Predictable Reversals:
Credit Booms, Debt Service and Prolonged Slumps*

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Abstract

Traditional economic models have had difficulty explaining why booms in household credit have predictable negative after-effects that may last for up to a decade. This paper explains why: when taking on new debt, borrowers commit to a pre-specified path of future debt service. We first show theoretically that there are two key properties of the data that give rise to a pronounced lag between credit booms and debt service: (i) that new borrowing is strongly auto-correlated and (ii) that debt contracts are long term. Then we analyze a panel of household debt in 17 countries and find that on average, the lag between peaks in credit booms and peaks in debt service is four years. Furthermore, we show that this delayed increase in debt service explains why credit booms are associated with lower future output growth and higher probability of crisis for up to seven years. Our results thus provide a systematic transmission mechanism from credit expansions to prolonged adverse real effects, highlighting a significant challenge for macroeconomic management.

JEL Codes: E17, E44, G01, D14
Keywords: new borrowing, debt service, financial cycle, real-financial linkages

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1 Introduction

Debt service is the inescapable counterpart to borrowing. When taking on new debt, borrowers increase their spending power in the present but commit to a pre-specified future path of debt service, consisting of interest payments and amortizations. In the presence of long-term debt, keeping track of debt service explains why credit-related expansions are systematically followed by downturns several years later. This paper describes the lead-lag relationship between new borrowing and debt service analytically and shows empirically that it provides a systematic transmission channel whereby credit expansions lead to future output losses and higher probability of financial crisis.

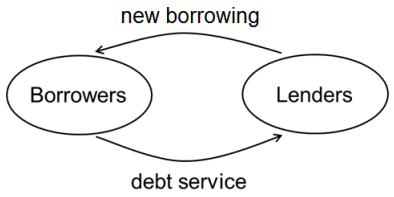

Figure 1: New borrowing and debt service

We begin by providing a simple accounting framework that describes how new borrowing generates a well-specified schedule of debt service. When new borrowing is auto-correlated and debt is long term - features that are present in the real world - we demonstrate two systematic lead-lag relationships: First, debt service peaks at a well-specified interval after the peak in new borrowing. The lag increases both in the maturity of debt and the degree of auto-correlation of new borrowing. The reason is that debt service is a function of the stock of debt outstanding, which continues to grow even after the peak in new borrowing. Second, net cash flows from lenders to borrowers reach their maximum before the peak in new borrowing and turn negative before the end of the credit boom, since the positive cash flow from new borrowing is increasingly offset by the negative cash flows from rising debt service.

Using a panel of 17 countries from 1980 to 2015, we empirically confirm the dynamic patterns identified in the accounting framework. We focus on the household sector since long-term debt contracts are most prevalent in this sector, especially for mortgages. But we also draw comparisons with the corporate sector at several points in the paper. Building on a new BIS database (Drehmann et al (2015)) we obtain time series of new borrowing and debt service. We show that new borrowing is strongly auto-correlated over an interval of six years. It is also positively correlated with future debt service over the following ten years. In the data, peaks in debt service occur on average four years after peaks in new borrowing.

Next, we investigate the implications for the real economy leading to three key findings. First, we document that new household borrowing has a clear positive impact, and its counterpart, debt service, a significantly negative impact on output growth, both of which last for several years. Together with the lead-lag relationship between new

borrowing and debt service this implies that credit booms have a significantly positive output effect in the short run, which reverses and turns into a significantly negative output effect in the medium run, at a horizon of five to seven years.

Second, using a novel decomposition method, we demonstrate that most of the negative medium-run output effects of new borrowing in the data are driven by predictable future debt service effects. Our results therefore provide a systematic transmission mechanism for earlier findings in the literature on the real effects of credit booms.[1]

Third, we also show that debt service is the main channel through which new borrowing affects the probability of financial crises. Consistent with a recent literature that has documented that debt growth is an early warning indicator for financial crises, we find that new borrowing increases the likelihood of financial crises in the medium run.[2] Debt service, on the other hand, negatively affects the likelihood of crises in the short turn. Taken together and performing a similar decomposition as before, we show that the negative effects of the future debt service generated by an increase in new borrowing nearly fully accounts for the increase in crisis probability.

Our results are robust to the inclusion of range of control variables as well as changes in sample and specification. Our baseline regressions control for interest rates and wealth effects. The results do not change when we control for additional macro factors, including credit spreads, productivity, net worth, lending standards, banking sector provisions and GDP forecasts, nor when we consider sub-samples of the data, e.g. a sample leaving out the Great Recession, or allow for time fixed effects. And despite at most 35 years of data, the relationships even hold at the country level.

We also compare new borrowing and debt service to more traditional measures of credit booms used in the macro-finance literature. Conceptually, new borrowing and debt service are easy to interpret economically as they enter budget constraints directly and therefore capture the economic forces responsible for the delayed adverse real effects of credit booms in a straightforward way. From a statistical point of view, they do not show pronounced trends in contrast to traditional credit-to-GDP aggregates, which have been trending upward for several decades. This is an advantage as it avoids arbitrary de-trending methods like HP-filters or linear trends typically used in the literature. By running a horse race for predicting output or crises, we find empirically that debt service in particular outperforms the traditional measures, both by generating higher R^2 statistics and by exhibiting higher t-statistics in regressions in which both variables are included.

We believe that the transmission mechanism from new borrowing to debt service and real economic activity that we document in this paper is of great relevance for

[1] The negative medium-run effect of new borrowing on growth is documented e.g. by Mian and Sufi (2014), Mian et al. (2013, 2017) and Lombardi et al. (2016). Claessens et al. (2012), Jorda et al. (2013), and Krishnamurthy and Muir (2016) document a link between credit booms and deeper recessions.

[2] See e.g. Borio and Lowe (2002), Reinhart and Rogoff (2009), Schularick and Taylor (2012), and Drehmann and Juselius (2014), among others.

developing realistic models and policies to deal with credit booms and busts.[3] For example, our results highlight a potential trade-off when trying to stimulate the economy by encouraging the expansion of debt. New borrowing has positive effects in the short run, but as it will mechanically increase debt service in the future, these benefits may be offset by the associated drag in growth in the medium run. Equally, this trade-off has potential implications for using monetary policy to lean against the wind as dampening a credit boom with higher policy rates may weaken growth in the short run but avoid higher debt service – and low output and higher crisis risk– in the medium run.[4] More broadly, our results show that policy needs to take into account contractual features that affect future debt service and, thus, have a predictable effect on economic activity.

The paper is structured as follows. In the ensuing section, we provide a simple accounting framework to illustrate the main channels at work. In Sections 3 and 4, we discuss the data and document the lead-lag relationship between new borrowing and debt service. In Section 5 we turn to the real implications of debt service and describe the transmission channel from new borrowing to debt service and, in turn, to economic activity and crisis risk. Section 6 concludes. Appendix A contains proofs and further analytic results for the accounting framework and the decomposition of impulse response functions. In Appendix B, we describe the empirical methodology that we develop to decompose what fraction of the future real effects of new borrowing is explained by debt service.

2 Accounting for Debt Service

This section lays out a simple accounting framework that clarifies the key mechanism underlying the lead-lag relationship between new borrowing, future debt service, and the net cash flows between borrowers and lenders. The framework highlights the key roles of auto-correlated new borrowing and long-term debt contracts, both of which are present in the data, in generating an interesting lead-lag structure.

Accounting framework Consider a borrower who borrows B_t in period t in long-term debt. Assume, for simplicity, a constant amortization rate δ and fixed interest rate r. In period $t+1$, this contract implies a debt service of $(r+\delta)\,B_t$, consisting of interest payments and amortization, and a remaining stock of debt outstanding of

[3] A recent strand of literature has emphasized the potential aggregate demand effects of flows of resources between borrowers and lenders. See e.g. Farhi and Werning (2016), Korinek and Simsek (2016), and Schmitt-Grohé and Uribe (2016). However, this literature assumes one period debt and is thus silent on the lag structure between credit booms and debt service.

[4] Juselius et al (2017) develop this theme further by introducing debt service and leverage into a standard reduced form model of the economy. They run counterfactual simulations and conclude that a monetary policy rule that takes financial developments systematically into account during both good and bad times could help dampen the financial cycle, leading to significant output gains and little change in inflation.

$(1-\delta)\,B_t$, which is carried over to the next period. After k periods, a balance of $(1-\delta)^{k-1}\,B_t$ is left of the original amount borrowed, implying debt service obligations of $(r+\delta)\,(1-\delta)^{k-1}\,B_t$.

The total stock of debt outstanding at the beginning of period t, D_t, follows the law-of-motion

$$\begin{aligned} D_t &= (1-\delta)\,D_{t-1} + B_{t-1} \\ &= \sum_{j=0}^{t-1} (1-\delta)^{t-j+1}\,B_j \end{aligned} \tag{1}$$

Hence, the stock of debt can be represented as a moving average of past new borrowing $(B_j)_{j=0}^{t-1}$.

Total debt service, S_t, is given by the debt service obligations from all past borrowing $(B_j)_{j=0}^{t-1}$ that are due in period t, or equivalently, on the stock of debt D_t,

$$\begin{aligned} S_t &= (\delta+r)\,D_t \\ &= \sum_{j=0}^{t-1} (\delta+r)\,(1-\delta)^{t-j+1}\,B_j \end{aligned} \tag{2}$$

The net cash flow from lenders to the borrowers in a given period t consists of the new borrowing B_t minus all the debt service obligations due in period t,

$$N_t = B_t - S_t = B_t - (\delta+r)\,D_t \tag{3}$$

Observe that the standard case of short-term debt corresponds to $\delta = 1$. In that case, the above formulas reduce to $D_t = B_{t-1}$, $S_t = (1+r)\,B_{t-1}$ and $N_t = B_t - (1+r)\,B_{t-1}$. In other words, with short-term debt, it is unnecessary to distinguish between new borrowing in the previous period and the stock of debt in the current period.

Accounting implications of a credit boom We now use these accounting relationships to trace out the implications of a boom in new borrowing in long-term debt for the lag structure between borrowing and debt service.

Consider an exogenous process of new borrowing $\{B_t\}$ which involves $T > 2$ periods of new borrowing $B_t > 0$ for $t \in \{1, ...T\}$ and that is hump-shaped, i.e. there is a unique interior peak at a time $1 \leq t^* < T$ such that $B_{t^*} = \max_{t\in\{1,...T\}} \{B_t\}$ and borrowing is increasing up until the peak $B_1 < B_2 < \cdots < B_{t^*}$ and decreasing after the peak $B_{t^*} > B_{t^*+1} > \cdots > B_T$.

For expositional simplicity, we maintain the assumptions of constant interest and amortization rates. Furthermore, we impose a mild condition on timing: the process of new borrowing up until the peak t^* cannot be too drawn out over time, captured by the analytic condition $(\delta+r)\,t^* < 1$. After T, we assume no further borrowing so $B_t = 0$ for $t > T$.

Given these assumptions, we find the following relationships between new borrowing and debt service:

Proposition 1 (**Lead-lag structure of new borrowing and debt service**). *(i) The peak in debt service $\hat{t}$ occurs after the peak in new borrowing t^*. The lag between the two peaks $t^* - \hat{t}$ is weakly decreasing in the amortization rate δ.*

(ii) The net cash flow from lenders to borrowers peaks weakly before the peak in new borrowing and turns negative after the peak in new borrowing but weakly before the end of the credit boom.

The formal proof of the proposition is given in Appendix A.1 but the intuition is straightforward. For part (i) of the proposition, observe that debt service is a function of the stock of debt, or technically speaking, debt service is a moving average of new borrowing. When new borrowing peaks, the stock of debt and thus debt service is still increasing, since new borrowing is still positive and existing debt depreciates at the comparatively low rate of δ. After the peak in new borrowing, a lower amortization rate pushes back the time when debt service outweighs the positive (but declining) effects of new borrowing, which moves the peak in debt service further away from the peak in new borrowing.

For part (ii) of the proposition, observe that at the peak of new borrowing, where the growth rate of new borrowing is zero, debt service is still increasing. This implies that the the difference between the two, i.e. the net cash flow from lenders to borrowers, is decreasing and must have already peaked. At some point, the net cash flow turns negative since debt service becomes greater than new borrowing. As long as the credit boom is not too drawn out, this happens after the peak in new borrowing. Furthermore, it happens before the end of the credit boom – once the boom is over and there is no more new borrowing, the net cash flow consists entirely of debt service and must be negative.

Some of the results in the proposition are stated as weak inequalities due to the discrete time nature of our framework. Appendix A shows that in an equivalent continuous time framework all of the stated inequalities hold strictly.

Figure 2 illustrates our findings. We assume that new borrowing (light-blue bars) is given by an exogenous bell-shaped process that starts at t_0 and lasts for 9 periods, with a peak at $t = 3$.[5] The beige bars depict the resulting debt service obligations, which continue to grow even when new borrowing is already declining. The black line depicts the net cash flow from lenders to borrowers, i.e. the difference between new borrowing and debt service. In line with Proposition 1, the net cash flow peaks before the peak in new borrowing and turns negative before the boom is over.

Analytic results for a unit impulse in new borrowing Although new borrowing in the data is typically a bell-shaped process during credit booms, it is useful to consider the special case of a unit impulse in new borrowing that decays exponentially. This

[5]For illustration purposes, we set $r = 5\%$ and $\delta = 15\%$ in this simulation.

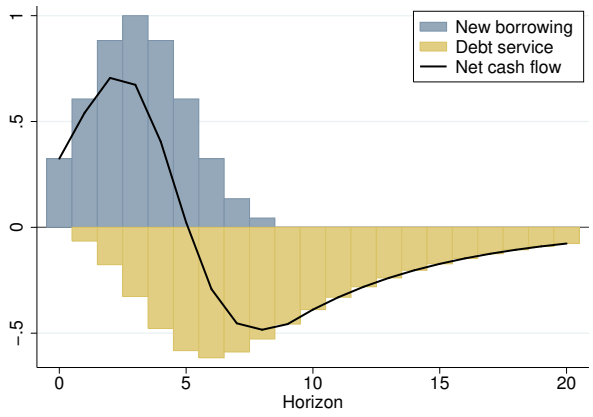

Figure 2: The evolution of new borrowing and debt service during a credit boom. The simulation assumes an exogenous credit boom and uses equations (1) and (2). Debt is long term with $\delta = 15\%$ and $r = 5\%$.

process allows us to obtain analytic results for the timing of the peak in debt service. It also corresponds to the way that shocks are typically modeled in theoretical models.

Assume that there is a unit impulse to new borrowing at time 0 that decays exponentially at rate $\rho \in [0, 1)$. As a result, new borrowing at time t is $B_t = \rho^t$. This process of new borrowing is a limit case of the class of credit boom processes covered by Proposition 1 that is shifted by one period, with $t^* = 0$ and $T \to \infty$. The results of the proposition therefore still apply, but they can be sharpened by obtaining analytic expressions for the timing of the peak in debt service.

The debt stock resulting from a unit impulse in new borrowing is a moving average given by the geometric sum

$$\begin{aligned} D_t &= \sum_{s=0}^{t} (1-\delta)^{t-s} B_s = (1-\delta)^t \rho^0 + (1-\delta)^{t-1} \rho + \cdots + (1-\delta)^0 \rho^t \\ &= (1-\delta)^t \frac{1 - \left(\frac{\rho}{1-\delta}\right)^{t+1}}{1 - \frac{\rho}{1-\delta}} \end{aligned} \tag{4}$$

Proposition 2 (Peak in debt service). *Following a unit impulse of new borrowing that decays at rate $\rho \neq 1 - \delta$ with $\rho, \delta \in (0, 1)$, debt service peaks at an integer time index in the interval $\left(\hat{t} \pm 1\right)$ where*

$$\hat{t} = \frac{\ln\left[\ln \rho / \ln\left(1-\delta\right)\right]}{\ln\left(1-\delta\right) - \ln \rho} - 1$$

which satisfies $d\hat{t}/d\rho > 0$ and $d\hat{t}/d\delta < 0$.[6]

[6] In the special case $\rho = 1 - \delta$, the geometric sum for D_t is given by $\rho^t (t+1)$, which is maximized at $\hat{t} = -1/\ln \rho - 1$.

As in the previous proposition, our discrete time setup implies that we can only obtain an interval $\left(\hat{t} \pm 1\right)$ for the peak. The appendix provides a proof and shows that an equivalent proposition for a continuous time version of our model delivers a precise value for $\hat{t}$.

Intuitively, the proposition captures that a higher amortization rate δ leads to an earlier peak in debt service since debt is paid off more quickly. Similarly, a higher auto-correlation ρ leads to a later peak in debt service since borrowers continue to accumulate debt for a longer period.

