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How repayments manipulate our perceptions about loan dynamics after a boom

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ABSTRACT

We propose a method to decompose net lending flows into loan origination and repayments. We show that a boom in loan origination is transmitted to repayments with a very long lag, depressing the growth rate of the stock for many periods. In the euro area, repayments of the mortgage loans granted in the boom preceding the financial crisis have been dragging down net loan growth in recent years. This concealed an increasing dynamism in loan origination, especially during the last wave of ECB's non-standard measures. Using loan origination instead of net loans has important implications for understanding macroeconomic developments. For instance, the robust developments in loan origination in recent times explain the strengthening in housing markets better than net loans. Moreover, credit supply restrictions during the crisis are estimated to be smaller. Overall, there is a premium on using loan origination and repayments in economic models, especially after large booms.

JEL Classification: E17, E44, G01, D14

Keywords: new lending, loan repayments, amortisation rate, housing markets.

Non-technical summary

Since the start of Stage III of EMU in 1999, the annual growth rate of loans to households for house purchase granted by euro area monetary financial institutions (MFIs) has fluctuated substantially. Looking at the most recent period, the recovery in mortgage loans which started in 2014 has been very gradual both at the euro area level and across the largest euro area countries. These timid developments give rise to two puzzles. First, they stand in sharp contrast with those observed in output, house prices and residential investment, which have experienced increasingly vigorous developments in most euro area countries since 2014. Second, it is a common perception that the positive impact of the ECB's non-standard measures on bank lending (as reported by survey data) has paradoxically not been translated into stronger credit figures.

This paper offers a solution to these puzzles by uncovering the two-faced nature of transaction flows, composed of loan origination and principal repayments. Using loan origination as the key variable for lending dynamics as opposed to net loans shows (i) that, rather than departing from historical regularities, the strengthening in housing markets observed recently in the euro area is, like in previous episodes, also supported by credit, and (ii) that lending has accelerated particularly during the last wave of ECB's non-standard measures, revealing a stronger impact from the supply side and reconciling the evidence from hard and survey data.

To reach these conclusions, we propose a method to decompose MFI loan net flows into loan origination and repayments, and use these two components in standard credit models, which typically use net flows (or the loan stock) as an input variable. Our decomposition method consists in a simulated loan portfolio, whose growth replicates the growth rate of loans observed in the data. We focus on bank loans to households for house purchase for three reasons. First, the typical long-term maturity of these contracts illustrates better the lead-lag relationship between booms in loan origination and loan repayments. Second, housing markets play a key role in modern economies, as evinced by the global financial crisis. Third, the financing for households who decide to buy a house in the euro area occurs almost exclusively via bank lending, which frees the analysis from the interaction with alternative financing sources, such as debt securities.

In line with the literature studying aggregate debt service (principal and interest payments considered together), we base our analysis on the properties of the repayments generated by the so-called *French loan* (characterised by having constant instalments and an ex-ante known repayment scheme). Besides being the most popular contract in the euro area – and easy to generalise to most variable rate contracts

– the advantage from focusing on this type of loan is mathematical tractability, as it delivers closed-form expressions for the remaining principal and the repayment schedule. We derive analytically the laws of motion of the stock and repayments (and therefore also that of the amortisation rate), so that they are fully consistent with the properties of the individual French loans composing the portfolio. When matched with actual data, this allows us obtaining plausible portfolio repayments, which being a predetermined function of past granted loans, provide an anchor to disentangle loan origination from repayments. In addition, our consistent framework allows us simulating scenarios in order to analyse the intertwined dynamics between loan origination, the loan stock and the amortisation rate. Based on this, we show that booms in loan origination have a substantially lasting and delayed downward impact on net loan volumes. Specifically, after a large boom, the typical long repayment structure of loans creates a persistent base effect that depresses the growth rate of the loan stock for many periods ahead. The latter calls for focusing on loan origination rather than on changes in the loan stock and on using alternative scale variables, such as GDP, in order to have a more accurate perception of the prevalent loan dynamics at every point in time, especially after large swings in loan origination.

Our portfolio simulation based on euro area data shows that repayments of the lending boom registered in the run-up to the financial crisis have been an increasingly dragging force for net loan growth in recent years, concealing an increasing dynamism in loan origination. The growth of net loans is expected to be increasingly dampened by loan repayments (most of them coming from the loans granted during the pre-crisis boom) until about 2022. The estimated annual loan origination in mid-2018 is at levels comparable to those estimated for the years immediately before the peak of the boom. Our method also delivers a plausible decomposition for the four largest euro area countries, with the estimated loan origination flows standing at historical highs in Germany and France.

In a set of empirical exercises using our estimated loan origination and/or repayments, we show that, compared with the cases when the credit variable is net loans: (i) Loan origination plays a more relevant role in explaining the recent strengthening in housing markets, which, if confirmed, would warrant a close monitoring of that market with respect to financial stability risks; (ii) Loan origination seems to have played a more relevant role in explaining consumer price developments in the post-boom period; (iii) Not including the growing repayments in the estimation of credit supply shocks magnifies the dampening impact of credit supply restrictions on the economy in the post-crisis, while slightly underestimating the positive credit supply impulse during the recovery phase.

Overall, these results suggest that there is a premium on adjusting economic models that use lending as an input to account for loan origination and/or repayments, especially after large credit booms.

"When we look at the universe, we are seeing it as it was in the past."

(Stephen Hawking, A Brief History of Time, 1988)

1. Introduction

Since the start of Stage III of EMU in 1999, the annual growth rate of loans to households for house purchase granted by euro area monetary financial institutions (MFIs) has fluctuated substantially (Figure 1). Looking at the most recent period, the recovery in mortgage loans which started in 2014 has been very gradual both at the euro area level and across the largest euro area countries. These timid developments give rise to two puzzles. First, they stand in sharp contrast with those observed in output, house prices and residential investment, which have experienced increasingly vigorous developments in most euro area countries since 2014 (Figures 2, Figure 1A and Figure 2A in the Annex).[2] Second, it is a common perception that the positive impact of the ECB's non-standard measures on bank lending (as reported by survey data) has paradoxically not been translated into stronger credit figures.[3]

This paper offers a solution to these puzzles by uncovering the two-faced nature of transaction flows, composed of loan origination and principal repayments. Using loan origination as the key variable for lending dynamics as opposed to net loans shows (i) that, rather than departing from historical regularities, the strengthening in housing markets observed recently in the euro area is, like in previous episodes, also supported by credit, and (ii) that lending has accelerated particularly during the last wave of ECB's non-standard measures, revealing a stronger impact from the supply side and reconciling the evidence from hard and survey data.

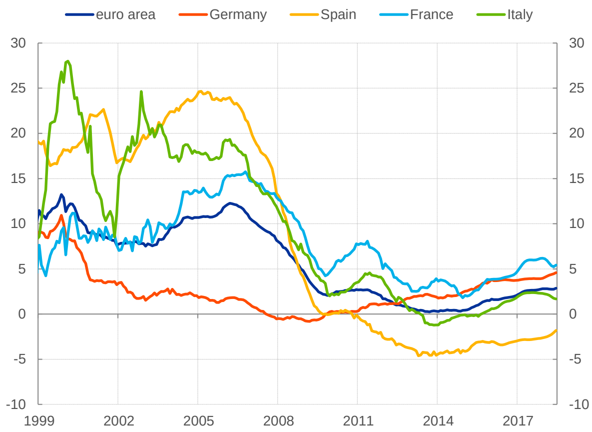
To reach these conclusions, we propose a method to decompose MFI loan net flows into loan origination and repayments, and use these two components in standard credit models, which typically use net flows (or the loan stock) as an input variable. Our decomposition method consists in a simulated loan portfolio, whose growth replicates the growth rate of loans observed in the data. In this paper, we focus on bank loans to households for house purchase for three reasons. First, the typical

[2] While creditless recoveries in economic activity are well documented in the literature (Calvo et al. 2006; Claessens et al., 2009; Abiad et al., 2011), it is more difficult to square the recent developments in mortgage lending in the euro area with those in house prices and residential investment.

[3] According to the Bank Lending Survey (BLS), the Asset Purchase Programme (APP) had a positive impact on the liquidity position and market financing conditions of euro area banks. In particular, banks indicated that they had mainly used the additional liquidity related to the APP to grant loans. Moreover, banks assessed the ECB's negative deposit facility rate to have had a positive impact on their lending volumes. Lastly, banks reported using the targeted longer-term refinancing operations (TLTROs) mostly for granting loans.

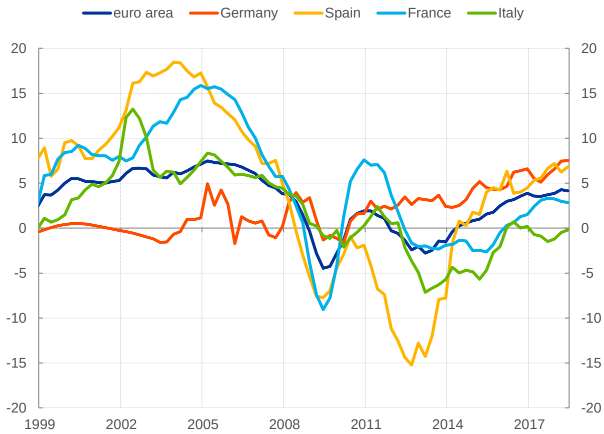
long-term maturity of these contracts illustrates better the lead-lag relationship between booms in loan origination and loan repayments. Second, housing markets play a key role in modern economies, as evinced by the global financial crisis and documented in several studies (Muellbauer and Murphy, 2008; Mian and Sufi, 2009, 2011 and 2014; Iacoviello and Neri, 2010, Calza et al., 2013). Third, the financing for households who decide to buy a house in the euro area occurs almost exclusively via bank lending, which frees the analysis from the interaction with alternative financing sources, such as debt securities.[4]

Figure 1. MFI loans to households for house purchase in selected euro area countries
(annual percentage changes)



Source: ECB and authors' calculations.
Notes: Loans to households for house purchase are adjusted for sales and securitisation. Adjusted loans before 2015 are constructed by allocating all securitisation and loan sales adjustments of loans to households to loans to households for house purchase. From 2015 onwards, internally available data on securitisation and loan sales of house purchase loans are used to adjust the series. Latest observation: June 2018.

Figure 2. Residential property prices in selected euro area countries
(annual percentage changes)



Source: Eurostat and authors' calculations.
Notes: For Germany, annual data interpolated to quarterly frequency using a cubic spline function before 2003. Latest observation: 2018 Q2.

Our paper adds to a very scarce literature that aims to understand the specific roles of new borrowing and debt service. Based on the practices in the US Federal Reserve and the Bank for International Settlements (BIS), Drehmann et al. (2015) present a methodology to measure debt service ratios and highlight the importance of these ratios for understanding the interactions between debt and the real economy. Drehmann et al. (2017, 2018) describe analytically the lead-lag relationship between households' new lending and debt service, and show empirically that this relationship provides a systematic transmission channel whereby credit expansions lead to future output losses and higher probability of financial crisis.

[4] Schmidt and Hackethal (2004) propose a method to decompose net flows in the context of corporate finance.

In line with the literature studying aggregate debt service (principal and interest payments considered together), we base our analysis on the properties of the repayments generated by the so-called *French loan* (characterised by having constant instalments and an ex-ante known repayment scheme). Besides being the most popular contract in the euro area – and easy to generalise to most variable rate contracts – the advantage from focusing on this type of loan is mathematical tractability, as it delivers closed-form expressions for the remaining principal and the repayment schedule. However, it is well-known that aggregation effects introduce a wedge between the repayment dynamics of an individual loan and that of an entire portfolio. As outstanding exponents of the literature, Drehmann et al. (2017, 2018), starting from a French loan, derive a formula to compute the contemporaneous amortisation rate of a stock of debt. While intuitively appealing, their formula is not intertemporally consistent with the repayment schedule of that type of loan, which results in a severe underestimation of the actual amortisation rate of the stock.

We instead derive analytically the laws of motion of the stock and repayments (and therefore also that of the amortisation rate), so that they are fully consistent with the properties of the individual French loans composing the portfolio. When matched with actual data, this allows us obtaining plausible portfolio repayments, which being a predetermined function of past granted loans, provide an anchor to disentangle loan origination from repayments. In addition, our consistent framework allows us simulating scenarios in order to analyse the intertwined dynamics between loan origination, the loan stock and the amortisation rate. Based on this, we show that booms in loan origination have a substantially lasting and delayed downward impact on net loan volumes. Specifically, after a large boom, the typical long repayment structure of loans creates a persistent base effect that depresses the growth rate of the loan stock for many periods after the end of the loan origination boom. The latter calls for focusing on loan origination rather than on changes in the loan stock and on using alternative scale variables, such as GDP, as suggested by Biggs et al. (2009), in order to have a more accurate perception of the prevalent loan dynamics at every point in time, especially after large swings in loan origination.

Finally, rather than using a constant maturity, as assumed in Drehmann et al. (2017) and by the BIS when computing debt service ratios, or contractual maturity as in Drehmann et al. (2018), we use a measure of the prevailing effective maturity, relying on the information contained in the Household Finance and Consumption Survey (HFCS). In a *ceteris paribus* analysis, we show that changes over time in the loan maturities of the magnitude of those observed in the euro area over the last 20 years, cause changes in the amortisation rate of size similar to those caused by booms in loan origination.

Our portfolio simulation based on euro area data shows that repayments of the lending boom registered in the run-up to the financial crisis have been an increasingly dragging force for net loan growth in recent years, concealing an increasing dynamism in loan origination. The growth of net loans is expected to be increasingly dampened by loan repayments (most of them coming from the loans granted during the pre-crisis boom) until about 2022. The estimated annual loan origination in mid-2018 is at levels comparable to those estimated for the years immediately before the peak of the boom. Our method also delivers a plausible decomposition for the four largest euro area countries, with the estimated loan origination flows standing at historical highs in Germany and France.

In a set of empirical exercises using our estimated loan origination and/or repayments, we show that, compared with the cases when the credit variable is net loans: (i) Loan origination plays a more relevant role in explaining the recent strengthening in housing markets, which, if confirmed, would warrant a close monitoring of that market with respect to financial stability risks; (ii) Loan origination seems to have played a more relevant role in explaining consumer price developments in the post-boom period; (iii) Not including the growing repayments in the estimation of credit supply shocks magnifies the dampening impact of credit supply restrictions on the economy in the post-crisis, while slightly underestimating the positive credit supply impulse during the recovery phase. In addition, when net loans are replaced by loan origination, adverse credit supply shocks lead to a more negative impact on the macroeconomy.

Overall, these results suggest that there is a premium on adjusting economic models that use lending as an input to account for loan origination and/or repayments, especially after large credit booms.

The remainder of this paper is organised as follows. Section 2 presents the conceptual framework and the related statistical landscape. Section 3 operationalises the framework described in Section 2 by assuming that the stock is composed of French loans. After describing the properties of such type of loans and the implications thereof when aggregating them into a loan portfolio, it presents a feasible, consistent approach to decompose bank loan flows. Section 4 reports the results of the decomposition for the euro area and the large euro area countries. Section 5 discusses robustness checks, while Section 6 presents the results of a set of empirical applications. Section 7 concludes.

2. The conceptual framework and the related statistical landscape

The analysis on loan dynamics in the euro area is commonly made based on net lending flows, typically expressed as a percentage of the stock of loans in the previous period, as reported in Figure 1.

Our purpose is to disentangle how much of the net flows reflect loan origination and how much is driven by the repayments of previously granted loans. The aim of this section is to provide a conceptual description of the main concepts used throughout the paper and the relationships between them. We also provide an overview of the available (and not available) data, which ultimately justifies the need for our exercise.

Our analysis of loan dynamics relies on four main concepts: net lending flows, stock of loans, loan origination and loan repayments. The first two are the key ingredients of the official figures on growth rate of bank lending as reported by the MFI Balance Sheet Items statistics (BSI), the month-on-month version of which is computed as:

$$g_t = \frac{F_t}{S_{t-1}} \tag{1}$$

where S_t is the nominal outstanding amount (or stock) of loans reported by euro area MFIs in month *t* and F_t is the net flow of lending to the economy granted by MFIs in month *t*. Every month, the net flow of lending is not observed but derived as an adjusted measure of the first difference of the stock:

$$F_t = \Delta S_t - Adj_t \tag{2}$$

where Adj_t denotes write offs/write downs, reclassifications and sales/transfers of loans.[5] This adjustment is warranted for monetary analysis purposes, as the aim in that field is to deal with a measure that tracks as close as possible the actual flow of financing via loans from banks to the economy. Therefore, already net of other distortions, the net flow of lending in month t can be conceptually decomposed into the flow of newly originated loans in that month (LO_t) minus the flow of repayments in the same month (R_t):[6]

$$F_t = LO_t - R_t \tag{3}$$

[5] Moreover, interest receivable on loans is recorded on the balance sheet as it accrues rather than when it is actually received, but in the category "remaining assets" and not in "loans". Therefore, only loans actually extended, net of repayments, are recorded in the BSI, and not the larger amounts including accruing interest.
[6] Conceptually, this expression is analogous to the national accounts identity that decomposes the net capital formation into gross capital formation and capital depreciation.

Unfortunately, none of these components is recorded by the BSI statistics, which has motivated us to disentangle them. However, before discussing the methodology to decompose net flows, it is useful to specify what we understand by loan origination and repayments, both at micro and aggregate levels, as well as to state what we already know about them.

With loan origination we refer to all new fresh money/financing that banks make available to the economy. At the individual bank level, this consists of all financial contracts, terms and conditions that specify the interest rate of a loan for the first time. This has two implications. First, all renegotiations that leave the principal amount unchanged are not considered in the concept of loan origination. Second, when the principal amount of an already existing loan is renegotiated, the increment (or decrement) in the nominal amount should be considered a new loan. At the macro level, our concept of loan origination also excludes the so-called loan substitutions, which refer to the cases when a borrower cancels the loan with a bank in order to open a new one in another bank because of better conditions offered by the second institutions.

