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

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Abstract

The latest financial crisis has posed several challenges for policymakers about prevention and mitigation measures regarding these episodes. In this respect, the Basel Committee of Banking Supervision (BCBS) has issued a set of recommendations of macro-prudential policies that have been applied in several economies by accommodating them to their local context. In particular, it emerges the Countercyclical Capital Buffer (CCyB) and the Credit-to-GDP gap as a reference for its activation. In this context, this paper describes the Chilean issues relevant to its application, such as the structure of the credit portfolio, changes in macroeconomic and financial cycles, and data restrictions. Then, a set of early warning indicators (EWI) which conforms to these local particularities is proposed. 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 local past episodes of fragility. Finally, we discuss some remaining challenges for the application of CCyB in Chile.

Resumen

La última crisis financiera ha planteado varios desafíos para los reguladores sobre las medidas de prevención y mitigación en relación a estos episodios. En este sentido, el *Basel Committee of Banking Supervision* (BCBS) ha emitido un conjunto de recomendaciones de políticas macro-prudenciales que se han aplicado en varias economías adaptándolas a su contexto local. En particular, surge el Colchón de Capital Contracíclico (CCyB) y la brecha de crédito a PIB como referencia para su activación. En tal contexto, este documento describe los puntos relevantes para su aplicación en Chile, tales como la estructura del portafolio de créditos, los cambios en los ciclos macroeconómicos y financieros y las restricciones de datos. Luego, se propone un conjunto de Indicadores de Alerta Temprana (EWI) que se ajustan a estas particularidades locales. Para ello, se analizan y resuelven algunas limitaciones importantes en el cálculo de estas métricas: brechas de información, coherencia con la estructura financiera nacional y la excesiva amplitud de los episodios de fragilidad pasados. Finalmente, se discuten algunos desafíos pendientes para la aplicación del CCyB en Chile.

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1 Introduction

The global financial crisis of 2008-2009 has 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 system-wide perspective of regulation was only partial (Claessens & Kodres, 2014). Accordingly, the 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 anticipate, prevent and prepare the financial system to system wide events of financial fragility. In particular, in the Basel III framework, the BCBS has proposed the Counter-Cyclical 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 ago, 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. On a more recent contribution, Harding & 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. (2011), Martinez & Oda (2017e)). 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 & Valencia (2012), Reinhart & Rogoff (2009))¹. 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 because of myopia or changes in risk tolerance (Minsky (1972, 1982), Shin (2010)).

¹For instance, Laeven & Valencia (2012) indicate that about 1/3 of the financial crises were preceded by excessive credit growth.

Consequently, financial policies that limit credit overruns are designed to smooth the cycle and attempt to correct aggregate risk externalities (BCBS (2010, 2017), IMF (2011)). There are various alternatives, some of these include monetary policy, credit growth limits, specific eligibility restrictions (e.g. Loan-to-value, Debt-to income, etc), and capital and liquidity requirements², 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 are originated in excessive credit growth (Drehmann & 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), ESRB (2013)). The BCBS proposes its implementation in the capital agreement of Basel III and it is included within the Chilean proposal for a General Banking Act of 2017.

For the activation of the CCyB, the BCBS guidelines (BCBS, 2010, 2011; Drehmann & Tsatsaronis, 2014) and the ESRB recommendations (Detken et al. 2014; ESRB, 2014) 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.

In this paper, in line with the international practice, we select and test a group of metrics 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 obey to our quality as emerging economy, and other idiosyncracies. Specifically, in our estimations 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

²As Dell’Ariccia et al. (2012) mentions, capital and liquidity requirements have been successful in its 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 intends to be automatic whereas the CCyB guidelines leaves scope for guided discretion. Second, DynP rules affect income statements but not balance sheets or capital ratios directly, as in the case of CCyB. Finally, DynP cannot be adapted to international standard accounting practices, and hence has been discontinued. For more details see Table (5) in Appendix.

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, in light on the international experience, we highlight and discuss some remaining challenges for the application of CCyB in Chile.

This paper is organized as follows. Section 2 describes Chilean financial system characteristics and considerations that are relevant for the design and computation of EWI in the context of the CCyB application. Given the particularities raised in the previous section, Section 3 explains in detail a proposal for the Chilean economy. Section 4 analyzes the results of the associated statistical estimates and its capacity to anticipating periods of financial fragility in Chile. Section 5 covers relevant robustness checks of the estimates. Section 6 frames a more general set of indicators. In light to the recent situation of the Chilean financial system and the proposal of EWI and results, Section 7 highlights the current challenges for the implementation of the CCyB in Chile. Finally, Section 8 concludes.

2 CCyB in the Chilean context

The Chilean banking regulation has not suffered from major modifications since the 90s. However the framework is about to be changed under the new Banking Act that will include the use of macro-prudential policies, such as the CCyB. There are relevant considerations that we discuss in this sections in respect to the international experience, as a reference for practical issues of application, and we cover Chilean specificities that should be accounted for.

2.1 International experience

Although only few countries have activated the CCyB (BCBS (2017)), most of them have worked for several years to complement the available material that underpins its framework and application of this macro-prudential policy (e.g. Borio (2014), Borio et al. (2014), Drehmann & Tsatsaronis (2014)). For instance, as a reference, we have the cases of UK and Spain. Detken et al. (2014), propose and test several indicators for the case of UK, they highlight the relevance on 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 EWI for the Spanish economy. They have found that indicators of credit intensity, private sector debt sustainability, real state and external imbalances are useful comple-

ments of the standard Credit-to-GDP gap.

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

In that sense, the implementation practice among countries and the definition of EWI for the CCyB activation has an ample range but a common denominator: the definition of a set of complementary indicators as guideline for policy action. Table (1) shows that most of countries monitor a range of indicators, some of these 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) and most of them use the parameter of smoothing suggested by Drehmann et al. (2010) (i.e. $\lambda = 400k$). Although HP 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.

