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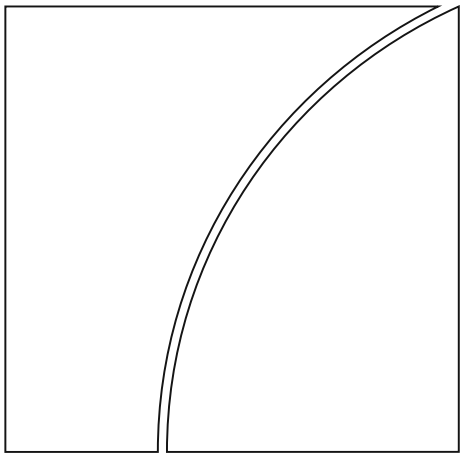

Financial stability implications of a prolonged period of low interest rates

Report submitted by a Working Group established by the Committee on the Global Financial System

The Group was co-chaired by Ulrich Bindseil (European Central Bank) and Steven B Kamin (Board of Governors of the Federal Reserve System)

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Preface

Interest rates have been low in the aftermath of the Global Financial Crisis, raising concerns about financial stability. In particular, the profitability and strength of financial firms may suffer in an environment of prolonged low interest rates. Additional vulnerabilities may arise if financial firms respond to "low-for-long" interest rates by increasing risk-taking.

In light of these concerns, the Committee on the Global Financial System (CGFS) mandated a Working Group co-chaired by Ulrich Bindseil (European Central Bank) and Steven B Kamin (Federal Reserve Board of Governors) to identify and provide evidence for the channels through which a "low-for-long" scenario might affect financial stability, focusing on the impact of low rates on banks and on insurance companies and private pension funds (ICPFs).

The following report presents the Group's conclusions about whether prolonged low rates induce fragility in the financial system because of repercussions on banks and ICPFs. The first message is that while banks should generally be able to cope with solvency challenges in a low-for-long scenario, ICPFs would do less well. Banks can undertake a number of adjustments to shield profitability from low rates, whereas ICPFs are characterised by negative duration gaps that make them vulnerable to falling interest rates. The second message is that even though the Working Group identified only a relatively limited amount of additional risk-taking by banks and ICPFs in response to low rates, a low-for-long scenario could still engender material risks to financial stability. For example, even in the absence of greater risk-taking, a future snapback in interest rates could be challenging for financial institutions. Banks without sufficient capital buffers could face solvency issues, driven by both valuation and credit losses. ICPFs, instead, could face liquidity problems, driven either by additional collateral demands linked to losses on derivative positions or by spikes in early liquidations.

The adjustment of financial firms to a low interest rate environment warrants further investigation, especially when low rates are associated with a generalised overvaluation of risky assets. I hope that this reports provides both a sound rationale for ongoing monitoring efforts and a useful starting point for future analysis.

Philip Lowe

Chair, Committee on the Global Financial System
Governor, Reserve Bank of Australia

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Executive summary

The decade following the Great Financial Crisis (GFC) has been marked by historically low interest rates. Yields have begun to recover in some economies, but they are expected to rise only slowly and to stabilise at lower levels than before, weighed down by a combination of cyclical factors (eg lower inflation) and structural factors (eg productivity, demographics). Moreover, observers put some weight on the risk that interest rates may remain at (or fall back to) very low levels, a so-called "low-for-long" scenario. An environment characterised by "low-for-long" interest rates may dampen the profitability and strength of financial firms and thus become a source of vulnerability for the financial system. In addition, low rates could change firms' incentives to take risks, which could engender additional financial sector vulnerabilities.

This report identifies and provides evidence for the channels through which a "low-for-long" scenario might affect financial stability, focusing on the impact of low rates on banks (in both advanced and emerging market economies) and on insurance companies and private pension funds (ICPFs). The report assumes that this scenario is driven by weakness in economic growth and inflation; other factors could also lead to persistently low interest rates, although perhaps with different implications for financial stability.

For banks, low rates might reduce resilience by lowering profitability, and thus the ability of banks to replenish capital after a negative shock, and by encouraging risk-taking. These effects can be expected to be particularly relevant for banks operating in jurisdictions where nominal deposit rates are constrained by the effective lower bound, leading to compressed net interest margins. For banks in emerging market economies (EMEs), such adverse effects might materialise not only as a result of low domestic interest rates but also as a consequence of "spillovers" from low interest rates in advanced economies (AEs), which can encourage capital inflows into EMEs, excessive local credit expansion, and heightened competitive pressures for EME banks.

For ICPFs, low interest rates boost the present discounted value of both assets and liabilities. However, because the assets held by ICPFs generally are of shorter duration than their liabilities (contractual payments on life insurance or pension policies), the present value of liabilities rises more than that of assets, thus undermining solvency. In addition, the scope for claimholders to terminate life insurance contracts early (surrender options) can become a source of liquidity vulnerability for insurance companies if a period of low interest rates ends with a sudden snapback in rates. Distress or outright failure of particular ICPFs could be transmitted to the rest of the financial system and to the broader economy through counterparties in the financial sector and/or stakeholders in the non-financial sector. Moreover, heightened liquidity needs induced by firm distress could amplify downward corrections in valuations through fire sales.

The *main findings of the report on the impact* of low rates on banks and ICPFs are:

Banks. Based on econometric evidence, simulation models, and reviews of past stress tests, the Working Group found considerable evidence that low interest rates and shallower yield curves depress net interest margins (NIMs). This effect was more pronounced for banks facing constraints on their ability to reduce deposit rates, for example, because of very low interest rates or strong competitive pressures.

Nevertheless, banks generally appear to have found ways to shield their overall return-on-assets (RoA) from prolonged low interest rates (including by cost-cutting, strengthening fee-based income, extending asset duration and increasing exposure to the housing sector), although some of these adaptations may prove less viable going forward (e.g. cost-cutting). Accordingly, econometric simulations of the effect of a low-for-long scenario for interest rates over the next decade or so suggest that, compared with a "baseline" scenario in which interest rates rose gradually and in line with most observers' expectations, banks would generally experience reduced net interest margins but much less damage to overall profitability.

The Working Group found little systematic correlation between interest rates and measures of bank soundness and risk-taking. Banks have increased asset durations and shifted more loans into the housing sector since the GFC, but have not exhibited signs of more exuberant reaching for yield. Even where interest rates have fallen to very low levels, aggregate measures of bank soundness have not deteriorated to a marked extent, including in Europe and Japan.

ICPFs. As anticipated, solvency metrics – especially funding ratios – would almost certainly deteriorate in a low-for-long scenario. That said, these challenges would likely play out over a longer time period than for banks – as a result of their long liability maturities, ICPFs have long horizons – providing greater room for orderly adaptation and reducing the likelihood of broader financial disruptions.

The evidence suggests that ICPFs could be trying to adapt to the low interest rate environment by increasing asset duration and (possibly) tilting portfolios to assets with lower credit quality. As in the case of banks, however, these shifts do not appear to have markedly increased ICPF's exposure to future shocks.

Risks. Although persistently low interest rates would appear not to substantially ratchet up financial stability risks at the most general level, the Working Group did identify a range of concerns and caveats which suggest that a "low-for-long" scenario, were it to materialise, would require careful consideration and monitoring:

First, even if banks in the aggregate manage to maintain adequate profitability, some banks (or even national banking systems) could come under strain, especially those that focus on retail lending and deposit activities and that operate in competitive markets. Moreover, it is possible that because of the inherent limitations of the type of (multi-country) analysis performed by the Working Group, the damage that low rates could cause may have been underestimated.

Second, the relatively restrained risk-taking evidenced by financial institutions in recent years may reflect tighter regulation and de-risking following the GFC. Such restraint might erode over time if interest rates remain low and continue to put downward pressure on returns and profitability.

Third, although the adverse effects of low interest rates on the profitability and balance sheets of ICPFs would likely play out gradually, so that problems can normally be addressed in an orderly manner, it is quite possible that some firms might not find ways to adapt and as a result experience solvency problems, with knock-on effects to other parts of the financial system.

Fourth, a period of prolonged low interest rates could well be followed by a sharp surge or "snapback" in interest rates. Such a snapback could be challenging for financial institutions, even in the absence of additional risk-taking. Banks would likely experience valuation losses on long-duration assets and credit losses on loans. Adaptations to maintain profitability during low-interest rate periods, such as

lengthening asset maturities and shifting loans to the interest-sensitive real-estate sector, would exacerbate the effects of a subsequent snapback. Banks in EMEs might face even greater challenges if sharply higher interest rates in AEs triggered a reversal of capital flows and a sharp sell-off in EME assets, as underscored by the "taper tantrum" experience in 2013. Finally, although ICPFs would likely see improvements in solvency ratios in the event of a snapback (because of negative duration gaps), these gains might be tempered to the extent that ICPFs had lengthened their asset durations and taken on riskier investments during the preceding low-interest-rate period. Moreover, these firms could experience liquidity problems driven by losses on derivative positions – which would result in greater collateral demands – and by increased surrenders of insurance policies.