In the euro area, the MFI Interest Rate statistics (MIR) collects data that can help us to calibrate the size of the loan origination flow. First of all, it publishes data on new business loans since 2003. However, there are profound differences between the MIR measure of new business loans and our loan origination concept, the most fundamental one being that MIR new business includes all renegotiations of existing loan contracts,[7] and so the flow of MIR new business loans should in general be substantially larger than the loan origination flow. As such, the MIR new business provides an upper bound to loan origination, and we use this information in our estimations. In addition, since end-2014, the MIR statistics collects the amount of renegotiated loans. Subtracting this amount from the MIR new business volumes allows constructing a measure officially labelled as “pure new loans”, the monthly flows of which have been published since August 2017 (with internal estimates going back to December 2014). As it excludes explicit renegotiations, this measure is much closer to our concept of loan origination, but the lack of earlier data prevents us from using it for policy analysis when the use of historical data is required. The latter notwithstanding, it provides a much stricter upper bound to loan origination flows. Specifically, our measure of loan origination should be still strictly below the MIR “pure new loans”, as this measure does not account for all renegotiated loans resulting from a transfer from one bank to another one,[8] and cannot cope with the above-referred loan

[7] A renegotiation refers to the active involvement of the household or non-financial corporation in adjusting the terms and conditions of an existing loan or deposit contract, including the interest rate.
[8] In the transfers of loans from one MFI to another with the active involvement of the borrower, the reporting agents should report the renegotiating loans from another MFI on a best-efforts basis. For further details, see (ECB, 2017).

substitutions. Nevertheless, the difference between the two measures should be relatively small compared with the difference between the ideal measure of loan origination and the MIR new business. Therefore, we use the MIR "pure new loans" as an ex-post cross check for the plausibility of our estimations.

As regards repayments, we use this concept to refer to the payments from the borrower to the lender that result in a decline of the principal amount of the loan. As such, this excludes the interest payments. This adds a further restriction to identity (3), as, barring measurement errors and early repayments, repayments are predetermined at every point in time, depending on the stock of loans until the previous period:

$$R_t = f(S_{t-1}) \tag{4}$$

Abstracting from the adjustment introduced in equation (2), or using the notional stock NS_t which abstracts from them,[9] one can combine equations (2) and (3) and obtain:

$$NS_t = \sum_{\tau=0}^{t} LO_\tau - \sum_{\tau=1}^{t} R_\tau \tag{5}$$

where the notional stock of loans at every point in time is expressed as the sum of all loans granted in the past minus all accumulated repayments. In general, the repayment amount ($R_{l,t}$) at every point in time (t) of a loan (l) granted in ($t = \tau_l$) depends on the consistent interaction between the original principal amount ($LO_{l,t}$), the loan maturity (M_l) and the instalment structure (P_l), which in practically all cases will introduce in the game the interest rate applied on the initial and remaining principal amounts ($i_{l,t}$):

$$R_{l,t} = f\left(LO_{l,t=\tau l}, M_l, P_l, i_{l,\tau l} \dots i_{l,t}\right) \tag{6}$$

And so, for the entire loan stock, repayments at every point in time will be:

$$R_t = \sum_l R_{l,t} \tag{7}$$

implying that the repayments attached to a loan portfolio are the sum of typically non-linear interactions between the original principal amounts of all outstanding loans and their respective terms and conditions (maturity, instalment structure and interest rates applied). With these considerations

[9] Indexes of notional stocks are computed in the BSI by means of a chain-index series to isolate the changes in outstanding amounts arising purely from transactions (ECB, 2012).

and concepts in mind, the next section proposes a method to decompose net lending flows into loan origination and repayments.

3. A simulated loan portfolio approach

Our purpose is to disentangle how much of the *observed* net flows reflect loan origination and how much is driven by repayments of previously granted loans. In that respect, our analysis is a partial equilibrium approach, as we take the maximisation problem of households and banks as given. Having established that, the simple relationship described in equation (3) and the conceptual restrictions described thereafter in Section 2 impose sequentiality on our course of action. In particular, the predetermined nature of the repayments term (R_t), which at the aggregate level comes as the result of the sum of typically non-linear amortisation schedules, puts a premium on first analysing the dynamics of loan repayments, both at the level of an individual loan (sub-Section 3.1) and at the level of the loan portfolio (or stock, sub-Section 3.2 and sub-Section 3.3), based on tractable functional forms. Once that is achieved, we can simulate the dynamics of a portfolio, which when restricted to the observed net flows (and the impossibility for every monthly flow to exceed the monthly MIR new business) provides a decomposition of the latter into loan origination and repayments (sub-Section 3.4).

3.1 The repayment dynamics of a single loan

We base our analysis on the dynamics of the so-called *French loan*, characterised by having constant instalments and interest rate over its life, and therefore an amortisation scheme known ex-ante. This greatly simplifies the expressions while at the same time not coming at great cost in terms of generality, as the amortisation scheme of the French loan is the most usual scheme in the vast majority of the euro area countries (ECB, 2009). In addition, we show that under reasonable assumptions, the amortisation scheme of the French loan is shared by common variable rate loans.[10] Our goal in this sub-section is to obtain closed-form expressions for the repayment schedule, the law of motion of the remaining principal amount and the contemporaneous amortisation rate that allow us to characterise the repayment dynamics of a loan.

[10] For an analysis of the properties of the different mortgage modalities, see Chambers et al. (2009) and Piskorski and Seru (2018). For a cross-country analysis of mortgage market structure, see Campbell (2013).

Our starting point is the well-known equivalence between the present value of an asset and the present discounted value of the future cash flows,[11] whereby the present value of an asset is equal to the discounted value of all the future cash flows of the asset. In our case, the asset is a loan with original principal amount (L_0) and maturity (M), the future cash flows are the loan instalments (P_t) and the discount rate is the prevailing gross interest rate (i_t):

$$L_0 = \frac{P_1}{(1+i_1)} + \frac{P_2}{(1+i_1)(1+i_2)} + \cdots + \frac{P_M}{(1+i_1)\ldots(1+i_M)} \tag{8}$$

For the case of the French loan, the above equivalence becomes a sum of a geometric progression with a ratio equal to $(1+i)^{-1}$. After appropriate simplifications and term rearrangements, it takes the form of the typical formula for the calculation of the fixed periodic instalment of a French loan:

$$P = \frac{iL_0}{1-(1+i)^{-M}} \tag{9}$$

We also know that the remaining principal amount of a loan evolves according to:

$$L_t = L_{t-1} - R_t \tag{10}$$

which for a French loan corresponds to:

$$L_t = L_{t-1} - (P - iL_{t-1}), \text{ or more conveniently: } L_t = (1+i)L_{t-1} - P \tag{11}$$

Applying forward recursion to the second formulation of equation (11) from t=1 onwards, the remaining principal of a French loan at period t can be expressed as the capitalised initial principal amount up to period t minus the sum of a geometric progression of the instalments between period 1 and t:

$$L_t = L_0(1+i)^t - P\frac{(1+i)^t - 1}{i} \tag{12}$$

[11] The fundaments of the intertemporal equivalence of monetary amounts through the interest compensation dates back at least to the School of Salamanca, whose scholars treated interest as the opportunity cost of the lent money. See for instance Azpilcueta (1568), page 48: *"…it can also be justified [that]…merchants may take more if they await the payment until Monday than if they only await until Sunday: and more if they await until Tuesday, than if they were to await until Monday: because the change in the interest is larger the larger the likely amount of earnings that one forgoes is, and it is certain that the dealer who forgoes deals and the exchanger who forgoes exchanging his money for two days lose more money than if they forwent their activities for one day, and he who forgoes deals for two days loses more than he who forgoes them for one, etc."*.

Combining equations (9) and (12), the law of motion for the remaining principal of a French loan can be expressed just in terms of the interest rate, the loan maturity and the periods elapsed since the loan was granted, defining a negative exponential function over the loan life (t), ranging between L_0 and 0.

$$L_t = L_0 \frac{1-(1+i)^{t-M}}{1-(1+i)^{-M}} \tag{13}$$

The complementary expression for the law of motion of the loan repayments can be easily obtained by further using equation (10), which defines repayments as the difference between the remaining principal in two consecutive points in time:

$$R_t = L_0(1+i)^{t-M}\left[\frac{1-(1+i)^{-1}}{1-(1+i)^{-M}}\right] \qquad \text{for } t \geq 1 \tag{14}$$

Equation (14) reveals a well-known feature of the French loan: its repayment amounts grow more than proportionally as the loan approaches its maturity:

$$\frac{dR_t}{dt} > 0, \quad \frac{d^2R_t}{dt^2} > 0 \tag{15}$$

Furthermore:

$$\sum_{t=1}^{M}(1+i)^{t-M}\left[\frac{1-(1+i)^{-1}}{1-(1+i)^{-M}}\right] = 1 \tag{16}$$

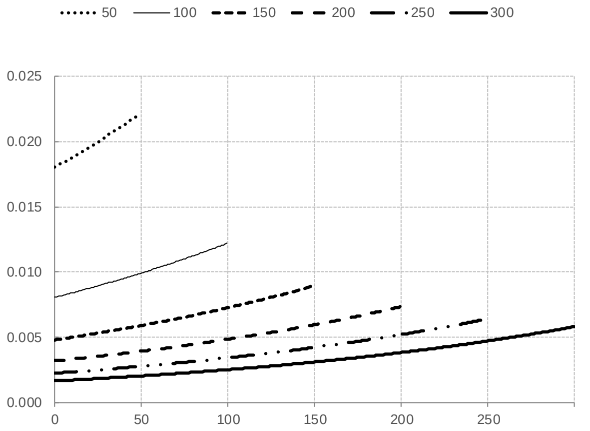
which ensures that the original principal amount has been paid in full by the time the loan matures. Equation (14) also satisfies the intuitive *ceteris paribus* dynamics with respect to maturity and interest rate applied: for a given initial principal amount and interest rate, the repayment amounts at every point in time decline, eventually becoming zero as the loan becomes a perpetual debt (Figure 3):

$$\frac{dR_t}{dM} < 0, \quad \lim_{M\to\infty} R_t = 0 \tag{17}$$

The sensitivity of the repayment schedule to various interest rates is somehow more interesting. Because loan instalments are of fixed amount, a higher interest rate implies that the instalments of the initial phase have a higher interest payment share, and so repayments in that phase must be small. However, as the original principal amount must be repaid in full by the time the loan matures (equation (16)), then principal repayments have to increase as maturity approaches in order to offset the smaller repayments in the initial phase. Therefore, the curvature of the repayment schedule increases with higher interest rates, becoming more and more tilted towards the maturity period (Figure 4):

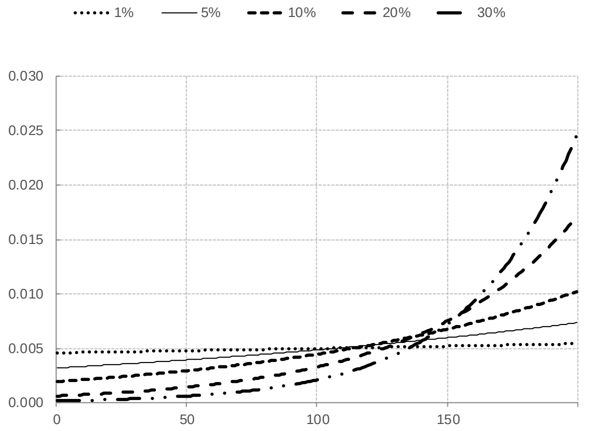
$$\frac{dR}{di} < 0, \quad \lim_{i \to \infty} R_t = 0 \tag{18}$$

Figure 3. Sensitivity of the repayment schedule of a French loan to different loan maturities
(EUR; months)



Notes: Monthly repayments of a French loan with an original principal amount of €1 at 5% per annum. The x-axis displays time since origination of the loan in months.

Figure 4. Sensitivity of the repayment schedule of a French loan to different interest rates
(EUR; months)



Notes: Monthly repayments of a French loan with an original principal amount of €1 and a maturity of 200 months. The x-axis displays time since origination of the loan in months.

We can also combine the repayments and remaining principal schedules (equations (13) and (14)) to derive the contemporaneous amortisation rate (AR_t):

$$AR_t = \frac{R_t}{L_t} = \left[\frac{1 - (1 + i)^{-1}}{(1 + i)^{M-t} - 1}\right] \tag{19}$$

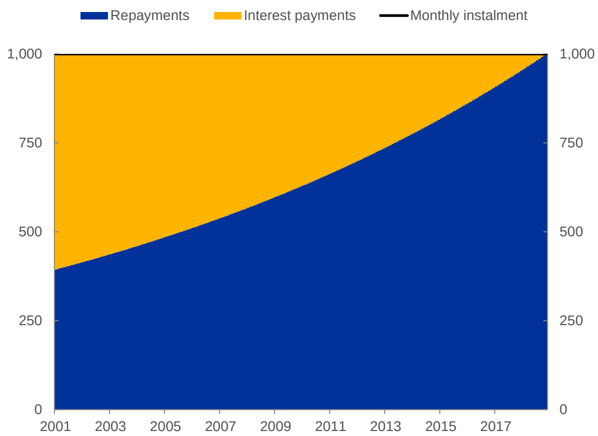
Equation (19) is defined for values of *t* between 0 and *M-1* (the stock at maturity is zero and therefore at that moment the ratio becomes infinite), and describes a positive exponential function. This implies that, like the repayment amounts, the amortisation rate grows over the life of the loan at an increasing rate. However, the pace of increase is higher than that of the repayment amounts, and it exacerbates towards the end of the loan life, reflecting that at that stage accelerating repayments cause the remaining principal amounts to decrease rapidly.

The analysis of the repayment dynamics of a French loan can be easily extended to nest loans with variable interest rates, which are popular in a number of euro area countries. The most straightforward example is the case when a variable/adjustable rate loan is set under the expectations that the market interest rate will remain constant over the life of the loan. In such a case, the amortisation schedule remains identical, with interest rate applied on the loan over time adjusting to market rates according to the contract terms and conditions. In this approach the instalment at every point in time is computed as:

$$P_t = R_t + L_{t-1} i_t \tag{20}$$

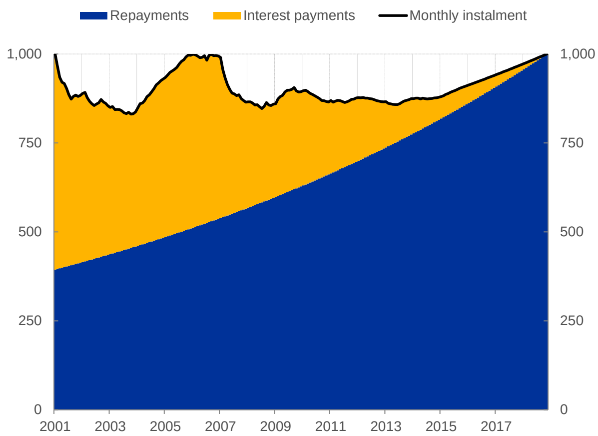
Figures 5 and 6 compare the case of a pure French loan with that of a stylised variable rate loan. In particular, Figure 5 shows the distribution between interest payments and repayments of a hypothetical loan with fixed interest rate, while Figure 6 illustrates the extreme case when the interest payments are adjusted every month based on the actual prevailing bank lending rate.

Figure 5. Example of monthly instalment of a loan with fixed interest rate
(EUR)



Notes: Monthly instalment of a French loan granted in 2001, with a €140,000 principal, 18-year maturity and fixed interest rate.

Figure 6. Example of monthly instalment of a loan with variable interest rate
(EUR)



Notes: Monthly instalment of a French loan granted in 2001, with a €140,000 principal, 18-year maturity and variable interest rate.

3.2 The repayment dynamics of a loan portfolio (stock)

It is a well-known in the literature that aggregation effects introduce a wedge between the repayment dynamics of an individual loan and that of an entire portfolio. To deal with this problem, Drehmann et al. (2017), inspired by the literature studying aggregate debt service (principal and interest payments considered together), establish an analogy between the stock of debt at every point in time and the initial principal amount of a French loan. Relying on that analogy, they derive the amortisation rate for a French loan in its first period and use it as the amortisation rate of the debt stock at every point in time, applying the prevalent interest rate and a constant maturity.[12] While intuitively appealing (it

[12] The amortisation rate used by Drehmann et al. (2017), $i/((1+i)^M - 1)$, corresponds to our equation (19) for t = 1, i.e. in the first period of a French loan.

moves inversely to both interest rate and maturity), their formula has two serious drawbacks. First, it does not evolve according to the composition and maturity structure of the loans constituting the portfolio, and, second, it results in a severe underestimation of the actual amortisation rate of the loan portfolio. The reason for the latter is that, as a French loan displays growing repayments over time, the systematic use of the amortisation rate of a French loan in its first period to compute the repayments of a debt over time is not time consistent. In particular, equation (16), which ensures that a debt is fully repaid by the time it matures, is not satisfied.[13]

In this sub-section we analyse the dynamics of the stock, the repayments, and in particular the amortisation rate, of a portfolio of French loans fully consistent with the properties of these loans at the individual loan level. To do so, we rely on the formulas derived in the previous sub-section. As our main interest is to analyse the aggregation properties of accumulating loans over time, we work under the simplifying assumption that a single loan is granted at every point in time *t*, resulting in an open-ended series of loans with initial principal amounts: $L_{0,1}, L_{0,2}, \dots, L_{0,l}$, with $L_{0,1}$ being granted at time *t=0*, generating its first repayment at time $t = 1$ and maturing (i.e. generating its last repayment) in $t = M_l$.

In general, the law of motion of the stock of loans (S) at time *t* can be described as the sum of the remaining principal amounts of all outstanding loans at the end of period *t*. As loans progressively mature over time, in our single-loan-per-period setup this describes a sum over a moving window, which reaches a steady-state size equal to M in period $t = M - 1$. From that period onwards, the remaining principal amounts composing this window correspond to the loans ranging from the oldest outstanding loan (L_{t-M+2}) to the loan granted in period *t* (L_{t+1}).[14] Using equation (13), and assuming that all loans share the same interest rate (*i*) and maturity (*M*), the outstanding amounts (or stock) of a portfolio of French loans at time *t* can be expressed as:

[13] For example, a French loan with an initial principal amount of €100, a maturity of 200 months and an interest rate of 5% per annum, generates monthly repayments ranging from €0.3213 in the first period to €0.7349 in the last period of the loan, ensuring that the €100 principal amount will be repaid. If, instead, the amortisation rate of the first period of that loan (0. 3213%) is used to compute all the repayments over the life of the loan, only €64.25 will have been repaid by when the maturity date arrives. As it is straightforward to compute, a constant rate of repayment over initial principal amount would have required a monthly repayment of €0.5 euros a month (i.e. a rate of 0.5%). In other words, for this particular example, the formula used by Drehmann et al. (2017) results in an underestimation of more 35% of the actual amortisation rate.

[14] L_{t-M+2} is the oldest outstanding loan because L_{t-M+1} generates its last repayment (i.e. it matures) in period *t*, and thus it can no longer be considered to be outstanding in that period. The index of the most recent outstanding loan ($t + 1$) reflects that, in our framework, loans are labelled by the period in which the first repayment of a loan is generated.

$$S_t = \sum_{l=t-M+2}^{t+1} L_{0,l} \frac{1-(1+i)^{\tau-M}}{1-(1+i)^{-M}} \qquad \text{for } l \geq 1 \tag{21}$$

where $\tau = t - l + 1$ denotes, for each loan, the number of periods since that loan was granted. Figure 3A in the Annex illustrates an example of this framework in a matrix form.