Table 1: International practice in EWI for CCyB

Framework	Description	Countries
Indicators	Monitor 1 to 30 indicators.	EU
	Pre-identified indicators. Includes 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.	Russia, UK, France, Germany
	Domestic banking system credit.	Australia, Belgium,
	Domestic banking and total credit	Hong Kong SAR, Korea, Switzerland
Filtering method (HP)	More definition of credit (different types: public/private, domestic/foreign, etc.)	France, Denmark, Germany, Italy
	Adjusted by historical deviations	Luxembourg, Russia
	Plus econometric models	Italy
	Adjusted by GDP decrease	Spain
	Adjusted by projections	Germany
	Range of smoothing parameter	Norway
	One & two-sided	Denmark
	Rolling	Japan
	Adjusted by currency fluctuations	Korea
		Brazil, Russia

Source: Own elaboration based on BCBS (2017).

2.2 Chilean particularities

The BCBS calculates the Chilean Credit-to-GDP ratio by using the publicly available macro-financial data and a standard statistical filter. According to the recommendations of the Basel Committee of Banking Supervision (BCBS, 2010; Drehmann & 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 it 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 parameter of trend-smoothing (i.e. λ) 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 a uniform criteria that works well for the majority of countries (Drehmann et al., 2010; Drehmann & Tsatsaronis, 2014), the Chilean particularities call for taking into account data and methodological considerations in the estimation of adequate EWI. In this respect, we revise the usage of credit information and data coverage.

2.2.1 Credit definition and Chilean financial structure

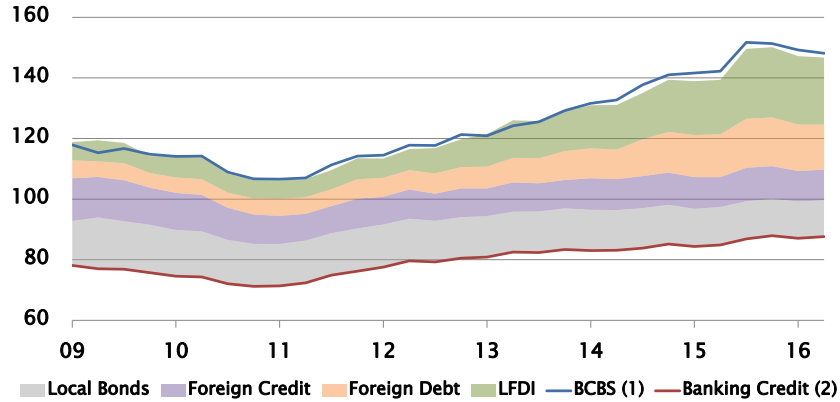
Despite the advantages of using the BCBS core Credit-to-GDP gap indicator, its properties rely heavily on the definition of "credit". Additionally, as proposed in Giese et al. (2014) and Castro et al. (2016), different features of financial crises can be anticipated and captured with alternative indicators that may perform better than the BCBS proposal. Hence, the activation of the CCyB should consider a set complementary indicators as it is the 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 non-financial private sector - namely total credit -, which includes local and foreign banking credit, bonds, and debt associated with foreign direct investment (FDI)³.

³The BCBS publishes this indicator for a set of countries in its site and is publicly available.

In the case of Chile, as opposed to most advanced economies, the dynamics of the local banking loans behaves differently to other sources of credit, especially to those coming from foreign markets. In particular, the differences of the total credit growth compared to the local banking credit is explained by the issuance of external bonds during the period from 2009 to 2015, and to obligations associated with FDI. As indicated in Chapter III of the Central Bank of Chile's Financial Stability Report for the second half of 2016 (CBC, 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 is originated 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 international favorable financial conditions, without necessarily augmenting the exposure of the banking system to the Chilean corporate sector (Figure (1)).

Figure 1: Non-bank credit incidence on the Credit-to-GDP (1)(2)(3)
(percentage)



(1) Excludes other local loans such as leasing and non-bank factoring, loans with commercial houses. Possible differences with external data due to the exchange rate used.

(2) Credit from all sectors to the non-financial private sector as a percentage of annual GDP.

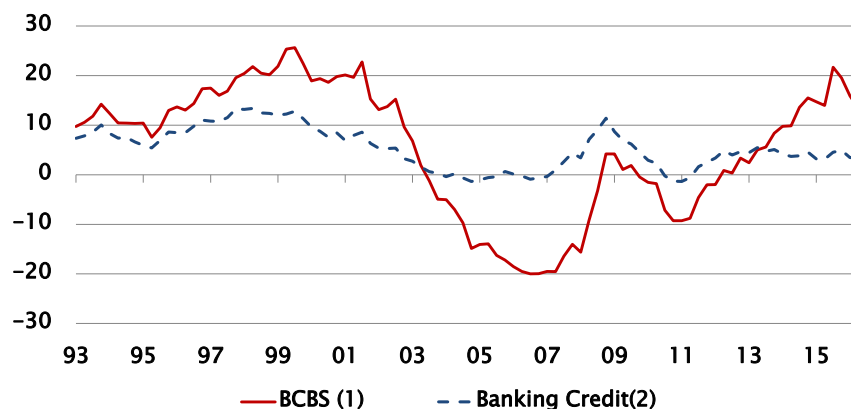
(3) Banking as a percentage of annual GDP.

Source: Own elaboration based on information from BIS and CBCh.

Using the same sample period and filtering technique than the one proposed

by the BCBS, but incorporating a different definition of credit could lead to different diagnosis with respect to financial fragility anticipation. Figure (2) shows the evolution of two versions of the Credit-to-GDP gap depending on the credit specification: i) the BCBS that uses total credit (red line) ii) an alternative that uses local credit only (blue line). According to the total credit criteria, from mid 2014 Chile, the BCBS metric shows an important gap, and consequently it would be anticipating 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 and 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.

Figure 2: Credit-to-GDP Gap (1)(2)(3)
(percentage)



(1) Gap in relation to the trend calculated by HP filter with factor of 400,000 in cumulative windows.

(2) Credit from all sectors to the non-financial private sector as a percentage of annual GDP.

(3) Banking as a percentage of annual GDP.

Source: Own elaboration based on information from BIS and BCCH.