To showcase that both long-term debt ($\delta < 1$) and auto-correlated new borrowing ($\rho > 0$) are necessary to obtain an interesting and non-degenerate lead-lag structure, it is useful to consider the two extremes $\delta = 1$ and $\rho = 0$:

Corollary 3 (**Necessity of both auto-correlation and long-term debt**). *If either $\delta = 1$ or $\rho = 0$, the lag between an impulse to new borrowing and the peak in debt service becomes degenerate and collapses to $\hat{t} = 1$.*

The case $\delta = 1$ captures one-period debt contracts as is typically considered in theory models (see the left-hand panel of Figure 3 for an illustrative example). New borrowing is still autocorrelated and continues to be given by $B_t = \rho^t$ – after the initial unit impulse at $t = 0$, it decays slowly. Debt service is given by $S_t = (1 + r)\rho^{t-1}$ for $t \geq 1$, and is simply the mirror image of new borrowing lagged by one period. Intuitively, since any new borrowing is immediately paid off in the following period, there is no prolonged lead-lag relationship between new borrowing and debt service. Given that new borrowing peaks at $t = 0$, debt service peaks at $t = 1$.

The case $\rho = 0$ captures a unit impulse to new borrowing without auto-correlation (centre panel, Figure 3). In that case, no new borrowing occurs after the initial impulse. Hence, the stock of debt peaks at $t = 1$, i.e. in the period right after the impulse to new borrowing, and is declining immediately after. Debt service, given by $S_t = (r + \delta)(1 - \delta)^{t-1}$ for $t \geq 1$, follows the same pattern and also peaks at $t = 1$.

The case with auto-correlation ($\rho > 0$) and long term debt ($\delta < 1$) is illustrated in the right-hand panel of Figure 3. In this case, we obtain a non-degenerate lag relationship between the peak in new borrowing and the peak in debt service, as described by the corollary. This case is rarely considered in theory papers but is empirically the most relevant .

In summary, our simple accounting framework thus suggests that it is the combined effects of auto-correlated new borrowing and long-term debt that account for the substantial lags between peaks in new borrowing and debt service. The key empirical issues that we address in the remainder of this paper is to document that this relationship holds in the data and to investigate to what extent the lagged response of debt service can account for delayed negative real effects of credit booms.

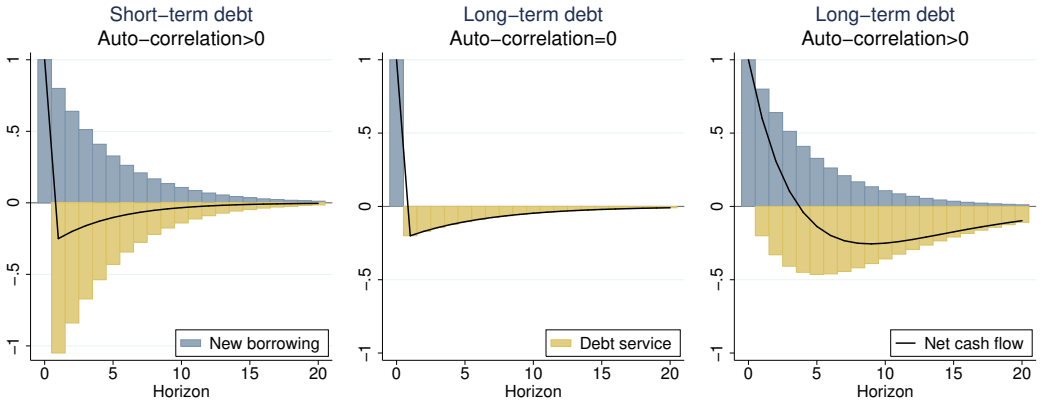

Figure 3: The evolution of new borrowing and debt service after a unit impulse to new borrowing The simulation uses equations (1) and (2) with $r = 5\%$. If debt is short term $\delta = 100\%$. If debt is long term $\delta = 15\%$. If new borrowing is autocorrelated,$\rho = 0.8$.

3 Data and Measurement

Our main variables of interest are new borrowing and debt service. This section discusses how we measure both variables in the aggregate, which variables we use to measure the real effects of credit booms and what controls we employ. We use an unbalanced panel of annual data from 17 countries from 1980 to 2015.[7] The exact definitions, sources, and availability for all variables are listed in Tables 3 and 4 in Appendix D.

In the main text, we focus on the household sector for three reasons. First, this is the sector in which long debt maturities and auto-correlated new borrowing are most prevalent, giving rise to the most interesting lead-lag relationships. Second, in doing so, we also complement a literature that has demonstrated negative effects of household debt in the medium run (e.g. Jorda et al (2016) or Mian et al (2017)) and show that their results arise from the lead-lag relationship between new borrowing and debt service that our paper identifies. Third, data availability on debt maturities is considerably better in the household sector compared to the corporate sector. For completeness, we also report a summary of results for the corporate sector in Appendix C.

New borrowing and debt service We construct measures of debt service and new borrowing using three main data series as inputs. The first input series is the stock of household debt $D_{i,t}$ in country i at time t from the BIS database compiled by Dembiermont et al (2013). This variable captures credit to the household sector from all sources, including bank credit, cross-border credit and credit from non-banks. The

[7] Countries are Australia, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, Korea, the Netherlands, Norway, Portugal, Spain, Sweden, the United Kingdom and the United States.

second series is total interest paid by households, $R_{i,t}$, from national accounts.[8] The third is debt maturity estimates from the BIS database on debt service by Drehmann et al (2015) that is publicly available from 1999 onward.

From our accounting framework we can obtain expressions for new borrowing and debt service in terms of the raw input series. Equation (1) tells us that new borrowing, $B_{i,t}$, equals the change in the stock of debt plus amortizations

$$B_{i,t} = \Delta D_{i,t} + \delta_{i,t} D_{i,t-1}$$

Debt service, $S_{i,t}$, is similarly given by the sum of interest and amortizations,

$$S_{i,t} = (\delta_{i,t} + r_{i,t})\, D_{i,t}$$

The average interest rate on the stock of debt can be calculated by dividing interest expenses by the stock of debt, i.e. $r_{i,t} = R_{i,t}/D_{i,t}$.

We estimate the amortization rate by following the methodology of Lucket (1980), Dynan et al (2003) and Drehmann et al (2015), i.e. by approximating it with the amortization rate of an installment loan with a maturity that corresponds to the average maturity m of the stock of debt outstanding.[9]This implies an amortization rate of

$$\delta_{i,t} = \frac{r_{i,t}}{(1 + r_{i,t})^m - 1}$$

With this formula, the amortization rate moves inversely to the interest rate ($d\delta_{i,t}/dr_{i,t} < 0$) and varies substantially over time, as observed in the data.

Data on maturities is generally limited. Collecting the available evidence, Drehmann et al (2015) find that 18 years is the average maturity for total household debt across countries and time, with a minimum of 16 and a maximum of 19 years.[10] As this variation has a limited impact on debt service estimates, the BIS applies a constant maturity for simplicity, which we follow here. For the corporate sector, the average effective maturity is 13 years. But as Drehmann et al (2015) acknowledge, this is estimate is more uncertain given the importance of rollovers for corporate sector debt (e.g. Mian and Santos (2017)).

[8] As in Drehmann et al (2015), we also include financial intermediation services indirectly measured (FISIM) in our measure of $R_{i,t}$. FISIM is an estimate of the value of financial intermediation services provided by financial institutions which consumers pay as part of their borrowing costs. In the beginning of our sample, national accounts data on interest paid is not available for all countries. In that case, we proxy interest paid on the stock of debt by using an alternative interest rate such as the average interest rate on bank loans.

[9] This methodology is used by both the US Fed and the BIS to construct time series of aggregate debt service. A derivation of the formula is provided in Appendix A.3. See Drehmann et al (2015) for simulation results that show that the approximation error resulting from our formula with average maturity and interest rate does not significantly alter the dynamics of debt service compared to what would be obtained by aggregating individual loan-level data on interest rates and maturities.

[10] Drehmann et al (2015) assess the maturity of total household debt including inter alia consumer loans as well as mortgages. As an additional cross check, they confirm this result by collecting maturities for mortgages and consumer debt to then derive country-specific weighted averages.

For the ensuing empirical analysis, we normalize both new borrowing and debt service by nominal GDP obtained from national accounts and take logs. We denote the resulting normalized variables by $b_{i,t} = B_{i,t}/Y_{i,t}$ and $s_{i,t} = S_{i,t}/Y_{i,t}$. We plot these series for the household sector for the individual countries in Figure 19 in Appendix D.

Real variables We study the real implications of new borrowing and debt service by looking at two variables: output growth and the incidence of banking crises. We denote logged real GDP from national accounts by $y_{i,t} = \ln(Y_{i,t}/P_{i,t})$ so that real output growth is $\Delta y_{i,t}$.

We use Laeven and Valencia (2012) for financial crisis dates and extend their dataset using additional information from central banks as discussed in Drehmann and Juselius (2014). Overall, we have 19 crisis observations, 11 of which are related to the Great Financial Crisis. As a robustness check, we also use a broader definition of crises by Reinhart and Rogoff (2009), which adds three further crisis observations prior to 2000.

Controls Since our ultimate interest lies in the real effects of new borrowing and debt service, we control for several variables that could also have real effects through private expenditure. In addition to lagged output growth, our baseline set of controls consist

- the real three-month money market rate,
- the spread between the short-term money market rate and the prime lending rate,
- the change in the average lending rate on household debt,
- the growth rate in real residential property prices, and
- crisis dummies,

and up to two lags of each of them. The rationale behind these controls is as follows: The (ex-post) real three-month money market rate captures the effect of real interest rates on the expenditure of financially unconstrained consumers. The spread between the short-term money market rate and the prime lending rate captures that the expenditure of constrained consumers is linked to credit spreads, as suggested by conventional models. We control for the change in the average lending rate since outstanding loans are not fully repriced in each period. Together, these controls should ensure that the debt service effects that we capture are not confounded with more conventional effects of interest rates. Finally, we use the growth rate in real residential property prices to capture changes in household wealth that might affect expenditure. In addition, the baseline specification contains a dummy that equals 1 in crisis years as well as a separate dummy that equals 1 in 2009 to control for the global financial crisis, which affected all countries even if they did not have a financial crisis.

We perform additional robustness tests by controlling for further variables that may affect household decisions. We do not include these variables in the baseline specification because data availability is generally limited. Our extended set of controls consist of:

- the growth rate in labor productivity[11], the change in CPI inflation, the term premia measured by the difference between the 10 year government bond and thre month money market rate, the growth rate of unemployment, and the growth rate of the real exchange rate as additional controls for changes in the business cycle environment.[12] We also add consensus forecasts for next years output growth as one proxy for future expectations,

- net worth calculated as the difference between household assets and household liabilities as recorded in the national accounts to capture net worth effects discussed in the literature,

- the corporate credit spread and the term spread between short tern and long term government bonds as these variables have been found to have good leading properties for the business cycle (e.g. Gilchrist and Zakrajsek (2012) or Krishnamurthy and Muir (2016)).

- lending standards and banking sector provisions to control for potential supply side considerations stemming from the banking sector.

4 New Borrowing and Debt Service

In this section we document that the basic relationships postulated in the accounting framework hold in the aggregate time series in the data: new borrowing is significantly auto-correlated, and there is a robust lead-lag relationship between the peak in new borrowing and the peak in debt service.

4.1 Patterns in the raw data

New borrowing is significantly autocorrelated, with a correlation coefficient ρ across consecutive periods of 0.8 as illustrated in the autocorrelogram for new borrowing in the left-hand panel of Figure 4. The autocorrelation of new borrowing is positive up to six years ahead.

As the accounting framework suggests, in the presence of high autocorrelation and long-run debt, new borrowing is positively correlated with future debt service for quite some time (Figure 4). New borrowing leads debt service by several periods, with the peak correlation occurring in period 4, just before the autocorrelation of new borrowing turns negative. Proposition 2 of our accounting framework implies a similar lead-lag pattern with $\rho = .8$ and $\delta = 0.05$.

[11] Gorton and Ordonez (2016) find that shocks to productivity often start booms, and that booms are more likely to end in crisis if productivity is low.

[12] It is well know that CPI inflation, the unemployment rate and the real exchange rate contain sizable low-frequency components across countries. As this can bias their coefficients toward zero when used as regressors for a non-trending variable, such as real GDP growth, we use their growth rates rather than levels.

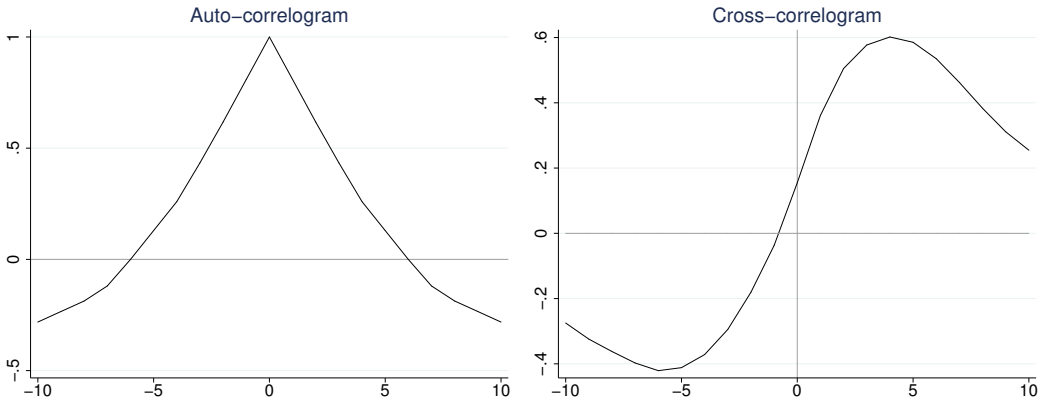

Figure 4: Auto-correlation of new borrowing and cross-correlation between new borrowing and debt service for the household sector. We normalize new borrowing and debt service by country-specific averages.

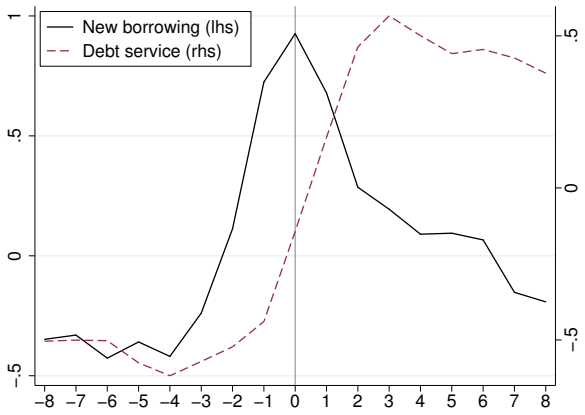

Figure 5: The evolution of new borrowing and debt service +/- 8 years around peaks in new borrowing of households (time 0). The lines show the cross-sectional averages of the relevant variable at each year. Peaks in new borrowing are identified as local maxima within a five year window. We normalize new borrowing and debt service by country-specific averages and standard deviations.

Figure 5 showcases the phase-shift between new borrowing and debt service more clearly. It depicts the average evolution of the two variables around peaks in new borrowing (defined as local maxima within a five-year window).[13] Such peaks are followed by peaks in debt service three years later. The figure also shows clearly that debt service continues to rise when new borrowing already decreases. Figure 19 in Appendix D documents that the lead-lag relationships are also present at the individual country level.

A comparison with the corporate sector illustrates the results of the accounting framework (see Figure 16 in Appendix C). As the autocorrelation across periods is 0.4 in the corporate sector versus 0.8 in the household sector and debt has a shorter maturity, the lead-lag relationship between new borrowing and debt service is significantly more compressed. The cross-correlogram is at its maximum after 2 years and peaks in new borrowing are followed by peaks in debt service after 1 year. This suggests that traditional models with one period debt may capture the interactions between debt and the real economy better for the corporate sector than for households.

4.2 Effect of new borrowing on future debt service

To study the relationship between new borrowing and debt service in the data more formally, we use local projections a la Jorda (2005).[14] In particular, we estimate for each horizon h projections for new borrowing, b, and debt service, s, with ,

$$b_{i,t+h} = \mu_{b,i}^{h+1} + \beta_{bb}^{h+1} b_{i,t-1} + \beta_{bs}^{h+1} s_{i,t-1} + controls + \varepsilon_{b,i,t+h}^{h} \tag{5}$$

$$s_{i,t+h} = \mu_{s,i}^{h+1} + \beta_{sb}^{h+1} b_{i,t-1} + \beta_{ss}^{h+1} s_{i,t-1} + controls + \varepsilon_{s,i,t+h}^{h} \tag{6}$$

where $\mu_{j,i}^{h+1}$ is a country fixed effect, *controls* captures our control variables, and $\varepsilon_{j,i,t+h}^{h}$ is the projection residual for $j = \{b, s\}$. With this convention for the indeces, the h successive β_{bb}^{h} and β_{sb}^{h} coefficients trace out the impulse response of future new borrowing and future debt service, respectively, to a unit increase in new borrowing at time t over h successive years (see Annex B).

