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Working Paper

Constructing a cyclical Systemic Risk Indicator (cSRI) for Malta

CBM Working Papers, No. WP/01/2024

Provided in Cooperation with:

Central Bank of Malta, Valletta

Suggested Citation: Vella, Sarah (2024) : Constructing a cyclical Systemic Risk Indicator (cSRI) for Malta, CBM Working Papers, No. WP/01/2024, Central Bank of Malta, Valletta

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Constructing a cyclical Systemic Risk Indicator (cSRI) for Malta*

Sarah Vella[†]

WP/01/2024

*I would like to thank Dr William Gatt Fenech for his helpful comments and suggestions and Dr Michele Andreani for his assistance in the construction of this indicator. I would also like to thank Ms Wendy Zammit, Mr Alan Cassar, Deputy Governor Mr Oliver Bonello, Deputy Governor Mr Alexander Demarco, Governor Professor Edward Scicluna and other participants in internal seminars for their helpful feedback. I wish to thank Dr Jan Hannes Lang for kindly reviewing this paper and suggesting areas for improvement.

A summary of this work is published in [Box 1](#) of the Financial Stability Report 2022. Any adjustments made in this paper after the publication of the Box are made with the aim to continuously improve this work. The same narrative and conclusions as those previously published still hold. Any errors are my own.

The views expressed in this paper are the author's own and do not necessarily reflect the views of the Central Bank of Malta. Correspondence: publicrelations@centralbankmalta.org.

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Abstract

Cyclical systemic risk arises when macro-financial imbalances accumulate over time. Past financial crises which occurred in several countries around the world have shown that heightened cyclical risk can lead to exorbitant economic and financial costs if the appropriate macroprudential policies are not enacted at the correct time. Although many indicators are monitored in the conduct of macroprudential oversight and analysis, there is to date no in-house country-specific composite indicator for cyclical risk for Malta developed by the Central Bank of Malta. This paper addresses this gap by building a cyclical systemic risk indicator (cSRI). The cSRI is driven by the 2-year growth rate in real bank credit, the 1-year change in the debt service to income ratio, the house price to income ratio and the 2-year growth rate in real total debt. These sub-indicators are believed to have early warning characteristics on financial distress. This indicator forms part of a cyclical risk analysis framework of the Central Bank of Malta, complementing other tools that support the formulation of macroprudential policy recommendations.

JEL Classification: G21, G23, G51

Keywords: Cyclical systemic risk, Real bank credit, House price to income, Debt service to income, Real total debt

Contents

1	Introduction	4
2	Literature Review	6
2.1	Domestic systemic risk indicator (d-SRI)	6
2.2	Country-specific studies	6
2.3	Systemic risk variables	8
2.3.1	Credit developments	8
2.3.2	Overvaluation of property prices	8
2.3.3	Private sector debt burden	8
2.3.4	Overall imbalances	9
3	Methodology	9
3.1	Sub-indicators	9
3.2	Principal Component Analysis (PCA)	12
4	The cSRI	13
5	Sensitivity Analysis	15
5.1	Adding the unemployment rate	15
5.2	Using transacted house prices	16
6	Signalling Properties of the cSRI	18
7	Conclusion	20
	Appendix A Data Appendix	25
	Appendix B Other Measures Considered	26
B.1	Measures of external imbalances	26
B.2	Measures of strength of banks' balance sheet	27
	Appendix C Signalling Properties of the Basel gap	28

1 Introduction

Cyclical systemic risk is dependent on the phase of the financial cycle. During the expansionary phase aggregate risk builds up due to growing credit, and surging financial and real estate asset prices, increasing private sector debt and collateral values. Once the general risk appetite decreases and doubts about the financial system’s sustainability arise, a contraction in the demand for these assets leads the financial cycle to reach its peak (Hodula and Pfeifer, 2018). Some macroprudential policies are aimed at decreasing the financial cycle’s pro-cyclical nature and the build-up of systemic risk. The spillover of severe financial market stress on the real economy has been shown to be costly due to decreased output and the negative impact associated with the wellbeing of society (Laeven and Valencia, 2012; Lo Duca et al., 2017). Due to this threat, the importance of building additional country-specific cyclical systemic risk measures cannot be understated. However, the monitoring of cyclical systemic risk and the identification of financial cycle periods when implementing macroprudential policies is a non-trivial task.

The countercyclical capital buffer (CCyB) is the main instrument that aims to address cyclical systemic risk, and is guided by a measure of the credit gap that aims to signal banking crises (ESRB, 2014). The CCyB is calibrated on the Basel gap - the deviation of the credit-to-GDP ratio from its long-term trend, the latter derived from a one-sided Hodrick-Prescott filter. Many studies show that the Basel gap offers reliable early warning signals for a systemic banking crisis (Borio and Lowe, 2002; Borio and Drehmann, 2009; Detken et al., 2014). However, as well documented in the literature, the Basel credit gap has several shortcomings that triggered the adoption of other methods to model financial cycles and for CCyB calibration.¹ Due to these weaknesses, complementary cyclical systemic risk measures have been developed by central banks.

Tölö (2020) highlights how the monitoring of credit dynamics is useful but not enough to identify the phase of the financial cycle. It is important that considerable information about financial cycles are summarised into one index due to the vast range of financial cycle indicators in existence. By synthesising and summarising financial cycle risks, the sub-indicators’ dynamics can easily be monitored whilst conveying relevant information about the build-up of systemic risk in the economy. When such a composite indicator has effective signalling properties, the negative impact caused by the systemic financial crisis can be mitigated preemptively when pronounced systemic risk is shown to be building up.

Presently, a cyclical systemic risk indicator (CSRI) for euro area countries exists (Detken et al., 2018). The CSRI has been developed by combining a domestic cyclical systemic risk indicator (d-SRI) and an exposure-based systemic risk indicator (e-SRI). The d-SRI measures the accumulation of imbalances that exist in the domestic non-financial private sector and is computed based on a pooled dataset for several euro area countries. The e-SRI captures risks stemming from cross-border spillovers. The combination of the d-SRI and the e-SRI is based

¹Lang et al. (2019) highlight the following three main weaknesses. Firstly, credit expansions spill into the credit-to-GDP trend after a credit boom, generating a persistently high trend. The resulting Basel gap would remain negative for quite some time. Second, the gap is impacted by the time series length that is used. This decreases the measure’s robustness when countries have short credit time series. Third, issues related to the ease of communicating results may arise when the credit-to-GDP data and its trend are both moving upwards but the trend is increasing at a faster rate, leading to a narrowing gap.

on sub-indicators that have early warning features that can predict vulnerable periods prior to a systemic crisis. When reviewing the CSRI, [Constâncio et al. \(2019\)](#) note that considerable cross-country heterogeneity in the CSRI exists across the euro area. The authors emphasize the importance of having country-specific macroprudential policies, including a country-specific CSRI.

Whilst a d-SRI for Malta exists, the application of existing cyclical systemic risk indicators may not always be adequate due to the following issues. The d-SRI is based on past systemic crises. Unlike other countries, Malta did not experience systemic crises in its recent macroeconomic past, and any observed systemic stress in Malta was short-lived and was not comparable to that of other countries used to obtain the d-SRI. The d-SRI sub-indicators, weights and normalisation, which are discussed in more detail in the next section, are not specifically adapted to reflect the financial system characteristics of a specific country. Hence, the sub-indicators used in the d-SRI may require modification or be dropped when applied to the Maltese economy. For instance, in recent years Malta registered a strong net international investment position (NIIP) which increases the likelihood that the current account overestimates the financial stability risk present. This impact on the d-SRI can be amplified given the high default weight of 22% on the current account in the d-SRI. In the case of Malta, balance of payments data are still subject to substantial data revisions between successive news releases. A large weight on the current account therefore leads to large historical changes to the d-SRI for Malta, as explained in [Appendix B](#). Furthermore, the default d-SRI 5% weight on the debt service ratio may be quite low. This 5% weighting has been imposed as sub-indicators are not allowed to have a lower weight. High indebtedness of non-financial corporations (NFCs) and households could play an important role in driving cyclical systemic risk in Malta, and therefore it may be important to attribute more weight to this sub-indicator.

In light of these issues, the main motivation behind this paper is to construct a cyclical systemic risk indicator (cSRI) that summarises cyclical risk and financial crisis vulnerabilities specific to the Maltese economy. A country-specific indicator for Malta can be used to complement other cyclical systemic risk measures and to identify periods of high cyclical systemic risk, leading to timely macroprudential policy response. This country-specific indicator is constructed as a subset of early warning sub-indicators which include the 2-year real bank credit growth, the 1-year change in debt service to income ratio, the house price to income ratio and the 2-year real total debt growth. This paper presents the details of how the cSRI is constructed, and shows its usefulness for signalling developments in cyclical risks. The cSRI is one of the indicators that the Central Bank of Malta uses to monitor cyclical systemic risk in Malta.