2.2.2 Anticipating financial fragility without crises data?

Standard criteria - such as the ones provided in Laeven & Valencia (2008, 2012) and Reinhart & Rogoff (2009) - only identify one financial crisis for the Chilean economy since the 80s: 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 Martínez et al. (2017) data compilation.

Martínez et al. (2017) define three Chilean financial fragility periods for the same time span: i) the local banking crisis (LBC) (in the early 80s); and the manifestation of external phenomena ii) the Asian crisis (AC) (in the late 90s) and iii) the Global Financial crisis (GFC) (around 2008). The LBC fragility period roughly coincides with the one defined in Laeven & Valencia (2008, 2012) (i.e. 1981-1985) and it is the one with the highest impact on credit contraction, profitability and credit risk, whereas the effect on these variables for subsequent periods of fragility is milder but still significant.

The identification of EWI 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, BCBS recommends having as much depth 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 system 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 were transmitted to the local economy and how this impacted on the banking. It is useful as a case study, particularly to review the macro-financial context that led to the crisis and the need for bank intervention. This is despite the fact that many of the conditions of regulation and 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 CCyB and develop metrics that allow its activation. In particular, it highlights the financial deepening it has suffered in the last 50 years and the status of 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) macroeconomic context and its implications in the credit cycle.

As for the considerations related to the information to be used, in a country like 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, such as the Asian and global financial crisis, although, as noted by their effects 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 would be synchronized. In particular, the idea of linking the activation of CCyB with misalignments of the global financial cycle arises. These mismatches would 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 & Rogoff, 2009, and others).

Although it is advisable to take external vulnerabilities into account because it has some relation to the occurrence of past crises, especially the LBC (Laeven & Valencia, 2008, 2012; Reinhart & Rogoff, 2009, and others), it is necessary to contrast it 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 little 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, although not as signals, but as a context of vulnerability that favors the transmission of shocks. For example, it can be noted that 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 external situation is more dubious since both episodes occurred in a context of current account surplus. Very likely the impact of both recent episodes was mitigated by a 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 & Tsatsaronis (2014)). In this way, the CCyB is not oriented to avoid the external vulnerability *per se*, for that purpose are available other macro-prudential policies that can be applied coordinately.

3 EWI for the Chilean financial system

The objective of the framework is to define a leading indicator which adequately anticipates periods of financial distress in order to trigger the CCyB. In the Chilean context there are only few attempts to define early warning indicators, but they are focused on a less accurate definition of financial fragility and with a micro instead of a macro approach.⁴

The literature suggests the use of the "gaps" as financial indicators. These gaps are defined as deviations of each variable (measured in percentages) from its trend. The gap also is equivalent to the series cyclical component. In particular, the construction of gaps are based on the estimated cycles by commonly used time-series frequency filters. Borio & Lowe (2002, 2004) proposed the use of the Credit-to-GDP gap as an indicator of the financial cycle.

3.1 Filter alternatives⁵

The 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 to be the 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 removed stochastic cycles corresponding with the unwanted frequencies (outside of a specific range or band of length of cycle). There is a trade-off in choosing q : larger values of q cause the gain

⁴For instance, Ahumada & Budnevich (2001) uses the past-due loan index as an indicator of credit risk, which also characterize periods of financial fragility. They found that an increase of the capital levels tends to reduce the credit risk. Also, they establish that a high credit growth is related to an increment of the nonperforming loans in about 9 to 12 months later, especially for foreign banks.

⁵For more details, see Borgy et al. (2009)

of the BK filter to be closer to the gain of the ideal filter, but larger values also increase the number of missing observations in the filtered series, though. On the other hand, Christiano & Fitzgerald (2003) propose a CF filter that minimize 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 process and is not symmetric.

A different approach is to obtain the cycle of a series by removing its trend. Hodrick & Prescott (1997) state the HP filter a trend-removal technique. The trend is estimated by minimizing the distance of the estimated trend from the series and the time variation of the trend. Since there is a trade-off between both objectives, the parameter lambda defines the relative weight of the second component. Therefore, the larger the lambda, the smoother the trend.

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 trend and actual values, and time changes of the trend	Error between the coefficients in their filter and the ideal band-pass filter	Mean squared error between the estimated component and the true component

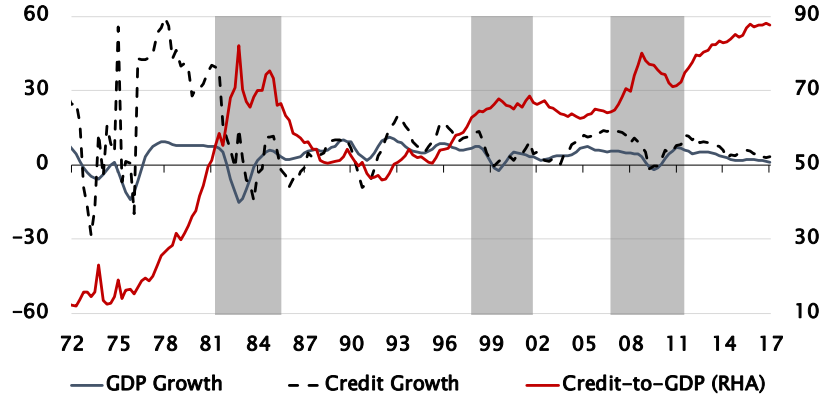
After the cycle is estimated, we evaluate its predictive power of the financial fragility episodes. This requires two components, the definitions of the fragility periods and the metric of anticipation power. The targeted periods are taken from Martinez et. al (2017). On the other hand, the Receiver Operating Characteristic (ROC) analysis quantifies the accuracy of a variable to discriminate between states. It is based on the sensitivity, the fraction of correctly classified positive cases; and the specificity, the fraction of correctly classified negative cases. Typically, the procedure use the complement of the specificity, that is, the false positives. Both metrics constructs the ROC curve. Finally, the performance of an indicator is usually summarized by the area under the ROC curve (AUROC) that can be interpreted as the probability that the correct classification of the variable will be greater than a random variable (Detken et al., 2014).

3.2 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 80's, were collected from the SBIF archives, processed and analyzed in Martínez et. al (2017).

