# Growthless Credit Booms and Creditless Recoveries*

Mikael Juselius and Mathias Drehmann†

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**Abstract**

Mandatory debt service payments can, in the aggregate, have a considerable negative impact on consumption and investment. This may counteract the positive effects of increased net worth on credit and output and lead to a common phenomena that we call growthless credit booms. It can also help explain creditless recoveries - a puzzling but well documented fact. Together, aggregate debt service payments and net worth explain a large part of the variation in US credit and output growth over the past three decades, including that experienced in the Great Recession. Our results highlight that during a growthless credit boom an economy is on an unsustainable path even if standard business cycle indicators, such as output growth, are at their normal levels. Ultimately, though, credit has to be repaid from future income at the expense of future expenditure.

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†Bank for International Settlements. Mikael Juselius: mikael.juselius@bis.org. Mathias Drehmann: mathias.drehmann@bis.org

# 1 Introduction

Creditless recoveries are a stylized but somewhat puzzling fact. After recessions have bottomed out, output often picks up without a corresponding pickup in credit, especially in the wake of a credit boom or financial crisis (eg Calvo et al (2006) or Claessesn et al (2009)). A less noted but even more surprising fact is that output growth rarely moves much beyond its long-run average during the preceding boom. We call this phenomena a growthless credit boom. Both puzzles can be understood by recognizing that in addition to the widely analyzed interactions between net worth, credit and output there is an important channel that has generally been overlooked: mandatory debt service payments on the outstanding stock of credit that have a considerable negative impact on consumption and investment.

Empirically, feedbacks between net-worth, credit and debt servicing burdens are important drivers of the economy around a credit boom. Initially, an increase in asset prices and thus net worth feeds into higher credit and output growth. As the boom progresses, credit stocks and associated debt burdens rise, increasingly offsetting the positive effects from credit growth. Hence, we observe a growthless credit boom. At some point, the growth enhancing effects from new credit are no longer sufficient to counterbalance the drag on expenditure from debt service payments. Asset prices fall and the credit boom comes to an end. Both channels now work in the same direction, leading to sharp declines in credit and output. Spending only returns to normal as credit stocks and debt service burdens are reduced. At this stage, net worth still remains depressed, holding back credit even though output growth has recovered, ie we observe a creditless recovery.

We show that both channels have substantial quantitative effects on US credit and output growth since 1985, helping inter alia to explain why growth was not particularly impressive in the run-up to the recent crisis and why the "Great Recession" has been so severe and prolonged - developments that led Summers (2013) to think about the possibilities of secular stagnation in the US.[1] While we do not have to say anything about the suggested potential drivers of secular stagnation, such as a drop in productivity or changing demographics, the net-worth and debt service burdens account for a substantial part in explaining the macro developments around the recent crisis in the United States. For example, consumption growth was approximately normal during 2005 and

[1]The debate about secular stagnation has so far played out mainly in the press and in more conjunctural pieces such as Krugman (2013), Taylor (2013) or Canuto et al (2014)).

2006. Rising asset prices increased credit growth, which in turn boosted consumption growth by 1 percentage point. Debt service burdens on the other hand reduced it by 0.9 percentage points. During the "Great Recession" from late 2007 to mid 2009, however, both effects contributed to depressing annual consumption growth by on average 1.5 percentage points. Afterwards, continuously low net worth forced households to delever, reducing consumption growth by around on average 1.8 percentage points from mid 2009 until the end of 2013. Shedding of debt and ultra-loose monetary policy had pushed debt service burdens below steady-state levels in mid-2010. Yet, the positive consumption effects only started to outweigh low net worth by mid 2013, bringing consumption back to more long run levels.

We are not the first to recognize debt service burdens as an important additional driver for consumption and investment.[2] It was for example understood by the FED in the recession in the early 1990s that "difficulties faced by borrowers in servicing their debts ... prompted many to cut back expenditures and divert abnormal proportions of their cash flows to debt repayment. This in turn fed back into slower economic growth." (p.3, Greenspan (1993)).[3] Several micro studies also show that households tend to cut consumption rather than default on their loans in face of high debt service payments (eg Olney (1999), Johnson and Li (2010), Dynan (2012)). This also applies to firms, where higher debt service payments reduce investment because of its cash flow sensitivity.[4]

To uncover the aggregate effects of net worth and debt service burdens over the cycle, we will work directly with aggregate time-series data as micro evidence alone cannot comprehensively address this question. For instance, there is a large literature showing that basic properties of representative-agent micro models are generally not preserved under aggregation if agents are heterogeneous (eg Forni and Lippi (1999)). Yet, the theoretical literature has identified the heterogeneity of agents and the potential of feedback effects from individual optimal behaviour to macro outcomes as key elements

[2]There is strong micro econometric evidence for a positive link between net worth and expenditure. For example, Gan (2007) or Chaney et al (2012) document this for the corporate sector. For the household sector, for example, in a series of papers, most recently summarised in a book, Mian and Sufi (2014) empirically show the feedback effects between real estate prices, household credit and consumption.

[3]At the same time, the FED was puzzled about the creditless recovery as growth had picked up in 1993 without any matching expansion in credit (Greenspan (1993)).

[4]Following Fazzari et al (1988), there has been extensive debate in the literature how the observed cash flow sensitivity of investment relates to financial constraints. Controlling more effectively for potential endogeneity issues, available collateral or access to credit, the recent literature supports the finding that lower cash flows decrease investment for financially constrained firms (eg Rauh (2006), Gan (2007), Campello et al (2011) or Chaney et al (2012)).

in understanding how real and financial variables interact at the macro level.

Net worth constraints have been at the heart of the macro finance literature since the seminal papers by Bernanke and Gertler (1990), Bernanke et al (1999) and Kiyotaki and More (1997). In these type of models, financial frictions limit the pledgeability of assets so that investors cannot fully fund projects with debt. Thus, positive shocks to asset prices, and hence collateral values, increase credit and output, which in turn feeds back to higher asset prices. We find clear empirical evidence that this is the case. But whereas these models imply that asset-to-debt ratios remain constant, our empirical evidence suggests that aggregate debt levels do not adjust as quickly as asset prices so that this ratio fluctuates over the cycle.

More recently, aggregate demand externalities associated with high debt service burdens have been suggested as one explanation why the recent post-crisis recovery has been so weak (eg Eggerston and Krugman (2012), Farhi and Werning (2013), Korineck and Simsek (2014)). To avoid default, the budget constraint implies that borrowers have to cut back on expenditure to compensate for higher debt service burdens or lower income.[5] In a general equilibrium framework, the reduction in demand from borrowers can, however, be compensated by an increased demand from lenders, unless frictions such as the zero lower bound prevent interest rates from falling sufficiently low. Our results show that demand externalities associated with high debt service burdens seem to be more generally at work, even during credit booms and when nominal interest rates are well above zero.

To measure the effects of net worth and debt service burdens at the macro level, it is necessary to separate between steady-state and transitory developments as the latter are more relevant for the cycle. Technically, we model the transitory components as mean-reverting deviations from two intuitive empirical steady-states. Steady-state net worth is approximated by a cointegrating relationship between credit-to-GDP and real asset prices. But the results are robust to several other specifications, for example, directly based on the assets-to-credit ratio. Similarly, we derive a steady-state for the aggregate debt service burden both from a direct measure of this variable and, as a robustness check, from a cointegration relationship between credit-to-GDP and the lending rate. Throughout the paper, we use quarterly time-series data for the United States from 1985-2013. And we provide separate results of the total non-financial private sector as well as the household and corporate sectors.

[5] Borrowers could also roll over credit. But this is only possible for a limited time in the aggregate as debt has to be repaid at some point so that borrowing does not become a Ponzi scheme.

In a second step, we study how deviations from net-worth and debt service steady states affect expenditure and credit growth. We find that positive deviations from the debt service steady-state feed negatively into future consumption and investment growth. On the other hand, positive deviations from long-run net worth increase future credit growth. Credit growth, in turn, has a positive impact on expenditure growth and vice versa, in line with standard financial accelerator effects. Technically, we obtain these results by including the deviations from two steady-states as error correction mechanisms (ECMs) in a vector auto-regressive (VAR) model for real private credit and expenditure growth. The model also includes a real interest rate as an additional ECM to control for the cost of refinancing, as well as, endogenous real asset price and output growth to control for wealth and income effects. The results are robust with respect to variations in the sample. For example, the same quantitative results hold even if the recent credit boom and subsequent recession are excluded.

The relevance of aggregate debt service burdens and net-worth has strong implications for macroeconomic assessments and thus policy. Most importantly, our results suggest that an economy can be on an unsustainable path even though output growth - or traditional real time measures of the output gap for that matter - appears to be normal. The reason is that during a growthless credit boom two countervailing forces are at work: there is the growth enhancing effect of new credit and a growth reducing effect of debt service burdens. These effects push demand in opposite directions. If debt service burdens are ignored, it would also appear ex-post, to use the much stretched phrase by financial stability practitioners, that vulnerabilities were building up in the background and crystallised with vehemence once asset prices collapsed. In contrast, our analysis highlights that such dynamics should not come as a surprise. Over time, loosened net worth conditions increase the stock of credit thus raising debt service burdens, which counteract the positive effects from new credit. At some point, the latter effect begins to dominate, asset prices collapse, and a severe recession follows.

The rest of the paper is organized as follows: Section 2 places it in the context of the growing empirical literature on macro financial linkages. Section 3 provides the empirical evidence of growthless credit booms and creditless recoveries. After laying down the empirical approach in Section 4, results are presented in Section 5. Section 6 shows what our results imply for credit and expenditure growth in the United States since 1985, allowing us to explain the phenomena of growthless credit booms and creditless recoveries. The final section concludes and discusses policy implications. A series of appendices provide further robustness checks.

## 2 Relation to the literature

Several stylised facts have emerged from the empirical literature analysing macro financial developments during credit booms and busts or around financial crises, in particular from the works of Reinhart and Rogoff (2009), Taylor and Schularick (2012), Jorda et al (2013, 2014), Claessens et al (2009, 2011), Mendoza and Terrones (2008), Drehmann et al (2012) and the literature on early warning indicators of financial crisis.[6] The story can be summarised as follows:

Credit booms, often measured by very high credit growth or large deviations of the credit to GDP ratio from its trend, tend to go hand in hand with surges in asset and particularly property prices.[7] At the late stage of the boom, debt service burdens start to rise substantially above long-run values. Once the boom ends, financial crises often occur, or at least several periods of severe macroeconomic stress. During the bust phase, asset prices and debt service burdens fall. And the associated recession is generally much deeper and more prolonged than recessions that are not preceded by a credit boom, independent of whether a financial crisis occurred or not. Once the economy has turned around, the recovery tends to be creditless, ie output picks up without a pickup in credit.[8]

We add one "stylised fact" to this literature by showing that output does not move much beyond its normal trend during a credit boom, in particular during the later stages, ie the credit booms tend to be growthless. It has already been shown that that GDP growth is not particularly strong or even slowing somewhat in the years ahead of crises (eg Reinhart and Rogoff (2008), Drehmann et al (2011)). But the literature has not move beyond this fact and related it to the prevailing macro finance literature which suggests a strong positive correlation between credit and output, contrary to this findings. Unspectacular output growth ahead of the recent crisis was also one factor that led Summers (2013) to speculate about the possibilities of secular stagnation. Yet, we show here that growthless credit booms are rather common phenomena and occurring frequently ahead of crises.

We also complement the literature by providing a unified empirical framework that

[6]This literature cannot be adequately summarised here. In addition to the importance of credit developments, the recent literature highlights the role of debt service payments as early warning indicators (eg Drehmann and Juselius (2013) or Alessi et al (2014)).

[7]It has also been shown that credit booms are not rate events and that they tend to be longer and more pronounced than standard business cycles.

[8]Creditless recoveries were first identified by Calvo et al (2006). More recent work includes Abidad et al (2011), Bijsterbosch and Dahlhaus (2011) or Upper and Takats (2013)).

helps to explain some of the key stylised facts. Our results show that when asset prices rise, net-worth goes up, which in turn increases credit growth. At the same time, the increase in debt service payments holds back expenditure, leading to a growthless credit boom and a rapid increase in credit-to-GDP ratios, typical ex-post measures of credit booms. Once the downward drag of debt service payments outweighs the beneficial impact of net-worth, the cycle turns. At this point, the recession is especially severe as net worth is depressed and debt service payments are very high. Once debt service payments return to steady-state levels, output starts to pick up and we observe a creditless recovery.

