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Evaluating the macroprudential stance in a growth-at-risk framework

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Abstract

The ultimate objective of macroprudential policy is to contribute to financial stability by curbing the build-up of systemic risks and alleviating negative outcomes for the economy should risks materialise. Measuring and communicating whether policy goals are achieved is challenging, as financial crises are rare and risks are often only measurable in case they materialise.

The European Systemic Risk Board, ESRB, proposes using the growth-at-risk, GaR, approach in order to evaluate the macroprudential policy stance.

The memo outlines the advantages and disadvantages of using the approach for evaluating the macroprudential stance in Denmark.

While GaR is not suitable for precise forecasts of growth in GDP and house prices, it can be a strong tool to illustrate the goal of macroprudential policy and facilitate discussions of questions policymakers often face: are policies effective to curb risks or alleviate downturns; do policies have different effects in the short vs. medium run; can build up of financial imbalances boost economic growth today while increasing risks of sharp downturns in the future.

Introduction

In the aftermath of the global financial crisis, macroprudential policy has become increasingly important to address different types of risks in the financial system. The ultimate objective of macroprudential policy is to contribute to financial stability by curbing the build-up of systemic risks and strengthening the resilience of the financial system.

Financial crises are associated with significant costs – both for society and at the individual level. The build up of financial imbalances over time might lead to prolonged and protruded downturns in case risks materialise, with significant welfare loss and a long path to recovery.[1] Macroprudential policy aims at curbing build up of imbalances in the upward phase of the financial cycle, and dampening the depth of a crisis when risks materialize.

Macroprudential policy is multi-dimensional both in terms of intermediate objectives and instruments. Moreover, there is no single definition of financial stability and the key variables for capturing systemic financial risk continue to evolve. It can therefore be challenging to link the policy goals to metrics and potential target levels. This creates a clear contrast between macroprudential policy and other economic policy areas - monetary and fiscal policies in particular.

Both of these policy areas have traditionally been characterized by a clear mapping between a select

[1] Recent studies point also to an asymmetry in the boom and bust phase of the business cycle, see also Stéphane Dupraz, Emi Nakamura, Jón Steinsson (2022), A Plucking Model of Business Cycle; and also across individual households, see Kjetil Storesletten, Chris I. Telmer, Amir Yaron, The welfare cost of business cycles revisited: Finite lives and cyclical variation in idiosyncratic risk

number of policy instruments (government expenditures and taxes for fiscal policy, interest rate setting for monetary policy) and clear and measurable policy objectives (GDP growth and price stability).

Despite the highlighted challenges, supporting macroprudential decision-making with analytical tools can provide a range of benefits. Therefore, the ESRB proposes a more formal framework for evaluating the effectiveness of macroprudential policy, or a macroprudential stance.

The macroprudential stance is formally defined as the balance between systemic risk and resilience relative to financial stability objectives given implemented macroprudential policies. A macroprudential stance assessment should be informative about the extent to which macroprudential actions achieve the financial stability objective through these actions.

Traditional policy areas, such as fiscal and monetary policy measure the effectiveness of policy actions and the policy stance through measuring effects on e.g. GDP. Macroprudential policies aim at curbing risks of negative outcomes for the economy should risks materialise. The focus would therefore naturally be on curbing risks of sharp downfalls in GDP, i.e. tail risks, rather than the effect on current GDP.

The growth-at-risk approach offers the opportunity to assess effects of risks and policies on both the median and the tail. The growth-at-risk thus offers a suitable framework to assess the macroprudential policy stance.

By providing a clear orientation through quantitative metrics, the macroprudential stance can contribute to mitigating policymakers' inaction bias. A credible stance concept can facilitate communication on consistent policy actions and anchor expectations. This is because the concept of stance conveys summary information on the use of policy instruments, on their adequacy to meet policy objectives given the identified risks, and on the required policy orientation. This could help anchor expectations and allow for a more effective transmission of policy.

By providing indications of the interactions between systemic risk assessments and macroprudential policy, it can help manage expectations about future macroprudential policy actions. The stance framework with a common language also provides a bridge to other macroeconomic policies - monetary and fiscal policies in particular – not the least to ease policy coordination.

Assessing the level of systemic risk compatible with the financial stability objective requires operational methods for the measurement of all components that inform the stance assessment.

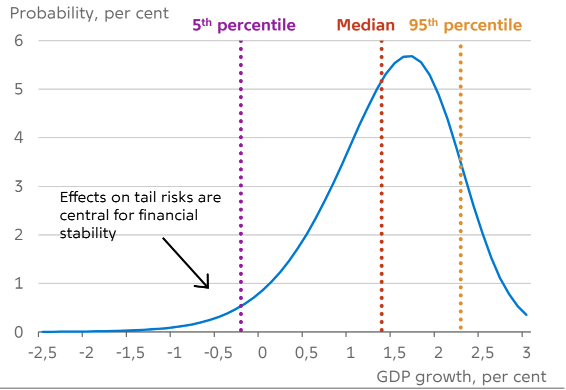
In line with the conceptual work, the data includes indicators of systemic risk and financial stress (e.g. early warning indicators, financial market data), metrics of resilience of financial institutions (measures of leverage or bank capital), indicators of macro-prudential policy actions and structural factors of the economy and the financial system. The key feature across methodologies is to employ these indicators and parse them through analytical tools to obtain quantitative metrics of stance. The analytical tools support policymakers in their assessment if implemented macroprudential policy instruments are too loose or too tight relative to the neutral stance.

Growth-at-risk: A tool for evaluating policy actions

The fundamental idea behind growth-at-risk is to estimate the probability of different outcomes of future growth in e.g. GDP, house prices, consumption, etc., given the current financial and economic conditions.

While traditional forecasting focuses on the most likely growth scenario, often described by the mean, growth-at-risk allows us to explore the risk of sharp falls in GDP or house prices, which is central for financial stability analysis and macroprudential policy, see Chart 1.

Predicted GDP growth distribution Chart 1



Note: Fitted density distribution of average annualized GDP growth 8 quarters ahead.
Source: Illustrative chart.

While the framework can be used as an addition to existing risk monitoring and policy analysis, there are some important caveats that need to be considered when interpreting the results, see Table 1.

Framework can support policy analysis and risk monitoring

One of the major advantages of the growth-at-risk model, is that the framework allows to investigate how *current* financial conditions as well as policies impact the *entire distribution* of *future* growth in GDP or house prices.

