B Measuring credit gaps for macroprudential policy

Jan Hannes Lang and Peter Welz[126]

Excessive credit growth and leverage have been key drivers of past financial crises, notably the recent global financial crisis. For the appropriate setting of countercyclical macroprudential policy instruments, it is therefore important to identify periods of excessive credit developments at an early stage. This special feature discusses the standard statistical method for computing credit gaps and compares it with an alternative approach to measuring credit excesses based on fundamental economic factors. Theory-based credit gaps could provide a useful complement to statistical measures of cyclical systemic risk.

Introduction

It is well known that prolonged excessive credit growth can be a source of cyclical imbalances and the build-up of systemic risks to financial stability. Indeed, strong credit growth has preceded many historic episodes of financial instability, most notably the global financial crisis, resulting in high leverage and, ultimately, the materialisation of systemic banking crises.[127]

Learning a lesson from the global financial crisis, macroprudential policy has been equipped with instruments that can be used to target cyclical systemic risks. Specifically, the countercyclical capital buffer (CCyB) – a key macroprudential instrument agreed under the Basel III framework – is designed to counter procyclicality in the financial system and to strengthen resilience of banks via higher capital requirements in the form of buffers which they need to build up during phases of excessive credit growth. The rationale behind this measure is that by strengthening its capital base the banking system will be able to absorb losses during the downswing of the financial cycle without constraining the flow of credit to the economy. Appropriate setting of macroprudential policy therefore requires reliable measures of cyclical systemic risk, notably risks emanating from excessive credit developments.

There is no straightforward method for measuring excessive credit provision in the economy. A desirable feature of any method would be that it allows the fraction of credit that is excessive to be distinguished from the fraction that can be justified by fundamental economic factors. This is a challenging task because it requires a detailed understanding of the interaction between credit demand and supply factors in an economy. Statistical credit gaps are a practical approach to measuring excessive credit developments and are currently used by macroprudential authorities, following ESRB guidelines.

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126 The theory-based household credit gaps in this special feature are based on the methodology and results in Lang, J. H. and Welz, P., “Semi-Structural Credit Gap Estimation”, mimeo, 2017.

127 See, for example, Schularick, M. and Taylor, A. M., “Credit Booms Gone Bust: Monetary Policy, Leverage Cycles, and Financial Crises, 1870-2008”, *American Economic Review*, Vol. 102(2), 2012, pp. 1029-1061, and the references therein.

A prominent measure of credit gaps is the "Basel gap", which is defined as the difference between the ratio of total credit relative to GDP and its long-run statistical trend.[128] Many studies have found that the Basel gap is one of the best single early warning indicators of systemic banking crises.[129] Accordingly, it is used in the benchmark buffer guide for the CCyB as recommended by the European Systemic Risk Board (ESRB).[130] However, the Basel gap can have some undesirable properties and may therefore not be applicable in all countries and at all times.

As a complement to the Basel gap, macroprudential authorities are expected to monitor a broad set of information for the assessment of cyclical systemic risks. Such indicators include various asset prices (e.g. deviations of property and equity prices from trend), credit condition surveys, real GDP growth, current account dynamics, and data on the ability of non-financial firms and households to meet their debt obligations.[131]

In addition, the analysis of cyclical systemic risks may be complemented by model-based approaches. For example, the above-mentioned indicators can be combined into early warning models for predicting periods of financial vulnerability that often precede systemic banking crises. More recently, composite financial cycle estimates have been constructed in an attempt to summarise the joint developments of credit and asset prices by taking into account their mutual co-movement. Financial cycles have been shown to possess early warning signalling properties that are comparable to those of the Basel gap.[132]

Ideally, credit gap measures would allow for economic interpretation by taking into account fundamental factors that influence credit demand and supply. This special feature presents one approach to constructing such a credit gap with a focus on household credit.[133] Specifically, using economic theory, fundamental economic factors are derived that may drive the trend or long-run level of household credit. The structural economic information underlying this approach is the feature

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128 Technically speaking, the trend is computed recursively for each quarter using a Hodrick-Prescott (HP) filter with a smoothing coefficient of 400,000, which implies that credit cycles are about four times longer than business cycles, i.e. in the range of 25-30 years.

129 See Detken, C., Weeken, O., Alessi, L., Bonfim, D., Boucinha, M. M., Castro, C., Frontczak, S., Giordana, G., Giese, J., Jahn, N., Kakes, J., Klaus, B., Lang, J. H., Puzanova, N. and Welz, P., "Operationalising the countercyclical capital buffer: indicator selection, threshold identification and calibration options", *Occasional Paper Series*, No 5, ESRB, June 2014, and further references therein.

130 See Recommendation of the European Systemic Risk Board of 18 June 2014 on guidance for setting countercyclical buffer rates (ESRB/2014/1).

131 The focus in this special feature is on the build-up phase of cyclical systemic risks that requires indicators with good early warning properties. For the release phase, market-based indicators that can be measured at higher frequency are more appropriate.

132 See Schüler, Y., Hiebert, P. and Peltonen, T., "Characterising the financial cycle: a multivariate and time-varying approach", *Working Paper Series*, No 1846, ECB, 2015, and the special feature entitled "Capturing the financial cycle in euro area countries", *Financial Stability Review*, ECB, November 2014.

133 Arguably, different economic fundamental factors drive credit demand and supply for households and non-financial corporations, so each requires a different modelling set-up. The focus on household credit is motivated by the fact that household debt may be a potential driver of business cycles and, when reaching unsustainable levels, may be the origin of financial crises. See, for example, Mian, A. and Sufi, A., *House of Debt: How They (and You) Caused the Great Recession, and How We Can Prevent It from Happening Again*, University of Chicago Press, Chicago, 2014; and Mian, A., Sufi, A. and Verner, E., "Household Debt and Business Cycles Worldwide", NBER Working Paper No 21581, National Bureau of Economic Research, 2015.

that distinguishes it from the trend computation underlying the Basel gap, which relies on statistical methods.