The effects of an impulse to new borrowing takes several years to dissipate and is followed by a peak in debt service after four years (Figure 6).

The left-hand panel shows the impulse response from a unit shock to new borrowing based on a specification that includes our baseline controls (see Section 3). New borrowing remains elevated for five years, with the first four being statistically significant. Immediately after the shock, debt service (right-hand panel) begins to rise significantly; it peaks after four years and remains significantly elevated even after eight years.

[13] Results are quantitatively very similar if typical business cycle dating algorithms as in Harding and Pagan (2002) are used and we impose a minimum cycle length of five years to identify credit booms.

[14] We follow the convention of using "prediction" to refer to within-sample impulse responses.

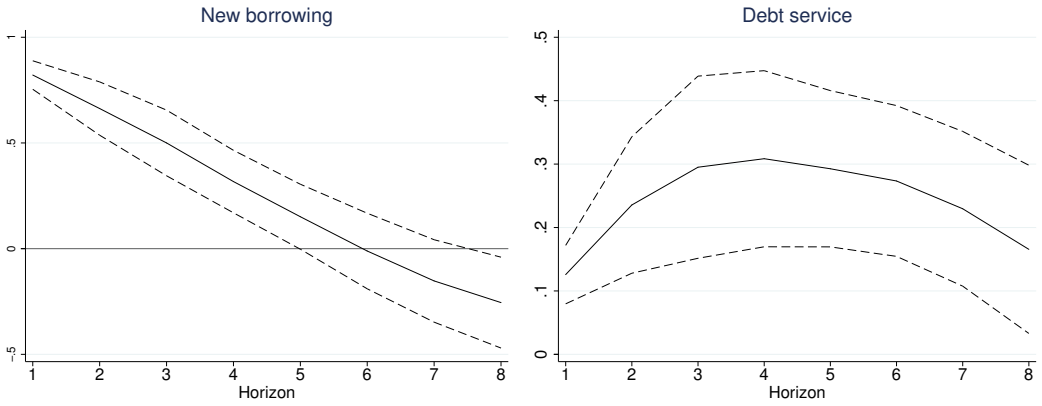

Figure 6: Impulse response of new borrowing and debt service to a unit increase in new household borrowing at t_0 using local projections (5) and (6) for horizons $h = 1$ to 8. The specification includes our baseline controls (see Section (3)). Errors are clustered at the country level. Dotted line are the 95% confidence bands.

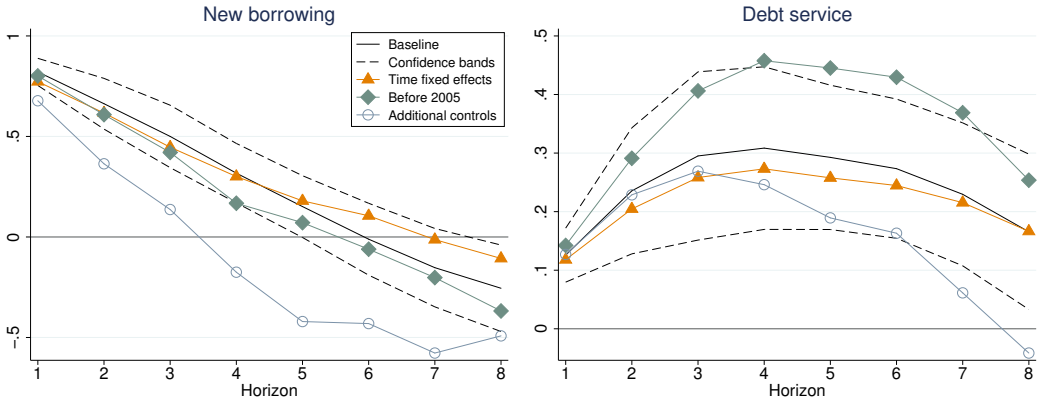

Figure 7: Impulse response of new borrowing and debt service after a unit increase in new household borrowing at t_0 using local projections (5) and (6) for horizons $h = 1$ to 8 and different specifications. All specifications control for our baseline controls. In "Additional controls" we also control for the extended it set of variables discussed in Section (3)). Errors are clustered at the country level. Dotted lines are the 95% confidence bands of the baseline specification (Figure (6)).

The persistence of new borrowing and the lead-lag relationship between new borrowing and debt service are very robust in the data. The patterns remains the same if we add time fixed effects (orange line with triangles, Figure 7) to the baseline specification or exclude the run-up and aftermath of the great financial crisis (green line with diamonds). It also remains the same if we include the additional controls, including credit spreads or changes in net-worth, from Section 3 in the specification (light blue line with circles).

The accounting relationship between lower autocorrelation (and lower maturities) and less time between the peak new borrowing and the peak in debt service is also borne out by the robustness checks. If we add the additional controls, shocks to new borrowing are less autocorrelated, which is largely due to decreased sample size. The impulse of new borrowing only remains statistically significantly positive for three years after which it turns negative. Given decreased persistence of new borrowing, the accounting framework would suggest that debt service should also peak earlier, which is indeed the case. Similarly, the autocorrelation is lower and maturities are shorter for the corporate sector. For this sector, we estimate that the impulse response of debt service following an increase in new borrowing peaks more quickly and the significant impact decays more rapidly compared to the household sector (Figure 17 in Appendix C). As the estimated impulses embed all factors that dynamically respond to the initial debt impulse, including changes in policy rates, these findings underscore the robustness of the accounting framework.

5 New Borrowing, Debt Service and Real Activity

In this section, we investigate the empirical effect of new borrowing on future real economic activity. We show that debt service represents the main transmission channel through which new borrowing affects subsequent output growth and the probability of crisis.

5.1 Effects on future output growth

To shed light on the link between new borrowing, b, debt service, s, and real output growth, Δy, we estimate local projections of the form

$$\Delta y_{i,t+h} = \mu_{y,i}^{h+1} + \beta_{yb}^{h+1} b_{i,t-1} + \beta_{ys}^{h+1} s_{i,t-1} + controls + \varepsilon_{y,i,t+h}^{h} \tag{7}$$

for increasing values of h. The estimates of β_{yb}^{h} and β_{ys}^{h} for successive values of h trace out the impulse response of GDP growth from unit increases in new borrowing and debt service, respectively.

Figure 8 shows that new household borrowing predicts a slowdown in output growth with a sizable delay, whereas an increase in household debt service has immediate

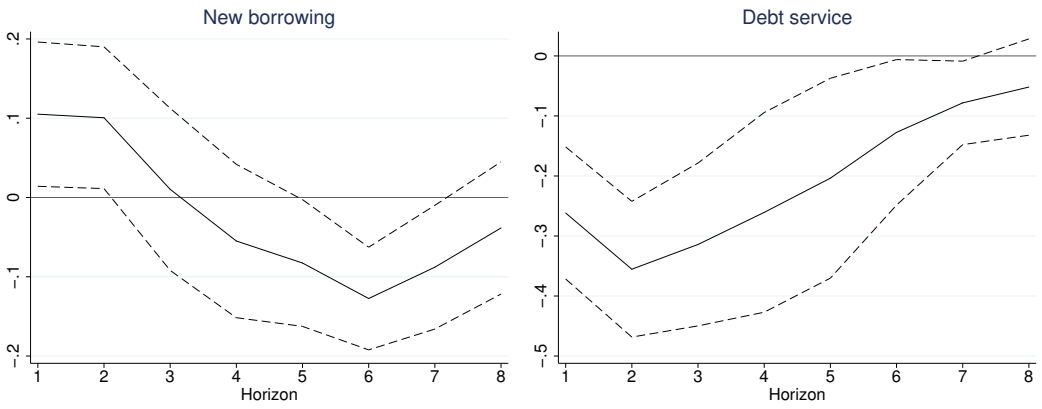

Figure 8: Impulse response of GDP growth after a unit increase in new household borrowing or household debt service at t_0 using local projections (7) for horizons $h = 1$ to 8 with our baseline controls (see Section (3)). Errors are clustered at the country level. Dotted line are the 95% confidence bands.

negative effects.[15] GDP growth significantly increases by around 10 basis points for the first two years following a percentage increase in new debt, after which it declines and becomes 10 basis points lower than normal in years 5 to 7 (Figure 8, left-hand panel). While these may seem like small numbers, peaks in new borrowing are on average between 5 to 10 percentage points higher than normal across countries, implying eventual losses of up to 1 percentage point of GDP growth. The negative effects of new borrowing at medium horizons are in line with the output responses to a unit change in the credit-to-GDP ratio that has recently been documented in the literature (see e.g. Mian et al. (2017)).

In contrast, the local projection on GDP growth of a unit increase in household debt service (right-hand panel) is large and significantly negative for the first three years and then starts to decline.[16] On impact, a unit increase in debt service decreases GDP growth by 25 basis points. This is also large as peaks in debt service are on average between 2 to 10 percentage points above normal across countries. This result is novel and highlights the value added of debt service in the presence of long-term debt contracts for understanding debt dynamics and their impact on the real economy.

The estimated output effects of new household borrowing and household debt service are robust to alterations in both sample and specification (Figure 9). In particular, the impact of debt service on output is always negative and highly significant at short horizons, whether we use only data up to 2005, add time fixed effects or additional controls. The results for new borrowing are somewhat more mixed. While the immediate

[15] Detailed estimates from several different specification at the 1, 3 and 5 year horizons are reported in Table 5 in Appendix D.

[16] This finding complements micro level evidence in e.g. Olney(1999), Johnson and Li (2010), and Dynan (2012) who document negative effects from debt service burdens on household expenditure.

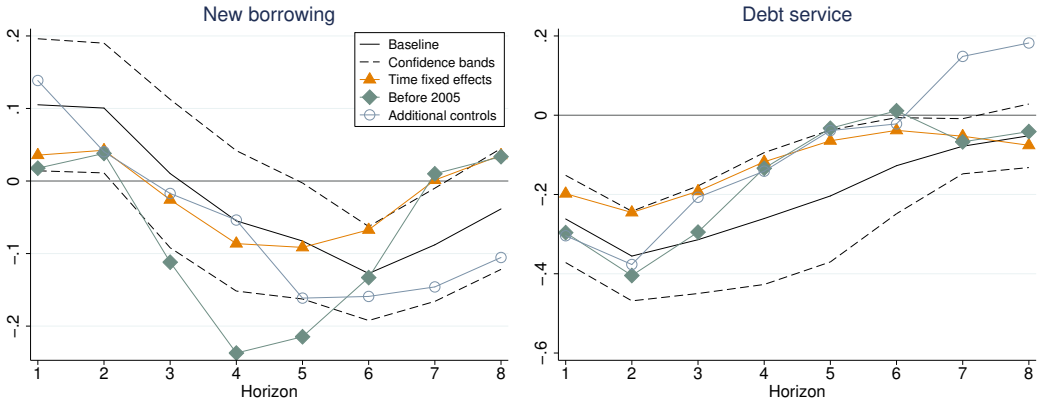

Figure 9: Impulse response of GDP growth after a unit increase in new borrowing or debt service at t_0 using local projections (7) for horizons $h = 1$ to 8 with different specifications. All specifications control for our baseline controls. In "Additional controls" we also control for the extended it set of variables discussed in Section 3). Errors are clustered at the country level. Dotted lines are the 95% confidence bands of the baseline specification (Figure 8).

year impact on output is always estimated to be positive, this effect is not significant for all specifications. In contrast, the significant and negative medium-term effects of new borrowing are a very robust feature of the data.

These results raise the question about long-run effects of household credit booms. Adding up the yearly effects displayed in Figure 8 (left-hand panel) suggests that the cumulative net effects of an impulse to new borrowing on output over the eight year period are negative. A similar picture also emerges from the robustness tests. This suggests that household credit booms and the ensuing predictable busts may have long-run deleterious effects on the level of output.[17] mirroring e.g. Cerra and Saxena (2008) who find that crises that follow credit booms are associated with permanent output losses.

From a high-level perspective, dynamics are similar for the corporate sector (see Figure 18 in Appendix C). Yet, coefficient estimates are lower and only weakly significant.[18] This is in line with Mian et al (2017) who found little impact of corporate debt on GDP. In light of the accounting framework and our previous results, it is nonetheless interesting to see that the medium-term negative effect of new borrowing on GDP occur earlier for the corporate sector (the minimum is in year 4) than for the household sector (the minimum is in year 6). But given the weak impact of new corporate borrowing on

[17] For a further elaboration on this point see Juselius et al. (2017).

[18] Significance levels are also somewhat sample dependent. For example, looking at expanding samples from 1995 to the end shows that in most samples new corporate borrowing has a significant negative impact in year 4 but not so if we end in the direct aftermath of the dot-com bubble. Corporate debt service, on the other hand, has a significant negative impact on GDP growth in the next year if the sample ends before the Great Financial Crisis. Corporate debt service has also a strong negative impact on next year's investment growth that is stable across samples.

GDP, we concentrate on household debt for the remainder of the paper.

The timing and delay between the impulse to new borrowing and the negative response of GDP growth closely match the timing between peaks in new borrowing and peaks in debt service (see Figure 6). This suggest that the negative effects of debt may be related to rising debt service in line with our accounting framework. We study this question next.

5.2 A novel method for decomposing local projections

To assess how much of the negative effects of new borrowing flow through debt service, we decompose the impulse response functions. We provide an intuitive description of our decomposition method in the following and develop a detailed formal description in Appendix B.

The local projections on GDP growth trace out the impulse response function that, after the first round, embodies all factors that dynamically respond to the initial debt impulse and feed into the real economy, including the future debt service obligations that it generates. Hence, they capture the "net effect" of the debt impulse. From equation (7) the net effect at time $t+h$ is

$$\text{net effect}_h = \beta_{yb}^h. \tag{8}$$

The part of the net effect that goes via debt service can be calculated in two steps. First, for any prediction horizon $h > 1$, we regress debt service at time $t+h-1$ on new borrowing (and controls) at time t as in equation (6). The coefficients on new borrowing, β_{sb}^{h-1}, from this regression tell us how debt service in $t+h-1$ changes due to a unit increase in new borrowing at t. Second, we know from estimating equation (7) that the direct effect of debt service at $t+h-1$ on output growth at $t+h$ is β_{ys}^1. Combining these estimates, we calculate the "debt service effect" as:

$$\text{debt service effect}_h = \beta_{ys}^1 \beta_{sb}^{h-1} \tag{9}$$

and the effects of all remaining factors as

$$\text{other effects}_h = \beta_{yb}^h - \beta_{ys}^1 \beta_{sb}^{h-1}. \tag{10}$$

The other effects will include, for example, any direct effects of new borrowing on output. If these are relevant at the aggregate level, we would expect them to be positive.

5.3 Decomposing the effect of borrowing on future output

The decomposition shows that increasing debt service can, to a large degree, account for the delayed slowdown in GDP growth following an initial increase in new household borrowing. This can be seen from Figure 10 which reports the net effect (black line), the debt service effect (beige bars) and other effects (light-blue bars) given the baseline specification up to 8 years after the debt impulse.

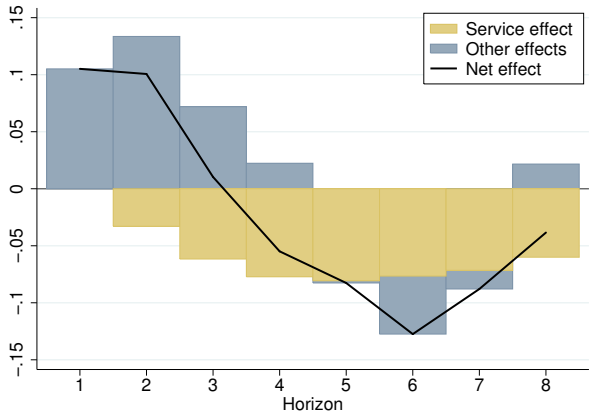

Figure 10: Decomposition of the net effect of new borrowing on future GDP growth (equation (8)) into the service effect (equation (9)) and the other effects (equation (10)) for horizons h=1 to 8, controlling for our baseline controls (see Section (3)).