# 3 The puzzles: growthless credit booms and creditless recoveries

To document creditless recoveries and growthless booms, we first to identify credit booms and subsequent recovery periods. As credit booms often end up in financial crises (eg Jorda et al (2011) or Gourinchas and Obstfeld (2012)), our first approach is to define the years leading up to a crisis as a boom and the years following it as a recovery period.

An alternative approach, in line with Claessesn et al (2009), is to use a simple turning point methods to identify peaks in (the log of) real credit. We adopt the computerised algorithm by Harding and Pagan (2002), which builds on business cycle dating algorithms by Burns and Mitchell (1946) and Bry and Boschan (1971). The algorithm first searches for local maxima (minima) in real credit within five-quarter windows centered at each t. The identified points are then taken to define peaks (troughs) of the cycle if they fulfill two conditions: (i) each cycle has a minimum length of 5 quarters; and (ii) each phase (expansion or contraction) is at least two-quarters long. As it is hard to label a 2 quarter expansion a credit boom, we arbitrarily require that the expansion phase must last at a minimum three years.[9]

We establish the puzzles using quarterly data from 33 countries starting in 1985 or at the earliest date when credit and GDP data become available.[10] As a measure of

[9] In total, we identify 60 peaks in credit this way. If we exclude peaks where the expansion phase was less than 4 years, the number decreases to 28 but results remain robust.

[10] The countries are Australia, Belgium, Brazil, Canada, China, the Czech Republic, Denmark, Finland, France, Germany, Great Britain, Hong Kong SAR, Hungary, Indonesia, Ireland, Italy, Japan, Malaysia, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, Russia, South Africa,

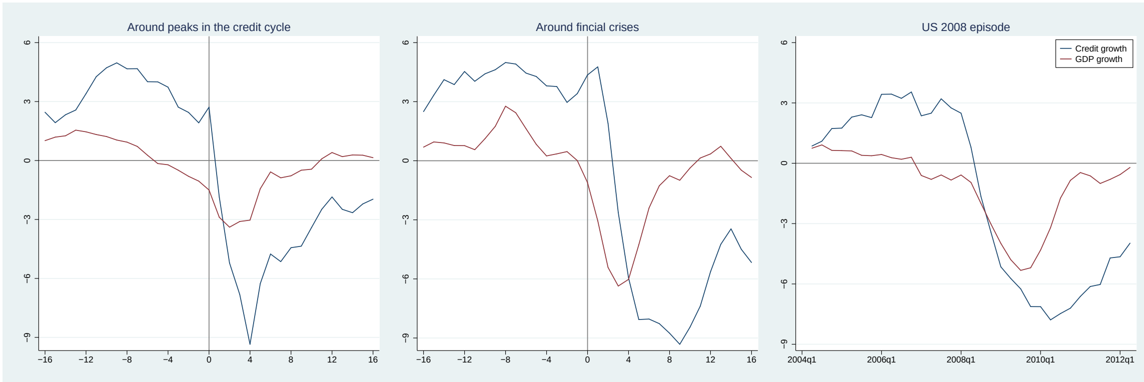


Figure 1: Growthless credit booms and credit less recoveries. Evolution of real quarterly credit growth and real quarterly GDP growth in the United States and +/-16 quarters around 60 peaks in the credit cycle or 35 financial crises (time 0 in the panels). For peak\crises panels, series are normalised by country specific long run averages first, before taking averages for each quarter.

credit, we use total credit to the private non-financial sector taken from the BIS website (Dembiermont et al (2013)). GDP is taken from national data sources and both series are deflated by the GDP deflator. With respect to the dating of systemic banking crises we follow Drehmann and Juselius (2013), who take the dates from Laeven and Valencia (2012), but ignore three crises that were primarily driven by cross-border exposures.

Growthless credit booms and creditless recoveries are clearly evident in Figure 1. The left-hand and middle panels show the average evolution of real quarterly credit and GDP growth 16 quarters around financial crises or peaks in the credit cycle (time 0 in the graph).[11] The right-hand panel simply focuses on the US since 2004. In the 16 quarters before peaks\crises, credit growth is several percentage points above the normal and only slows down a few quarters ahead of the event. At the same time, real GDP growth is only somewhat higher than its historical norm, particularly early in the boom, after which it starts to decline and falls below the average level in last year before the turning point\crises. After the event, both credit and GDP initially fall very rapidly. Yet, GDP growth recovers more quickly than credit growth.

These patterns can also be established more formally. To do so, we regress quarterly real GDP or real credit growth on 8 dummies, one for each year before and after crises/peaks.[12] The dummies take the value one during four quarters of a specific year

South Korea, Spain, Sweden, Switzerland, Thailand, Turkey and the United States.

[11] Results are qualitatively similar when using cross-country medians.

[12] Year 1 after the peak\crises starts with the quarter of the event. As robustness check, we also ran regressions including dummies for year 5 or even 6 before and after crises\peaks. Results do not change qualitatively and are available on request. They indicate that credit booms may start earlier.

| Credit and output growth around turning points in the credit cycle | | | | |
|---|---|---|---|---|
| | Around peaks in credit | | Around financial crises | |
| | Credit growth | GDP growth | Credit growth | GDP growth |
| Year 4 before | 1.8* | 1.0* | 3.2** | 0.6 |
| Year 3 before | 3.7*** | 0.7 | 3.2** | 2.0*** |
| Year 2 before | 3.7*** | -0.5 | 3.3** | 0.6 |
| Year 1 before | 1.2 | -1.6*** | 2.9** | -0.3 |
| Year 1 after | -7.0*** | -3.7*** | -5.3*** | -7.4*** |
| Year 2 after | -5.6*** | -1.3** | -8.8*** | -1.6** |
| Year 3 after | -3.0*** | -0.3 | -7.5*** | -0.1 |
| Year 4 after | -2.2** | -0.2 | -5.0*** | -0.7 |
| Constant | 5.9*** | 3.4*** | 6.0*** | 3.2*** |

Table 1: OLS regression of quarterly real credit or quarterly real GDP growth on 8 dummies, one for each year before or after crises/peaks. Dummy for year X takes the value 1 in the 4 quarters of year X and is zero otherwise. * $p<0.05$, ** $p<0.01$, *** $p<0.001$.

and zero otherwise. We also include a constant, which simply measures the average growth rates outside the eight year windows.

Table 1 reports the regression results. At the initial stage of a credit boom (year 4 before), credit is growing between 2-3 percentage points faster and output about 1 percentage point faster, than normal, based on the results around peaks in the credit cycle. In the following years, credit growth maintains the momentum or even accelerates. Output growth, in contrast, returns to its historical norm or even falls below it in the last year before the turning point. This shows that credit booms are on average growthless. After the turning point, credit growth remains depressed for four years, whereas output growth returns to normal already after two years - a creditless recovery. The timing of results using crisis dates is somewhat different as credit often peaks after a crisis and the number of events are different. But the results are qualitatively the same.

## 4 Empirical approach

Our main hypothesis is that growthless credit booms and creditless recoveries can be explained by developments in net worth and debt service payments which have opposing effects. In this section, we lay down an empirical approach for testing this conjecture.

For example in year 5 before peaks, credit growth is 1.7 percentage points higher than normal. But this is only significant at the 5% level.

We first establish empirical benchmarks for when aggregate net worth and debt service costs are above or below the norm. The idea is to estimate long-run steady-states for net worth and the debt service burden. We then link deviations from the two stead-states to future credit and expenditure growth. We do this by including them as error correction terms in a VAR.

For the analysis, we distinguish between the total non-financial private sector (TS), the household sector (HS) and the non-financial corporate sector (CS). Variables names are defined in Table (2) and data sources in Appendix A. We use small letters to denote the natural logarithm of a variable, for example $p_t = \ln(P_t)$, and the superscript $r$ to denote real variables, for example $y_t^r = y_t - p_t$ and $r_t^r = r_t - \Delta p_t$.

Throughout the paper, we use US quarterly time-series data covering the sample period 1985q1-2013q4.[13] We limit the analysis to the United States as this allows for a cleaner exposition and a detailed analysis of the household and corporate sectors separately. In addition, we can control for changes in LTV ratios, which are not available in a cross-country setting. It also enables us to do numerous robustness tests which are presented in Annex B and C. In a companion paper, we, however, confirm that similar results hold for xx countries (...).

## 4.1 Specifying the steady-state debt service burden

The economics behind the debt service burden, defined as the ratio of debt service payments to income, are simple. A standard budget constraint implies that debt service payments (ie interest and amortisations) have to be paid out of income, absent new borrowing, a sale of assets or default. Hence, given steady-state levels of income and expenditure, there should also be a steady-state level for the debt service burden.

Deviations from the steady state debt service burden may occur if for example there are shocks to income and interest rates, or if there is an expansion in credit. To the extent that loans are not rolled over indefinitely and steady-state income does not change, borrowers have to ultimately adjust their expenditure to correct such deviations. Alternatively, borrowers could also try to sell assets. This is a valid strategy for an

[13] We start the estimation in 1985 to avoid two potential structural breaks related to the beginning of the Great Moderation in 1984 (eg Kim and Nelson (1999) or McConnell and Perez-Quiros (2000)) and the liberalisation of financial markets in the early 1980s allowing for more flexible ways to finance consumption and investment (eg Jermann and Quadrini (2006)). As a robustness check, we used a sample starting in 1980, the earliest point when we have household debt service ratios available from the FED. Results are qualitatively the same and available on request.

| Variable names | |
|---|---|
| $D_t$ | Credit from all sources (PS: credit to total private non-financial sector; HS: credit to the household sector; CS: credit to the non-financial corporate sector) |
| $A_t$ | Value of assets |
| $Y_t$ | Income (PS: GDP; HS: disposable income; CS: gross operating surplus) |
| $E_t$ | Private expenditure (PS: HS+ CS; HS: private consumption; CS: gross fixed capital formation) |
| $LTV_t$ | Loan-to-value (LTV) ratio on new mortgage loans for first time home buyers |
| $P_{H,t}$ | Residential property price index |
| $P_{C,t}$ | Commercial property price index |
| $P_{E,t}$ | Equity price index |
| $P_t$ | GDP deflator |
| $r_t$ | Average sector specific lending rate of the stock of credit |
| $m$ | Average sector specific remaining maturity of the stock of credit |
| $r_{M,t}$ | Federal funds rate |
| $r_{BAA,t}$ | Yield on BAA bonds |
| $\pi_t$ | Spread $(r_{BAA,t} - r_{M,t})$ |

Table 2: Time varying variables are index by $t$. We use small letters to denote the natural logarithm of a variable, for example $p_t = \ln(P_t)$, and the superscript $r$ to denote real variables, for example $y_t^r = y_t - p_t$ and $r_t^r = r_t - \Delta p_t$. If given, information in brackets specifies the definition for the private non-financial sector (PS), the household sector (HS) and the non-financial corporate sector (CS).

individual borrow but may in the aggregate lead to a negative feedback loop between increased deleveraging needs and falling asset prices. A final option is to default, but micro-econometric evidence (eg Olney (1999)) strongly indicates that borrowers only do so once the other options are exhausted.

How far aggregate expenditure is affected by deviations from the steady-state debt service burdens is an empirical question. In a closed economy, lenders may theoretically compensate the shortfall in expenditure from borrowers, but only if interest rates decrease sufficiently, which may not be possible when there are frictions such as the zero lower bound (eg Eggerston and Krugman (2012), Farhi and Werning (2013), Korineck and Simsek (2014)). This is less clear in an open economy, when agents have borrowed from abroad.[14] In addition, low current expenditure to finance high debt service burdens may also be the outcome of an optimal borrowing decisions in earlier periods. For instance, if interest rates fell below the discount rate, it could have been optimal for consumers to trade off high expenditure financed with debt in earlier periods against low consumption when debt service payments are high later on.[15] The presence of collateral constraints will even amplify these dynamics (Kermani (2012)).

