

Martínez, Juan Francisco; Oda, Daniel

Article

Characterization of the Chilean financial cycle, early warning indicators and implications for macro-prudential policies

Latin American Journal of Central Banking (LAJCB)

Provided in Cooperation with:

Center for Latin American Monetary Studies, Mexico City

Suggested Citation: Martínez, Juan Francisco; Oda, Daniel (2021) : Characterization of the Chilean financial cycle, early warning indicators and implications for macro-prudential policies, Latin American Journal of Central Banking (LAJCB), ISSN 2666-1438, Elsevier, Amsterdam, Vol. 2, Iss. 1, pp. 1-20,
<https://doi.org/10.1016/j.latcb.2021.100024>

This Version is available at:

<https://hdl.handle.net/10419/336315>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.



<https://creativecommons.org/licenses/by-nc-nd/4.0/>

Contents lists available at [ScienceDirect](https://www.sciencedirect.com)

Latin American Journal of Central Banking

journal homepage: www.elsevier.com/locate/latchb

Characterization of the Chilean financial cycle, early warning indicators and implications for macro-prudential policies[☆]



Juan Francisco Martínez*, Daniel Oda

Central Bank of Chile, Chile

ABSTRACT

From the perspective of an emerging country – Chile – we analyze the recommendations of the Basel Committee of Banking Supervision (BCBS) regarding the design and implementation of indicators to guide countercyclical capital buffer (CCyB) policy decisions. We analyze the sensitivity of the predictive power to the calculation methodology of different early warning indicators (EWIs), including the standard credit-to-GDP gap. To meet these goals, we expand the available data of loans, using quarterly data from 1970 to 2017, which covers three financial fragility periods. Additionally, we adjust the methodologies according to the domestic financial structure and the excessive amplitude of past local episodes. Finally, we discuss some remaining challenges for the application of the CCyB in Chile.

1. Introduction

The global financial crisis of 2008–2009 evidenced important banking business regulation gaps on providing stable and efficient financial markets. On the one hand, banks' balance sheets and risk tolerance grew excessively. On the other, risk exposures and a system-wide perspective of regulation were only partial (Claessens and Kodres, 2014). Accordingly, macro-prudential policy frameworks have been revisited and complemented. The Basel Committee of Banking Supervision (BCBS) has made contributions to enhance the banking regulations frameworks across the world by including features that limit externalities or systemic effects caused by particular institutions. These are focused on anticipating, preventing, and preparing the financial system for wide events of financial fragility. In particular, in the Basel III framework, the BCBS has proposed the countercyclical capital buffer (CCyB) as a macro-prudential policy to limit the effects of excessive credit growth.

Although the CCyB has only recently been proposed and implemented, its rationale goes back several decades, and it is based on the cyclical behavior of the economy. There is a vast research stream that has investigated the cyclical properties of the macroeconomy. Systematized statistical work can be traced back to early 20th century research, such as Moore (1914), which studies the relationship of economic variables to weather conditions. In a more recent contribution, Harding and Pagan (2002) find a quantification and characterization of the business cycle by using a method based on an algorithm that identifies turning points. On the other hand, there is also evidence that suggests that the financial variables behave in a cyclical and synchronized fashion (Claessens et al., 2011a; 2011b; Martínez and Oda, 2019). However, financial cycles have different characteristics compared to macroeconomic ones: they have lower frequency and higher amplitude (Borio, 2014). This work also highlights the properties of credit dynamics on anticipating busts and consequently, financial fragility. Thus, it proposes to build buffers to deal with financial procyclicality.

Additionally, several cross-country studies propose that financial crises are preceded by an excessive credit growth and point this out as one of the main determinants of financial fragility (Gourinchas et al., 2001; Laeven and Valencia, 2012; Reinhart and Rogoff, 2009).¹ In the same way, Kauko (2012) shows empirical evidence that the combination of rapid credit growth and the current account

[☆] We are grateful to Felipe Garcés for his assistance on this document. The opinions expressed in this article are the authors' own and do not necessarily represent the views of the Central Bank of Chile or its board members. The usual disclaimer applies.

* Corresponding author.

E-mail addresses: jmartinez@bcentral.cl (J.F. Martínez), dodaze@bcentral.cl (D. Oda).

¹ For instance, Laeven and Valencia (2012) indicate that about 1/3 of financial crises have been preceded by excessive credit growth.

<https://doi.org/10.1016/j.latchb.2021.100024>

Received 5 February 2020; Received in revised form 30 November 2020; Accepted 18 January 2021

Available online 25 March 2021

2666-1438/© 2021 The Authors. Published by Elsevier B.V. on behalf of Center for Latin American Monetary Studies. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>)

deficit predicted the increase in nonperforming loans during the global financial crisis. Consistent with this evidence, it is also argued that in times of macroeconomic booms the perception of risk is distorted and agents tend to over-leverage either due to myopia or changes in risk tolerance (Minsky, 1972, Minsky, 1982; Shin, 2010). Consequently, financial policies that limit credit overruns are designed to smooth the cycle and attempt to correct aggregate risk externalities (Basel Committee on Banking Supervision, 2010, Basel Committee on Banking Supervision, 2017; International Monetary Fund, 2011). There are various alternatives, some of which include monetary policy, credit growth limits, specific eligibility restrictions (e.g., loan-to-value, debt-to-income, etc.), and capital and liquidity requirements,² such as the dynamic capital requirements or CCyB (Dell’Ariccia et al., 2012). The latter has been proposed by the BCBS to target a specific objective, which is system-wide events of financial fragility that originate in excessive credit growth (Drehmann and Tsatsaronis, 2014). Mainly, this policy intends to (i) construct buffers in times of booms and (ii) avoid over-leverage that leads to perverse incentives (Borio, 2014; European Systemic Risk Board, 2013). The latter intention generates a direct consistency between the dynamics of the credit and the policy objective, which must be considered in the design of its application.

In this line, the BCBS proposed its implementation in the capital agreement of Basel III in 2010, and it was included within the Chilean General Banking Act of 2019. According to Article 66 of the act,³ the Central Bank of Chile, in consideration of the economic cycle, is able to activate or deactivate an additional capital requirement of a countercyclical nature, applicable to all banks constituted in the country. This requirement may be set in a range of 0–2.5% of risk-weighted assets, and the term to comply with this requirement may not be less than six months.

For the activation of the CCyB, the BCBS guidelines (Basel Committee on Banking Supervision, 2010; Drehmann and Tsatsaronis, 2014) and ESRB recommendations (Detken et al., 2014a; European Systemic Risk Board, 2014; Kalatie et al., 2015) introduce the credit-to-GDP gap as the best single indicator for anticipating banking crises and hence as a reference in this phase of the implementation. However, they also indicate that other indicators and judgement should complement the CCyB instrument management. Consequently, international monetary authorities have proposed a series of leading indicators that complement the analysis of the activation. For example, the ESRB proposes a set of indicators grouped into six categories: credit developments, potential overvaluation of property prices, private-sector debt burden, external imbalances, potential mispricing of risk, and strength of bank balance sheets.

In this sense, the ability to predict financial crises of several sets of indicators and calculation methodologies has been evaluated. Although the indicators have been studied in a wide group of countries in a systematic way (Aldasoro et al., 2018), the evaluation of the methodologies has mainly focused on European countries (Kalatie et al., 2015; Castro et al., 2016; Tolo et al., 2018; Baba et al., 2020) where there are more extensive series of data and a consensus on the periods crisis. Determining both dimensions represents a challenge for emerging economies. Therefore, it is relevant to define a systematic methodological framework that allows for addressing these restrictions.

In this paper, in line with the international practice, we select and test a group of metrics, in addition to the suggested credit-to-GDP gap, that in our view are more adequate for the Chilean context regarding the anticipation of periods of financial fragility. We start by describing the local particularities and issues that adhere to our qualities of an emerging economy and other idiosyncracies. Specifically, in our estimations, the real credit gap (relative to its historical trend) stands out in terms of its anticipating capacity. However, we also test complementary indicators that illustrate other features of the cycle and should be considered for policy analysis. To do this, we analyze and solve some important limitations in the calculation of these metrics: information gaps, coherence to domestic financial structure, and excessive amplitude of past episodes of fragility. Finally, after the empirical analysis, on the basis of the international experience, we highlight and discuss some remaining challenges for the application of the CCyB in Chile.

This paper is organized as follows. Section 2 describes the characteristics and considerations of the Chilean financial system that are relevant to the design and calculation of EWIs in the context of the CCyB application. Given the particularities raised in the previous section, Section 3 describes the data and explains the methodology to be applied for the Chilean economy. Section 4 analyzes the results of the associated statistical estimates and their ability to anticipate periods of financial fragility in Chile and covers the relevant robustness checks of the estimates. Finally, in light of the recent situation of the Chilean financial system and the proposed EWIs and results, Section 5 highlights the current challenges for the implementation of the CCyB in Chile and concludes.

2. Literature review

2.1. International experience

Although only a few countries have activated the CCyB (Basel Committee on Banking Supervision, 2017), most of them have worked for several years to complement the available material that underpins the framework and application of this macro-prudential policy (e.g., Borio et al., 2014; Borio et al., 2014; Drehmann and Tsatsaronis, 2014). For instance, as a reference, we have the cases

² As Dell’Ariccia et al. (2012) mentions, capital and liquidity requirements have been successful in their different forms, especially to build buffers, but less so to counteract credit booms. In particular, the Spanish dynamic loan loss provisions (DynP) scheme seems a promising alternative. These have proven to be significant in partially smoothing the 2000s Spanish credit boom (Jiménez et al., 2017). Although in theory the dynamic provisioning should work in a similar manner to the CCyB, there are some differences. First, the DynP application is intended to be automatic, whereas the CCyB guidelines leaves some scope for guided discretion. Second, DynP rules affect income statements but not balance sheets or capital ratios directly, as in the case of the CCyB. Finally, DynP cannot be adapted to international standard accounting practices and hence have been discontinued.

³ The Spanish version of the Chilean General Banking Act is available at the following link: <http://bcn.cl/2f7wh>.

Table 1
International practice in EWI for CCyB.

Framework	Description	Countries
Indicators	Monitor 1 to 30 indicators.	EU
	Pre-identified indicators, including qualitative variables.	Australia, Singapore
	One core indicator and a broad set.	Switzerland
	Two core indicator and a broad set (e.g., property prices).	Hong Kong SAR
	Set of qualitative and quantitative indicators.	Canada, US
Measure of credit	More than 15 indicators.	Russia, UK, France, Germany
	Domestic banking credit.	Australia, Belgium, Hong Kong SAR, Korea, Switzerland
	Domestic banking and total credit.	France, Denmark, Germany, Italy
Filtering method (HP)	More definitions of credit (different types: public/private, domestic/foreign, etc.)	Luxembourg, Russia
	Adjusted by historical deviations.	Italy
	Plus econometric models.	Spain
	Adjusted by GDP decrease.	Germany
	Adjusted by projections.	Norway
	Range of smoothing parameters.	Denmark
	One- & two-sided.	Japan
	Rolling windows.	Korea
	Adjusted by currency fluctuations.	Brazil, Russia

Source: Own elaboration based on (Basel Committee on Banking Supervision, 2017).

of the UK and Spain. Detken et al. (2014a) propose and test several indicators for the case of the UK, highlighting the relevance of relying on complementary indicators that help in the decision-making process of the CCyB activation and deactivation. In a similar way, Castro et al. (2016) perform a complete literature review and empirical work to test various EWIs for the Spanish economy. They have found that indicators of credit intensity, private-sector debt sustainability, real state and external imbalances are useful complements of the standard credit-to-GDP gap. Aldasoro et al. (2018) indicates that household and international debt are relevant leading indicators of a banking crisis for a large number of countries. Meanwhile, Kalatie et al. (2015) and Tolo et al. (2018) check a large set of indicators based on the ESRB recommendations, which include property prices and strength of bank balance sheets, to mention a few. They suggest that, although the credit-to-GDP gap is the best individual predictor, countries should select the indicators that best fit their particular contexts, given the best available data. However, although the literature has analyzed several indicators, it has not calibrated the calculation parameters of each metric (e.g., window length, smoothing parameter, etc.).