The dynamics of these effects largely follow the predicted patterns from our accounting framework (Figure 2). Following an increase in new borrowing at t_0, the other effects are generally positive and decline over time. This is broadly in line with what one would expect from new borrowing and the fact that new borrowing is autocorrelated. The only real exception occurs in years 6 and 7 where the other effects are visibly negative. In contrast, the effects of debt service are always negative and increase until they reach their peak in year 5. The net effect - or the effect of net cash flow in terms of our accounting framework - turns negative in the third year. This is between the peak in new borrowing and the peak in debt service as our accounting framework predicts. The minimum net effect occurs in year 6 or in year 5 if one disregards the additional negative other effects.

The estimated service effect and other effects of the decomposition are robust. Figure 11 compares the baseline decomposition (top left-hand panel) to those obtained from several alternative specifications:[19]

Results from pre-2005 sub-sample (middle panel, top row) suggest that the results are neither driven by the Great Recession nor the boom that preceded it. As shown in Figure 9 the negative medium-term effects of new borrowing are even stronger in this sample than in the baseline specification. But so is the debt service effect. This may partly reflect the inability of central banks to lower nominal interest rates much below the zero lower bound in the most recent decade (e.g. Korinek and Simsek (2016)). Adding time fixed effects also does not change the picture qualitatively (right-hand panel, top row).

The debt service effect is very robust to the set of control variables, whereas the effect of new borrowing varies a bit more with the specification (second row). For

[19] We continue to add our baseline controls in all robustness checks, unless otherwise stated.

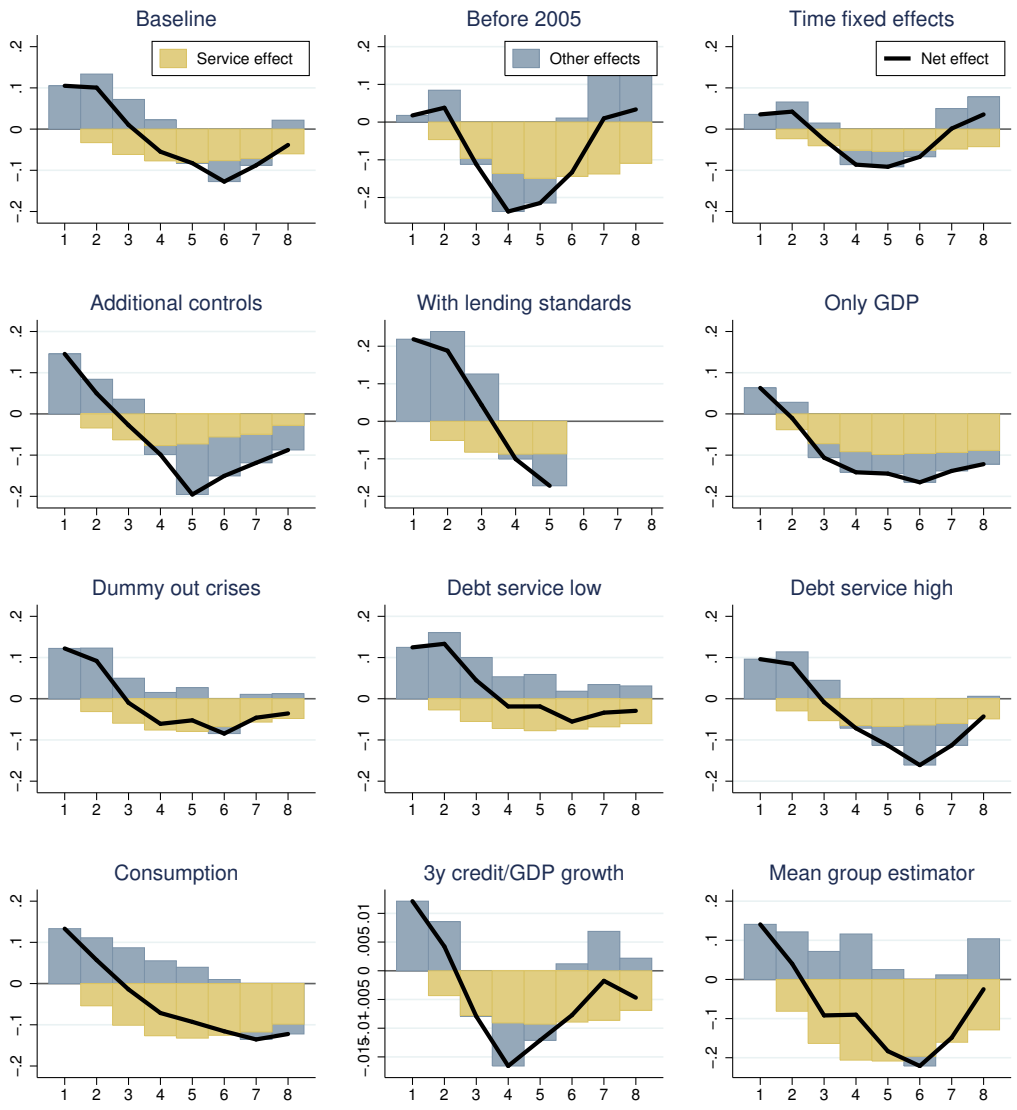

Figure 11: Decomposition of the net effect of new borrowing on future GDP growth (equation (8)) into the service effect (equation (9)) and the other effects (equation (10)) for horizons h=1 to 8, for different specifications. We always use our baseline controls (see Section (3)), except in "Only DGP" where we only control for 2 lags of GDP growth. In "Additional controls" we also add the extended set controls (see Section 3). "With lending standards" also controls for lending standards. Given limited data availability, projections are only undertaken up to horizon 5; "Dummy out crisis" adds country and crisis specific dummies taking the value of one in the year of a crisis and two years afterwards. "Debt service high" and "Debt service low" account for the possibility of a state dependent impact of new debt, where high\low states differentiate between periods when debt service is above\below the country specific mean at t_0. In "Consumption", we decompose the net effect of new borrowing on future consumption growth rather than real GDP growth. In "3y credit/GDP growth" we decompose the net effect of the three year growth rate in the household credit-to-GDP ratio on GDP growth instead of the net effect of new borrowing.

example, if we include the additional controls for net worth, credit spreads, provisions of the banking sector and additional business cycle indicators listed in Section 3, the effects of the new borrowing become slightly stronger in year one, yet turn more quickly downwards and reach lower levels in year 5. Given unchanged service effects, the other effects become now more strongly negative. Yet, the service effect continues to explain around 50% of the negative effects. Controlling for lending standards produces a similar picture.[20]Equally, controlling only for lags of GDP growth leaves the debt service effect unaffected whilst leading to stronger net-effects than in the baseline specification. These robustness checks are very reassuring as the decomposition could be misleading if the controls, or the lack thereof, bias our coefficient estimates.

The results in Figure 11 also suggest that the negative other effects of new borrowing in the medium run are state dependent (third row). For instance, financial crises seem to account for some of the negative effects of credit growth in the medium run. Once we add a country and time specific dummy for the crisis years and the next two years thereafter, the negative other effects in years 6 and 7 almost fully disappear. Equally, if debt service is low at t_0, new borrowing has far less negative net effects in the medium run than in the baseline specification (or than if debt service is originally high). But as the initial conditions do not seem to matter for the debt service effect, the other effects are positive in this case.

There also seem to be no other negative effects of new borrowing if we consider the impact on real consumption growth rather than GDP growth (left-hand panel, lower row). In this case, the effects of new debt and debt service are more pronounced as could be expected given our focus on household debt. Interestingly, the estimated decomposition looks virtually identical to our analytical results with long-term debt when shocks to new borrowing are autocorrelated (as simulated in Figure 3).

It is also interesting to relate our results to previous findings in the literature. Mian et al. (2017) find that credit-booms – defined by three-year growth in the household debt-to-GDP ratio – can predict subsequent slowdowns in GDP growth. To compare our results with theirs, we replace new borrowing with the three-year growth rate in debt-to-GDP in our set-up(9). The predicted negative effects on future GDP growth from a unit increase in the three-year growth rate in debt-to-GDP - corresponding to our net effect - documented by Mian et al. (2017) also hold in our sample (middle panel, lower row). And as before debt service can almost fully account for these negative effect.

Using the mean group estimator (Pesaran and Smith (1995)) shows that the panel homogeneity assumption seems restrictive, in particular for the debt service effect (right-hand panel, lower row). In this case, the debt service effect becomes much larger than in other specification (around 2.5 times in comparison to the baseline). The net-effects are also larger, yet the other effects are positive (except in year 6 where they are close to zero). Given the strong results, it is unsurprising that the decomposition also holds at the country level despite the fact that we have at most 35 years of data

[20]Data in this case are very limited. With the exception of the US, lending standards have only been recorded since 2003 or even 2006 if they are available at all. We therefore only show local projections up to horizon 5.

for an individual country (see Figure 20 in the Appendix D). The marked impact of allowing for country heterogeneity suggests that differences in financing conditions, such as different maturity structures or fixed versus floating rates, have implications for the transmission of new debt to debt service and the economy more broadly.

5.4 Effects on the probability of crises

There is a growing empirical literature on the link between credit booms and financial crises (e.g. Borio and Lowe (2002), Reinhart and Rogoff (2009) or Schularick and Taylor (2012)) that finds strikingly similar lead-lag relationships to the ones that we report for debt and output growth. For instance, a large increase in the debt-to-GDP ratio above a long run trend substantially increases the probability of a banking crisis. In this section, we investigate the extent to which projected future debt service, resulting from a debt impulse, can account for the increase in crisis probability.[21] This is also natural from a theoretical perspective because it is the debt service obligations, not borrowing in itself, that risk triggering defaults by borrowers, and ultimately a financial crisis.

To study the effects of new borrowing and debt service on the probability of banking crises, we adapt our previous empirical framework to binary response models. We take the crisis indicator at $t+h$ as the outcome variable and use it to model the probability of a crisis conditional on new borrowing, debt service and our baseline control variables in a panel logit framework with country fixed effects. To avoid post-crisis bias, we drop the first two 2 years after a financial crisis (Bussiere and Fratzscher (2006)). As robustness checks, we also use simple OLS with panel fixed effects, additional macro controls, the alternative crisis definition and the 5 year growth rate in the debt-to-GDP ratio in place of new borrowing.[22]

The local projections show that both new borrowing and debt service increase the probability of a crisis, but the effect of debt service is more direct whereas the effect of new borrowing takes time to materialize. This can be seen from Figure 12 which shows the estimated local projections on the probability of crisis from unit increases to these two variables. New borrowing (left panel) does seem to have some impact on the likelihood in the following year, but the strongest and most significant effects are for years 4 and 5. By contrast, a unit increase in debt service (right panel) has a large and significant effect on the crisis probability in years 1 to 3 after which it declines slowly and becomes insignificant. This is consistent with the lead-lag relationship between new borrowing and debt service that we identified earlier.

Our results are robust across a range of specifications (Figure 13). The results are nearly identical if we use the broader crisis definition of Reinhart and Rogoff (2009).

[21] A few recent studies that look at debt service in this context find that it is an excellent early warning indicator, particularly at shorter forecasting horizons (e.g. Drehmann and Juselius (2013), Detken et al (2014)).

[22] Since we only observe household debt service for Korea from 1996 onward, we drop the Korean crisis from our model.

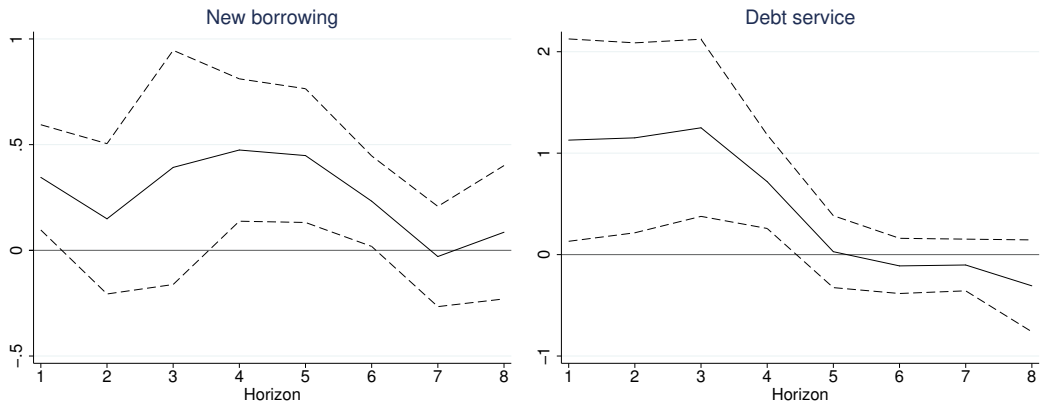

Figure 12: The impact of new borrowing and debt service on the probability of crises as measured by the respective coefficients in local projections for horizons $h = 1$ to 8. We estimate a panel logit with country fixed effects and control for our baseline controls (see Section (3)). Dotted line are the 95% confidence bands.

Equally, coefficient estimates for both new borrowing and debt service are very similar for years 1 and 2 if we drop all additional controls. And even in the following years, they are not significantly different from the baseline estimates. Differences seem most stark if we additionally control for corporate credit spreads and banking sector provisions. However, this is due to a reduction in sample size, implying also four less crisis observations.[23]

5.5 Decomposing the effect of debt on the crisis probability

Our results are, as before, suggestive of debt service being the main variable through which a credit boom leads to a higher probability of a crisis in the future. This is formally confirmed in Figure 14 which decomposes the local projections from a unit increase in debt on the crisis probability into the service effect and other effects (upper panel) in a similar manner as in Section 5.3: debt service always has a sizable positive effect on the crisis probability. And after year one where the debt service effect is zero by construction, it almost fully explains the net effect of new borrowing.

The estimated service effect and other effects are robust (Figure 15). For instance, relying on the broader crisis definition in Reinhart and Rogoff (2009) (upper left-hand panel), adds 3 further crisis to the previous 19 crisis observations, but has a limited impact on our decomposition.

Corporate credit spreads and banking sector provisions seems to explain most of

[23]The sample size drop from more than 400 to 258 if we include provisions and corporate credit spreads. If we run our baseline specification on this restricted sample, the debt service coefficient in period 1 is for example 2.124 versus 2.166 if we include provisions and spreads as shown in Figure 13. Given the limited number of crisis observations, we could not employ our extended set of controls.

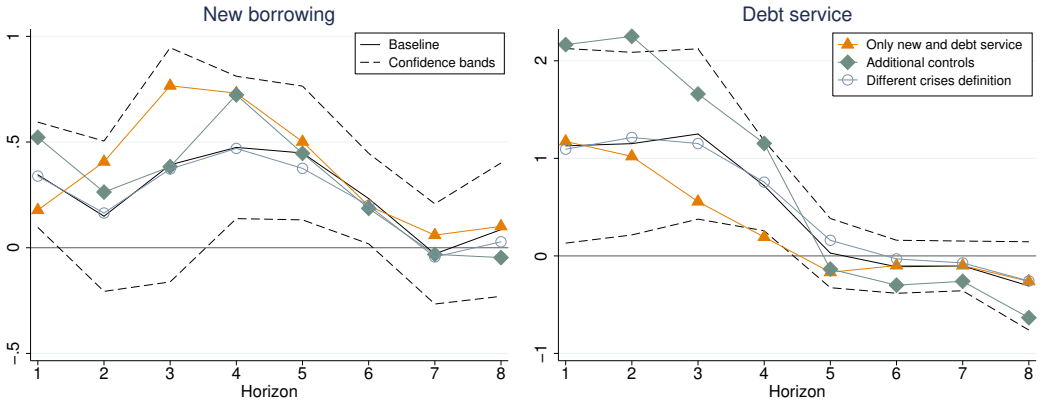

Figure 13: The impact of new borrowing and debt service on the probability of crises as measured by the respective coefficients in local projections for horizons $h = 1$ to 8 for different specifications. All models are estimated using a panel logit with country fixed effects and controlling for our baseline controls (see Section (3)), except in "Only new borrowing and debt service" which includes no further controls. In "Additional controls" we also control for corporate credit spreads and banking sector provisions. Dotted line are the 95% confidence bands of the baseline specification.

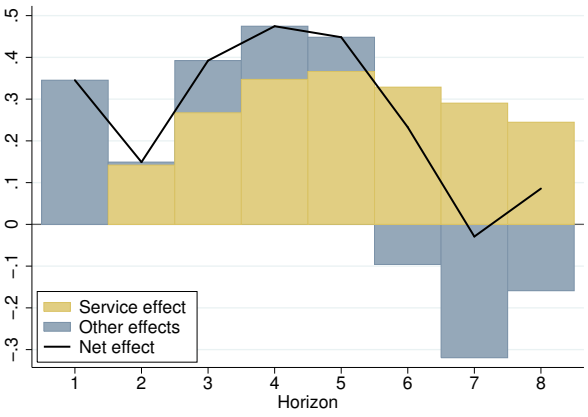

Figure 14: Decomposition of the net effect of new borrowing on the future likelihood of crises (equation (8)) into the service effect (equation (9)) and the other effects (equation (10)) for horizons h=1 to 8, controlling for our baseline controls (see Section (3)).