The remainder of this special feature explains in more detail how economic theory can be used to derive a household credit gap as an alternative to statistical credit gaps. The dynamic and structural properties of the alternative credit gap are presented and it is shown that the theory-based gaps have good early warning signalling power for systemic banking crises, which is an important property to inform countercyclical macroprudential policy-setting. Before going into the details of the alternative approach, the next section sets out the main properties of the statistical Basel gap.

The "Basel gap" – a prominent statistical credit gap measure

The "Basel gap" is a useful and commonly employed statistical indicator of credit excesses. Many studies have found that the Basel gap is one of the best early warning indicators of systemic banking crises,[134] and it is therefore used in the benchmark buffer guide for the CCyB as recommended by the ESRB. Specifically, the credit-to-GDP gap is transformed into the benchmark buffer guide add-on in the following way: when the gap is below a lower threshold of 2 percentage points, the buffer add-on is zero. It increases with the gap until the buffer add-on reaches its maximum level of 2.5 per cent at the point where the gap exceeds an upper threshold of 10 percentage points.

However, the Basel gap can have some undesirable statistical properties.[135] In particular, there are indications that the Basel gap performs less well in situations where predictions are made beyond the available data.[136] In addition, in certain situations the Basel gap might be biased downwards and therefore potentially underestimate cyclical systemic risks. For example, in the aftermath of a period of prolonged excessive credit growth Basel gaps tend to attain implausibly large negative values. Indeed, large negative Basel gaps are currently observed in a number of euro area countries with values ranging between -30 percentage points and -50 percentage points (see **Chart B.1**). The mechanics behind this phenomenon are that part of the credit excesses of the boom period will be incorporated into the statistical trend estimate, which is highly persistent. The longer the boom phase lasts in credit markets, the more the statistical trend inherits part of the excess in credit

134 See, for example, Borio, C. and Lowe, P., "Asset prices, financial and monetary stability: exploring the nexus", BIS Working Paper No 114, July 2002; Borio, C. and Drehmann, M., "Assessing the risk of banking crises – revisited", *BIS Quarterly Review*, March 2009; and Detken et al. (2014) op. cit.

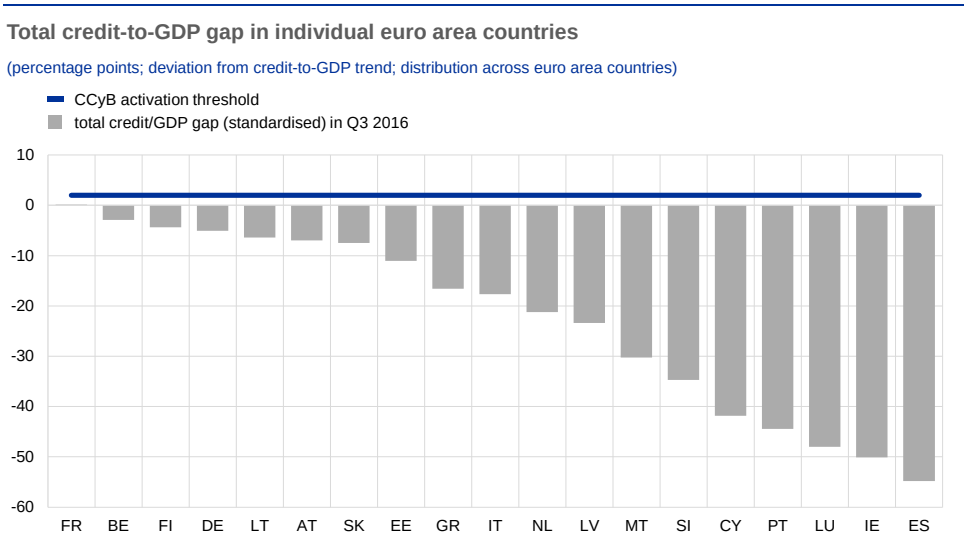
135 For a discussion of shortcomings of the Basel gap, see also Castro, C., Estrada, A. and Martínez, J. "The countercyclical capital buffer in Spain: an analysis of key guiding indicators", *Documentos de Trabajo*, No 1601, Banco de España, 2016; Repullo, R. and Saurina, J., "The countercyclical capital buffer of Basel III: A critical assessment", CEPR Discussion Paper No 8304, 2011; Edge, R. M., Meisenzahl, R. R., "The Unreliability of Credit-to-GDP Ratio Gaps in Real Time: Implications for Countercyclical Capital Buffers", *International Journal of Central Banking*, December 2011, pp. 261-298.

136 The good early warning properties found in the literature pertain to in-sample forecasting results. Out-of-sample forecasting exercises suggest that the Basel credit gap has weaker early warning properties. For example, credit growth rates at low frequencies tend to perform better in such settings.

developments, which may lead to a statistical trend level above the one that is justified by economic fundamentals. When a deleveraging phase starts in such a situation, an excessively large negative credit gap can open up, partly explained by the higher-than-justified statistical trend estimate.

Chart B.1

Basel credit gaps display large negative values in a number of euro area countries



Sources: ECB and ECB calculations.
Notes: The gap is calculated as the deviation of the total credit-to-GDP ratio from its long-term trend. The trend is calculated via a recursive HP filter with a smoothing parameter of 400,000, in line with the standardised method in the recommendation of the ESRB.