The Basel Committee on Banking Supervision also suggests that a mechanistic implementation of the recommended countercyclical capital buffer methodology could have negative consequences in many emerging, developing and small economies (Basel Committee on Banking Supervision, 2014). Therefore, they recommend improving the understanding of their particular credit cycles and not rely solely on the credit-to-GDP ratio.

In that sense, the implementation practice among countries and the definition of EWIs for the CCyB activation has an ample range but a common denominator: the definition of a set of complementary indicators as guidelines for policy action. Table (1) shows that most of the countries monitor a range of indicators, some of which include the monitoring of domestic banking credit and also the total credit dynamics. Moreover, some economies revise additional dimensions of credit, considering its type and location. Regarding the statistical method to obtain the cyclical component of credit, the vast majority of countries calculate the Hodrick-Prescott (HP) filter, and most of them use the parameter of smoothing suggested by Drehmann et al. (2010) (i.e., $\lambda = 400k$). Although the HP filter is commonly used, some economies have implemented important adaptations. For instance, Italy adjusts for historical deviations, Korea uses a rolling window and Brazil and Russia adjust for currency fluctuations.

2.2. Chilean particularities

The BCBS calculates the Chilean credit-to-GDP ratio by using publicly available macro-financial data and a standard statistical filter. According to the recommendations of the Basel Committee of Banking Supervision (Basel Committee on Banking Supervision, 2010; Drehmann and Tsatsaronis, 2014), the credit-to-GDP gap is the best single early warning indicator (EWI) of financial crisis for a wide range of countries and is an adequate trigger for the activation of the CCyB. As proposed by Drehmann et al. (2010), this indicator is calculated using a one-sided Hodrick-Prescott filter with a trend-smoothing parameter (i.e., lambda) of 400k for quarterly data. The numerator of the ratio contains components that meet a broad definition of credit, and the denominator includes the quarterly flow of GDP. For the Chilean case, the BCBS considers series that start in 1983, and the filtered credit-to-GDP (i.e., the gap) starts in 1993, after processing 10 years of data.

Although the parameterization and calculations used by the BCBS in estimating the credit-to-GDP ratio allow them to use uniform criteria that works well for the majority of countries (Drehmann et al., 2010; Drehmann and Tsatsaronis, 2014), the Chilean particularities call for taking into account data and methodological considerations in the estimation of adequate EWIs. In this respect, we revise the usage of credit information and data coverage. Baba et al. (2020) find similar results for some European countries. The credit-to-GDP gap could be misleading. They point out that in periods in which credit growth exceeds GDP, growth could reflect

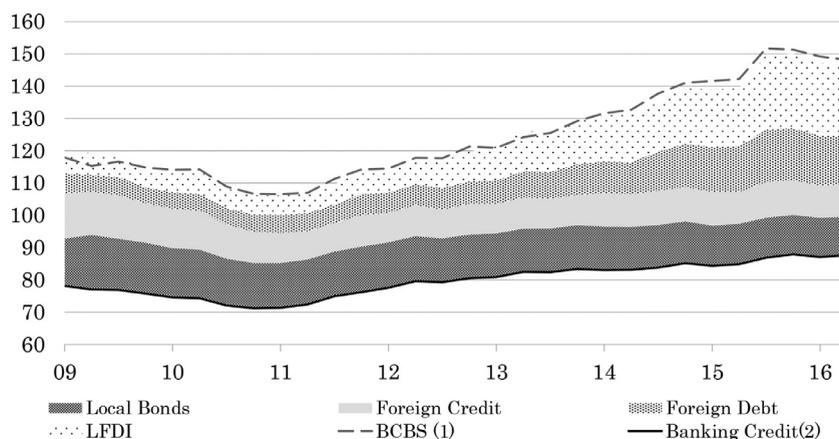


Fig. 1. Nonbank credit incidence on the credit-to-GDP (percentage). *BCBS* corresponds to credit from all sectors to the nonfinancial private sector as a percentage of annual GDP as reported by the BIS. Possible differences with local data are due to the exchange rate used. *Banking credit* is equal to the local banking credit to the nonfinancial private sector as a percentage of annual GDP. *FDI* corresponds to the foreign direct investment as a percentage of annual GDP. *Foreign debt* includes all debt instruments emitted abroad, excluding credits, as a percentage of annual GDP. *Foreign credit* is equal to credits with foreign institutions, mainly banks, as a percentage of annual GDP. *Local bonds* corresponds to bonds emitted in local currency, CLP and inflation-indexed currency (UF) as a percentage of annual GDP. Source: Own elaboration based on information from BIS and the Central Bank of Chile.

financial deepening and not necessary risk taking. On the other hand, the ratio could sharply increase due to a negative shock to the GDP rather than excessive credit growth.

2.2.1. Credit definition and the Chilean financial structure

Despite the advantages of using the BCBS core credit-to-GDP gap indicator, its properties rely heavily on the definition of “credit.” Additionally, as proposed in Giese et al. (2014) and Castro et al. (2016), different features of financial crises can be anticipated and captured with alternative indicators that may perform better than the BCBS proposal. Hence, the activation of the CCyB should consider a set of complementary indicators in accordance with international practice.

Following Drehmann et al. (2011), one of the main advantages of the credit-to-GDP gap is that for a variety of countries (mainly advanced economies) it is the best in capturing system-wide vulnerabilities that end up affecting the banking sector. In the numerator, the BCBS ratio uses a broad definition of credit to the nonfinancial private sector – namely total credit – which includes local and foreign banking credit, bonds and debt associated with foreign direct investment (FDI).⁴

In the case of Chile, the banking credit represents less than 70% of total credit. A similar context occurs in Colombia, where banking credit is around 70% of total credit, although it is more than 80% for Brazil and less than 50% for Mexico.⁵

Additionally, as opposed to in most advanced economies, the dynamics of the local banking loans in Chile behaves differently from those of other sources of credit, especially those coming from foreign markets. In particular, the differences between the total credit growth and the local banking credit are explained by the issuance of external bonds during the period from 2009 to 2015 and by obligations associated with FDI.⁶ As indicated in Chapter III of the Central Bank of Chile’s Financial Stability Report for the second half of 2016 (Central Bank of Chile, 2016), the increase in foreign debt is concentrated in bond instruments of large local corporations, generally with low credit risk and low exposure to banking-sector credit. On the other hand, the FDI-associated debt originates in a matrix-subsidiary relationship, which distinguishes it from other types of funding sources and is a characteristic of large international commodity producers (e.g., mining companies). Adding up the two effects, the sharp increase in foreign debt in recent years is associated with favorable international financial conditions, without necessarily augmenting the exposure of the banking sector to the Chilean corporate sector (Fig. 1).

Using the same sample period and filtering technique as the one proposed by the BCBS but incorporating a different definition of credit could lead to a different diagnosis with respect to financial fragility anticipation. Fig. 2 shows the evolution of two versions of the credit-to-GDP gap depending on the credit specification: i) the BCBS, which uses total credit, and ii) an alternative that uses banking credit only. According to the total credit criteria, in mid-2014 Chile, the BCBS metric shows an important gap and consequently would anticipate a critical period of financial fragility in the following years. In such a case, the buffer would be completely activated at the end of 2016. In contrast, by using banking credit only, the gap of 2016 would be much closer to 2%, and the activation of the CCyB would be less clear, since these levels are far from those recorded before the Asian crisis and the GFC. Additionally, while the banking credit presented a gap close to 10% before the GFC, the total credit gap was negative or close to zero.

⁴ The BCBS publishes this indicator for a set of countries on its site, and it is publicly available.

⁵ See figure 15 on Appendix A for further details.

⁶ In the case of Mexico, credit growth prior to the global financial crisis was dominated by banking, relative to other sources that even contracted.

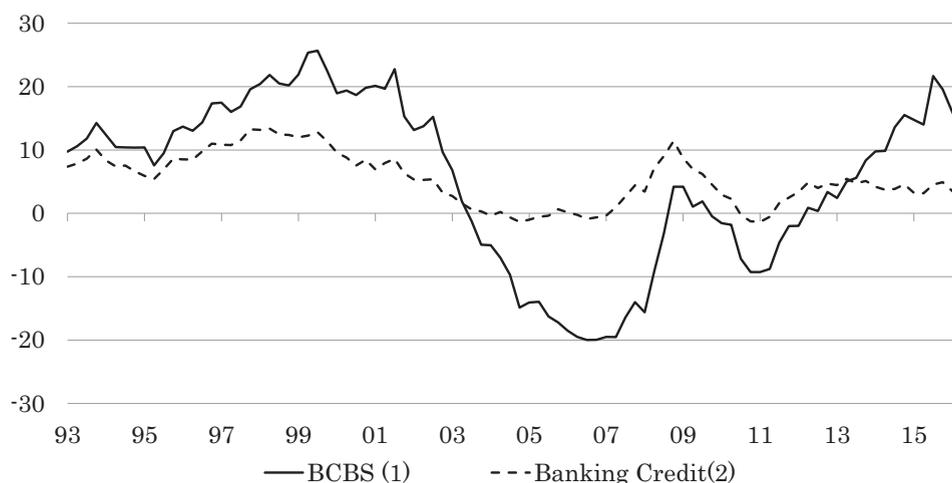


Fig. 2. Credit-to-GDP gap (percentage). Series are presented as a gap relative to their own trend calculated by an HP filter with a factor of 400,000 in cumulative windows. *BCBS* corresponds to credit from all sectors to the nonfinancial private sector as a percentage of annual GDP as reported by the BIS. Possible differences with local data are due to the exchange rate used. *Banking credit* is equal to the local banking credit to the nonfinancial private sector as a percentage of annual GDP. Source: Own elaboration based on information from BIS and the Central Bank of Chile.

2.2.2. The challenge of having data to anticipate periods of crisis

Standard criteria - such as the ones provided in [Laeven and Valencia\(2008,2012\)](#) and [Reinhart and Rogoff \(2009\)](#) - only identify one financial crisis for the Chilean economy since the 1980s: the local banking crisis that started in 1981. However, as mentioned, the BCBS analysis only starts in 1993 because of data limitations. To overcome this issue, we rely on [Martinez et al. \(2018\)](#) data compilation. They define three Chilean financial fragility periods for the same time span: i) the local banking crisis (LBC) (in the early 80s); ii) the manifestation of the Asian crisis (AC) in the local economy (in the late 90s) and iii) the global financial crisis (GFC) (around 2008). The LBC, or the Chilean financial crisis between 1981Q3 and 1985Q3, was characterized by the insolvency of several financial institutions due to increased credit risk, the product of financial liberalization and lack of regulation. This period roughly coincides with the one defined in [Laeven and Valencia\(2008,2012\)](#) (i.e., 1981–1985) and is the one with the highest impact on credit contraction and profitability. The Asian crisis, which had an effect in Chile during 1998Q1 to 2001Q3, generated an increase in the current account deficit, which increased credit risk, generating a slowdown in credit growth and losses for the banking sector. Finally, the global financial crisis, which is considered for Chile between 2007Q1 and 2011Q2, was characterized by greater liquidity restrictions and an increase in credit risk.

The identification of EWIs that anticipate financial fragility periods becomes difficult when the time span does not include a crisis. This is mainly because the signals that the filtering procedure produces may not be strong enough to identify and anticipate milder fragility periods. Therefore, the BCBS recommends having as much depth of historical data as possible. For example, the Banca d'Italia uses the effort of [De Bonis et al. \(2012\)](#) to extend its series of credit and economic activity until the nineteenth century ([Alessandri et al., 2015](#)) and thus improve the adjustment of the indicators, mainly given that most of the crises in its banking sector occurred prior to 1950.

In addition, one benefit of extending the historical depth of the indicators and incorporating the LBC is that there is a well-documented detail of the channels through which a different kind of shocks was transmitted to the local economy and of how this impacted the banking. This crisis is useful as a case study, particularly to review the macro-financial context that led to the crisis and the need for bank interventions. This is despite the fact that many of the conditions of regulation and the macroeconomic framework have changed. Indeed, the drastic change in the amplitude and frequency of the credit cycle in the Chilean economy implies that an adjustment must be made to the gap estimates ([Section 2](#)).

2.2.3. CCyB for emerging economies

Chile is an emerging country and as such has suffered some phenomena that must be taken into account when implementing a CCyB and developing metrics that allow its activation. In particular, it is necessary to highlight the financial deepening it has suffered in the last 50 years and the status of its small and open economy, which makes it relatively more vulnerable to external shocks. Given the above, in relation to determining the appropriate EWIs as a reference for the activation of CCyB, it is necessary to have considerations about i) incorporation/discard of past information and ii) the macroeconomic context and its implications in the credit cycle.