To measure debt service burdens we follow the FED methodology (Lucket (1980) and Dynan et al (2003)). The main assumption is that interest payments and amortizations on the aggregate debt stock are repaid in equal portions over the average remaining maturity of the loans, ie that debt is structured as an installment loan. The justification is that the differences between the repayment structures of individual loans will tend to cancel out in the aggregate.[16] Using the standard formula for calculating the debt service costs of an installment loan and dividing by income yields a proxy for the aggregate debt service burden; the debt service ratio (DSR) given by

$$DSR_t = \frac{r_t D_t}{(1-(1+r_t)^{-m})} \frac{1}{Y_t} \tag{1}$$

where $D_t$ is the total level of debt in the economy, $r_t$ the average lending rate, $Y_t$ income

[14]Foreign lenders often constitute an important source of funding during credit booms (eg Avdjiev et al (2012)).

[15]Interest rates falling below the discount rate may be the result of financial liberalisation (eg Mendoza et al (2009)) or if agents are heterogeneous with respect to the elasticity of inter-temporal substitution in consumption (Guvenen (2009)).

[16]For example, consider 10 loans of equal size for which the entire principal is due at maturity (bullet loans), each with 10 repayment periods and taken out in successive years over a decade. After 10 periods, when the first loan falls due, the flow of repayments on these 10 loans will jointly be indistinguishable from the repayment of a single installment loan.

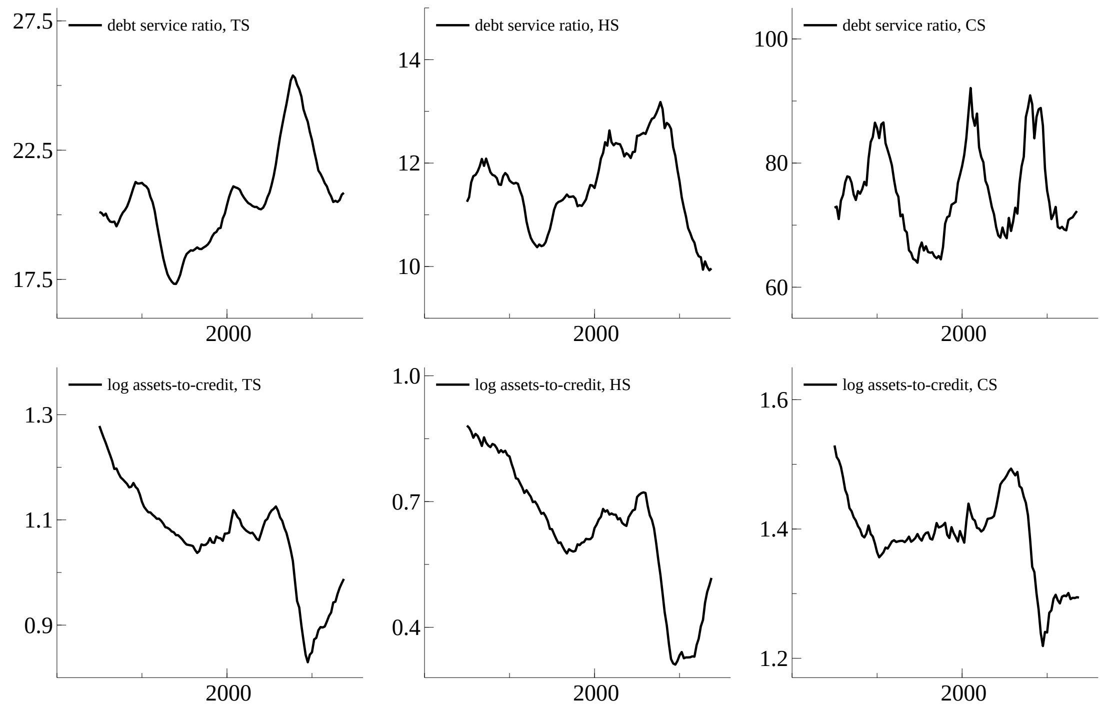


Figure 2: Debt service ratios and log asset-to-credit ratios for the total private non-financal (TS), the household (HS) and the non-financial corporate (CS) sectors.

and $m$ the average remaining maturity of the outstanding stock of debt.

We supplement estimates of the household sector DSR provided by the FED with estimates based on (1) for the total non-financial private sector and the non-financial corporate sector derived in Drehmann and Juselius (2012). The debt service ratios for the three sectors are shown in Figure 2 (upper row).[17]

Taking logs of (1) and writing it in terms of deviations, $\upsilon_{DSR,t}$, from a constant, $\psi_3$, we get

$$d_t - y_t + f(r_t) - \psi_3 = \upsilon_{DSR,t} \tag{2}$$

where $f(r_t) = \ln(\frac{r_t}{(1-(1+r_t)^{-s})})$. Note that (2) provides a steady-state relationship between the credit-to-GDP ratio and the average lending rate. And as discussed above, we conjecture that positive (negative) deviations from this steady state decrease (increase)

[17]The aggregate DSR is not a simple weighted average of the household and corporate sector DSRs. A main reason is that the measures used for income in the household and corporate sectors do not sum to GDP which is used as income for the total private sector. Also, the FED has access to more accurate proxies for the average lending rate and uses a finer division of various loan types for the household sector.

expenditure, which is a testable proposition.

In the main part of the paper, we assume that the steady-state can be approximated by the long run average of the DSR. Indeed, the DSRs in all three sectors fluctuate around this average as can be seen in Figure (2). We also show more formally in Appendix B that a linearised version of equation (2) produces stationary mean reverting errors, ie there is indeed cointegration between credit-to-GDP and the lending rate.

## 4.2 Specifying steady-state net worth

Financial frictions typically prevent borrowers from financing projects fully with debt. Hence, new borrowing by agent $i$ is limited by the pledgeablilty of collateral so that the asset value cannot exceed the specific multiple $\gamma$ of debt, or $A_i/D_i \leq \gamma$. In many macro models with financial frictions agents are homogenous, so that this constraint holds for the aggregate. Borrowers in these models will also generally be constrained in equilibrium and finance one period projects with one period debt so that aggregate debt will change with underlying asset values. Given atomistic behaviour, this in turn generates the potential for aggregate feedback effects between asset prices, credit and output.

However, the mapping between individual constraints and the aggregate is not as straight forward if borrowers finance long term projects with long term debt. But this is certainly the case as the average new loan has a 20 year maturity.[18] If we now assume for illustration purposes an economy with overlapping generations where borrowers take out a loan once (eg to buy a house) and then pay it back over the next 20 years in equal proportions, the aggregate asset to debt ratio in the economy will be roughly half of initial LTV ratio, everything else equal.

Similar considerations also suggest that there will be swings around the steady-state asset to debt ratio. In our simple example economy, swings in asset prices would only affect new borrowing. And thus, it would take 20 periods before debt to asset ratio is would reach long-run levels after asset prices permanently change. Clearly, in reality firms manage leverage continuously and households can engage in home equity withdrawals or delever by shedding assets. But unconstrained borrowers, whose asset values exceed debt levels, may still not adjust instantaneously. More generally, agent heterogeneity can lead to endogenous leverage cycles as shown by eg Fostel and

[18] Our best estimate of the average remaining maturity for the total private non-financial sector in the US is 10.5 years, indicating that the average new loan as a 20 year maturity.

Genakopolos (2013).

We therefore have to allow for the potential of positive and negative deviations from any empirical steady-state relationship between total debt and aggregate assets ($A_t$). Taking logs, the aggregate credit-to-asset ratio, which we also refer to as net worth, can be written as

$$a_t - d_t - \psi_1 = \upsilon_{NW,t} \tag{3}$$

where $\psi_1$ is the steady-state value of net worth and and $\upsilon_{NW,t}$ the deviation from it. If there is a steady-state, then $\upsilon_{NW,t}$ should be stationary, which we can test for. Moreover, for the steady-state in (3) to be meaningful, we should expect positive (negative) values of $\upsilon_{NW,t}$ to lead to future increases (decreases) in credit growth which is also a testable prediction.

Equation (3) can be estimated directly as $A_t$ and $D_t$ are available from the US financial accounts. We do so in Appendix B. But $\psi_1$ may have changed over time as credit growth has persistently exceeded asset growth so that there is a slight downward trend in $a_t - d_t$ (lower panels in Figure 2).[19] Possible reasons for this could be supply side factors, such as financial innovation or relaxed credit standards, that have allowed the private sector to hold more credit for a given amount of assets.

The decline the (log) net worth is primarily related to the household sector. Figure 2 shows that there is hardly any trend in (log) net worth of the corporate sector, until the recent crisis where it falls substantially. Not so for the household sector suggesting that loan-to-value ratios (LTV) have changed since the mid-80s. This is in line with the median LTV on new loans for first time home buyers as estimated by Muellbauer et al. (2013).[20] This variable increases steadily from approximately 90% in the mid 80's to 97% in the mid 2000's and then starts to decline again in the wake of the crises (upper left hand panel Figure 3).

Assuming that the growth rate in $LTV_t$ for first time home buyers is proportional (with proportion $\psi_2$) to the change in aggregate loan-to-value ratios, we modify (3) to

$$a_t - d_t - \psi_1 + \psi_2 ltv_t = \upsilon_{NW,t} \tag{4}$$

where $ltv_t = \ln(LTV_t)$ and $\upsilon_{NW,t}$ is expected to be stationary. Again, equation 4 can be estimated directly, which we do in Appendix B.

However, assets $A_t$ recorded in the financial accounts are a mix of book and market-

[19] Formally, the null hypothesis that $\upsilon_{NW,t}$ from (3) is stationary is rejected due to the trend.

[20] We are grateful to Muellbauer et al. for sharing this series with us.

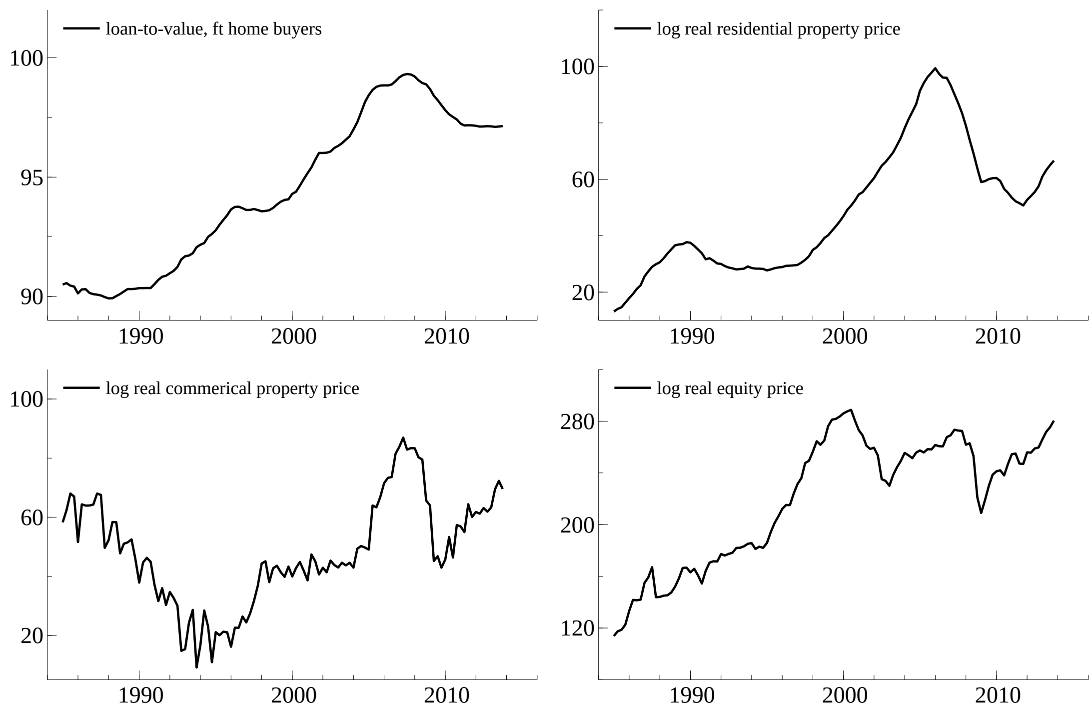


Figure 3: Loand-to-value ratio and real asset prices.

to-market values (eg Emmons (2006)) and may therefore not fully reflect the value of pledgeable assets. We therefore consider an alternative proxy for $A_t$ which relies on asset prices explicitly. This is based on the idea is that the real stock of assets is built up over time from real output. Suppose that a fraction $\mu$ of real output, $Y^r = Y_t/P_t$, is invested into durable assets and $\delta$ is the depreciation rate. Then real assets, $A_t^r = A_t/P_{A,t}$, follow $A_t^r = (1-\delta)A_{t-1}^r + \mu Y_t^r$, which in steady-state implies $A_t^r = \lambda Y_t^r$ with $\lambda = \mu/\delta$. Rearranging steady-state real assets yields

$$A_t = P_{A,t}\left(\lambda \frac{Y_t}{P_t}\right) \tag{5}$$

To derive an expression for the real asset price index we assume that it is a Cobb-Douglas index of $n$ different asset classes, ie $P_{A,t} = \Pi_{i=1}^{n} P_{A_i,t}^{\psi_{A_i}}$ with $\sum_{i=1}^{n} \psi_{A_i} = 1$ and $P_{A_i,t}$ is the price of an asset of class $i$. In the empirical section below, we distinguish between three asset classes as shown in Figure 3: residential real estate, commercial real estate, and equity.