The statistical shortcomings of the Basel gap can be illustrated with a stylised example. In this example, it is assumed that the economy has experienced equal growth rates of credit and GDP and that the initial credit-to-GDP ratio is 100%. The economy then enters a period of 20 quarters in which credit growth increases, e.g. on the grounds of exuberant optimism not justified by economic fundamentals, so the actual credit trend justified by economic fundamentals should be unchanged. Specifically, it is assumed that credit growth exceeds GDP growth by 8 percentage points per annum and thereafter settles back to the growth rate of GDP. The credit trend and gap are computed in the same way as in the case of the Basel gap. Given these assumptions, the credit-to-GDP ratio rises and the statistical trend follows slowly, thereby inheriting the excess in credit, although the trend should have remained unchanged at 100% (see **Chart B.2**). This implies that, although the estimated credit gap becomes positive, it is underestimated because of the inflated trend. Similarly, once the credit growth rate settles back to its initial level, a large and persistent negative credit gap opens up because of the inflated credit trend level that still incorporates the past excess (see **Chart B.3**).

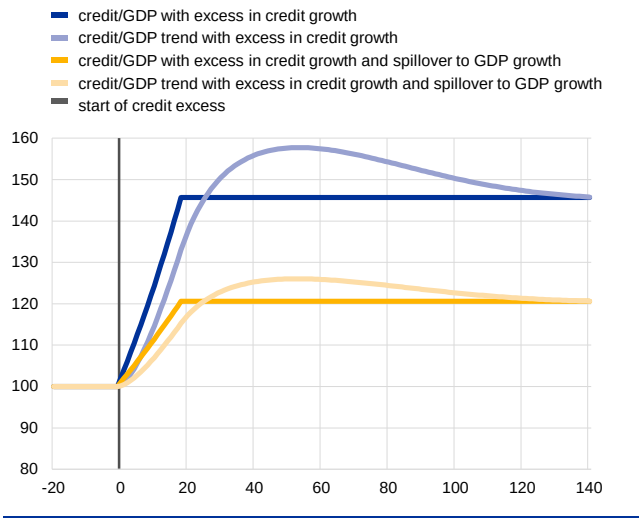
This admittedly stylised situation demonstrates the potential problem of the Basel gap to underestimate the size of positive or overestimate the size of negative gaps. A second variant allows for an impact of excess credit growth on GDP growth by assuming that in reaction to the higher credit growth the annual GDP growth rate increases by 4 percentage points and thereafter both growth rates settle back to their initial values. In this case, the underestimation of the credit gap in the

build-up phase is exacerbated, while the overestimation of the negative gap is mitigated.

An alternative situation of overestimated credit gaps could occur during periods of economic transition. The reason for this phenomenon is that during economic transition phases, credit growth usually outpaces GDP growth for an extended period, which can often be justified by economic fundamentals and which should therefore lead to relatively small credit gaps. A purely statistical method will find it difficult to distinguish between such a justified acceleration in credit growth and an acceleration that is due to exuberant optimism. Indeed, in certain euro area countries that were subject to structural change a few decades ago, large and persistent positive credit gaps could be observed that might be partly explained by structural transition.[137]

Chart B.2

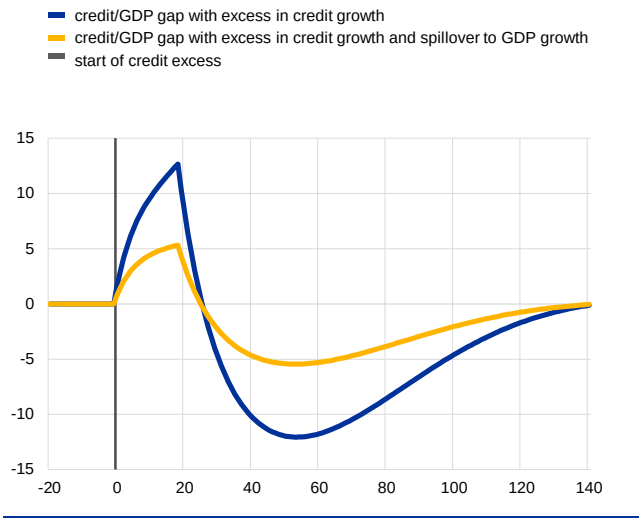
Simulated effects of excessive credit growth on the credit-to-GDP ratio and its statistical trend



Sources: Simulated data, ECB calculations.
Notes: The assumptions are: (i) that before quarter 0, credit and GDP are growing at the same pace and the level of the credit stock and the four-quarter sum of GDP are identical; (ii) that from quarter 0, the credit stock grows at 8 percentage points per annum above its previous growth rate and above the growth rate of GDP for a period of 20 quarters; and (iii) that the credit growth rate then reverts back to its initial level, which is equal to the GDP growth rate. The trend is computed recursively using an HP filter with a smoothing parameter of 400,000, as in the case of the Basel gap.

Chart B.3

Simulated effects of excessive credit growth on the statistical credit-to-GDP gap



Sources: Simulated data, ECB calculations.
Notes: See Chart B.1.The gap is computed as the difference between the simulated credit-to-GDP ratio and the recursive trend.

This discussion shows that it would be desirable to attach more economic interpretation to credit gaps. Specifically, it would be desirable to understand the underlying driving factors that explain the size and dynamics of credit gaps. One possibility in this direction is to make use of a detailed accounting-type breakdown of the total credit data into its components, which are available from euro area sectoral accounts statistics. Such a breakdown is demonstrated in **Box A**.

137 This problem of excessively long past periods of positive credit-to-GDP gaps has been observed for Ireland, Italy, Portugal and Spain. See, for example, Detken et al. (2014) for a more detailed discussion of this problem with the Basel credit-to-GDP gap.