As for the considerations related to the information to be used, in a country such as Chile the cycles of macroeconomic and financial variables have changed radically in their amplitude and frequency since the LBC. The development of a more robust macroeconomic and regulatory framework has reduced the volatility of cycles and their impact on the real economy. On the other hand, the frequency of fragility events has tended to increase because the opening of the local economy has made it more susceptible to global phenomena,

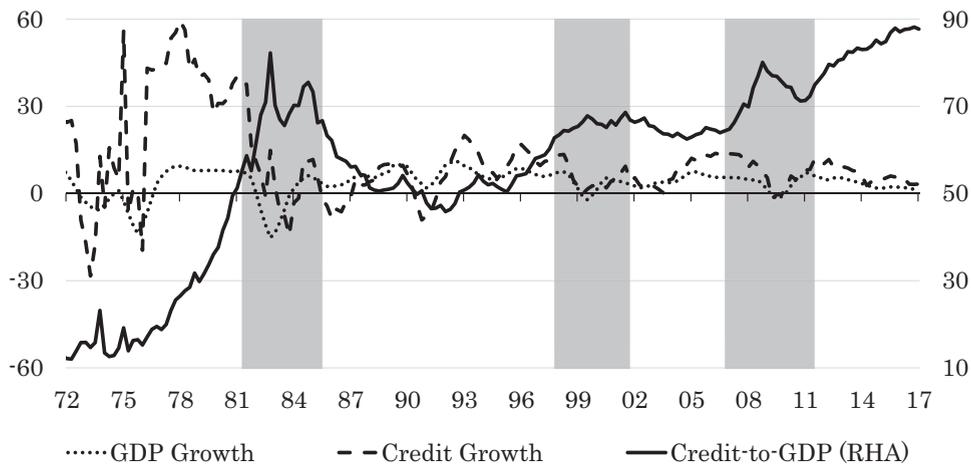


Fig. 3. Dynamics of banking credit and GDP (percentage). *GDP growth* corresponds to the real annual percentage change of the GDP. *Credit growth* corresponds to the real annual percentage change of local banking credit to the nonfinancial private sector as a percentage of annual GDP. The gray areas represent periods of financial fragility, delimited according to [Martínez et al. \(2018\)](#). Source: Own calculations based on information from the CMF and the Central Bank of Chile.

such as the Asian and global financial crisis, although, as noted by their effects, such events have been much lower than in the past. Thus, the procedure for calculating gaps in relation to historical data should consider an adjustment that is more relevant to the most recent observations without losing the advantages of greater historical depth.

A large exposure to the global economy may lead policy makers to focus the activation of the CCyB on external imbalances of the real and financial activity because eventually the local and external cycles will be synchronized. In particular, the idea of linking the activation of the CCyB with misalignments of the global financial cycle arises. These mismatches will eventually have effects on changes in capital flows and consequently on the external financial position of the economies, which in turn could give rise to episodes of vulnerability ([Reinhart and Rogoff, 2009](#)).

Although it is advisable to take external vulnerabilities into account because they have some relation to the occurrence of past crises, especially the LBC ([Laeven and Valencia, 2008, 2012; 2009](#)), it is necessary to contrast them with relevant recent evidence. Regarding the relationship between capital flows and the global financial cycle, the evidence is mixed. On the one hand, [Baskaya et al. \(2017\)](#) find significant effects of higher global risk appetite in capital flows to an emerging economy, such as Turkey. However, [Cerutti et al. \(2017\)](#) find some evidence of the global financial cycle in capital flows for a variety of countries.

Thus, due to their relevance in the possible effects, metrics associated with the external vulnerabilities of the Chilean economy should be considered, not as signals but as a context of vulnerability that favors the transmission of shocks. For example, only the LBC has relevant movements associated with the current account. If the potential activation of the buffer had been analyzed, then the deficit should have been taken into account. However, in the more recent crises (AC and GFC), the signaling power of the external situation is more dubious since both episodes occurred in a context of a current account surplus. The impacts of both recent episodes were very likely mitigated by more robust internal and external macroeconomic contexts. Put differently, the external macroeconomic situation provided a less favorable context of vulnerability.

Finally, it has to be stressed that the CCyB policy has a very precise target, which is not seeking to protect the local economy against all sources of shocks. Instead, it is designed and targeted to build buffers and avoid the volatility of cycles in the face of crises caused by excessive credit growth ([Drehmann and Tsatsaronis, 2014](#)). In this way, the CCyB policy is not oriented to avoid external vulnerability *per se*; for that purpose, other macro-prudential policies are available that can be applied coordinately.

3. Data and methodology

3.1. Data

In order to contrast the quality of the signal of the leading indicators, we need to incorporate the maximum number of stress events in the sample. Therefore, we use quarterly data from 1970Q1 to 2017Q1. The data contained in this sample period, especially before the 80s, were collected from the CMF archives, processed and analyzed in [Martínez et al. \(2018\)](#).

Bank loans before the 1980s represented less than the 50% of the annual GDP ([Fig. 3](#)). Considering the development of this sector in those years, relatively small changes with respect to the GDP are related to high volatility in the credit growth. Nonetheless, the credit-to-GDP grew faster and steadily until the first fragility period without any evident signal of distortion. This kind of trend has not been seen after the local banking crisis. However, we observe that before fragility periods, the credit grew faster than the GDP did, which confirms the evidence shown in [Drehmann et al. \(2010\)](#).

3.2. Methodology

The framework for implementing the CCyB should include the definition of EWI to guide policy decisions. In the Chilean context, only a few attempts have been made to compute anticipatory metrics of financial fragility. However, they focused on a less accurate definition of financial distress and with only a micro perspective.⁷

Following the international practice (Basel Committee on Banking Supervision, 2017), we tested the anticipating properties of the credit-to-GDP gap as a leading indicator but made some relevant distinctions. Given the structure of the Chilean financial system, we also revised the cyclical component associated with the real total local banking credit, which is unaffected by the GDP's dynamics. Additionally, we slightly modify the standard time-series filtering framework – used by the BCBS - to address structural breaks occurred in the Chilean economy.

The literature suggests using the "gaps" as financial indicators. These gaps are defined as the deviations of each variable (measured in percentages) from its trend. Therefore, this gap is also equivalent to the cyclical component of the series. Following Watson (1986), we can decompose a time series y_t into a trend n_t and a cycle z_t :

$$y_t = n_t + z_t \quad (1)$$

In particular, the construction of gaps is based on the cycles estimated with commonly used time-series frequency filters.⁸ Precisely, Borio and Lowe (2002, 2004) proposed the use of the credit-to-GDP gap as an indicator of the financial cycle.

The use of filters has some issues, such as end-point problems, sensitivity to the length of the series, the influence of past large movements of the series and the choice of smoothing parameter (Baba et al., 2020). We will address each of these elements by using different filter approaches or by measuring sensitivity to the parameters. This strategy is simpler and more direct than using multivariate filters or regressions because it does not impose any structures or economic models, which are also sensitive to their specification.

Symmetric moving-average (SMA) filters basically estimates the cyclical component using a weighted average of the leads and lags of the series. Baxter and King (1999) define the BK filter as an SMA filter with q leads and lags terms that minimized the difference between the coefficients in their filter and an ideal band-pass filter. The band-pass filters remove stochastic cycles corresponding to the unwanted frequencies (outside of a specific range or band of a cycle length). There is a trade-off when choosing q : larger values of q cause the gain of the BK filter to be closer to the gain of the ideal filter but also increase the number of missing observations in the filtered series. On the other hand, Christiano and Fitzgerald (2003) propose a CF filter that minimizes the mean squared error between the estimated component and the true component, with the assumption that the series is a random-walk process. Thus, this filter is optimal for random-walk processes and is not symmetric.

An alternative methodology of obtaining the cyclical component of the series is eliminating its trend. Hodrick and Prescott (1997) state that the HP filter is a trend-removal technique. The trend is estimated by minimizing the distance of the estimated trend from the series and the trend's time variation. Because there is a trade-off between both objectives, the parameter λ defines the relative weight of the second component. Therefore, the larger the λ , the smoother the trend.

In addition to choosing the filter methodology, it is important to determine the extent of data that will be used to calculate the gap in each period. Typically, all available information is used to estimate series cycles. However, these indicators are aimed at activating the CCyB policy. Therefore, these metrics should be calculated for each period, with the information available only as of that date. Although the end of the data window to be used is chosen, its beginning must also be defined. For example, Basel Committee on Banking Supervision (2010) uses a cumulative or one-sided window. In other words, the data are used from the beginning of the sample to a specific period. However, under this framework, the calculated gap is influenced by data from several years before. If the dynamics of cycles vary over time, the use of very old data could distort the estimation of recent cycles. Note that, although commonly used filters give less weight to data from further in the past, they still have a significant impact. For this reason, an alternative is to use rolling windows. This is equivalent to zeroing all observations outside the window or truncating the relatively low weights, which correspond to the earliest, to zero. In our case, we will test different window lengths to determine which one has the best predictability.

After the cycle is estimated, we evaluate its ability to predict financial fragility episodes. This requires two components: the definitions of the fragility periods and the metric of anticipation power. The targeted periods are taken from Martínez et al. (2018), as defined in section 2.2.2. On the other hand, the receiver operating characteristic (ROC) analysis quantifies a variable's accuracy in discriminating between states and is widely used in this literature (Detken et al., 2014b; Aldasoro et al., 2018; Tolo et al., 2018). It is based on the sensitivity, meaning the fraction of correctly classified positive cases, and the specificity, referring to the fraction of correctly classified negative cases. Typically, the procedure uses the complement of the specificity – that is the false positives. Both metrics are used to construct the ROC curve.

Finally, an indicator's performance usually is summarized by the area under the ROC curve (AUROC) which can be interpreted as the probability that the correct classification of the variable will be greater than a random variable (Detken et al., 2014b). An alternative measure of the goodness of fit comes from modelling the probability of a crisis, such as in a logit model, and assessing the predictive power of different metrics by using loss functions (Kalatie et al., 2015). This methodology is consistent with the AUROC

⁷ For instance, Ahumada & Budnevich (2001) uses the past-due loan index as an indicator of credit risk, which also characterizes periods of financial fragility. They found that an increase in capital levels tends to reduce the credit risk. In addition, they establish that high credit growth is related to an increment in nonperforming loans about 9 to 12 months later, especially for foreign banks.

⁸ Note that time-series growth can be considered a special case of filter, where $n_t = y_{t-h}$.

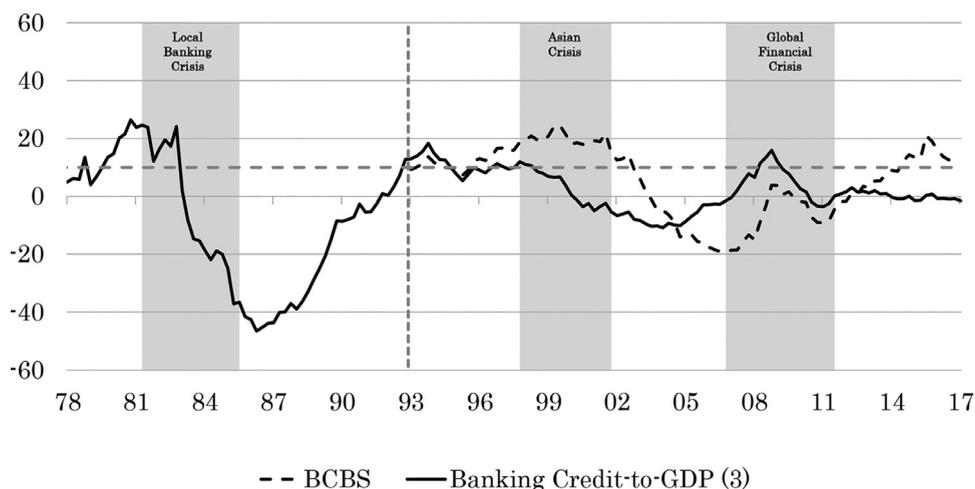


Fig. 4. Banking credit-to-GDP gap vs. BCBS (percentage). *BCBS* corresponds to credit from all sectors to the non-financial private sector as a percentage of annual GDP, reported as its gap relative to their own trend calculated by HP filter with factor of 400,000 in cumulative windows. *Banking credit-to-GDP* is equal to the local banking credit to the nonfinancial private sector as a percentage of annual GDP, reported as its gap relative to their own trend calculated by HP filter with a factor of 400,000 using a 10-year rolling window. The gray areas represent periods of financial fragility as delimited according to [Martínez et al. \(2018\)](#). The gray dotted line represents the 10% threshold. Source: Own calculations based on information from the CMF, BIS and Central Bank of Chile.

that we use, as both are based on type I and II errors, and it is equivalent in the uni-variate case. Although the multivariate case is interesting and essential for the policy application, we leave this for further research because our main objective is to rank single indicators.