This paper is divided as follows. Section 2 provides some background on the d-SRI and other country-specific indicators. Sections 3 and 4 present the methodology and the cSRI, respectively. A sensitivity analysis behind the constructed cSRI is presented in Section 5 whilst the signalling properties of the cSRI are discussed in Section 6.

2 Literature Review

2.1 Domestic systemic risk indicator (d-SRI)

The systemic risk indicator which is developed in this paper for Malta, is based on the d-SRI proposed by [Lang et al. \(2019\)](#) as it is used by the European Central Bank (ECB) for the euro area and at a country-level. The d-SRI is computed as the optimal weighted average of six early warning indicators normalised indicators from the pooled indicator distribution. The selected variables are also based on the ESRB Recommendation C ESRB/2014/1 which provides guidance on variables that indicate the accumulation of system-wide risk linked with times of excessive credit growth, aimed to detect cyclical movements.² [Lang et al. \(2019\)](#) use a panel data approach incorporating euro area countries, Sweden, Denmark and the UK covering a sample period from 1970s until 2016. The use of pooled data also aids to lessen any sample selection bias that arises from short data samples for countries like Malta. However, pooled data can ignore any structural dissimilarities across countries, emphasising the need of having a country-specific indicator.

The authors argue that a panel dataset is able to take into account any common movements in the particular sub-indicators during the time of a systemic crisis. A pooled normalisation of the sub-indicators and constant weights guarantee a harmonised indicator across countries. The authors use a dependent variable that captures the vulnerability of a country to a systemic crisis, provided by [Lo Duca et al. \(2017\)](#), to derive the weights for the d-SRI. Since there is no indication that a systemic crisis was experienced in Malta during the time period considered by [Lang et al. \(2019\)](#), this approach may not be adequate in the case of Malta. The weights attributed to all sub-indicators in the d-SRI are shown in Table 1. The authors also show the optimal weights change when either equity prices or the current account are excluded from the d-SRI. The d-SRI which excludes real equity prices is referred to in this paper when making any reference to the d-SRI. This exclusion is made due to the lack of depth in the Malta Stock Exchange, where price movements are caused by few transactions. [Lang et al. \(2019\)](#) test the indicator’s ability to anticipate the likelihood and severity of future crises, and find that it is able to identify cyclical systemic risks that originate from changes in real estate markets, domestic credit, external imbalances and asset prices.

2.2 Country-specific studies

Both the Central Bank of Slovakia and the Czech National Bank use composite financial cycle indicators to set the CCyB rate. The estimates from the indicators are translated to a benchmark buffer guide. The Central Bank of Slovakia uses a composite cyclical risk indicator called the “cyclogram” ([Rychtárik, 2014](#); [Kupkovič and Šuster, 2020](#)). Six core variables and seven supplementary variables are aggregated into the cyclogram under three main categories: customers, financial cycles and banks. Historical distributions are used to evaluate the indicators’

²The variables indicating the accumulation of system-wide risk as suggested by ESRB/2014/1, include measures of potential overvaluation of property prices, measures of credit developments, measures of external imbalances, measures of the strength of banks’ balance sheets, measures of private sector debt burden, measures of potential mispricing of risk, and, measures derived from models combining the credit-to-GDP gap and the rest of the measures ([ESRB, 2014](#)).

Table 1: Overview of d-SRI weights

Sub-indicator	Benchmark	d-SRI weights	
		Ex. equity	Ex. current account
2-year change in bank credit to GDP ratio, p.p.	36%	45%	52%
2-year growth rate of real total credit, %	5%	5%	5%
3-year change in RRE price to income ratio, p.p.	17%	23%	21%
Current account to GDP ratio, %	20%	22%	-
2-year change in the debt service ratio, p.p.	5%	5%	5%
3-year growth rate of real equity prices, %	17%	-	17%

Source: [Lang et al. \(2019\)](#)

link to the buffer guide. This work contributes to the financial cycle literature for small open economies like Malta.

Similarly, the Czech National Bank adopts a financial cycle indicator that covers a wide range of indicators such as credit growth, property prices and the current account deficit-to-GDP ratio whilst taking into account endogenous co-movement between input variables. Weights are constructed to estimate the future loan losses in an optimal manner. Hence, variables that do not explain the materialisation of credit risk are attributed minimal weights in the indicator ([Plašil et al., 2013](#)).

The Central Bank of Ireland maintains more than 80 macroprudential indicators that explain the evolving nature of systemic risk within the modern financial system. These indicators are complemented by values that indicate pronounced risk and visualisation methods such as heatmaps and are categorised according to four objectives. [Ryan et al. \(2017\)](#) outline the consideration of enhancing the practicality of the indicator by setting thresholds according to any of the following three main methods. Firstly, the signal extraction method laid out by [Drehmann et al. \(2012\)](#) and [Borio and Drehmann \(2009\)](#) is used to examine the behaviour of indicators preceding past financial crises and to signal if the indicator is above a given threshold. Secondly, thresholds are set by analysing the historical or cross country distribution of an indicator and identifying stable values by deriving average values. However, this method is purely statistical whilst cross country comparisons would not reflect cross country structural differences. Thirdly, existing early warning indicator literature such as [Lo Duca and Peltonen \(2011\)](#) and [Drehmann et al. \(2011\)](#) and international policy setting groups such as the [Basel Committee on Banking Supervision \(2010\)](#) and [ESRB \(2014\)](#) are consulted, to establish the correct thresholds. These indicators are examined whether to be correct or not by assessing the difference between the false warnings and correct predictions across the threshold ranges.

A recent paper by [Škrinjarić \(2023\)](#) studies various possible techniques to develop a cyclical risk composite indicator that aims to mitigate the financial system’s pro-cyclicality in Croatia. These alternative techniques include the cyclogram, the financial cycle composite indicator and the systemic cyclical risk indicator amongst others. The author acknowledges that the construction of a cyclical risk composite indicator is hampered by the short sample period available and the instability of the variables required for cyclical risk monitoring. The author identifies that the most suitable composite indicator to adequately monitor systemic risk in Croatia is a modi-

fication of the d-SRI presented by [Lang et al. \(2019\)](#). The d-SRI for Croatia uses variables that have historically indicated potential risks before a financial crisis, enabling easier interpretation. A drawback in using this approach is that data normalisation is only performed using Croatian data rather than a pooled dataset, rendering it less comparable with that constructed for other countries by [Lang et al. \(2019\)](#).

2.3 Systemic risk variables

This section describes the main macro-financial variables aimed to detect cyclical movements according to existing literature. These variables are grouped according to the variables that indicate the accumulation of system-wide risk linked with times of excessive credit growth as provided by the ESRB Recommendation C ESRB/2014/1 ([ESRB, 2014](#)).

2.3.1 Credit developments

A banking institution’s main activity is lending. Hence, credit developments play a dominant role when analysing the build-up of cyclical systemic risk. In the literature, credit developments have shown to have good predictive power of past banking crises ([Borio and Lowe, 2002](#); [Schularick and Taylor, 2012](#); [Aldasoro et al., 2018](#)). When future incomes are anticipated to increase as a result of economic growth, the borrowing demand of the private sector increases. Banking institutions are more inclined to provide loans to riskier clients during times of economic optimism as lending standards may be relaxed whilst economic agents typically experience declining ability to identify risk during economic growth ([Plašil et al., 2015](#)).

2.3.2 Overvaluation of property prices

When compared to other real economy-based measures, house prices relative to household income have more predictive power in anticipating a crisis ([Detken et al., 2014](#)). In fact, rising house prices impose a major concern on financial stability when combined with strong credit growth ([Behn et al., 2013](#); [Jordà et al., 2015](#)). Loan financing is typically used to fund a house purchase whilst the value of a house plays a vital role in the collateral process. Hence, housing-backed loans form a considerable part of the balance sheets of banking institutions and households, rendering such market players vulnerable to house price corrections. Banks may suffer significant losses brought by home mortgage defaults and defaults in loans to construction firms during an economic downturn. One of the drivers that leads to increasing real estate prices during an economic upturn is the wealth impact, which leads to an expansion in real estate demand. [Grinderslev et al. \(2017\)](#) show how dynamics in the real estate market anticipate fluctuations in the loan market, providing some information for future lending.

2.3.3 Private sector debt burden

The accumulation of rising indebtedness can negatively impact a country’s financial stability ([Rinaldi and Sanchis-Arellano, 2006](#)). Unsustainable indebtedness results in credit risk as borrowers such as households and firms would not be in a position to cover their debt service

obligations. Consequently, Gross Domestic Product (GDP) and consumption are impaired leading to vulnerability in the longer term (Lombardi et al., 2017). Most studies consider debt ratios when analysing financial stability in a country. For example, Plašil et al. (2015) consider the debt-to-disposable income ratio to conclude that financial stability was being impaired through solvency reductions as the private sector had been overestimating its ability to service debt in the future. Debt service ratios and debt income ratios have been shown to be indicative of past financial crises (Drehmann and Juselius, 2014; Giese et al., 2014). Furthermore, Detken et al. (2014) conclude that household debt burden is more useful in terms of signalling financial crises when compared to non-financial corporate debt service ratios.