Using the expression for the price index in (5), taking logs, and substituting for assets in (3) yields

$$y_t - d_t - \psi_1 + \psi_2 ltv_t + \sum_{i=1}^{n} \psi_{A_i}(p_{A_i,t} - p_t) = \upsilon_{NW,t} \tag{6}$$

where, out of convenience, we take $\psi_1$ to also include $\ln(\lambda)$.

One advantage of (6) is that it allows us to establish the connection between various asset prices and credit, as well as to clarify the link between (log) credit-to-GDP - an often used empirical measure of leverage - and (log) net worth. Moreover, by including real asset prices we are likely get a more accurate measure of their pledgeability and how this affects credit.

In the results section below, we therefore focus on (6) to obtain an estimate of $\upsilon_{NW,t}$. It turns out that this specification also yields the highest explanatory power over real credit growth in all three sectors. But as discussed earlier we estimate the results base on equations (3) and (4) as well and results are both quantitatively and qualitatively similar for specifications in the total private and the household sectors. The biggest differences arise in the corporate sector. We report and discuss this issue in detail in Appendix B.

### 4.3 Estimating the net-worth steady-states

It is possible to estimate the above net worth relationships for each sector and simultaneously test their empirical validity using cointegration analysis. To this end, we use a vector auto-regressive (VAR) model written in error correction form

$$\Delta x_t = \gamma_0 + \Pi x_{t-1} + \sum_{i=1}^{l-1} \Pi_i \Delta x_{t-i} + \Gamma s_t + \boldsymbol{\varepsilon}_t \tag{7}$$

where $x_t$ is a $q$ dimensional vector of endogenous variables, $s_t$ is a vector of other deterministic terms than the constant (such as seasonal and impulse dummies), and $\varepsilon_t \sim N_q(0, \Sigma)$ is the error term.

In Appendix B we show for the total private non-financial sector that approximately the same results are obtained if the relationships are estimated by OLS directly. This, however, is imprecise as the empirical model is seriously misspecified and involves several untested assumptions. The advantage of adopting a more VAR approach is greater precision and valid inference. Moreover, (7 ) allows us to treat all variables as endogenous at the outset and test several of the underlying assumptions, which is informative on its own.

The parameter matrix $\Pi$ in (7) captures the cointegration properties of the data. If this matrix is of full rank, ie $rank(\Pi) := v$ and $v = q$, then $x_t$ is stationary and all linear relationships are trivially cointegrating. To build intuition for this, note that if $x_t$ is a scalar variable, (7) becomes identical to the specification of the Augmented Dickey-Fuller (ADF) test. In this case, the unit root is rejected if $\Pi \neq 0$. The corresponding condition when $x_t$ is a vector, which ensures that none of its scalar variables have unit-roots, is that $\Pi$ has full rank. Conversely, if $v = 0$, the $x_t$ process is not cointegrated and all of its scalar variables have unit-roots. Again this can be compared to the null hypothesis of the ADF-test. Most interestingly, if $0 < v < q$, there are $v$ cointegration relationships and $q - v$ common stochastic trends. In this case $\Pi$ can be represented as the product of two $(q \times v)$ matrices of full column rank, $\alpha$ and $\beta$. That is $\Pi = \alpha\beta'$, where $\beta' x_{t-1}$ describes the cointegration relationships and $\alpha$ describes how they feed into the left-hand side growth rates.

We use the likelihood ratio (LR) test (Johansen (1995)) to test the null hypothesis that the rank of $\Pi$ is equal to a specific integer. Determining the correct rank of $\Pi$ seemingly requires applying this test to all values of $v$ between 0 and $q$. However, a testing sequence that ensures correct overall power and size starts from the null hypothesis of rank zero, successively increases the rank by one, and then stops when the first non-rejection occurs.

Cointegration relationships have a property that simplifies the analysis considerably: they are super consistent and invariant to extensions of the information set (Phillips (1991)). This means that, for the sole purpose of establishing the validity of a long-run relationship, we can work with the smallest possible set of variables. For example, the minimal system required to test that (4) is valid is $x_t = (y_t - d_t,\, ltv_t,\, p^r_{H,t},\, p^r_{C,t},\, p^r_{E,t})'$ in which case we expect one cointegration relationship ($v = 1 < q = 2$) between the credit to GDP ratio, the LTV ratio and asset prices.

This is an important and convenient property that we rely on several times. First, within larger VAR systems, there can be a number of different cointegration relationships, some of which may be less relevant for describing the interaction between financial and real variables and inference may be less precise. Focusing on minimal information sets sidesteps this added complexity. Second, we can of course appeal to the same property and study how the estimated steady-state deviations affect various growth rates outside the minimal system. As such, we can also include the deviations from additional potentially relevant cointegration relationships in the analysis.

## 4.4 Modeling growth rates

Given the long-run steady-states, it is straight forward to study how their deviations feed into various growth rates. This is, for example, directly done for the variables that enter (7). However, it might also be of considerable interest to know how the steady-state deviations feed into variables outside the original system, such as real GDP and consumption growth. To analyze such effects we take the estimated steady-state deviations as given and appeal to the property that cointegration vectors are invariant to extensions of the information set. This allows us to study an expanded system given by

$$\Delta z_t = \gamma_0 + \alpha_1(\upsilon_{NW},\, \upsilon_{DSR})'_{t-1} + \sum_{i=1}^{l-1} \Pi_i \Delta z_{t-i} + \Gamma_2 s_t + \boldsymbol{\varepsilon}_t \tag{8}$$

where $x_t$ is included in a larger vector of other endogenous variables, $z_t$. We can even go one step further an add the deviations from other cointegration relationships to (8) to control for omitted level effects. For instance, in the empirical application below, we add $\alpha_2(r^r_M)'_{t-1}$ to the left hand side of (8) to make sure that our estimated net worth and debt service deviations provide information beyond that contained in the real interest rate.

It is often of interest to test that one variable of the system, $z_{i,t}$ say, precedes another, $z_{j,t}$ say, in the long-run. This is equivalent to the restriction that the row in the matrix $\alpha_1$ which corresponds to $z_{i,t}$ is zero, i.e. that $z_{i,t}$ does not error correct to deviations from the steady state. If the null hypothesis cannot be rejected, $z_{i,t}$ is said to be weakly exogenous with respect to the long-run parameters of the model.

# 5 Results

This section reports the estimation results. We only discuss the results for steady-state net worth here, since the steady-states for the DSRs can be reasonably well approximated by their sample average. We then present our results on how deviations from net worth and debt service burdens impact on credit and output growth.

## 5.1 Steady-state net worth

We estimate steady-state net worth given by specification (6). Making use of the property that cointegration relationships are super consistent and invariant to extensions of the information set (Phillips (1991)), we only include the minimal number of variables necessary to estimate this specification, ie we set $x_t = (y_t - d_t,\, ltv_t,\, p^r_{H,t},\, p^r_{C,t},\, p^r_{E,t})'$ in (7) for each sector separately.

We include an unrestricted constant and seasonal dummies in all three VAR models, and select the lag length based on standard information criteria (we find $l = 2$ in most cases). We also use impulse dummies to block out large outliers, with particular attention to so-called additive outliers as these can bias tests for cointegration (Bohn-Nielsen (2004)). These dummies do not, however, have a large impact on the results. The definitions of all the dummies are listed in Appendix B.

To further reduce the dimensionality and complexity of the estimated systems, we undertake preliminary testing and only report results after excluding insignificant variables from the cointegration space. For the total private sector, a test for the null hypothesis that equity prices can be excluded from the cointegration space was not rejected (p-value 0.63). For the household sector, commercial property prices (p-values 0.11) and equity prices can be excluded (p-values 0.28). For the corporate sector, residential property prices (p-values 0.69) and LTV ratios can be excluded (p-values

0.07). The results are, however, both quantitatively and qualitatively very similar if no variable is dropped but the estimates are less precise.[21]

We find clear evidence of one cointegrating steady-state relationship in each of the three sectors. This can be seen from the upper part of Table 3 which reports the results of Johansen's LR test for the rank of $\Pi$. In all three models, the null hypothesis of no cointegration between the variables (ie $v = 0$) is rejected at the 5% significance level, whereas the null hypothesis that there is one cointegration relationship cannot be rejected.[22] This is a benefit from using a minimalistic system, and hugely convenient as it implies that we do not have to search for the relationship (6) within a cointegration space - a process that is both difficult and may be subject to judgment.

The estimated cointegration coefficients correspond intuitively to a net worth steady-state (middle part of Table 3). For the total private sector, for example, the coefficient on $ltv_t$ has the expected positive sign, suggesting that relaxed credit conditions, as approximated by the increase of LTV ratios from 90% in the 80's to 97% in the mid 2000s, pushed up credit-to-GDP ratios by around 20%. The coefficients on asset prices are strictly between zero and one. They also imply that a 10% increase in residential and commercial property prices leads to an increases of around 2% in credit-to-GDP ratios in the long-run. These may sound like small effects, yet they account for a large part of the increase in credit to GDP ratios. For example, real residential property prices nearly doubled from 1985 to the peak before the recent crisis. At the same time credit-to-GDP rose by approximately 50%.

The results for the household and corporate sectors are qualitatively similar. As noted above, commercial property prices and equity prices where excluded from the household sector models whereas residential property prices and LTV ratios were excluded from the corporate sector models. The LR tests for the rank of $\Pi$ of the models suggests that the appropriate choice of cointegration rank is one ($v = 1$) in both cases. This implies that is one steady-state relationship in each sector. Again, the estimated cointegration coefficients are in line with those expected from (6). Note, that the coefficients on the relevant real asset prices for each sector almost double in magnitude relative to the total private non-financial sector.

The estimated steady-states capture the broad trend in credit-to-GDP well and

[21] Results are available on request.

[22] Given the appropriate testing sequence described in Section 4.3, the remaining tests for $v > 1$ are redundant and reported for completeness.