4. Results

Typically, the methodologies are based on filters that use one-sided samples. In other words, older observations have a permanent influence on the estimations. Accordingly, the results will be biased if the cycle drastically changed in terms of frequency, amplitude or trend. All in all, we opted to use a Hodrick-Precott filter with a lambda of 400k using a rolling window of 10 years.⁹

A relative high banking credit-to-GDP gap anticipated the local banking crisis and the Asian crisis in about 2 years ([Fig. 4](#)). However, the signal was too low to have foreseen the recent global financial crisis. On the other hand, this methodology outperforms the BCBS calculations. For instance, the latter failed to identify the latest crisis and crossed the 10% threshold in September 2014 (as in December 1995), but there is no evidence of a crisis so far.

With the banking credit gap, we are able to anticipate all of the fragility periods in the sample at an average of 3 years, although the signal for the recent crisis is low ([Fig. 5](#)).

In addition, we compare the rolling window HP filter with other commonly used filters such as the Christiano-Fitzgerald (CF) and band-pass filters ([Table 2](#)). Because the CF filter is not symmetric, it can estimate the cyclical components at the end of the sample. Note that the objective of the framework is to formulate real time policies. That being said, we must use all of the available information at a moment of the policy decision and without delay.¹⁰

According to the AUROC analysis,¹¹ the calculation of the credit-to-GDP gap has an optimal window for the rolling HP filter of close to 9 years, with a lag of 9 quarters to anticipate fragility periods. In the case of the CF filter, the best combination is a window of 10 years and a lag of 5 quarters ([Fig. 6](#)).

In the case of credit gap, the combination of window and lags rests on two options: a window of 20 years and a 5-quarter lag, and a 10-year window with a 12-quarter lag ([Fig. 7](#)). Because an anticipation of about 3 years is recommended, we chose a rolling window of 10 years. Then, the higher AUROC for the CF filter is reached with a window of 8 years and a lag of 14 quarters.

Given the previous calculations, we took a 10-year window as the standard. In order to determine if this pattern occurs in other Latin American countries, we used the same analysis for Mexico.¹² The results shown in Appendix A indicate that, for both [Reinhart and Rogoff \(2009\)](#) and [Laeven and Valencia \(2012\)](#) crisis definitions, the optimal window is between 10 and 11 years. The 10-year window would anticipate financial crises in 3 years by using the credit-to-GDP gap. However, when using the banking credit gap, a 10-year window would remain optimal, although it would anticipate crises in a range of 3–5 years.

⁹ The robustness check for this method is described in the next subsection.

¹⁰ For example, the Baxter-King filter uses leads. Thus the value for a particular date cannot be calculated until the lead data are observed.

¹¹ See [Detken et al. \(2014b\)](#) for further details.

¹² The series for Colombia and Brazil were also analyzed. However, due to the low temporal coverage of the data and, therefore, of their crisis periods, the results were not robust.

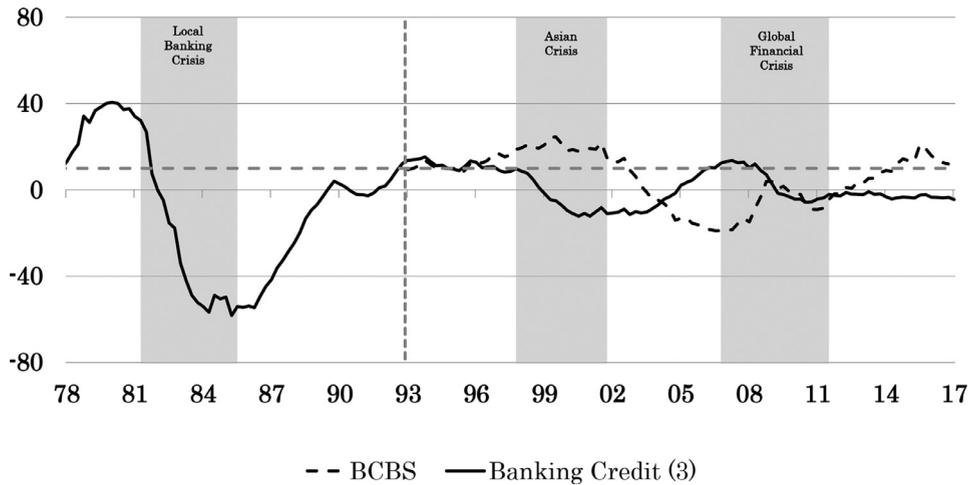


Fig. 5. Banking credit gap vs. BCBS (percentage). *BCBS* corresponds to credit from all sectors to the non-financial private sector as a percentage of annual GDP, reported as its gap relative to their own trend calculated by HP filter with factor of 400,000 in cumulative windows. *Banking credit* is equal to the local banking credit to non-financial private sector in real terms, reported as its gap relative to their own trend calculated by HP filter with factor of 400,000 using a 10 year rolling window. The gray areas represent periods of financial fragility delimited according to [Martínez et al. \(2018\)](#). The gray dotted line represents the threshold of 10%. Source: Own calculations based on information from the CMF, BIS and Central Bank of Chile.

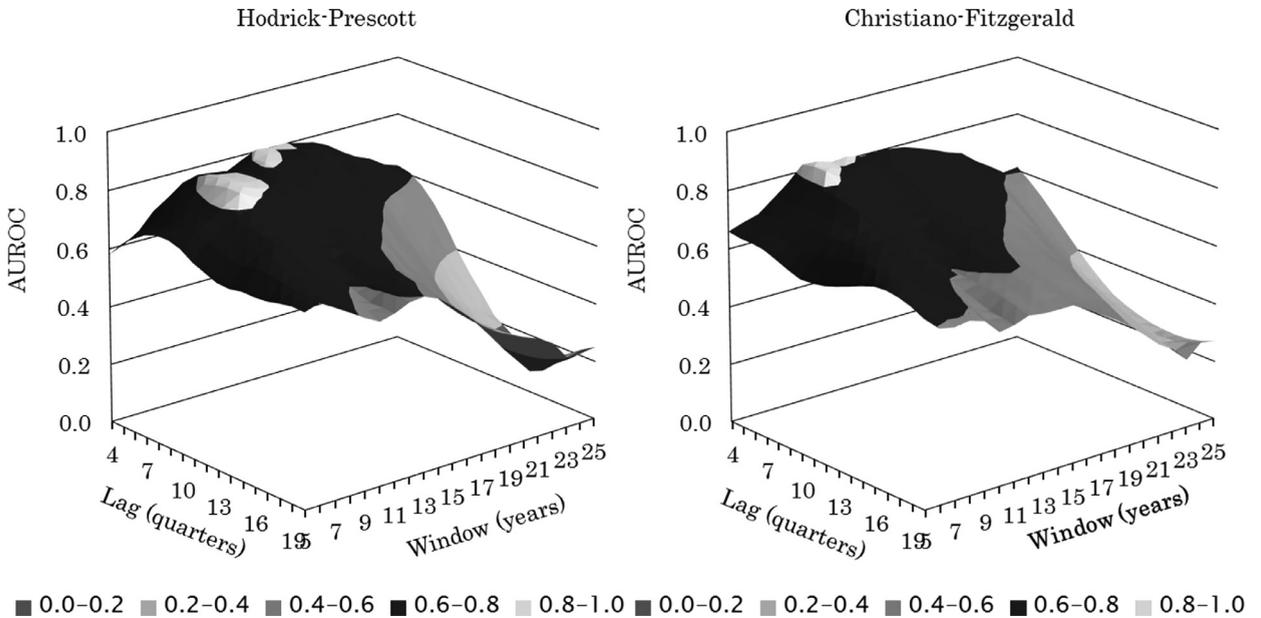


Fig. 6. Area under the ROC curve (AUROC) of the banking credit-to-GDP gap (index). Values corresponds to the AUROC for the banking credit-to-GDP gap relative to its own trend, calculated by HP filter with a factor of 400,000 by length of rolling window, and lag with respect to its corresponding quarter. Periods of financial fragility are delimited according to [Martínez et al. \(2018\)](#). Source: Own calculations based on information from the CMF and the Central Bank of Chile.

The AUROC indicator in this cut shows that the credit gap has a stronger relation with fragility periods than the credit-to-GDP gap does ([Figure 8](#)). Furthermore, the rolling version of the filter is more informative than its one-sided counterpart. On the other hand, both HP and CF filters have an AUROC over 0.8.

Nonetheless, the optimal lag for the rolling HP filter was 12 quarters (3 years), versus 10 quarters for the CF filter ([Table 3](#)). In that sense, the proposed methodology gives a reasonably longer period to accumulate capital. When using the credit-to-GDP gap, the rolling HP filter provides a better AUROC.

As mentioned before, the international evidence suggests a 2% threshold to gradually activate the CCyB and a 10% threshold for it to be fully implemented ([Basel Committee on Banking Supervision, 2010](#)). An optimal cut-point will balance the maximization of good signals and good silence ([Detken et al., 2014b](#)). Indeed, there is a trade-off between increasing the good signals (lowering the type I error) and increasing good silence (minimizing the type II error).

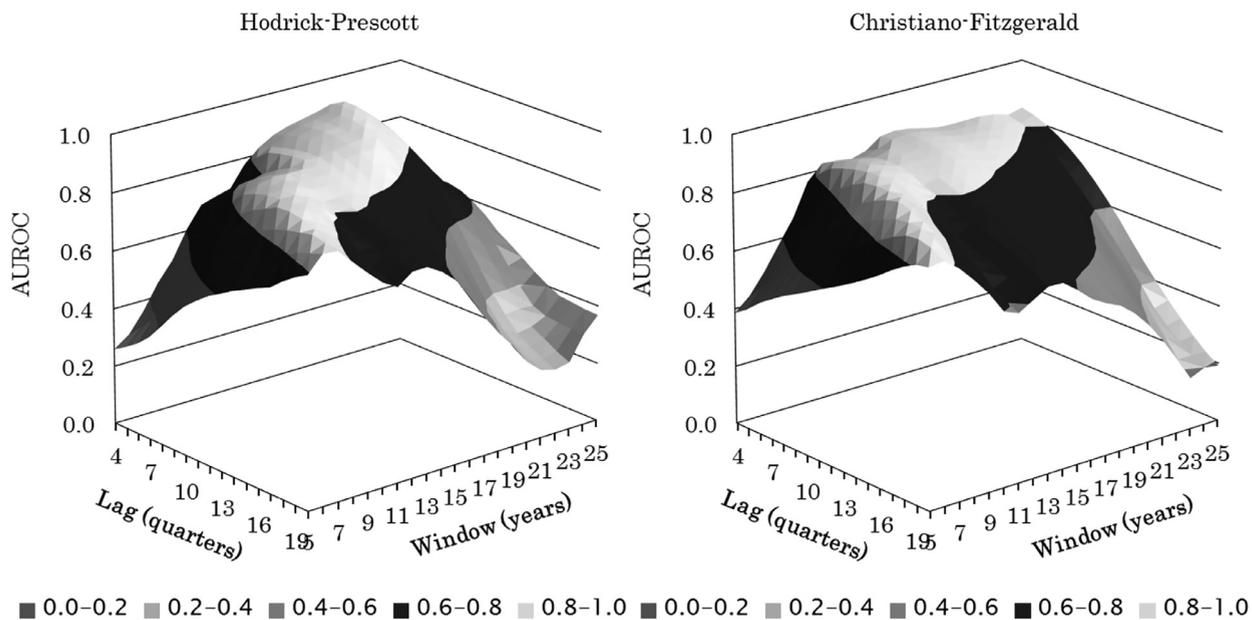


Fig. 7. Area under the ROC curve (AUROC) of banking credit gap (index). Values corresponds to the area under the AUROC for the real banking credit gap relative to its own trend, calculated by HP filter with a factor of 400,000 by length of rolling window, and lag with respect to its corresponding quarter. Periods of financial fragility are delimited according to Martínez et al. (2018). Source: Own calculations based on information from the CMF and the Central Bank of Chile.