2.3.4 Overall imbalances

Apart from the implications on financial stability resulting from private sector indebtedness discussed above, literature shows that high government (and private) indebtedness can elevate systemic risk and the probability of a financial crisis (Manasse et al., 2003; Dawood et al., 2017). Hodula and Pfeifer (2018) find that the level of government debt before a crisis is positively related with cyclical and credit risk materialisation. Ari et al. (2020) identify that high public debt, high corporate debt of short term maturity and high credit growth are fundamental variables that rapidly increase the growth of non-performing loans (NPLs) during a banking crisis. Hence, these different types of debt may also contribute to higher systemic risk.

3 Methodology

3.1 Sub-indicators

The d-SRI is used as the starting point for the selection and composition of the sub-indicators. However, once replicated using the default weights provided from a pooled distribution, the resulting indicator is not a good reflection of the recent financial environment in Malta, as discussed above. A wide range of methods are considered to derive the sub-indicator weights. Existing literature makes use of an early warning model to derive the predictive ability of various indicators to signal future crises (Lang et al., 2019; Alessi and Detken, 2018; Candelon et al., 2012; Kaminsky and Reinhart, 1999). The absence of a recent history of financial crises in Malta renders the approach used to derive weights by Lang et al. (2019) for the d-SRI unfeasible. Instead, this paper uses Principal Component Analysis (PCA) as a way to capture important co-movement among the set of variables. The application of PCA ensures that the resulting composite indicator maximises the information content found in the data while reducing its dimensionality. Since this technique is purely statistical, a number of criteria which guide the suitability of the results were set. Firstly, the factor loadings of the sub-indicators were expected to capture a positive relationship with cyclical systemic risk in line with a priori expectations. Secondly, none of the chosen sub-indicators were allowed to dominate in terms of the weighting scheme used. If the above two criteria were satisfied the resulting cSRI was then assessed using expert judgment to assess whether the peaks and troughs lined up with a narrative of events over the sample period. If this was judged to be unsatisfactory, different variable transformations

were explored (such as switching between ratios and different period growth rates). The variables considered were always based on the ESRB Recommendation C ESRB/2014/1 which provides guidance on variables that indicate the accumulation of system-wide risk linked with times of excessive credit growth, aimed to detect cyclical movements such as in the d-SRI.³ The chosen sub-indicators satisfying such criteria had to drive a cSRI that is capable of reflecting most accurately Malta’s recent cyclical systemic risk environment when compared to earlier versions of the cSRI derived. For example, whilst the bank credit-to-GDP ratio had a positive relationship with cyclical systemic risk, its weight dominated the cSRI due to the significant growth recorded in Malta’s GDP in recent history resulting in a cSRI that reflected the economic developments in GDP rather than the financial environment in Malta. The 1-year and 2-year growth rates in credit were tested and the latter was ultimately used instead of the ratio. During the process, the current account was characterised by frequent data revisions as explained in Appendix B. Instead of using the current account due to the associated repercussions, total debt is used as a proxy to track Malta’s borrowing/lending position indirectly. Higher public or private debt finance a current account deficit whilst less public or private debt may be accumulated when the current account registers a surplus.

The variables which met the criteria discussed above are the 2-year real bank credit growth rate, the house price to income ratio, the 1-year change in the debt service to income ratio and the 2-year growth rate in real total debt, and are plotted in Figure 1.⁴ They are considered on a quarterly basis, ranging from 2006Q1 to 2022Q4. The variables selected are also based on the desired characteristics that variables used in a cyclical composite indicator should have, as outlined in EU and UN (2017).⁵

³The variables indicating the accumulation of system-wide risk as suggested by ESRB/2014/1, include measures of potential overvaluation of property prices, measures of credit developments, measures of external imbalances, measures of the strength of banks’ balance sheets, measures of private sector debt burden, measures of potential mispricing of risk, and, measures derived from models combining the credit-to-GDP gap and the rest of the measures (ESRB, 2014).

⁴Technical details about these variables as well as sources are outlined in Appendix A. Other variables pertaining to the macroeconomy, strength of banks’ balance sheets and external imbalances were considered but not used as explained in Appendix B.

⁵These characteristics include consistency, clarity, objectivity, impartiality, transparency, comparability, methodological soundness, interpretability and readability. In practice, it is not always straightforward or possible to meet all of these criteria.

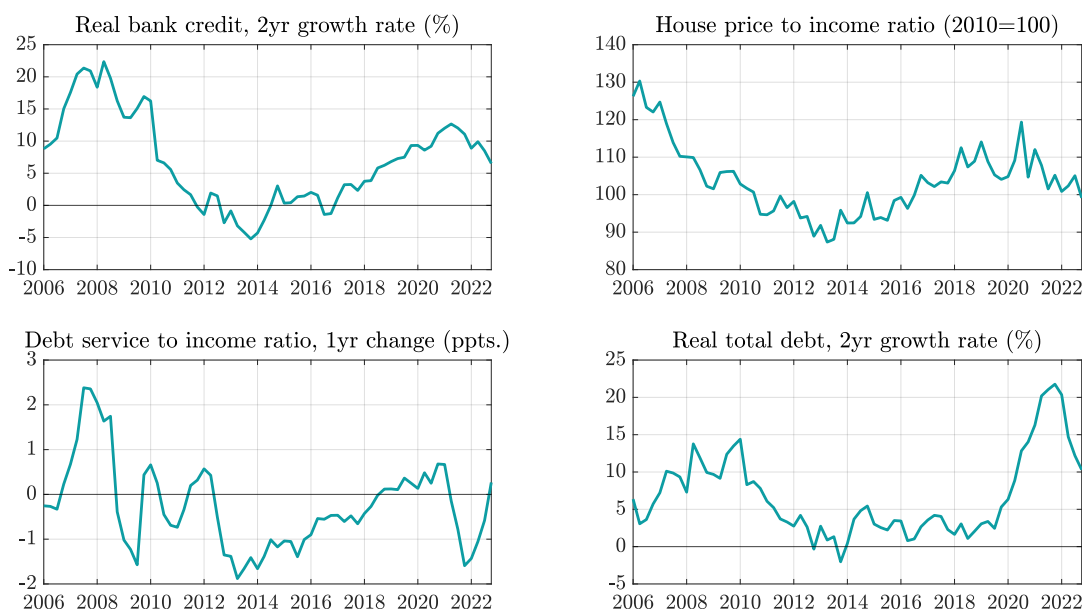


Figure 1: cSRI sub-indicators

Sources: Central Bank of Malta; ECB Statistical Data Warehouse; Eurostat; author's calculations.

The 2-year growth in real bank credit peaks in 2008, then declines significantly reaching a trough by 2014. This variable then trends upwards until 2022 but at a slower pace when compared to its historic upward trend experienced before 2008. The 2-year real bank credit growth rate and the house price to income ratio have similar dynamics over the years as seen in Figure 1. The house price to income ratio peaks around 2007, reaches a trough by 2013 and then modestly increases before stabilising at the long-run average. Between 2006 and 2012, the change in the debt service to income ratio fluctuates significantly before increasing steadily from 2013 onwards until 2020. A significant drop in the change in the debt service to income ratio is experienced around 2022 due to the considerable decrease in GDP caused by the COVID-19 pandemic. The 2-year growth rate in real total debt remains positive, mainly below 15 per cent, during the sample period considered. A significant increase in real total debt is experienced in 2022 due a considerable increase in public government debt reflecting the significant fiscal measures by Government to ease the effects brought about by the pandemic.

3.2 Principal Component Analysis (PCA)

The weights for each sub-indicator are obtained using the PCA method. The cSRI constructed in this paper is based on the weighted sum of the individual normalised sub-indicators, $z_{i,t}$, apportioned according to their respective allocated weights, w_i .⁶

$$cSRI_t = \sum_i z_{i,t} w_i \quad (1)$$

The cSRI is generated as the first principal component able to summarise the sub-indicators the most efficiently without sustaining significant information loss.⁷ This estimation is done on a sample period ranging from 2006Q1 to 2022Q4.⁸ Around 63% of the variation in the observed sub-indicators is explained by the cSRI. The factor loadings and resulting weights for the cSRI are displayed in Table 2.