Box A

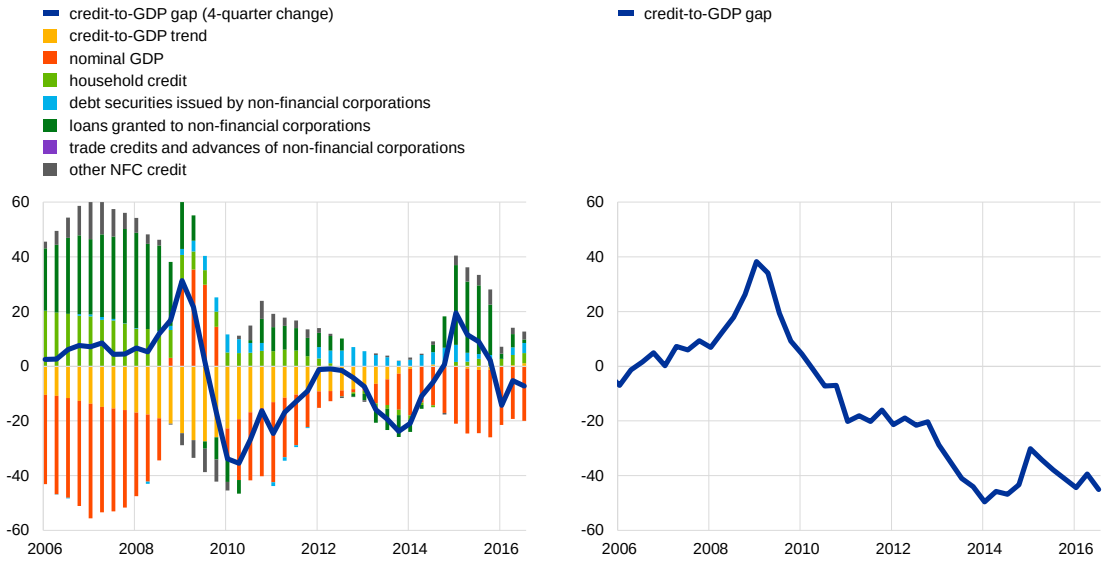
Decomposing the driving forces behind changes in the Basel credit-to-GDP gap[138]

In the assessment of cyclical systemic risks and when setting the countercyclical capital buffer, macroprudential authorities are required to consider deviations of the ratio of credit to GDP from its long-term trend.[139] For this assessment various credit series are available, which differ with respect to how broadly they define credit. The analysis in this box considers a broad measure of credit based on the euro area sector accounts, which capture all outstanding credit instruments by sector, and decomposes the changes in the credit-to-GDP gap into its contributions.[140]

Chart A

Contributions to the annual changes in the euro area credit gap

(differences in percentage points)



Sources: ECB (ESA 2010 quarterly financial and non-financial sector accounts) and ECB calculations.
Note: The trend is calculated using an HP filter (400,000) applied to the ratio of total credit to nominal GDP.

The advantage of broad credit is that it is possible to perform a decomposition of the credit-to-GDP gap not only into the contributions from credit, nominal GDP and the trend component, but also into credit by household and non-financial corporate (NFC) sector and by credit instrument, such as loans, debt securities and trade credit.[141] Such a decomposition provides insights into the

138 Prepared by Daniel Goetze and Stephan Fahr.

139 The legal requirement is laid down in Article 136 of the Capital Requirements Directive IV. In addition to the standardised credit-to-GDP gap measure (the "Basel gap"), Member States are encouraged to calculate additional credit-to-GDP gaps following national alternative methodologies (see Detken et al., 2014).

140 Alternative levels have been computed by Bassett, W., Daigle, A., Edge, R. and Kara, G.,"Credit-to-GDP Trends and Gaps by Lender- and Credit-type", FEDS Note, December 2015.

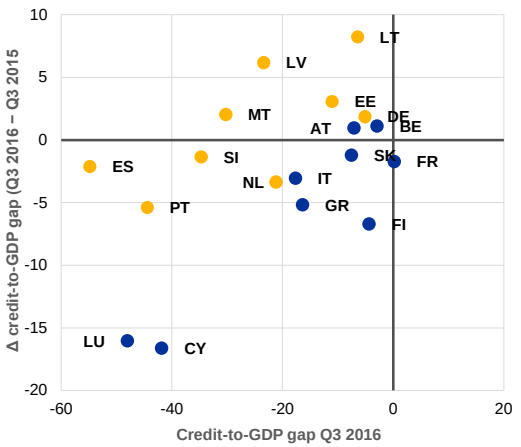
141 Alternative credit definitions, such as narrow domestic bank credit to the non-financial private sector, may provide different credit-to-GDP gaps and decompositions into different uses of credit (consumer versus housing) or for different sub-sectors (NACE classification).

dynamics of the credit cycle and guidance for a potential macroprudential policy response using countercyclical capital buffers.[142]

The decomposition of the euro area credit-to-GDP gap since 2006 reveals three broad episodes. The first phase, characterised by a build-up towards the crisis, saw a sustained increase in credit, especially in the form of loans to NFCs, accompanied by increases in nominal GDP and a growing trend component (see **Chart A**). The growing nominal GDP and trend appear as negative contributions and narrowed the credit-to-GDP gap ahead of the financial crisis. In turn, in the second phase starting in 2009, the broad-based deleveraging led to a declining gap measure, which was counteracted by the positive contributions from contracting economic activity. Finally, in the third phase during the recovery starting in the second half of 2014, the long-term credit-to-GDP trend started to provide marginally positive contributions to the gap measure.

The trend component is particularly large following abrupt accelerations or decelerations of the credit-to-GDP ratio. The contribution of the trend component can be seen as a lagging indicator and absorbs structural shifts occurring in the credit intermediation of the economy. At the same time, a prolonged steady increase or decrease in the credit-to-GDP ratio might unduly bias the credit-to-GDP gap. The strong increase before the financial crisis generates a negative bias, whereas a prolonged period of deleveraging (as has been observed in several euro area countries) creates an upward bias. Both biases warrant careful interpretation of the gap measure for policy implementation. The decomposition in **Chart A** helps in revealing the quantitative effects of such bias.