Furthermore, the framework allows us to investigate whether the effects are different across different quantiles of the distribution. For example tightening macroprudential policies might have a small negative impact on current median GDP-growth (costs) while it curtails downside tail risks to GDP growth (benefits).

The framework can also be used to investigate the effects of policies across different time horizons. For example, tightening macroprudential policies might have a small negative effect in the very short run, while boosting growth in the medium-to-long run.

As the entire distribution is estimated each quarter, the growth-at-risk can also be used as a monitoring tool to track development in tail risks or shifts in the distribution over time.

Limitations implore careful interpretation of results

Although the method offers clear benefits in terms of the possibility for policy analysis of trade-offs, it comes with limitations, which should be considered when interpreting the results.

The underlying model is based on quantile regression (Koenker and Bassett 1978), which was used in the GaR context in Adrian et. al. (2018)[2]. Just like traditional regression analysis, quantile regression is concerned with the conditional distribution of a variable (Y) given other variables (X). However, in traditional regression analysis, it is the mean in the distribution of Y given X that is modelled as a function of X, while in quantile regression models it is a given quantile, e.g. the 5% quantile, in this conditional distribution that is modelled as a function of X. .

The method employs aggregate macroeconomic data at a quarterly basis providing relatively small samples. While 40 years of quarterly GDP growth data is a reasonably long time-series sample, it also means that only 8 of the observations are below the 5th percentile.[3] The few realisations do not imply that the regression coefficients are estimated inconsistently, but it makes it extremely hard to obtain precise estimates.[4]

[2] Adrian et al (2018), "The Term Structure of Growth-at-Risk." Working Paper 42. Washington: Hutchins Center on Fiscal and Monetary Policy, Brookings Institution. Koenker, R., and Bassett, G. W. (1978). "Regression Quantiles." Econometrica 46:33–50.

[3] It might be a reasonable fix to simply use the 10th percentile in stead of the 5th, thereby doubling the number of observations, although the problem persists.

[4] See also discussion in Mikkel Plagborg-Møller et al., *When Is Growth at Risk?*, Brookings Papers on Economic Activity, Spring 2020.

Advantages and disadvantages associated with GaR

Table 1

	Advantages	Disadvantages
Model specification	▪ Models different effects of input variables for different quantiles ▪ Models different effects for different time horizons	▪ Few observations mean imprecise estimates ▪ Level is uncertain and difficult to interpret ▪ Causal interpretations of coefficients are hard to justify ▪ Mismatch between median growth and actual forecast
Policy analysis	▪ Can *illustrate* purpose of financial stability ▪ Can contribute to monitoring the development of risks over time ▪ Can be used to analyze trade-offs of policy actions (median vs. tail; short vs. long-run) ▪ Allows an investigation of drivers behind increasing risks	▪ Only available at the macro-level ▪ Not possible to analyze effects of specific policy actions ▪ Not possible to use to calibrate policy actions ▪ Not possible to distinguish between policy actions ▪ Not taking transmission channels into consideration

The limited number of observations for specific percentiles limits the number of input variables. It can therefore be necessary to use only a few input variables.

A lot of financial variables with potentially predictive properties have a high degree of covariation. Therefore, a composite index combining the information from the different variables is used. While this allows for the quantile regression to be identified, it comes at the cost of flexibility and added unclarity in terms of aggregation weights.

Likewise, it can be hard to use information on single policy tools as input variables if there are few changes in policy over time. It is therefore necessary to make an aggregate index of all policy measures in order to increase variation.

Finally, it is important to recognise that the model does not imply causality, which makes it problematic to use for assessing policy effects. Rather, the model estimates correlations between the different variables, thereby describing past comovements. Quite often the model is used to predict growth distribution shifts following policy actions. Such predictions assume that past correlations will also be correct in the future.

Model limitations imply limitations for policy analysis
The challenges associated with the chosen modelling framework have also repercussions for the use of growth-at-risk to support policy analysis.

Given the limitations of the model framework, we focus on interpreting the dynamics and directions of change rather than levels when presenting the results. The estimates serve as an illustration and a starting point for discussion of the likely policy implications, rather than precise forecasts.

Some of the aforementioned challenges will be further elaborated in the application of the method throughout the note. The following sections will look at how two specific applications of the growth-at-risk can be used to underpin macroprudential policy discussions:

- Application 1: GDP-at-Risk
- Application 2: House Prices-at-Risk

Application 1: GDP-at-Risk

The first application focuses on analysing the effect of current financial conditions and imbalances to downside risks to real GDP growth in the future. Focus is on the risk of significant falls in GDP resulting from the materialisation of risks in the financial system.

We use a quantile regression model (Koenker and Basset 1978) to estimate the impact of cyclical systemic risks and macroprudential policy on the distribution of GDP growth over the next eight quarters.

The choice of eight quarters balances forecast accuracy over the shorter-term horizon and the importance of the longer-term horizon for the transmission of financial imbalances and policy actions. A shorter time horizon would increase forecasting accuracy with the potential risk for the assessments to chase short-term movements in the data.[5] Although the entire distribution is estimated, the main focus in the analysis is on the median and the tail (5th percentile). The model includes[6]:

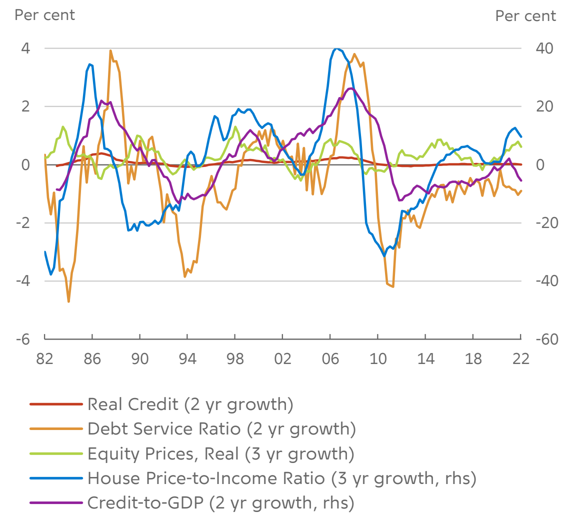
- An index of systemic risks (SRI)
- Real GDP growth
- Two indices for policy actions:
    - An index of Borrower Based Measures (BBM)
    - An index of Capital Based Measures (CBM)

Systemic Risk Indicator captures cyclical risks

The Systemic Risk Indicator (SRI) captures cyclical risks. The indicator reflects build-up of cyclical systemic imbalances and vulnerabilities as measured by six sub-indicators for developments in credit, asset prices and risk perception, see also box 1. The SRI could be interpreted as a measure of financial conditions or the financial cycle, as it captures variation in cyclical risk with medium-term implications for real GDP growth. Due to the early warning properties of the six sub-indicators entering the SRI, it provides an effective signal of banking crises three to four years ahead.