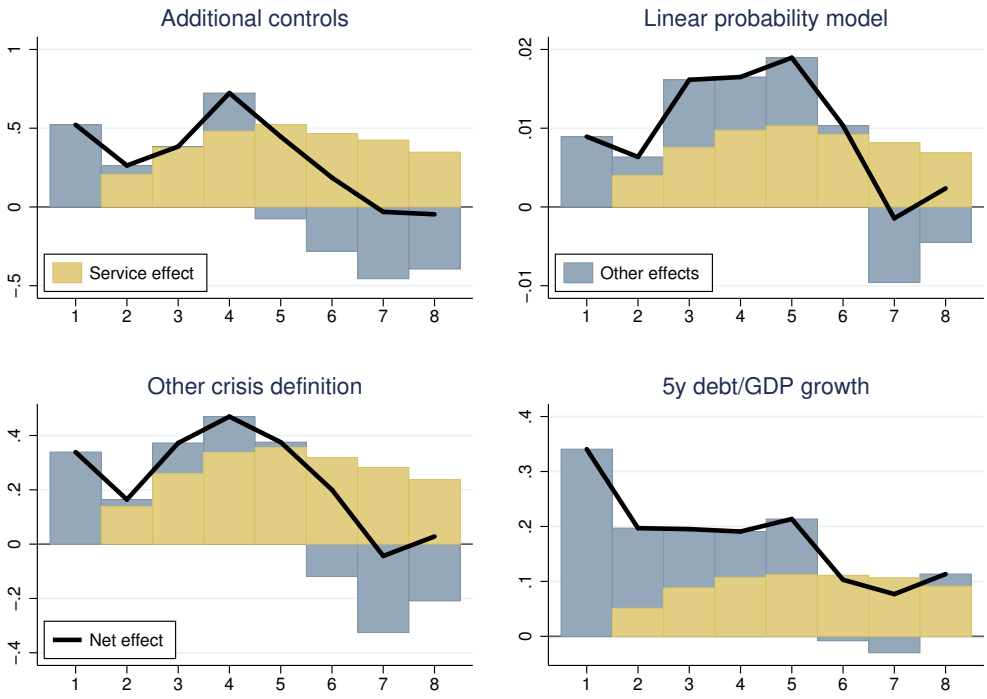

Figure 15: Decomposition of the net effect of new borrowing on the future likelihood of crises (equation (8)) into the service effect (equation (9)) and the other effects (equation (10)) for horizons h=1 to 8, for different specifications. We always include our baseline controls (see Section (3)). In "Other crisis definition" we rely on Reinhart and Rogoff 2008) for additional crisis dates prior to the Great Financial Crisis. In "Additional controls" we also control for banking sector provisions and corporate credit spreads. In "Linear probability model" we use instead of a panel logit model a simple panel OLS approach. In "5y debt to GDP growth" " we decompose the net effect of the five year growth rate in the household credit-to-GDP ratio on probability of crisis instead of the net effect of new borrowing.

the positive other effects (upper right hand panel). If we control for both variables in addition to the baseline controls at time t_0, the net effect is only marginally affected, whereas the debt service effect is strengthened. Hence, other effects are now zero or even reduce the probability of financial crisis except in year 4.[24]

Using 5 year changes in the household debt-to-GDP ratio instead of new borrowing, as is more common in the literature (e.g. Schularick and Taylor (2012)), reduces the debt service and net effects. Interestingly, the changes offset each other so that the other effects in particular in years 3 to 5 are virtually unchanged.

5.6 Comparison with alternative measures of credit booms

It is worthwhile to ask how our measures – new borrowing and debt service normalized by GDP – compare to other measures of credit booms that have traditionally been used in the empirical macro-finance literature, such as credit-to-GDP ratios.

Conceptual differences Conceptually, one difference is that our measures capture flows between borrowers and lenders, which enter budget constraints and thus encapsulate contemporaneous and future liquidity effects of credit relationships, as emphasized eg by Eberly and Krishnamurthy (2014). Traditional measures, on the other hand, relate to credit stocks. Changes in the stock of credit are a function of the flow of new borrowing and of amortizations but not of the flow of interest payments, as we emphasized in equation (1) in our accounting framework. Whether stock or flow concepts have more explanatory power for real variables is ultimately an empirical question that we examine below. However, if the described flows matter, the stock of credit or even changes in the stock are imperfect measures of these flows.

A second difference is that credit-to-GDP ratios have been growing for decades in most countries. To econometrically deal with trending variables, researchers have therefore either detrended (e.g. Drehmann et al (2010)) or differenced credit-to-GDP ratios (e.g. Schularick and Taylor (2012)) in empirical work linking credit booms to real developments, which reduces the informational content inherent in these variables and makes it more difficult to economically interpret the estimated relationships. Calculating debt service, by contrast, can be seen as an economically meaningful way of detrending the credit-to-GDP ratio, since low-frequency changes in the terms of credit over the past four decades, such as declines in nominal interest rates, have roughly offset the upward trends in credit-to-GDP ratios.[25]

Relevance for real variables Ultimately, however, we are interested in determining whether our measures of new borrowing and debt service outperform traditional credit-to-GDP measures in empirical applications. To assess this, we run a horse race. The

[24] Given the limited number of crisis observations, the logit model does not converge anymore if even more controls are added

[25] Technically speaking there is a cointegrating relationship between credit-to-GDP ratios and interest rates (Juselius and Drehmann (2014)).

	Dependent variable: $\Delta y_{i,t+1}$								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$b_{i,t}$	0.11**					0.09	0.13**	0.13	0.09*
	(0.05)					(0.06)	(0.05)	(0.074)	(0.04)
$s_{i,t}$	−0.26***					−0.26***	−0.26***	−0.26***	−0.29***
	(0.06)					(0.06)	(0.06)	(0.05)	(0.06)
$\Delta d_{i,t}$		0.04				0.01			
		(0.03)				(0.03)			
$\Delta_3(d-y)_{i,t}$			0.27				−0.69		
			(1.03)				(1.25)		
gap^M				0.50				−0.32	
				(0.36)				(0.68)	
gap^{HP}					4.98				6.51**
					(3.11)				(2.80)
R^2	0.53	0.49	0.51	0.52	0.50	0.52	0.54	0.55	0.54
Obs	529	529	509	495	529	529	509	495	529

Table 1: The effects of different credit boom measures on output growth: $b_{i,t}$new borrowing; $s_{i,t}$ debt service; $\Delta d^r_{i,t}$ real annual credit growth; $\Delta_3(d_{i,t}-y_{i,t})$ three year growth rate in the credit-to-GDP ratio; gap^Mdeviation of the credit-to-GDP ratio from its filtered one-sided HP trend with $\lambda = 1600$; gap^{HP} credit-to-GDP gap based on the two-sided HP filter with $\lambda = 6.25$ for annual data. All models are estimated with panel fixed effects and our baseline controls (see Section 3). Standard errors in parenthesis are clustered along the country dimension. ***/**/* indicates significance at the 1% / 5% / 10% level.

alternative measures that we consider are the one-year growth rate of real debt, $\Delta d^r_{i,t}$, the three year growth rate in the credit-to-GDP ratio, $\Delta_3(d_{i,t}-y_{i,t})$,[26] the credit-to-GDP gap that filters out medium-term cycles and that is used under Basel III to calibrate countercyclical capital buffers, gap^M,[27] and a credit-to-GDP gap based on the two-sided Hodrick-Prescott filter, gap^{HP}, with $\lambda = 6.25$, as is standard for annual data. We first assess their predictive performance for one-year ahead GDP growth and then for the probability of banking crises.

Debt service and new borrowing strengthen the empirical relationships for one-year-ahead GDP growth compared to alternatives where these two variables are left out (Table 1). As can be seen from columns (1)-(5), only new borrowing and debt service are significant predictors of future output one year ahead. On their own, other measures are insignificant. New borrowing and debt service also explain a larger share of the variation in the data as captured by R^2. Similar results emerge if new borrowing and debt service are added jointly with each of the alternative measures in turn (columns (6)-(9)). The debt service effect, in particular, remains remarkably stable and significant when including alternative measures. New borrowing is slightly more sensitive, suggesting that there might be some overlap in what is captured by new borrowing and

[26]The five-year growth rate in the credit-to-GDP ratio used for instance by Jorda et al (2013) performs similarly to the three-year growth rate.

[27]The medium-term credit gap is the deviation of the credit-to-GDP ratio from its HP filtered one-sided trend with $\lambda = 1600$ for annual data.

	Dependent variable: I (crisis at time $t+1$)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$b_{i,t}$	0.18**					0.22*	0.18	0.08	0.20
	(0.09)					(0.11)	(0.12)	(0.18)	(0.12)
$s_{i,t}$	1.17***					1.16***	1.15**	1.07**	1.46***
	(0.43)					(0.44)	(0.45)	(0.47)	(0.45)
$\Delta d^r_{i,t}$		0.03				−0.03			
		(0.04)				(0.08)			
$\Delta_3(d-y)_{i,t}$			5.96**				−0.40		
			(2.54)				(3.32)		
gap^M				4.27***				2.25	
				(1.63)				(3.96)	
gap^{HP}					0.93				−22.35**
					(8.34)				(9.36)
Pseudo R^2	0.10	0.01	0.02	0.03	0.01	0.10	0.11	0.11	0.11
AUC	0.87	0.60	0.70	0.69	0.62	0.87	0.87	0.87	0.89
AUC low	0.79	0.53	0.60	0.58	0.55	0.79	0.78	0.78	0.81
AUC high	0.96	0.67	0.79	0.80	0.69	0.96	0.95	0.95	0.96
Obs	418	420	384	370	426	417	384	370	418

Table 2: The effects of different credit boom measures on the likelihood of crises: $b_{i,t}$new borrowing; $s_{i,t}$ debt service; $\Delta d^r_{i,t}$ real annual credit growth; $\Delta_3(d_{i,t}-y_{i,t})$ three year growth rate in the credit-to-GDP ratio; gap^Mdeviation of the credit-to-GDP ratio from its filtered one-sided HP trend with $\lambda = 1600$; gap^{HP} credit-to-GDP gap based on the two-sided HP filter with $\lambda = 6.25$ for annual data. All models are estimated as panel logit with country fixed effects but no further controls. Standard errors in parenthesis are clustered along the country dimension. AUC: area under the ROC curve as measure of signalling quality with AUC low/high lower and upper confidence bands. The indicator outperforms a random variable if the AUC is significaly different from 0.5. The perfect indicator has AUC=1. ***/**/* indicates significance at the 1% / 5% / 10% level.

the alternative measures of debt.

Our results in Table 1 also lend support to the view that the liquidity effects of credit booms, captured by new borrowing and debt service, play a significant role in driving real output dynamics as argued, for example, by Eberly and Krishnamurthy (2014).

In predicting financial crises in the next year, similar conclusions on the relevance of new borrowing and debt service versus other measures of credit booms apply (Table 2). As can be seen from column (1), both debt service and new borrowing significantly increase the probability of a financial crises one period ahead, and the within-sample predictive performance of the model is very high (AUC = 0.87). Out of the alternative measures, both the three year growth rate in credit-to-GDP and the medium-term credit-to-GDP gap perform well, although their within sample predictive performance is substantially lower (with AUCs around 0.70). Debt service, in particular, compares favorably to the other measures in joint specifications (columns (6)-(9)). Again, there seems to be some collinearity between new borrowing and other measures of debt. For instance, new borrowing, the three year growth rate in credit-to-GDP and the medium-

term credit-to-GDP gap all become insignificant in the joint specification, and the standard HP filtered gap even becomes negative.

When interpreting the results in Table 2 from a policy perspective, it is important to keep in mind that macroprudential policies tend to require a longer lead time than one year. For instance, under the Basel III rules, banks have 12 months to comply with an increase in countercyclical capital buffer requirements. In addition, data are reported with lags, and policy makers generally tend not to act on data developments immediately, but observe trends for some time before they change policies (e.g., Bernanke, 2004). As the signalling quality of debt service decreases over time (Figure 12), the medium-term credit-to-GDP gap or medium-term growth rates in credit-to-GDP ratios are important inputs in steering macroprudential policies to reduce medium-term financial cycle risks.[28]

6 Conclusions

This paper shows that debt service accounts for much of the adverse real effects of credit, systematically linking past credit booms to predictable future slumps in economic activity. We lay out a simple accounting framework that describes how debt service can build up with a sizable lag if debt is long-term and new borrowing is auto-correlated, as it typically is in the data. In a panel of 17 countries from 1980 to 2015, we show that the lag between peaks in new borrowing and debt service is on average four years for the household sector. We also show that predicted future debt service accounts for the majority of the transmission mechanism from an impulse to household borrowing to predicted output losses and increases in crisis probability in the medium run.

Our findings raise several important questions related to the measurement and theory of credit cycles. For one, given the important real effects of debt service, it is crucial to improve its measurement. It would be particularly beneficial to obtain more regular and granular information on maturity and amortization schedules. This applies to the household sector, and the more so to the corporate sector, where these data are not too reliable. While our preliminary results for the corporate sector in Annex C confirm the findings for the household sector, better data and more work is needed to enhance our understanding of the transmission from corporate borrowing to the real economy.

Our results also highlight the need for theory models to incorporate the credit market features that account for the lag structure of debt service in the data. In particular, doing justice to the data requires auto-correlated new borrowing and long-term debt.[29] Furthermore, the strong and systematic pattern in output and crisis

[28] Comparing the medium-term credit-to-GDP gap and debt service, Drehmann and Juselius (2014) find that the medium-term credit-to-GDP gap performs well, even over horizons of up to five years ahead of crises, but that debt service is a very precise early warning indicator two years ahead of crises. They also show that combining the information from the two indicators is ideal from a policy perspective.

[29] Garriga et al (2013) and Gelain et al (2015) have recently incorporated long-term debt in quantitative models of credit fluctuations.

probabilities that is generated by flows from lenders to borrowers and vice versa begs explanation. This pattern is consistent with models in which lenders and borrowers have different marginal propensities to consume and borrowers are financially constrained so the negative demand effects of high debt service cannot be offset by additional borrowing. Monetary policy cannot counter the resulting aggregate demand effects when it is constrained by the zero lower bound.[30] However, our paper also finds strong negative output effects of debt service that seem to have not been offset by monetary policy during normal times. This raises the question of why, which we leave for future research.

The systematic transmission channel whereby credit expansions can have long-lasting adverse real effects also raises important questions for policy makers. Our empirical results highlight that new borrowing has positive effects but debt service negative effects on the real economy. But the accounting relationship implies a clear link between new borrowing and future debt service. Hence, this raises question such as how policymakers should optimally respond and how they should trade off current output concerns with future debt service obligations. We hope that our findings will be useful for future efforts to better model financial cycles and optimal policy.

[30]For models that explain the real effects of the financial crisis of 2008/09 through this prism, see e.g. Eggertsson and Krugman (2013), Guerrieri and Lorenzoni (2011) and Korinek and Simsek (2016).

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A Proofs and Additional Results

A.1 Lag Structure Between New Borrowing, Net Cash Flows, and Debt Service

Proof of Proposition 1 (i) At the peak of new borrowing t^*, debt is still growing $\Delta D_{t^*+1} = -\delta D_{t^*} + B_{t^*} > 0$ if new borrowing exceeds amortization, $B_{t^*} > \delta D_{t^*}$ at t^*. An upper bound on debt D_{t^*} is $t^* B_{t^*}$. Our analytic condition on timing implies that $\delta D_{t^*} \leq \delta t^* B_{t^*} < B_{t^*}$ so debt is still growing at the peak of new borrowing and $\Delta D_{t^*+1} > 0$. Debt service is a linear transformation of the stock of debt outstanding $S_t = (\delta + r) D_t$ and therefore peaks after t^*.

At the peak $\hat{t}$ in the stock of debt, we find $\Delta D_{\hat{t}} > 0 > \Delta D_{\hat{t}+1}$. If we consider a higher amortization rate $\tilde{\delta} > \delta$, the resulting time series for the stock of debt $\tilde{D}_t$ features $\Delta \tilde{D}_{\hat{t}} < \Delta D_{\hat{t}}$, which turns negative weakly before $\hat{t}$. Since the peak in new borrowing is exogenous, the lag $t^* - \hat{t}$ is decreasing in δ.