Finally, three other risks, which have sometimes been associated with a low-for-long scenario, were beyond the scope of the Working Group's report. There would be some chance that prolonged low interest rates might encourage asset bubbles and subsequent crashes. And, low rates might encourage excessive risk-taking in other types of financial institutions besides banks and ICPFs, such as in the market-based intermediation sector. Finally, interactions between banks, ICPFs and other institutions could act as a system-wide amplifier of interest rate shocks.

Policy implications. The first line of defence by prudential authorities should be to continue to build resilience in the financial system by encouraging adequate capital, liquidity, and risk management. At the same time, consideration might be given to policies that address more specific concerns posed by the low-for-long and snapback scenarios. The Working Group supports enhanced monitoring of financial institutions' exposure to low-for-long and snapback risks, especially through stress tests that can capture both gradual build-ups and sudden reversals. The adoption of regimes that allow insolvent insurance companies to be resolved without systemic disruption would also be especially important.

Introduction

Most parts of the global economy have experienced a prolonged period of historically low interest rates. Despite recent moderate increases in yields in several economies, interest rates are generally expected to rise only slowly over the near to medium term, and to eventually stabilise below levels prevailing in previous decades. Moreover, observers put some weight on the risk that interest rates may remain at low levels for the foreseeable future, reflecting both cyclical and structural factors. Persistently low rates would likely affect the profitability of financial firms, thus potentially impacting the structure and resilience of the financial sector. They might also incentivise changes in the business models of financial firms potentially bringing about changes in their desired risk profile and exposures. As a result, a prolonged period of low interest rates could have implications for the stability of the financial system.

The CGFS mandated this Working Group (WG) to identify and provide evidence for the channels through which persistently low interest rates might financial stability, whether positively or negatively. The analysis focuses on three classes of financial institutions: banks, insurance companies and pension funds. The choice was motivated by the importance of these firms for the functioning of the financial system and the interest rate sensitivity of their business model performance. The WG did not address the effect of low interest rates on capital markets and non-bank financial intermediaries, but such research would also be desirable

As an organising framework, the WG compared the likely performance and behaviour of financial institutions under three scenarios covering the period 2017–27. The *baseline* scenario, which is consistent with mainstream economic forecasts and central bank inflation targets, involves a gradual rise in interest rates to more normal levels. The *low-for-long* scenario entails an interest rate trajectory that is materially lower than in the baseline, reflecting a stronger depressive influence of the structural drivers (demographics, productivity, etc) that appear to be restraining interest rates at present. The *snapback* scenario, where interest rates remain quite low initially but then rise sharply, captures the possibility that adjustments by financial institutions to low rates may make them more vulnerable should interest rates rise rapidly.

The WG used a range of quantitative methods to compare the performance of banks, insurance companies, and pension funds across the different scenarios. For the banking sector, where ample data are available, empirical relationships were estimated between the level of interest rates and banks' performance and risk-taking.[1] Coupled with additional evidence from stress tests, bank models and case studies, these relationships informed assessments of the profitability, solvency and risk-taking behaviour of firms may be affected by low interest rates, and how these firms might be affected by a subsequent snapback in rates. The analysis pays particular attention to the situation of emerging market economy (EME) banks, whose performance responds not only to low interest rates in their own economies, but also to interest rates in advanced economies (AEs). For insurance companies and pension funds, where less data are available and the impact of interest rates plays out over longer periods, the WG developed a simulation model to assess how solvency metrics

[1] It is typically difficult to clearly identify the contribution of ex ante risk-taking to ex post adverse outcomes, adding uncertainty to empirical estimates of ex ante risk-taking behaviour.

would be affected across the scenarios (prolonged low rates, snapback) and how this impact would depend on the behaviour of affected firms.

Importantly, this report focuses on the impact of prolonged low interest rates on financial firms but not on the impact on asset prices, nor on the risk that low rates might engender asset bubbles and financial stability problems. The latter are important issues, but addressing them would unduly widen the scope of the analysis. Additionally, while low interest rates should lead to higher asset valuations, it is unclear that they should lead to asset bubbles per se. Nonetheless, given that higher asset valuations may complicate the identification of risk-taking by financial firms, the results about risk-taking in this report should be interpreted with caution. Finally, by focusing exclusively on banks and ICPFs, and not addressing other types of financial intermediary, the report abstracts from possible interactions between sectors and any ensuing system-wide effects.

This project follows several previous efforts to assess the prospective impact of persistently low interest rates on financial stability, including ESRB (2016), IMF (2016) and IMF (2017). The ESRB report is both broader in scope – in that it considers not only the implications of persistently low rates, but also those of ongoing structural changes in the financial system – and narrower, as it looks exclusively at the European Union. The later Global Financial Stability Report (IMF (2017)) also employs a scenario approach but, importantly, it does not distinguish between baseline, low-for-long and snapback. Moreover, this WG report goes beyond these previous studies in a number of ways.[2] First, it provides a more explicit "bottom line" on the likely effects of low interest rates on financial stability. Second, it bases this bottom line on a more systematic quantitative mapping between interest-rate scenarios and financial stability outcomes. And, third, it extends the analysis to EMEs, a group of economies not usually addressed in previous analyses of this topic.

The report is organised in five chapters. Chapter 1 describes the interest rates scenarios used in the analysis. Chapter 2 focuses on the impact of low rates on banks, while Chapter 3 addresses the special implications for emerging market banks. Chapter 4 discusses how prolonged low rates might affect financial stability through their impact on insurance companies and pension funds. The final chapter offers conclusions and discusses issues of relevance to policymakers.

[2] The analysis of banks in the report is also closely related to CGFS (2018), which explores the drivers of bank profitability and the link between profitability and financial stability.

1. Interest rate scenarios

The scenarios developed by the WG define what is meant by "persistently low interest rates", and enable the WG to make quantitative projections of the impact of different interest rate paths on the profitability and behaviour of key financial intermediaries. The scenarios cover the period 2017 to 2027 for 23 jurisdictions, and consist of paths of the three-month rate, the 10-year yield, inflation, GDP and potential GDP, at an annual frequency.[3]

As discussed above, there are three scenarios for each jurisdiction: (i) the *baseline*, which is intended to be consistent with mainstream economic forecasts, (ii) the *low-for-long* (L4L), which involves a persistently lower level of interest rates, and (iii) the *snapback*, which is a variant of the L4L with a steep increase in rates after 2022. Graph 1 shows the paths of a selection of key variables for each scenario for the United Kingdom, a choice motivated exclusively by illustration purposes. Annex I provides more details on the assumptions underlying these scenarios, including graphs for each jurisdiction.

1.1 Baseline scenario

The baseline scenario (see Graph 1, red lines) uses IMF projections, which are assumed to represent mainstream projections. IMF projections from the October 2017 WEO are used and run through 2022 (IMF (2017)). The WG's extension of the IMF projections beyond 2022 starts with pinning down the value of the short real rate and inflation at the terminal date (2027). The economy is assumed to have reached a steady state with output at potential by then so that the real three-month rate is equal to the natural rate, r*. The level of r* is calculated as the real three-month rate projected by the IMF in 2022, for countries where the IMF projection has plateaued by that year (Canada, the EMEs and the United States), and as a function of the growth rate of potential real GDP, for other economies. Central banks are assumed to have achieved their inflation target by the terminal date, and thus the 2027 nominal three-month rate is equal to the sum of r* and the inflation target.[4] The 10-year yield is then determined as the sum of the nominal three-month rate plus a country-specific term spread, which for 2027 is set to be equal to the average spread between 1999 and 2016. Between 2022 and 2027 the short rate, term spread and long yield are assumed to converge linearly from their last value in the WEO projection to their terminal value.

1.2 Low-for-long scenario

Relative to baseline, the low-for-long scenario (see Graph 1, blue lines) projects a lower path for interest rates, actual and potential GDP growth and inflation. In particular, inflation undershoots the policy target and the path of r* is lower, reflecting declines in potential GDP growth and other factors usually associated with secular stagnation.

[3] To reflect the long horizons of ICPFs and to capture some of the possible adverse effects of a snapback in rate on these firms, scenarios had to be extended to 2037 and augmented with additional asset price variables.