The model includes the aggregate SRI rather than the individual sub-indicators. The choice is due to the high level of correlation between the sub-indicators, see Chart 2.

High comovement makes indentification difficult Chart 2



Note: Variables aggregated into the Systemic Risk Indicator.
Source: Danmarks Nationalbank.

Policy indices reflect policy decisions

Macroprudential policy is captured by two separate indices, reflecting the most commonly employed macroprudential measures: capital-based measures, CBM, and borrower-based measures, BBM.

[5] For robustness we also tracked implications for shorter and longer horizons and covered 1, 4, 8, 12 and 16 quarters. The model presented here is the result of testing a number of different specifications, based on a model with a larger number of variables, including a financial stress indicator, indicator for structural risks, as well as a number of interaction terms similar to the ones presented in ESRB (2021), "Report of the Expert Group on Macroprudential Stance – Phase II (implementation)". Many of the input variables proposed by the ESRB are found to be insignificant predictors of the distribution of future Danish GDP growth. This partly results from a high degree of collinearity induced by interaction terms involving variables with little variation. In addition, we found that the CLIFS merely adds a lot of statistically insignificant noise to the stance without changing the underlying movement patterns. We therefore suggest a simple model which excludes CLIFS and the interaction terms and use this in the subsequent analysis. This model captures the effects of systemic risk build-up, as well as the two macroprudential indicators.

[6] The variables are included following the work at the ESRB that tested a number of different models and concluded that this was the best model.

GDP-at-Risk in a simplified version for Denmark, 8 quarters ahead

Table 2

		Tail	Median	Interpretation
Cyclical risks	SRI	--	--	Increasing systemic risk decreases median growth and expected growth in tail risk scenario.
Macroprudential policy	BBM	+	+	Tightening BBM has a positive effect on the median and tail.
	CBM	+	--	Tightening CBM has a positive impact on tail GDP and negative impact on median GDP.

The CBM expresses banks' capital requirement as a percentage of the total risk exposure amount. The BBM is based on the first-year debt servicing cost of a first-time home buyer. The BBM considers not only the traditional macroprudential policy actions such as an LTV limit, but also other policy actions that might not be macroprudential by design, but have a macroprudential impact. An example of such a regulatory measure is the introduction of interest-only loans, see also box 2.

Systemic risk weighs down on GDP growth

We use a quantile regression model to estimate the impact of cyclical systemic risks (SRI) and macroprudential policy (CBM and BBM) on the growth distribution of GDP over the next eight quarters.

The results of the model suggest that increasing cyclical systemic risk has historically had a significant negative impact on both the tail (5th percentile) and the median of the growth distribution at an 8 quarter horizon, see Table 2.

The coefficient of the systemic risk indicator is, however, quite different across different quantiles. An increase in systemic risks indicates a lower median and lower tail growth while the impact is somewhat more limited on the upper tail. That is, most likely it will lower growth – both in the most likely outcome and in the event of a crisis – but it will not have much of an impact on the strength of a strong expansion.

Macroprudential policy curbs tail risks

The results also suggest that macroprudential policy might be useful to curb downside risk to GDP. Tightening borrower-based measures in periods of increasing systemic risk would reduce tail risks and increase median growth in the median run.[7]

The model also suggests that tightening capital-based measures would reduce tail risks. A release of capital requirements in stress periods could on the contrary help mitigate downside risks to GDP. The results correspond to ESRB's findings and also corroborate previous findings in the literature.[8]

Shifts in distribution can be used in risk monitoring

The few observations in the data sample imply that the estimated level of median and tail GDP-growth are uncertain. Furthermore, it might be difficult to attribute any specific interpretation to the level of the tail and median (e.g. tail estimate signals *high* level of tail risk). Therefore, it could be useful to inspect the *changes* in the levels of the median and the tail.

In the run-up to the financial crisis, we see a sharp deterioration of tail GDP (5th percentile), signalling risk of sharp falls in GDP, see Chart 3, left.

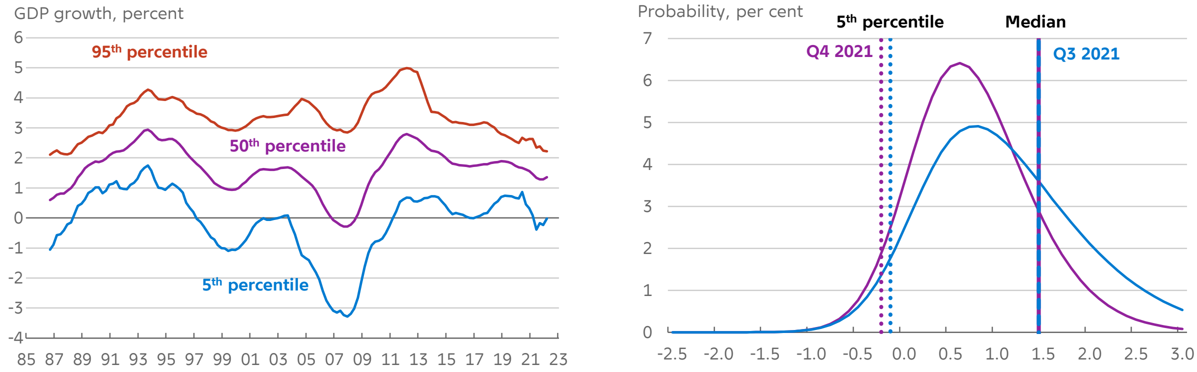
[7] The finding is not in conflict with general macroeconomic theory, as it suggests a small positive effect for GDP growth in the short-to-medium run, and is thus temporary.