Cointegration results for Equ. (6)

Rank test statistic

| | $v=0$ | $v=1$ | $v=2$ | $v=3$ | $v=4$ |
|---|---|---|---|---|---|
| TS | 0.01$^{\star}$ | 0.16 | 0.41 | 0.13 | –$^{1)}$ |
| HS | 0.00$^{\star\star}$ | 0.13 | 0.31 | –$^{2)}$ | –$^{2)}$ |
| CS | 0.00$^{\star\star}$ | 0.16 | 0.14 | –$^{3)}$ | –$^{3)}$ |

Estimated cointegration vectors ($v=1$)

| | $y_t - d_t$ | $ltv_t$ | $p^r_{H,t}$ | $p^r_{C,t}$ | $p^r_{E,t}$ |
|---|---|---|---|---|---|
| TS | 1 | 2.44 (7.88) | 0.19 (3.57) | 0.23 (5.64) | –$^{1)}$ |
| HS | 1 | 2.83 (10.09) | 0.35 (8.39) | –$^{2)}$ | –$^{2)}$ |
| CS | 1 | –$^{3)}$ | –$^{3)}$ | 0.40 (4.74) | 0.09 (3.10) |

Test for weak exogeneity

| | $y_t - d_t$ | $ltv_t$ | $p^r_{H,t}$ | $p^r_{C,t}$ | $p^r_{E,t}$ |
|---|---|---|---|---|---|
| TS | 0.00$^{\star\star}$ | 0.25 | 0.17 | 0.36 | –$^{1)}$ |
| HS | 0.00$^{\star\star}$ | 0.65 | 0.64 | –$^{2)}$ | –$^{2)}$ |
| CS | 0.00$^{\star\star}$ | –$^{3)}$ | –$^{3)}$ | 0.00$^{\star\star}$ | 0.35 |

Table 3: $^{\star}$Denotes rejection at the 5% significance level. $^{\star\star}$Denotes rejection at the 1% significance level. Rank test: $p$-values of the null hypothesis that the rank equals $v$. Estimated cointegration relationships ($\beta' x_t$): $t$-values in parenthesis. Tests for weak exogeneity: $p$-values of the null hypothesis that the variable is weakly exogenous. TS: total private non-financial sector, HS: household sector, CS: non-financial corporate sector. $^{1)}$ A test for the null hypothesis that $p^r_{E,t}$ can be excluded from the cointegration space was not rejected with p-value 0.63.$^{2)}$ Tests for the null hypothesis that $p^r_{C,t}$ and $p^r_{E,t}$ can be excluded from the cointegration space were not rejected with p-values 0.11 and 0.28.$^{3)}$ Tests for the null hypothesis that $ltv_t$ and $p^r_{H,t}$ can be excluded from the cointegration space were not rejected with p-values 0.07 and 0.69.

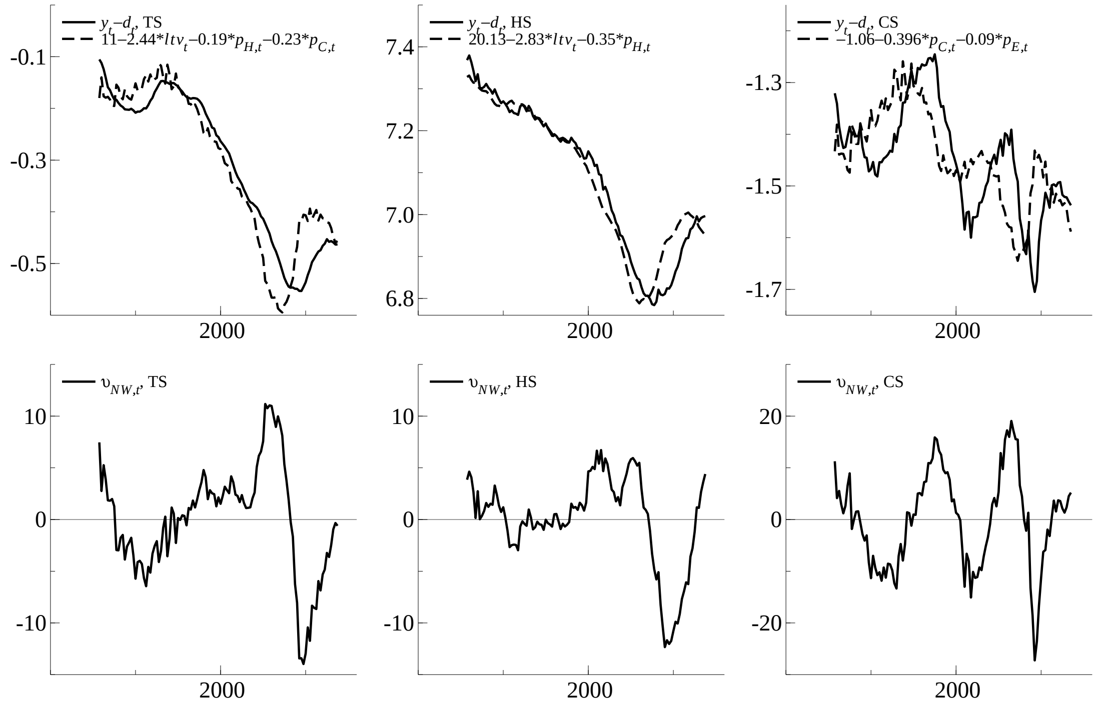


Figure 4: Credit-to-GDP ratios (log), etimated net-worth steady-states and deviation $\upsilon_{NW}$ for the total non-financial private (TS), the household (HS) and the non-financial corporate (CS) sectors.

their deviations are clearly mean reverting (lower panels).[23] This can be seen from Figure 4 showing in the upper panels the inverse of the aggregate credit-to-income ratio (solid lines) and the estimated steady-states (dotted lines) in the different sectors. But adjustment back to steady-state is slow, resulting in long "cycles", in particular in the household sector.

### 5.1.1 Tests for weak exogeneity

An interesting auxiliary finding of our analysis is that the LTV ratio and the real asset prices are generally the long-run drivers in the systems. This can be seen from the lower part of Table 3 which reports the results from testing each variable in turn for weak exogeneity with respect to the other variables in the system, i.e. that they drive steady-state deviations but do not adjust to them. This hypothesis is rejected (or borderline

[23]Given the higher volatility of asset prices and interest rates, the estimated steady-state are more volatile than credit-to-GDP ratios, helping to explain the bulk of high-frequency movements in deviations from steady state.

rejected) at the 5% significance level for the credit-to-GDP ratio in all three sectors. Hence, this variable endogenously adjust to deviations from steady-state within the system.

Weak exogeneity cannot, however, generally be rejected for the LTV-ratio and the real asset prices. This implies that these variables generate long swings in the data which determine credit-to-GDP over the long run.[24] Interestingly, real commercial property prices are weakly exogenous in the total private sector model, from which real equity prices could be excluded, but not weakly exogenous in the corporate sector model where real equity prices are found to be weakly exogenous. Hence, there seems to be a pecking order: low frequency swings in equity prices are transmitted to commercial property prices and then to credit-to-GDP.

### 5.2 Steady-state deviations and growth

We are now in a position to test how deviations from net worth and debt service steady-states affect credit and expenditure growth. For ease of exposition, we focus the discussion around the estimated coefficients for net worth deviations ($\upsilon_{NW,t-1}$) and debt service deviations ($\upsilon_{DSR,t-1}$) and refer to Appendix C for complete descriptions of the estimated systems.

To study the growth effects of the steady-state deviations, we use the vector error correction model in (8). Again, we use the fact that cointegration vectors are super consistent. A natural specification for the vector of endogenous variables, $z_t$, is to include real credit, $d_t^r$, real output, $y_t^r$, real asset prices, $p_{A,t}^r$, the loan-to-value ratio, $ltv_t$, and the real lending rate, $r_t^r$. This specifications collects the minimum amount variables without discarding relevant information as all these variables enter the steady-states (6) and (2) because $d_t - y_t$ is a transform of $d_t^r = d_t - p_t$ and $y_t^r = y_t - p_t$. Based on a preliminary analysis, however, we find that having $ltv_t$ and $r_t^r$ in $z_t$ only has a marginal effect on the remaining equations in the system. Hence, to increase the precision of the estimates, we drop these two variables from $z_t$. Thus, they only affect the system through their influence over the steady-states. We add real private sector expenditure, $e_t^r$. In the end, we use a parsimonious specification with $z_t = (d_t^r, e_t^r, y_t^r, p_{A,t}^r)'$. Finally, we add the real federal funds rate, $r_{M,t-1}^r$, as an additional "cointegration" term to the

[24] This results dos not imply that asset prices are weakly exogenous with respect other variables outside the system, such as policy rates and technology shocks. Furthermore, over shorter horizons there can be, and are, two-way feedbacks between the credit and asset prices.

| Growth effects of the steady-state deviations | | | | | | |
|---|---|---|---|---|---|---|
| | Total private | | Households | | Corporates | |
| | $\Delta d_t^r$ | $\Delta e_t^r$ | $\Delta d_t^r$ | $\Delta e_t^r$ (con.) | $\Delta d_t^r$ | $\Delta e_t^r$ (inv.) |
| $\upsilon_{NW,t-1}$ | **0.092** (6.58) | −0.014 (−0.73) | **0.113** (5.42) | −0.024 (−1.36) | **0.078** (6.61) | −0.005 (−0.22) |
| $\upsilon_{DSR,t-1}$ | −0.010 (−1.68) | **−0.026** (3.42) | **0.021** (2.46) | **−0.022** (−3.05) | −0.004 (−0.22) | **−0.066** (−3.94) |

Table 4: Estimated loadings to the net worth ($\upsilon_{NW}$) and debt service ($\nu_{DSR}$) deviations in the equations for real credit ($\Delta d^r$) and expenditure ($\Delta e^r$) growth. Expenditure consists of consumption (con.) and investments (inv.). Boldface values indicate significance at the 5% level.

right hand side of (8) to control for the costs of refinancing.[25] As before, we also block out large outliers by adding impulse dummies in $d_t$ (listed in Appendix C).[26]

We find that net worth deviations are a key driver of future real credit growth. Table 4 highlights that $\upsilon_{NW,t-1}$) has a significant and positive effect on reduced-form[27] credit growth in all three sectors. That is, above trend net worth in this period leads to higher real credit growth in the next. And the effect is economically large. For example, a 10% net worth deviation for the total private sector leads to a 0.92 percentage point increase in per quarter real credit growth. Thus, in 2005 and 2006, deviations in net worth pushed up annual real credit growth by 4 percentage points.

Table 4 also clearly shows that debt service deviations ($\upsilon_{DSR,t-1}$) hamper growth in real private expenditure. In all sectors, deviations from the steady-state debt service ratio have a significant and negative effect on future expenditure growth. The effects are again economically large: A 10% debt service deviation this quarter reduces total real private expenditure by 0.26 percentage points, real consumption by 0.22 percentage points, and real investments by 0.66 percentage points in the next quarter. To get a proper sense of the magnitude of these effects, debt service costs before the recent crisis were approximately 21% above steady-state in the total private sector.

Endogenous feedback effects between credit, expenditure, and income growth are also important drivers of the system (see full model results in Appendix C). In line with the predictions of standard macro-finance models, for instance, high net worth feeds into

[25]The main results stay intact for alternative specifications where, for example, $ltv_t$ and $r_t$ are retained in $z_t$ or $r^r_{M,t-1}$ is excluded from the system. The results from these alternative specifications are available upon request.

[26]This was done by the automatic procedure Autometrix in PcGive, described in Hendry (). Some of the dummy variables reduce seemingly strong correlation caused by joint large outliers in the variables, but otherwise do not have a large effect on the system.

[27]That is, once all endogeneous feedback effects are taken into account.

credit growth, which in turn increases consumption growth and thus GDP. Surprisingly, though, our results show that net worth deviations do not have any significant direct effect on expenditure growth and debt service deviations do have any significant direct effect on credit growth directly. This can be seen from the off-diagonal coefficient estimates in Table 4 which are generally insignificant.[28]

## 5.3 Robustness over time

How much of our results are driven by observations around the recent financial crisis? The answer turns out to be not much, even though a few properties of the system have changed to some extent in recent years. This can be seen by looking at estimates that recursively expand the sample from 1985q1-1999q4 until all data are included (Figure 5).

For credit growth, the short run loadings related to both steady-state deviations are generally stable over time. The impact of net worth deviations is constant, positive and significant in all sectors, even though it somehow drops for the household sector in the wake of the dot-com bubble in the early 2000s (lower row). The same applies to the loadings of the debt service deviations, which are generally both stable but insignificant over time (upper row). The only exception is in the household sector, where these deviations receive a positive and significant coefficient at the end of the sample, suggesting that low on debt service burden during this crisis may have directly supported higher credit growth.

For expenditure growth, the loadings to the DSR steady-state deviations are similarly stable over time, but the coefficients the net worth deviations display more variation over time, indicating the potential for non-linear effects or structural breaks (Figure 6). The loadings to debt service deviations in expenditure growth become significantly negative by the sample midpoint in the 2000s in all three sectors as the confidence bands are initially too wide. This could be a result of slow error correction so that a lot of time observations are needed to detect it statistically. It may also hint at some non-lienearities, in the sense that very high debt service burdens may be more detrimental to expenditure growth than very low ones are beneficial.