Alternatively, the stock of a loan portfolio at time t can also be defined as the sum of the initial principal amounts of all outstanding loans minus all the repayments generated by those loans until that period:

$$S_t = \sum_{l=t-M+2}^{t+1} L_{0,l} - \sum_{l=t-M+2}^{t} \sum_{\tau=1}^{M-l+1} R_{\tau,l} \qquad \text{for} \begin{cases} l \geq 1 \\ \text{and} \\ M-l+1 \geq 1 \end{cases} \tag{22}$$

Equation (22) is the decomposition of the loan stock which, for modelling convenience, is used in sub-Section 6.3. It also provides a more visual intuition to grasp the dynamics of the stock of a loan portfolio (Figure 4A in the Annex contains a concreate example of it). Once the window of outstanding loans has reached its steady state size, maturing loans are replaced with newly originated loans, with older outstanding loans in the window contributing progressively less than younger loans to the portfolio stock as time goes by. This reflects that older outstanding loans have generated a higher number of repayments than younger loans, an effect that is amplified in a portfolio uniquely composed of French loans (as for that loan modality the size of each repayment grows over the life of a loan). The latter can be seen by replacing $R_{\tau,l}$ in equation (22) with the repayment function of a French loan (equation (14)):

$$S_t = \sum_{l=t-M+2}^{t+1} L_{0,l} - \sum_{l=t-M+2}^{t} \sum_{\tau=1}^{M-l+1} L_{0,l}(1+i)^{\tau-M}\left[\frac{1-(1+i)^{-1}}{1-(1+i)^{-M}}\right] \qquad \text{for} \begin{cases} l \geq 1 \\ \text{and} \\ M-l+1 \geq 1 \end{cases} \tag{23}$$

Assuming that all loans in the portfolio share the same initial principal amount (i.e. $L_{0,l} = L_0$), the loan stock becomes constant as soon as the moving window reaches its steady-state size, as none of the summed elements depend on t.

Similarly, one can obtain the expression for the repayments generated by the portfolio at every point in time by summing all the repayments of all the outstanding loans used to compute the portfolio stock (see example in Figure 5A in the Annex):

$$R_t = \sum_{l=t-M+1}^{t} L_{0,l}(1+i)^{\tau-M}\left[\frac{1-(1+i)^{-1}}{1-(1+i)^{-M}}\right] \qquad \text{for } l \geq 1 \tag{24}$$

where $\tau = t - l + 1$. Equation (24) is another moving sum with a fixed rolling window of a size equal to that of equation (21). In the case of constant loan origination amounts over time, its terms are also independent of the time dimension *t*, and so equation (24) also describes a function which becomes constant once the window size for repayments of outstanding loans stabilises in period M – 1.[15] Before the repayments window reaches its steady-state size, the portfolio repayments follow a positive exponential function, as older loans in the window accumulate a higher number of repayments. As for equations (21) and (23), in a French loan framework, this effect is amplified.

With all loans being identical in terms of size, maturity and interest rate applied, the ratio of the loan stock and repayments at the portfolio level at every point in time determines an aggregate contemporaneous amortisation rate (R_t/S_t), which grows exponentially until period M – 1 and remains constant thereafter.

3.3 Dynamics of the stock and amortisation rate of a portfolio when loan parameters are not constant over time

In this section we progressively relax each of the three characteristics that, in the previous sub-section, made the loan origination process invariant over time: initial principal (or loan origination) amount, interest rate and maturity. Finally, we also relax the assumption that our loan portfolio is composed by French loans.

We start by assuming that, instead of remaining equal over time, initial principal amounts grow at a constant rate over time. At this point, it is crucial to notice that the most basic characteristic of an instalment loan (not only in those of a French type) is that the principal amount granted today is repaid back over a (large) number of periods in the future. This introduces a lagging mechanism in the transmission of shocks from the loan origination process to the stock via its repayment schedule which

[15] The size of the repayments window is equal to that of remaining principals. However, it ranges over loans one position behind as the loan granted in period *t* (L_{t+1}) does not generate any prepayment in that period, while the loan maturing in period *t* does.

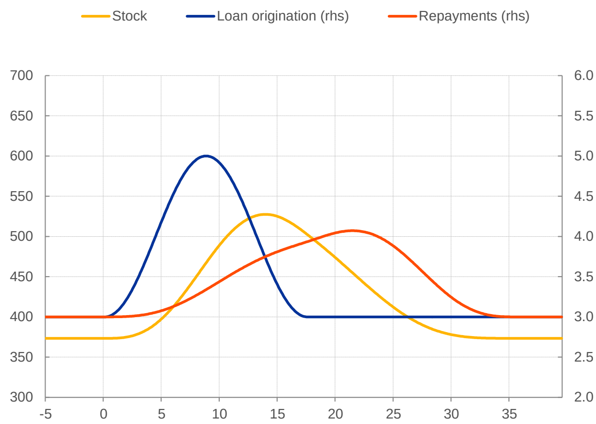
can intuitively be grasped by observing the implications that this new assumption has on the loan stock as implied by equation (22) and illustrated by Figure 5A in the Annex. The fact that loan origination grows at a constant growth rate instead of remaining flat over time will cause the stock to grow at the same growth rate in the steady-state, which will result in a constant amortisation rate. The only difference will be that steady-state amortisation rate will be lower than in the flat loan origination case. This reflects the lagging mechanism described in equations (23) and (24), whereby increases in loan origination are transmitted to repayments with a longer delay than to the stocks, which causes in the periods before both repayment and stock windows reach their steady-state size (i.e. for $t \leq M$) the stock (which is the denominator of the amortisation rate) to grow faster than the repayments generated by the portfolio in each of those periods. The outcome of this simple exercise already anticipates that the level of the amortisation rate is closely linked to the referred lagging mechanism, a crucial determinant of which is the maturity of the loans composing the portfolio in periods where the growth rate of stock and portfolio repayments differ.

In reality, however, we rarely observe loan origination to grow at a constant rate, but rather to follow more or less defined cyclical patterns. This creates desynchronised movements in loan origination, the loan stock, the accumulated repayments and the amortisation rate. The interaction between a time-varying loan origination and the different lagging patterns introduced by stock and repayments schedule can be illustrated by simulating a lending boom. As expected, the impulse of one boom in the loan origination process is transmitted with a longer lag to the portfolio repayments than to the portfolio stock (Figure 7).

As repayments increase with a longer lag than the stock, the boom translates first into a decrease of the amortisation rate, which only starts to return towards its original level once the boom in loan origination has ended (see blue line in Figure 8, where the repayment rate is displayed with inverted sign). Figure 8 also includes the loan origination rate, defined as the loan origination at time t ($LO_t \equiv L_{0,t+1}$) over the stock in the same period (LO_t / S_t), and the instantaneous growth rate of the stock ($\Delta S_t / S_t$). This way, the growth rate of the stock can be interpreted as the contribution of the loan origination rate minus the contribution of the repayment rate, a representation that can be immediately derived by dividing all the terms in equation (3) by the contemporaneous stock.

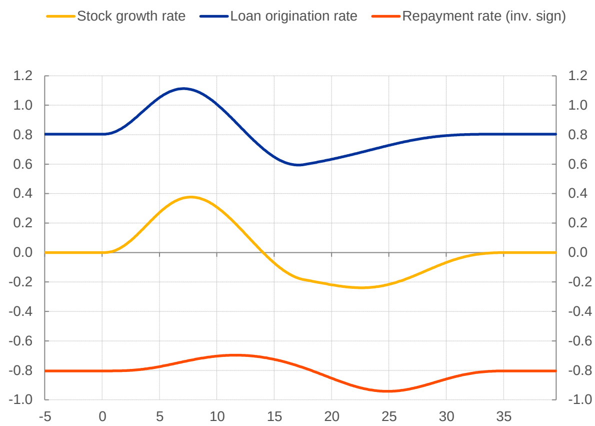
The simulation depicted in Figures 7 and 8 also reveals that using the loan stock as a scale variable, as it is common in the analysis of loan developments, has implications for the perceived lending dynamics, especially after large booms in loan origination. The typically long maturities of mortgage loans introduce a long-lasting dependence of the loan stock on past loan origination, as it depends on the repayments of all outstanding loans. This not only delays the dynamics of the loan stock, but, more importantly, produces a long-lasting base effect after the boom that results in an undershooting not only of the stock growth rate but also of the loan origination rate. This result is not a unique feature of a portfolio composed of French loans, as it also holds when the portfolio is composed by loans with constant amortisation amounts (see Figure A6 and especially Figure A7 in the Annex). It therefore puts a premium on using alternative scale variables, such as GDP, as suggested by Biggs et al. (2009), in order to have a more accurate perception of the prevalent loan dynamics at every point in time.

Figure 7. Transmission of a one-boom cycle in loan origination to the loan stock and repayments
(EUR)



Notes: Loan portfolio composed of French loans with equal maturity (18 years) and interest rate (5%). Time dimension expressed in years since the onset of the boom. The length of the boom in loan origination is chosen to match the maturity of the loans composing the portfolio.

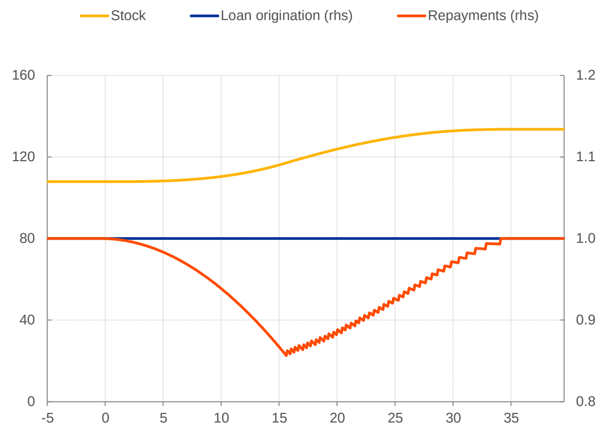
Figure 8. Transmission of a one-boom cycle in loan origination to the loan stock and repayments
(ratio to contemporaneous stock)



Notes: Loan portfolio composed of French loans with equal maturity (18 years) and interest rate (5%). Time dimension expressed in years since the onset of the boom. The length of the boom in loan origination (shown in Figure 7) is chosen to match the maturity of the loans composing the portfolio.

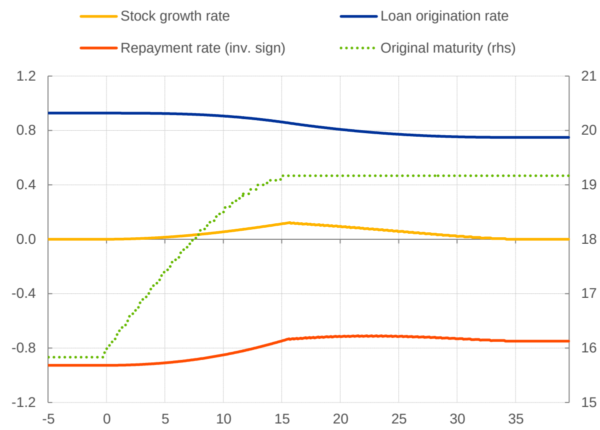
Finally, we briefly discuss the sensitivity of these indicators of the loan portfolio with respect to changes in maturity and prevailing interest rates. For that, we simulate increases in maturity and decreases in interest rate similar to those observed in the data over the last 20 years. Other things equal, an increase in the original maturity from 16 to 19 years leads to a decline in monthly repayments (Figure 9), as an equal original principal amount has to be repaid over more periods (Figure 3). The latter also leads to a higher stock, as the remaining principal amounts of the outstanding loans decline at a smaller rate. The simulated increase in loan maturity delivers a decrease in the amortisation rate of about 22 basis points (2.6 percentage points in annual terms) over the period through which the increase in maturities occurs (Figure 10).

Figure 9. Transmission to loan stock and repayments of a progressive 3-year increase in the original loan maturity
(EUR)



Notes: Loan portfolio composed of French loans with equal maturity and interest rate (5%). Time dimension expressed in years since the increase in the loan maturity.

Figure 10. Transmission to loan stock and repayments of a progressive 3-year increase in the original loan maturity
(ratio to contemporaneous stock)

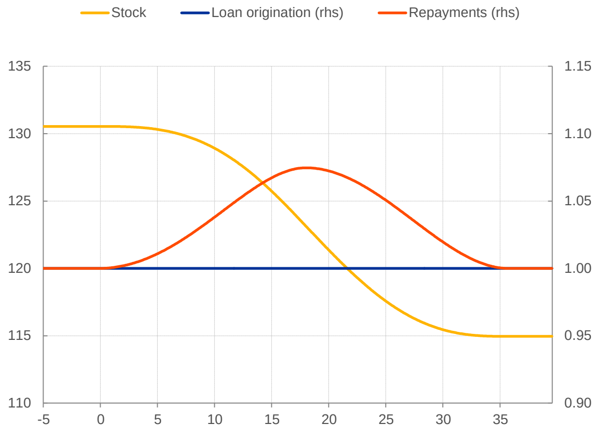


Notes: Loan portfolio composed of French loans with equal maturity and interest rate (5%). Time dimension expressed in years since the increase in loan maturity.

Similarly, a progressive decrease of 5 percentage points in the interest rate at which each of the loans are granted results in an increase of the amortisation rate of about 13 basis points, equivalent to 1.5 percentage points in annual terms (Figure 11 and Figure 12). The channel through which this occurs is a transitory increase in repayments, due to a flatter repayment schedule of the loans composing the portfolio (Figure 4).

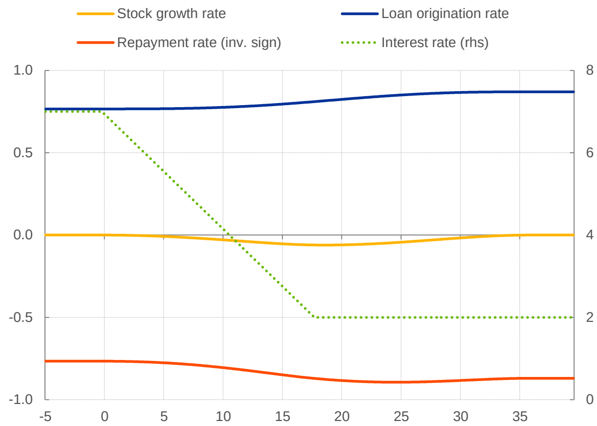
The impact of the maturity increase on the amortisation rate is relatively large (of the order of magnitude of that created by changes in loan origination), which would call for caution when the constant maturity assumption is used, as done by the BIS and in Drehmann (2017). At the same time, the sensitivity analysis with respect to maturity and interest rate just presented is – as already said before – a *ceteris paribus* analysis. In reality, longer maturities tend to come hand in hand with higher original principal amounts, and many times (typically in periods of financial liberalisation) also with declines in interest rate. This is probably the reason why the literature tends to find a weak correlation between changes in the maturity and in the amortisation rate. But this might be a historical regularity that does not need to be always respected.

Figure 11. Transmission to loan stock and repayments of a progressive decline in the prevailing interest rate
(EUR)



Notes: Loan portfolio composed of French loans with equal maturity (18 years) and constant loan origination. Time dimension expressed in years since the decline in the interest rate.

Figure 12. Transmission to loan stock and repayments of a progressive decline in the prevailing interest rate
(ratio to contemporaneous stock)



Notes: Loan portfolio composed of French loans with equal maturity (18 years) and constant loan origination. Time dimension expressed in years since the decline in the interest rate.

3.4 The simulation algorithm

In this sub-section we present a simulation algorithm that allows us to decompose the net flows of loans to households for house purchase into loan origination and loan repayments in a framework fully consistent with the properties of a portfolio of French loans discussed above, and with the conceptual and statistical framework described in Section 2.

For that, we operate with a model economy which is populated by one bank which takes the series of growth in net loans as given. Every month the bank grants a loan at the following conditions: (i) prevailing average maturity; (ii) prevailing average interest rate; (iii) with known amortisation schedule, corresponding to that of a standard equal instalment loan (or *French loan*), which as explained in sub-Section 3.1 can be easily generalised to cater for both variable and fixed interest rate arrangements; and (iv) with an original principal amount such that the portfolio growth replicates the growth of MFI adjusted loans to households for house purchase. Operationally, we apply a two-stage approach. First, we simulate a loan portfolio where the loan origination at every point in time is the sum of the actual monthly net flow (F_t) and the repayments generated by all outstanding loans in the portfolio, which in the first stage are fully predetermined, and therefore known, at period t:

$$\widehat{LO}_t = F_t + \hat{R}_t \tag{25}$$

subject to the simulated loan origination at every point in time not being larger than the observed MIR new business (NB_t), which must be the absolute upper bound of loan origination, as it includes renegotiations (see Section 2):[16]

$$\widehat{LO}_t \leq NB_t \tag{26}$$

The predetermined portfolio repayments ($\hat{R}_t$ in equation (25)) are computed based on a formula analogous to equation (24) but with maturity and interest rate set equal to those prevailing in the actual data at every point in time:[17]

$$\hat{R}_t = \sum_{l_t=t-M_t+2}^{t} \sum_{\tau=t-l_t+1}^{t-l_t+1} \widehat{LO}_t (1+i_t)^{\tau_t - M_t} \left[\frac{1-(1+i_t)^{-1}}{1-(1+i_t)^{-M_t}}\right] \tag{27}$$

for $l \geq 1$. Finally, we use the loan origination implied by the simulation algorithm to obtain the following ratio:

$$\alpha_t = \frac{\widehat{LO}_t}{NB_t} \tag{28}$$

As equation (27) is fully predetermined by time t, it does not take into account repayment shocks. To allow R_t absorbing short-term shocks to repayments (such as voluntary repayments), we smooth α_t using a centred 7-month moving average ($\tilde{\alpha}_t$). The final estimated loan origination and repayments are then computed ex-post using $\tilde{\alpha}_t$, satisfying the following formulas:[18]

$$\widetilde{LO}_t = \tilde{\alpha} NB_t \quad \text{and} \quad \tilde{R}_t = \widetilde{LO}_t - F_t \tag{29}$$

The portfolio is initialised in March 1980 to mitigate initial condition effects.