[8] Duprey and Ueberfeldt (2020), "Managing GDP Tail Risks", *Bank of Canada Staff Working Paper* and Brandao-Marques et al. (2020) "Leaning against the wind: An empirical cost-benefit analysis", IMF *Working paper No. 20/123* identify positive effects of the use of macroprudential policy on the downside risk of GDP growth. By accounting for interactions with the cycle, Galán (2020) identifies that tightening borrower-based measures during booming periods improves GaR, while loosening capital measures during crises has important positive effects on the left-tail of GDP growth. See also ESRB (2021), "Report of the Expert Group on Macroprudential Stance – Phase II (implementation)".

Distribution moves over time and as regression variables change

Chart 3

Time dimension of median, lower and upper tail growth | **Shifts in distribution over time can be used to track development in risks**



Note: *Left*: Latest observation Q1 2022. *Right*: Density distribution of GDP growth 8 quarters into the future as of 3rd and 4th quarter of 2021.
Source: Danmarks Nationalbank and own calculations.

The GDP-at-Risk can also be used to track development in the distribution over time – both in tail risks and the median. For example risks of GDP falls as expressed by the 5th percentile deteriorated from the third quarter of 2021 to the fourth quarter of 2021, see Chart 3, right. At the same time there is no substantial change in median GDP in the same period. Both the ECB and the IMF as well as a number of central banks use the GDP-at-risk in their regular monitoring of systemic risks.

Using GDP-at-risk to assess the macroprudential stance

The analysis so far has focused on investigating the effects of systemic risks and macroprudential policy on the median and the tail of GDP growth separately, focusing on risks embedded in the lower tail of the growth distribution. However, policy makers often face the challenge of containing downside risk to GDP growth stemming from the financial system without hampering current growth when these risks do not materialise. The macroprudential stance as described by the ESRB offers such a metric.

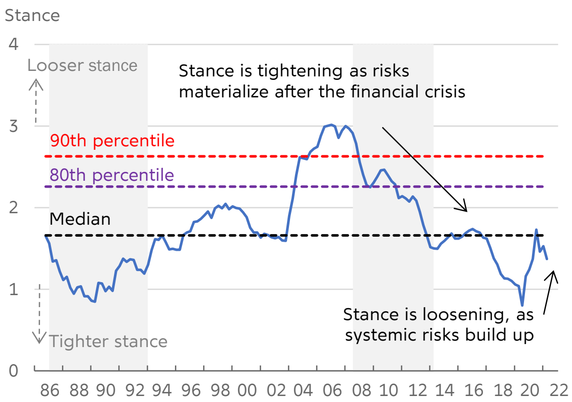
The macroprudential stance measures the distance between the median and the tail

The macroprudential stance is measured by the distance between the median and the tail (5th percentile) of the GDP growth:

$$Stance = median - tail$$

This stance metric offers an intuitive interpretation of policy-makers' choice. Risk-neutral policymakers would focus on maximising median expected growth disregarding any potential trade-offs for the tail of the distribution. An infinitely risk-averse policymaker would on the contrary aim at lowering downside risks regardless of the implications for expected growth. The specific trade-off which policymakers would find acceptable will depend on the tolerance for downside risks, but also on the effectiveness of macroprudential policy instruments to counteract changes in expected median and tail growth from macro-financial shocks.

Stance reflects distance between median and tail Chart 4



Note: Latest data point is Q1 2022.
Source: Own calculations.

Evaluating the macroprudential stance
Evaluating whether the macroprudential stance is loose or tight would ultimately depend on the policymakers' preferences. As the policymakers' "optimal level" of policy is ultimately not observable, the ESRB suggests using the stance metric's historical distribution to put the stance into perspective. The current macroprudential stance for Denmark is around its historical median level, and in that sense, it could be considered neutral, see Chart 4.

The interpretation of the stance is not entirely straightforward, even when using the historical distribution as a benchmark. The capital reforms following the financial crisis were a response to the extremely loose financial conditions and risk build-up in the period preceding the financial crisis. In that sense, it could be discussed whether the historical distribution should be based on the entire historical sample, or whether the crisis periods should be excluded as they are an extreme that policymakers would rather avoid altogether.

The selective approach to determining the evaluation window is rather common in the literature of early warning indicators. The choice is motivated by the fact that policymakers would typically seek to address risks well ahead of a crisis in order to avoid extreme outcomes.

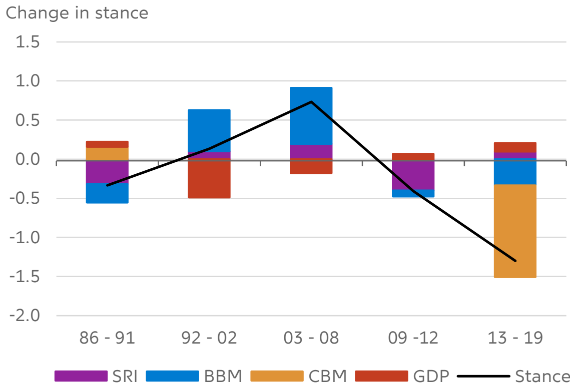
It might also be relevant to consider how far above/below a specific historical threshold the stance metric is, as well as whether the stance metric is *increasing* or *decreasing*. An increase in the stance metric would signal an overall loosening in the macroprudential stance. That could be due to either an increase in systemic risk or a loosening of macroprudential policies. The distance between the median and the tail is increasing, suggesting loosening of the stance.

Identifying drivers behind changes in the stance
The development in the stance largely reflects the historic experience surrounding the latest financial crisis. A decomposition of the changes in the stance indicator suggests that loosening of borrower-based measures in the pre-financial crisis period contributed to a loosening of the macroprudential stance. In 2003, policymakers chose to introduce the so called interest only loans. The interest-only loans allow borrowers to pay only interest, without amortising the loan, for an initial period of 10 years. In effect, the introduction of this type of loans meant that house-buyers could borrow much larger amounts for the same monthly installment, allowing them to accumulate debt. The introduction of these loans is therefore considered to be effectively loosening regulation. That exacerbated the risk build-up during the period, leading to a continuous increase in the distance between the median GDP growth and the tail, i.e. the stance, see Chart 5 .

In the post-crisis period from 2013 to 2019, the entire capital requirements framework was revised, resulting in a significant increase in requirements to both the quantity and quality of bank capital. This capital reform is reflected in a large tightening of the capital-based measure used as an input in the model. The tightening in the period was not a response to the build-up of cyclical risks, but rather a structural reform aiming at correcting some of the flaws that became apparent in the aftermath of the financial crisis, see also Box 2. As there is no corresponding increase in the systemic risks during this period, the tightening of capital measures contributes significantly to a tightening of the macroprudential stance as meas-ured by the decrease in the median-to-tail distance.