Table 2: Contributions to the cSRI

Sub-Indicators	Factor Loadings	Weights (%)
Real bank credit, 2-year growth rate	0.60	35.6%
Debt service to income ratio, 1-year change	0.48	23.3%
House price to income ratio	0.49	23.8%
Real total debt, 2-year growth rate	0.42	17.3%
Proportion of variance explained	63.4%	

The weight on real bank credit growth rate is relatively high, but does not dominate the other weights, in line with the criteria set above. The debt service to income ratio and the house price to income ratio have approximately equal weights. All sub-indicators move in the same direction of domestic cyclical systemic risk, in line with a priori expectations. Real bank credit also acts as a substitute in raising funds on the capital market. The real bank credit component is also reflected within the real total debt sub-indicator, attributing further importance to real bank credit. The debt service to income sub-indicator has a higher weight than 5% when compared to the d-SRI, considering that high private sector indebtedness can be important to drive cyclical systemic risk in Malta.

⁶Before implementing the PCA, the sub-indicators are standardised given the PCA attributes more weight to variables that have a relatively higher variance than the other variables with lower variance. This is done by subtracting the mean and dividing by the standard deviation for each value of each sub-indicator using data for Malta.

⁷Numerous PCAs were generated during the research process due to the different variables considered, data transformations and different sample periods.

⁸The sample starts from 2006Q1 due to the lack of data available for credit to NFCs as debt securities before 2004. This variable is used in the 1-year change in the debt service to income ratio sub-indicator and in the 2-year growth rate in real total debt sub-indicator. Provisional data and several assumptions were used to derive the cSRI for the last observation (2022Q4) as not all data for this quarter was published at the time of writing of this paper. Hence, the cSRI at this data point can be subject to further revision.

4 The cSRI

The cSRI derived ranging from 2006Q1 to 2022Q4, together with its contributions, is shown in Figure 2. The build-up of positive values reflects the net accumulation of systemic risk when above zero, and the phasing down of cyclical risk when the indicator trends downwards (even if above zero). Negative values indicate very low cyclical risk.

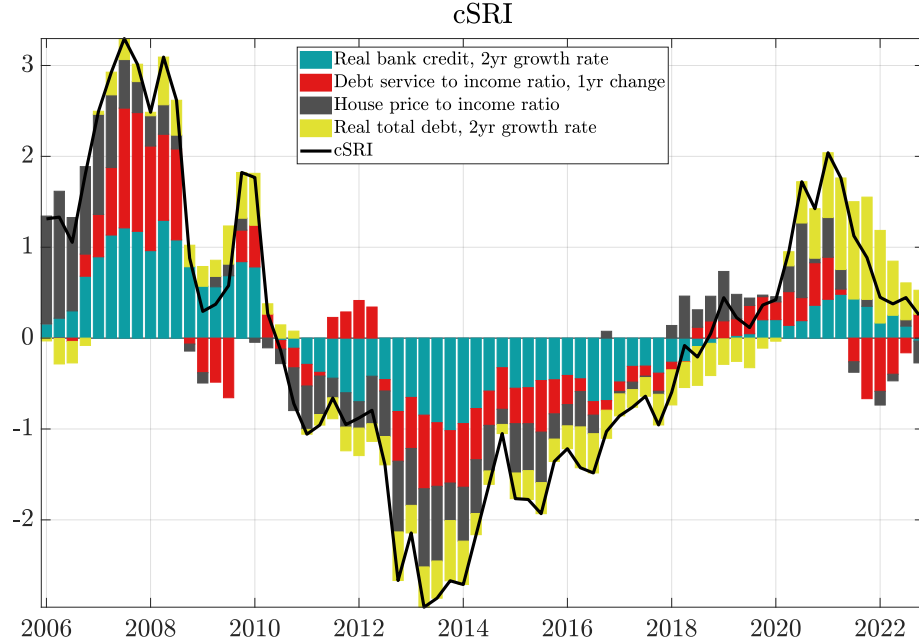


Figure 2: cSRI

House price overvaluation was evident during the time of the European Union membership in 2004 which peaked in 2006-2007 (Micallef, 2016). During such period, the cSRI is partly driven by an elevated increase in the house price to income ratio and the growth in real bank credit being reflected as well through real total debt. Between 2006 and 2010, the indicator remains elevated as almost all sub-indicator variables contribute to heightened systemic risk, leading the cSRI to reach high values during 2007Q3 and 2008Q2. Private sector debt in Malta was following an upward trend as an increase in household indebtedness was reflecting an expansion in the mortgage market. This reflects the positive and later negative contribution of the 1-year change in the debt service to income (DSTI) ratio to cyclical systemic risk prior to 2010. This period coincided with the Global Financial Crisis (GFC) when extreme stress was experienced in global financial markets and banking systems. During the GFC, lending to companies contracted whilst household credit flow remained positive in Malta. More government debt was being registered by the end of 2009, yet still below the euro area average during the time (Bonello, 2010). A notable GDP outlay was the assistance to manufacturing firms in addition to other stimulus measures (Bonello, 2010). The increase in general government debt could have likely increased

the cyclical systemic risk present. However, the contribution of real total debt remains small when compared to the other sub-indicators. After 2010, the 2-year growth rate in real total debt stabilised, contributing to lower cyclical systemic risk.

From 2010 and until 2018, the 2-year growth in bank credit was more modest when compared to prior years. Coupled with its relatively large weight, this sub-indicator contributed to lower systemic risk during this period. Tighter bank lending standards were in force between 2011 and 2013 causing financing demands by NFC to stabilise, as shown from the Bank Lending Survey (Zerafa, 2017). Such credit conditions stabilised the private sector burden, which could have contributed to lower systemic risk environment. By 2013, a trough in house prices was reached and the house price to income ratio was on a constant decline until 2013. The lowest value of the cSRI is registered during 2013 as favourable economic performance was being experienced as a turning point in Malta's economic cycle. After 2013, an upward trend in the cSRI characterises the build-up of systemic risk. House prices increased significantly in 2014 and 2015, reaching equilibrium levels by the end of 2015 (Gatt and Grech, 2016). To stimulate the housing market, several government measures were implemented, such as the Capital Gains Tax reform, the 2014 investment registration scheme as well as the stamp duty reduction for different classes of property buyers. This coincided with an increasing house price to income ratio and a negative contribution to systemic risk until 2018. Low cyclical systemic risk is maintained for several years until 2019.

During the COVID-19 pandemic, financial stability risks stemming from the housing market remained contained, potentially partly due to government guarantee schemes and the moratoria implementation, the latter also reducing the likelihood of bank loan defaults, keeping asset quality in check for banks.⁹ During 2020, private sector debt increased due to an increase in corporate indebtedness. However, the 4-quarter increase in the GDP from 2020Q4 to 2021Q4 was quite significant due to a one-off decrease in GDP as a result of the COVID-19 pandemic, causing a sharp decline in the DSTI ratio. By the end of 2020, resident credit growth increased due to higher credit to NFCs potentially being impacted by schemes such as the Malta Development Bank (MDB) COVID Guarantee Scheme, while household lending growth remained rather stable. At the height of the COVID-19 pandemic, the cSRI peaks again in 2021 being mostly driven by the contribution of public debt within the real total debt sub-indicator. To fill the funding needs caused by decreasing revenue, the stock of general government debt increased significantly when compared to 2019 (Attard and Farrugia, 2022). Financial stability risks likely remained contained in the subsequent year partly due to such pronounced government intervention in addition to other interventions by the ECB. Banking institutions had enough liquidity and capital as well as a continuous flow of deposits which also likely led to financial stability risks to remain contained. Investor confidence recovered, causing stronger growth in the 2-year bank credit growth contributing to higher cyclical risk when compared to the long-run. The

⁹The Central Bank of Malta (CBM) issued Directive 18: *"On Moratoria on Credit Facilities in Exceptional Circumstances"* on 13 April 2020 to regulate the temporary six-month suspension of repayments on capital and interest. This moratoria was implemented on credit facilities advanced by credit and financial institutions to borrowers who were negatively impacted by COVID-19, prior to 13 April 2020. During 2021, borrowers were allowed to extend their existing moratoria or to apply for a new moratoria subject to a number of conditions (Central Bank of Malta, 2021). Other central banks and macroprudential authorities similarly enacted their own moratoria.

2-year growth rate in bank credit decreased to reach 2019 levels by the end of 2022, reducing its contribution to the cSRI. The growth rate in real total debt also followed a downward trend during 2022 mainly due to a slower increase in government debt when compared to 2021. Government support measures were being phased out and economic activity recovered, leading to higher tax revenue. By 2022Q4, the cSRI indicates low yet stable cyclical risk.

This qualitative time-series analysis of the cSRI shows that the indicator is able to deliver a sensible narrative about the accumulation of cyclical systemic risk in Malta over time. The cSRI is equipped with macro-financial variables which are closely aligned with the movement of cyclical systemic risks in Malta, delivering reasonable insights on Malta’s recent financial and macroeconomic environment.