Chart B
Credit-to-GDP gaps against one-year credit-to-GDP gap change



Sources: ECB (ESA 2010 quarterly financial and non-financial sector accounts) and ECB calculations.
Note: Orange dots denote countries with a declining credit-to-GDP trend.

The decomposition of changes to the credit-to-GDP gap allows countries to be grouped according to their dynamics. For those countries which have experienced a positive change in the credit-to-GDP gap since the third quarter of 2015 (**Chart B**, upper part), it is particularly important to identify those countries that have experienced a positive trend contribution (marked in orange) resulting from a declining credit-to-GDP gap. A quantitative analysis reveals that the trend contribution for Estonia, Germany, Latvia and Malta is larger than the total change over the year, indicating that if an activation of the countercyclical capital buffer were to be considered on the basis of the changes, it would primarily be based on a declining trend component rather than on actual credit conditions. In turn, similar considerations can be made for negative components. The negative contributions from the trend in France and Slovakia are larger than the headline changes

[142] The decomposition of the quarterly changes of the gap is defined as $d(gap) = d\left(\frac{credit}{NGDP} - trend\right) = \frac{1}{NGDP}\left(d\ credit - \frac{dNGDP}{NGDP}\right) - d\ trend$, where *credit* is total credit to the non-financial private sector from the sectoral accounts, *NGDP* is nominal GDP from the national accounts and *trend* is the credit-to-GDP trend computed using an HP (400,000) filter, following the Basel and ESRB guidelines. Additional decompositions into the sub-components of credit follow the same formula.

in the credit-to-GDP ratio. Should credit accelerate in such a case, the trend component would become ever more negative and bias the credit-to-GDP gap negatively, which would imply an under-reporting of risks.

The quantitative assessment indicates that the credit-to-GDP gap serves as an important indicator for assessing the build-up of systemic risks and considering countercyclical buffers, but a closer look at its components informs policy-makers of the main driving forces. It also indicates that additional indicators should complement the analysis of cyclical risks together with structural or semi-structural methodologies in order to draw policy conclusions.

An alternative way to attach more economic interpretation to credit gaps would make explicit use of economic theory. Such an approach is described in the next section for the case of household credit.

Household credit gaps based on economic theory

Conceptually, the equilibrium level of household credit in an economy should depend on structural factors, the economy's production capacity and the level of interest rates. For example, a higher credit stock can be sustained with a higher production capacity, while lower interest rates reduce the debt service burden, allowing households to finance a higher debt stock. In addition, the demographic structure of the economy has an impact on the supply of savings that can be used to finance loans. Finally, the quality of institutions should also affect financial development and can be expected to be important for determining the equilibrium level of credit. For example, a higher credit stock might be financed without a negative impact on financial stability in an economy that is characterised by an effective financial regulatory system.

These insights from economic theory regarding the fundamental drivers of the household credit trend are used to build an economic model for household credit gaps that can be estimated. The most important technical details of the model construction and estimation results for 12 EU countries are discussed in **Box B**. The next section shows the salient properties of the estimated theory-based household credit gaps and draws some comparisons with the properties of the Basel gap.

Box B
Construction and estimation of a theory-based household credit gap

Literature on structural credit gap estimation that explicitly incorporates economic theory is still scarce. Most studies do not use a structural economic model to derive the trend equation for credit and they usually make use of co-integration techniques to establish a long-run relationship between credit and a set of observed explanatory variables, such as real GDP, interest rates, the

debt service burden, residential and commercial property prices and equity prices.[143] Theory-based household credit gap measures rely on a different econometric approach, namely an unobserved components model, and make use of a set of explanatory variables that are directly derived from a structural economic model that embeds an interpretation of the long-run (equilibrium) relationship with the credit variable.

A modification of a structural model of secular stagnation is used to formally derive the factors that drive the trend component of household credit.[144] The assumed demographic structure in the model suggests that the bulk of borrowing in an economy is accounted for by young and low income households who borrow from middle-aged households that are saving for retirement. Loan demand and supply is balanced by the equilibrium real interest rate. Households' borrowing capacity is constrained by a fraction of their future expected income. This fraction of borrowing-constrained households should, in turn, depend on the economy's structural characteristics and institutional quality, which can change over time. This may comprise factors such as the efficiency of the legal system, the existence and quality of credit registers, asset liquidation costs that are of a structural nature, and the relative importance of full recourse and non-recourse loans. Hence, it turns out that the structure of the theoretical model, combined with additional simplifying assumptions, determines that the major economic factors behind the trend level in real household credit are potential real GDP, the equilibrium real interest rate, the tightness of the borrowing constraint and the size of the population cohort that borrows.

For estimation purposes, the theory-based trend equation for household credit can be used in an unobserved components model.[145] In this setting, the logarithm of observed real household credit (c_t) can be decomposed into a trend component (c_t^*) and cyclical component ($\widehat{c_t}$). The credit trend is estimated on the basis of the fundamental factors derived from the theoretical model, i.e. real potential output (y_t^*), a quality of institutions proxy (θ_t), the equilibrium real interest rate (r_t^*) and the share of middle-aged people in the total population (dem_t). As is common in the empirical literature, it is assumed that the household credit cycle follows a stationary AR(2) process and the following system is estimated:[146]

143 Recent contributions include, for example, Juselius, M. and Drehmann, M., "Leverage dynamics and the real burden of debt", BIS Working Paper No 501, Bank for International Settlements, 2015; Albuquerque, B., Baumann, U. and Krustev, G., "US household deleveraging following the Great Recession – a model-based estimate of equilibrium debt", *The B.E. Journal of Macroeconomics*, Vol. 15(1), 2015, pp. 255-307; and Buncic, D. and Melecky, M., "Equilibrium credit: The reference point for macroprudential supervisors", *Journal of Banking & Finance*, Vol. 41(C), 2014, pp. 135-154. Castro et al. (2016) also use co-integration techniques, but include structural information on financial liberalisation in their set of determinants.