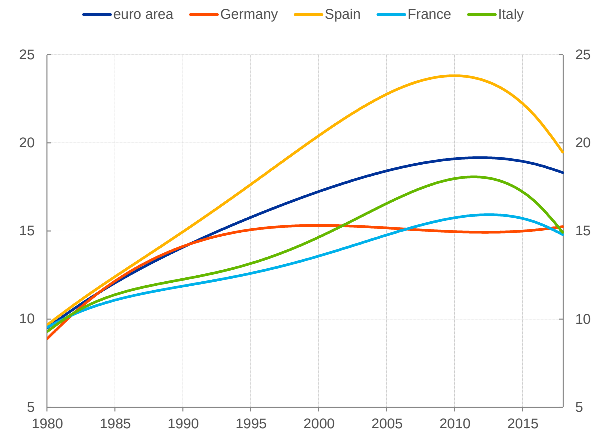
3.5 The data

For our simulation exercise, we use actual historical series on loan volumes, lending rates, and, to the extent possible, also maturities for the euro area. As discussed above, the length of the loan contract M is a key factor in determining the repayment schedule, but unfortunately data on maturities are scarce. We rely on information on the effective maturity of mortgages collected via the Household Finance

[16] This restriction is only applied from 2003 onwards, when MIR new business data are available.
[17] For simplicity, we assume that the initial stock NS_0 is never repaid. We relax this assumption in Section 5.
[18] Partial and total early repayments are indeed allowed in all euro area countries. In many euro area countries, fees related to early repayments are due (ECB, 2009).

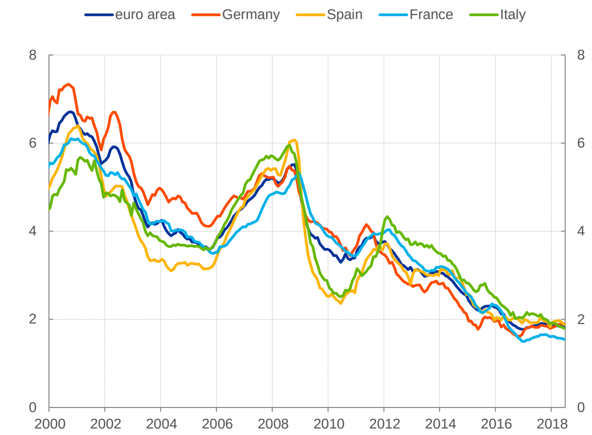
and Consumption Survey (HFCS), which provides reliable data only from 1999 to 2014.[19] Based on those data, a continuous series for loan maturities between 1980 and 2014 is computed by using a polynomial interpolation of order 4 and considering a very short maturity at the beginning of our sample period (10 years). The maturity for 2015-2018 is derived by extrapolation of this trend. The resulting series for the euro area and the four largest euro area countries are plotted in Figure 13. Loan maturity generally increased before the crisis in a context of expanding loan principal amounts and easing access to credit in many euro area countries. Moreover, rising life expectancy and the related increase in the retirement age may also have led to an extension of the maturity (ECB, 2009). The upward trend reverted after the crisis reflecting the sharp contraction of mortgage credit.[20]

Figure 13. Average maturity of loans to households for house purchase
(years)



Source: Authors' calculations based on HFCS data.
Notes: See footnote 19. Latest observation: June 2018.

Figure 14. Bank interest rate on new loans to households for house purchase
(percentage per annum)



Source: ECB.
Notes: Data before 2000 for internal use only. Latest observation: June 2018.

As regards lending volumes, adjusted net loans to households for house purchase (i.e. adjusted for sales and securitisation) are internally available only from 2015 onwards. Adjusted loans before 2015 are constructed taking the non-adjusted loan series as the basis and allocating to loans to households for house purchase all securitisation and loan sales adjustments of loans to households. The

[19] By construction, for the early years of the sample of the HFCS we only observe long maturity loans. To address this issue, we first restrict the sample to loans with an initial maturity of over 15 years (so samples are comparable across origination years) and then apply this pattern backward to the maturity of all loans in 2014. We consider mortgages whose purpose is to purchase the household main residence, to purchase another real estate asset, or to refurbish or renovate the residence. Mortgage renegotiations and mortgage refinancing are excluded. No data are available for Finland. No data on renegotiations are available for Spain, France and Italy. No data are available for Spain in 2013 and 2014. The maturity for the euro area is computed by aggregating euro area country figures using as weights BSI outstanding amounts of loans to households for house purchase.
[20] See also ECB (2016).

developments of net loans are reported in Figure 1. New business volumes since 2003 are collected via the MIR.

Lastly, for the interest rate we use the bank interest rate on new loans to households for house purchase available in the MIR. The lending rates for the euro area and the large euro area countries are shown in Figure 14. Across the large euro area countries, the lending rate for Germany was the highest in the period 2003-2007, on account of the relatively long interest rate fixation period, while it was the lowest for Spain and Italy, two countries characterised by a high share of variable rate housing loans (ECB, 2009). This pattern was partly reverted after the sovereign debt crisis. Since the announcement of the credit easing package in June 2014, lending rates in euro area countries have been on a downward trend and cross-country heterogeneity has substantially diminished.

4. Results

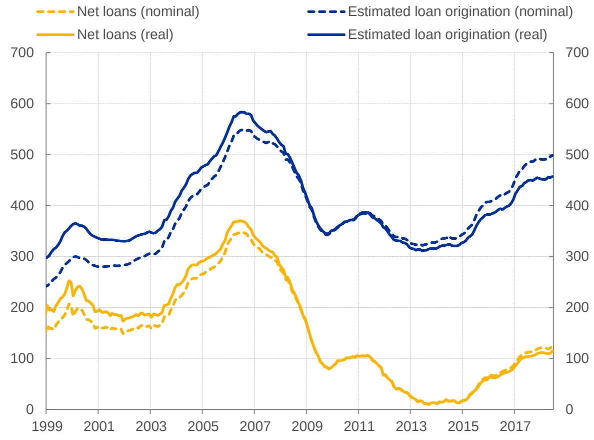
4.1 Baseline results

In line with the discussion in Section 3 regarding loan dynamics after a boom, the decomposition of net loans based on our simulated loan portfolio approach suggests that the repayments generated by the loans granted during the boom that preceded the global financial crisis have been an increasingly dragging force for net loans in recent years, with loan origination growing at an increasingly faster pace. The estimated loan origination in the twelve months up to June 2018 amounted to around €500 billion, very close to the peak reached in 2006 and around the levels recorded in 2005 if the comparison is made with deflated figures (Figure 15). A similar picture is obtained by looking at loan origination over GDP (Figure 16). Loan origination seems to accelerate at the beginning of 2015, after the announcement of the sovereign bond purchase programme of the ECB, which compressed significantly long-term rates (Altavilla et al., 2015a), and thereby lending rates for housing loans.

Looking at the decomposition of net loans into estimated repayments and estimated loan origination, the latter amounted to more than 11% of the adjusted stock of loans to households for house purchase in the twelve months up to June 2018, the highest figure since 2008, but still below the peak reached in 2006 (green area in Figure 17). The developments in loan origination are confirmed by the new loan series based on MIR data (also expressed relative to the stock), which is used as a cross-check for our estimates. As expected, our loan origination measure is below the MIR “pure new loans”, as that figure does not account for all renegotiated loans resulting in a transfer to another bank and for the so-called loan substitutions, which are renegotiations from an economic point of view but not from a statistical point of view (see Section 2). Different from the analysis of the accumulated 12-month flows (whether in nominal terms, in real terms or as a percentage of GDP), the contribution to the loan stock of loan origination and repayments suggests that loan origination in June 2018 was weaker than in the pre-boom period. This is likely to reflect the expected dynamics of LO_t/S_t after a large boom (see also Figure 8), which would call for analysing loan origination independently of the stock.

Figure 15. Nominal and real net loans and estimated loan origination

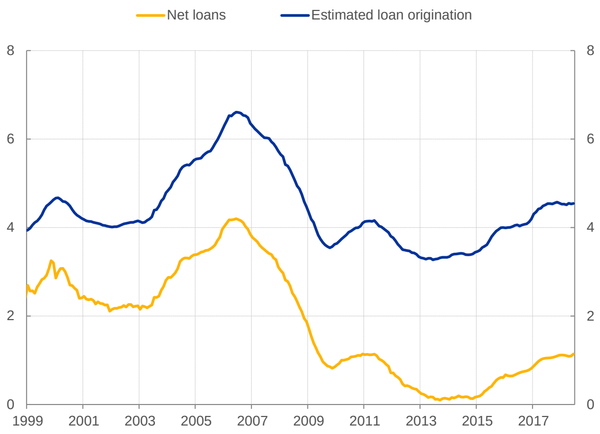
(accumulated 12-month flows in EUR billion: nominal and deflated by the GDP deflator)



Source: ECB and authors' calculations.
Latest observation: June 2018.

Figure 16. Loans relative to GDP

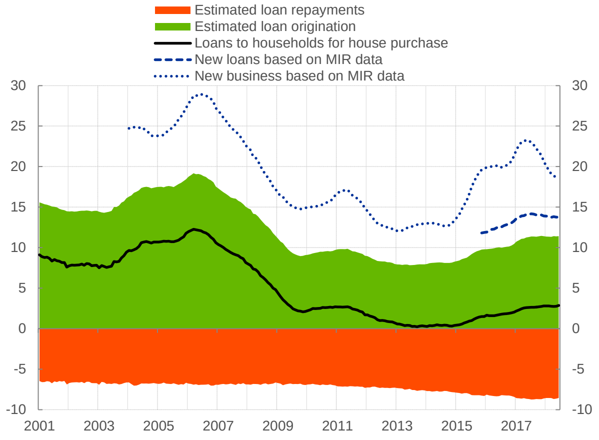
(accumulated 12-month flows over nominal GDP)



Source: Authors' calculations.
Notes: Accumulated 12-month flows over nominal GDP of previous year. Latest observation: June 2018.

Figure 17. Net flows decomposition

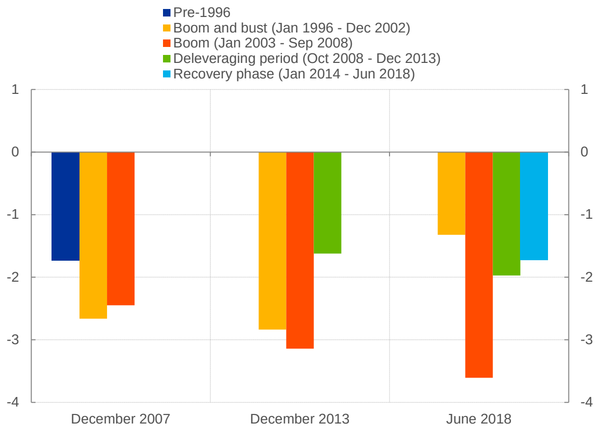
(p.p. contributions to annual growth rate, annual percentage changes)



Source: ECB and authors' calculations.
Notes: New business and new loans based on MIR data are the ratios of the accumulated 12-month flows of "new business" and "pure new loans" from the MIR to the stock of loan to households for house purchase. MIR "pure new loans" are publicly available since August 2017 and only internally available since December 2014. Latest observation: June 2018.

Figure 18. Breakdown of the contribution of repayments by period of origination

(p.p. contributions to annual growth rate)

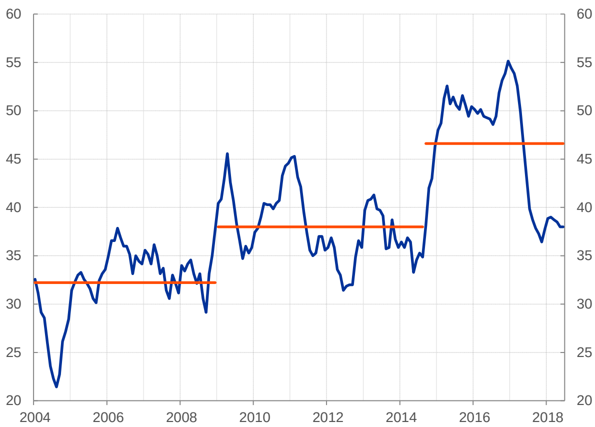


Source: Authors' calculations.

Repayments of loans granted in the boom period have been a growing dragging force for net loans in recent years (red area in Figure 17). In June 2018, repayments dragged down loan growth by around 2 p.p. more than in 2006. This reflects the impact of the large amount of mortgages granted in the years before the financial crisis, as principal repayments typically increase over the life of a loan.[21] The largest contribution to the repayments in June 2018 comes indeed from the loans granted in the latest boom (Figure 18), with a lower, but growing, contribution from loans granted after the crisis.

We then compute the amount of implied renegotiations as the difference between the new business based on MIR data and our estimated loan origination. Interestingly, three periods can be identified (Figure 19). In the pre-crisis, the implied average share of renegotiated loans in the euro area was relatively low, amounting to around 32% of total loans. This share increased in the aftermath of the financial crisis, as many borrowers experienced difficulties to repay their loans. A more pronounced increase in the share of renegotiated loans is observed since 2015 onwards. This reflects the significant compression of lending rates brought about by the asset purchase programme of the ECB, which led many borrowers to renegotiate their mortgages in order to lock in the more favourable rates.

Figure 19. Implied renegotiations
(percent of total new loans)



Source: Authors' calculations.
Latest observation: June 2018.

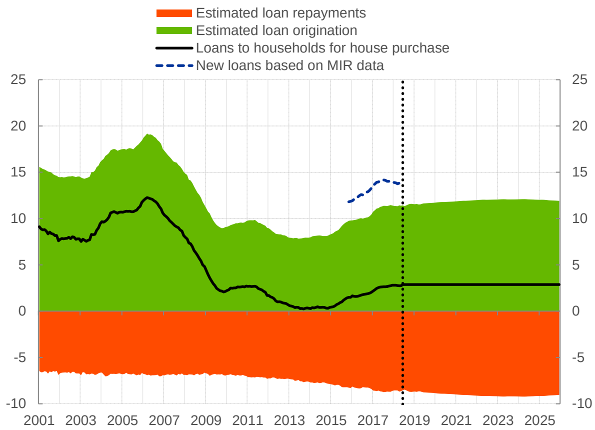
4.2 A decomposition of projected net flows

The results discussed in the previous sub-section point to a growing relevance of repayments for net loans in the recent years. The question is now for how long will repayments continue to drag net loan growth. To have an idea about the expected dynamics of repayments, we consider a scenario in which the annual growth rate of net loans is assumed to be constant for eight years after the end of our sample period. The decomposition of this hypothetical annual growth rate is shown in Figure 20. In line with the simulated impact of a boom in Section 3, the contribution of repayments to the annual growth rate of net loans is expected to peak in 2022-2023, about 15 years after the end of the boom. At

[21] Moreover, increasing amortisations in the recent past may also reflect, to a lesser extent, some temporary country-specific factors, such as increases in voluntary repayments encouraged by tax incentives, as for instance in the Netherlands. These shocks to the predetermined path of repayments are partly captured in our model by the smoothed α_t (see sub-Section 3.4).

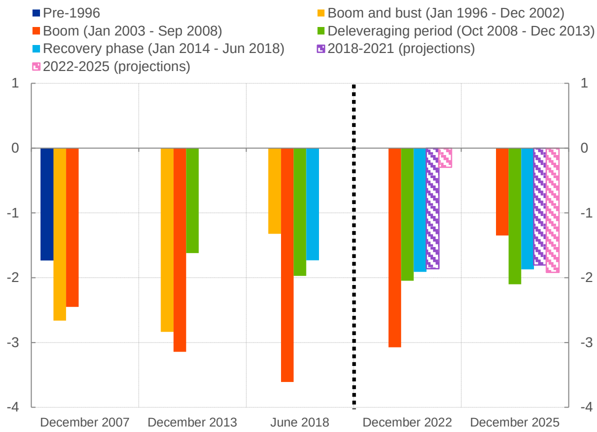
that point they are projected to be dragging down loan growth by 3.5 p.p. more than in 2006. Also in line with our theoretical simulation, the largest contribution to the repayments in December 2022 is still expected to come from the loans granted in the period 2003-2008, while at the end of 2025 their repayments will represent only a minor part of total amortisations (Figure 21). These results suggest that, unless loan origination accelerates substantially in the near future, the annual growth of net loans will remain weak by historical standards for a prolonged period of time.

Figure 20. Projected net flows decomposition
(p.p. contributions to annual growth rate, annual percentage changes)



Source: ECB and authors' calculations.
Notes: See Figure 17.

Figure 21. Breakdown of the contribution of repayments by period of origination
(p.p. contributions to annual growth rate)

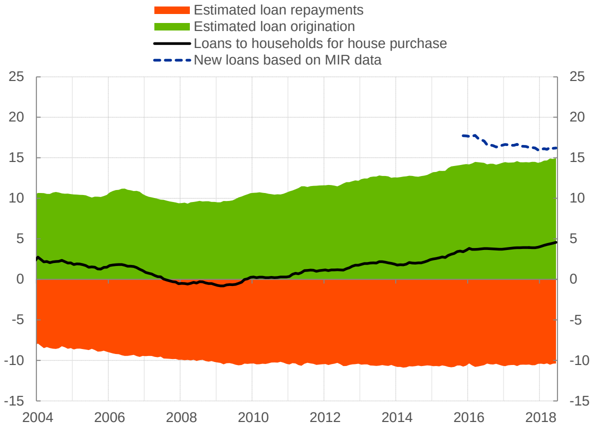


Source: Authors' calculations.

4.3 A decomposition of net flows for the large euro area countries

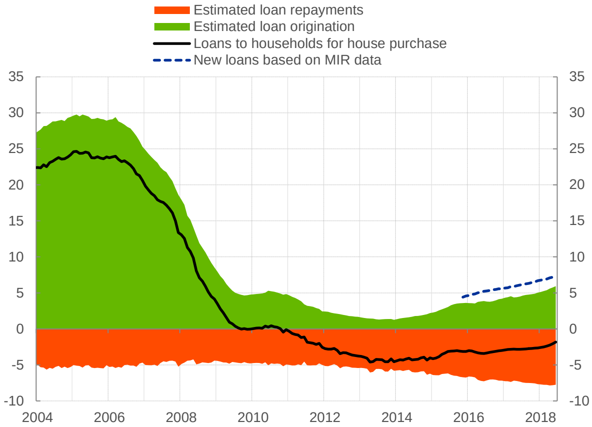
To identify possible cross-country heterogeneity, the simulation of the loan portfolio is also conducted for the four largest euro area countries. Not surprisingly, repayments are estimated to have grown in the recent past in those countries that experienced a boom in mortgage lending in the period 2003-2008, namely Spain, France and Italy (Figures 22 to 25). The estimated loan origination is around 15% of the adjusted stock of loans in the twelve months up to June 2018 in Germany and France, while it is around 10% in Italy and 5% in Spain. In June 2018, loan origination dynamics relative to the stock appear to be robust in the first two countries, moderate in Italy and still subdued in Spain. These findings are confirmed by the new loan series based on MIR data. Interestingly, in Spain the estimated loan origination and the series based on the MIR "pure new loans" (the statistical series which is closest to our concept of loan origination) display a very similar pattern, confirming that our decomposition method is also valid in countries where most mortgages are contracted with a variable rate.