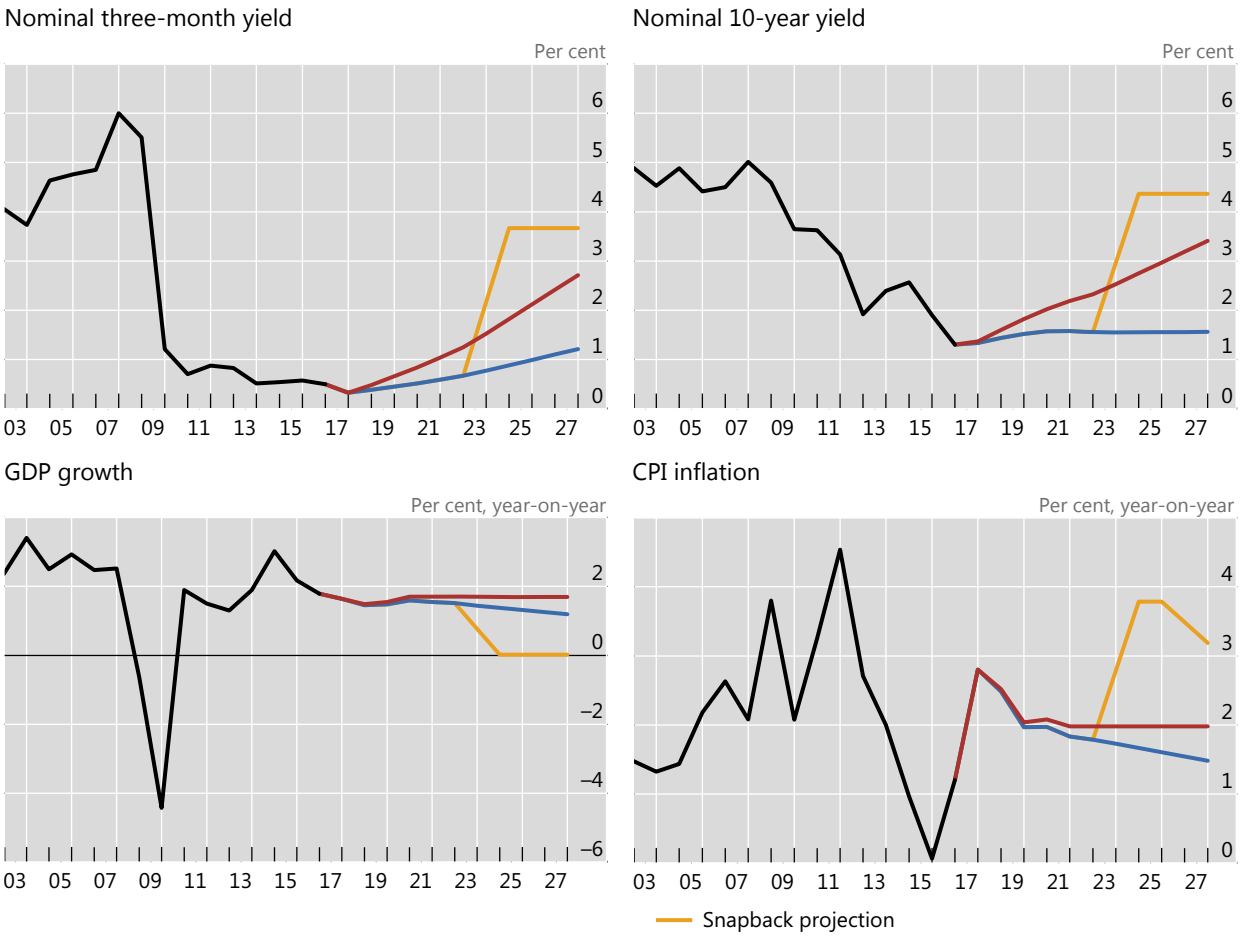
[4] Not all countries in the sample have a point target for inflation. For those who use an interval target, the midpoint has been used. For those that have a "less than or equal to" type target, the upper bound was used.

The natural rate r*, the inflation rate and the nominal short rate all start at the same level as in baseline in 2017, but end up respectively 100, 50 and 150 basis points lower than baseline by 2027. The 10-year yield is set so that the term spread converges linearly to a terminal value which is half the average term spread between 1999 and 2016. This is motivated by the possibility that low interest rate environments reduce term premiums. While potential growth is lower than in baseline, the path of the output gap is unchanged.

1.3 Snapback scenario

The snapback scenario (see Graph 1, yellow lines) builds on the L4L scenario but features a rapid run-up in inflation, starting partway through the projection period (in 2023), that engenders a correspondingly rapid increase in short- and long-term interest rates.[5] The surge in inflation could be motivated by any number of factors; here, it is assumed that a slower rate of potential GDP growth implies a wider output gap and a heightening of price pressures. Inflation rises 2 percentage points above

Interest rate scenarios: United Kingdom — Graph 1



Sources: IMF, *World Economic Outlook October 2017*; WG, scenarios workstream.

[5] In this report, snapback is triggered by an abrupt increase in inflation expectations. There could be other triggers, such as rising government financing needs, which would result in a material rise in sovereign yields. Another alternative trigger could be a suddenly stronger growth outlook.

its L4L rate after a couple of years, leading to a tightening of monetary policy that pushes the three-month interest rate up by 300 basis points. The 10 year yield rises even more, in part reflecting the re-emergence of an inflation risk premium in the term spread. These higher rates induce a recession, but because inflation remains above target, interest rates remain elevated.

2. Impact of low interest rates on banks

This chapter addresses the risks that low interest rates can pose to financial stability through their impact on banks. After reviewing recent trends in bank profitability, the chapter presents econometric analysis identifying the effects of low rates on bank profits and risk-taking. Using these results and other evidence (information from stress tests, simulation analysis of Swiss banks, and the historical experience of many banks), it then assesses whether a low-for-long scenario would lead to worrisome losses in profitability and increases in risk-taking, and whether a snap back in rates would adversely affect banks that had positioned themselves for continued low rates.

2.1 Channels

Low rates may diminish the resilience of banks by restricting profitability, and thus the ability to replenish capital after a negative shock, and by encouraging risk-taking, thus increasing the risk of future losses. The risks to financial stability from a low interest rate environment depend on the extent to which profitability is reduced and the degree to which measures taken to offset such losses increase vulnerability.

Low rates affect bank profitability mainly through net interest margins (NIMs). Specifically, when short-term interest rates decline, banks may be unwilling or unable to lower deposit rates below a given level, even as returns on loans and other assets decline, and this should lower NIMs. In particular, if market rates become negative, banks may be unable to adjust deposit rates accordingly. A flatter yield curve should also lower NIMs, to the extent that banks' loans and other assets have longer durations than their liabilities.[6]

There are mitigants to the negative effect of lower interest rates on NIMs. During the transition from higher to lower interest rates, banks benefit from the revaluation of longer-term assets (consistent with a positive duration gap between assets and liabilities).[7] Banks can also offset lower NIMs by issuing riskier loans (see below) and through business adjustments, for instance by increasing fee-based business. And, in an environment of deficient aggregate demand, low interest rates may support loan demand, thus potentially moderating reductions in NIMs and return-on-assets (RoA). Nevertheless, these offsets may prove difficult and provide only one-off or temporary

[6] See Borio et al (2017), Claessens et al (2017), Covas et al (2015), Bundesbank (2015), Bikker and Vervliet (2017) and Di Lucido et al (2017) for evidence.

[7] The role of valuation changes features prominently in the concept of the reversal interest rate on monetary policy, as introduced by Brunnermeier (2017). It occurs when recapitalisation gains from the duration mismatch are offset by decreases in net interest margins, lowering banks' net worth and tightening their capital constraint.

benefits; so profitability in such an environment would likely be lower than in an environment with more normal macroeconomic conditions.

Low interest rates may also trigger a search for yield by banks, partly in response to declining profits, exacerbating financial vulnerabilities. Evidence from prior analyses suggests that banks may increase risk-taking in response to low rates through shifts toward lower quality lending in return for higher yields.[8] Especially relevant to this report, some studies argue that the effects become stronger the longer low rates persist.[9] Other avenues for risk-taking include increases in maturity mismatches, as lenders increase the duration of their assets and borrowers try to lock in low rates, higher leverage, as banks might extend high volumes of loans in addition to changing risk features of loans, and perhaps even currency mismatches. Boosting bank risk-taking and thus lending is one of the means by which lower interest rates support demand in a weak economic environment – the relevant question for financial stability is whether this risk-taking is adequately compensated and whether the revenues generated from this risk-taking are used to build buffers to absorb future possible losses.

Notably, as explored further later in this chapter, the effect of interest rates on both profitability and risk-taking will differ depending on banks' business models, balance sheets and banking sector environments.

2.2 Profitability

2.2.1 Trends in bank profitability since the GFC

The GFC brought about a severe contraction in bank profitability across many jurisdictions (Graph 2, left-hand and centre panels). RoA – defined as net profit as a percentage of average assets – in the AEs fell from an average of 0.98% in 2006 to 0.24% in 2008, and despite the recent recovery, RoA has not returned to pre-crisis averages.[10] Bank profitability in the EMEs declined more moderately during the crisis and has since remained high compared with its early 2000s average.