144 See Eggertsson, G. and Mehrotra, N., "A Model of Secular Stagnation", NBER Working Paper No 20574, National Bureau of Economic Research, 2014. The model features a demographic structure of overlapping generations with three cohorts: young, middle-aged and old. Households face an exogenous borrowing constraint in the model.

145 This method is common for the estimation of output gaps or equilibrium real interest rates. For output gaps, see, for example, Clark, P., "The Cyclical Component of U.S. Economic Activity", *Quarterly Journal of Economics*, Vol. 102(4), 1987, pp. 797-814. For equilibrium real interest rates, see, for example, Laubach, T. and Williams, J. C., "Measuring the Natural Rate of Interest", *Review of Economics and Statistics*, Vol. 85(4), 2003, pp. 1063-1070, and Mésonnier, J.-S. and Renne, J.-P., "A time-varying 'natural' rate of interest for the euro area", *European Economic Review*, Vol. 51(7), 2007, pp.1768-1784.

146 The AR(2) specification is standard in the output gap and real interest rate gap literature, referenced in the previous footnote. Estimation of the system of equations is performed in a state-space set-up by means of maximum likelihood, where the Kalman filter is used to compute the likelihood function. The coefficients for real potential GDP and the non-linear transformation of the institutional quality proxy are constrained to be equal to one, based on the implied coefficients from the structural model. Further technical details and robustness checks are contained in Lang and Welz (2017).

$$c_t = c_t^* + \widehat{c_t}$$
$$c_t^* = \beta_0 + y_t^* + \theta_t + \beta_1 r_t^* + \beta_2 dem_t + \varepsilon_t^*$$
$$\widehat{c_t} = \alpha_1 \widehat{c_{t-1}} + \alpha_2 \widehat{c_{t-2}} + \widehat{\varepsilon_t}$$

The household credit gaps are estimated for 12 EU countries using data starting in the early 1980s, taking into account data limitations.[147] Real potential GDP and the equilibrium real interest rate are treated as exogenous observed variables to keep the estimation procedure simple.[148] Real potential GDP is taken from the European Commission's annual AMECO database and is linearly interpolated to obtain a quarterly frequency. The equilibrium real interest rate is approximated by means of an HP-filtered trend component with a smoothing parameter of 1,600.[149] The total household credit aggregate includes loans and debt securities and is deflated by the consumer price index from the OECD Main Economic Indicators. The different population ratios of middle-aged people to all people with incomes are constructed from detailed annual demographic data provided by Eurostat, and are linearly interpolated to obtain quarterly series.

The quality of institutions of a country is closely linked to its productive capacity.[150] Accordingly, since long historical data for this concept are not available, real potential GDP per capita is used as a proxy variable for the quality of institutions of a country. This choice can be seen as an instrumental variable, exhibiting a high positive correlation with financial development and hence institutional quality. In addition, it seems plausible that a household's borrowing capacity in terms of expected income should be bounded below at zero, while it should increase with better institutional quality, for example due to effective financial regulation. However, it can be expected that this process will reach a saturation point. Therefore, real potential GDP per capita is transformed using a logistic function in order to be converted to a proxy for institutional quality.[151]

The estimated coefficient signs of the model are all in line with economic theory and intuition. The estimated interest rate coefficients are negative across countries, as expected (see **Table A**): higher equilibrium real interest rates should increase the debt service burden for a given stock of credit and, all else being equal, should therefore reduce the amount of household credit justified by fundamentals. The estimated coefficients for the population ratio are positive (see **Table A**), again in line with economic intuition: if a higher share of aggregate income goes to the people that are most likely to hold debt on their balance sheets, the sustainable level of debt should increase for a given level of aggregate income, interest rates and institutional quality.

147 The countries are Belgium, Denmark, Finland, France, Germany, Ireland, Italy, the Netherlands, Portugal, Spain, Sweden and the United Kingdom.

148 In principle, both variables are endogenous and should be jointly estimated alongside the household credit trend. To keep the system of equations parsimonious and the number of parameters to estimate small, both concepts are assumed to be observed for the purpose of this special feature.

149 Ten-year government bond yields provided by the ECB are used as the relevant interest rate. The real interest rate is obtained from the difference between the nominal interest rate and the average inflation rate that materialised over the subsequent ten years for all of the periods up to the first quarter of 2005; for the following quarters 1.9 is subtracted. This way of constructing real interest rates can be justified by rational expectations, as, on average, realised inflation should be equal to expected inflation under rational expectations.

150 See, for example, Acemoglu, D., Johnson, S. and Robinson, J. A., "Institutions as a Fundamental Cause of Long-Run Growth", in Aghion, P. and Durlauf, S. (eds.), *Handbook of Economic Growth*, Vol. 1, Chapter 6, Elsevier, 2005, pp. 385-472.

151 For a similar idea, see also Ugarte Ruiz, A., "Understanding the dichotomy of financial development: credit deepening versus credit excess", BBVA Research Working Paper No 15/01, Banco Bilbao Vizcaya Argentaria, January 2015.