Similarly, the loadings to deviations in net worth show some fluctuations, in particular for the corporate sector. In the household sector, the loadings are consistently

[28]The only exception is in the household sector, where debt service deviations have a positive and significant sign in the credit equation. This result, however, appears to be driven by the most recent crisis: the effect is insignificant in any sample that ends prior to 2013 (see Section 5.3).

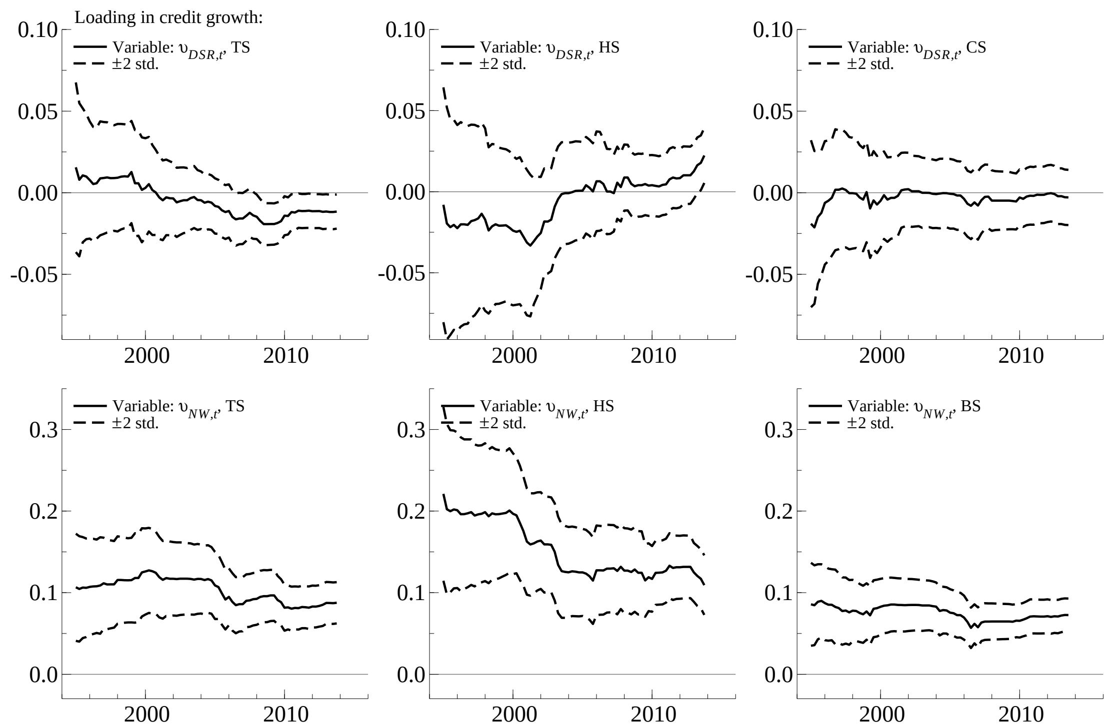


Figure 5: Recursive estimates of the loadings to the net worth and debt service deviations from the real credit growth equation. The training sample is 1985q1-1994q4. TS: total non-financial private sector, HS: household sector, CS: non-financial corporate sector.

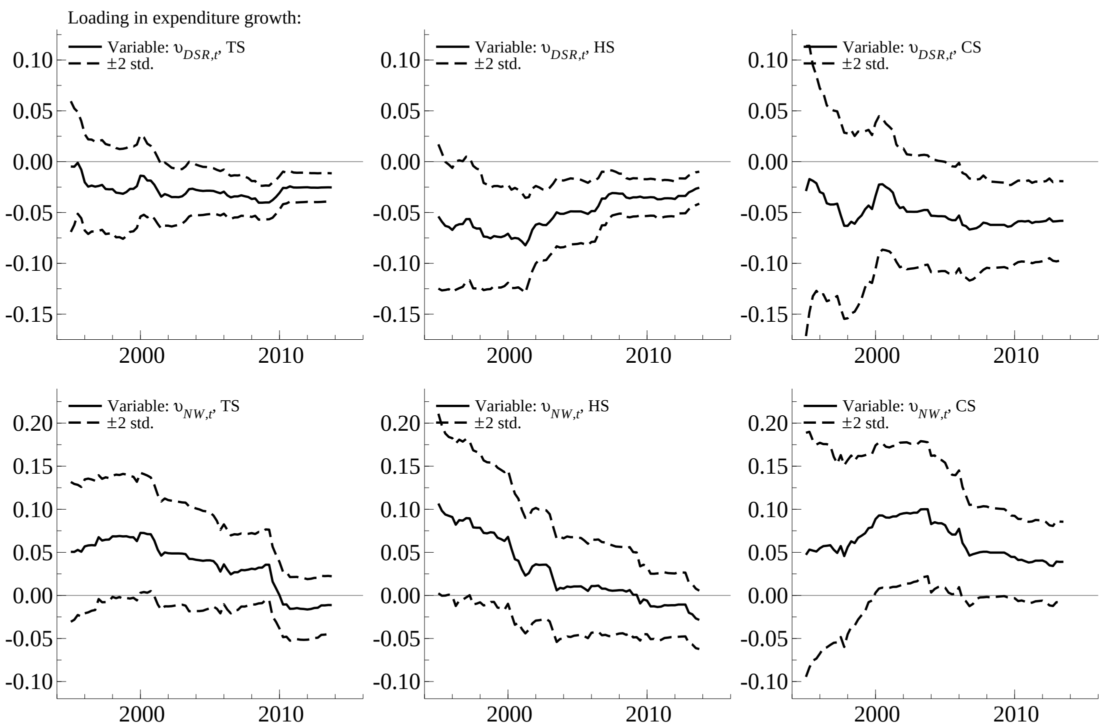


Figure 6: Recursive estimates of the loadings to the net worth and debt service deviations from the real expenditure growth equation. The training sample is 1985q1-1994q4. TS: total non-financial private sector, HS: household sector, CS: non-financial corporate sector.

insignificant and the effect of credit on consumption is more indirect. In contrast, from 2000 until the financial crisis, deviations from steady-state net worth in the corporate sector had a positive and significant direct impact on corporate investment. Economically it may well be the case that there is a positive, direct effect. But the crisis could to be a structural break as there are indications that firms' behaviour changed substantially in its wake. For example, companies have been holding back investment and hoarded cash in the post-crisis period, given increased uncertainty and a very weak macro outlook.[29] Assessing this more fundamentally is, however, beyond this article. But independent of the sample, though, net worth affects investment in the system, either directly or indirectly through its impact on credit growth.

# 6 Net-worth, debt service payments and the evolution of credit and expenditure growth

In this section, we use our results to take a closer look at the impact of net worth and debt service deviations on the evolution of credit and expenditure growth in the United States since 1985. This also allows us to explain the phenomena of growthless credit booms and creditless recoveries.

To illustrate the impact of both constraints on the economy, we isolate the effects of the steady-state deviations from the estimated system. For this, we set the VAR residuals to zero and take initial conditions, the evolution of debt service and net-worth deviations as given. We then feed the steady-state deviations one-by-one, as well as both together, through our estimated models (full sample results) and calculate the implied evolution of credit and expenditure growth in the US since 1985. The results are shown in Figure 7, which also includes the net worth and debt service deviations in the upper row.

A clear pattern of three cycles emerges for the corporate sector. And viewed through the lens of net worth and debt service burdens, a typical cycle could be characterised as follows: during the boom phase, debt service burdens are below steady-state levels whereas net worth is above, together boosting credit and expenditure growth. As credit expands more rapidly than income, debt service burdens increase above steady-state levels over time, putting a drag on the economy until it enters a recession. At

[29] See for example "Investor calls grow for corporates to splash their cash", Financial Times, 22 January 2014.

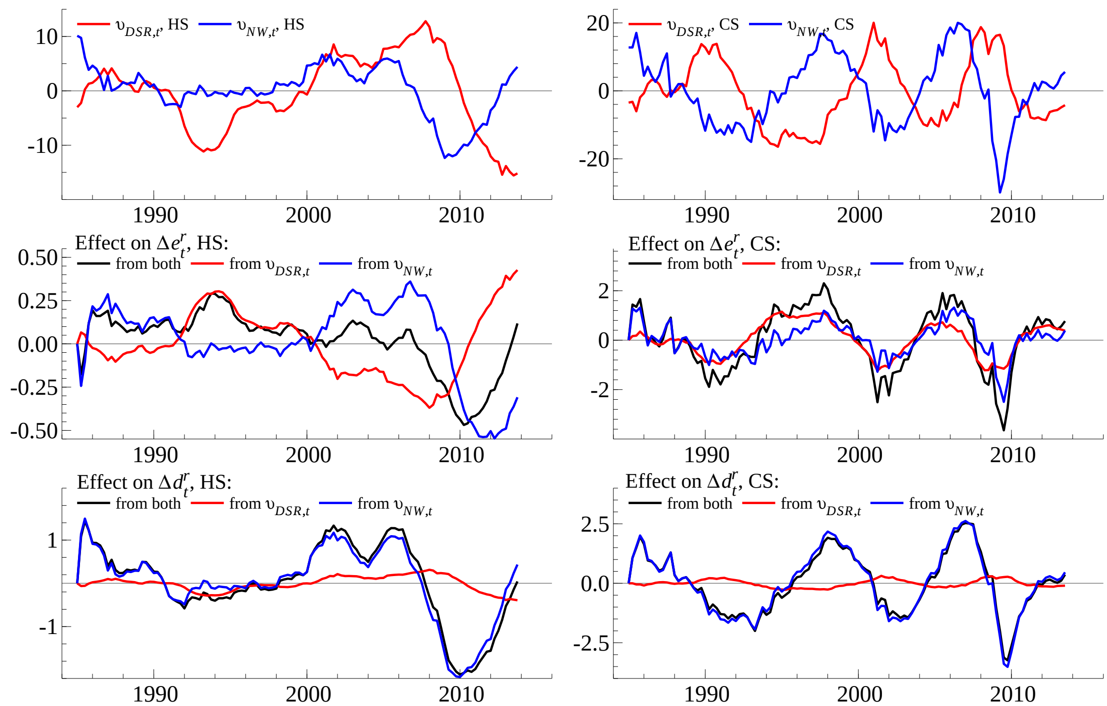


Figure 7: The joint and individual effects of net worth ($\nu_{NW}$) and debt service ($\nu_{DSR}$) deviations on real expenditure growth ($\Delta e^r$) and real credit growth ($\triangle d^r$) for the household sector (HS) and non-financial corporate sector (CS). Effects are calculated by setting the VAR residuals to zero and taking initial conditions, the evolution of debt service and net-worth deviationse as given to then feed the deviations one-by-one, as well as both together, through the estimated models (full sample results).

this point, low net worth forces companies to delever. As debt service burdens are still high, both effects depresses investment substantially. But the economy starts to recover as deleveraging and a lowering of interest rates decreases debt service burdens below steady-state levels whilst also helping to bring back net worth above longer levels.

Household sector developments are markedly different. First, there are certainly not three but more like two cycles in net worth and debt service burdens for the household sector since 1985. Net worth deviations were high in the mid-1980s and then again from 2000 onwards until the crisis. Both times, this significantly affected credit growth, increasing debt service burdens above steady-state levels.

Second, and more important, net worth and debt service burdens can push consumption growth in opposite directions, sometimes for several years. These effects are particularly strong from 2000 onwards until the outbreak of the crisis. During this period, rapidly rising property prices boosted net worth above long-run levels, which in turn increased credit growth but also indirectly supported consumption. Yet, high credit growth increased high debt service burdens even further putting an ever growing drag on consumption growth. In 2005 and 2006, both effects nearly offset each other as rising asset prices increased consumption growth by 1 percentage point, whereas debt service burdens reduced it by 0.9 percentage points. During the "Great Recession" from late 2007 to mid 2009, both effects worked in the same direction, depressing annual consumption growth by on average 1.5 percentage points.