A range of different factors has been at work – besides reduced NIMs – to affect bank profitability, including the long cyclical slump, changes in banks' business models and developments in the regulatory environment.[11] In fact, overall banking system profitability was driven primarily by a reduction in non-interest income, with the slowdown in interest revenues coming in second (Graph 2, right-hand panel). In an attempt to recover profitability, banks have partially offset these declines by

[8] See European Systemic Risk Board (2016), Bean et al (2015), Altunbas et al (2014), Maddaloni and Peydró (2011), Jimenez (2014), Gaggl and Valderrama (2010), Dell'Ariccia et al (2017), Aramonte et al (2015), Kandrac and Schlusche (2016), Morais et al (2015), Heider et al (2017), Basten et al (2016) and Ioannidou et al (2015). That said, Arce et al (2018) show that banks whose net interest income is adversely affected by negative rates take less risk.

[9] For example, an IMF (2017) case study distinguishes responses of larger and smaller Japanese banks, Jiménez et al (2014), Ioannidou et al (2015) and Acharya et al (2016) report stronger effects for weakly capitalised banks, and Maddaloni and Peydró (2011) find banks take more risk if capacity constraints in securitisation activity are binding.

[10] Based on the data in the World Bank Global Financial Development Database for 25 AEs, including the United States.

[11] See CGFS (2018), which also points out that in some cases, low profitability might signal the existence of excess capacity and structural impediments to exit for individual banks.

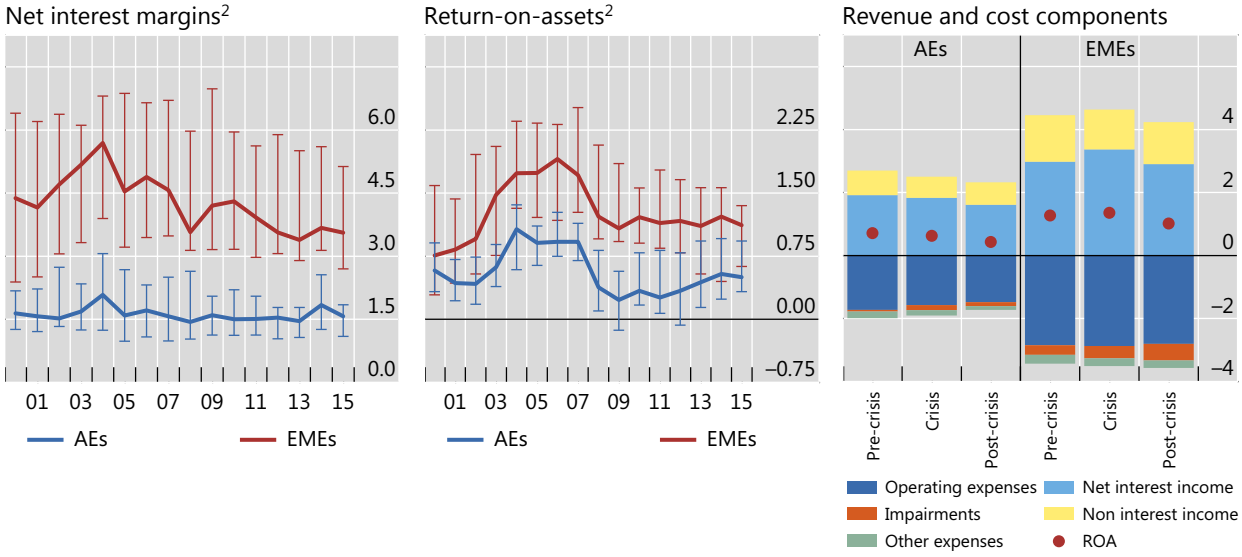
increasing fee-based business, changing the composition and terms of loans, and reducing costs, albeit with varying degrees of success across jurisdictions. The left-hand panel of Graph 3 indicates that in economies where NIMs fell between the pre-GFC years and 2013–15, RoAs generally also fell. However, the link between the two appears to be rather weak.

The centre and right-hand panels of Graph 3 take an initial look at the relationship between changes in interest rates and profitability since the GFC. As indicated in the centre panel, most economies have experienced declines in interest rates and in NIMs since the GFC. However, there is almost no correlation between the two developments. Similarly, the right-hand panel indicates the lack of correlation between changes in interest rates and RoAs.

All told, despite the declines in NIMs and RoAs in the low interest rate years following the GFC, these declines do not correlate strongly with the low rates themselves. However, the bilateral correlations explored here fail to control for a range of relevant factors that may be obscuring the relationship between interest rates, NIMs and RoAs. Below, this issue is addressed in a more thorough and systematic fashion.

Trends in bank profitability[1]

In per cent — Graph 2

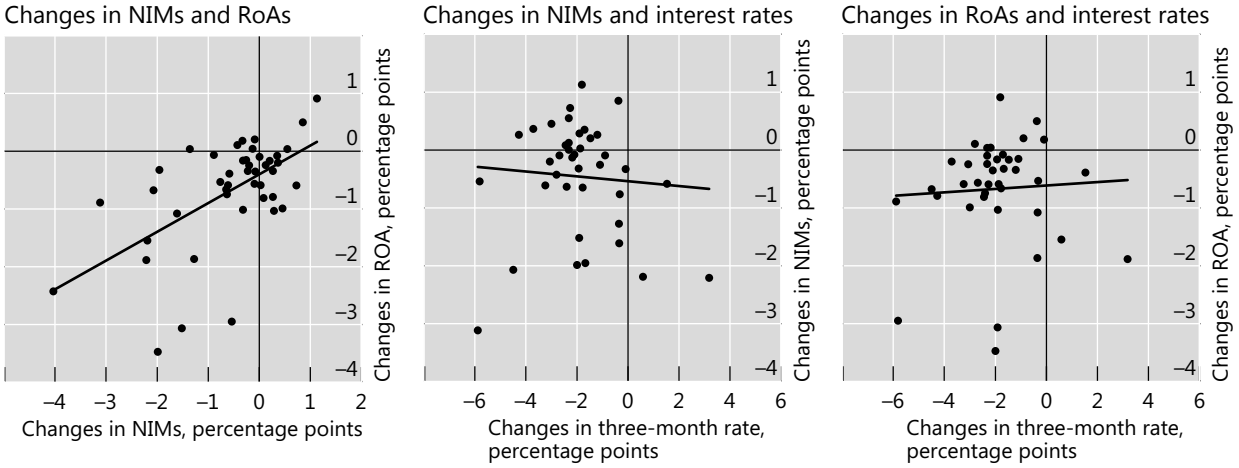


[1] Country groups are based on the BIS definitions of AEs and EMEs. The panels show the medians of the aggregates of each country group. [2] The vertical lines in the left-hand and centre panels denote interquartile ranges.

Sources: Bankscope; World Bank Global Financial Development Database.

Profitability and interest rates

Changes from average 2004-06 to 2013-15 Graph 3



Source: World Bank Global Financial Development Database.

2.2.2 Estimating the impact of low rates on bank profitability

This section presents the results of econometric analysis conducted by the WG to explain changes in net interest margins and return-on-assets, controlling for a range of macroeconomic and structural factors.

The analytical methodology in this report uses two types of regression to identify the link between measures of profitability, such as NIMs and RoA, and the level of interest rates. The first regression type is applied to a panel of aggregate country-level data for 19 countries (labelled Country-Level Analysis), while the second uses bank-level information for more than 10,000 banks across 45 jurisdictions (labelled Bank-Level Analysis).[12] More details of the database and econometric procedures are provided in Annex II.

The regressions adopt a similar structure for both the dependent variables of interest (NIM and RoA) and for both data sets. Each model explains the dependent variable as a function of its lagged value, the three-month interest rate, the slope of the yield curve (difference between the 10-year yield and the three-month rate) and several macroeconomic and banking-sector (or bank) control variables.

Table 1 summarises the estimation results for NIMs, showing only the impact of macroeconomic variables (more detailed results are discussed in Annex IV). As expected, the coefficients on both the three-month interest rate and the slope of the yield curve are positive and statistically significant. The estimated magnitude of their near-term effects is small, but taking into account the large coefficient on the lagged dependent variable, the long-run effect is larger. For example, according to the results of the country-level analysis (column 1), a 1 percentage-point rise in the short rate boosts NIM by only 6 basis points in the near term but by 33 basis points in the long

[12] In the bank-level analysis, the number of banks depends on a particular metric under consideration.