Figure 22. Net flows decomposition - Germany
(p.p. contributions to annual growth rate, annual percentage changes)



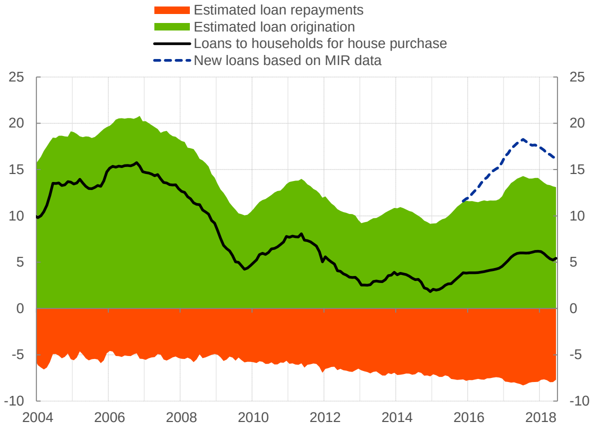
Source: ECB and authors' calculations.
Notes: See Figure 17.

Figure 23. Net flows decomposition - Spain
(p.p. contributions to annual growth rate, annual percentage changes)



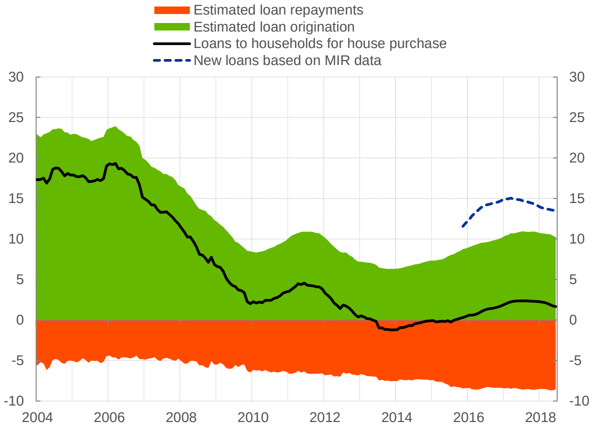
Source: ECB and authors' calculations.
Notes: See Figure 17.

Figure 24. Net flows decomposition – France
(p.p. contributions to annual growth rate, annual percentage changes)



Source: ECB and authors' calculations.
Notes: See Figure 17.

Figure 25. Net flows decomposition - Italy
(p.p. contributions to annual growth rate, annual percentage changes)



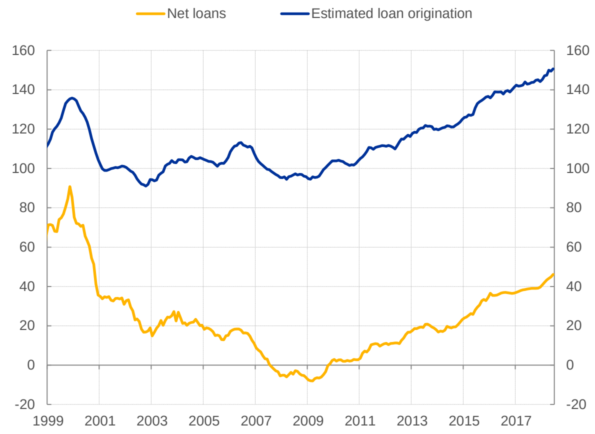
Source: ECB and authors' calculations.
Notes: See Figure 17.

A slightly different picture emerges when looking at the accumulated 12-month real flows (Figures 26 to 29) or the accumulated 12-month flows relative to GDP (Figures 9A to 12A in the Annex). In Germany and in France, loan origination is estimated to be at historical highs. While this is not surprising for Germany, given the stability of the German housing market in the last two decades,[22] the current levels of real loan origination in France may signal an on-going build-up of excessive credit, which may in turn pose risks to financial stability in this country going forward. In Italy, loan

[22] For the reasons for the stability of the German housing market, see Voigtländer (2014).

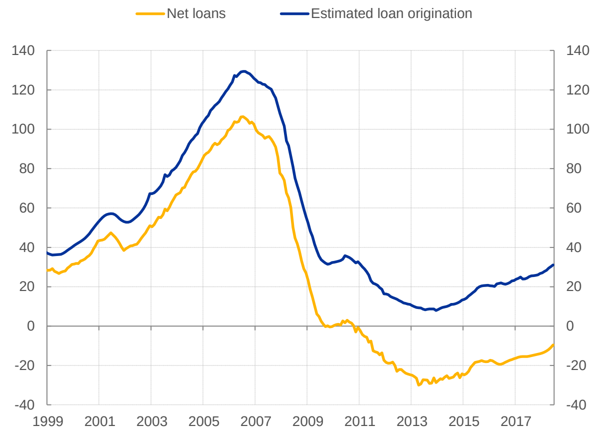
origination in real terms seems to have recently stabilised at the levels recorded in 2003, while in Spain it is gradually recovering, but remains well below the levels observed in the boom.

Figure 26. Real net loans and estimated loan origination - Germany
(accumulated 12-month flows in EUR billion deflated by the GDP deflator)



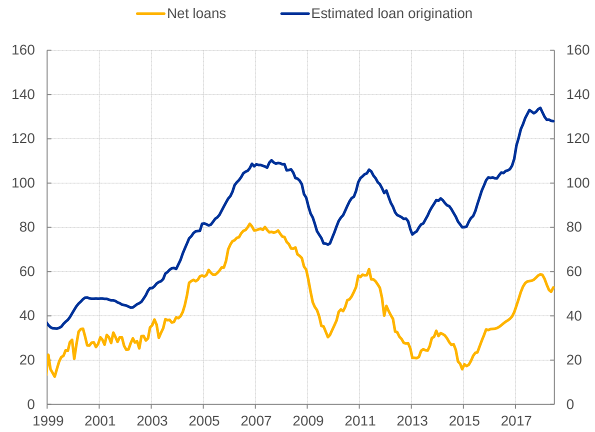
Source: ECB and authors' calculations.
Latest observation: June 2018.

Figure 27. Real net loans and estimated loan origination - Spain
(accumulated 12-month flows in EUR billion deflated by the GDP deflator)



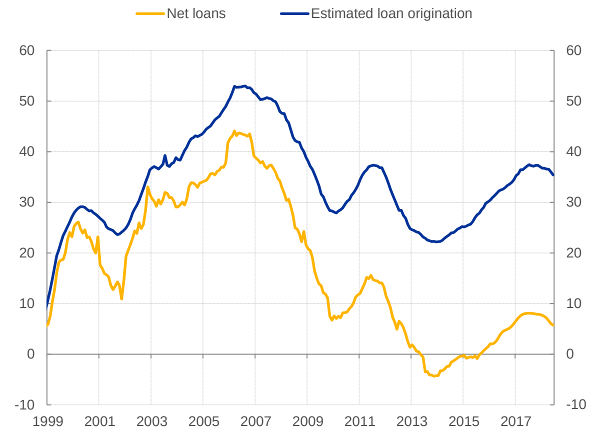
Source: ECB and authors' calculations.
Latest observation: June 2018.

Figure 28. Real net loans and estimated loan origination - France
(accumulated 12-month flows in EUR billion deflated by the GDP deflator)



Source: ECB and authors' calculations.
Latest observation: June 2018.

Figure 29. Real net loans and estimated loan origination - Italy
(accumulated 12-month flows in EUR billion deflated by the GDP deflator)



Source: ECB and authors' calculations.
Latest observation: June 2018.

4.4 Comparing the cyclical properties of net loans and loan origination

The simulation exercise presented in Section 3 shows that, after a large boom in lending, the long-lasting dependence of the stock on past loans depresses both the level and the growth rate of the stock well beyond the end of the boom in loan origination (Figure 7 and Figure 8). Clear evidence on the validity of this prediction has been reported in sub-Sections 4.1-4.3.[23] The same simulation also points to a change in the lead-lag relationship between net loans and loan origination after a boom (Figure 8A in the Annex). In particular, while slightly leading loan origination in the run-up to a boom, net loans are expected to lag behind afterwards, as repayments of the huge amount of loans granted in the expansionary phase start to increasingly weigh on the stock. In this sub-section, we briefly analyse the cyclical properties of actual net loans and the estimated loan origination. Specifically, we first compute the medium-run cyclical component of the monthly flows of net loans and loan origination using two alternative HP-filter specifications.[24] We then identify the timing of the peak and trough of the resulting series during the most recent boom-and-bust episode. Focusing on the period around the peak, we find that the turning point in the cyclical component of net loans is slightly leading that of loan origination in the euro area and across the large euro area countries considered in the analysis. By contrast, the trough observed in net loans in the post-crisis clearly lags behind that of loan origination, as the negative contribution of repayments to net loans continues to increase even after loan origination has stopped declining. These findings show that, after a large boom in lending, loan origination gains leading properties with respect to the stock, which is no longer a proper indicator of the instantaneous lending dynamics.

Table 1. Timing of peaks and troughs in the last boom-and-bust cycle

		Peak in the boom	Trough in the bust
Euro area	Net loans	[Oct 2005 - Jan 2006]	[Aug 2013 - Aug 2013]
	Loan origination	[Jun 2006 - Jul 2006]	[Oct 2012 - Jan 2013]
France	Net loans	[Sep 2006 - Nov 2006]	[Nov 2013 - Feb 2014]
	Loan origination	[Feb 2007 - Dec 2007]	[Feb 2012 - Jan 2013]
Italy	Net loans	[Aug 2005 - Dec 2005]	[Dec 2013 - Apr 2014]
	Loan origination	[May 2006 - Jun 2006]	[Jun 2013 - Aug 2013]
Spain	Net loans	[Jul 2005 - Dec 2005]	[May 2013 - Jan 2014]
	Loan origination	[Nov 2005 - Feb 2006]	[Mar 2013 - Sep 2013]

Source: Authors' calculations.
Notes: The timing of peaks and troughs are identified on the HP-filtered series of the monthly flows of net loans and loan origination using two standard values for the smoothing parameter λ (14,400 and 129,600). Germany is not included in this analysis, given the absence of a boom-and-bust cycle in mortgage lending in the 2000s in this country.

[23] Moreover, as the contribution of repayments to the stock only changes at a very low frequency, the long-run relationship between loans and macroeconomic variables is affected. A Johansen cointegration test conducted over the period 1999 Q1-2018 Q2 shows that loan origination (12-month accumulated flows) and real GDP (12-month differences) are cointegrated, while no cointegration relationship is found between net loans and real GDP.
[24] As there is uncertainty as regards the length of the medium-term cycle, we use two different values for the smoothing parameter λ (14,400 and 129,600).

5. Robustness checks

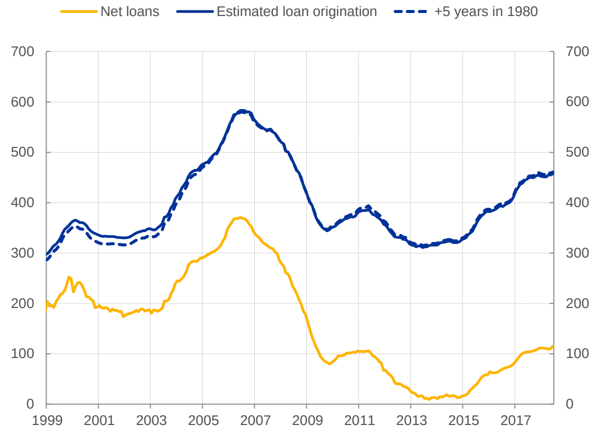
Our simulation exercise is carried out using some assumptions which apply to both the data input and the algorithm. For instance, our maturity series is based on survey information between 1999 and 2014, but data for before and after that period are based on trend extrapolations. Moreover, we apply our methodology to a series of notional stocks, which by construction excludes write-downs and write-offs. In practice, however, write-down/offs reduce the size of future repayments. A similar argument, but in the opposite direction, applies to the repayments of the loans granted before March 1980, which in the baseline model are explicitly disregarded. It is therefore important to investigate the robustness of the findings discussed in Section 4.

5.1 Changing the maturity assumption

One of the key ingredients of our simulated portfolio is the average length of a loan, which is calculated combining the information contained in the HFCS (which may still be subject to sample biases despite our efforts to clean for them, as explained in sub-Section 3.5) with the assumption that at the beginning of the 1980s loans were granted with a 10-year maturity. We first run our simulation exercise by changing the latter assumption. In particular, new loans in 1980 are assumed now to have a maturity of 15 years. A continuous series for loan maturities over the full sample period is recomputed by using a polynomial interpolation of order 4, as in sub-Section 3.5. As shown in Figure 30, this change in the average maturity does not have a significant impact on the estimated loan origination after 1999.

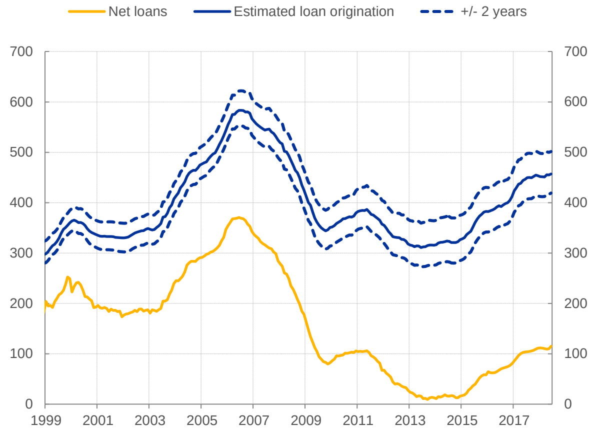
We now apply a more dramatic change to the maturity assumption by shifting the average length of a loan by 2 years upwards and downwards over the full period. The results are reported in Figure 31. By increasing (decreasing) the length of the loan, at every point in time loan origination is estimated to be lower (higher), reflecting lower (higher) repayment amounts (see Section 3). In particular, in June 2018, the uncertainty surrounding our baseline estimates is around €50 billion. Nevertheless, the main messages of our analysis do not change significantly: real loan origination is still estimated to have accelerated at the beginning of 2015 almost reaching in June 2018 the levels recorded in 2005.

Figure 30. Real net loans and estimated loan origination - Changing loan maturity, first period (1980-1998)
(accumulated 12-month flows in EUR billion deflated by the GDP deflator)



Source: ECB and authors' calculations.
Latest observation: June 2018.

Figure 31. Real net loans and estimated loan origination - Changing loan maturity, full period (1980-2018)
(accumulated 12-month flows in EUR billion deflated by the GDP deflator)



Source: ECB and authors' calculations.
Latest observation: June 2018.

5.2 Incorporating loan write-downs

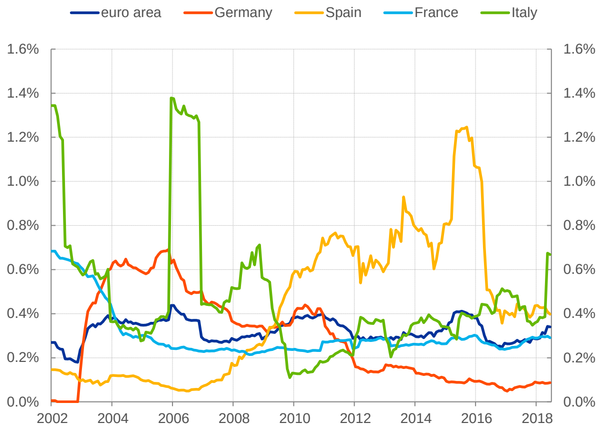
Our simulation exercise is based on notional stocks, which by construction abstract from reclassifications and other breaks in the series. This reduces the number of assumptions in the model, as incorporating write-downs/offs requires linking these unrealised repayments with their respective loan origination. Abstracting from them implies, however, that we are missing the fact that some loans were not fully repaid, thereby overstating the loan developments derived from the simulation exercise. In this sub-section, we investigate the extent to which the impact of write-offs/downs is significant by incorporating them to the analysis in the following manner. First of all, we compute the average of the interest rate of outstanding loans at time *t*, as well as their average remaining maturity (both weighted using loan origination). Second, we use the available BSI data on write-downs/offs of total loans to households (Figure 32), and assume that they all refer to loans for house purchase.[25] Third, we treat the BSI write-downs/offs as negative loans granted in period *t* at the average conditions computed in the first step. Finally, the repayments of these negative loans are computed and subtracted, according to their schedule, from the repayments computed under zero write-down/offs.

The results, reported in Figure 33, indicate that, when loans that were actually not repaid are taken into account, loan origination is estimated to be slightly lower than in our baseline specification. Lower

[25] Internal ECB data suggest that the majority of write-downs/offs of loans to households refer to consumer credit and other lending.

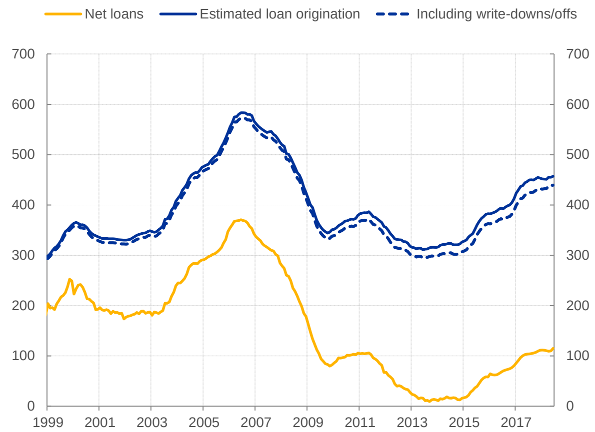
loan origination when write-downs/offs are taken into account is not a surprising outcome, as the occurrence of write-downs/offs means lower repayments and, for a given level of net flows, lower repayments imply lower loan origination. Nevertheless, changes are small and, therefore, the main message of the baseline model remains valid: loan origination in June 2018 is estimated to be at the levels similar to those of 2004-2005.

Figure 32. Share of write-downs/offs of MFI loans to households over total MFI loans to households in selected euro area countries
(accumulated 12-month flows over the stock)



Source: ECB and authors' calculations.
Latest observation: June 2018.

Figure 33. Real net loans and estimated loan origination – Including write-downs/offs
(accumulated 12-month flows in EUR billion deflated by the GDP deflator)



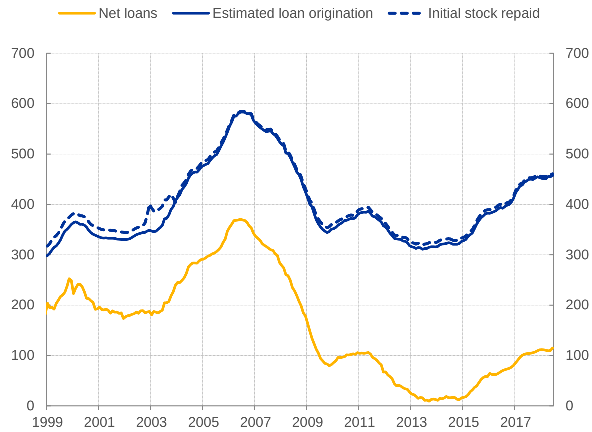
Source: ECB and authors' calculations.
Latest observation: June 2018.

