likelihood than the latter.

Based on these results we conclude that leverage variables may not be able to signal an impending crisis with any sufficient precision. Financial obligations ratios, on the other hand, seem more relevant in this respect, as they can account for regime shift dynamics in the credit loss rates associated with episodes of severe financial distress.

4.3 Explaining credit losses

Table 4 reports the key parameter estimates of the STR-models. As can be seen from the table, both the estimated coefficients measuring the speed of transition between regimes, κ_1 , and the estimated thresholds, κ_2 , are positive, indicating that regime 2 dominates for values *above* the thresholds. Furthermore, the estimates of κ_1 indicate that speeds of transitions between regimes are rather fast in all cases. Each regime is characterized by the parameters γ_{is} and $\gamma_{\tilde{y}}$, describing the effect of $\tilde{i}_t^S$ and $\tilde{y}_t$ on $\tilde{cl}_t^j$ in the relevant regime (except in the equation for $\tilde{cl}_t^B$ where only $\tilde{i}_t^S$ enter the regimes). The parameters in the first regime are generally negative but not significant, whereas in the second regime both parameters become negative and significant. It is notable that the effect on credit losses from a change in the output gap or the interest rate spread is much larger in the second regime. Therefore, the financial system becomes much more exposed to real economic fluctuations when the financial obligations ratios are above the estimated threshold values. Thus, the second regime describes unstable periods where even small negative shocks can lead to massive credit losses. In this sense, the threshold values, κ_2 , can be viewed as estimates of the *maximum sustainable debt burden* (MSDB) with respect to a given credit category. Our estimates suggest that the

Figure 7: Transitions in the loss rate on real estate loans. The upper panel depicts the loss rate on real estate loans, whereas the lower panel depicts the financial obligations ratio associated with household's real estate debt and the corresponding MSDB estimate. Episodes when regime 2 dominate are demarked by grey bars.

levels of both total loans and real estate loans become unsustainable (i.e. susceptible to high loss rates), when the financial obligation ratio associated with households real estate loans exceed 10.19% and 10.08%, respectively. Similarly, the level of business loans becomes unsustainable when the financial obligations ratio associated with total business debt exceeds 10.44%.

The upper panel of Figure 7 depicts the loss rate on real estate loans, and the lower panel depicts the financial obligations ratio related to household real estate debt along with a line demarking the corresponding MSDB estimate. The periods during which the second regime dominates are demarked by grey bars in the figure. As can be seen, there are only two unstable periods in the sample. The first begins in 1989Q2, roughly one year in advance of the recession in the early 1990's, and ends at its peak. The second begins in 2005Q1, *over two years in advance of the recent crisis*, and has not yet ended by the last observation in our sample (2010Q2). Hence, armed with this MSDB estimate it might have been possible to foresee the recent crisis a full two years before its actual occurrence. In addition, the magnitude and duration by which the financial obligations ratio exceed the MSDB line seem to explain both the severity and length of the ensuing downturns. Indeed, this may explain why only the latter period developed into what is known as a full-blown financial crisis.

Similarly, Figure 8 depicts the loss rate on business loans and the corresponding

Figure 8: Transitions in the loss rate on business loans. The upper panel depicts the loss rate on business loans, whereas the lower panel depicts the financial obligations ratio associated with total business sector debt and the corresponding MSDB estimate. Episodes when regime 2 dominate are demarked by grey bars.

financial obligations ratio. As can be seen from the figure, there are three unstable periods in our sample, each beginning between 1-2 years prior to one of the three known U.S. recessions in the sample, and ending roughly at their peaks. Note also, that prior to the 1990's recession, the MSDB of business loans is exceeded in 1988Q2, a full year earlier than the MSDB of households real estate loans. However, prior to the recent crisis the relative timing is reversed, i.e. the household sector MSDB was exceeded first.

5 Conclusions

Recent theories on the connection between financial frictions and systemic events have highlighted the role of leverage. However, these theories are silent about the effect of interest rates and debt maturity on debt sustainability. In this study we investigate the abilities of debt to income ratios, a measure of leverage, and financial obligations ratios, which capture the notion of debt burdens, to account for dynamics related to systemic events in credit loss rates over the period, 1985Q1-2010Q2.