Impact of interest rates on net interest margins

Table 1

Explanatory variables	Country-level analysis	Bank-level analysis			
	All countries	All countries	AEs	EMEs	Memo: AEs excl. United States
	(1)	(2)	(3)	(4)	(5)
Lagged dep. variable	0.82***	0.46***	0.53***	0.36***	0.46***
Short-term rate	0.06*	0.05***	0.05***	0.12***	0.04*
Yield curve slope	0.05***	0.10***	0.10***	0.10**	0.08**
Inflation	-0.01	0.01	0.00	0.01	0.01
GDP growth	0.01	0.01	0.02*	0.01	0.01
Number of observations	295	103495	98507	4988	23097
Number of countries	19	45	25	20	24
Number of banks		10018	9435	583	2442

***/**/* denotes results significant at the 1/5/10% level.

term.[13] Results from the banking-level data (columns 2–5) indicate similar sensitivities in the near term, but notably lower sensitivities in the long term.[14]

Table 2 replicates the analysis shown in Table 1, but focuses on explaining overall return-on-assets rather than just net interest margins. RoAs are generally not significantly associated with changes in short-term interest rates or yield curve slopes. This is consistent with the view that banks compensate for compressed net interest income through other channels, such as increasing non-interest income (as further documented by Altavilla et al (2017), Borio et al (2015)); some measures, such as reducing provisioning and impairment costs, or boosting volumes of risky lending, could raise financial stability concerns, as explored below.

2.2.3 Projecting the impact of low rate scenarios on bank profitability

To assess the effects of low rates on bank performance over a prolonged future period, the models shown in Tables 1 and 2 are used to evaluate the prospective effects of the baseline and the low-for-long scenarios presented in Chapter 1. Specifically, mechanical projections of NIMs and RoAs are constructed using the coefficient estimates obtained from columns (3) and (4), based on the bank-level data, for AEs and EMEs respectively. These projections should be taken to be only illustrative of possible outcomes, as there are wide uncertainties about both the model estimates and scenario assumptions.

The projection results, shown in Graph 4, show that net interest margins in the AEs pick up in the baseline scenario (orange line), reflecting increases in short-term

[13] The long run effect is calculated by dividing the short-term coefficient by 1 minus the coefficient on the lagged dependent variable: $0.06 + 0.06*0.82 + 0.06*0.82^2 + 0.06*0.82^3 + \ldots = 0.06 / (1 - 0.82) = 0.33$.

[14] The decline in NIMs associated with declines in interest rates appears to contradict the typical research finding (for example, in event studies) that bank stock prices rise when interest rates decline. Explanations for this apparent inconsistency include: first, lower rates reduce the rate at which future profits are discounted, potentially boosting the present value of those profits. Second, other components of banks' return-on-assets may change in ways that offset declines in NIMs.

interest rates, the slope of the yield curve and GDP growth. NIMs remain flat in EMEs where interest and growth rates are not assumed to rise much further in the baseline. In the low-for-long scenario (blue line), NIMs decline further and undershoot their baseline paths by about 0.3 to 0.4 percentage points, suggesting a material risk to the financial condition of banks. These projections are broadly consistent with the results of the ECB (2017) stress test, described in Box A, which projected a decline in banks' net interest income should interest rates remain at recent levels.

However, consistent with the results in Table 2, overall profitability as represented by RoA is much less sensitive to interest rates and the undershooting of

Impact of interest rates on return-on-assets

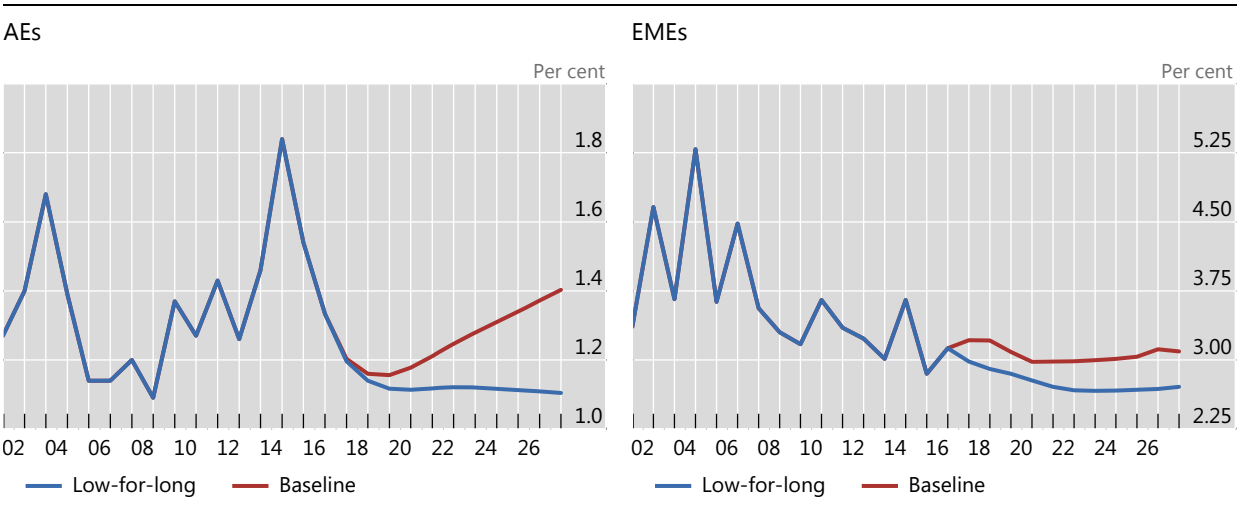
Table 2

	Country-level analysis		Bank-level analysis		
Explanatory variables	All countries	All countries	AEs	EMEs	Memo: AEs excl. United States
	(1)	(2)	(3)	(4)	(5)
Lagged dep. variable	0.48***	0.27***	0.31***	0.13***	0.17***
Short-term rate	0.02	-0.01	–0.02**	0.03	–0.01
Yield curve slope	0	–0.09***	–0.11***	-0.01	–0.02
Inflation	0	0.01	0.00	0.03	–0.01
GDP growth	0.05***	0.04***	0.05***	0.04**	0.02***
Number of observations	295	103495	98507	4988	23097
Number of countries	19	45	25	20	24
Number of banks		10018	9435	583	2442

***/**/* denotes results significant at the 1/5/10% level.

NIM projections using data from banking system aggregates

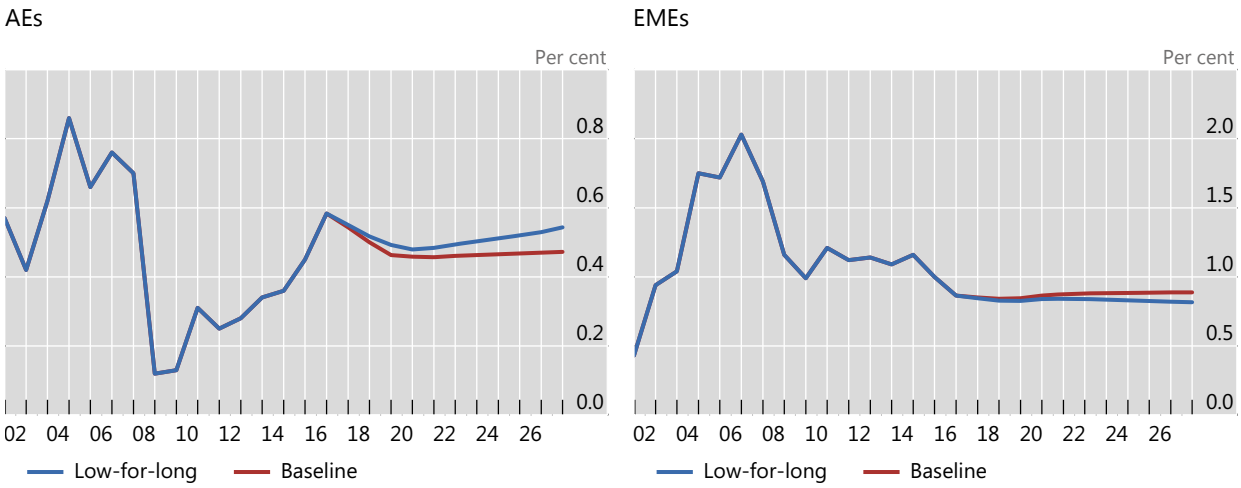
Graph 4



The median of the projections for 13 AEs is shown in the left-hand panel and the median of the projections for nine EMEs in the right-hand panel.

Source: WG calculations.

ROA projections using data from banking system aggregates Graph 5



The median of the projections for thirteen AEs is shown in the left-hand panel and the median of the projections for nine EMEs in the right-hand panel.

Source: Working Group calculations.

RoAs in the low-for-long scenario relative to the baseline path is quite small (Graph 5).[15] This is consistent with the results of the stress test conducted by the Bank of England (also discussed in Box A), where UK banks reported that in order to maintain profitability throughout a prolonged low rate period they will undertake business model adjustments.