5 Sensitivity Analysis

5.1 Adding the unemployment rate

As mentioned above, the cSRI is tested to include other variables such as the unemployment rate which captures the percentage of individuals from 15 to 64 years that are unemployed according to the Labour Force Survey (LFS). [Lang et al. \(2019\)](#) show that the peak d-SRI value before crises is correlated with subsequent unemployment rate increases during these crises. However, although the factor loading on the unemployment rate carries the expected (positive) sign, it is very small and yields a very low weight to the unemployment rate. This is taken as evidence that this macroeconomic variable does not provide additional contribution to the cSRI (Table 3). The inclusion of the unemployment rate reduces the variance explained of the PC significantly from 63% to 51%, indicating a lower degree of relatedness to the other subcomponents.

Table 3: Contributions to the cSRI - adding the unemployment rate

Sub-Indicators	Factor Loadings	Weights (%)
Real bank credit, 2-year growth rate	0.60	35.7%
Debt service ratio, 1-year change	0.48	23.3%
House price to income ratio	0.49	23.8%
Real total debt, 2-year growth rate	0.41	17.2%
Unemployment, rate	0.00	0.0%
Proportion of variance explained	50.7%	

It can be argued that the unemployment rate typically lags business and financial cycles, rather than leading them. [Lang et al. \(2019\)](#) note how increases in the unemployment rate for euro area countries are registered only after the maximum level of the d-SRI is reached on the onset of a systemic financial crisis. Unemployment rises a year after the onset of a crisis and is likely to significantly increase in the subsequent years. When a crisis materialises, increasing values of the cSRI are still associated with increasing real economy costs given the sub-indicators of the cSRI capture the accumulation of macro-financial imbalances.

5.2 Using transacted house prices

Another sensitivity analysis that is performed involves another measure of the house price to income ratio. The National Statistics Office (NSO) transacted house price index is used instead of the Central Bank of Malta (CBM) advertised house prices. Before 2009, the growth rate in the NSO house price index seems to lag behind the growth rate of the CBM house price index (Figure 3). From 2010 onwards both growth rates follow similar paths with more subdued growth rates in the NSO house price index from 2017 onwards (Figure 3).

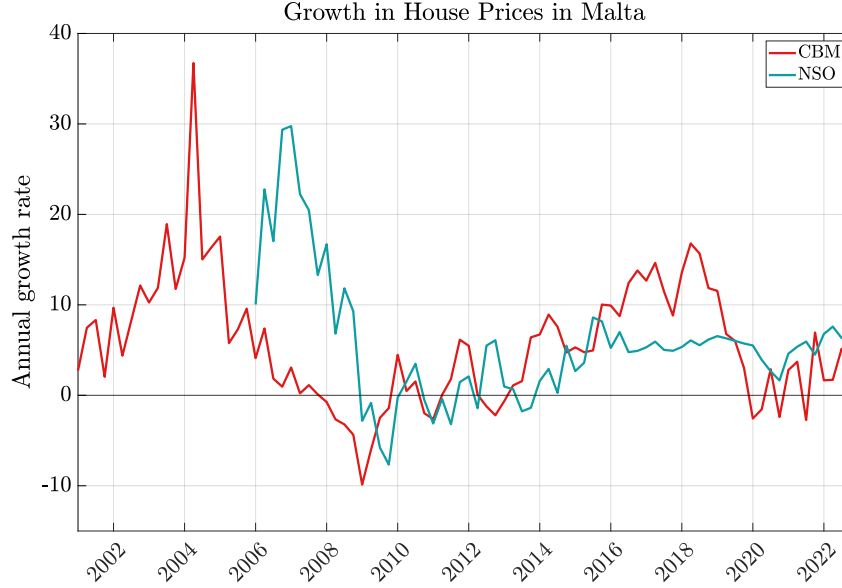


Figure 3: Annual growth rates in property prices across different price indices

Figure 4 plots the contributions of the cSRI when using the NSO house price index using the re-estimated PC weights as shown in Table 4. The weight of the house price to income ratio decreases from 23.8% to 20.6% when the transacted house price index is used. This weight decrease is apportioned to real total debt whose weighting increases from 17.3% to 19.8%. The PC explains 61% in the variance in the dataset used, a decrease of almost 3 percentage points compared to when using advertised house prices.

Table 4: Contributions to the cSRI - using transacted house prices

Sub-Indicators	Factor Loadings	Weights (%)
Real bank credit, 2-year growth rate	0.61	37.2%
Debt service ratio, 1-year change	0.47	22.4%
House price to income ratio	0.45	20.6%
Real total debt, 2-year growth rate	0.45	19.8%
Proportion of variance explained	60.5%	

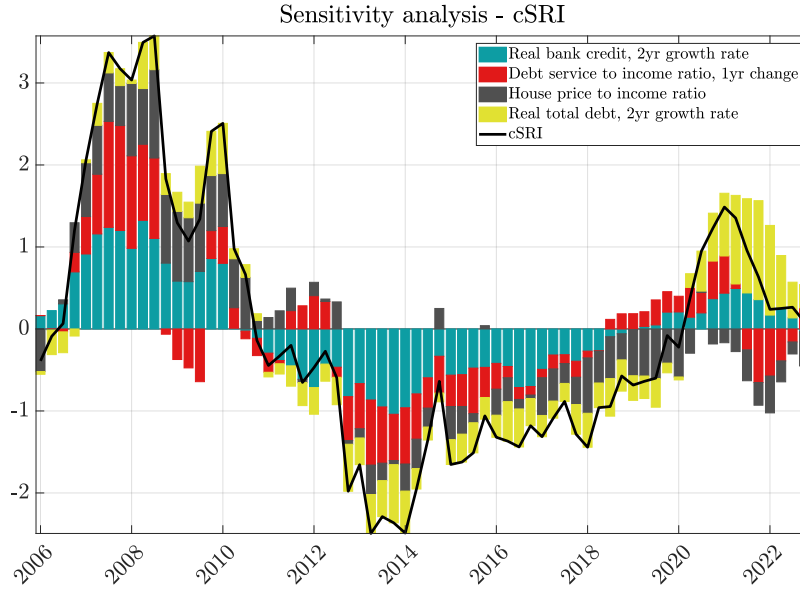


Figure 4: cSRI based on transacted house prices

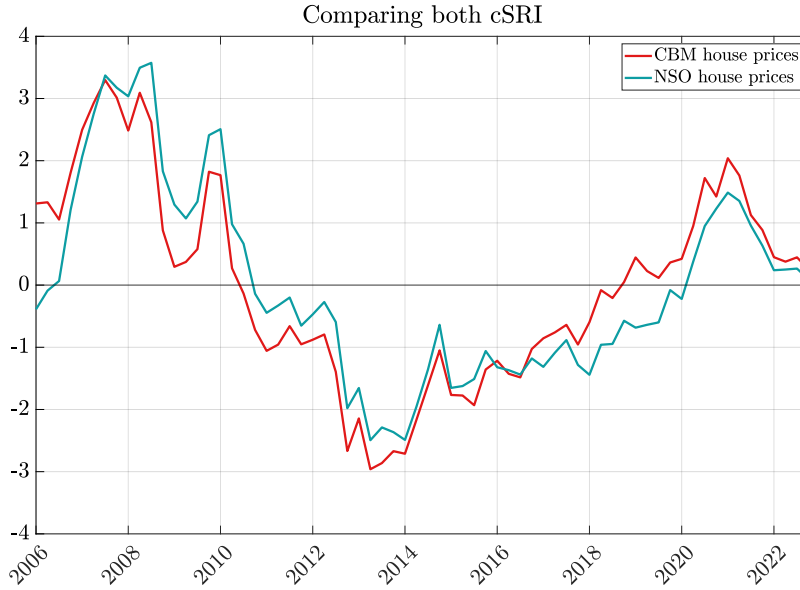


Figure 5: cSRI using different house price indices

The cSRI based on NSO house prices has some lagging features when compared to the cSRI based on CBM house prices before 2010 and after 2020 (Figure 5). For the rest of the sample, both cSRIs have similar dynamics. Both indicators peak in 2008Q2, however the peak of the cSRI based on the NSO house prices is more pronounced owing to a higher growth rate in the

NSO house price index when compared to the CBM index (Figure 3). The heightened cyclical risk indicated as a result of the COVID-19 pandemic is also more subdued when considering the indicator based on NSO house prices as the latter grew within the same range as prior years (Figure 3). The CBM index has more desirable properties for the construction of the cSRI. Firstly, it incorporates market expectations and therefore signals expected developments in the economy. Secondly, it is also updated more frequently than the NSO index, allowing the cSRI to be updated with more timely data.