Bank loans before the 80s represented less than the 50% of the annual GDP (Figure (3)). Considering the development of this sector in those years, relative small changes respect to the GDP are related to a 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 shown after the local banking crisis. However, we observe that before fragility periods the credit grew faster than the GDP, which confirms the evidence shown in Drehmann et al. (2010).

Figure 3: Banking Credit-to-GDP (1)
(percentage)



(1) The gray areas represent periods of financial fragility delimited according to Martínez et al (2017e).

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

4 Results

Following the international practice (BCBS, 2017), we test the anticipating properties of the Credit-to-GDP gap as a leading indicator making some relevant

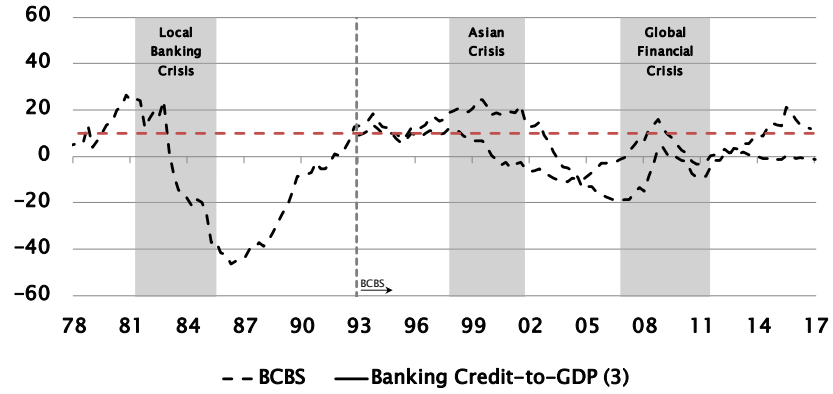
distinctions. Given the structure of the Chilean financial system, we also revise the cyclical component associated with the real total local banking credit, which is not affected by the dynamic of the GDP. Additionally, we slightly modify the standard time series filtering framework - used by the BCBS - to address structural breaks occurred in the Chilean economy.

Typically, the methodologies are based on filters that uses one-sided samples. In other words, older observations have a permanent influence in the estimations. Accordingly, if the cycle drastically changed in terms of frequency, amplitude or trend, the results are biased. All in all, we opted to use a Hodrick-Precott filter with a lambda of 400k using a rolling window of 10 years⁶.

A relative high Banking Credit-to-GDP gap anticipates the local banking crisis and the Asian crisis in about 2 years (Figure (4)). But, 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 fails to identifying the latest crisis, and the crossed the 10% threshold in September 2014 (as in December 1995) but there is no evidence of a crisis so far.

⁶Robustness check of this method is described on the next section.

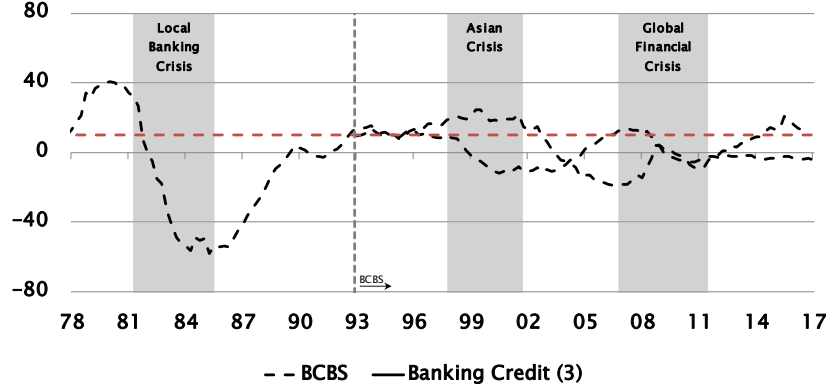
Figure 4: Banking Credit-to-GDP Gap vs BCBS (1)(2)(3)
percentage



(1) Based on Hodrick-Prescott filter with lambda equal to 400,000. The BCBS uses the total private credit to GDP and the proposal only the banking component.
 (2) The gray areas represent periods of financial fragility delimited according to Martínez et al (2017e). The red dotted line represents the threshold of 10%.
 (3) The proposal also considers a 10 year rolling window for the calculation of the cyclical component.
 Source: Own calculations based on information from the SBIF, BCBS and Central Bank of Chile.

With the banking credit gap, we are able to anticipate all the fragility periods in the sample with an average of 3 years, although the signal of the recent crisis is low (Figure (5)).

Figure 5: Banking Credit Gap vs BCBS (1)(2)(3)
(percentage)



(1) Based on Hodrick-Prescott filter with lambda equal to 400,000. The BCBS uses the total private credit to GDP and the proposal only the banking component.
(2) The gray areas represent periods of financial fragility delimited according to Martínez et al. (2017e). The red dotted line represents the threshold of 10%.
(3) The proposal also considers a 10 year rolling window for the calculation of the cyclical component.
Source: Own calculations based on information from the SBIF, BIS and Central Bank of Chile.

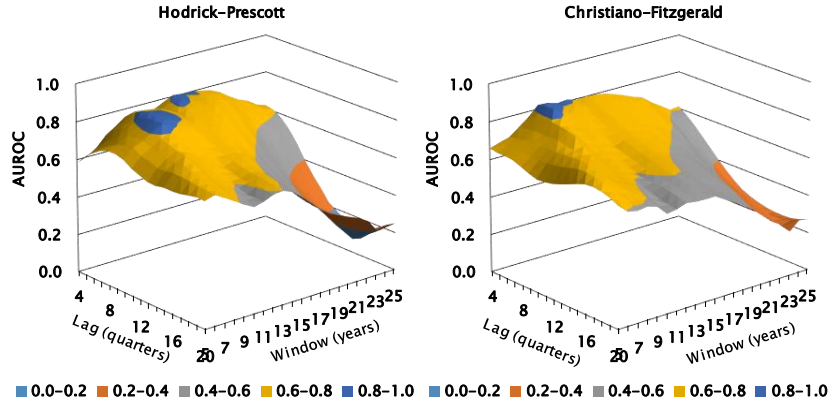
Besides, we compare the rolling window HP filter with other commonly used filters such as Band-pass filter Christiano-Fitzgerald (CF). Since CF filter is not symmetric, it can estimate the cyclical components upon the end of the sample. Notice that the objective of the framework is to formulate real time policies. Saying that, we have to use all the available information at moment of the policy decision and without delay⁷.