Decomposition of stance largely reflects the experience surrounding the financial crisis

Chart 5



Note: Periods for decomposition reflect previous crises periods and periods of risk build up up to crisis.
Source: Own calculations.

Real-time estimates deviate from full sample version of stance

When using an indicator in policy discussions, it is relevant to look at how well the indicator would perform in guiding policy discussions on a specific point in time using only data available at that time point. One way to assess the performance of the indicator is to look at the estimates in real time. I.e. what would the indicator look like if it is estimated only based on data available up to a specific point in time vs. based on the full sample? For example, if policy makers use the indicator on October 1 2008, would the estimate be different depending on whether we use the full sample of data or only data up to October 1 2008.

We use real time estimation of the stance metric in order to evaluate how well the stance metric would perform to guide policy discussions compared to a stance metric estimated based on the full data sample. The estimation shows that there are large discrepancies in the level of the two indicators, see Chart 6.

There could be a number of different reasons behind the deviations between the real-time estimates and the full sample version of the macroprudential stance. Real-time estimates are based on shorter samples and are thus more volatile by nature. Furthermore, the differences are likely due to the lack of stability of the underlying parameters.

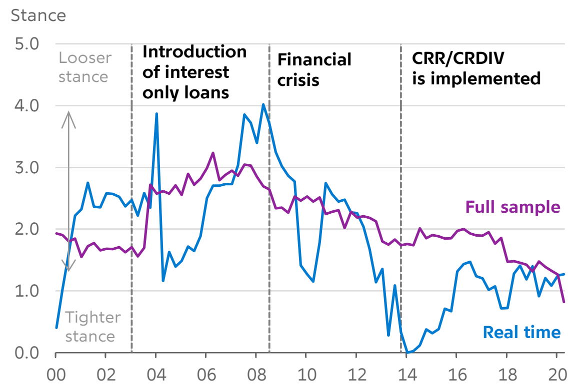
Also, the macroprudential index is effectively a combination of very different policies occurring over the sample period. Although these policies may share similar macroprudential elements, they can additionally have other potentially rather different impacts on quantiles and stance, thus inducing parameter instability. In particular, the introduction of loans with deferred amortisation in 2003 (4th quarter) and the tightening of capital requirements in 2013 (1st quarter) indicate the start of periods of particularly persistent deviations between the graphs. The deviations could also be the result of measures taking effect, which is reflected in the indicators after the implementation period.

It is beyond the scope of the paper to resolve these issues, but future work could explore improvements of the model in order to achieve a better fit between real-time and full-sample estimates.[9]

[9] Using an automated model selection algorithm applied to a model with distinct dummies for each policy would make it possible to test (rather than assume a priori) which of the individual policies have similar impact and can thus be lumped together into one index. In this way, an empirically backed set of macroprudential indices (each including a more homogenous group of policies) could be obtained, expectedly implying more stable parameters and better real time assessment.

Real-time estimation deviates from full sample estimation

Chart 6



Note: Estimates shown in the chart reflect the estimation period from 1985 until 2020.
Source: Own calculations.

Although there are large deviations between the real time series and the full sample, the measure might still be useful to inform policy decisions. As previously discussed, the level of the macroprudential stance might be difficult to interpret. Therefore, use of the stance could focus on the direction rather than the level of the stance indicator. Both the real-time and full sample indicator move generally in the same direction, and would be consistent in signalling tightening or loosening of the stance. The real-time stance measurement correctly signalled a substantial loosening of macroprudential policy in the run up to the global financial crisis.

Evaluating policy actions

The primary purpose of the model is to evaluate the overall policy stance, and thus whether current policies are sufficient to curb systemic risks.

The model can also be used to analyse how increases in systemic risk or tightening policies would influence the GDP growth distribution. The proposed metrics can be used to kick-off policy discussions, e.g. whether it is necessary to implement new measures given the level of risks. The growth-at-risk can be used to assess whether implementing new measures would reduce the probability of negative outcomes for GDP, given the level of risk and policies already in place. Also, it is possible to evaluate the effects of increasing risk or tightening policies at different time horizons. Policy conclusions should be carefully interpreted in light of the limitations of the framework described in the beginning of the memo.

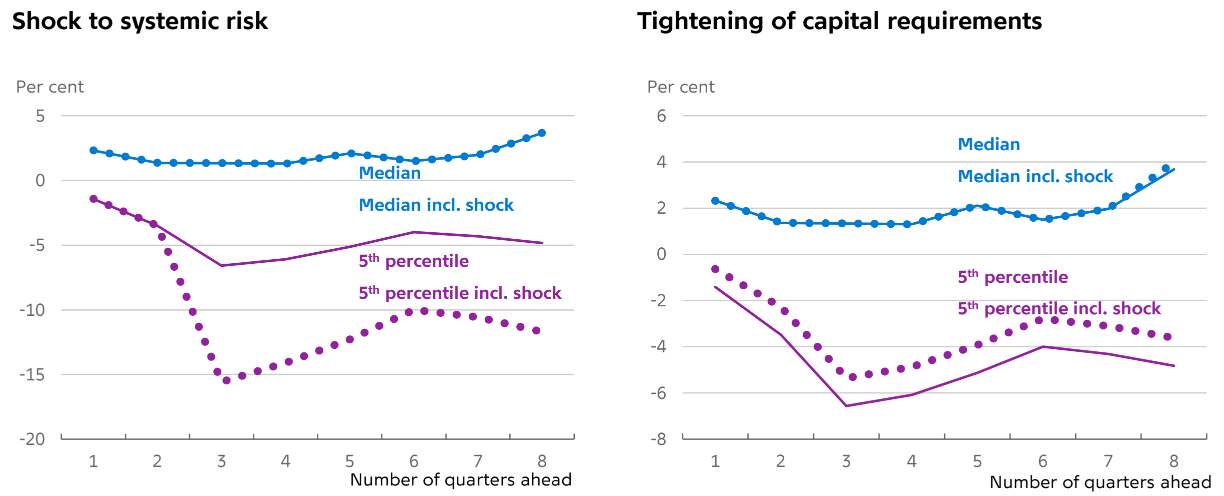
Increases in systemic risks exacerbate tail risk scenarios

A one-time increase in the systemic risk indicator, SRI, by 1 standard deviation, for example, has no significant impact on the median expected GDP growth, see chart 7, left. However, the increase contributes to a significant and persistent decrease in the 5th percentile of GDP-growth. This indicates that the tail risk of GDP-growth are increasing when systemic risks build up. The increase in tail risk is especially pronounced after two quarters.
The results imply that an acceleration in build-up of systemic risks might not have significant effects on median GDP-growth. From a macroeconomic perspective, the development would thus appear benign for current developments in GDP. However, from a financial stability perspective, the results also imply that the development might increase the risk of sharp downfalls in GDP.