(ii) The change in the net cash flow at the peak of new borrowing issuance t^* is given by $\Delta N_{t^*+1} = \Delta B_{t^*+1} - \Delta S_{t^*+1}$. At t^*, we find that $\Delta B_{t^*+1} < 0$ by the definition of the peak in new borrowing, and the second term is negative since, per point (i), $\Delta D_{t^*+1} > 0$ and $S_{t^*+1} = (r + \delta) D_{t^*+1}$. This implies that net cash flow is already declining at t^* or earlier.

Our condition on the timing of new borrowing implies $(\delta + r) D_{t^*} < (\delta + r) t^* B_{t^*} < B_{t^*}$. As a result, we find $N_{t^*} > 0$ so net cash flow is still positive at the peak in new borrowing. Furthermore, after the the credit boom at time $T + 1$, we observe that $N_{T+1} = -(\delta + r) D_{T+1} < 0$. Taken together, $N_{t^*} > 0 > N_{T+1}$, proving point (ii) of the proposition.

Proposition 1 in continuous time The results of Proposition 1 on the lag structure between new borrowing, debt service, and net cash flows can be proven with strict inequalities when we move to a continuous time framework.

Consider an exogenous hump-shaped process of new borrowing over a continuous interval $[0, T]$ that satisfies $B_0 = B_T = 0$ and $B_t > 0$ in between, i.e. for $t \in (0, T)$. The process is continuous and differentiable over the interval $[0, T)$ with a single maximum at t^* so that $\dot{B} > 0$ for $t \in [0, t^*)$ and $\dot{B} < 0$ for $t \in (t^*, T)$, i.e. new borrowing is increasing up to its peak and decreasing after the peak. Furthermore, assume that the process of new borrowing until the peak t^* is reached is not too drawn out over time, captured by the analytic condition $(\delta + r) t^* < 1$. After T, we assume no further issuance so $B_t = 0$ for $t > T$.

Given these assumptions, total debt outstanding grows at rate

$$\dot{D}_t = B_t - \delta D_t \tag{11}$$

The two statements that are the equivalent of Proposition 1 in continuous time and their respective proofs are as follows (with the modifications due to the continuous time setup emphasized in bold):

*(i) The peak in debt service $\hat{t}$ occurs after the peak in new borrowing t^*. The lag between the two peaks $t^* - \hat{t}$ is **strictly** decreasing in δ.*

Proof. At the peak of new borrowing t^*, debt is still growing $\dot{D}_t > 0$ if borrowing exceeds amortization, $B_t > \delta D_t$. An upper bound on debt D_{t^*} is $t^* B_{t^*}$. Our analytic condition on timing implies that $\delta D_{t^*} < \delta t^* B_{t^*} < B_{t^*}$ so debt is still growing at the peak of new borrowing and $\dot{D}_{t^*} > 0$. Debt service is a linear transformation of the stock of debt outstanding $S_t = (\delta + r) D_t$ and is therefore also still growing at t^* when debt issuance is starting to decline.

Let us denote the peak of debt service by $\hat{t} > t^*$, which is when the change in the stock of debt peaks so $\dot{D}_{\hat{t}} = 0$. We observe that $\hat{t} < T$, i.e. the stock of debt and debt service peak before the process of new borrowing is over at T, since $\dot{D}_T = -\delta D_T < 0$. In summary, $\hat{t} \in (t^*, T)$. □

*(ii) The net cash flow from lenders to borrowers peaks **strictly** before the peak in new borrowing and turns negative after the peak in new borrowing but **strictly** before the end of the credit boom. Net cash flow reaches its minimum after the peak in debt service.*

Proof. Net cash flows in our setting here are given by $N_t = B_t - (\delta + r) D_t$ with derivative

$$\dot{N}_t = \dot{B}_t - (\delta + r) \dot{D}_t \tag{12}$$

At the peak of new borrowing t^*, we find that $\dot{N}_{t^*} < 0$ because the first term $\dot{B}_{t^*} = 0$ by the definition of the peak, and the second term is negative since we have just shown that $\dot{D}_{t^*} > 0$. This implies that net cash flow is already declining at t^* when new borrowing reaches its peak, proving the first part of the statement.

Our condition on the timing of new borrowing implies $(\delta + r) D_{t^*} < (\delta + r) t^* B_{t^*} < B_{t^*}$. This implies that $N_{t^*} > 0$ so net cash flow will turn negative *after* the peak in new borrowing. Furthermore, at the end of the credit boom, we observe that $N_T = -(\delta + r) D_T < 0$. Taken together, $N_{t^*} > 0 > N_T$, and by continuity of N_t there must be a value $t^* < t < T$ such that $N_T = 0$, proving the second part of the statement

Finally, we observe that net cash flow is still declining when the level of debt and debt service peak at $\hat{t}$ since

$$\dot{N}_{\hat{t}} = \dot{B}_{\hat{t}} - (\delta + r) \dot{D}_{\hat{t}} = \dot{B}_{\hat{t}} - 0 < 0$$

This proves the last part of the statement. □

Proof of Proposition 2 The peak in debt service coincides with the peak in debt. Although equation (4) is derived for integer values of t, it defines a continuous function of t with a maximum that is interior to the interval $[0, \infty)$. Maximizing the expression with respect to t yields the first-order condition

$$\ln(1 - \delta) \cdot \left[1 - \left(\frac{\rho}{1 - \delta} \right)^{t+1} \right] = \left(\frac{\rho}{1 - \delta} \right)^{t+1} \ln \left(\frac{\rho}{1 - \delta} \right)$$

which readily simplifies to the expression reported in the proposition,

$$\hat{t} = \frac{\ln\left[\ln\rho/\ln\left(1-\delta\right)\right]}{\ln\left(1-\delta\right)-\ln\rho} - 1$$

By definition, the maximum of the continuous function is within ± 1 of the integer function. The sign of $d\hat{t}/d\rho$ equals the sign of the expression $\frac{\ln(1-\delta)}{\ln\rho} - 1 - \ln\left[\frac{\ln(1-\delta)}{\ln\rho}\right]$. Define $x = \frac{\ln(1-\delta)}{\ln\rho} > 0$ and observe that the function $f\left(x\right) = x - 1 - \ln x$ is strictly positive for $x \neq 1$.

Proposition 2 in continuous time In continuous time, we consider the same exponentially declining process of new borrowing $B_t = \rho^t = e^{-\eta t}$ as in the discrete version of Proposition 2, where $\eta = -\ln\rho$. The statement that is the equivalent of Proposition 2 in continuous time and its proof are as follows:

Following a unit impulse of new borrowing that decays at rate $\eta \neq \delta$ with $\eta, \delta \in (0,1)$, debt service peaks at

$$\hat{t} = \frac{\ln\eta - \ln\delta}{\eta - \delta}$$

which satisfies $d\hat{t}/d\eta > 0$ and $d\hat{t}/d\delta < 0$.[31]

(The difference from the discrete-time case is that we can determine the exact peak instead of providing an interval that contains the peak in debt service.)

Proof. We substitute this process into the law of motion (11) and (for $\eta \neq \delta$) solve the resulting differential equation to find

$$\begin{aligned} D_t &= \int_{s=0}^{t} e^{-(t-s)\delta} e^{-\eta s} ds = e^{-t\delta} \int_{s=0}^{t} e^{s(\delta-\eta)} ds \\ &= e^{-t\delta}\left[\frac{e^{s(\delta-\eta)}}{\delta-\eta}\right]_{s=0}^{t} = e^{-t\delta}\left[\frac{e^{t(\delta-\eta)}-1}{\delta-\eta}\right] = \frac{e^{-\eta t}-e^{-t\delta}}{\delta-\eta} \end{aligned}$$

The maximum of debt service, coinciding with the maximum in the debt stock, is given by the first-order condition to $\max_t D_t$, or equivalently,

$$\eta e^{-\eta t} = \delta e^{-t\delta}$$

$$\text{which can be solved for } \hat{t} = \frac{\ln\eta - \ln\delta}{\eta - \delta}$$

which satisfies

$$\frac{d\hat{t}}{d\eta} = \frac{\frac{\eta-\delta}{\eta} - \ln\eta + \ln\delta}{\left(\eta-\delta\right)^2} = \frac{1 - \frac{\delta}{\eta} + \ln\frac{\delta}{\eta}}{\left(\eta-\delta\right)^2} < 0$$

$$\frac{d\hat{t}}{d\delta} = \frac{-\frac{\eta-\delta}{\delta} + \ln\eta - \ln\delta}{\left(\eta-\delta\right)^2} = \frac{1 - \frac{\eta}{\delta} + \ln\frac{\eta}{\delta}}{\left(\eta-\delta\right)^2} < 0$$

[31] In the case $\eta = \delta$, the solution is $D_t = e^{-\eta t}t$ which is maximized at $\hat{t} = 1/\eta$.

The inequalities follow since the function $f(x) = 1 + x - \ln x$ satisfies $f(x) < 0 \, \forall x \neq 1$. Since $sign\left(d\hat{t}/d\rho\right) = -sign\left(d\hat{t}/d\eta\right)$, the signs are the same as in the discrete time case. □

A.2 Accounting for Write-Downs and Default

If we account explicitly for write-downs and default, the laws-of-motion in our accounting framework are modified in two ways.

Missed payments First, borrowers may default on the flow of debt service by missing an amount M_t of the debt service payments that they owe. This implies an actual flow of debt service payments

$$S_t = (\delta + r) D_t - M_t \tag{13}$$

We assume that missed payments M_t are added to the stock of debt and are, for simplicity, compounded at the same interest rate r.

Write-downs Secondly, lenders may write down an amount W_t of the stock of debt. As a result, the modified law of motion for debt is

$$D_{t+1} = (1 - \delta) D_t - W_t + B_t + M_t \tag{14}$$

and the net cash flow from lenders to the borrowers in a given period t satisfies

$$N_t = B_t - S_t = B_t - (\delta + r) D_t - M_{t-1} \tag{15}$$

Mapping to the data Our measurement of new borrowing and debt service is affected as follows:

The data series on the stock of debt fully accounts for the implications of both write-downs and missed payments, captured by the two new terms in equation (14). To obtain a times series of new borrowing that accounts for these effects, we thus have to add back write-downs and subtract missed payments,

$$B_t = \Delta D_{t+1} + \delta D_t + W_t - M_t$$

The time series for debt service owed that we constructed in Section 3 is based on actual interest paid (which *excludes* missed interest obligations) and estimated amortizations owed (which *include* missed amortizations). If we assume that borrowers miss interest and amortization in equal proportion m, then missed payments are described by

$$M_t = m (\delta D_t + r D_t) \tag{16}$$

Actual interest payments are then given by the expression

$$R_t = (1-m)\, r D_t \tag{17}$$

If D_t, M_t and R_t are observable in the data and we use our usual imputation procedure for amortization δ, we can eliminate r and solve the two equations (16) and (17) for m. This allows us to obtain both debt service obligations $\delta D_t + R_t/(1-m)$ as well as actual debt service flows $S_t = (1-m)\,\delta D_t + R_t$.

A.3 Debt service on installment loans

Consider a debt in the amount of D at interest rate r that is to be repaid in m equal future installments. The value of debt must equal the present discounted value of m future debt service payments S, discounted at the interest rate r. This gives rise to the geometric series

$$D = \frac{S}{1+r} + \cdots + \frac{S}{(1+r)^m} = \frac{S}{(1+r)^m} \cdot \left[1 + \cdots + (1+r)^{m-1}\right] = \frac{S}{(1+r)^m} \cdot \frac{1-(1+r)^m}{1-(1+r)}$$

or equivalently

$$S = \frac{rD}{1-(1+r)^{-m}} \tag{18}$$

Debt service as a fraction of the stock of debt can be decomposed into the corresponding interest and amortization rate, $S/D = r + \delta$. Using this in equation (18), the amortization rate can be expressed as

$$\delta = \frac{S}{D} - r = \frac{r}{1-(1+r)^{-m}} - r = \frac{r - r + r\,(1+r)^{-m}}{1-(1+r)^{-m}} = \frac{r}{(1+r)^m - 1}$$

Furthermore, we find that

$$\frac{d\delta}{dr} = \frac{(1+r)^m - 1 - rm\,(1+r)^{m-1}}{\left[(1+r)^m - 1\right]^2} = \frac{(1+r)^{m-1}\left[1 - r\,(m-1)\right] - 1}{\left[(1+r)^m - 1\right]^2} < 0$$

The sign of the numerator of the expression follows since $(1+x)^m\,(1-mx) < 1$ for any $x, m > 0$.

B Decomposing Impulse Response Functions

This appendix explains our econometric methodology for decomposing the impulse responses of new borrowing. We first explain our decomposition using a linear local projection with one auto-regressive term that can easily be compared to a VAR(1) benchmark. We also describe how it can be applied in our specific setting to decompose the effects of new borrowing on real variables. We then present the methodology for a more general auto-regressive structure.

Econometric setup Let z_t be a $n \times 1$ random vector with $n \geq 3$ partitioned into four elements $z_t = (z_{1,t},\, z_{2,t},\, z_{3,t},\, z_{4,t})'$, where for convenience the three first elements are scalars and the last element, z_{4t}, is a vector (possibly the empty vector, if $n = 3$). Suppose that we are primarily interested in knowing how $z_{2,t+h}$ responds to a shock to $z_{1,t}$. Moreover, we also want to know how much of this impulse response is due to the fact that $z_{3,t}, ..., z_{3,t+h-1}$changes in response to the original shock to $z_{1,t}$.

In the specific context of Section 5, for example, the first element is new borrowing, i.e. $z_{1,t} = b_{i,t}$, the second element is output growth, i.e. $z_{2,t} = \Delta y_{i,t}$, the third element is debt service, i.e. $z_{3,t} = s_{i,t}$, and the fourth element is a vector of controls, i.e. $z_{4,t} = controls_{i,t}$.

To express the impulse response and its decomposition, we need to specify a process for z_t. For ease of exposition, we first consider the linear local projection of z_{t+h} on the space generated by z_{t-1}, which is given by

$$z_{t+h} = \mu_{h+1} + A_{h+1} z_{t-1} + \upsilon_{h,t+h} \tag{19}$$

where μ_{h+1} is a vector of constants, A_{h+1} is an $n \times n$ matrix of coefficients, and $\upsilon_{h,t+h}$ is an error term. The error term is a h^{th} order moving average of a set of reduced form *i.i.d.* disturbances, ν_t, arriving in each time period from t to $t + h$ (see Jorda (2005)). For $h = 0$, specifically, we have $\upsilon_{0,t} = \nu_t$. Using the index $h + 1$ on the parameters of (19) is convenient for expressing the impulse response at $t + h$, as will become clear shortly.

Impulse response Let d_i be a shock to the i^{th} element of vector z_t, technically defined as a linear combination of the reduced form disturbances, ν_t. The simplest example is a unit shock $d_1 = (1,\, 0,\, 0,\, 0)'$.[32] The impulse response of z_{t+h} from d_i, denoted $IR(z_{t+h},\, d_i)$, can be defined as

$$IR(z_{t+h},\, d_i) = E(z_{t+h} \mid \nu_t = d_i;\, Z_t) - E(z_{t+h} \mid \nu_t = 0;\, Z_t) \tag{20}$$

for $h = 0,\, 1, ...,$ where $E(\cdot \mid \cdot)$ denotes the expectation from the best mean squared error predictor and $Z_t = (z_{t-1},\, z_{t-2}...)'$ represents past information that is known at time t.

To calculate the impulse response (20) based on the process defined in (19), note that $E(z_{t+h} \mid Z_t) = E(E(z_{t+h} \mid z_t) \mid Z_t)$ by the law of iterated expectations. The expectation $E(z_{t+h} \mid z_t)$ can be found by leading the time index in (19) by one period and considering the forecast $h - 1$ periods ahead. This gives $E(z_{t+h} \mid z_t) = \hat{\mu}_h + \hat{A}_h z_t$ where the hat denotes the estimated value from the predictor. Moreover, from (19) with $h = 0$ we find that $z_t = \mu_1 + A_1 z_{t-1} + d_i$ when $\upsilon_{0,t} = \nu_t = d_i$ and $z_t = \mu_1 + A_1 z_{t-1}$

[32] More generally, d_i could refer for example to a column of the inverse lower triangular matrix that is used in a Cholesky decomposition, if shocks are identified by a Wold-causal order of z_t when $h = 0$.

when $\nu_t = 0$. Combining these results we get

$$\begin{aligned} IR(z_{t+h},\, d_i) &= E\left(E(z_{t+h} \mid z_t) \mid \nu_t = d_i;\, Z_t\right) - E\left(E(z_{t+h} \mid z_t) \mid \nu_t = 0;\, Z_t\right) \\ &= \left(\mu_h + \hat{A}_h\left(\mu_1 + A_1 z_{t-1} + d_i\right)\right) - \left(\mu_h + \hat{A}_h\left(\mu_1 + A_1 z_{t-1}\right)\right) \\ &= \hat{A}_h d_i \end{aligned} \tag{21}$$

with the normalization $\hat{A}_0 = I$. The impulse response in (21) is our first object of interest. With $z_t = (b_{i,t},\, \Delta y_{i,t},\, s_{i,t},\, controls_{i,t})'$ and $d_1 = (1,\, 0,\, 0,\, 0)'$, the expression (8) in the main text corresponds to $IR(\Delta y_{i,t+h},\, d_1)$.