According to the AUROC analysis⁸, the calculation of the Credit-to-GDP gap has an optimal window of the rolling HP filter 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 (Figure(6)).

⁷For example, Baxter-King filter uses leads. So the value for a particular date cannot be calculated until the lead data is observed

⁸See Detken et al. (2014) for further details.

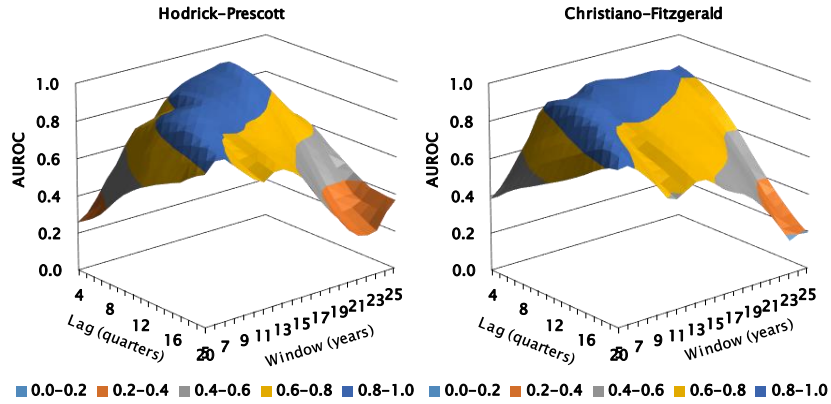
Figure 6: Banking Credit-to-GDP Gap - AUROC



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

In the case of Credit gap, the combination of window and lags rest on two options, a window of 20 years and a 5 quarters lag, and a 10 year window with a lag of 12 quarters (Figure(7)). Since it is recommended an anticipation of about 3 years, we choose 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.

Figure 7: Banking Credit Gap - AUROC

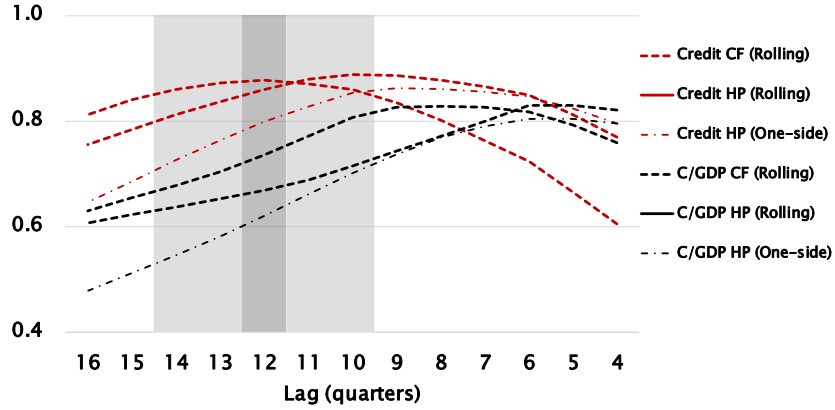


Source: Own calculations based on information from the SBIF and Central Bank of Chile.

Given the previous calculations, we take a window of 10 years as a standard.

The AUROC indicator in this cut shows that the Credit gap has a stronger relation with fragility periods than the Credit-to-GDP gap (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.

Figure 8: AUROC by lag
(index)



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

Nonetheless, the optimal lag of the rolling HP filter is 12 quarters (3 years) versus 10 quarters of the CF filter (Table (3)). In that sense, the proposed methodology gives a reasonable longer period to accumulate capital. In the case of using the Credit-to-GDP gap, the rolling HP provides a better AUROC.

Table 3: Area Under the Receiver Operating Characteristic (AUROC)

		3 years	Min	Max	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

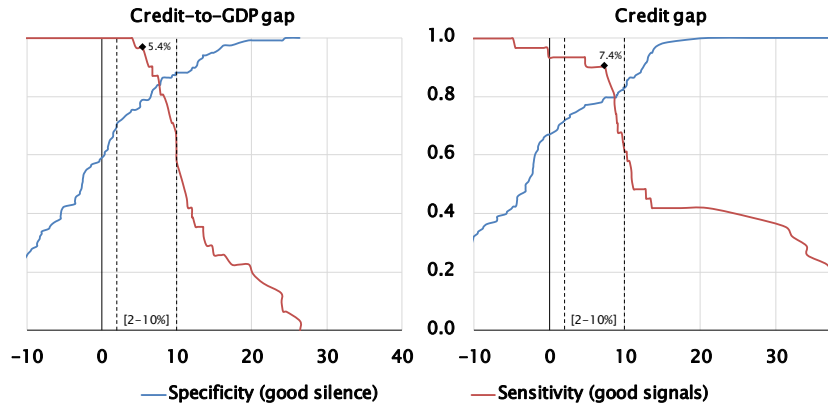
Source: Own calculations based on information from the SBIF and Central Bank of Chile.

As mentioned before, the international evidence suggest a threshold of 2% to gradually activate the CCyB and a threshold of 10% to be fully implemented

(BCBS, 2010). An optimal cut-point will balance the maximization of good signals and good silence. Indeed, there is a trade-off between increase the good signals (lowering the type I error) and increase the good silence (minimizing the type II error).

With a threshold of 2%, we capture all of the positive cases, but with a 31% of false positives using the Credit-to-GDP gap (Figure (9)). False positives reduces to 12% with a cut-point of 10%, but identifies 55% of the positive events. That means that the number of the type II error is 28% and 17% for the 2 and 10% cut-point respectively, while it identifies 94% and 39% of the positive cases. A threshold which balance equally both characteristics 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.