Policy tightening curbs downside risks without weighing on growth

Similarly, it is possible to investigate the effect of tightening capital requirements. Tightening capital requirements by 1 percentage point could reduce tail risks (lifting the expected growth outcome at the 5th percentile), while also lifting marginally median GDP growth eight quarters after the capital requirement increase, see chart 7, right.

Systemic risks decrease tail growth while tightening capital requirements increase tail growth Chart 7



Note: *Left:* Shock to systemic risk. *Right:* Tightening of capital requirements. In both charts insignificant coefficients are set to zero.
Source: Own calculations.

The model signals need for policy action
The above results could be useful to kick off an initial discussion of whether a tightening of policies would help curb increasing systemic risks. The model, however, cannot be used to identify which instrument is most appropriate to use, or how to calibrate a given instrument. Further analysis using other models and methods would be necessary in order to identify the most appropriate instrument to use and how to calibrate it.

Application 2: House prices-at-Risk

The Growth-at-Risk approach can also be applied to the housing market. Negative developments in the property market may have implications for the financial system and the economy, and vice versa.

Housing market busts are common causes of banking crises, not least given the importance of real estate in the balance sheets of households and credit institutions.[10] Denmark is among the advanced economies where the correlation between the real economy, credit and real estate prices is the highest.[11] The close relationship between the housing market, the real economy and the banking sector means that it is highly relevant to explore a version of the macroprudential stance based on house price growth.

Following the same approach, we estimate the impact of cyclical and structural risks as well as macroprudential policy on the house price growth distribution *8* quarters ahead.

The model includes:
- House prices-to-income ratio
- Housing investments-to GDP ratio
- Debt service rate
- Index for Borrower Based Measures (BBM)

Cyclical risks are captured by the house-prices-to-income ratio. House-prices-to-income captures the valuation of housing relative to household income, and is used as a proxy for the build up of cyclical risks.

The housing investment ratio is used as a proxy for *structural factors* that might amplify the effects of a negative shock. From a macroeconomic point of view, the indicator captures the supply of housing, which would influence expected house price growth. In the context of macroprudential policy and systemic risks, the indicator is used to describe the size of the real estate sector (housing construction and real estate firms) relative to the size of the economy. A high ratio might signal a business structure highly concentrated in the real estate sector. Real estate and construction comprise 17 per cent of the gross value added in Denmark. Furthermore, a larger share of housing investments relative to GDP might mean that the economy and the financial sector are more exposed to fluctuations in activity.

House prices-at-Risk for Denmark, 8 quarters ahead

Table 3

		Tail	Median	Interpretation
Cyclical risks	GDP-growth	+	--	Increasing GDP-growth has a positive effect on the tail but negative on the median on a two year horison
	House price growth	+	+	House price growth has a positive effect on both the median and tail
	House prices to income	--	--	House prices to income has a negative effect. The higher leverage to income, the larger expected price corrections in the future
	Debt servicing rate	--	--	Debt servicing rate has a negative effect on both the tail and the median
Structural risks	Housing investments	--	+	Housing investments has a negative effect on the tail and a positive effect on the median
Macroprudential policy	BBM	+	--	Tightening BBM has a negative effect on the median and positive on the tail.

10 See, for example, Hartmann, P., "Real estate markets and macroprudential policy in Europe", Working Paper Series, No 1796, ECB, 2015

11 Grinderslev et al. (2017), *Financial Cycles: What are They and What Do They Look Like in Denmark*? Danmarks Nationalbank, Working Paper series No 115.

Macroprudential policy is captured by the borrower-based measure, as already described in the previous chapter.

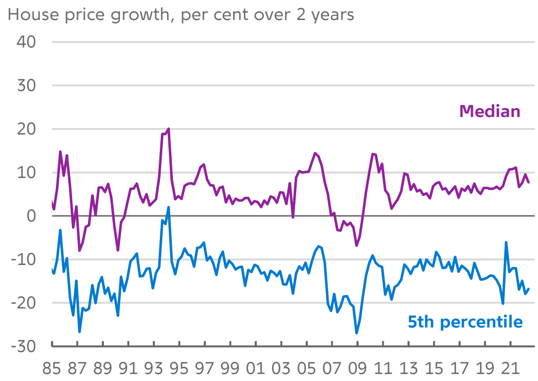
The results of the analysis suggest that increasing risks as measured by the house-price-to-income, would increase the tail risks for house price growth, see table 3. However, tightening borrower-based measures as risks build up could curb the magnitude of a potential house price decrease in the tail risk scenario.

Measuring tail risks of house prices over time

Using this model we consider the development in tail risks and uncertainty surrounding house prices in Denmark. Similarly to the GDP-at-Risk, the exact levels of the tail estimates should be used with caution. However, the changes in e.g. the tail estimates can be used as an indication of growing tail risks. The 5th percentile of house price growth rates signals the build up of risks in the run up to the financial crisis of 2008. Examining the build-up towards this event, there is a gradual decrease from 2000 to 2005, see Chart 8. This suggest a gradual worsening of risk scenarios of future house price growth suggesting the build-up of risks on the housing markedet.

Considering the recent developments of the tail risks surrounding house prices, the results suggests a corresponding and gradual increase in tail risks (decrease in the estimate for the 5th percentile) of house price growth from 2017 up until today. Covid-19 does however momentarily generate larger fluctuations.

Worsening risk scenario of house price growth Chart 8



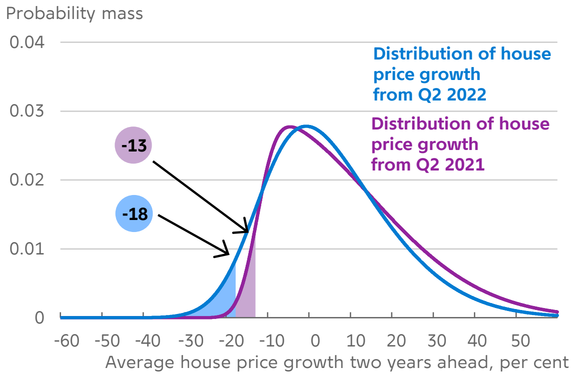
Note: Latest observation is Q2 2022.
Source: Danmarks Nationalbank.