2.2.4 The role of the low-yield environment, business models, and banking system structure

The relatively benign story told by these RoA projections should be interpreted with caution, both because the parameters of the model are subject to considerable uncertainty, and because these average profitability projections may obscure much greater sensitivities to low interest rates in particular situations or for particular categories of banks and banking systems.

First, earlier research has identified non-linearities in the relationship between interest rates and bank profitability, with the impact of rates on profits being stronger when rates are especially low (for example, below zero) than when they are at more historically normal levels.[16] In Table 3 below, the bank-level regression sample is divided into observations corresponding to interest rates below 1.25% (referred to as within the low-yield-environment period, or LYE Years) and those above that threshold (Non-LYE Years).[17] The estimates point to a significantly larger effect of short-term interest rates on NIMs when rates are low. This non-linearity appears to be concentrated in the AEs excluding the United States; in other regressions (not shown), no such non-linearity was indicated for EMEs or the United States.

[15] For advanced economies, RoA under the low-for-long actually exceeds RoA under the baseline. This reflects a negative coefficient on the slope variable, which is most likely a statistical aberration.

[16] See, for example, Borio et al (2015) and Claessens et al (2018).

[17] The 1.25% LYE threshold was used in Claessens et al (forthcoming). The regressions were not applied to the country-level data owing to the paucity of observations.

Second, the effect of interest rates on profitability is likely to depend on the nature of the banking market. In Table 4, the regression sample is divided into countries whose banking markets have low concentration – indicating that banks face strong competitive pressures and thus have low pricing power – and those that have high concentration. The estimation results indicate that NIMs are considerably more responsive to interest rates in less concentrated markets, likely because banks must pass rate declines to their loan customers and have less latitude to reduce deposit rates. This may help explain why, as described in Box B, Swiss retail bank margins have been hit hard by low rates, whereas Scandinavian banks have not.

NIM and RoA sensitivities and the low yield environment

Table 3

Explanatory variables	AEs, Non-LYE Years	AEs, LYE Years	Memo: AEs excl. United States, Non-LYE Years	Memo: AEs excl. United States, LYE Years
	(1)	(2)	(3)	(4)
Panel A: Net interest margins				
Short-term rate	0.01	0.21***	–0.03*	0.11***
Yield curve slope	0.04	0.07***	0.00	0.17***
Panel B: Return-on-assets				
Short-term rate	–0.04	0.28***	–0.06*	0.12***
Yield curve slope	–0.08	–0.14***	–0.11*	0.02

***/**/* denotes results significant at the 1/5/10% level.

NIM and RoA sensitivities and bank concentration

Table 4

Explanatory variables	Country-level analysis		Bank-level analysis	
	Countries with low concentration	Countries with high concentration	Countries with low concentration	Countries with high concentration
	(1)	(2)	(3)	(4)
Panel A: Net interest margins				
Short-term rate	0.10**	0.02	0.14***	0.07**
Yield curve slope	0.08***	0.02	0.22***	0.06
Panel B: Return-on-assets				
Short-term rate	0.01	–0.03	0.01	0.05
Yield curve slope	0.04**	0.14**	–0.01	0.00

Countries with low concentration are those with concentration ratios in the bottom 25% of the distribution and with high concentration in the top 25%. Asterisks denote statistical significance.

***/**/* denotes results significant at the 1/5/10% level.

Impact of interest rates on net interest margins

Table 5

	Effect on net interest margin				Effect on return-on-assets			
	of short rate:		of slope:		of short rate:		of slope:	
	AEs	EMEs	AEs	EMEs	AEs	EMEs	AEs	EMEs
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Total assets								
In upper quartile	0.05**	0.12***	0.09**	0.10***	0.01	0.02	–0.12*	–0.01
In lower quartile	0.05***	0.16*	0.10***	0.19***	–0.01***	–0.09	–0.06***	–0.04
Loans over assets								
In upper quartile	0.01	0.20***	0.06*	0.18***	–0.01	0.06*	–0.11***	0.05*
In lower quartile	0.08***	0.13***	0.14***	0.12	0.06***	0.02	0.03***	–0.05
Deposits over liabilities								
In upper quartile	0.05***	0.42***	0.09***	–0.63*	0.01***	0.42***	–0.07***	0.40
In lower quartile	0.01	0.14***	0.07**	0.09***	0.01	0.04	–0.06	–0.02

Upper quartile refers to banks in the top 25% of the distribution and lower quartile to banks in the bottom 25%. Asterisks denote statistical significance.

***/**/* denotes results significant at the 1/5/10% level.

Finally, bank's business model can affect the sensitivity of its profits to interest rates. To the extent that the effect of interest rates on profitability works through lending and deposit margins, banks with extensive conventional lending and deposit-taking activities would likely experience the largest effects of interest rates on their margins and profitability. Profits of banks that have a more diversified activities portfolio, and hence rely more on fee income, might be subject to a smaller impact from a decline in interest rates. Table 5 compares the estimated effect of interest rates on profits when the sample of banks is divided according to different bank characteristics. It provides some, albeit mixed, evidence in favour of the view that less-diversified, lending-and-deposit focused banks may take the largest hit from low rates: banks with a higher share of deposits in total liabilities exhibit greater sensitivities of NIMs to interest rates. However, the prediction that banks with a greater share of loans in total assets will exhibit greater sensitivity of their profits to interest rates only appears to hold in EMEs.[18] Finally, the overall size of banks does not appear to make much of a difference for AE banks, but smaller EME banks do appear to exhibit higher NIM sensitivities to interest rates.

[18] It is also plausible that the NIMs of banks with predominantly fixed rate loans would be affected less by low rates, but the bank-level data source did not distinguish between fixed and floating rate loans. Annex IV reports NIM and RoA regressions that distinguish between banks based on whether fixed or floating rate mortgages are more common in their home country. Counterintuitively, for banks in the full set of advanced economies, the results suggest that bank NIMs are more sensitive to short rates in fixed rate countries, but excluding US banks, the distinction disappears. The coefficients on the yield curve slope are higher for banks in fixed rate countries, consistent with at least some of this fixed rate lending being funded at shorter maturities.

All told, these regressions provide some evidence that, for retail-focused banks in concentrated markets, and especially where interest rates are very low or even negative, the effect of a low-for-long scenario on NIMs and RoAs would likely be considerably greater than indicated in Graphs 4 and 5. This concern is supported by other, more granular analyses. Box B presents the results of a very detailed model-based analysis of domestically oriented retail banks in Switzerland. In this market, interest rates on assets, primarily mortgages, follow market rates downward in the low-for-long scenario and depress margins and overall returns. Bank stress tests represent another source of granular analysis. As discussed in Box A, stress tests undertaken by the ECB and German regulatory authorities point to diminished profitability as a consequence of lower rates, especially (in the German case) for smaller banks.

Box A

Interest rates, bank profitability and risk-taking: evidence from stress tests

Interest-rate scenarios have been featured in a number of recent supervisory stress exercises in the United Kingdom, Germany, the euro area, Switzerland and the United States (Annex III). These stress test results provide further evidence that lower interest rates can weigh on bank profitability. For example, the ECB exercise for interest rate risk in the banking book found that if interest rates remained at their low end-2016 levels, the net interest income of 111 significant euro area banks would fall on average by 7.5%. Similarly, a BaFin/Bundesbank survey indicates that a move to higher rates would provide significant support to the profitability of smaller German credit institutions.

Some stress tests incorporate adjustments in banks' balance sheets or broader business strategies, which can potentially offset part of the earnings impact of low rates. In the exploratory scenario of the 2017 Bank of England stress test, UK banks indicated they would respond to a lower-for-longer rates scenario by cutting operating costs – particularly by closing branches and reducing employees – and increasing non-interest income (such as fees).① The 2017 BaFin/Bundesbank exercise found that many small- and medium-sized German banks would consider mergers as a means to achieve cost efficiencies and business scale.

However, banks' strategic responses can also entail increased risks. One third of banks in the 2017 BaFin/Bundesbank exercise projected a deterioration in their CET1 ratios in part due to engaging in riskier lending activities.② In contrast, in the 2017 BoE lower for longer scenario, UK banks did not expect to increase riskier lending despite heightened competition and falling interest margins. However, both of these stress tests found that some banks would try to offset the squeeze in margins by raising loan production, and this could lead to relaxed lending standards and heightened risks.

Stress tests can also gauge the vulnerability of banks to sharp snapbacks in interest rates. The 2016 analysis by the Swiss National Bank found that the impact of rates can depend on the magnitude of the shock.③ While a 200 basis point increase in rates would boost banks' net interest margins, a 400 basis point increase would be expected to disproportionately boost the rates paid on bank liabilities and thus compress margins, on balance.