Table A

Estimated model coefficients have the correct signs in line with economic theory and plausible magnitudes

(estimated coefficients of the theory-based household credit gap model; stars indicate statistical significance at various significance levels: * = 10%, ** = 5%, *** = 1%)

	BE	NL	FR	DE	ES	FI	UK	IE	IT	DK	SE	PT
Intercept	-0.4	1.2**	0.3	0.5	0.8	-0.04	3.0***	1.0	-0.1	2.0***	-0.3	6.6***
Population ratio	0.4	4.6	2.6	4.4**	2.2	1.1	2.9***	1.2	1.2	2.1**	0.6	7.8***
Equilibrium real rate	-5.8***	-13.4***	-4.5***	-4.4**	-3.6**	-3.2**	-6.8***	-4.3	-10.4***	-13.4***	-5.6***	-2.2
AR(1) cycle coefficient	1.91***	1.96***	1.77***	1.85***	1.91***	1.88***	1.93***	1.92***	1.93***	1.96***	1.82***	1.88***
AR(2) cycle coefficient	-0.93***	-0.97***	-0.79***	-0.86***	-0.93***	-0.90***	-0.95***	-0.93***	-0.94***	-0.98***	-0.85***	-0.91***
Credit cycle shock SD	0.004***	0.003***	0.007***	0.004***	0.005***	0.008***	0.005***	0.008***	0.008***	0.002***	0.008***	0.018***
Number of observations	137	97	140	140	137	140	140	140	140	81	137	140
Log likelihood	390	265	437	444	359	410	437	340	303	247	426	326

Source: ECB calculations based on Lang and Welz (2017) op. cit.
Notes: The estimated household credit cycles do not suffer from unit root problems, as the AR(1) coefficient is below 2 and the sum of the AR(1) and AR(2) coefficients is strictly below one in all cases.

The magnitudes of the estimated coefficients imply reasonable responses of the sustainable level of household credit to economic fundamentals. The estimated interest rate coefficients are in a range of -3 to -6 for most of the countries (see **Table A**), suggesting that for a 1 percentage point reduction in the equilibrium real interest rate, the level of household credit justified by fundamentals increases by between 3% and 6%. The estimated population ratio coefficients are in most cases in the range of 0.5 to 3, which implies that a 1% increase in the share of middle-aged people in the total population leads to an increase in the trend level of household credit of between 0.5% and 3%. To put these magnitudes into perspective, the simple structural overlapping generations model that is used to derive the trend equation for household credit implies a unit coefficient for the population ratio: each additional per cent of aggregate future expected income that is assigned to people that are most likely to hold debt should increase one-for-one the amount of borrowing that can be justified by fundamentals.

Empirical properties of theory-based household credit gaps

Overall, estimated household credit cycles based on economic theory are long. Estimated household credit cycles have an average length of around 20 years across the EU countries studied (see **Chart B.4**). However, the cycle length varies between 15 and 25 years across countries. In addition, in all of the countries studied, household credit gaps display large amplitudes in the range of +/-15% to +/- 25%. Large amplitudes and long cycle lengths have also been observed for Basel gaps and for estimates of financial cycles.[152]

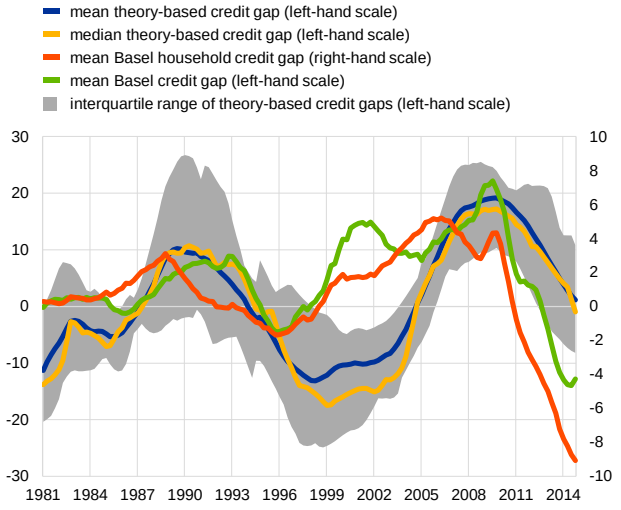
[152] See also the special feature entitled “Capturing the financial cycle in euro area countries”, *Financial Stability Review*, ECB, November 2014.

Chart B.4

Theory-based household credit gaps exhibit long cycles of around 15-25 years

Cyclical component of the real household credit stock

(Basel gaps: percentage points; theory-based gaps: percentage deviation from real household credit trend; distribution across EU countries)



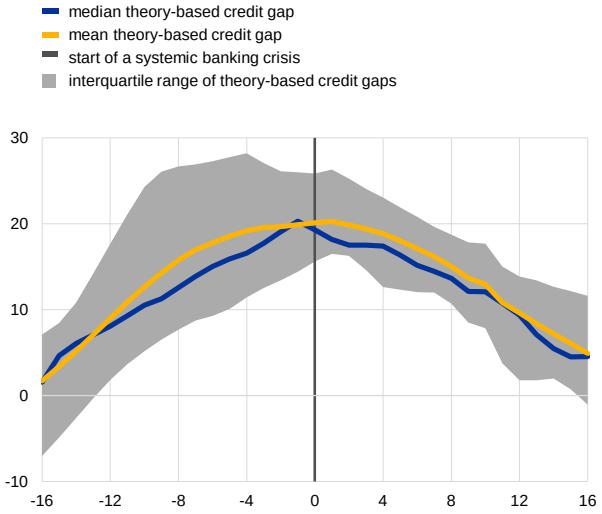
Source: ECB calculations based on the method in Lang and Welz (2017).
Notes: The chart shows the mean, median and interquartile range of the theory-based household credit gaps across 12 EU countries (Belgium, Denmark, Finland, France, Germany, Ireland, Italy, the Netherlands, Portugal, Spain, Sweden and the United Kingdom). As a comparison, the mean of the statistical Basel gap related to total credit and the Basel gap related to household credit across the same set of EU countries is shown.