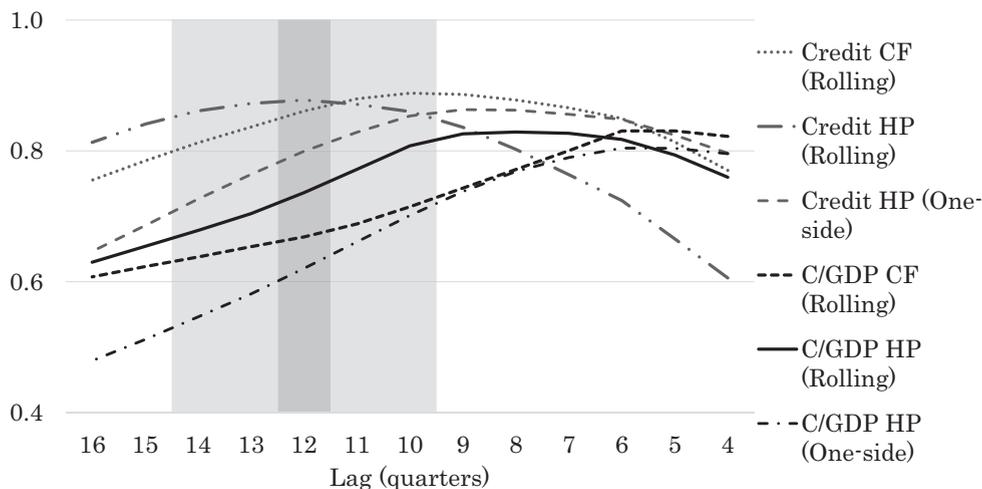


Fig. 8. Area under the ROC curve (AUROC) by lag (index). Values corresponds to the AUROC for each indicator gap relative to its own trend, calculated by CF or by HP filter with a factor of 400,000. One-side filters uses data from 1970 onward, while Rolling uses a 10-year window. Source: Own calculations based on information from the CMF and the Central Bank of Chile.

Table 2
Filter alternatives.

	Hodrick-Prescott (1997)	Baxter-King (1999)	Christiano-Fitzgerald (2003)
Type	High-pass	Band-pass	Band-pass
Parameters	Smoothing parameter lambda	Range of low and high frequencies; number of leads and lags	Range of low and high frequencies
Series	Unspecified	Covariance-stationary processes	Random-walk process
Leads/Lags weighting	None	Symmetric	Symmetric and asymmetric
Loss function	Weighted function of the error between the trend and actual values, and the trend's time changes	Error between the coefficients in their filter and the ideal band-pass filter	Mean squared error between the estimated component and the true component

Table 3
Area under the receiver operating characteristic curve (AUROC).

		3 years	Min	Max	Optimal lag (years)
Banking credit	HP rolling window	0.88	0.61	0.88	3.00
	HP one-sided	0.80	0.65	0.86	2.25
	Christiano-Fitzgerald	0.86	0.76	0.89	2.50
Credit-to-GDP	HP rolling window	0.74	0.63	0.83	2.00
	HP one-sided	0.62	0.48	0.80	1.50
	Christiano-Fitzgerald	0.67	0.61	0.83	1.25

Source: Own calculations based on information from the CMF and the Central Bank of Chile.

	1600	25,600	129,600	400,000
Variable	US GDP	Credit/GDP	Credit/GDP	Credit/GDP
Frequency	Quarterly	Quarterly	Quarterly	Quarterly
Cycle	7.5	2x	3x	4x
Empirically	5			
Reference	Hodrick-Prescott	Drehmann et al.	Drehmann et al.	Drehmann et al.
Year	1980	2010	2010	2010

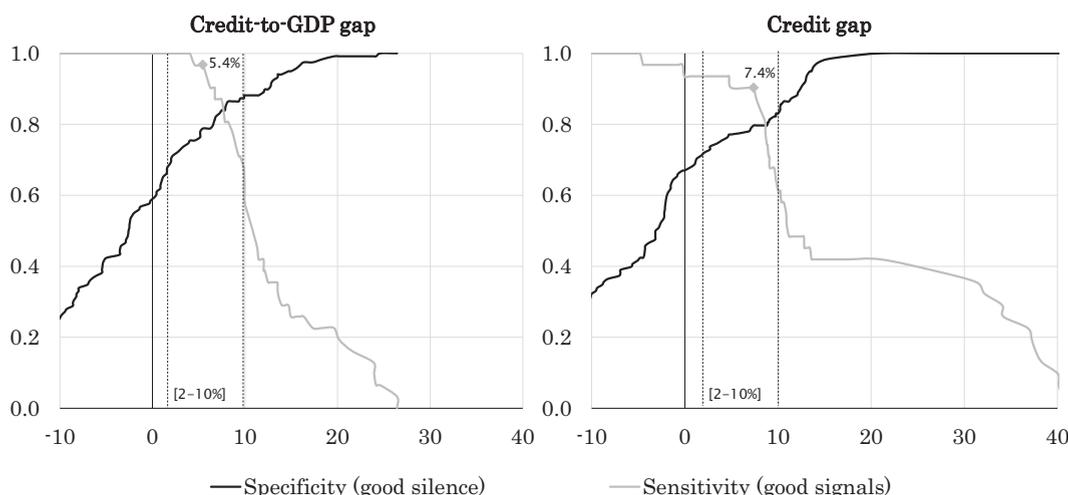


Fig. 9. Receiver operating characteristic (ROC) analysis (index). *Specificity* is equal to the proportion of nonfinancial fragility quarters correctly identified (true negatives), while *Sensitivity* is equal to the proportion of financial fragility quarters correctly identified (true positives). *Credit-to-GDP* is equal to the local banking credit to nonfinancial private sector as a percentage of annual GDP, reported as its gap relative to its own trend calculated by HP filter with a factor of 400,000 using a 10-year rolling window. *Credit gap* is equal to the local banking credit to nonfinancial private sector in real terms, reported as its gap relative to its own trend calculated by HP filter with factor of 400,000 using a 10-year rolling window. Source: Own calculations based on information from the CMF and the Central Bank of Chile.

With a 2% threshold, we capture all of the positive cases, but with 31% false positives when using the credit-to-GDP gap (Fig. 9). False positives decrease to 12% with a 10% cut-point, but identify 55% of the positive events. That means that the percentages of type II error are 28% and 17% for the 2% and 10% cut-points respectively, which identify 94% and 39% of the positive cases. A threshold that balances both characteristics equally is 5.4% for credit-to-GDP gap and 7.4% for the credit gap. Therefore, given this preliminary analysis, it is reasonable to adopt a range of 2% to 10% for the activation of the CCyB.

4.1. Robustness checks

The results from the HP filter depend on the choice of smooth parameter. Hodrick and Prescott (1980) suggests that a lambda of 1,600 is associated with a business cycle of approximately 7.5 years. Empirically, a business cycle has an average frequency of 5 years for OECD countries (Cotis and Coppel, 2005). Drehmann et al. (2010) states that a financial cycle is 4 times longer than the real cycle. Using the frequency adjustment proposed by Ravn and Uhlig (2002), a lambda of 400k corresponds to a cycle of around of 15–20 years.

Lambdas of 25.6k to 400k do not change the results drastically when using a 10-year rolling window (Fig. 10). The cycle obtained with a lambda of 1600 is not informative and is not consistent with the recommendations of the BCBS for financial data. Therefore,

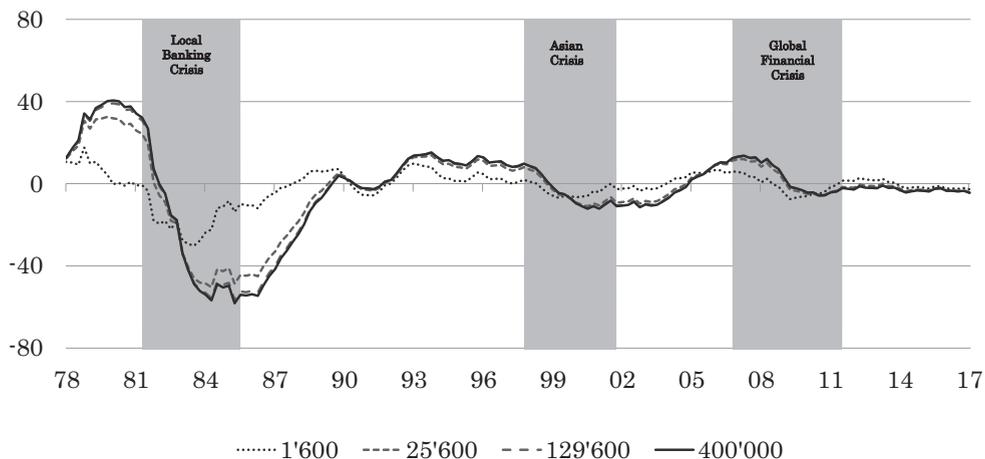


Fig. 10. Banking credit gap by parameter value (percentage). *Banking credit gap* is equal to the local banking credit to the nonfinancial private sector in real terms, reported as its percentage difference relative to their own trend calculated with a HP filter using a 10-year rolling window by smoothing factor. The gray areas represent periods of financial fragility, delimited according to Martínez et al. (2018). Source: Own calculations based on information from the CMF and the Central Bank of Chile.

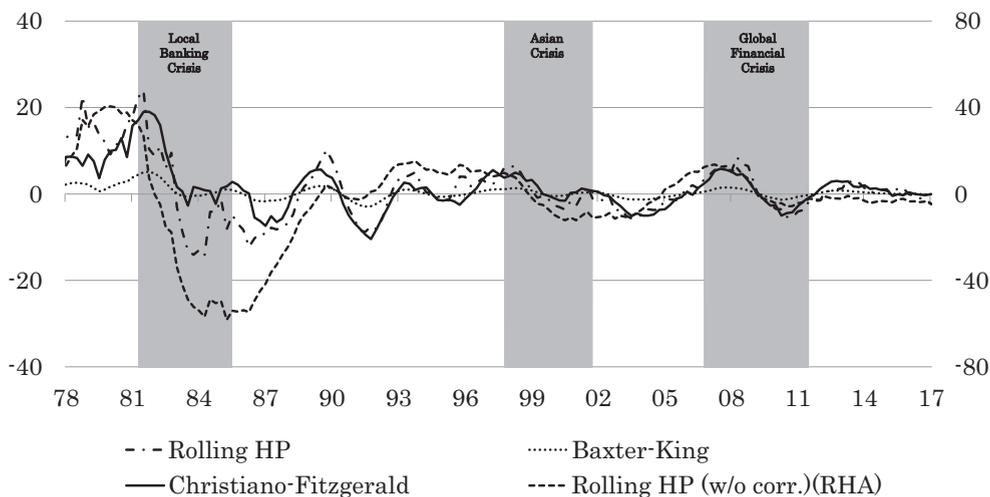


Fig. 11. Banking credit gap with end-point correction (percentage). *Banking credit gap* is equal to the local banking credit to the nonfinancial private sector in real terms, reported as its percentage difference relative to its own trend calculated by CF or by HP filter with a factor of 400,000 and a rolling window of 10 years. All filters includes a lead of 3 years of data. The projections out-of-sample are based on the stress test models proposed by Martínez et al. (2017). The gray areas represent periods of financial fragility, delimited according to Martínez et al. (2018). Source: Own calculations based on information from the CMF and the Central Bank of Chile.

the analysis suggests using a value of 400k. However, it must be reinforced that the parameter choice is not necessarily extensible to other economies and depends specifically on each economy’s idiosyncrasies (Wezel, 2019).

A disadvantage of the filters is that they suffers from end-point bias.¹³ One possible solutions is to use an estimation of future values of the series for the end-points. In our case, we assume a perfect forecast model for data before 2017q1 (e.g. we use observed future data for each date) and the projections from the Monetary Policy Report of the Central Bank of Chile.