Figure 9: ROC analysis
(index)



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

5 Robustness checks

The results from the HP filter depend on the choice of the smooth parameter. Hodrick & 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 & Coppel (2005)). Drehmann et. al (2010) states that a financial cycle is 4 times longer than the

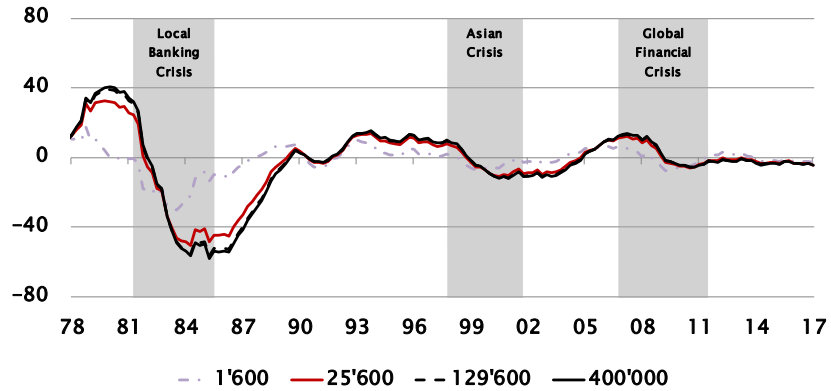
real cycle. Using the frequency adjustment proposed by Ravn & Uhlig (2002), the lambda for a cycle around of 15 to 20 years corresponds to 400k.

Table 4: HP lambda selection

	1'600	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

Fixing a 10 year rolling window, lambdas of 25.6k to 400k do not change drastically the results (Figure (10)). The cycle obtained by a lambda of 1600 is not informative and is not consistent with the recommendations of the BCBS for financial data. Therefore, the analysis suggests the use of a value of 400k.

Figure 10: Banking Credit Gap by parameter value (1)(2)
(percentage)



(1) Based on Hodrick-Prescott filter using a rolling window of 10 years.

(2) The gray areas represent periods of financial fragility delimited according to Martínez et al (2017e).

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

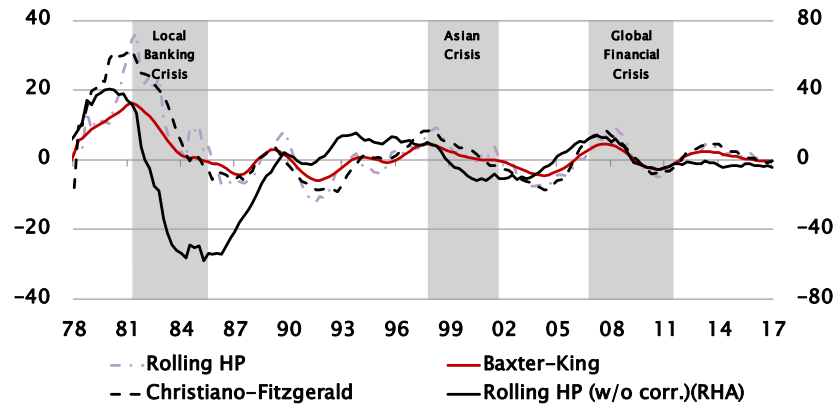
A disadvantage of the filters is that they suffers from the end-point bias⁹. One possible solutions is to use an estimation of future values of the series for the

⁹The end-point bias arises because the lack of futures values for the last observed data. In the case of filters such as Baxter-King, the cycle cannot be calculated for the latest observations.

end-points. In our case, we assume a perfect forecast model for data previous of 2017q1 (e.g. we use observed future data for each date) and the projections of 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 (Figure(11)). Despite that, the usually methods only adequately anticipates the local banking crisis. One possible explanation is that the use of futures values already incorporates and adjusts by the crisis information, incorporating it in the trend and reducing the cycle. In that sense, the bias gives important information to anticipate fragility periods. Aside, if we have the correct estimation model, we can just use it to directly predict fragility periods. Thus, we opt for the rolling HP without correction because is simpler and more informative.

Figure 11: Banking Credit Gap with End-point correction (1)(2)
(percentage)



(1) Based on Hodrick-Prescott filter using a rolling window of 10 years. All filters includes a lead of 3 years of data. Projections out of sample based on stress test models.

(2) The gray areas represent periods of financial fragility delimited according to Martínez et al (2017e).

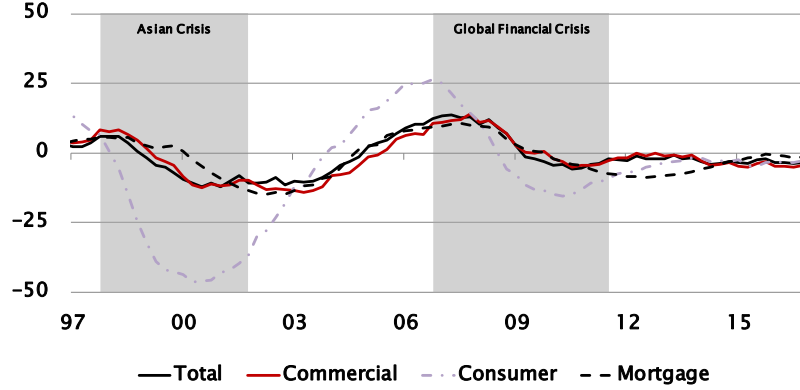
Source: Own calculations based on information from the SBIF and Central Bank of Chile.

We also separate the loans dynamic by type of credit. However, the available data only cover the recent crisis¹⁰. Nonetheless, its analysis suggest that Consumer credit gap grew before the global financial crisis, while the commercial

¹⁰Also the data available for housing prices is limited. See Figure (14) in the Appendix.

credit and mortgage were on its trend (Figure (12)).

Figure 12: Banking Credit Gap by type of credit (1)(2)
(percentage)



(1) Based on Hodrick-Prescott filter with lambda equal to 400,000 using a rolling window of 10 years.

(2) The gray areas represent periods of financial fragility delimited according to Martínez et al. (2017e).