Sizeable interest-rate snapbacks – occurring alongside moderate recessions – featured in the US Federal Reserve's 2013, 2014 and 2015 Dodd Frank Act Stress tests' adverse scenarios.④ This analysis found that (for most banks) snapbacks that involved the yield curve shifting up and flattening and generating lower returns from maturity transformation implied relatively more stress relative to snapbacks that involve the yield curve shifting up and steepening. Both scenarios implied large unrealised capital losses to available for sale securities portfolios.

① Bank of England, Stress testing the UK banking system: 2017 results, 2017. ② BaFin, Results of the 2017 low-interest rate survey, 2017. ③ SNB, Financial Stability Report, 2016. ④ FRB, Dodd-Frank Act Stress Test 2013: Supervisory Stress Test Methodology and Results, Dodd-Frank Act Stress Test 2014: Supervisory Stress Test Methodology and Results and Dodd-Frank Act Stress Test 2015: Supervisory Stress Test Methodology and Results.

Box B

Implications of a low-for-long scenario – A simulation analysis for Swiss retail banks

This box describes the impact of the scenarios developed by the WG – baseline, low-for-long, and snapback – on the balance sheets of Swiss commercial retail banks, an important subset of the domestic banking system in Switzerland.① These banks are active mainly in the domestic mortgage market and net interest income is by far their dominant source of income.

The analysis is based on a simulation tool used by the Swiss National Bank (SNB) for periodic stress-test exercises and is applied to individual bank-level data. The sample consists of all (97) domestically oriented commercial (retail) banks in Switzerland.② The most relevant components of the earnings projections are net interest income and credit losses, and are based on a detailed modelling of banks' interest income, expenses and default probabilities.

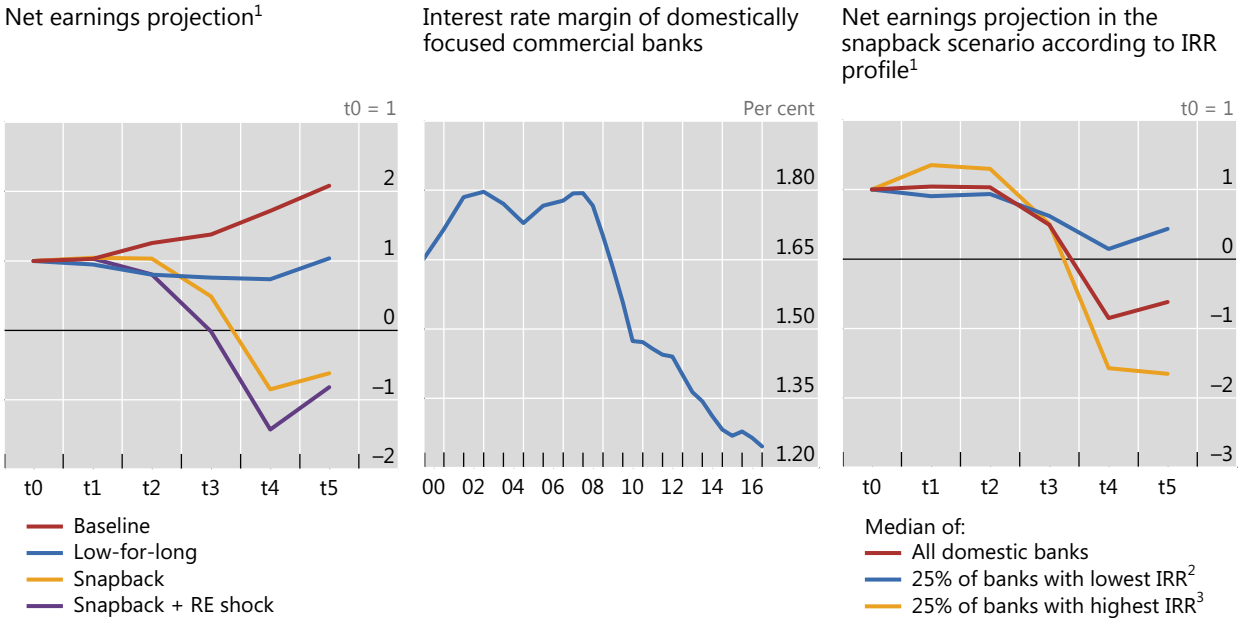
The simulated impact of the scenarios on banks' earnings is depicted in the left-hand panel of Graph B. By the end of the projection period, banks' annual earnings in the baseline scenario (the red line) are nearly doubled compared with end-2016. This increase derives from higher interest rate margins, which are currently compressed given Switzerland's ultra-low interest rate environment (Graph B, centre panel). In contrast, in the low-for-long scenario, earnings decrease further from their 2016 level (left-hand panel, blue line) and thus fall well below the baseline path. This difference reflects the further erosion of interest margins, as mortgages are rolled over at lower rates and interest rates on retail deposits remain constant at zero.

The impact of the snapback scenario is even more severe (left-hand panel, yellow and purple lines). The main drivers of these losses are (i) the materialisation of (direct) interest rate risk – as funding costs increase faster than interest income – and (ii) a surge in loan losses as borrowers face higher debt service costs (indirect interest rate risk). The losses are even greater if the snapback scenario includes a 30% fall in housing prices (the purple line).

Thus, for moderate and gradual interest rate increases (baseline scenario), the positive impact on banks' earnings from rising interest rate margins tends to dominate, but for larger and sharper rate increases (snapback scenario), the rise in funding costs outpaces the increase in asset returns, including because asset quality deteriorates, and particularly if housing prices collapse.④

Retail banks in Switzerland: implications of a low-for-long scenario

Graph B



[1] Swiss domestically oriented banks. Net earnings indexed to 1 in t0. [2] Banks with an initial standardised duration gap below 1.2 years. Assumed repricing of one year for non-maturity positions with effective repricing maturity below one year. [3] Banks with an initial standardised duration gap above 1.9 years. RE stands for real estate. IRR stands for interest rate risk.

Sources: FIINMA, SNB.

Moreover, the composition of banks' balance sheet portfolios is critical. In the snapback scenario, initially when interest rates are low, "high-risk" banks – banks that have pushed out the duration of their assets versus their liabilities (yellow line on the right-hand panel of Graph B) – are more profitable than those with a smaller duration gap (blue line). However, once interest rates increase substantially, high-risk banks incur heavy losses while the impact on 'lower-risk' banks is mild. Evidence from Switzerland shows that banks have significantly increased their exposure to interest rate risk since the beginning of the low interest rate phase.⑤

At present, banks' capital cushions appear to be sufficient to absorb the losses associated with either a low-for-long or a snapback scenario. However, the picture could change if banks increase their risk appetite, if capital cushions deteriorate, or if interest rates overshoot during the normalisation process.

① Swiss G-SIBs were not included in the analysis, as the scenario analysis for them relies on a different, not fully comparable, framework. However, past analysis suggests that domestically oriented banks are significantly more exposed to the interest rate risks posed in the scenarios due to their business profile and geographic orientation and diversification. ② To implement the stress test, the scenarios were compressed and front-loaded to align with the SNB simulation tool requirements of a five-year horizon. ④ For a detailed discussion of the mechanisms at stake, see SNB (2016), pp 26–30, www.snb.ch/en/mmr/reference/stabrep_2016/source/stabrep_2016.en.pdf. ⑤ See for example, Swiss National Bank, *Financial Stability Report*, 2017, chart 18, p 23, www.snb.ch/en/mmr/reference/stabrep_2017/source/stabrep_2017.en.pdf.

2.3 Risk-taking

As noted in Section 2.1, lower interest rates and reduced profitability can provide an incentive for banks to pursue higher-yielding business strategies at the cost of assuming a greater risk of future losses. This section assesses the extent to which bank risk-taking has increased in recent years and how far changes in risk-taking can be attributed to changes in interest rates.

Recent trends. Direct measures of bank risk-taking are difficult to compile for representative samples of banks for many countries. Graph 6 shows the evolution, over time and for advanced and emerging market banks, of such aggregate balance-sheet ratios as are available that potentially capture risk-taking or the outcomes of risk-taking by banks. On net, between 2000 and 2015, banks in the AEs that were most impacted by the GFC notably reduced the ratio of loans to deposits.[19] This is consistent with a pull-back from risk-taking, although it likely reflects in part the increase in aggregate deposits associated with balance sheet monetary stimulus in these economies. In contrast, in other AEs, both credit-to-deposits and the gap between the maturities of assets and liabilities increased on net, suggesting increased-risk-taking, although the balance sheet space allocated to liquid assets recovered to pre-GFC levels. Perhaps most importantly, both sets of advanced-economy banks massively improved capital positions. Overall, despite lower interest rates, advanced economy banks appear to have become more resilient, although some of these developments may reflect a regulatory and supervisory push for banks to de-risk.