We document three important findings: *(i)* Leverage increases cannot, by themselves, adequately account for credit loss dynamics related to systemic events, contrary to findings in the existing literature. The major reason for this result is that the per-

sistent declines in interest rate levels throughout the period have altered the degrees of leverage which are sustainable. In contrast, financial obligations ratios, which explicitly take the terms of credit into account, can be used to capture the salient features of credit loss dynamics. *(ii)* Episodes of financial distress generally follow 1-2 years after financial obligations ratios in the household or business sectors cross estimated critical threshold values from below, and end shortly after these ratios return to below threshold values. The estimated thresholds are slightly above 10% in both sectors, and can be interpreted as measuring a maximum sustainable debt burden (MSDB). Moreover, the magnitude of the corresponding deviations from the MSDB, has explanatory power with respect to the severity and length of the ensuing recessions. *(iii)* Severe events also follow when both household and business sector financial obligations ratios reach unsustainable levels simultaneously. Such event are more rare, as the cycle in household sector financial obligations ratios, which is primarily related to real estate debt, is of significantly longer duration than the corresponding business sector cycle. In this sense, the former cycle may be more revealing about impending financial crises. This finding is consistent with Leamer (2008), among others, who highlight the importance of household finance for macroeconomic fluctuations.

The empirical findings of the present paper point to the central role of real estate financial obligations in generating crisis events. As households, in particular, seem to have higher exposure to this debt category, it would be desirable to decompose the financial obligations according to various households characteristics, for example with respect to age and income cohorts (Iacoviello (2005)). Indeed, such decompositions can likely provide us with more precise MSBD estimates, and thus with better assessments of the systemic credit risk exposures of banks arising from household finance.

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Appendix A

The sources and definitions of the data are reported in Table 5. In addition, a few transitory impulse dummies were used in connection with the VAR estimates. These dummies (labeled $DYYQ$) take the value 1 at date YYQ and -1 at the consecutive date, where YY and Q refer to the year and quarter digits, respectively. The model for $\mathbf{y}_t = (cl_t^T, i_t^M)'$ includes $D894$, the model for $\mathbf{y}_t = (cl_t^R, i_t^M)'$ includes $D904$, $D914$ and $D923$, and the model for $\mathbf{y}_t = (cl_t^R, i_t^M)'$ includes $D894$ and $D014$.

Data and definitions	
Var.:	Definition:
cl_t^j	Net charge-off rate on loan category j of all insured U.S. commercial banks. $j = T$ (total loans), R (real estate loans), and B (business loans). Source: FRS
l_t^j	Debt to income ratio (in %). $j = H$ (total debt, households'), HR (real estate debt, households'), B (total debt, businesses), BR (real estate debt, businesses). Income equals total wages and salaries for households and non farm business income for businesses. Sources: FRS and BEA.
f_t^j	Financial obligations ratio. For $j = H, HR$ the series are taken from the FRS. For $j = B, BR$ the series are calculated as $l_t^j i_t^M / 400 + l_t^j / 12$.
p_t^R	House price index (all transactions) divided by CPI index. Sources: FHFA and BLS.
i_t^M	Effective federal fund rate (3-month average). Source: FRS
i_t^G	Yield on 10-year Treasury securities. Source: FRS
π_t	Consumer price inflation (4-quarter moving average). Source: BLS
u_t	Unemployment rate (seasonally unadjusted). Source: BLS
q_t	Real effective exchange rate (CPI weighted). Source: OECD
$\tilde{i}_t^S$	$i_t^M - i_t^G$
$\tilde{i}_t^T$	Deviations from a standard Taylor's rule, $\tilde{i}_t^T = i_t^M - 3.5 - 1.5(\pi_t - 2) - 0.5\tilde{y}_t$.
$\tilde{y}_t$	$100(\ln(Y_t/Y_t^*))$, where Y_t is real output and Y_t^* is potential output. Source: OECD.
y_t^L	GDP per capita. Source: BEA.

[†] Sources: Federal Reserve System (FRS), Bureau of Economic Analysis (BEA), Bureau of Labor Statistics (BLS), Congressional budget office (CBO), OECD databases (OECD), Federal Housing Finance Agency (FHFA).

Table 5: Variable definitions and sources.