The correction of the end-point reduces the amplitude of the estimated cycles, even for the HP filter (Fig. 11). Despite that, the usual methods only adequately anticipates the local banking crisis. One possible explanation is that the use of futures values already incorporates and is adjusted by the crisis information, incorporating it in the trend and reducing the cycle. In that sense, the bias gives important information for anticipating fragility periods. As an aside, if we have the correct estimation model, we can just use it to predict fragility periods directly. Thus, we opted for the rolling HP without correction because is simpler and more informative.

¹³ The end-point bias arises because of the lack of futures values for the last observed data. In the case of filters such as the Baxter-King filter, the cycle cannot be calculated for the latest observations.

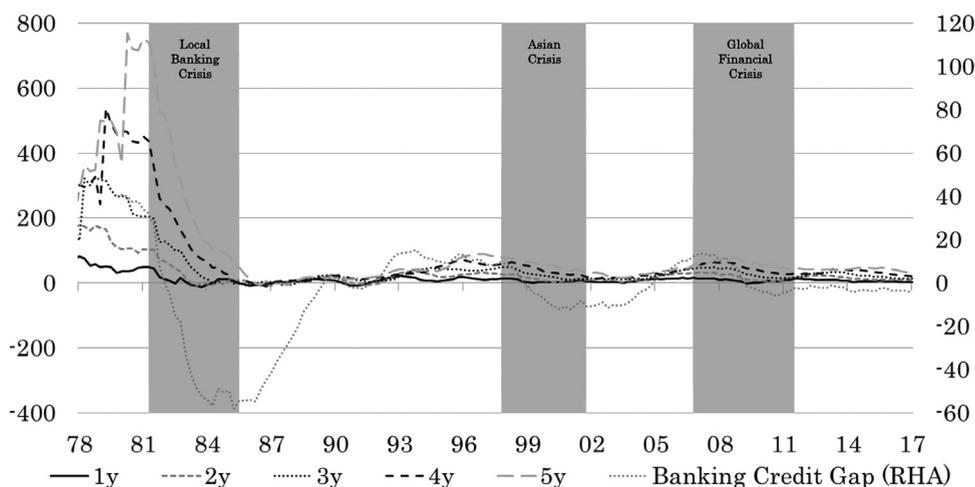


Fig. 12. Total credit growth by windows (percentage). Real percentage change of the local banking credit to the nonfinancial private sector by window length. The gray areas represent periods of financial fragility, delimited according to Martínez et al. (2018). Source: Own calculations based on information from the CMF, BIS and the Central Bank of Chile.

On the other hand, we can compare the efficiency of the banking credit gap with credit growth metrics. The credit growth series is influenced by the strong expansion during the 1970s and 1980s (Figure 12). The growth of credit in longer periods (e.g., growth in 5 years) provides a certain dynamic that allows periods of financial fragility to be brought forward. Strong growth is observed before all the crisis. However, this signal is quite weak for the global financial crisis. As a consequence, the growth series are less efficient than the banking credit gap for anticipating periods of crisis.¹⁴

We also separated the loan dynamics by type of credit. However, the available data only cover the recent crisis.¹⁵ In this sense, the low temporal coverage of these cycles makes the series non-stationary,¹⁶ which generates a problem in the interpretability of the results (Kaletie et al., 2015). Nonetheless, its analysis suggests that the consumer credit gap grew before the global financial crisis and that some greater growth could be seen prior to the Asian crisis (Fig. 13). The credit to households shows a cycle with greater amplitude, particularly for consumer credits. However, mortgage and business credit have similar dynamics to that of total bank credit. Therefore, if we only rely on the period of the global financial crisis, consumer credit would be a better indicator. However, a larger series is required to confirm this hypothesis.

4.2. Complementary indicators

As mentioned previously, although the banking credit gap is a good indicator for anticipating periods of financial fragility, it must be complemented with more information in the decision-making process of whether to activate the CCyB. Excessive credit growth is a relevant determinant of financial fragility; however, this is not a unique dimension. Therefore, in order to accumulate buffers to face the downward phase of the cycle, the activation of the CCyB must consider other sources of risk. For example, a sharp fall in housing prices could generate a significant increase in the delinquency rate of mortgages and represent important losses to the financial system, even if credit have been growing moderately.

There are two relevant issues to consider when selecting core indicators. The first is the historical coverage of the data. The EWI property of the indicator can be only evaluated if it correctly detected past events. Additionally, the metrics must follow a homogeneous construction criterion in order to filter accounting or methodological changes. The second issue is the availability of the data. Delays in the publication of the information as well as different periodicities or changes between preliminary and final numbers could determine the outcome of the analysis. Therefore, the framework must consider all risk dimensions within a confidence interval.

The BIS grouped the core indicators of systemic risk used to guide the CCyB decision into six categories: i) credit, ii) households, iii) businesses, iv) the banking sector, v) market risk, and vi) macroeconomic indicators. The list of core indicators used is presented in Fig. 14. The figure is a graphical mapping with which to examine time-series deviations of each characteristic of the system, in a

¹⁴ Figure 19 in Appendix B shows the AUROC results for the growth series. The banking credit gap provides higher AUROC values, as well as an advance period closer to 3 years, than the different growth windows do.

¹⁵ Detken et al. (2014b) proposes property prices as an alternative indicator with good predictive power; however the available data are limited. See Fig. 20 in Appendix C.

¹⁶ Several tests failed to reject the presence of unit root in those series, and we cannot accept it for other longer series that we use. See Appendix D for details.

Consistent with our previous analysis, both credit-to-GDP and banking credit gap turned red before fragility periods. Other indicators such as GDP and copper price gave a good signal for one particular fragility periods but not in others. Shorter indicators, like stock market prices or IPSA, give correct signals to anticipate fragility periods but based only on the last global financial crisis.

Although the list of variables can be extended, the framework described is a graphical toolkit that helps with measuring an economy's conditions in a comprehensive way.

5. Conclusions

5.1. Challenges for the CCyB application

Although the CCyB is, in principle, a valuable macro-prudential policy that is available for counteracting the cyclical effects and externalities produced by banking intermediation, it certainly involves several challenges for its implementation. In this analysis, we focus on three dimensions that we consider important given the current status of the Chilean regulation, which is converging to international standards: i) reference indicators for activation and release, ii) calibration of the adequate buffers based on the estimated impact and iii) ensuring an adequate governance setting for its implementation.

The application of the CCyB involves reshaping the traditional macroeconomic methodology toolkit to account for developments in the financial markets and their interactions with the real economy. In particular, the state of the art in the design and estimation of metrics for helping with deciding whether to use the CCyB do not involve a major transformation of estimation techniques. Conversely, the currently available methods are adaptations of well-established statistical and econometric techniques. The issue is more about identifying particular characteristics of the financial and business cycle (Borio et al., 2014) and its relevance for macro-prudential policy. In this respect, the mere concept of financial cycles is a significant digression from the mainstream policy paradigm.

Due to the natural methodological inertia exposed above, in the Chilean case, there are few gaps in the technical tools associated with the CCyB. However, in order to favor its implementation, it is necessary to improve the availability and depth of data for preparing the decision-supporting material. The described difficulty is especially true for financial or banking variables, which had been taken into account less often, as compared to macroeconomic indicators. Despite the work of Martínez et al. (2018) which contributed to extending key financial data series until the 1970s, it may be still be relevant to increase the data coverage. Lack of data is also a common problem for other countries in the region. The information available in the BIS databases does not provide sufficient coverage to make a deeper analysis that includes at least 3 financial crises. In particular, measuring the efficiency of EWIs using only the global financial crisis is not reliable. For this reason, it is advisable to obtain and standardize financial series, as well as to determine periods of crisis.

Although the CCyB guidelines (Drehmann and Tsatsaronis, 2014; European Systemic Risk Board, 2014) involves a rigorously guided discretionary decision process – given the uncertainty nature of the macroeconomic and financial environment – its application has several challenges. In fact, there is little evidence on the effects of this type of policy, as reported by the Basel Committee on Banking Supervision (2017).¹⁸ This is especially relevant for a country that has not experimented with such policies in the past, as in the case of Chile. In particular, the activation and release timing and the associated capital charge calibration are key to avoiding unintended consequences of the CCyB policy, such as exacerbating credit contractions. Additionally, a potential vulnerability associated with this tool is that – despite being well-grounded in theory – it is difficult to estimate the macro-financial economic impact of the CCyB (Drehmann and Tsatsaronis, 2014; Kohn, 2016). Even if the timing and calibration are the correct ones for the CCyB, the policy application must be coordinated with others to be consistent and effective (Borio et al., 2014). To overcome the difficulty in creating counterfactual scenarios with limited data from countries that have implemented the CCyB, an alternative that has emerged is the development of theoretical models that allow to estimate the effects of different policy measures and regimes in different macroeconomic contexts (Borio et al., 2014).

An additional problem for CCyB policy is that its target (i.e., the financial cycle) could reflect a variety of phenomena, which do not necessarily make its application timely. In particular, when focusing on developments in the credit market, we should be able to distinguish between shocks from demand or supply, which is not an easy task. If, for example, a relaxation in the conditions of credit supply causes excess credit, then there is a greater margin of action in the policy. If, on the other hand, the shock comes from the demand, then it instead may be a symptom of effective financing needs in a growing phase of the business cycle. Despite the difficulty in distinguishing both phenomena, Jara et al. (2017) provide estimates that allow us to infer the determinants of lending activity, which, when using the Senior Loan Officer Survey (SLOS), can be used to distinguish effects of supply and demand, controlling for macroeconomic and idiosyncratic variables of banks. However, this should be studied further as part of an ample research agenda, to help fine-tune the CCyB.

Conditional on the institutional arrangement of monetary authorities and banking supervisors (i.e., whether both institutions are embedded in one authority), the corporate governance arrangement for the CCyB's policy implementation shows multiple alternatives. In the Chilean case, the financial supervisor (CMF) is separated from the CBC, which requires greater effort in coordination. However, important steps have already been taken to improve coordination between both authorities, such as the establishment of the Financial Stability Board¹⁹ in 2014 (Law 20789) and the development of frameworks with which to monitor aggregate risks for the stability

¹⁸ One of the few documented examples is the work of Jiménez et al. (2017) which discusses the dynamic provisioning (DynP) effects in Spain. They find that the DynP scheme helped to reduce the effects of the global financial crisis on banking credit growth. However, although useful, this policy is not completely equivalent to the CCyB (see Solheim, 2016, for more details).

¹⁹ It is chaired by the Ministry of Finance and involves all supervisors and assists in the capacity of hearing the CBC.

of the Chilean financial system. In addition, the forthcoming reform of the general banking law and the proposed Financial Market Commission – which has a more focused approach on supervising individual entities – would deliver additional benefits in terms of the coordinated implementation of macro- and micro-prudential policies. Whatever the coordination framework among authorities, international practice (Basel Committee on Banking Supervision, 2017) suggests that decisions to activate the CCyB are mostly taken according to a framework similar to those of monetary policy. That is, with background provided by the staff and decisions of the board. Once the policy decision scheme is defined, it is necessary to prepare the necessary documentation for the policy framework.

5.2. Final remarks

Macro-prudential policies are necessary to address the externalities caused by the behavior of economic agents, which was especially true after the global financial crisis, which had important consequences for the credit markets of advanced and emerging countries. In particular, the CCyB emerged as an alternative focused on avoiding excessive credit fluctuations and building buffers to deal with periods of fragility. In this context, the present document analyzes some key aspects in implementing the CCyB for the Chilean case.

In the case of the Chilean economy, there are some particularities related to the type and depth of information needed to estimate early warning indicators. Regarding the type of information, an analysis was carried out that showed the types of exposures of the local financial sector and the variability of the economic cycle, and we concluded that the ratio of real bank credit to its historical trend is a good “single” candidate for complementing the BCBS-proposed credit-to-GDP gap indicator. Then, this hypothesis was confirmed by comparing several alternative indicators and parameterizations, of which – according to its 3-year anticipatory power – the HP filter was chosen with a smoothing parameter (lambda) of 400k and a rolling window of 10 years. Although the applied methodology has the objective of anticipating periods of financial fragility, it can be extended to find indicators with which to predict other types of crises, such as currency or sovereign. Furthermore, the proposed indicators based on credit may also serve such purposes. However, the links between the credit market with other type of crises should be explored further.