5.3 Relaxing the assumption on the initial stock

For simplicity, the baseline simulation algorithm is run under the assumption that the initial stock is never repaid. We now test the importance of this assumption by including a repayment schedule for the loans outstanding in March 1980. In particular, we assume that, over the decade prior to the beginning of our simulation, the bank grants a new loan every month at the following conditions: (i) average maturity in March 1980; (ii) average interest rate in March 1980; (iii) with known amortisation schedule, corresponding to that of a French loan; and (iv) with a constant original principal amount such that the resulting stock in March 1980 is the actual one. In addition, we carry out the same exercise using the first alternative assumption on maturity presented in sub-Section 5.1 to assess the impact of a longer maturity (around 15 years instead of close to 10 years) of the loans outstanding in March 1980.

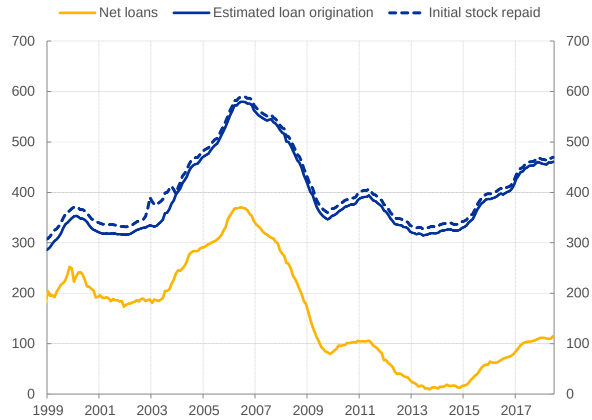
The real loan origination implied by these two exercises is very similar to the one from the baseline simulation, especially since the boom, adding reassurance to the assessment that loan origination is currently at the levels recorded in 2005 (Figure 34 and Figure 35). The slightly higher loan origination, particularly visible before 2004, reflects the larger amount of repayments that are recorded in the first decade of the simulation period once we allow for the initial stock to be repaid. Indeed, for a given level of net flows, higher repayments from past loans are mechanically mirrored by higher loan origination, which, in turn, generates more repayments in the future.

Figure 34. Real net loans and estimated loan origination – Baseline specification
(accumulated 12-month flows in EUR billion deflated by the GDP deflator)



Source: ECB and authors' calculations.
Latest observation: June 2018.

Figure 35. Real net loans and estimated loan origination – Alternative maturity assumption
(accumulated 12-month flows in EUR billion deflated by the GDP deflator)



Source: ECB and authors' calculations.
Notes: The continuous blue line indicates the estimated loan origination from the specification with the first alternative assumption on maturity (i.e. new loans in 1980 are assumed to have a maturity of 15 years – see sub-Section 5.1). Latest observation: June 2018.

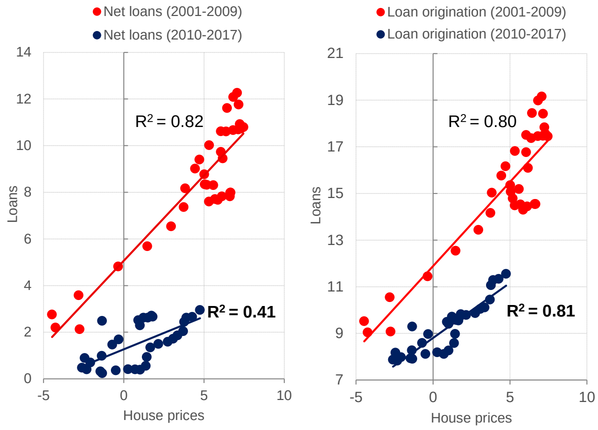
6. Empirical applications

The majority of macroeconomic exercises which consider lending dynamics rely on net loan figures. However, the conceptual discussions above and the results of our simulation exercise reveal that the dynamics in net lending (whether in flows or stocks) may be long-lastingly affected by the pre-determined nature of repayments granted in previous periods, thereby not reflecting the instantaneous lending dynamics. This is even more the case for periods preceded by large lending booms. For this reason, we briefly investigate the impact of taking into account loan origination and repayment dynamics in exercises that typically require the use of lending figures, in particular the implications for the analysis of house prices and consumer prices, as well as for the estimation of credit supply factors. Each of these pieces of analysis would *per se* deserve a deeper and more thorough investigation, but they are briefly presented here to illustrate the benefits from taking into account loan origination in the analysis of lending dynamics.

6.1 Explaining housing market dynamics

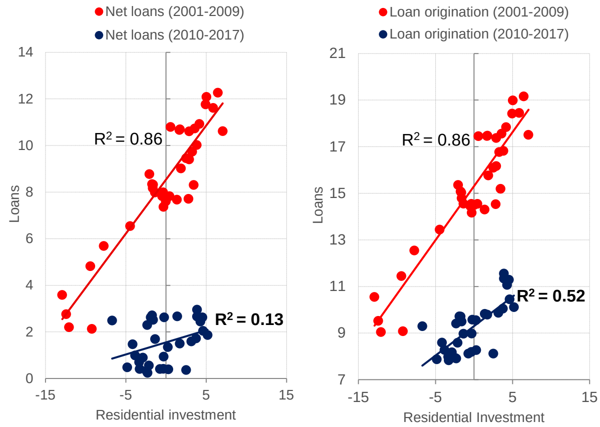
An analysis of housing market dynamics based on headline net loan growth measures has led commentators to conclude that the recent dynamism of housing markets in the euro area has been mainly driven by factors other than credit, thereby underestimating the potential risks coming from an overheating of this market segment.[26] Indeed, the explanatory power of net loan growth for house prices and residential investment has dropped significantly since 2010 (Figures 36 and 37, left panels). However, the high explanatory power of loans is restored when considering our estimated loan origination instead of net loan growth (Figures 36 and 37, right panels), suggesting a more relevant role for bank credit in explaining the pick-up in house prices and residential investment than indicated by net loan figures.

Figure 36. Loans to households for house purchase and house prices
(annual percentage changes; p.p. contributions to annual growth rate)



Source: Eurostat, ECB, authors' calculations.
Latest observation: 2018 Q2.

Figure 37. Loans to households for house purchase and residential investment
(annual percentage changes; p.p. contributions to annual growth rate)



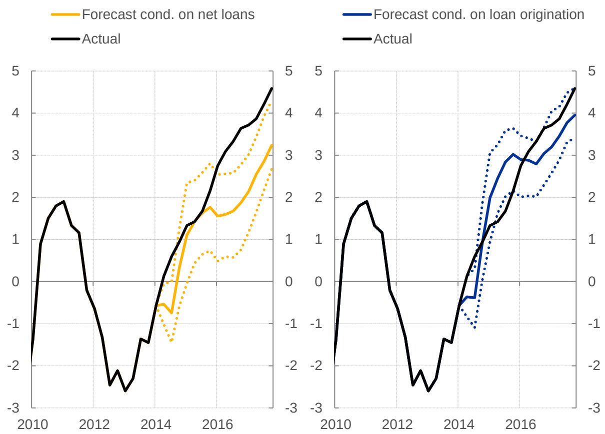
Source: Eurostat, ECB, authors' calculations.
Latest observation: 2018 Q2.

This evidence is confirmed by model-based house price forecasts. More specifically, we estimate a Bayesian VAR that includes real GDP, GDP deflator, loans to households for house purchase, house prices, and the spread between the lending rate to households for house purchase and the short-term

[26] Other factors that may explain the recent pick-up in house prices in the euro area relate to supply constraints, demographic changes, such as the increase in urban population, and the growing relevance of buy-to-let investors. For more details, see EMF (2017).

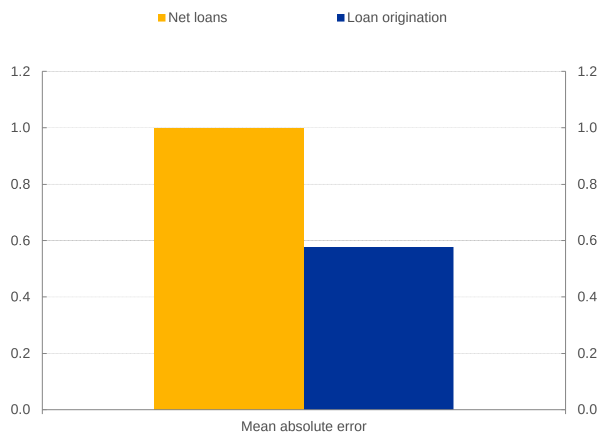
interest rate.[27] Such a parsimonious multivariate approach is able to capture the endogenous interactions between core macroeconomic variables that are relevant for housing market developments. The model is estimated in log-levels using quarterly data from 1999 Q1 to 2014 Q1, just before the announcement of the credit easing package of the ECB. Forecasts of house prices are then computed for the period 2014 Q2 – 2017 Q4 conditionally on the actual path of the other variables in the system. As regards loans, net loans and loan origination are used alternately as endogenous variables. When we include net loans, the projected path of house prices lies below the actual one, particularly since 2016 onwards (Figure 38, left panel). A much more accurate prediction of the recent recovery in house prices is obtained when considering loan origination instead of net loans (Figure 38, right panel, and Figure 39).

Figure 38. House price conditional forecasts
(annual percentage changes)



Source: Eurostat, ECB, authors' calculations.
Notes: House price forecasts based on a BVAR model including real GDP, GDP deflator, loans to households for house purchase, house prices, and the spread between the lending rate to households for house purchase and the short-term interest rate. Estimated using quarterly data from 1999 Q1 to 2014 Q1. Forecasts computed conditionally on the actual path of the other variables in the system. Continuous lines indicate the median forecast; dotted lines indicate the 16 and 84 percentiles. Latest observation: 2017 Q4.

Figure 39. Forecast errors of house prices
(annual percentage points)



Source: Eurostat, ECB, authors' calculations.
Notes: Mean absolute error for the period 2014 Q2 – 2017 Q4. House price forecasts based on a BVAR model including real GDP, GDP deflator, loans to households for house purchase, house prices, and the spread between the lending rate to households for house purchase and the short-term interest rate. Estimated using quarterly data from 1999 Q1 to 2014 Q1. Forecasts computed conditionally on the actual path of the other variables in the system. Forecast errors based on the median forecast.

The results presented in this section suggest that loan origination has higher information content than net loans when it comes to explain house prices. This might reflect the fact that, as borrowers have a precise purpose when asking for a new loan (in this case the acquisition of a dwelling), the fresh money received via the loan has an immediate impact on the housing market. By contrast, the money removed from previous mortgage borrowers ("old money") is likely to affect the housing market to a

[27] We follow the hierarchical modelling approach by Giannone et al. (2015). For BVARs including lending variables for the euro area, see Altavilla et al. (2015b) and Altavilla et al. (2016).

lesser extent. This is because if borrowers were to hold this "old money" instead of repaying it back, they would most likely used it for many other purposes than acquiring an additional dwelling. Overall, our findings have important policy implications: stronger housing market dynamics supported by robust developments in new mortgages warrants a closer monitoring of that market with respect to financial stability risks than what an assessment derived by net loan figures would recommend.

6.2 Loans as a leading indicator of consumer price inflation

The previous sub-section shows a clear example in which loan origination has a higher explanatory power than net loans for house prices via the direct impact of the fresh money received by agents with a clear purpose. A similar, although weaker, mechanism may operate between mortgage loans and consumer prices in general. Indeed, both the construction and the purchase of a house entail the acquisition of a large number of goods and services included in the consumer price index. The money removed from previous mortgage borrowers ("old money") is likely to affect consumer prices less than the fresh money does, but more than in the case of house prices, as there are many goods and services that could have been acquired with the repaid money. In addition, the debt service associated with a credit boom may also reduce future economic activity, as documented in Drehmann et al. (2017, 2018), thereby exerting a downward pressure on consumer prices. Therefore, we should expect to have a benefit from using loan origination to predict consumer prices, but to a smaller extent than when predicting house prices.

To test empirically the forecasting properties of loan origination and net loans, we use the approach employed by Falagiarda and Sousa (2017), who assess the information content of monetary aggregates for future price developments. For tractability, the accumulated 12-month flows of loan origination are de-trended using a HP-filter with smoothing parameter λ of 10,000,000 to capture the very low frequency trend of the series. The accumulated series of net loans is de-trended using the trend of loan origination to take into account the dampening impact of repayments in the most recent period. As expected, the de-trended net loans and loan origination share the same pattern until 2008, when they start to diverge reflecting the growing impact of the amortisations of loan granted during the boom (Figure 40). Moreover, both series seem to have predictive power with respect to HICP inflation.

This prima-facie evidence is formally tested by assessing the out-of-sample forecast performance of models featuring loans as a predictor of inflation. More specifically, the forecasts are computed via recursive OLS estimation of the following equation with the data available up to time *t*. Each loan series enter the forecasting equation directly:

$$y_{t+h}^{h} = \alpha_0 + \sum_{j=1}^{p} \gamma_j' \, y_{t-j+1} + \sum_{j=1}^{m} \beta_j' \, L_{t-j+1} + \varepsilon_{t+h} \tag{30}$$

where y_{t+h}^{h} is the h-step ahead value of the HICP inflation, α_0 is a constant, p are lags of the dependent variable, m are lags of the predictors (net loans or loan origination) and ε_{t+h} is the error term. The h-step ahead forecast given information at time t is given by:

$$\hat{y}_{t+h|t}^{h} = \hat{\alpha}_0 + \sum_{j=1}^{p} \hat{\gamma}_j' \, \hat{y}_{t-j+1} + \sum_{j=1}^{m} \hat{\beta}_j' \, \hat{L}_{t-j+1} \tag{31}$$

The dependent variable is transformed as follows:

$$y_{t+h}^{h} = \frac{1200}{h} \ln\left(\frac{HICP_{t+h}}{HICP_t}\right) \quad \text{and} \quad y_t = 1200 \ln\left(\frac{HICP_t}{HICP_{t-1}}\right) \tag{32}$$

In order to simulate real-time forecasting, all parameters are re-estimated at each monthly iteration and the estimates are used to derive a forecast using the last available observation in the sample. The number of lags of the dependent variable (p) and lags of predictors (m) to be included in the models is re-optimised at each forecasting step using the BIC with the maximum number of lags set to six (Stock and Watson, 2002).

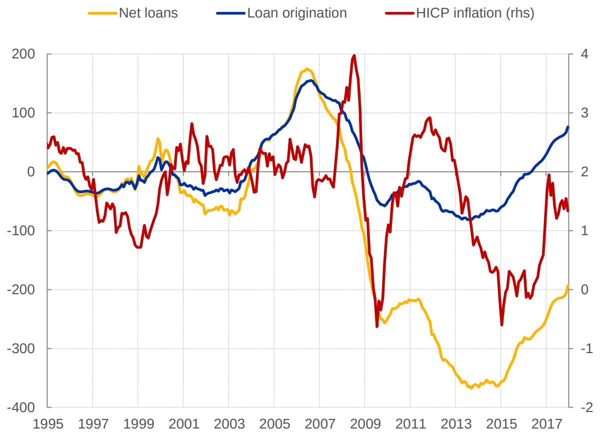
The first out-of-sample forecast is computed in January 2000 with the estimation conducted over the period 1990:1-2000:1-h. The values of the regressor at t=2000:1 are then used to forecast $y_{2000:1+h}^{h}$. The forecast horizons for which the forecasts are computed are 4, 8, 12, 18, 24 months ahead. For each h we compute the Mean Absolute Error (MAE). To evaluate the forecast performance of different models, we refer to the Relative Mean Absolute Error (RMAE), as the ratio of the MAE for a given model to the MAE of an AR(BIC) forecast:

$$y_{t+h}^{h} = \alpha_0 + \sum_{j=1}^{p} \gamma_j' \, y_{t-j+1} + \varepsilon_{t+h} \tag{33}$$

where the number of lags of inflation (p) is re-optimised at each forecasting step using the BIC with the maximum number of lags set to six. A value of the RMAE lower than one indicates that the specified model outperforms the AR(BIC) benchmark. Moreover, to assess equal forecast accuracy between two models we run the standard Diebold-Mariano test on the forecast errors.

The results, reported in Table 2, show that when loan origination is included in the forecasting equation the additional gains over the benchmark model are significant across horizons in the most recent period. As regards net loans, we observe a worsening versus the benchmark model in the period 2010-2017 (the period when the dynamics of this variable is systematically affected by the upward trend in the amortisation rate), even though the difference is not statistically significant. In the period 2000-2009, the differences with the benchmark are not significant for both loan series, except for loan origination at the 18-month horizon.[28] These findings suggest that loan origination seems to have played a more relevant role in explaining price developments in the post-boom period.

Figure 40. De-trended loans and HICP inflation
(lhs: deviations from index; rhs: annual percentage changes)



Source: Eurostat, ECB and authors' calculations.
Notes: Loan origination is de-trended using a HP-filter with smoothing parameter λ of 10,000,000. The series of net loans is de-trended using the trend of loan origination. Latest observation: December 2017.

Table 2. Forecasting HICP inflation using net loans and loan origination

		Forecast horizon (months)				
		4	8	12	18	24
Net loans	2000:01-2009:12	0.91	0.89	0.85	0.85	0.85
	2010:01-2017:12	1.01	1.07	1.11	1.07	1.12
Loan origination	2000:01-2009:12	0.94	0.96	0.95	0.96	0.96
	2010:01-2017:12	0.97	0.96	0.96	0.95	0.99

Source: Authors' calculations.
Notes: The root mean absolute error (RMAE) is reported. Green cells indicate that the improvement over the benchmark model (AR(BIC)) is statistically significant at the 5% level. The second column reports the out-of-sample period.

6.3 Implications for the structural identification of credit supply shocks

In the aftermath of the global financial crisis, policy-makers in the euro area have tried to understand to what extent the weakness in bank lending was due to tight credit supply conditions or weak demand for credit. Understanding the role of credit supply and demand was important also during the recovery phase, when bank lending to the non-financial private sector was supported by the ECB's non-standard measures. A vast literature has emerged trying to quantify the impact of credit supply conditions on lending volumes and economic activity in the euro area. Most of these studies have

[28] This finding is consistent with previous studies, which show that money-based models performed very poorly in the decade prior to the Great Recession, due to the low inflation volatility during that period (Reichlin and Lenza, 2007; Lenza 2008; Falagiarda and Sousa, 2017).

attempted to identify credit supply shocks through VARs by imposing sign restrictions on impulse responses (Hristov et al., 2012; Falagiarda and Bijsterbosch, 2015; Gambetti and Musso, 2017). Moreover, the majority of models include stock measures of credit, therefore neglecting the concept of loan origination, which is in principle more relevant than net loans for the quantification of credit supply conditions in real time.