6 Signalling Properties of the cSRI

Does the cSRI contain early warning properties about future economic outcomes? Impulse response functions (IRFs) using local projections are used in this paper to formally test the predictive power of the indicator on future real annual GDP growth.¹⁰ The aim of this exercise is to measure the ability of the cSRI in predicting large declines in future real GDP growth. The use of local projections to compute impulse response functions was introduced by Jordà (2005) in the application of monetary policy shocks.¹¹ Lang et al. (2019) use impulse responses obtained from local projections to analyse the predictive power of the d-SRI in movements in euro area GDP for the future. The authors find no immediate impact but a delayed yet significant impact at longer horizons. When the d-SRI increases by one standard deviation, future real GDP growth declines by approximately 4 percentage points, three to four years ahead, on average.

The model presented in equation 2 is used to shock future real annual GDP growth by the cSRI, using the sample period from 2006Q1 to 2022Q4. The first lag of the GDP for Malta and four lags of both the euro area GDP and the euro area shadow short rate (SSR) are included as control variables. These control variables are used to remove any other potential impact on future real annual GDP growth that is not caused by the shock on the indicator. The IRF is the vector of the estimated β_h at horizon 1 to h , representing the effect of changes in the indicator on GDP. The impulse responses for Malta are based on a horizon period of up to 20 quarters.¹²

$$GDP_{t+h}^{MT} = \alpha + \beta_h cSRI_t + \beta_{h,1} cSRI_{t-1} + \delta_h GDP_{t-1}^{MT} + \sum_{i=0}^4 \gamma_h GDP_{t-i}^{EA} + \sum_{i=0}^4 \mu_h SSR_{t-i} + \epsilon_t \quad (2)$$

Figure 6 shows the response of real GDP growth to a one standard deviation increase in the cSRI.¹³ The IRF presented shows that some signalling properties resulting from a shock in the

¹⁰The empirical linkages between economic growth and systemic risk have also been studied using single-equations and VAR-based quantile regressions, to evaluate the predictive properties of an indicator on real GDP growth in the short-run as performed by Chavleishvili and Kremer (2023). These authors find that the constructed variant of the ECB's Composite Indicator of Systemic Stress (CISS) (an indicator used to measure the severity of a crisis and the general financial conditions) for the euro area and the US has strong forecasting properties for the short-term economic activity when the economy is in a bad state.

¹¹Jordà (2005) presents the main idea behind local projections whereby at each period local projections are estimated rather than estimating vector autoregressions (VAR). Local projections allow the estimation of basic regression methods with simple regression packages and they are also equipped with misspecification robustness.

¹²The package 'lpirfs' was used in R to run the local projections (Adämmer, 2019).

¹³The confidence bands are based on the respective estimated standard errors signalling ± 1.96 standard

cSRI do exist. However, the impulse response functions are very sensitive and highly dependent on the regression specification used in equation 2. Hence, the response of real GDP growth to one standard deviation increase in the cSRI over a horizon of 20 quarters is only indicative and is subject to change when the regression specification is altered. Furthermore, degrees of freedom fall quickly over the horizon period given that only a maximum of 68 observations are available for estimation. The first trough in real GDP growth is recorded around one and a half year ahead. However, the wide confidence intervals at this point imply that this effect is estimated with high imprecision and is statistically not different from zero. The confidence intervals narrow when the next drop in real GDP growth is recorded, three to four years ahead. The confidence intervals at this point indicate a greater degree of precision to derive the following conclusion. On average, an increase of one standard deviation predicts a decline in future real GDP growth, three to four years ahead. This result is consistent with the implications on future real GDP growth derived by [Lang et al. \(2019\)](#), although the decline in GDP growth is much less pronounced, given that Malta did not experience any significant crisis during the sample period of this study. Hence, the cSRI conveys sensible early warning properties. The signalling properties of the cSRI are also superior to the signalling properties of the Basel gap for Malta. The Basel gap provides a counter-intuitive and insensible prediction on real GDP growth.¹⁴ The cSRI is the only indicator thus far which delivers the expected prediction for Malta.

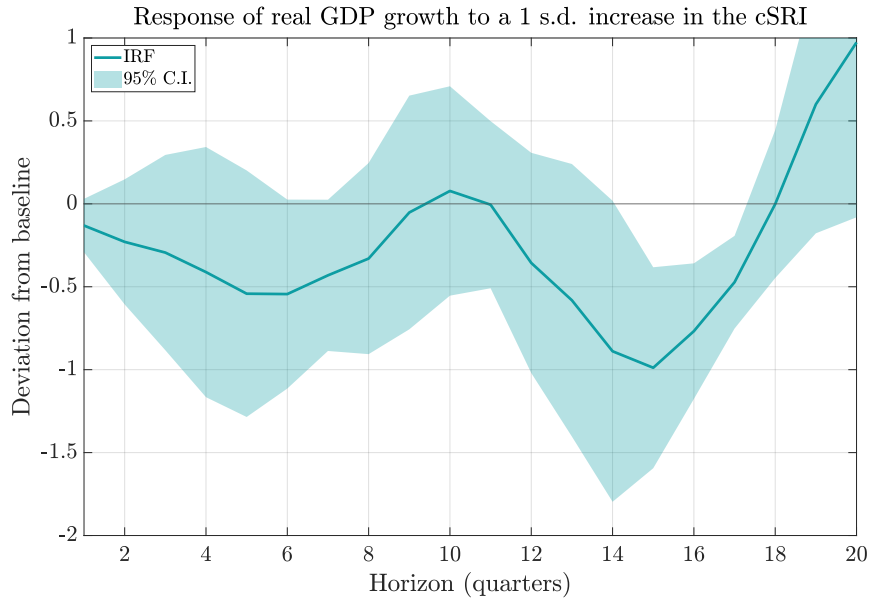


Figure 6: Signalling properties of the cSRI

deviation.

¹⁴Refer to Appendix C for further details.

7 Conclusion

This paper documents the construction of a simple yet effective indicator of cyclical risk in Malta, based on PCA on a set of relevant variables. The cSRI presented in this paper follows a cyclical profile over time, indicating periods of high and low risk in Malta. This risk emerges from credit developments, private sector debt burden, affordability of house prices and total debt developments. The cSRI can potentially flag a systemic crisis in advance, as this paper shows that the indicator has early warning characteristics on the basis of the macro-financial variables that feature in it. It is not envisaged that the cSRI will be used in a mechanical way, on account of the fact that its real-time signalling power remains to be tested more thoroughly. Furthermore, the conduct of policy is rarely reliant on a single indicator, but draws on multiple sources, given the uncertainty that may surround any particular indicator, especially when it is latent. To this end, the adoption of a cSRI contributes to the cyclical risk analysis framework of the Central Bank of Malta which is regularly assessed and improved.

References

- Adämmmer, P. (2019). lpirfs: An R Package to Estimate Impulse Response Functions by Local Projections. *The R Journal*, 11(2):421–438.
- Aldasoro, I., Borio, C. E., and Drehmann, M. (2018). Early warning indicators of banking crises: expanding the family. *BIS Quarterly Review*, March.
- Alessi, L. and Detken, C. (2018). Identifying excessive credit growth and leverage. *Journal of Financial Stability*, 35:215–225.
- Ari, A., Chen, S., and Ratnovski, L. (2020). COVID-19 and non-performing loans: lessons from past crises. *SSRN Electronic Journal*.
- Attard, J. and Farrugia, J. (2022). Box 4: The Fiscal Response to the COVID-19 Pandemic. *Quarterly Review 2022*, (2):72–77.
- Avgouleas, E., Ayadi, R., Bodellini, M., Casu, B., De Groen, W. P., and Ferri, G. (2021). *Non-performing loans-new risks and policies? What factors drive the performance of national asset management companies?* EPRS: European Parliamentary Research Service.
- Basel Committee on Banking Supervision (2010). *Basel III: A Global Regulatory Framework for More Resilient Banks and Banking Systems*. Bank for International Settlements, Switzerland.
- Behn, M., Detken, C., Peltonen, T. A., and Schudel, W. (2013). Setting countercyclical capital buffers based on early warning models: Would it work? *ECB Working Paper*, 1604.
- Bonello, M. C. (2010). Michael C Bonello: The Maltese economy – the recession and the challenges beyond. <https://www.bis.org/review/r100528b.pdf>. Speech by Mr Michael C Bonello, Governor of the Central Bank of Malta, to the Committee on Economic Affairs and Development of the Parliamentary Assembly of the Council of Europe, Attard, 28 May 2010.
- Borio, C. and Lowe, P. (2002). Assessing the risk of banking crises. *BIS Quarterly Review*, 7(1):43–54.
- Borio, C. E. and Drehmann, M. (2009). Assessing the risk of banking crises–revisited. *BIS Quarterly Review*, March.
- Candelson, B., Dumitrescu, E.-I., and Hurlin, C. (2012). How to evaluate an early-warning system: Toward a unified statistical framework for assessing financial crises forecasting methods. *IMF Economic Review*, 60(1):75–113.
- Central Bank of Malta (2021). Guide on the amendments to Central Bank of Malta Directive 18: “On Moratoria on Credit Facilities in Exceptional Circumstances”. <https://www.centralbankmalta.org/site/News-Releases/2020/Guide-to-Directive-18.pdf?revcount=833#:~:text=in%20Exceptional%20Circumstances%E2%80%9D&text=As%20a%20consequence%20of%20the,moratoria%20until%2031st%20March%202021>.
- Central Bank of Malta (2023). The countercyclical capital buffer rate. <https://www.centralbankmalta.org/countercyclical-capital-buffer>.