Modelling the distribution of individual points in time, we may examine more closely the results of the model. From the 2nd quarter 2021 to the 2nd quarter 2022 the tail risks of house price growth increase signaling increased risk of sharp falls in house prices, see Chart 9.

Macroprudential stance on the housing market

The macroprudential stance, i.e the distance between the median house price growth and the lower 5th percentile has been loosening as shown in Chart 10. This is the case both doing the build-up to the financial crisis in 2008 and since 2017.
The model prescribes this loosening stance to increased risks, while borrower-based measures haven't addressed this sufficiently to avoid an increased stance.

Modelling the distribution of house prices over time Chart 9



Note.: Density distribution of house price growth 8 quarters into the future as of the second quarter of 2021 and 2022.
Source: Danmarks Nationalbank.

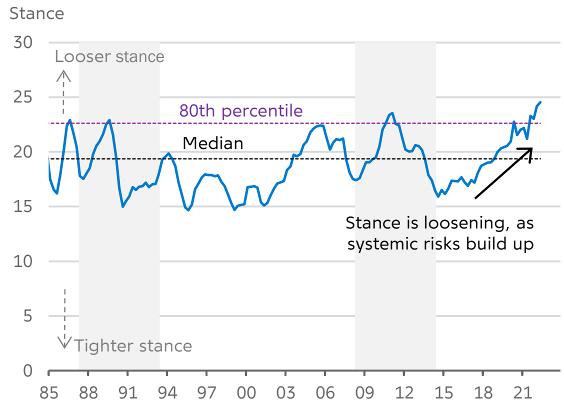
Borrower-based measures reduce tail risks
Similarly to the GDP-at-Risk it is possible to investigate how increasing systemic risks and tightening borrower-based measures impact tail risks. The estimates suggest, that increasing risks may be addressed by tightening borrower-based measures. Tightening borrower-based measures affects the 5th percentile of house price growth positively and thereby reduces a potential decrease of house prices in risk scenarios.

The costs of such a tightening is reflected in the effect on median house price growth. The model results point to a decresed median growth rate of house prices, see table 3.

Developing a framework for assessing macroprudential stance

The presented results provide insight in the initial work with developing a macroprudential stance for Denmark. Given the early stage in the experience with and understanding of macroprudential policies, the development of a fully-fledged measure of the macroprudential stance will rely on the experience gained over the coming years. The stance assessment is complicated by the fact that there is no single definition of financial stability, and the key variables for capturing systemic risk continue to evolve.

The macroprudential stance on the housing market is loosening Chart 10



Note.: Latest observation Q2 2022. The median and the 80th percentile illustrated in the chart are based on the full sample from 1974-2022.
Source: Danmarks Nationalbank.

The growth at risk framework is especially useful for assessing the impact of variations in cyclical systemic risk over the medium term as well as the impact of macroprudential policy. By providing indications of the interactions between systemic risk assessments and macroprudential policy, it can help manage expectations about future macroprudential policy actions.

However, given the limitations of the growth-at-risk approach, the estimates serve as an illustration and a starting point for discussion of the likely policy implications, rather than a precise forecast. Policy decisions would ultimately always require an in-depth analysis of both risks and implications based on a large variety of tools and information sets.

Constructing the Systemic Risk Indicator for Denmark

Box 1

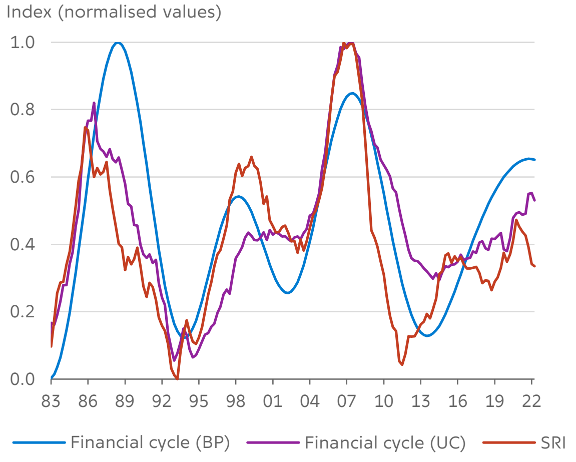
Following recent work at the ECB, our analysis builds on the domestic cyclical systemic risk indicator (d-SRI) as the main measure of cyclical risk, see chart 1.A**.** The d-SRI is a tractable, transparent and broad-based composite indicator that captures cyclical systemic risks from developments in domestic credit, real estate markets, asset prices and external imbalances. It is designed to signal financial crisis vulnerabilities sufficiently in advance, so that mitigating macroprudential policy action could be taken.

The d-SRI is constructed as the optimal weighted average of six early warning indicators after normalising the individual indicators. Indicator normalisation is done by subtracting the median and dividing by the standard deviation of the pooled indicator distribution across countries. Optimal indicator weights are chosen to maximise the early warning properties of the composite d-SRI for systemic financial crises that are at least partly due to domestic vulnerabilities. The optimal weighting procedure for the d-SRI assigns the largest weight to the bank credit-to-GDP change (52 per cent), followed by the residential real estate price-to-income ratio change (21 per cent), the real equity price growth (17 per cent), the debt service ratio change (5 per cent) and the real total credit growth (5 per cent). The weights are based on a sample of EU countries.

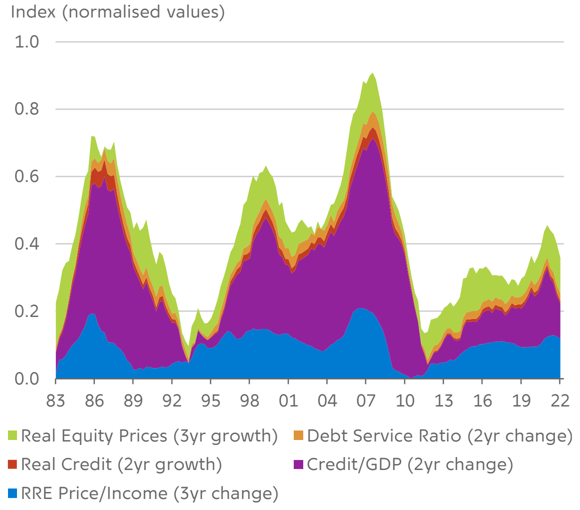
The d-SRI used to reach its peak value between four to eight quarters before the onset of past systemic financial crises in euro area countries, Denmark, Sweden and the United Kingdom. Both the in-sample and the out-of-sample early warning properties of the d-SRI are superior to those of the credit-to-GDP gap and other well-performing univariate early warning indicators.