The objective of this section is to investigate whether and how the credit supply estimates from a standard VAR model are affected when focusing on loan origination by removing the lagged (and practically predetermined) impact of repayments on the stock of loans. To this purpose, we first estimate a typical loan supply model: a hierarchical BVAR à la Giannone et al. (2015) in log-levels from 1999 Q1 to 2017 Q4 that includes real GDP, GDP deflator, the stock of loans to households for house purchase, the short-term interest rate and the lending rate to households for house purchase. Structural shocks are identified by imposing restrictions on the signs of the impulse response functions. The identification strategy, sketched in Table 3, is common in the literature on credit supply shocks. In particular, an expansionary credit supply shock leads to an increase in loans, real GDP, inflation and the short-term interest rate, while it pushes down the lending rate.

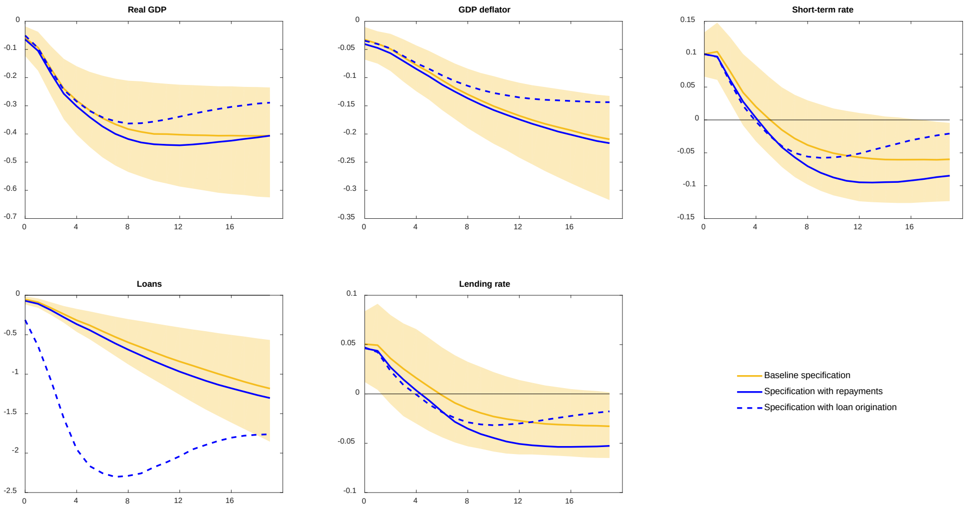
Table 3. Identification scheme (sign restrictions)

Shock	Responses to an expansionary shock				
	Real GDP	GDP deflator	Short-term rate	Lending rate	Loans
Aggregate supply	+	-	unrestricted	unrestricted	unrestricted
Aggregate demand	+	+	+	+	+
Monetary policy	+	+	-	unrestricted	+
Credit supply	+	+	+	-	+

Notes: Sign restrictions are imposed for one quarter.

We start the discussion of the results by showing the impact of a contractionary monetary policy shock. Figure 41 reports the median of the impulse responses to a monetary policy shock (yellow line) and the associated confidence interval represented by the shaded area (showing the 16th and 84th percentiles of the distribution). The impulse responses exhibit plausible patterns, with output and prices decreasing as a result of a contractionary monetary policy shock. A tightening of monetary policy also reduces loan volumes (*credit channel* of monetary policy) by worsening the financial position of households, reducing the value of their collateral and weakening the willingness and the ability of banks to grant loans.[29]

Figure 41. Impulse response functions to a monetary policy shock



Notes: The impulse responses are rescaled in order to have a 10 bps increase in the short-term interest rate at the peak. The responses of real GDP, GDP deflator and loans are in percentage points of log-levels.

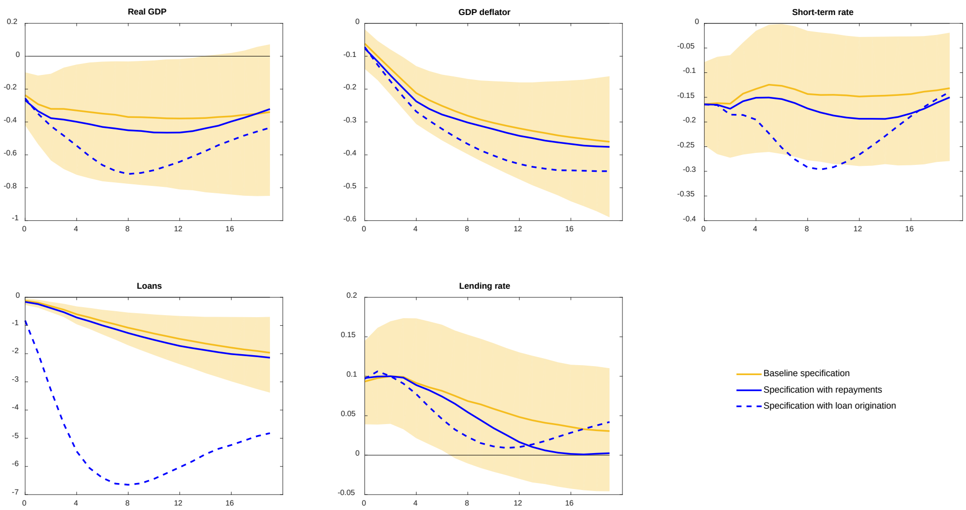
The impulse responses to a credit supply shock are shown in Figure 42. A contractionary credit supply shock has a significant and persistent negative impact on real GDP and the price level. Regarding loan volumes, credit supply shocks seem to have a longer-lasting impact, while the increase in the lending rate seems to be short-lived. Overall, these findings are in line with those reported in Bijsterbosch and Falagiarda (2015) and Gambetti and Musso (2017).

Having investigated the main dynamics of the baseline model, we now introduce loan origination and repayments to take into account the two-faced nature of the stock. Specifically, we conduct two exercises. In the first one – the most conservative and indirect exercise – the repayments of the outstanding loans are added as endogenous variable to the baseline specification.[30] The idea is that the baseline model suffers from an omitted variable bias, as repayments, a variable that has been gaining importance in the most recent period relative to the stock, is not included in the standard specification. In the second exercise, we replace the stock of loans with loan origination (the accumulated 12-month

[29] For more details on the credit channel in the context of housing finance, see ECB (2009).
[30] The sum of the repayments of all outstanding loans is the appropriate one to be included in a model estimated in levels, i.e. including the stock of outstanding loans. Due to the predetermined nature of the repayment variable, the response of repayments to the different shocks is left unconstrained.

nominal flows, as shown in Figure 15), keeping the identification scheme unchanged.[31] The latter is a more direct way of focusing on loan origination as the key lending variable reflecting the amount of fresh money reaching euro area households for the purpose of acquiring a dwelling.

Figure 42. Impulse response functions to a credit supply shock



Notes: The impulse responses are rescaled in order to have a 10 bps increase in the lending rate at the peak. The responses of real GDP, GDP deflator and loans are in percentage points of log-levels.

This first alternative specification implies a slightly more negative response of loans to a monetary policy shock than in the baseline model, especially in the medium term (Figure 41). The responsiveness of loans to a credit supply shock is also higher, especially so as the lending rate response displays a lower profile in the medium-term versus the baseline model (Figure 42). This is a first indication that, by not differentiating between loan origination and repayments, we are not obtaining a fair estimation of the actual state of credit supply conditions. Once we include repayments in our variable set, loans become more responsive to shocks, translating in turn into a larger impact on the economy. The larger reaction of loans is not surprising, as by controlling for repayments we are implicitly getting closer to the concept of loan origination, which tends to reflect a more instantaneous picture of loan dynamics than the stock (Figures 7 and 8 in Section 3). Nevertheless, the differences with respect to the baseline specification are not substantial, as repayments are simply included in the baseline model as an additional endogenous variable. By contrast, the specification with loan origination generates impulse responses that are more dissimilar to those from the baseline model. While the contractionary effects of a monetary policy shock to output and prices are milder, a credit

[31] A specification including both loan origination and repayments provides very similar results.

supply shock leads to a more negative impact on the macroeconomy,[32] suggesting that results might change substantially when loan origination is used instead of net loans.

The estimated impact of shocks on the actual developments of the endogenous variables is usually performed via the historical decomposition, which breaks down actual data into a trend and the accumulated effects of the structural shocks. When applied to our baseline specification, this exercise indicates that credit supply shocks contributed negatively to loan growth after the global financial crisis, and started to progressively become a less important factor constraining loans only after 2012, when the major tensions of the sovereign debt crisis faded away (Figure 43). In the last three years of our sample period, credit supply factors seem to have marginally supported bank lending (by 0.2 p.p. on average). As regards the impact on real GDP growth, the baseline model finds that bottlenecks in the supply of credit exacerbated the downturn in economic activity in the post-crisis (Figure 44). Their negative contribution has gradually declined, turning positive in 2013. This evidence is in line with that reported in the previous studies for the euro area mentioned above.

Figure 43. Estimated impact of credit supply shocks on loan volumes

(percentage points contributions to annual growth rate; contributions to accumulated 12-month flows in EUR billion)

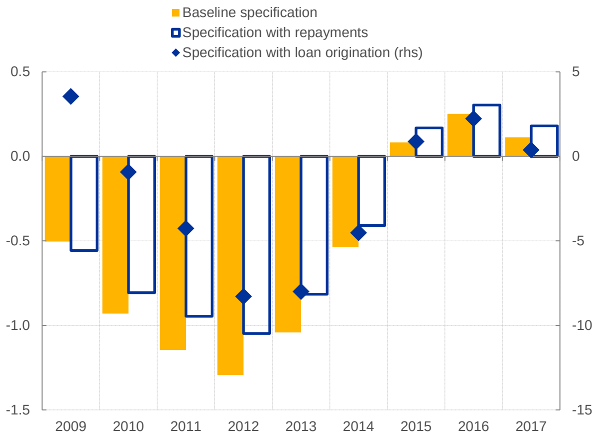
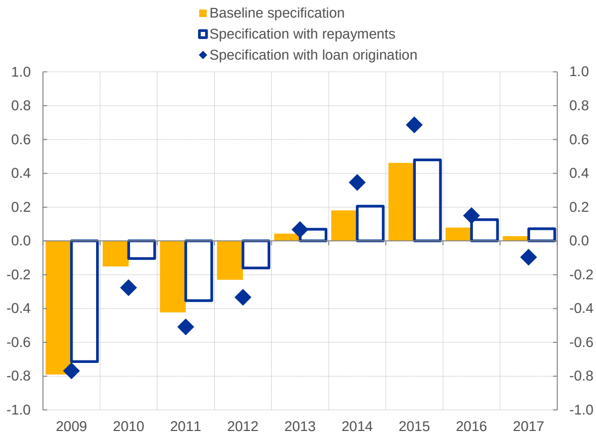


Figure 44. Estimated impact of credit supply shocks on real GDP

(percentage points contributions to annual growth rate)



Notes: Historical decomposition based on a BVAR with identification achieved via sign restrictions (see Table 3).

When we augment the model by including repayments, the impact of credit supply factors on loans is remarkably less negative over the period 2010-2014 compared with our baseline specification, while it is slightly higher in the most recent period. The same pattern can be observed for real GDP, although the difference between the two specifications is narrower. This evidence suggests that not including

[32] In this case, the impulse responses of loans cannot be compared with those from the baseline model, as the two loan series are different.

the growing amortisation rate in the estimation of credit supply shocks magnifies the dampening impact of credit supply restrictions on the economy in the post-crisis. By the same token, the model without repayments is likely to underestimate the positive impact coming from the supply side during the recovery phase. Under the specification using loan origination, the estimated negative impact of credit supply shocks on loan volumes in the period 2010-2014 is smaller than in the baseline model (using as a benchmark for comparison the last three years in the sample), while the impact on real GDP seems to be magnified in both upswings and downswings.

7. Concluding remarks

This paper sheds new light on the dynamics of loan volumes in the euro area by proposing a method to decompose net loan flows into loan origination and repayments. This method simulates a loan portfolio composed of individual loans granted at the prevailing average maturity and interest rate, and characterised by having constant instalments and a predetermined repayment schedule (the defining characteristics of the so-called *French loan*).

We first discuss the properties of the French loan at the individual level and derive functional forms for three key variables of a loan portfolio: stock, repayments and amortisation, in order to analytically address the so-called aggregation problem. We then simulate scenarios to analyse the dynamics of such portfolio variables following changes in loan origination, maturity and interest rate. We illustrate how the most basic characteristic of a typical term loan (the fact that the principal amount granted today is repaid back over a large number of periods in the future) introduces a lagging mechanism in the transmission of shocks from the loan origination process to the stock via its repayment schedule, a feature that is amplified if the portfolio is composed of French-style loans. The long lag with which the increase in loan origination is transmitted to the portfolio repayments creates a persistent base effect which depresses the growth rate of the loan stock for many periods after the end of the loan origination boom. This puts a premium on focusing on loan origination rather than on changes in the loan stock and on using alternative scale variables, such as GDP, in order to have a more accurate perception of the prevalent loan dynamics at every point in time.

Next, we simulate the dynamics of a portfolio of mortgage loans using actual data and show that repayments of the credit boom recorded in the run-up to the financial crisis have been an increasingly dragging force for net loan growth in recent years in the euro area, concealing an increasing dynamism in loan origination. In particular, the estimated annual loan origination in mid-2018 is at levels comparable to those estimated for the years immediately before the peak of the boom. Our method also delivers a plausible decomposition for the four largest euro area countries, with the estimated loan origination flows standing at historical highs in Germany and France. The robust developments in loan origination point to a stronger effectiveness of ECB's non-standard measures in supporting bank lending than that suggested by common net loan growth figures.

In a set of empirical exercises using our estimated loan origination and/or repayments, we show that, compared with the cases when the credit variable is net loans: (i) Loan origination plays a more relevant role in explaining the recent strengthening in housing markets, which, if confirmed, would warrant a close monitoring of that market with respect to financial stability risks; (ii) Loan origination seems to have played a more relevant role in explaining consumer price developments in the post-boom period; (iii) Not including the growing repayments in the estimation of credit supply shocks magnifies the dampening impact of credit supply restrictions on the economy in the post-crisis, while slightly underestimating the positive credit supply impulse during the recovery phase. In addition, when net loans are replaced by loan origination, adverse credit supply shocks lead to a more negative impact on the macroeconomy. Overall, these results suggest that there is a premium on adjusting economic models that use lending as an input to account for loan origination and/or repayments, especially after large credit booms.

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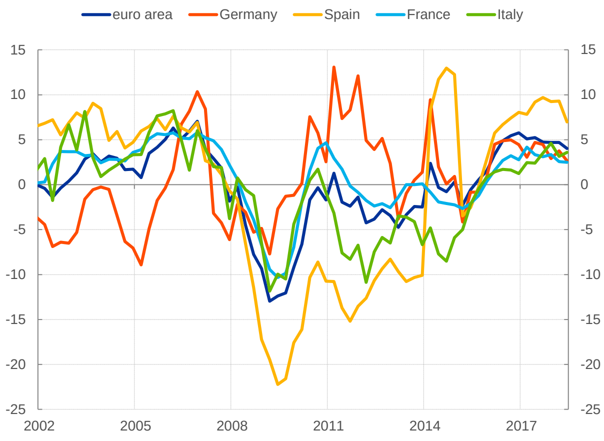
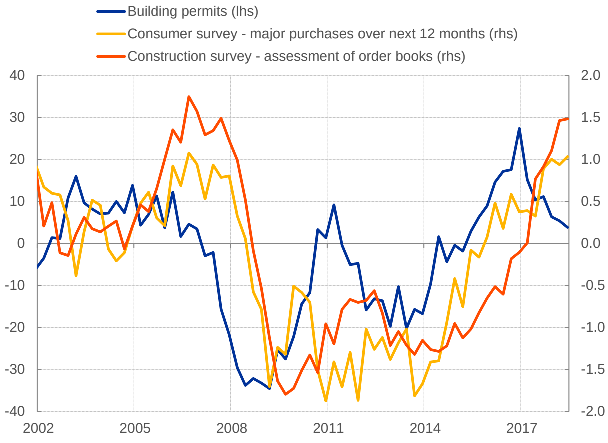
Annex – Additional figures and tables

Figure 1A. Housing investment in selected euro area countries
(annual percentage changes)



Source: Eurostat.
Notes: Gross fixed capital formation in dwellings. Latest observation: 2018 Q2.

Figure 2A. Short-term indicators of euro area housing markets
(lhs: annual percentage changes; rhs: standardised values)



Source: Eurostat, EU Commission and authors' calculations.
Latest observation: 2018 Q2.