- Chavleishvili, S. and Kremer, M. (2023). Measuring systemic financial stress and its risks for growth. *ECB Working Paper*, 2842.
- Constâncio, V., Cabral, I., Detken, C., Fell, J., Henry, J., Hiebert, P., Kapadia, S., Altimar, S. N., Pires, F., and Salleo, C. (2019). Macroprudential policy at the ECB: Institutional framework, strategy, analytical tools and policies. *ECB Occasional Paper*, 227.
- Dawood, M., Horsewood, N., and Strobel, F. (2017). Predicting Sovereign Debt Crises: An early warning system approach. *Journal of Financial Stability*, 28:16–28.
- Detken, C., Fahr, S., and Lang, J. H. (2018). Predicting the likelihood and severity of financial crises over the medium term with a cyclical systemic risk indicator. In *Financial Stability Review 2018*. European Central Bank.
- Detken, C., Weeken, O., Alessi, L., Bonfim, D., Boucinha, M., Castro, C., Frontczak, S., Giordana, G., Giese, J., Wildmann, N., et al. (2014). Operationalising the countercyclical capital buffer: indicator selection, threshold identification and calibration options. *ESRB: Occasional Paper Series*, 5.
- Drehmann, M., Borio, C. E., and Tsatsaronis, K. (2011). Anchoring countercyclical capital buffers: the role of credit aggregates. *BIS Working Paper*, 355.
- Drehmann, M., Borio, C. E., and Tsatsaronis, K. (2012). Characterising the financial cycle: Don’t lose sight of the medium term! *BIS Working Paper*, 380.
- Drehmann, M., Illes, A., Juselius, M., and Santos, M. (2015). How much income is used for debt payments? A new database for debt service ratios. *BIS Quarterly Review*, September.
- Drehmann, M. and Juselius, M. (2014). Evaluating early warning indicators of banking crises: Satisfying policy requirements. *International Journal of Forecasting*, 30(3):759–780.
- ESRB (2014). Recommendation of the European Systemic Risk Board of 18 June 2014 on guidance for setting countercyclical buffer rates. *ESRB/2014/1*, (2014/C 293/01).
- EU and UN (2017). *Handbook on Cyclical Composite Indicators for Business Cycle Analysis*. Publications Office of the European Union, Luxembourg.
- Gatt, W. and Grech, O. (2016). An Assessment of the Maltese Housing Market. *CBM Policy Note*, September.
- Giese, J., Andersen, H., Bush, O., Castro, C., Farag, M., and Kapadia, S. (2014). The credit-to-GDP gap and complementary indicators for macroprudential policy: Evidence from the UK. *International Journal of Finance & Economics*, 19(1):25–47.
- Grinderslev, O. J., Kramp, P. L., Kronborg, A. F., and Pedersen, J. (2017). Financial cycles: what are they and what do they look like in Denmark? *Danmarks Nationalbank Working Papers*, 115.
- Hodula, M. and Pfeifer, L. (2018). Fiscal-monetary-financial stability interactions in a data-rich environment. *Review of Economic Perspectives*, 18(3):195–224.

- Jordà, Ò. (2005). Estimation and inference of impulse responses by local projections. *American Economic Review*, 95(1):161–182.
- Jordà, Ò., Schularick, M., and Taylor, A. M. (2015). Leveraged bubbles. *Journal of Monetary Economics*, 76(S):1–20.
- Kaminsky, G. L. and Reinhart, C. M. (1999). The twin crises: the causes of banking and balance-of-payments problems. *American Economic Review*, 89(3):473–500.
- Kupkovič, P. and Šuster, M. (2020). Identifying the Financial Cycle in Slovakia. *NBS Working Paper*, 02/2020.
- Laeven, M. L. and Valencia, M. F. (2012). *Systemic banking crises database: An update*. International Monetary Fund.
- Lang, J. H., Izzo, C., Fahr, S., and Ruzicka, J. (2019). Anticipating the bust: A new cyclical systemic risk indicator to assess the likelihood and severity of financial crises. *ECB Occasional Paper*, 219.
- Lo Duca, M., Koban, A., Basten, M., Bengtsson, E., Klaus, B., Kusmierczyk, P., Lang, J. H., Detken, C., and Peltonen, T. (2017). A new database for financial crises in european countries. *ECB Occasional Paper*, 194.
- Lo Duca, M. and Peltonen, T. A. (2011). Macro-financial vulnerabilities and future financial stress-assessing systemic risks and predicting systemic events. *BOFIT Discussion Paper*.
- Lombardi, M. J., Mohanty, M. S., and Shim, I. (2017). The real effects of household debt in the short and long run. *BIS Working Paper*, 607.
- Manasse, P., Schimmelpfennig, M. A., and Roubini, N. (2003). *Predicting Sovereign Debt Crises*. International Monetary Fund.
- Micallef, B. (2016). Property price misalignment with fundamentals in Malta. *CBM Working Papers*, 03/2016.
- Plašil, M., Konečný, T., Seidler, J., and Hlaváč, P. (2015). In the quest of measuring the financial cycle. *CNB Working Paper*, 05/2015.
- Plašil, M., Seidler, J., Hlaváč, P., and Konečný, T. (2013). An indicator of the financial cycle in the czech economy. *Thematic article in the Financial Stability Report*, 2014.
- Rinaldi, L. and Sanchis-Arellano, A. (2006). Household debt sustainability: What explains household non-performing loans? An empirical analysis. *ECB Working Paper*, 607.
- Ryan, E. et al. (2017). The role of macroprudential indicators in monitoring systemic risk and setting policy. *Quarterly Bulletin Articles, Central Bank of Ireland*, 2:62–80.
- Rychtárik, Š. (2014). Analytical background for the counter-cyclical capital buffer decisions in Slovakia. *Biatec*, 22(4):10–15.

- Schularick, M. and Taylor, A. M. (2012). Credit booms gone bust: monetary policy, leverage cycles, and financial crises, 1870–2008. *American Economic Review*, 102(2):1029–1061.
- Škrinjarić, T. (2023). Introduction of the composite indicator of cyclical systemic risk in Croatia: possibilities and limitations. *Public Sector Economics*, 47(1):1–39.
- Tölö, E. (2020). Predicting systemic financial crises with recurrent neural networks. *Journal of Financial Stability*, 49(C).
- Zerafa, S. (2017). Access to finance for firms in Malta: Estimating the impact of reduced credit. *CBM Policy Note*, July.

Appendix A Data Appendix

Real bank credit

The 2-year real bank credit growth rate includes total lending to households and total lending to non-financial corporations, deflated by the harmonised index of consumer prices (HICP). This data is obtained from the Central Bank of Malta (CBM) and the Statistical Data Warehouse (SDW), respectively.

Debt service to income ratio

The 1-year change in debt service to income ratio (DSTI) is calculated based on the methodology for this debt service ratio provided by [Drehmann et al. \(2015\)](#):

$$DSTI_t = \frac{i_t \times D_t}{1 - (1 + i_t)^{-s_t}} \times \frac{1}{Y_t} \quad (\text{A.1})$$

where D_t = aggregate credit stock, i_t = average interest rate per quarter on the stock, s_t = average remaining maturity (constant across time), Y_t = aggregate income. This definition of the DSTI ratio incorporates total credit to households and NFCs as a whole. Nominal Gross Domestic Product (GDP) is used as a measure of aggregate income.

House price to income ratio

The house price to income ratio is based on chain-linked advertised house prices and disposable income obtained from CBM. Seasonally-adjusted disposable income is a per capita measure, obtained from internal estimates and expressed in per capita terms using interpolated population data.

Real total debt

The 2-year real total debt growth rate involves bank credit and government debt, and debt to NFCs obtained from CBM and SDW, respectively. The HICP deflator is then obtained from SDW to derive debt in real form.

Appendix B Other Measures Considered

B.1 Measures of external imbalances

The current account as a percentage of GDP, capturing external imbalances in the economy, is not included in the construction of the cSRI for Malta. During the research process, several systemic risk indicators were constructed where the current account sub-indicator was being included. During recent years Malta registered a strong net international investment position (NIIP) according to the latest dataset plotted (Figure B.1). With a strong NIIP, the current account can impose financial stability risks in an economy.