Severely depressed net worth can also explain why consumption growth has remained so low for so long, something which has puzzled policymakers and economist for some time. Even after the recession, low net worth forced households to delever, which in turn reduced consumption growth by around on average 1.8 percentage points from mid 2009 until the end of 2013. Shedding of debt and ultra-loose monetary policy had pushed debt service burdens below steady-state levels in mid-2010. Yet, the positive consumption effects only started to outweigh low net worth by the end of last year, at which point rising asset prices also started to relieve net worth constraints. But as net-worth deviations remain negative, credit growth continues to be depressed.

Growthless credit booms and creditless recoveries are a straightforward outcome from these results. Before the crisis, net worth supported high credit growth but high debt service burdens exerted an the opposite effect on expenditure, leading to a growth less credit boom. And after the recession had bottomed out, a creditless recoveries occurred as low debt service burdens boosted consumption growth whilst net worth remained very low, holding back credit growth.

# 7 Conclusion and policy implications

In this paper, we conduct an empirical investigation into macro-financial linkages. We show that high net worth increase credit growth which then feed into higher expenditure and output growth. In addition, there is an important channel that has been mainly overlooked: the effects of debt service payments on expenditure.

Technically, we estimate two intuitive long-run cointegrating relationships using data for the United States from 1985-2013. First, the net worth conditions relate to a steady-state relationship between the credit-to-GDP ratio and asset prices. Second, debt service conditions are associated with a steady-state relationship between the credit-to-GDP ratio and interest rates. We then study the effects that deviations from these steady-states have on both real credit and expenditure, controlling for several factors such as wealth, the term spread and the interest rate level. Using an error correction framework, we find that deviations from long-run net worth directly feed into future credit growth, whereas similar deviations from long-run debt service costs feed into future growth of consumption and investment.

At the minimum, our findings suggest that that policymakers, and macroeconomists more generally, should take debt service burdens into account. These burdens have first order negative effects on expenditure and output. And the results are robust to different empirical specifications, different estimation windows and a different set of countries (see companion paper).

But once this is acknowledged, it raises some fundamental questions. Most importantly, our results suggest that an economy can be on an unsustainable path even though output appears to be normal. During a growthless credit boom, two countervailing forces are at work: there is the growth enhancing effect of new credit and a growth reducing effect of debt service burdens. These effects push demand in opposite directions. The net effect on output is roughly zero. Yet, over time, loosened net worth conditions increase the stock of credit thus raising debt service burdens even further. At some point, the negative effects begins to dominate, asset prices collapse, and a severe recession follows.

We also show that the evolution of net worth and debt service burdens in the household and corporate sector do not necessarily move in lock-step. For example, in contrast to the corporate sector, the household sector was not much affected by the dot-com boom and bust. But given the slow moving buildup of net worth and debt service burdens, this can raise challenges for policymakers. For instance policy makers lowered interest rates to alleviate the recession in 2000 in the wake of the dot-com bust. But lower interest rates increased house prices and credit growth in the household sector, leading to unprecedentedly high debt service burdens ahead of the current crises, with a well-known consequences.

This paper opens many important research questions. For one, we conjecture that the opposing demand effects of high net worth and high debt service burdens may also explain why inflation has not moved much during the credit booms since the beginning of the Great Moderation. This is a question we intend to assess more formally in future work. Furthermore, we also conjecture that if the credit boom is large enough, households and firms will be so overextended that a reduction in consumption and investment is not enough to pay back debts, leaving default as the only option, thus leading to a banking crisis. Again, this seems to be borne out by the US data, but needs to be assessed more formally. Clearly, our results beg to be rationalized within a theoretical model, something we also leave for further work.

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# Appendix A (data)

# Appendix B (robustness, preliminary)

This Appendix discusses robustness of the results presented in the main text along two dimensions. First, we investigate how sensitive the results are to alternative specifications for steady-state net worth. Second, we study how robust the estimates are to alternative samples, and in particular if the results hold up when the last decade is excluded.

## Alternative specifications for steady-state net worth

We consider five alternative specifications for steady-state net worth:

$$-\pi_t - \psi_{11} = \upsilon_{NW1,t} \tag{9}$$

$$a_t - d_t - \psi_{21} = \upsilon_{NW2,t} \tag{10}$$

$$a_t - d_t - \psi_{31} + \psi_{32} ltv_t = \upsilon_{NW3,t} \tag{11}$$

$$y_t - d_t - \psi_{41} + \sum_{i=1}^{n} \psi_{A_{4i}} (p_{A_i,t} - p_t) = \upsilon_{NW4,t} \tag{12}$$

$$y_t - d_t - \psi_{51} + \psi_{52} ltv_t + \sum_{i=1}^{n} \psi_{A_{5i}} (p_{A_i,t} - p_t) = \upsilon_{NW5,t} \tag{13}$$

where $\psi_{i1}$, for $i = 1, ..., 5$, is a constant. The first specification measures the steady-state deviations by the difference between the inverse refinancing premium and its sample mean. The second specification reproduces Equation (3) in the main text. It identifies the deviations from the difference between the log asset-to-credit ratio and its sample mean. The third specification augments the second by the LTV ratio for first time home buyers (Equation (4) in the main text). The fourth specification uses the approximation for assets (5) in (10). The fifth specification uses (5) in (11) and reproduces our preferred specification in the main text.

Specifications (11), (12) and (13) require more elaborate estimations as they involve other steady-state parameters in addition to a constant. We consider two different approaches: (i) the CIVAR methodology outlined in Section 4.3 and (ii) direct estimates using OLS.[30]

We generally find support for one steady-state relationship in the CIVAR models for the three specifications. This can be seen from the upper part of Table 5 which reports the results of Johansen's cointegration rank test. The null hypothesis of no cointegration ($v = 0$) is rejected at the 5% significance level in the models for (12) and (13), whereas it cannot be rejected in the model for (11). In the latter case the test statistic is only marginally below the critical value, suggesting that $v = 1$ can be imposed without doing too much violence to the data. For the former two models, where $v = 0$ was clearly rejected, we also see that the null hypothesis of one cointegration vector ($v = 1$) cannot be rejected for (12) but is rejected for (13). Hence, there might be more than one cointegration relationship in the latter case. However, this data feature turns out to be largely irrelevant for our purposes: if two cointegration relationships are imposed ($v = 2$) the first cointegration vector is almost identical to the one obtained from imposing $v = 1$. Moreover, the second cointegration relationship is not a significant driver of real credit growth, but rather relates the LTV-variable to the real residential property price with the latter variable being weakly exogenous.[31] This suggests that steady-state net worth can be accurately estimated even if we ignore the possible second cointegration relationship.

The estimated coefficients from imposing $v = 1$ on the different models are reported in the lower part of Table 5. As can be seen from the table, both the CIVAR approach and the simple OLS yields estimates that are broadly in line with each other. There

[30]The main difference between the two approaches is that the CIVAR methodology allows us to test the cointegration assumptions explicitly, whereas the OLS regressions implicitly assumes that $v = 1$ holds. Moreover, the OLS estimates are severely misspecified, implying that the standard errors are not valid. Hence, inference based on these errors should be view with a great deal of caution. In contrast, the CIVARs fully exploits the dynamic interaction between the variables in the system and allows for more valid inference.

[31]This result implies that LTV ratios on new loans have a tendency to rise during periods of persistent asset price increases. A possible interpretation is that lenders become overly optimistic about the risks involved.

| Alternative specifications of steady-state net worth | | | | | | |
|---|---|---|---|---|---|---|
| | Equ. (11) | | Equ. (12) | | Equ. (13) | |
| | | | Rank test statistic | | | |
| $\upsilon = 0$ | 0.06 | | 0.03$^\star$ | | 0.01$^\star$ | |
| $\upsilon = 1$ | 0.10 | | 0.26 | | 0.16 | |
| $\upsilon = 2$ | – | | 0.41 | | 0.41 | |
| $\upsilon = 3$ | – | | 0.13 | | 0.13 | |
| $\upsilon = 4$ | – | | – | | –$^{1)}$ | |
| | | | Estimated cointegration vectors conditional on $\upsilon = 1$ | | | |
| | CIVAR | OLS | CIVAR | OLS | CIVAR | OLS |
| $a_t - c_t$ | 1 | 1 | – | – | – | – |
| $y_t - c_t$ | – | – | 1 | 1 | 1 | 1 |
| $ltv_t$ | 1.54 (3.67) | 1.91 (9.49) | – | – | 2.44 (7.88) | 3.60 (12.60) |
| $p^r_{H,t}$ | – | – | 0.41 (6.24) | 0.33 (6.31) | 0.19 (3.57) | 0.03 (0.75) |
| $p^r_{C,t}$ | – | – | 0.28 (4.13) | 0.22 (4.51) | 0.23 (5.64) | 0.22 (6.91) |
| $p^r_{E,t}$ | – | – | 0.10 (3.72) | 0.07 (3.25) | –$^{1)}$ | – |
| | | | Loading on $\upsilon_{NWi,t-1}$ in the equation for $\Delta d^r_t$ | | | |
| $\upsilon_{NWi,t-1}$ | 0.042 (4.84) | 0.045 (5.03) | 0.038 (4.14) | 0.045 (4.27) | 0.079 (6.18) | 0.068 (4.62) |

Table 5: Alternative specification for steady-state net worth.

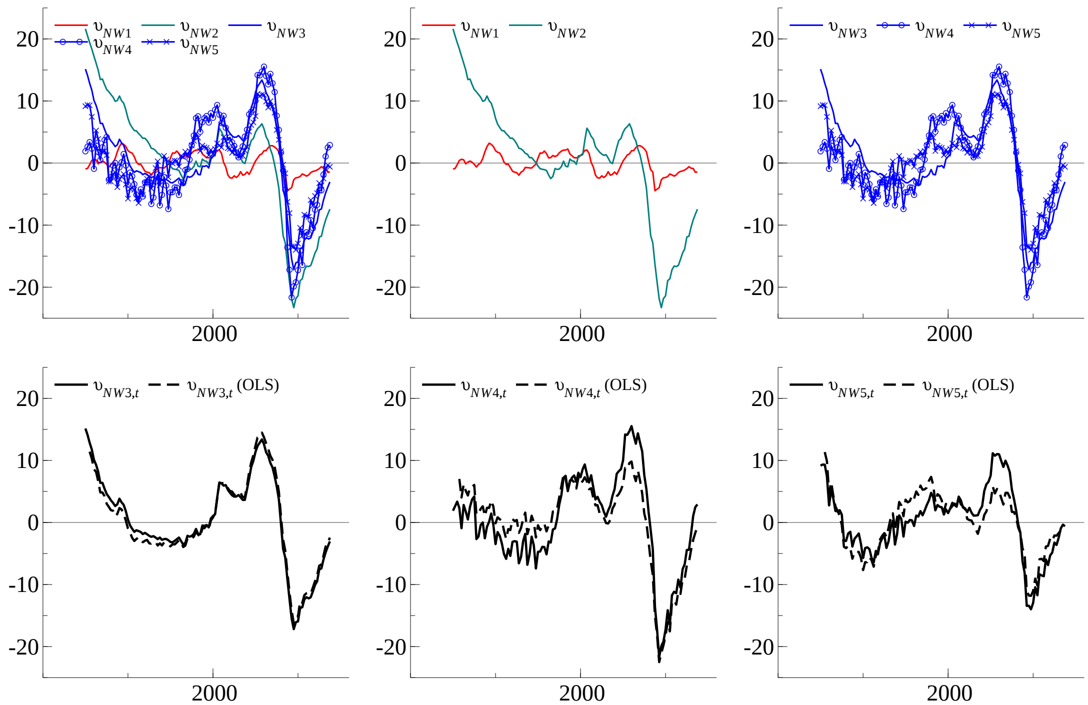


Figure 8: Deviations from long-run net worth based on alternative specifications and estimators.

is only one important exception: the coefficient on real residential property becomes very small and insignificant, whereas the coefficient on the LTV variable increases, in specification (13) when estimated by OLS. This result is likely due to the close connection between these two variables noted above. For instance, when the LTV variable is left out of the steady-state, as in specification (12), the coefficient on the real residential property price becomes much larger and is significant regardless of the estimator.