Systemic Risk Indicator (SRI) largely reflects developments in financial cycle

SRI tracks financial cycle



Credit-to-GDP drives movements in SRI



Note: *Left*: Chart compares the SRI to two different estimates of the financial cycle in Denmark based on a simple band-pass filter (BP) and an unobserved component model (UC). Financial cycle estimates have been transformed to take values in [0,1] to be on the same scale as the dSRI. *Right*: Chart illustrates how developments in the SRI are driven by its five sub-indicators: credit-to-GDP change (52 per cent), followed by the residential real estate price-to-income ratio change (21 per cent), the real equity price growth (17 per cent), the debt service ratio change (5 per cent) and the real total credit growth (5 per cent)

Source: Danmarks Nationalbank, ECB Occasional paper No 219, 2019.

Designing an indicator for macroprudential policy

Box 2

Macroprudential indicators are typically designed as a "dummy-type" index, obtained by assigning +1 for tightening and -1 for loosening policy decisions.[1] The values are accumulated over time to reflect the cumulative tightening/loosening impact of the measures. A dummy-type approach would not capture the magnitude of the initiated measures. Therefore, we use an alternative approach for constructing an indicator for capital-based measures and borrower-based measures, see chart A.

Capital-based measures

The measure is based on banks' Tier 1 capital requirement and reflects two major changes in capital requirements:

- Implementation of Basel I in 1990: The capital adequacy of Danish banks was to be measured against their risk-weighted assets rather than their total debt and guarantee commitments. The new rules entailed considerable easing of the statutory capital requirement for banks. The capital base was to make up at least 10 per cent of the risk-weighted assets in 1991 and 1992, 9 per cent in 1993 and 1994 and finally 8 per cent from 1995. Tier 1 capital had to make up at least 50 per cent of the total regulatory capital (i.e. 4 per cent of RWA).
- Implementation of Basel III (CRR/CRDIV) in 2013: The implementation of CRR/CRDIV entailed some tightening of the definition of capital and risk-weighted assets. The Tier 1 minimum capital requirement was also increased to 6 per cent, and a number of capital buffers were also introduced.

The indicator is based on the most recently announced fully phased-in changes in the combined buffer requirement. The advantage of this choice is that it is not necessary to focus on analysing the pass-through or effectiveness of policy decisions. At the same time, this choice acknowledges that it is the policy decision, not its implementation date, that is most relevant, as banks might act before the measure becomes binding. The drawback is that policies with longer and shorter phase-in periods are treated as equally effective, even though a longer phase-in period makes the policy less binding for a bank.

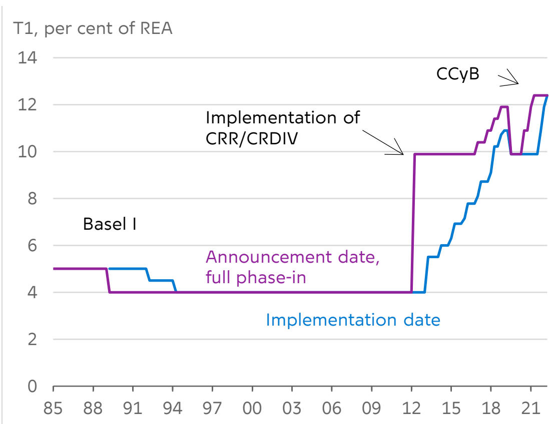
Borrower-based measures reflected in first-year debt servicing costs

The indicator is based on a stylised first-year debt servicing cost after tax for a first-time home buyer with a fully loan-financed purchase. The measure is basically the expected debt servicing costs for a loan of kr. 100. The debt servicing costs are calculated for four types of loans: fixed-rate with amortisation, fixed-rate with deferred amortisation, variable-rate with amortisation and variable-rate with deferred amortisation. Based on the four types of loans, the regulation measure variable is created as the minimum possible first-year payment for each period. The payments are calculated at a constant interest rate for the entire period to isolate changes due to, e.g., regulation, changes in the tax deductibility of interest expenses or introduction of new loan types.

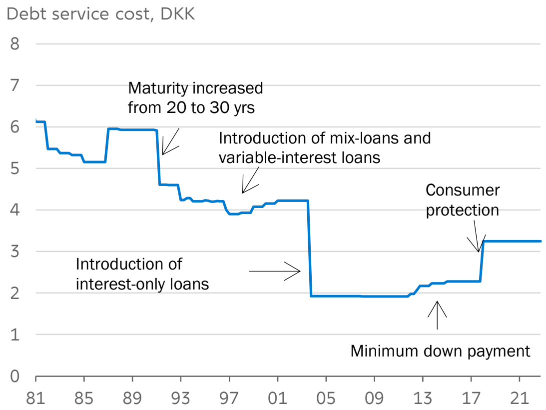
The measure does not include only typical macroprudential measures such as loan-to-value restrictions or down payment requirements. A number of other regulatory changes are also included as they might impact the residential real estate market and have a macroprudential effect. For example, the introduction of loans with deferred amortisation in 2003 allowed homeowners to take a loan with a significantly lower first-year payment, which meant that they could incur higher debt relative to their income than before. The introduction of loans with deferred amortisation is reflected in the fall in the first-year debt servicing costs in 2003, see chart.

Two indicators capture borrower based and capital based policy actions — **Chart A**

Capital Based Measures



Borrower Based Measures



Source: Danmarks Nationalbank, Otte, Yordanova (2020), *What's the Story Behind Danish Households' rising debt?*.

[1] Studies using similarly constructed MPIs are Claessens et al. (2013 JIMF), Cerutti et al. (2017 JFS), Bruno at al. (2017 JFS), Altunbas et al. (2018 JIMF), Akinci and Olmstead-Rumsey (2018, JFI), Gambacorta and Murcia (2019 IFC-B), Poghosyan (2019 IMF-WP), Everett et al. (2019 WP).

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