Figure 3A. Computation of the stock of a portfolio of loans with M = 4 (equation (21))

Stock at t = 1

	L_1	L_2	L_3	L_4	L_5	L_6
$t=0$	$L_{0,1}$	0	0	0	0	0
$t=1$	$L_{1,1}$	$L_{0,2}$	0	0	0	0
$t=2$	$L_{2,1}$	$L_{1,2}$	$L_{0,3}$	0	0	0
$t=3$	$L_{3,1}$	$L_{2,2}$	$L_{1,3}$	$L_{0,4}$	0	0
$t=4$	0	$L_{3,2}$	$L_{2,3}$	$L_{1,4}$	$L_{0,5}$	0
$t=5$	0	0	$L_{3,3}$	$L_{2,4}$	$L_{1,5}$	$L_{0,6}$
$t=6$	0	0	0	$L_{3,4}$	$L_{2,5}$	$L_{1,6}$
$t=7$	0	0	0	0	$L_{3,5}$	$L_{2,6}$
$t=8$	0	0	0	0	0	$L_{3,6}$

Stock at t = 2

	L_1	L_2	L_3	L_4	L_5	L_6
$t=0$	$L_{0,1}$	0	0	0	0	0
$t=1$	$L_{1,1}$	$L_{0,2}$	0	0	0	0
$t=2$	$L_{2,1}$	$L_{1,2}$	$L_{0,3}$	0	0	0
$t=3$	$L_{3,1}$	$L_{2,2}$	$L_{1,3}$	$L_{0,4}$	0	0
$t=4$	0	$L_{3,2}$	$L_{2,3}$	$L_{1,4}$	$L_{0,5}$	0
$t=5$	0	0	$L_{3,3}$	$L_{2,4}$	$L_{1,5}$	$L_{0,6}$
$t=6$	0	0	0	$L_{3,4}$	$L_{2,5}$	$L_{1,6}$
$t=7$	0	0	0	0	$L_{3,5}$	$L_{2,6}$
$t=8$	0	0	0	0	0	$L_{3,6}$

Stock at t = 3

	L_1	L_2	L_3	L_4	L_5	L_6
$t=0$	$L_{0,1}$	0	0	0	0	0
$t=1$	$L_{1,1}$	$L_{0,2}$	0	0	0	0
$t=2$	$L_{2,1}$	$L_{1,2}$	$L_{0,3}$	0	0	0
$t=3$	$L_{3,1}$	$L_{2,2}$	$L_{1,3}$	$L_{0,4}$	0	0
$t=4$	0	$L_{3,2}$	$L_{2,3}$	$L_{1,4}$	$L_{0,5}$	0
$t=5$	0	0	$L_{3,3}$	$L_{2,4}$	$L_{1,5}$	$L_{0,6}$
$t=6$	0	0	0	$L_{3,4}$	$L_{2,5}$	$L_{1,6}$
$t=7$	0	0	0	0	$L_{3,5}$	$L_{2,6}$
$t=8$	0	0	0	0	0	$L_{3,6}$

Stock at t = 4

	L_1	L_2	L_3	L_4	L_5	L_6
$t=0$	$L_{0,1}$	0	0	0	0	0
$t=1$	$L_{1,1}$	$L_{0,2}$	0	0	0	0
$t=2$	$L_{2,1}$	$L_{1,2}$	$L_{0,3}$	0	0	0
$t=3$	$L_{3,1}$	$L_{2,2}$	$L_{1,3}$	$L_{0,4}$	0	0
$t=4$	0	$L_{3,2}$	$L_{2,3}$	$L_{1,4}$	$L_{0,5}$	0
$t=5$	0	0	$L_{3,3}$	$L_{2,4}$	$L_{1,5}$	$L_{0,6}$
$t=6$	0	0	0	$L_{3,4}$	$L_{2,5}$	$L_{1,6}$
$t=7$	0	0	0	0	$L_{3,5}$	$L_{2,6}$
$t=8$	0	0	0	0	0	$L_{3,6}$

Figure 4A. Computation of the stock of a portfolio of loans with M = 4 (equations (22) or (23))

Stock at t = 1

	L_1	L_2	L_3	L_4	L_5	L_6
$t=0$	$L_{0,1}$	0	0	0	0	0
$t=1$	$R_{1,1}$	$L_{0,2}$	0	0	0	0
$t=2$	$R_{2,1}$	$R_{1,2}$	$L_{0,3}$	0	0	0
$t=3$	$R_{3,1}$	$R_{2,2}$	$R_{1,3}$	$L_{0,4}$	0	0
$t=4$	$R_{4,1}$	$R_{3,2}$	$R_{2,3}$	$R_{1,4}$	$L_{0,5}$	0
$t=5$	0	$R_{4,2}$	$R_{3,3}$	$R_{2,4}$	$R_{1,5}$	$L_{0,6}$
$t=6$	0	0	$R_{4,3}$	$R_{3,4}$	$R_{2,5}$	$R_{1,6}$
$t=7$	0	0	0	$R_{4,4}$	$R_{3,5}$	$R_{2,6}$
$t=8$	0	0	0	0	$R_{4,5}$	$R_{3,6}$

Stock at t = 2

	L_1	L_2	L_3	L_4	L_5	L_6
$t=0$	$L_{0,1}$	0	0	0	0	0
$t=1$	$R_{1,1}$	$L_{0,2}$	0	0	0	0
$t=2$	$R_{2,1}$	$R_{1,2}$	$L_{0,3}$	0	0	0
$t=3$	$R_{3,1}$	$R_{2,2}$	$R_{1,3}$	$L_{0,4}$	0	0
$t=4$	$R_{4,1}$	$R_{3,2}$	$R_{2,3}$	$R_{1,4}$	$L_{0,5}$	0
$t=5$	0	$R_{4,2}$	$R_{3,3}$	$R_{2,4}$	$R_{1,5}$	$L_{0,6}$
$t=6$	0	0	$R_{4,3}$	$R_{3,4}$	$R_{2,5}$	$R_{1,6}$
$t=7$	0	0	0	$R_{4,4}$	$R_{3,5}$	$R_{2,6}$
$t=8$	0	0	0	0	$R_{4,5}$	$R_{3,6}$

Stock at t = 3

	L_1	L_2	L_3	L_4	L_5	L_6
$t=0$	$L_{0,1}$	0	0	0	0	0
$t=1$	$R_{1,1}$	$L_{0,2}$	0	0	0	0
$t=2$	$R_{2,1}$	$R_{1,2}$	$L_{0,3}$	0	0	0
$t=3$	$R_{3,1}$	$R_{2,2}$	$R_{1,3}$	$L_{0,4}$	0	0
$t=4$	$R_{4,1}$	$R_{3,2}$	$R_{2,3}$	$R_{1,4}$	$L_{0,5}$	0
$t=5$	0	$R_{4,2}$	$R_{3,3}$	$R_{2,4}$	$R_{1,5}$	$L_{0,6}$
$t=6$	0	0	$R_{4,3}$	$R_{3,4}$	$R_{2,5}$	$R_{1,6}$
$t=7$	0	0	0	$R_{4,4}$	$R_{3,5}$	$R_{2,6}$
$t=8$	0	0	0	0	$R_{4,5}$	$R_{3,6}$

Stock at t = 4

	L_1	L_2	L_3	L_4	L_5	L_6
$t=0$	$L_{0,1}$	0	0	0	0	0
$t=1$	$R_{1,1}$	$L_{0,2}$	0	0	0	0
$t=2$	$R_{2,1}$	$R_{1,2}$	$L_{0,3}$	0	0	0
$t=3$	$R_{3,1}$	$R_{2,2}$	$R_{1,3}$	$L_{0,4}$	0	0
$t=4$	$R_{4,1}$	$R_{3,2}$	$R_{2,3}$	$R_{1,4}$	$L_{0,5}$	0
$t=5$	0	$R_{4,2}$	$R_{3,3}$	$R_{2,4}$	$R_{1,5}$	$L_{0,6}$
$t=6$	0	0	$R_{4,3}$	$R_{3,4}$	$R_{2,5}$	$R_{1,6}$
$t=7$	0	0	0	$R_{4,4}$	$R_{3,5}$	$R_{2,6}$
$t=8$	0	0	0	0	$R_{4,5}$	$R_{3,6}$

Figure 5A. Computation of the repayments generated by a portfolio of loans with M = 4

Repayments at t = 1

	L_1	L_2	L_3	L_4	L_5	L_6
$t=0$	$L_{0,1}$	0	0	0	0	0
$t=1$	$R_{1,1}$	$L_{0,2}$	0	0	0	0
$t=2$	$R_{2,1}$	$R_{1,2}$	$L_{0,3}$	0	0	0
$t=3$	$R_{3,1}$	$R_{2,2}$	$R_{1,3}$	$L_{0,4}$	0	0
$t=4$	$R_{4,1}$	$R_{3,2}$	$R_{2,3}$	$R_{1,4}$	$L_{0,5}$	0
$t=5$	0	$R_{4,2}$	$R_{3,3}$	$R_{2,4}$	$R_{1,5}$	$L_{0,6}$
$t=6$	0	0	$R_{4,3}$	$R_{3,4}$	$R_{2,5}$	$R_{1,6}$
$t=7$	0	0	0	$R_{4,4}$	$R_{3,5}$	$R_{2,6}$
$t=8$	0	0	0	0	$R_{4,5}$	$R_{3,6}$

Repayments at t = 2

	L_1	L_2	L_3	L_4	L_5	L_6
$t=0$	$L_{0,1}$	0	0	0	0	0
$t=1$	$R_{1,1}$	$L_{0,2}$	0	0	0	0
$t=2$	$R_{2,1}$	$R_{1,2}$	$L_{0,3}$	0	0	0
$t=3$	$R_{3,1}$	$R_{2,2}$	$R_{1,3}$	$L_{0,4}$	0	0
$t=4$	$R_{4,1}$	$R_{3,2}$	$R_{2,3}$	$R_{1,4}$	$L_{0,5}$	0
$t=5$	0	$R_{4,2}$	$R_{3,3}$	$R_{2,4}$	$R_{1,5}$	$L_{0,6}$
$t=6$	0	0	$R_{4,3}$	$R_{3,4}$	$R_{2,5}$	$R_{1,6}$
$t=7$	0	0	0	$R_{4,4}$	$R_{3,5}$	$R_{2,6}$
$t=8$	0	0	0	0	$R_{4,5}$	$R_{3,6}$

Repayments at t = 3

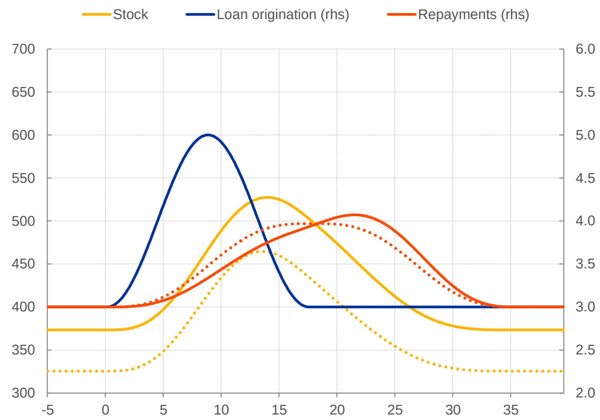
	L_1	L_2	L_3	L_4	L_5	L_6
$t=0$	$L_{0,1}$	0	0	0	0	0
$t=1$	$R_{1,1}$	$L_{0,2}$	0	0	0	0
$t=2$	$R_{2,1}$	$R_{1,2}$	$L_{0,3}$	0	0	0
$t=3$	$R_{3,1}$	$R_{2,2}$	$R_{1,3}$	$L_{0,4}$	0	0
$t=4$	$R_{4,1}$	$R_{3,2}$	$R_{2,3}$	$R_{1,4}$	$L_{0,5}$	0
$t=5$	0	$R_{4,2}$	$R_{3,3}$	$R_{2,4}$	$R_{1,5}$	$L_{0,6}$
$t=6$	0	0	$R_{4,3}$	$R_{3,4}$	$R_{2,5}$	$R_{1,6}$
$t=7$	0	0	0	$R_{4,4}$	$R_{3,5}$	$R_{2,6}$
$t=8$	0	0	0	0	$R_{4,5}$	$R_{3,6}$

Repayments at t = 4

	L_1	L_2	L_3	L_4	L_5	L_6
$t=0$	$L_{0,1}$	0	0	0	0	0
$t=1$	$R_{1,1}$	$L_{0,2}$	0	0	0	0
$t=2$	$R_{2,1}$	$R_{1,2}$	$L_{0,3}$	0	0	0
$t=3$	$R_{3,1}$	$R_{2,2}$	$R_{1,3}$	$L_{0,4}$	0	0
$t=4$	$R_{4,1}$	$R_{3,2}$	$R_{2,3}$	$R_{1,4}$	$L_{0,5}$	0
$t=5$	0	$R_{4,2}$	$R_{3,3}$	$R_{2,4}$	$R_{1,5}$	$L_{0,6}$
$t=6$	0	0	$R_{4,3}$	$R_{3,4}$	$R_{2,5}$	$R_{1,6}$
$t=7$	0	0	0	$R_{4,4}$	$R_{3,5}$	$R_{2,6}$
$t=8$	0	0	0	0	$R_{4,5}$	$R_{3,6}$

Figure 6A. Transmission of a one-boom cycle in loan origination to the loan stock and repayments

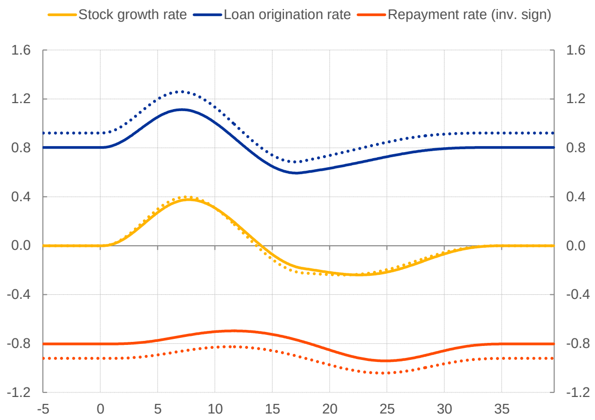
(EUR; French loan in solid lines; loan with fixed amortisation amount in dotted lines)



Notes: Loan portfolio composed of French loans with equal maturity (18 years) and interest rate (5%). Time dimension expressed in years since the onset of the boom. The length of the boom in loan origination is chosen to match the maturity of the loans composing the portfolio.

Figure 7A. Transmission of a one-boom cycle in loan origination to the loan stock and repayments

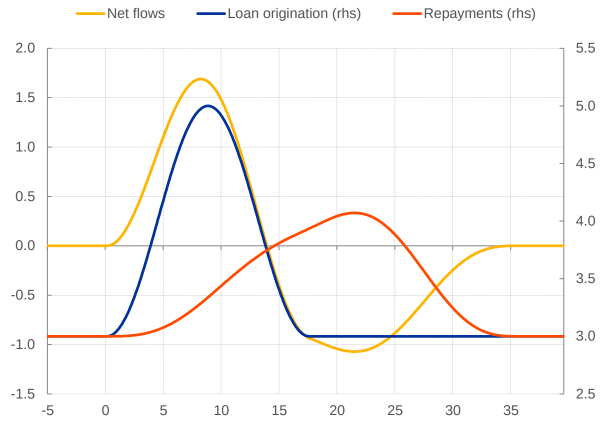
(ratio to contemporaneous stock; French loan in solid lines; loan with fixed amortisation amount in dotted lines)



Notes: Loan portfolio composed of French loans with equal maturity (18 years) and interest rate (5%). Time dimension expressed in years since the onset of the boom. The length of the boom in loan origination (shown in Figure 6A) is chosen to match the maturity of the loans composing the portfolio.

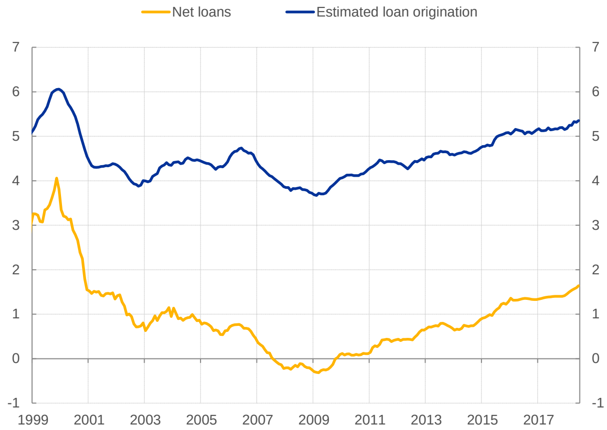
Figure 8A. Transmission of a one-boom cycle in loan origination to net flows and repayments

(EUR)



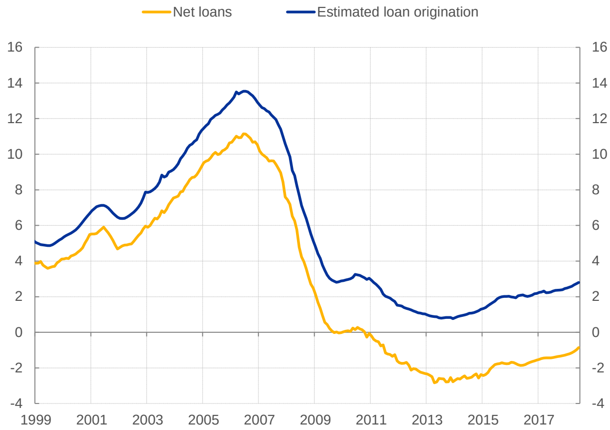
Notes: Loan portfolio composed of French loans with equal maturity (18 years) and interest rate (5%). Time dimension expressed in years since the onset of the boom. The length of the boom in loan origination is chosen to match the maturity of the loans composing the portfolio.

Figure 9A. Loans relative to GDP - Germany
(accumulated 12-month flows over nominal GDP)



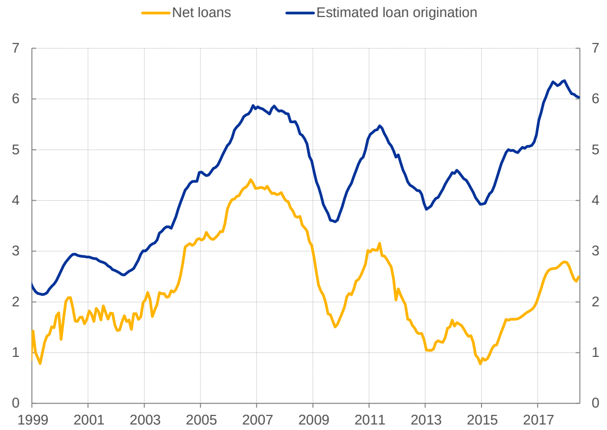
Source: Authors' calculations.
Notes: Accumulated 12-month flows over nominal GDP of previous year. Latest observation: June 2018.

Figure 10A. Loans relative to GDP - Spain
(accumulated 12-month flows over nominal GDP)



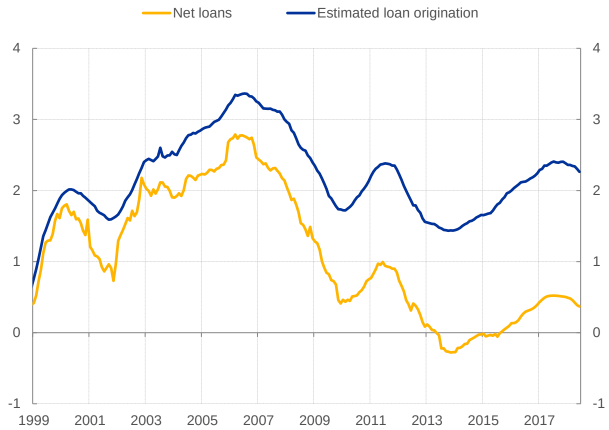
Source: Authors' calculations.
Notes: Accumulated 12-month flows over nominal GDP of previous year. Latest observation: June 2018.

Figure 11A. Loans relative to GDP - France
(accumulated 12-month flows over nominal GDP)



Source: Authors' calculations.
Notes: Accumulated 12-month flows over nominal GDP of previous year. Latest observation: June 2018.

Figure 12A. Loans relative to GDP - Italy
(accumulated 12-month flows over nominal GDP)



Source: Authors' calculations.
Notes: Accumulated 12-month flows over nominal GDP of previous year. Latest observation: June 2018.

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