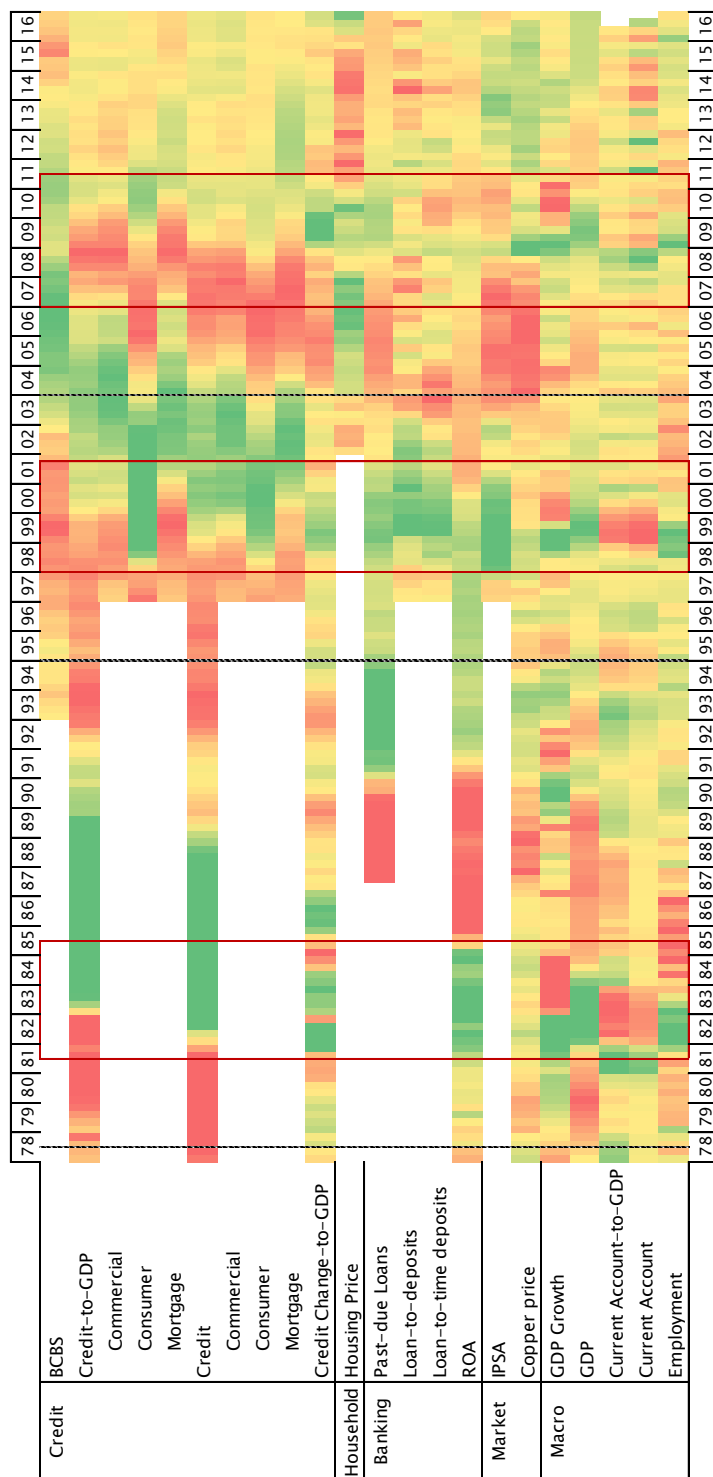
Source: Own calculations based on information from the SBIF and Central Bank of Chile.

6 Complementary Indicators

As we already mentioned, although the banking credit gap is a good indicator to anticipate periods of financial fragility, it has to be complemented with more information in the decision making process of the CCyB activation. An 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 has to 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 the credit have been growing moderately.

There are two relevant issues to be considered in the selection of core indicators. On the one hand, 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 have to follow a homogeneous construction criteria in order to filter accounting or methodological changes. On the other, the availability of the

Figure 13: Core Indicators of Systemic Risk Heatmap



- (1) Based on Hodrick-Prescott filter with lambda equal to 400,000 using a rolling window of 10 years.
 - (2) The red box represent periods of financial fragility delimited according to Martínez et al. (2017e).
 - (3) The dashed line delimits 3 year before the period of financial fragility.
 - (4) Colors are based on the range of each variable. Higher values are colored in red, while lower values are green. Past-due loans and unemployment have the colors reversed.
- Source: Own calculations based on information from the SBIF, BIS and Central Bank of Chile.

data. The delay in the publication of the information, different periodicities or changes between preliminary and final numbers could determine the outcome of the analysis. Therefore, the framework need to consider all risk dimensions and within a confidence interval.

The BIS grouped the core indicators of systemic risk used to guide CCyB decision into six categories: i) credit, ii) household, iii) business, iv) banking sector, v) market risk, and vi) macroeconomic indicators. The list of core indicators used are presented in Figure (13). The figure is a graphical mapping to examine time-series deviations of each characteristic of the system, in a similar fashion to the Office of Financial Research reports and Aikman et al. (2015). Each variable is calculated using a HP filter¹¹ and the colors are assigned from green (below) to red (above) depending on its deviation from its trend. Thus, an indicator in red is giving a signal to activate the CCyB.

Consistently with our previous analysis, both credit-to-GDP and banking credit gap turned red before fragility periods. Other indicators such GDP and Cooper 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 that statement is based only on the last global financial crisis case.

Despite that the list of variables can be extended, the framework described is a graphical toolkit which helps to measure the conditions of the economy in a comprehensive way.

7 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 the banking intermediation, it certainly involves several challenges for its implementation. In this analysis, we focus on three dimensions that we consider of importance 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) adequate governance setting for its implementation.

¹¹Variables are used in quarterly frequency. Financial variables are filtered using HP with a smooth parameter of 400,000 and a rolling window of 10 years. Macro variables are filtered using HP with a smooth parameter of 1,600 and a rolling window of 10 years.

The application of the CCyB involves reshaping the traditional macroeconomic methodology toolkit to account for developments in the financial markets and its interaction with the real economy. In particular, the state of the art in the design and estimation of metrics that helps decision making process on the CCyB do not involve a major transformation of estimation techniques. Conversely, current available methods are adaptations of well established statistical and econometric techniques. The issue is more about the identification of particular characteristics of the financial and business cycle (Borio, 2014) and its relevance for macro-prudential policy. In this respect, the mere concept of financial cycle is a significant digression of the mainstream policy paradigm.