Chart B.5

Theory-based credit gaps tend to increase well before systemic banking crises and decrease thereafter

Cyclical component of the real household credit stock

(percentage deviation from real household credit trend; quarters before/after start of a systemic banking crisis)



Source: ECB calculations based on the method in Lang and Welz (2017).
Notes: The results are based on a sample of 12 EU countries (see Chart B.4). The chart shows the mean, median and interquartile range of the theory-based household credit gaps before and after the onset of systemic banking crises across the sample of EU countries. The definition and dating of systemic banking crises is taken from Detken et al. (2014). In total, 18 systemic banking crises have occurred since the first quarter of 1980 for the set of 12 EU countries, and most of them were clustered around the global financial crisis.

Theory-based household credit gaps tend to increase well before systemic banking crises and decrease only slowly afterwards. On average, household credit gaps start to become positive around four years prior to the start of systemic banking crises (see **Chart B.5**). Moreover, they tend to increase continuously during the period leading up to a systemic banking crisis to reach excesses of, on average, around 20% above the level of real household credit that would be justified by fundamental factors. This is a useful property for the detection of cyclical systemic risks. Once a systemic banking crisis materialises, usually a slow deleveraging process begins that takes, on average, more than four years to bring real household credit back to a sustainable level. This observation is in contrast to the two Basel gaps based on total and household credit that, as discussed above, can drop relatively rapidly and attain large negative values after long periods of credit booms. Indeed, **Chart B.4** shows that the mean of the two Basel gaps computed across countries fell below the interquartile range of theory-based credit gaps after the recent financial crisis, reflecting strong deleveraging in the light of possibly inflated credit-to-GDP trends.

Theory-based credit gaps do not display excessively long periods of positive and negative gaps, which can be the case for statistical credit-to-GDP gaps. One example is the period between 1998 and 2004, during which, on average, the Basel credit gaps indicate booming credit developments, while the theory-based measures, on average, indicate negative gaps. The reason is that the fundamental

factors determine a credit trend that exceeds the statistical credit trend during this period. The main contributing factors to this development were declining equilibrium real interest rates and improving potential GDP across countries. This suggests that, relative to the statistical measures, the theory-based credit gaps might be better able to distinguish periods of justified high credit growth, e.g. periods of structural change, from periods of unjustified credit growth. False positive signals of imminent systemic banking crises could therefore be lower for the theory-based household credit gaps than for the Basel gap.

Early warning properties of different credit gap measures

Theory-based household credit gaps have good early warning properties for systemic banking crises. Results from standard univariate signalling analysis for various pre-crisis windows are promising. Notably, for the theory-based household credit gap, AUROC values, which are a measure of the early warning quality of an indicator, exceed AUROC values obtained for other important early warning indicators that are computed using purely statistical methods.[153] These indicators are the total Basel gap, the bank credit-to-GDP gap and the household credit-to-GDP gap (see **Table B.1**). The finding that theory-based household credit gaps outperform the purely statistical credit excess measures in most cases is encouraging, especially given the fact that the theory-based credit gaps are derived from economic fundamentals, which allow for additional interpretation of changes in this measure of excess credit. Such measures may therefore provide useful complementary information for the identification and analysis of cyclical systemic risk and thus, ultimately, for the setting of countercyclical macroprudential policy.

Table B.1

Theory-based household credit gaps have good early warning properties for systemic banking crises

	Theory-based household credit gap	Basel total credit-to-GDP gap	Basel bank credit-to-GDP gap	Basel household credit-to-GDP gap
Number of observations	1,102	1,094	1,102	1,014
Pseudo R2, 12-5 quarters	0.29	0.15	0.18	0.14
AUROC, 12-5 quarters	0.88	0.80	0.82	0.81
AUROC, 8-1 quarters	0.90	0.81	0.79	0.73
AUROC, 4-1 quarters	0.89	0.80	0.77	0.68

Sources: ECB calculations based on the method in Lang and Welz (2017).
Notes: The results are based on a sample of 12 EU countries (Belgium, Denmark, Finland, France, Germany, Ireland, Italy, the Netherlands, Portugal, Spain, Sweden and the United Kingdom). The area under the receiver operating characteristics curve (AUROC) is a global measure of the signalling performance of an early warning indicator. An AUROC value of 0.5 indicates an uninformative indicator and a value of 1 indicates a perfect early warning indicator. The AUROC is computed over various pre-crisis horizons (indicated e.g. by "12-5 quarters"), based on the definition and dating of systemic banking crises contained in Detken et al. (2014). The pseudo R-squared is obtained for a logit model that has the relevant credit gap on the right-hand side and the binary vulnerability indicator on the left-hand side, which takes a value of 1 during the 12 to 5 (or 8 to 1 or 4 to 1) quarters before the respective systemic banking crisis, and is zero otherwise, except during the four quarters before a crisis (where possible) and during actual crisis quarters, when it is set to missing. The various credit-to-GDP gaps are derived using a recursive HP filter with a smoothing parameter of 400,000, in line with guidance provided by the Bank for International Settlements (BIS) and the ESRB.

[153] AUROC stands for "area under the receiver operating characteristics curve", where the receiver operating characteristics (ROC) curve plots the noise ratio (false positive rate) against the signal ratio (true positive rate) for every possible threshold value. An AUROC value of 0.5 indicates an uninformative indicator, and a value of 1 indicates a perfect early warning indicator.

Concluding remarks

The theory-based credit gaps presented in this special feature share a number of advantageous properties with the Basel credit gap. These advantageous properties have been found to be useful for the early detection of cyclical systemic risks. However, some of the properties of the theory-based credit gap measures appear to be superior: they allow for economic interpretation, they do not tend to increase over excessively long periods of time before systemic banking crises and, notably, they do not tend to fall to such large negative values in the aftermath of financial booms as, for example, those observed for Basel credit gaps. Theory-based credit gaps could therefore provide a useful complement to purely statistical measures of credit excesses, thereby helping to inform the setting of countercyclical macroprudential policy.