Subsequently, some relevant challenges for the application of the CCyB in Chile are outlined: i) the improvement of the anticipatory properties of the EWIs over the economic cycle, including the test of alternative and/or combined indicators ii) providing a robust framework for identifying the activation and deactivation rules for the capital buffer and its impacts on the other financial and economic variables and iii) the policy and the organizational structure associated with policy decisions.

Finally, although the convergence of banking systems to international standards is recommended, some alternatives for improvement and refinement when implementing macro-prudential policies, particularly for the Chilean banking sector, can be gathered from this analysis.

Declaration of Competing Interest

This is to declare that my co-authors and I do not have any conflict of interests regarding the publication of this investigation. Please do not hesitate in contacting me if you have further questions or queries.

Appendix A. Mexico

This appendix shows the available data and the results of applying the sensitivity analysis to Mexico.

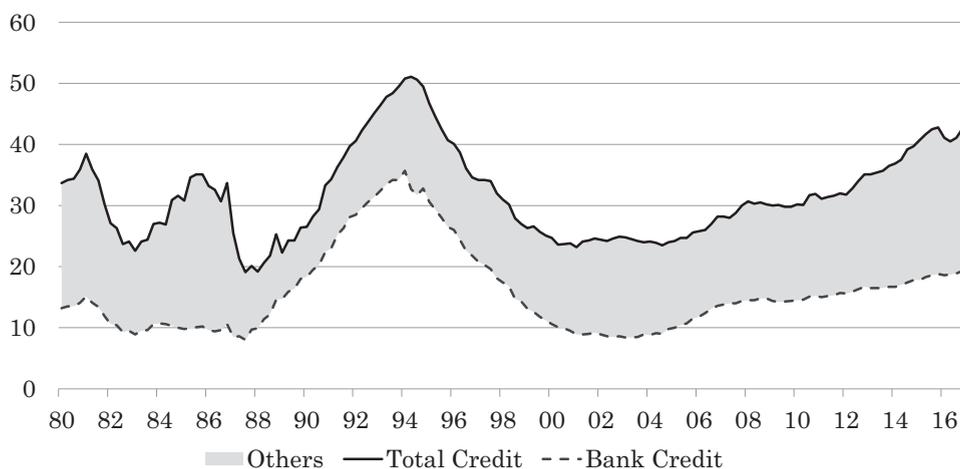


Fig. 15. Mexico: Importance of nonbank credit on the credit-to-GDP, in percentage. Source: Own calculations based on information from BIS.

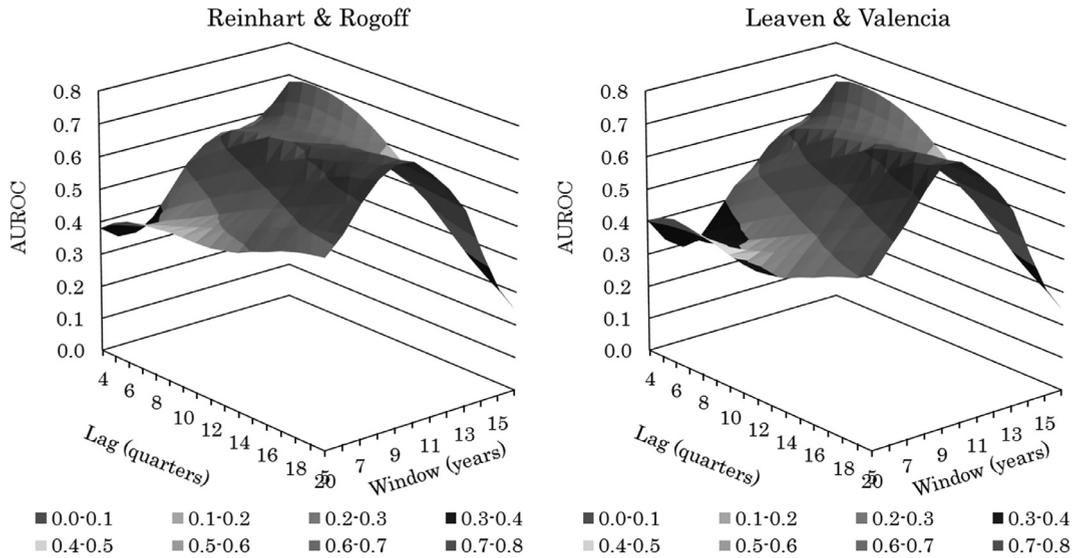


Fig. 16. Mexico: Banking credit gap - AUROC, in units. Source: Own calculations based on information from BIS.

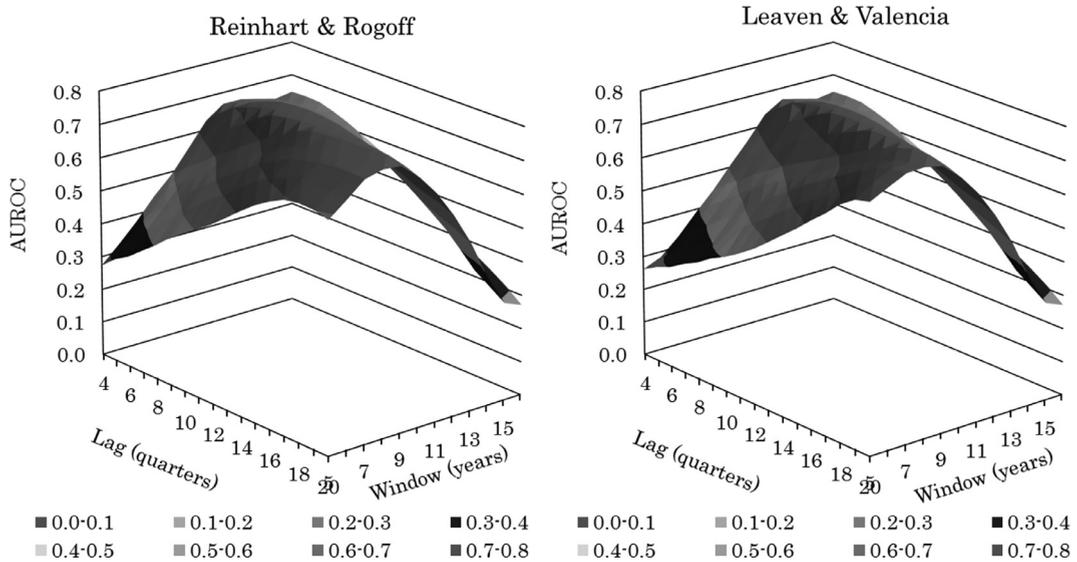


Fig. 17. Mexico: Banking credit-to-GDP gap - AUROC, in units. Source: Own calculations based on information from BIS.

Appendix B. Alternative measures of credit growth

An alternative metric of the credit dynamic, which corresponds to the ratio of the credit change over a fiveyear moving average of the GDP (Kauko, 2012), accounts for a misalignment in the short-term credit growth with respect to the long-term product trend.

$$\frac{\Delta C_t}{\overline{GDP}_t} = \frac{C_t - C_{t-1}}{\frac{\sum_{i=0}^{19} GDP_{t-i}}{20}} \tag{2}$$

We also calculated the change of the credit-to-GDP ratio over 5 years, in order to adjust for the trend of this indicator.

$$\Delta^{20} \left(\frac{C_t}{GDP_t} \right) = \frac{C_t}{GDP_t} - \frac{C_{t-20}}{GDP_{t-20}} \tag{3}$$

However, no excessive pre-crisis credit growth was observed with these metrics.

On the other hand, the results of the AUROC analysis suggest that the banking credit gap is more efficient in anticipating crises than other credit growth metrics are.

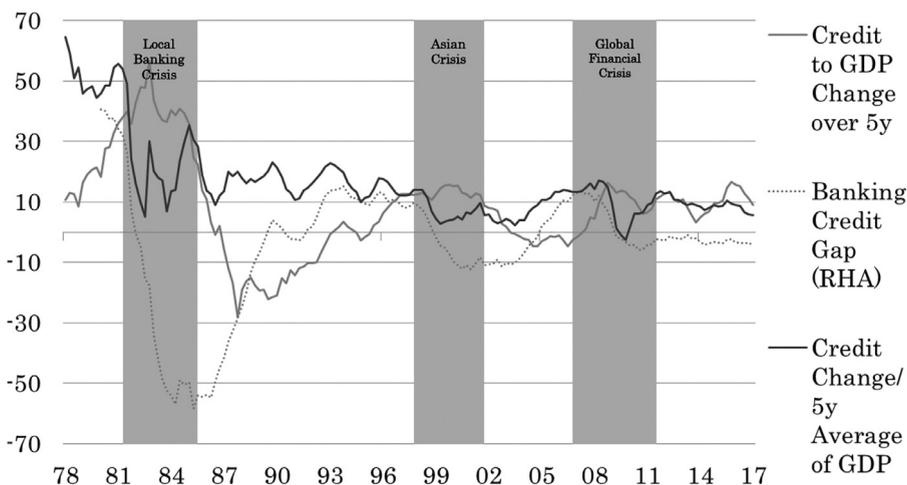


Fig. 18. Other metrics. Source: Own calculations based on information from the CMF and the Central Bank of Chile.

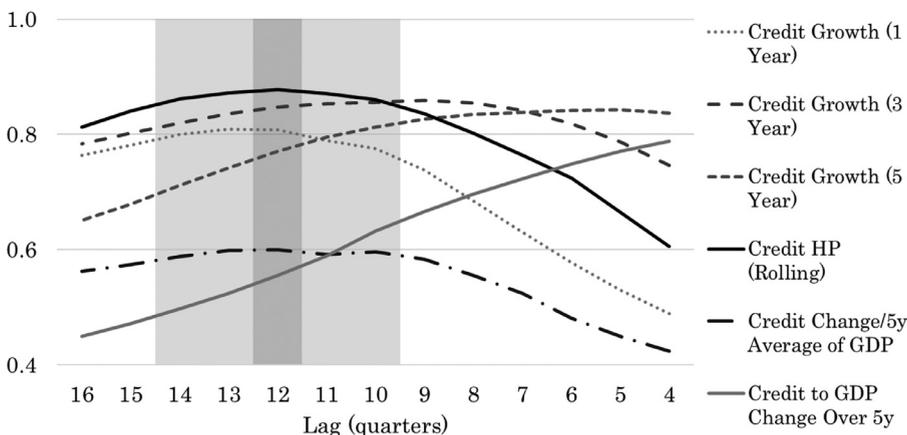


Fig. 19. Area under the receiver operating characteristic curve (AUROC) by lag, in area. Source: Own calculations based on information from the CMF and the Central Bank of Chile.

Appendix C. Housing prices

The real index of house prices (IRPV) for Chile was obtained from the Chilean Chamber of Construction (CChC), which is a union association for the construction sector. According to the methodology described in Idrovo and Lennon (2011), the IPRV is a set of real price indexes for new houses in the Santiago Metropolitan Region of Chile, based on a hedonic pricing methodology and with information on the properties from monthly surveys on sales promises reported by CChC member firms.

This series has been available from 2002 on a monthly basis. Although this series includes the global financial crisis, it should be considered that filtering methodologies, lose the first years of information, especially if the series are to be analyzed in real time. In the case of filters with 10-year rolling windows, the cycle calculated in the first window contains less information. In other words, with information from 2002, methodologically comparable cycles were calculated from 2011, after the global financial crisis. Despite this, if we take the estimates with partial information on these cycles, house prices can be used to anticipate the crisis period in at least 5 years and forecast a period of fragility during 2018. The latter is questionable, given that the banking sector did not show symptoms of fragility during this period, although it showed lower credit growth and profitability than in previous years (Financial Stability Report, First Half of 2019, Chapter III).