Due to the natural methodological inertia exposed above, in the Chilean case there are not much gaps in the CCyB associated technical tools. However, in order to favor its implementation, it is necessary to improve the availability and depth of data for preparing the supporting decision material. The described difficulty is especially true for financial or banking variables, which had been less taken into account, compared to macroeconomic indicators. Despite the work of Martínez et al. (2017) that contributed to extending key financial data series until 1970s, it may be still be relevant to increase its coverage.

Although the CCyB guidelines (Drehmann & Nikolau, 2014; ESRB, 2014) involves a rigorously guided discretionary decision process - given the uncertainty nature of the macroeconomic and financial environment - there are several challenges on its application. In fact, there is only little evidence on the effects of this type of policies as reported by the BCBS (BCBS, 2017)¹². 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 is key to avoid 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 & Tsatsaronis (2014), Kohn (2016), Karstens (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 (2014)). To overcome the difficulty in creating counterfactual scenarios with limited data

¹²One of the few documented examples is the work of Jimenez et al. (2017) and it regards to the dynamic provisioning (DynP) effects in Spain. They find that the DynP scheme helped to reduce the effects of the global financial crisis in the banking credit growth. However, although useful, this policy is not completely equivalent to the CCyB (see Solheim, 2016 for more details).

of countries that have implemented the CCyB, an alternative that emerges is the development of theoretical models that allow to estimate the effects of different policy measures and regimes in different macroeconomic contexts (Borio (2014)).

An additional problem for CCyB policy is that its target (i.e. 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, the excess of credit is caused by a relaxation in the conditions of credit supply, then there is a greater margin of action in the policy. If, on the other hand, the shock comes from the demand, then it may rather 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 Senior Loan Officer Survey (SLOS), distinguish effects of supply and demand, controlling for macroeconomic and idiosyncratic variables of banks. However, this should be further studied and be part of an ample research agenda, that helps in the CCyB fine tuning.

Conditional on the institutional arrangement of monetary authorities and banking supervisors (i.e. whether both institutions are embedded in one authority), the corporate governance arrange for the CCyB policy implementation shows multiple alternatives. In the Chilean case, the financial supervisor (SBIF) is separated from the CBC what involves a 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 Board¹³ in 2014 (Law 20789) and the development of frameworks to monitor aggregate risks for the stability 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 is the coordination framework among authorities, international practice (BCBS (2017)) suggests that the activation decisions of 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 of the policy framework.

¹³Which is chaired by the Ministry of Finance and where all supervisors are involved, and where it assists in the capacity of hear the CBC.

8 Final remarks

Macro-prudential policies are necessary to address the externalities caused by the behavior of economic agents, especially after the global financial crisis, which had important consequences for the credit markets of advanced and emerging countries. In particular, CCyB emerges 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 the implementation of 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 is carried out that shows the type of exposures of the local financial sector and the variability of the economic cycle, and it is concluded that the ratio of real bank credit to its historical trend is a good candidate for complementing the BCBS-proposed Credit-to-GDP gap indicator. Then, this hypothesis is confirmed by comparing several alternatives of indicators and parameterizations, where - according to its 3 year anticipatory power - the HP filter is chosen using a smoothing parameter (λ) of 400k and a rolling window of 10 years.

Subsequently, some relevant challenges for the application of the CCyB in Chile are outlined: the improvement of anticipatory properties of EWI over the economic cycle, the proper identification of activation of buffer, the robust estimation of impact on financial and economic aspects of 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 in the implementation of macro-prudential policies, particularly for the Chilean banking system, can be gathered from this analysis.

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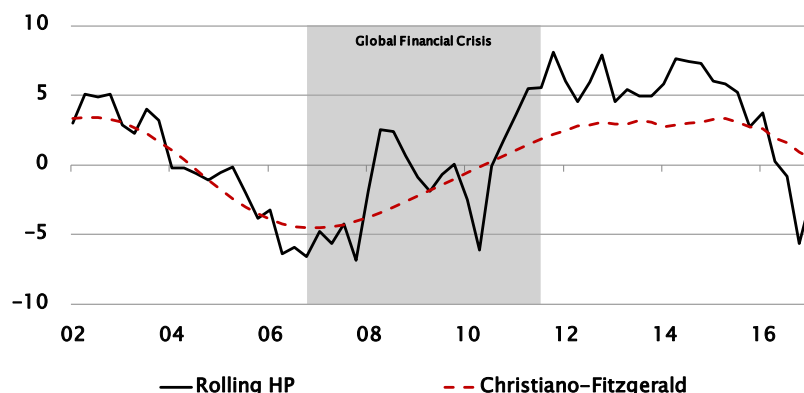
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9 Appendix

Figure 14: Housing Price Gap (1)(2)
(percentage)



(1) Based on Hodrick-Prescott filter with lambda equal to 400,000 using a rolling window of 10 years.

(2) The gray areas represent periods of financial fragility delimited according to Martínez et al. (2017e).

Source: Own calculations based on information from the CChC.

Table 5: Comparison between CCyB and dynamic provisions

Concept	CCyB	Dynamic provisions
Instrument	Capital	Provisions
Level	Tier 1	Stock/flow
Type	Stock	Normative/models
Accumulation	APR Decrease (composition or volume), capitalization	Loan decrease (it could be recomposition). Increase in loan-loss provisioning
Liberalization	Increase APR	Increase loans, write-off, negative expenditures
Limitation	Pro-cyclicality of loading risks	Pro-cyclicality of risks categories
Effects on return	Capital (denominator)	expenditures (numerator) and capital (denominator)
Activation	Policy decision	Automatic
Usage	System	Individual (with aggregated benchmark)
Externalities incorporation	Yes	No
Principal objective	Capital buffer (tier 1)	Smoothing cycle
Secondary objective	Smoothing cycle	Capital buffer (tier 2)

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