When considering the current account balance for Malta, substantial data revisions are being carried out on this dataset leading to large historical changes to the cSRI. In Figure B.1, two dataset vintages of the current account are compared. Until 2019, both dataset vintages (2022Q2 and 2022Q3) follow similar paths. However, from 2020 onwards significant revisions were made to the current account data whereby the vintages are differing significantly. For instance, during 2021 a current account deficit is registered by the 2022Q2 vintage whilst the 2022Q3 vintage registered a surplus. Further revisions are also expected to be made to data from 2004 onwards. Given that the path of the cSRI would depend on the current account dataset used, it is unwise to include this sub-indicator from a policy perspective as it would introduce a source of variation which can distort the assessment of the underlying risks. As a measure of overall imbalances, the real total debt sub-indicator is included in the cSRI instead. The inclusion of total debt still allows for the inclusion of Malta's borrowing position while it permits the abstraction from noise in balance of payments data.

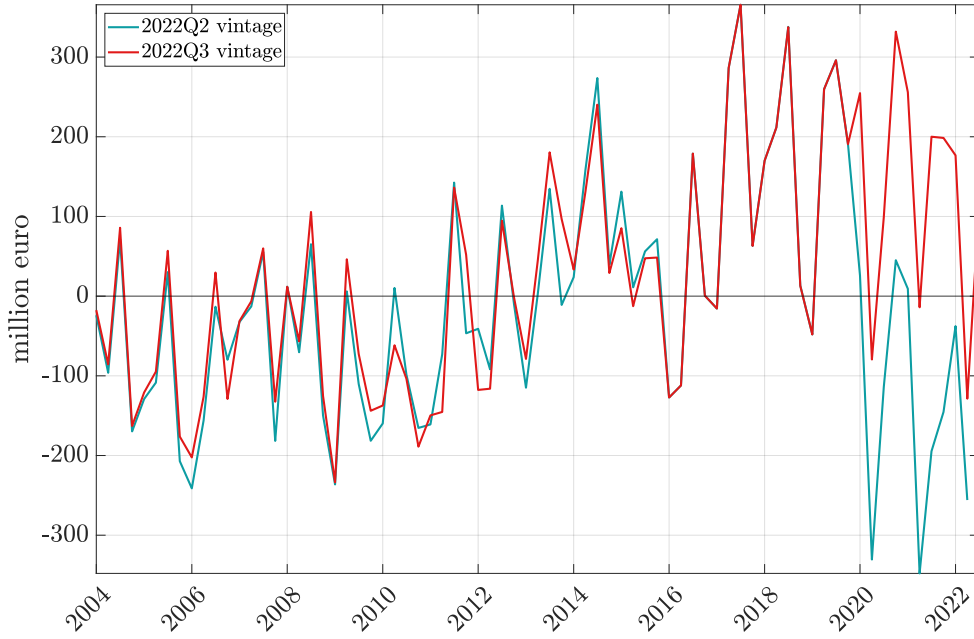


Figure B.1: Current account balance across data vintages

B.2 Measures of strength of banks' balance sheet

Another sub-indicator has been explored in the construction of the cSRI. This is the nonperforming loans (NPL) as a percentage of total gross loans. NPLs capture the banks' loans portfolio's credit quality which significantly alters their lending behaviour. The study of NPLs is important to understand the origins of future crises as having a high NPL burden could endanger the functionality and stability of banking systems (Avgouleas et al., 2021). When included in the cSRI, this sub-indicator did not have the expected relationship with the resulting cSRI. A lower NPL ratio indicated increasing systemic risk, which is counter-intuitive, and it was therefore excluded from the cSRI. This exclusion is in line with the beliefs of Lang et al. (2019) highlighting that measures of the strength of banks' balance sheets are not ideal measures to signal the accumulation of systemic risk. The authors argue that NPLs are able to reflect the banking system's resilience rather than the accumulation of systemic risk.

Appendix C Signalling Properties of the Basel gap

The impulse response functions (IRF) using local projections for the cSRI (Section 6), are replicated to test the predictive power of the Basel gap on future real annual GDP growth. The aim of this exercise is to compare the signalling properties of the cSRI with an existing measure of cyclical movements; the Basel gap. The IRF for the Basel gap is based on 68 observations like the cSRI (2006Q1-2022Q4) and on a horizon of 20 time quarters.

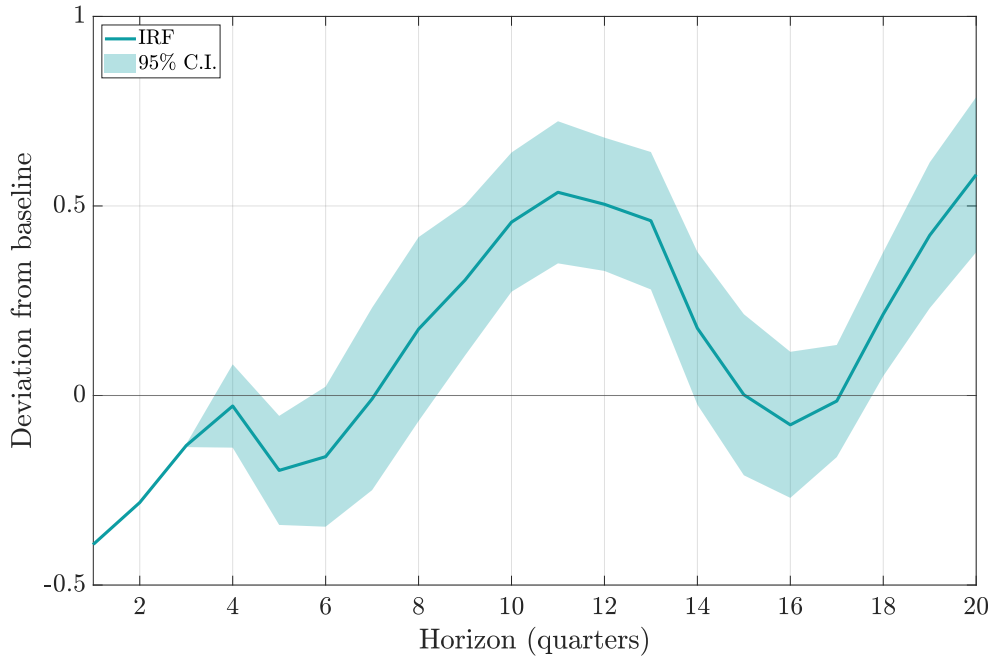


Figure C.1: The IRF of the Basel gap

Notes: The Basel gap is sourced from the CBM's announcement "*The Countercyclical Capital Buffer Rate*", dated March 2023 ([Central Bank of Malta, 2023](#)). Future real GDP growth does not significantly decline when the Basel gap increases by one percentage point, four years ahead.

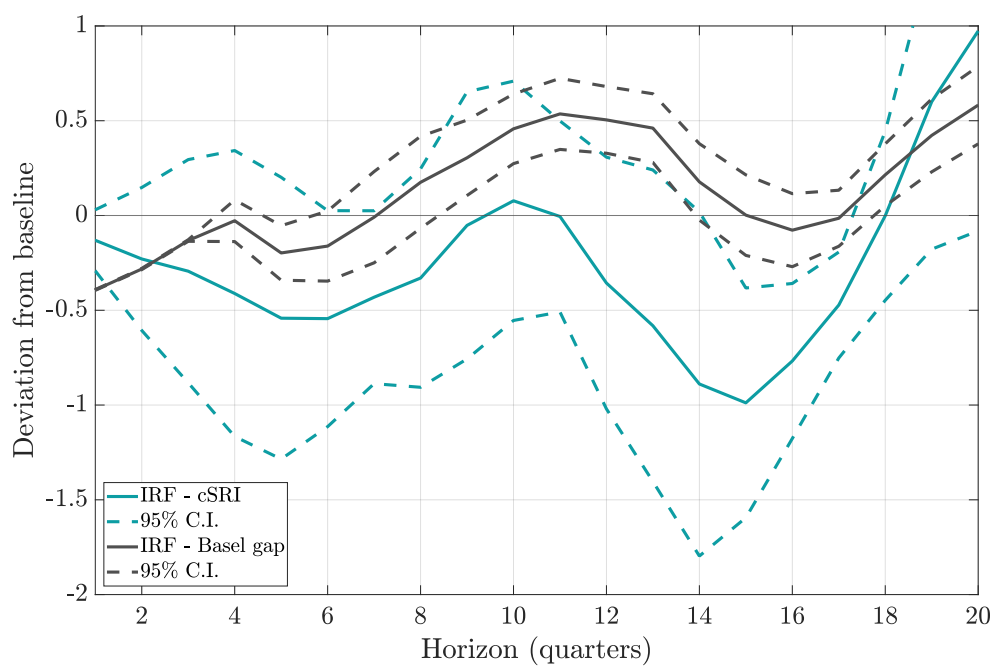


Figure C.2: Comparing the IRFs for the cSRI and the Basel gap

Notes: The IRF for the cSRI displays improved early signalling properties when compared to the IRF for the Basel gap.