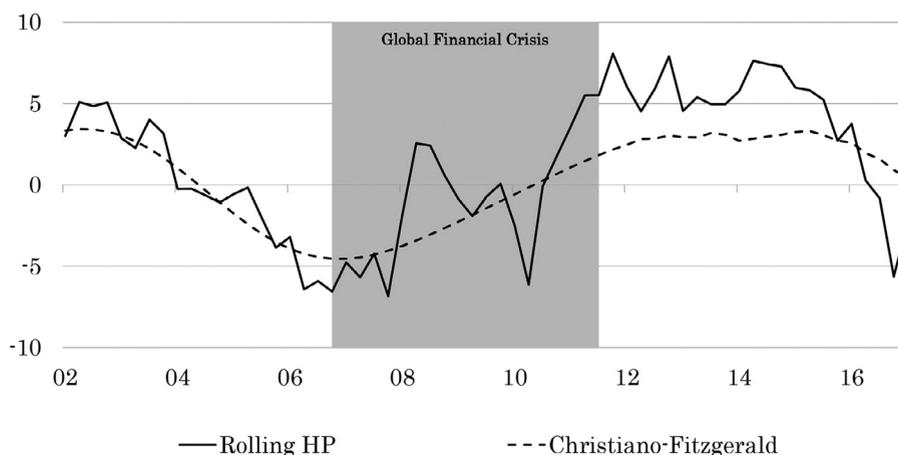


Fig. 20. Housing price gap, in percentages. (1) Based on Hodrick-Prescott filter with lambda equal to 400,000 with a rolling window of 10 years. (2) The gray areas represent periods of financial fragility, delimited according to Martínez et al. (2018). Source: Own calculations based on information from the CChC.

Appendix D. Unit root tests

Table 5
Unit Root Tests.

Variable	Sample	ADF						PP
		Lags						Lags
		(1)	(2)	(3)	(4)	(5)	(6)	(4)
Banking credit-to-GDP gap	1980–2017	1.98	2.34	2.60*	2.57	2.99**	2.78*	2.94**
Banking credit gap	1980–2017	2.56	3.2**	3.69***	3.86***	4.43***	3.77***	2.63*
Total banking credit gap	1999–2017	-1.32	-1.97	-2.47	-2.93**	-3.04**	-2.75*	-2.69*
Commercial banking credit gap	1999–2017	-1.40	-1.81	-1.99	-3.41**	-2.50	-2.39	-2.87**
Consumer banking credit gap	1999–2017	-2.58*	-3.21**	-3.69***	-6.90***	-3.99***	-3.29**	-2.19
Mortgage banking credit gap	1999–2017	-2.18	-2.91**	-3.47***	-3.81***	4.32***	3.58***	2.53
Housing prices	2012–2017	0.74	0.13	0.20	0.60	0.19	0.50	1.91
Banking credit growth, 1 year	1971–2017	3.34**	3.24**	4.15***	2.38	2.90**	3.04**	4.28***
Banking credit growth, 5 year	1975–2017	1.61	1.73	2.19	2.37	3.25**	2.74*	1.86

Note: The table presents the tstatistic of the augmented Dickey-Fuller test (ADF) and Phillips-Perron test (PP), with the null hypothesis that a unit root is present in the sample. The model for ADF is $y_t = \zeta_1 \delta y_{t-1} + \zeta_2 \delta y_{t-2} + \dots + \zeta_p \delta y_{t-p} + \alpha + \rho y_{t-1} + \epsilon_t$. Since the series are filtered, the trend is excluded. The model for PP is: $y_t = \rho y_{t-1} + \mu_t$, for which the Newey-West lags to use in calculating the standard error are $int[4(T/100)^{2/9}]$. Significance *10%, **5%, and ***1%.

References

- Aikman, D., Kiley, M.T., Lee, S.J., Palumbo, M., Warusawitharana, M.N., 2015. Mapping heat in the u.s. financial system. *Financ. Econ. Discuss. Ser.* (2015–59).
- Aldasoro, I., Borio, C., Drehmann, M., 2018. Early warning indicators of banking crisis: expanding the family. *BIS Q. Rev.*
- Alessandri, P., Bologna, P., Fiori, R., Sette, E., 2015. A note on the implementation of the countercyclical capital buffer in Italy. Occasional Paper. Bank of Italy.
- Baba, C., Dell'Erba, S., Detragiache, E., Harrison, O., Mineshima, A., Musayev, A., Shahmoradi, A., 2020. How Should Credit Gaps be Measured? An Application to European Countries. IMF Working Paper.
- Basel Committee on Banking Supervision, 2010. Guidance for National Authorities Operating the Countercyclical Capital Buffer. Working Paper.
- Basel Committee on Banking Supervision, 2014. Impact and Implementation Challenges of the Basel Framework for Emerging Market, Developing and Small Economies. Working Paper.
- Basel Committee on Banking Supervision, 2017. Range of practices in implementing the countercyclical capital buffer policy. Implementation.
- Baskaya, Y.S., Giovanni, J.d., Kalemli-Ozcan, S., Ulu, M.F., 2017. International Apillovers and Local Credit Cycles. Working Paper. National Bureau of Economic Research.
- Baxter, M., King, R.G., 1999. Measuring business cycles: approximate band-pass filters for economic time series. *Rev. Econ. Stat.* 81 (4), 575–593.
- Borio, C., 2014. The financial cycle and macroeconomics: what have we learnt? *J. Bank. Financ.* 45, 182–198.
- Borio, C., Drehmann, M., Tsatsaronis, K., 2014. Stress-testing macro stress testing: does it live up to expectations? *J. Financ. Stab.* 12, 3–15.
- Borio, C.E., Lowe, P.W., 2002. Asset Prices, Financial and Monetary Stability: Exploring the Nexus. Working Paper. BIS.
- Borio, C.E., Lowe, P.W., 2004. Securing Sustainable Price Stability: Should Credit Come Back From the Wilderness? Working Paper. BIS.
- Castro, C.E., Estrada, Á., Martínez-Pagés, J., 2016. The countercyclical capital buffer in Spain: an analysis of key guiding indicators. Documento de trabajo (1601). Central Bank of Chile, 2016. Financial Stability Report. Technical Report. CBC.
- Cerutti, E., Claessens, S., Rose, A.K., 2017. How Important is the Global Financial Cycle? Evidence from Capital Flows. Discussion Paper. CEPR.
- Christiano, L.J., Fitzgerald, T.J., 2003. The band pass filter. *Int. Econ. Rev.* 44 (2), 435–465.
- Claessens, S., Kodres, L.E., 2014. The Regulatory Responses to the Global Financial Crisis: Some Uncomfortable Questions. Working Paper. IMF.
- Claessens, S., Kose, M., Terrones, M., 2011a. Financial Cycle: What? How? When? IMF working paper. WP/11/76
- Claessens, S., Pazarbasioglu, C., Laeven, M.L., Nedelescu, O.M., Valencia, F., Dobler, M., Seal, K., 2011b. Crisis Management and Resolution: Early Lessons From the Financial Crisis. International Monetary Fund.
- Cotis, J.P., Coppel, J., 2005. Business cycle dynamics in OECD countries: evidence, causes and policy implications. In: Kent, C., Norman, D. (Eds.), *The Changing Nature of the Business Cycle*. Reserve Bank of Australia.
- De Bonis, R., Farabullini, F., Rocchelli, M., Salvio, A., 2012. A Quantitative Look at the Italian Banking System: Evidence From a New Dataset Since 1861. Quaderni di storia economica (Economic History Working Papers).
- Dell'Ariccia, G., Igan, D., Laeven, L., 2012. Credit booms and lending standards: Evidence from the subprime mortgage market. *J. Money Credit Bank.* 44 (2–3), 367–384.
- Detken, C., Weeken, O., Alessi, L., Bonfim, D., Boucinha, M.M., Castro, C., Frontczak, S., Giordana, G., Giese, J., Jahn, N., et al., 2014. Operationalising the Countercyclical Capital Buffer: Indicator Selection, Threshold Identification and Calibration Options. ESRB Occasional paper.
- Detken, C., Weeken, O., Alessi, L., Diana, B., Boucinha, M., Castro, C., Frontczak, S., Giordana, G., Julia, G., Jahn, N., Kakes, J., Klaus, B., Lang, J., Puzanova, N., Welz, P., 2014. Operationalising the countercyclical capital buffer: indicator selection, threshold identification and calibration options. *Occas. Pap. Ser.* (5).
- Drehmann, M., Borio, C.E., Gambacorta, L., Jimenez, G., Trucharte, C., 2010. Countercyclical Capital Buffers: Exploring Options. Working Paper. BIS.
- Drehmann, M., Borio, C.E., Tsatsaronis, K., 2011. Anchoring Countercyclical Capital Buffers: the Role of Credit Aggregates. Working paper. BIS.
- Drehmann, M., Tsatsaronis, K., 2014. The credit-to-gdp gap and countercyclical capital buffers: questions and answers. *BIS Q. Rev.*
- European Systemic Risk Board, 2013. Recommendation of the European systemic risk board of 4 april 2013 on intermediate objectives and instruments of macro-prudential policy. *Off. J. Eur. Union C 170/1*.
- European Systemic Risk Board, 2014. Recommendation of the European systemic risk board of 18 June 2014 on guidance for setting countercyclical buffer rates. *Off. J. Eur. Union C 293/1*.
- Gourinchas, P., Valdés, R., Landerretche, O., 2001. Lending Booms: Latin America and the World. Working Paper.
- Harding, D., Pagan, A., 2002. Dissecting the cycle: a methodological investigation. *J. Monet. Econ.* 49 (2), 365–381.
- Hodrick, R.J., Prescott, E.C., 1997. Postwar U.S. business cycles: an empirical investigation. *J. Money Credit Bank.* 1–16.
- Idrovo, B., Lennon, J., 2011. Índice de precios de viviendas nuevas para el gran Santiago. CChC Working Paper.
- International Monetary Fund, 2011. Macroprudential Policy: an Organizing Framework. Technical Report. IMF policy paper.
- Jara, A., Martínez, J.F., Oda, D., 2017. Bank's Lending Growth in Chile: the Role of the Senior Loan Officers Survey. Working Papers.
- Jiménez, G., Ongena, S., Peydró, J., Saurina, J., 2017. Macroprudential policy, countercyclical bank capital buffers, and credit supply: evidence from the Spanish dynamic provisioning experiments. *J. Polit. Econ.* 125(6), 2126–2177.
- Kalatie, S., Laakkonen, H., Tolo, E., 2015. Indicators Used in Setting the Countercyclical Capital Buffer. Discussion Papers.
- Kauko, K., 2012. External deficits and non-performing loans in the recent financial crisis. *Econ. Lett.* (115) 196–199.
- Kohn, D., 2016. Macroprudential Policy: Implementation and Effectiveness. Speech at European Central Bank, Frankfurt.
- Laeven, L., Valencia, F., 2008. Systemic Banking Crises: a New Database. Working Papers.
- Laeven, L., Valencia, F., 2012. Systemic Banking Crises Database: An Update. Working Papers.
- Martínez, J.F., Cifuentes, R., Becerra, J., 2017. Pruebas de tesin bancaria del banco central de Chile: Actualización. Working Paper.
- Martínez, J.F., Matus, J., Oda, D., 2018. Taxonomy of Chilean Financial Fragility Periods from 1975 to 2017. Working Paper.
- Martínez, J.F., Oda, D., 2019. Banking Synchronicity Index and Financial Cycles. Working Paper.
- Minsky, H.P., 1972. An evaluation of recent monetary policy. *Nebraska J. Econ. Bus.* 37–56.
- Wezel, T., 2019. Conceptual issues in calibrating the Basel III countercyclical capital buffer. IMF Working Papers, 19/86.
- Minsky, H. P., 1982. Financial innovations and financial instability: observations and theory.
- Moore, H.L., 1914. *Economic Cycles: Their Law and Cause*. The Macmillan Company, New York.
- Ravn, M.O., Uhlig, H., 2002. On adjusting the Hodrick-Prescott filter for the frequency of observations. *Rev. Econ. Stat.* 84 (2), 371–376.
- Reinhart, C.M., Rogoff, K.S., 2009. *This Time is Different: Eight Centuries of Financial Folly*. Princeton University Press.
- Shin, H.S., 2010. *Risk and Liquidity*. Oxford University Press.
- Solheim, H., 2016. New macroprudential tools: the countercyclical capital buffer in Norway. *Res. Pap.*
- Tolo, E., Laakkonen, H., Kalatie, S., 2018. Evaluating indicators for use in setting the countercyclical capital buffer. *Int. J. Cent. Bank.* 14 (2).
- Watson, M., 1986. Univariate detrending methods with stochastic trends. *J. Monet. Econ.* 18 (1), 49–75.