Decomposition Next we decompose how a shock d_1 to $z_{1,t}$ at time t propagates through the system (19) to affect $z_{2,t+h}$ at horizons $h \geq 0$. Specifically, we ask how much of the impulse response of $z_{2,t+h}$ runs through the predictable effects of the shock on the realizations of $z_{3,t}, \ldots, z_{3,t+h-1}$. (In the application in Section 5, this corresponds to asking how much of the effect of a credit impulse at time t on output y_{t+h} occurs via debt service $s_{t+1}, \ldots, s_{t+h-1}$.) For this purpose, rewrite the prediction of equation (19) as

$$\begin{aligned} \hat{z}_{t+h|t} &= \hat{\mu}_{h+1} + \hat{A}_{h+1} z_{t-1} \\ &= \hat{\mu}_{h+1} + \hat{A}_1 \hat{A}_h z_{t-1} + \left(\hat{A}_{h+1} - \hat{A}_1 \hat{A}_h\right) z_{t-1} \\ &\approx \hat{\mu}_{h+1} + \hat{A}_1 \hat{A}_h z_{t-1} \end{aligned} \tag{22}$$

where $\hat{z}_{t+h|t}$ is shorthand for $E(z_{t+h} \mid Z_t)$. The critical step in this derivation is the approximation in equation (22). This step is valid as long as $\hat{A}_{h+1} \approx \hat{A}_1 \hat{A}_h$. The equation holds exactly if the true data generating process (DGP) for z_t is a vector auto-regression (VAR), since $\hat{A}_{h+1} = (\hat{A}_1)^{h+1}$ in that case. In the more general case where the true DGP is not a VAR we are still likely to have $\hat{A}_{h+1} \approx \hat{A}_1 \hat{A}_1^h$ because the local projection and the VAR are the same at $h = 0$ and the approximation error in $\hat{A}_1 \hat{A}_1^h$ does not compound with h.[33]

The approximation in (22) allows us to separate between first round and higher round effects in the impulse responses. Using (21) together with (22) we get

$$\begin{aligned} IR(z_{t+h},\, d_i) &= \hat{A}_h d_i \\ &\approx \hat{A}_1 \hat{A}_{h-1} d_i \\ &= \hat{A}_1 IR(z_{t+h-1},\, d_i) \\ &= IR\left(z_{t+h},\, IR(z_{t+h-1},\, d_i)\right) \end{aligned} \tag{23}$$

This captures that the impulse response of a shock d_i at horizon $h > 1$ is approximately equal to the first round effects of the expected position of the system $h-1$ periods ahead.

[33] We describe below, after equation (25), how we verified that the approximation holds closely in our application.

In Section 5, our interest lies in the response of the 2^{nd} element of the vector z_{t+h} (output y_{t+h}) to a shock d_1 (i.e. to new borrowing). Focusing only on this first element and separating the vector $z_{t+h-1} = (z_{1,t+h-1},\, z_{2,t+h-1}, \ldots,\, z_{n,t+h-1}) = (z_{i,t+h-1})_{i=1}^{n}$ into its n individual scalar components and similar for the impulse response $IR(z_{t+h-1},\, d_1) = (IR(z_{i,t+h-1},\, d_1))_{i=1}^{n}$, equation (23) can be written as

$$\begin{aligned} IR(z_{2,t+h},\, d_1) \approx & IR\left(z_{2,t+h},\, IR(z_{t+h-1},\, d_1)\right) \\ = & IR\left(z_{2,t+h},\, (IR(z_{i,t+h-1},\, d_1))_{i=1}^{n}\right) \\ = & \underbrace{IR\left(z_{2,t+h},\, IR(z_{3,t+h-1},\, d_1)\right)}_{\text{service\_effect}} + \underbrace{IR\left(z_{2,t+h},\, (IR(z_{i,t+h-1},\, d_1))_{i\neq 3}\right)}_{\text{other\_effects}} \end{aligned}$$

Given our specification (19), we can denote these two terms in matrix notation as

$$\text{service\_effect} = IR\left(z_{2,t+h},\, IR(z_{3,t+h-1},\, d_1)\right) = \hat{A}_{23,1}\hat{A}_{3\cdot,h-1}d_1 \tag{24}$$

where $\hat{A}_{ij,h}$ denotes the ij^{th} element of $\hat{A}_h$ and $\hat{A}_{i\cdot,h}$ denotes its i^{th} row. The part of the impulse response that is due to all other factors is given by

$$\text{other\_effects} = IR\left(z_{2,t+h},\, (IR(z_{i,t+h-1},\, d_1))_{i\neq 3}\right) = \left(\hat{A}_{2\cdot,h} - \hat{A}_{23,1}\hat{A}_{3\cdot,h-1}\right) d_1. \tag{25}$$

With $z_t = (b_{i,t},\, \Delta y_{i,t},\, s_{i,t},\, controls_{i,t})'$ and $d_1 = (1,\, 0,\, 0,\, 0)'$, Equations (24) and (25) reduce to (9) and (10) in the main text. Finally, we verify that the approximation error from assuming $\hat{A}_{h+1} \approx \hat{A}_1\hat{A}_h$ in (23) is negligible (small) in our application by checking the difference between the scalar $(\hat{A}_{2\cdot,h} - \sum_{i=1}^{n}\hat{A}_{2i,1}\hat{A}_{i\cdot,h-1})d_1$ and $\hat{A}_{2\cdot,h}d_1$. We find that the approximation error is less that xx% of the impulse response for any $h = 1, ..., 8$.

General case It is easy to generalize these calculations to a p^{th} order local projection of the form

$$z_{t+h} = \mu_{h+1} + A_{h+1,1}z_{t-1} + ... + A_{h+1,p}z_{t-p} + \upsilon_{h,t+h} \tag{26}$$

Again we can rewrite the prediction of (26) in terms of its projected first-order effects as

$$\begin{aligned} \hat{z}_{t+h} &= \hat{\mu}_{h+1} + \hat{A}_{h+1,1}z_{t-1} + ... + \hat{A}_{h+1,p}z_{t-p} \\ &= \hat{\mu}_{h+1} + \hat{A}_{1,1}\left(\hat{A}_{h,1}z_{t-1} + ... + \hat{A}_{h,p}z_{t-p}\right) + ... \\ &\quad + \hat{A}_{1,p}\left(\hat{A}_{h-p,1}z_{t-1} + ... + \hat{A}_{h-p,p}z_{t-p}\right) \\ &\quad + \left(\hat{A}_{h+1,1} - \hat{A}_{1,1}\hat{A}_{h,1} - ... - \hat{A}_{1,p}\hat{A}_{h-p,1}\right) z_{t-1} + ... \\ &\quad + \left(\hat{A}_{h+1,p} - \hat{A}_{1,1}\hat{A}_{h,p} - ... - \hat{A}_{1,p}\hat{A}_{h-p,p}\right) z_{t-p} \\ &\approx \hat{\mu}_{h+1} + \left(\hat{A}_{1,1}\hat{A}_{h,1} + ... + \hat{A}_{1,p}\hat{A}_{h-p,1}\right) z_{t-1} + ... \\ &\quad + \left(\hat{A}_{1,1}\hat{A}_{h,p} + ... + \hat{A}_{1,p}\hat{A}_{h-p,p}\right) z_{t-p} \end{aligned} \tag{27}$$

with the normalizations $\hat{A}_{1-j,j} = I$ and $\hat{A}_{1-j,k} = 0$ for $j \geq 1$ and $1 \leq k \neq j$, as well as, $\mu_{-j} = 0$ for $j \geq 0$. The expression on the last line is valid if $\hat{A}_{h+1,j} \approx \hat{A}_{1,1}\hat{A}_{h,j} + ... + \hat{A}_{1,p}\hat{A}_{h-p,j}$, for $j = 1, ..., p$. As before, it will be zero if the true underlying DGP for z_t is a VAR. To see this, note that z_t can be written in companion form as

$$w_t = \mu + Aw_{t-1} + \upsilon_t$$

under the VAR assumption, where

$$w_t = \begin{bmatrix} z_t \\ \vdots \\ z_{t-p} \end{bmatrix},$$

$$A = \begin{bmatrix} A_{1,1} & A_{1,2} & \cdots & A_{1,p-1} & A_{1,p} \\ I & 0 & \cdots & 0 & 0 \\ 0 & I & \cdots & 0 & 0 \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & 0 & \cdots & I & 0 \end{bmatrix},$$

$$\upsilon_t = \begin{bmatrix} \nu_t \\ 0 \\ \vdots \\ 0 \end{bmatrix}.$$

Let

$$A^{h+1} = \begin{bmatrix} A_{1,1}^{(h+1)} & \cdots & A_{1,p}^{(h+1)} \\ \vdots & \ddots & \vdots \\ A_{p,1}^{(h+1)} & \cdots & A_{p,p}^{(h+1)} \end{bmatrix}$$

From Jorda (2005) we know that $A_{1,k}^{(h+1)} = A_{h+1,k}$ for all $h \geq 0$ and $k = 1, ..., p$. But given the definition of w_t this also implies

$$A^{h+1} = \begin{bmatrix} A_{h+1,1} & A_{h+1,2} & \cdots & A_{h+1,p} \\ A_{h,1} & A_{h,2} & \cdots & A_{h,p} \\ \vdots & \vdots & \ddots & \vdots \\ A_{h+1-p,1} & A_{h+1-p,2} & \cdots & A_{h+1-p,p} \end{bmatrix}$$

with the normalizations $A_{h+1-j,j-h} = I$ and $A_{h+1-j,k-h} = 0$ for $j \geq h+1$ and $0 < k \neq j$. But then the assumed VAR structure also implies that

$$\begin{aligned} A_{1,j}^{(h+1)} &= A_{1\cdot}A_{\cdot j}^{(h)} \\ &= A_{1,1}A_{1j}^{(h)} + ... + A_{1,p}A_{pj}^{(h)} \\ &= A_{1,1}A_{h,j} + ... + A_{1,p}A_{h-p,j} \end{aligned}$$

which shows the proposition.

Using (20) together with (27) gives

$$\begin{aligned} IR(z_{t+h},\, d_i) &= \hat{A}_{h,1} d_i \\ &\approx \hat{A}_{1,1}\hat{A}_{h-1,1} d_i + ... + \hat{A}_{1,p}\hat{A}_{h-1-p,1} d_i \\ &= \hat{A}_{1,1} IR(z_{t+h-1},\, d_i) + ... + \hat{A}_{1,p} IR(z_{t+h-1-p},\, d_i) \\ &\quad IR\left(z_{t+h},\, IR(z_{t+h-1},\, d_i), ...,\, IR(z_{t+h-1-p},\, d_i)\right) \end{aligned} \tag{28}$$

which concludes our decomposition in the p:th order case.

C Results for the Corporate Sector

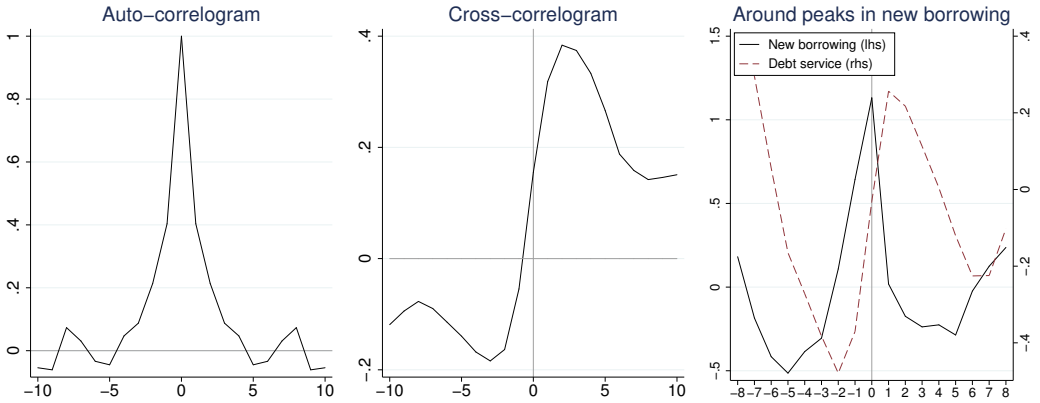

Figure 16: The relationship between new borrowing and debt service for the corporate sector in the raw data. The left-hand panel shows the auto-correlation of new borrowing and the middle panel the cross-correlation between new borrowing and debt service. The right-hand panel shows the evolution of new borrowing and debt service +/- 8 years around peaks in new borrowing (time 0). The lines show the cross-sectional averages of the relevant variable at each year. Peaks in new borrowing are identified as local maxima within a five year window. We normalize new borrowing and debt service by country-specific averages.

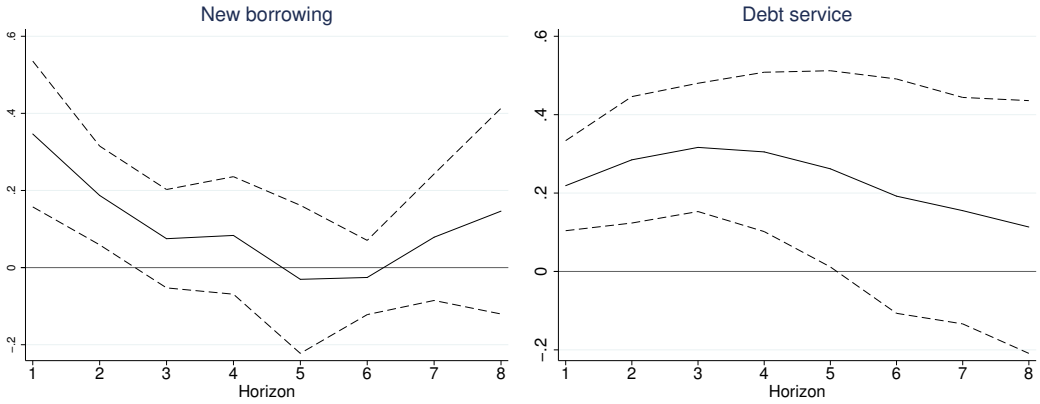

Figure 17: Impulse response of new borrowing and debt service to a unit increase in new corporate borrowing at t_0 using local projections (5) and (6) for horizons $h = 1$ to 8. The specification includes our baseline controls (see Section (3)). Errors are clustered at the country level. Dotted line are the 95% confidence bands.

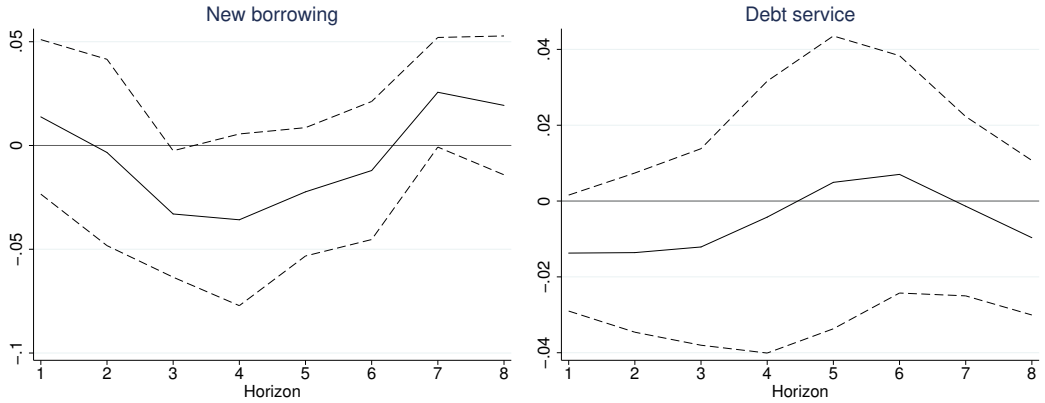

Figure 18: Impulse response of GDP growth after a unit increase in new corporate borrowing or corporate debt service at t_0 using local projections (7) for horizons $h = 1$ to 8 with our baseline controls (see Section (3)). Errors are clustered at the country level. Dotted line are the 95% confidence bands.