The estimated steady-state deviations from (11)-(13) are fairly similar in terms of their time patterns. Hence, it does not seem to matter much which of these specifications is adopted in the analysis. In contrast, the deviations (9) and in particular (10) show more diverse patterns. This can be seen from the three uppers panels in Figure 8. Which specification should we choose? Ultimately, the alternative estimates of the deviations from long-run net worth should be assessed based on how well they can account for credit growth (or, in particular, growth of new credit). The lower part of Table 5 reports the loadings to the different net worth deviations, corresponding to (11)-(13), in the equation for real credit growth from an estimated system of the form

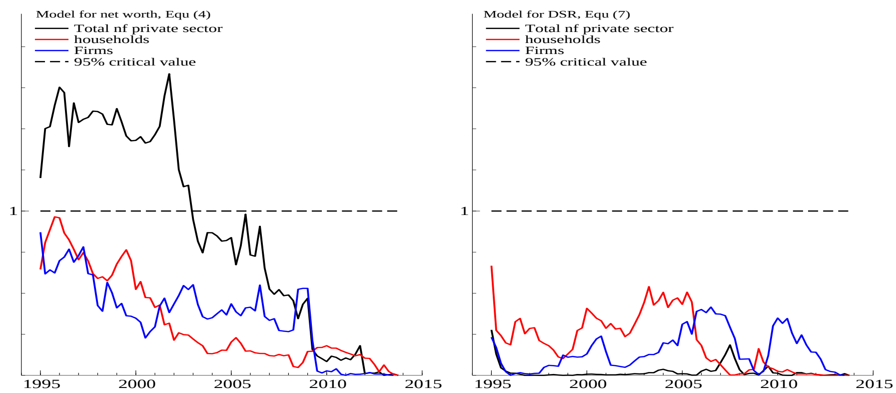


Figure 9: Recursive tests for parameter stability of the cointegration space. The test statistics are scaled so that the 95% critical value takes the value of unity. Values below unity indicate that the null hypothesis of a stable cointegration space cannot be rejected.

(8). As can be seen, the estimated deviations are highly significant in all cases. The best performing specification is (13) estimated by the CIVAR methodology, but the difference is not huge. In contrast, the deviations from specifications (9) and (10) do not perform equally well in (8). The estimated loadings to these deviations in the real credit growth equation, are 0.026 and 0.018, respectively, with corresponding t-values of 0.81 and 2.81.

## Parameter stability over different samples

We begin by studying parameter stability with respect to the estimated steady-states and then, taking these as given, with respect to their loadings in the VAR equations for real credit and expenditure growth. To do so, we recursively re-estimate the models, starting from a 15 year training sample (ie from 1985 to 2000) and successively enlarging it by one observation.

Stability tests for the steady-state parameters indicate that they are stable and, crucially, do not depend on developments around the recent financial crisis. Figure 9 reports tests for the null hypotheses that the recursively estimated cointegration vectors are identical to the full sample estimates. To enhance readability of the graphs, the 95% critical value is normalized to unity in the graph.

Parameter stability cannot be rejected except in one case. This is good news as it shows that our analysis is robust to dropping developments around the recent financial crisis, which arguably is special because of its magnitude. The one exception is the estimated net worth steady-state for the total private sector which shows a clear break in the early 2000's. The likely reason for the rejection is the chaning importance of the household sector compared to the corporate sector at that time. This suggest that results from combining the two sectors should be interpreted with greater caution.

### The linearized debt service steady-state

As a technical detail, the lower right-hand panel of Figure **??** highlights that estimating the debt service steady-state based on the non-linear installment loan formula (equation (2)) is more likely to reflect true debt serivice burdens than using the linearized version (equation (**??**)). While the deviations from both approaches show show very similar dynamics, the ones based on the linearzied verison are higher in the beginning of the sample and lower at the end. This is to be expected as it does not properly account for amortizations, which constitute a smaller share of debt payments when interest rates are high and vice versa. Hence, the deviations from the non-linear version is more likely to be in line with true private debt service conditions and we will primarily them in the analysis below.

## Appendix C (preliminary)

Table 4 in Section 5.2 reported the estimated loadings to the steady-state deviations from the equations for real credit and expenditure growth in (8). In this Appendix, we report the full system estimates.

For ease of exposition we explicitly write out the system. With the specific particular variable and parameter choices in Section 5.2, the system can be written as

$$\begin{pmatrix} \Delta d^r \\ \Delta e^r \\ \Delta y^r \\ \Delta p_A^r \end{pmatrix}_t = \gamma + \alpha \begin{pmatrix} \upsilon_{NW} \\ \upsilon_{DSR} \\ r_M^r \\ \pi \end{pmatrix}_{t-1} + \Pi \begin{pmatrix} \Delta d^r \\ \Delta e^r \\ \Delta y^r \\ \Delta p_A^r \end{pmatrix}_{t-1} + \Gamma s_t + \boldsymbol{\varepsilon}_t \tag{14}$$

where we have suppressed the redundant indices on the parameter matrices ($\gamma$, $\alpha$, $\Pi$, and $\Gamma$) and collected the two steady-state deviations and the additional "cointegration" relationships ($r^r_{M,t-1}$ and $\pi_{t-1}$) into one vector. The vector $s_t$ contains centered seasonal dummies and additional impulse dummies described in Table 6.

| Dummy Variables |
|---|
| Total private sector: |
| $d_1 = 1_{\{86:1\}}$, $d_2 = 1_{\{87:4\}}$, $d_3 = 1_{\{89:3\}}$, $d_4 = 1_{\{92:1\}}$, $d_5 = 1_{\{92:2\}}$, $d_6 = 1_{\{99:3\}}$, $d_7 = 1_{\{07:1\}}$ , $d_{58} = 1_{\{08:4\}}$ |
| Household sector: |
| $d_1 = 1_{\{87:2\}} - 1_{\{87:1\}}$, $d_2 = 1_{\{88:1\}}$, $d_3 = 1_{\{90:4\}}$, $d_4 = 1_{\{91:2\}}$, $d_5 = 1_{\{92:1\}}$, $d_6 = 1_{\{05:1\}}$, $d_7 = 1_{\{06:2\}}$, $d_8 = 1_{\{08:2\}}$, $d_9 = 1_{\{09:2\}}$, $d_{10} = 1_{\{12:1\}}$, $d_{11} = 1_{\{12:3\}}$, $d_{12} = 1_{\{12:4\}}$, $d_{13} = 1_{\{13:1\}}$ |
| Business sector: |
| $d_1 = 1_{\{87:4\}}$, $d_2 = 1_{\{93:4\}} + 1_{\{94:4\}}$, $d_3 = 1_{\{05:4\}}$, $d_4 = 1_{\{08:3\}}$, $d_5 = 1_{\{08:4\}}$, $d_6 = 1_{\{09:1\}}$ |

Table 6: Dummy variables. Several impulse dummies were included in the models to account for outliers using the automatic procedure Autometrix in PcGive. The dummy variables are labeled $d_i$, where $i$ is an index, and defined using the indicator function, $1_{\{yy:q\}}$, where $yy$ and $q$ are the year and quarter digits.

The full system estimates are reported in Table 7, with the expection of $\Gamma$ which is available upon request.

;

| Full system estimates | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Total (nf) private sector** | | | | | | | | |
| | $\Delta d_t^r$ | | $\Delta e_t^r$ | | $\Delta y_t^r$ | | $\Delta p_{A,t}^r$ | |
| | Est. | t-val | Est. | t-val | Est. | t-val | Est. | t-val |
| $\Delta d_{t-1}^r$ | **0.277** | 2.68 | 0.133 | 0.98 | -0.107 | -1.95 | **0.809** | 2.41 |
| $\Delta e_{t-1}^r$ | 0.145 | 1.67 | 0.200 | 1.75 | **0.259** | 5.61 | 0.283 | 1.00 |
| $\Delta y_{t-1}^r$ | 0.017 | 0.12 | 0.320 | 1.63 | **0.467** | 5.90 | 0.063 | 0.13 |
| $\Delta p_{A,t-1}^r$ | 0.013 | 0.48 | 0.010 | 0.27 | -0.010 | -0.69 | **-0.180** | -1.97 |
| $\upsilon_{DSR,t-1}$ | -0.008 | -1.38 | **-0.027** | -3.45 | -0.005 | -1.67 | -0.031 | -1.65 |
| $\upsilon_{NW,t-1}$ | **0.091** | 6.40 | -0.013 | -0.69 | **0.018** | 2.47 | -0.060 | -1.31 |
| $r_{M,t-1}^r$ | 0.047 | 1.68 | -0.048 | -1.32 | -0.005 | -0.37 | **-0.269** | -3.00 |
| $\pi_{t-1}$ | 0.036 | 0.96 | -0.018 | -0.36 | -0.019 | -0.96 | -0.164 | -1.34 |
| **Household sector** | | | | | | | | |
| | $\Delta d_t^r$ | | $\Delta e_t^r$ (con.) | | $\Delta y_t^r$ | | $\Delta p_{A,t}^r$ | |
| | Est. | t-val | Est. | t-val | Est. | t-val | Est. | t-val |
| $\Delta d_{t-1}^r$ | **0.373** | 3.670 | 0.166 | 1.940 | **0.252** | 2.340 | 0.241 | 1.650 |
| $\Delta e_{t-1}^r$ | **0.225** | 1.990 | 0.090 | 0.941 | **0.544** | 4.540 | 0.058 | 0.357 |
| $\Delta y_{t-1}^r$ | -0.065 | -0.944 | **0.130** | 2.250 | **-0.184** | -2.530 | 0.070 | 0.708 |
| $\Delta p_{A,t-1}^r$ | 0.001 | 0.020 | **0.102** | 3.440 | 0.063 | 1.700 | **0.838** | 16.600 |
| $\upsilon_{DSR,t-1}$ | **0.021** | 2.460 | **-0.022** | -3.050 | -0.008 | -0.864 | -0.016 | -1.300 |
| $\upsilon_{NW,t-1}$ | **0.113** | 5.420 | -0.024 | -1.360 | -0.036 | -1.650 | 0.009 | 0.303 |
| $r_{M,t-1}^r$ | 0.042 | 1.270 | -0.008 | -0.303 | -0.023 | -0.654 | 0.003 | 0.056 |
| $\pi_{t-1}$ | 0.051 | 1.210 | -0.045 | -1.270 | -0.085 | -1.910 | 0.092 | 1.520 |
| **Business sector** | | | | | | | | |
| | $\Delta d_t^r$ | | $\Delta e_t^r$ (inv.) | | $\Delta y_t^r$ | | $\Delta p_{A,t}^r$ | |
| | Est. | t-val | Est. | t-val | Est. | t-val | Est. | t-val |
| $\Delta d_{t-1}^r$ | **0.279** | 3.240 | 0.040 | 0.257 | 0.351 | 1.160 | 0.551 | 1.870 |
| $\Delta e_{t-1}^r$ | 0.023 | 0.459 | 0.155 | 1.710 | 0.190 | 1.090 | -0.014 | -0.085 |
| $\Delta y_{t-1}^r$ | -0.029 | -0.978 | -0.016 | -0.291 | -0.108 | -1.040 | **0.230** | 2.290 |
| $\Delta p_{A,t-1}^r$ | **-0.071** | -2.870 | 0.016 | 0.342 | 0.070 | 0.801 | **-0.242** | -2.840 |
| $\upsilon_{DSR,t-1}$ | 0.005 | 0.501 | **-0.066** | -3.940 | -0.056 | -1.760 | **-0.089** | -2.850 |
| $\upsilon_{NW,t-1}$ | **0.078** | 6.610 | -0.005 | -0.217 | **-0.083** | -2.010 | -0.052 | -1.300 |
| $r_{M,t-1}^r$ | -0.015 | -0.433 | 0.040 | 0.636 | -0.111 | -0.922 | -0.089 | -0.758 |
| $\pi_{t-1}$ | 0.057 | 0.966 | 0.041 | 0.378 | 0.074 | 0.352 | -0.286 | -1.410 |

Table 7: Estimated coefficents of the full equation systems in Section 5.2.