D Additional Tables and Graphs

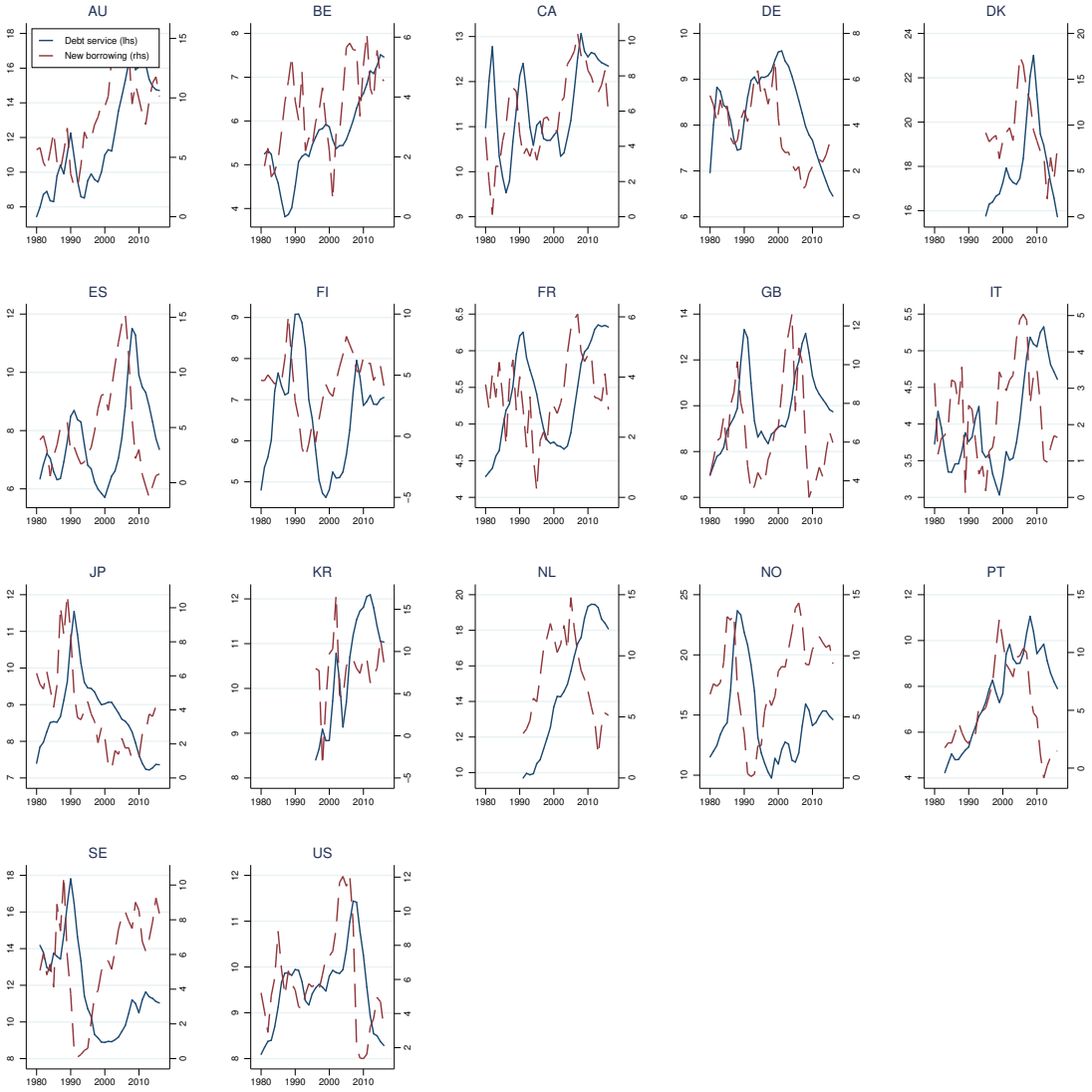

Figure 19: New borrowing and debt service for the household sector in different countries.

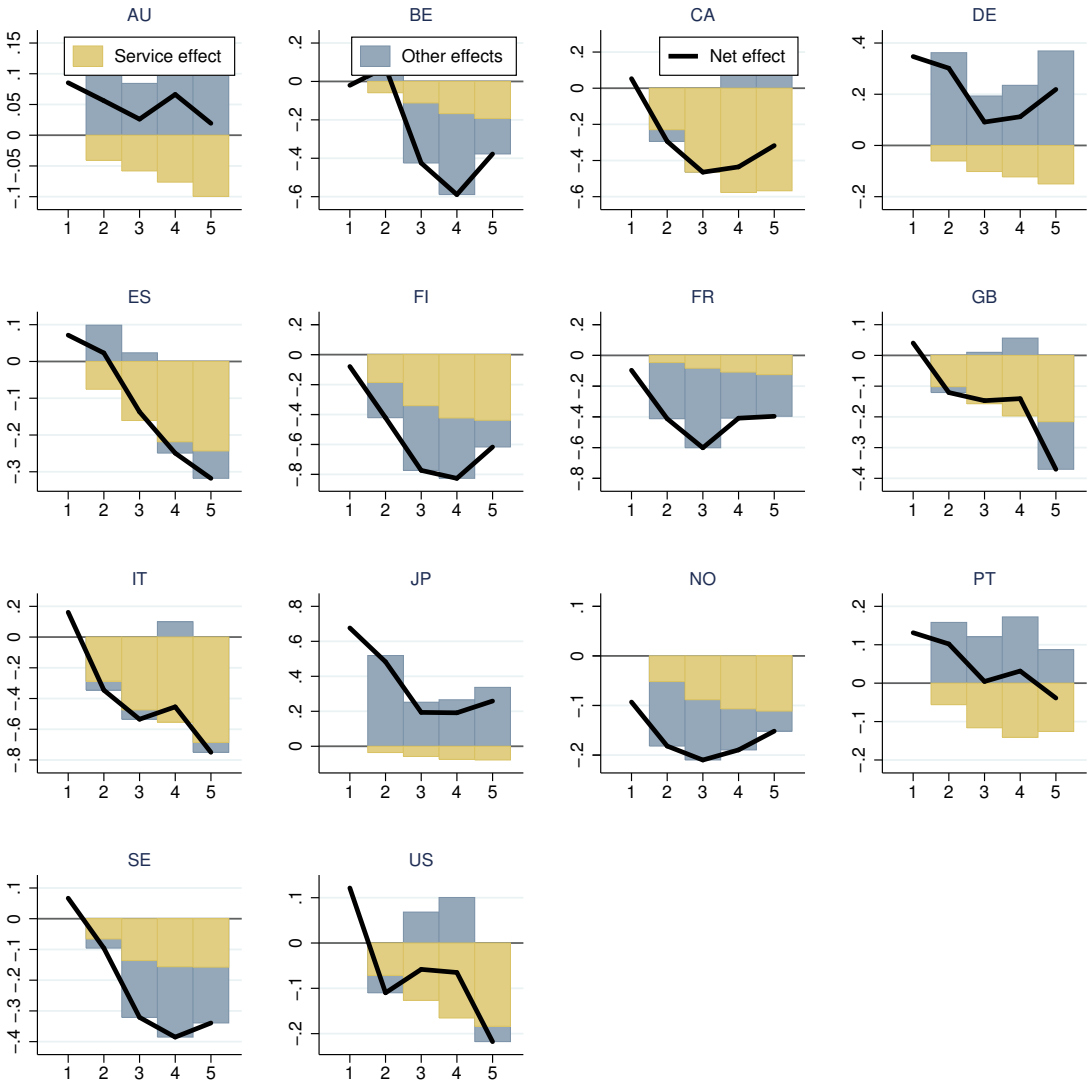

Figure 20: Decomposition of the net effect of new borrowing on future GDP growth (equation (8)) into the service effect (equation (9)) and the other effects (equation (10)) for horizons h=1 to 5 at the country level. Given limited data, we only include two lags of GDP growth as controls and project only 5 years ahead. Denmark, the Netherlands and Korea are also excluded as they have less than 25 data points.

Variable	Description	Source
Credit ($d_{i,t}$)	Credit to the household sector from all sources, including bank credit, cross-border credit and credit from non-banks deflated by the GDP deflator.	BIS
GDP ($y_{i,t}$)	Real GDP.	National Accounts
Debt service ($s_{i,t}$)	Debt service of the household sector.	BIS and own calculations
Interest rate on the stock of debt ($r_{i,t}$)	Interest payments and financial intermediation services indirectly measured (FISIM) divided by debt stock; all for the household sector. Where not available, backdated by alternative interest rates such as the average interest rates on bank loans to households.	National Accounts, central banks
Real short rate	3-month money market rate minus the CPI inflation rate.	Datastream
Lending spread	Prime lending rate minus 3-month money market rate.	Macrobond
Term spread	10 year government bond yield minus 3-month money market rate.	Global Financial Data
Corporate credit spread	Spread between lending spread and a corporate credit spread. As Krishnamurthy and Muir (2016) it is calculated as the spread between the general corporate bond index and the weighted average of the five and 10 year government bond rates.	Global Financial Data Merill Lynch, Moodys
Real exchange rate	Real effective exchange rate.	BIS
Property price	Residential property price deflated by the CPI.	BIS
Unemployment	Unemployment rate.	Global Financial Data, OECD, central banks
Labour productivity	Labour productivity.	OECD, FRED, World Bank
Inflation rate	First difference of the logarithm of the CPI.	National sources.
Future output growth	1-year ahead Consensus Forecasts for GDP growth.	Consensus Forecasts
Net worth	Total assets - total liabilities of the household sector.	National Accounts
Provisions	Aggregate provisions of the national banking sector.	Bankscope, OECD, Pesola (2011)
Lending standards	Bank lending standards.	Central banks

Table 3: Variable definitions and data sources.

	$d_{i,t}$	$y_{i,t}$	$s_{i,t}$	$r_{i,t}$	Short rate	Term spread	Lending spread	Credit spread	Exchange rate	Prop. pr.	Unempl.	Labour prod.	Infl.	GDP forec.	Net worth	Prov	Lend. std
AU	1980	1980	1980	1980	1986	1986	1986	1983	1980	1980	1980	1980	1980	1990	1989	1991	
BE	1980	1980	1980	1980	1980	1980	1981	1980	1980	1980	1980	1995	1980	1989	1999	1981	2003
CA	1980	1980	1980	1980	1980	1980	1980	1983	1980	1980	1980	1981	1980	1989	1990	1988	1999
DE	1980	1980	1980	1980	1980	1980	1980	1988	1980	1980	1980	1991	1980	1989	1999	1980	2003
DK	1994	1980	1994	1994	1980	1980	1980	1994	1980	1980	1980	1990	1980	1989	1998	1980	
ES	1980	1980	1980	1980	1980	1980	1980	1980	1980	1980	1980	1995	1980	1989	1999	1980	2003
FI	1980	1980	1980	1980	1980	1987	1980		1980	1980	1980	1980	1980	1989	1997	1980	
FR	1980	1980	1980	1980	1980	1980	1980	1980	1980	1980	1982	1980	1980	1989	1999	1988	2003
GB	1980	1980	1980	1980	1980	1980	1980	1980	1980	1980	1980	1980	1980	1989	1999	1987	2006
IT	1980	1980	1980	1980	1980	1980	1982	1980	1980	1980	1983	1981	1980	1989	1995	1984	2003
JP	1980	1980	1980	1980	1980	1980	1980	1980	1980	1980	1980	1980	1980	1989	1994	1989	2000
KR	1980	1980	1996	1996	1992	1992	1992	2000	1980	1980	1980	1983	1980	1990	2002	1990	
NL	1990	1980	1990	1990	1980	1980	1980	1980	1980	1980	1980	1996	1980	1989	2010	1980	2003
NO	1980	1980	1980	1980	1980	1980	1980		1980	1980	1980	1995	1980	1989	1995	1980	
PT	1980	1980	1983	1983	1983	1983	1983		1980	1988	1983	1995	1980	1989	1999		2003
SE	1980	1980	1980	1980	1980	1980	1980	1984	1980	1980	1980	1993	1980	1989	1999	1981	
US	1980	1980	1980	1980	1980	1980	1980	1980	1980	1980	1980	1980	1980	1989	1980	1980	1990

Table 4: Data sample.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Dependent variable is: $\Delta y_{i,t+1}$						
$b_{i,t}$	−0.02	0.06	0.11**	0.02	0.12***	0.04	0.14**
	(0.04)	(0.04)	(0.05)	(0.09)	(0.04)	(0.04)	(0.06)
$s_{i,t}$		−0.39***	−0.26***	−0.30***	−0.25***	−0.20***	−0.30**
		(0.08)	(0.06)	(0.07)	(0.04)	(0.07)	(0.10)
N	562	552	529	344	529	529	219
adj. R-sq	0.13	0.23	0.53	0.40	0.63	0.64	0.60
	Dependent variable is: $\Delta y_{i,t+3}$						
$b_{i,t}$	−0.25***	−0.20***	0.01	−0.11	−0.00	−0.03	−0.02
	(0.04)	(0.05)	(0.05)	(0.08)	(0.05)	(0.05)	(0.06)
$s_{i,t}$		−0.29***	−0.31***	−0.29***	−0.29***	−0.19**	−0.21
		(0.08)	(0.07)	(0.10)	(0.06)	(0.07)	(0.14)
N	528	518	496	310	496	496	198
adj. R-sq	0.11	0.17	0.44	0.24	0.51	0.60	0.56
	Dependent variable is: $\Delta y_{i,t+5}$						
$b_{i,t}$	−0.25***	−0.24***	−0.08*	−0.21***	−0.09**	−0.09***	−0.16**
	(0.05)	(0.05)	(0.04)	(0.05)	(0.04)	(0.03)	(0.06)
$s_{i,t}$		−0.09	−0.20**	−0.03	−0.19**	−0.06	−0.04
		(0.08)	(0.08)	(0.11)	(0.08)	(0.06)	(0.12)
N	494	484	462	276	462	462	174
adj. R-sq	0.11	0.11	0.40	0.19	0.48	0.57	0.57
Country FE	✓	✓	✓	✓	✓	✓	✓
Baseline contr.			✓	✓	✓	✓	✓
Outliers					✓		
Time FE						✓	
Extra contr.							✓

Table 5: Local projections of new borrowing ($b_{i,t}$) and debt service ($s_{i,t}$) on GDP growth at different horizons and specifications (7). Baseline controls: the real short-term money market rate, a credit spread, the change in the average lending rate on the stock of debt, real residential property price growth, a dummy for banking crises dates, a dummy for the Lehman failure, and country fixed effects. In the "outlier" specification (5) we block out the 10 largest outliers in the data. Extra controls: see Section 3. Standard errors in parenthesis are clustered along the country dimension. Adj. R^2 refers to the within variation coefficient of determination.

	(1)	(2)	(3)	(4)	(5)
	Dependent variable is: I (crisis at time $t+1$)				
$b_{i,t}$	0.178^{**} (0.087)	0.345^{***} (0.124)	0.522 (0.360)	0.339^{**} (0.133)	0.009^{**} (0.004)
$s_{i,t}$	1.174^{***} (0.430)	1.129^{**} (0.499)	2.166^{***} (0.708)	1.094^{**} (0.459)	0.032^{***} (0.008)
Pseudo R^2	0.10	0.13	0.20	0.14	0.13
Obs	418	408	258	402	408
	Dependent variable is: I (crisis at time $t+3$)				
$b_{i,t}$	0.766^{***} (0.169)	0.392 (0.277)	0.384 (0.412)	0.372^{*} (0.216)	0.016^{**} (0.006)
$s_{i,t}$	0.556^{***} (0.189)	1.250^{***} (0.436)	1.660^{***} (0.424)	1.152^{***} (0.407)	0.033^{***} (0.007)
Pseudo R2	0.14	0.18	0.23	0.17	0.19
Obs	390	381	198	375	381
	Dependent variable is: I (crisis at time $t+5$)				
$b_{i,t}$	0.501^{***} (0.119)	0.448^{***} (0.158)	0.446^{*} (0.256)	0.375^{**} (0.146)	0.019^{***} (0.005)
$s_{i,t}$	-0.168 (0.168)	0.029 (0.177)	-0.135 (0.366)	0.160 (0.180)	0.003 (0.005)
Pseudo R2	0.06	0.08	0.12	0.08	0.08
Obs	362	353	212	347	353
Baseline contr.		✓	✓	✓	✓
Extra contr.			✓		
R&R crisis dates				✓	
OLS regression					✓

Table 6: Local projections of new borrowing ($b_{i,t}$) and debt service ($s_{i,t}$) on the probability of banking crisis at different horizons and specifications. Models are estimated using panel logit with country fixed effects except in (5) where we use OLS. Baseline controls: the real short-term money market rate, a credit spread, the change in the average lending rate on the stock of debt, real residential property price growth. Extra controls: corporate credit spreads and banking sector provisions. In "R&R crisis dates" we use alternative crises dates provided by Reinhart and Rogoff (2009). Standard errors in parenthesis are clustered along the country dimension.