Trends in these metrics for emerging market banks were generally more gradual but also mixed. Banks in those countries noticeably increased credit-to-deposit ratios and reduced shares of liquid assets, but their asset-liability maturity gaps rose only

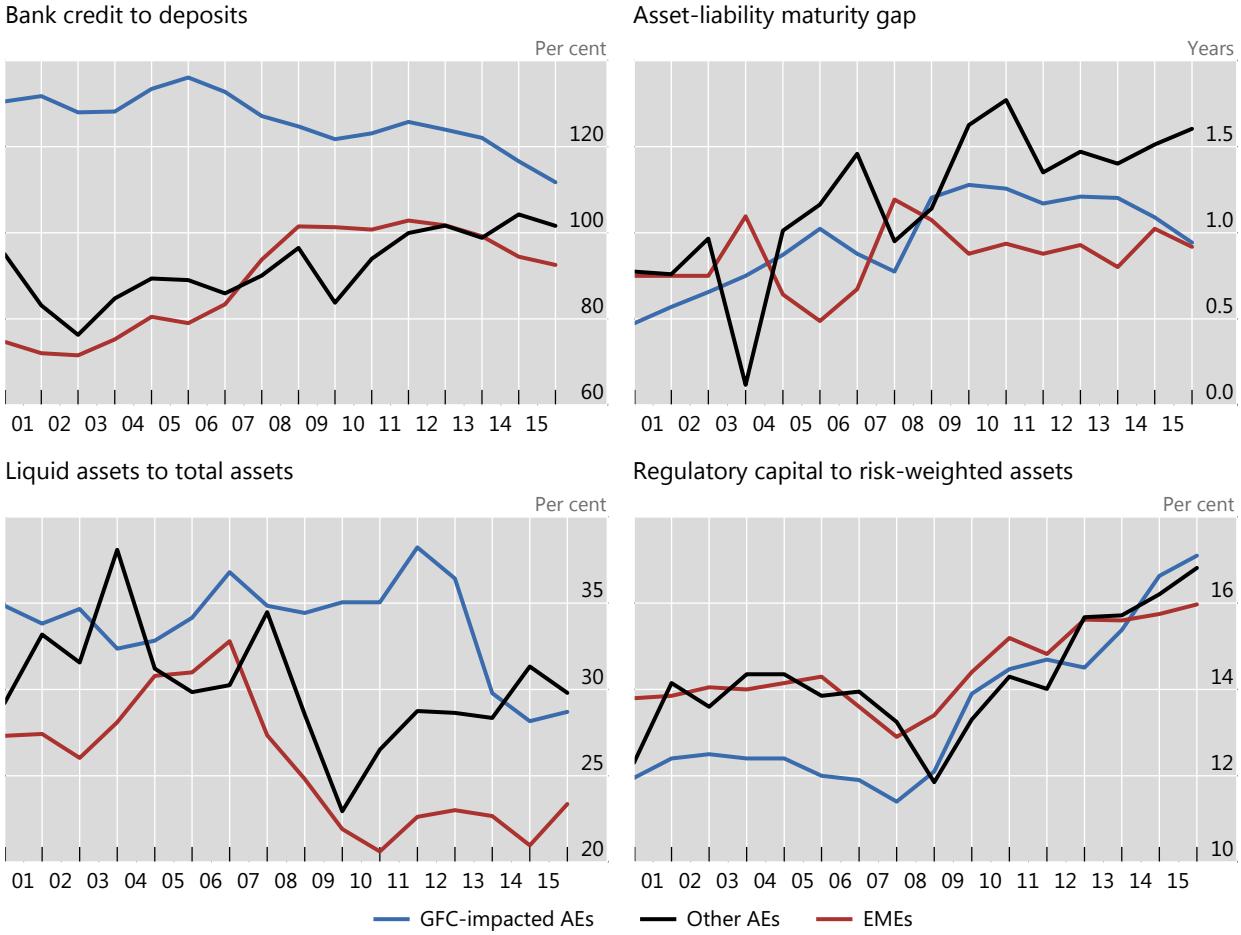
[19] The "most impacted" advanced economies considered here are: Austria, Belgium, Denmark, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal, Spain, Sweden, Switzerland, the United Kingdom and the United States.

slightly and they also considerably improved capital positions. Overall, the soundness of banks in EMEs did not deteriorate.

Evidence from the euro area and Japan. Homing in on two regions that have experienced periods of prolonged low interest rates, the WG found little evidence in either case that sustained low yields led to a significant accumulation of risks by banks.

In the euro area, this is in part because risk-taking incentives for banks have been accompanied by tightening prudential standards and other regulatory factors that constrain bank behaviour. The observed easing of credit standards in recent years is very moderate, compared with the severe tightening of standards observed between 2010 and 2012 (Graph 7). Consistent with this, the overall level of risk in banks' loan books declined in most portfolios in recent years, as indicated by the centre panel of

Trends in banking system soundness[1] Graph 6



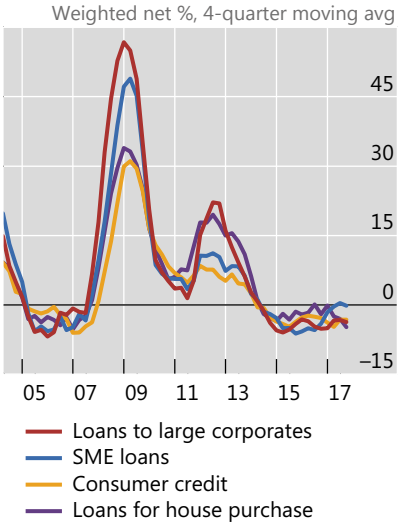
[1] Figures are obtained by taking the median of the aggregates for each country group. Country groups are defined using the BIS definitions of advanced and emerging market economies and the Laeven and Valencia (2012) database of systemic banking crises. Maturity gap is defined as the difference of the average maturity of assets and liabilities, both measures in years.

Sources: Bankscope, World Bank Global Financial Development Database.

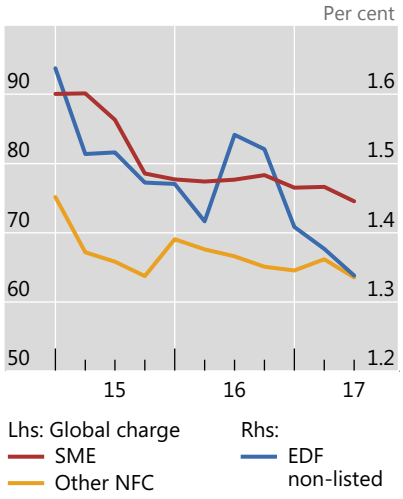
Euro area banks' risk-taking

Graph 7

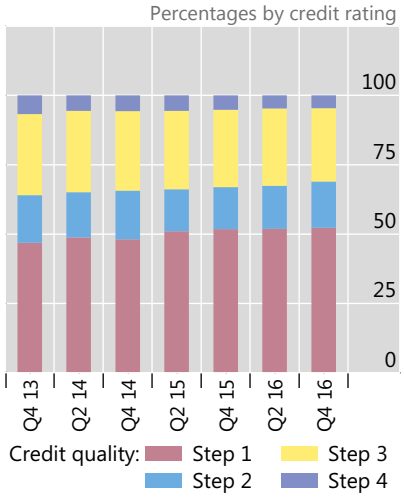
Credit standards for loans to the non-financial private sector



Global charge on banks' IRB corporate exposures and expected default frequencies (EDFs) of non-listed firms



Debt securities held by banks[1]



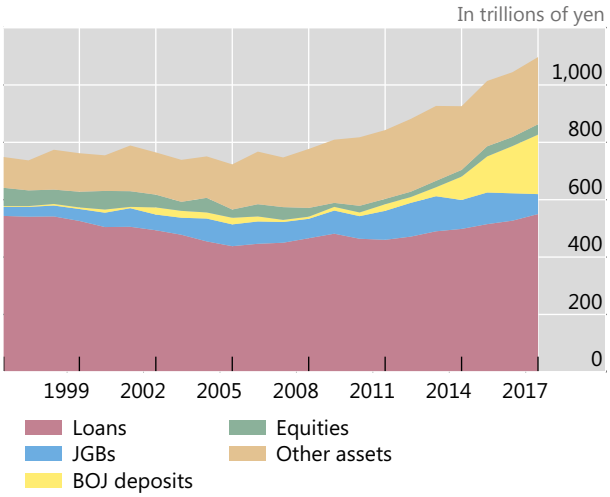
[1] The legend denotes credit quality steps defined in accordance with the Eurosystem credit assessment framework (ECAF). The first category includes securities rated from AAA to AA–, the second from A+ to A– and the third from BBB+ to BBB–. A fourth category is added which includes all rated securities with a rating below credit quality step 3. The analysis is based on the nominal amounts of euro- and foreign currency-denominated securities, including "alive" and "non-alive" securities. The investment fund sector does not include money market funds.

Sources: ECB; Moody's; ECB calculations.

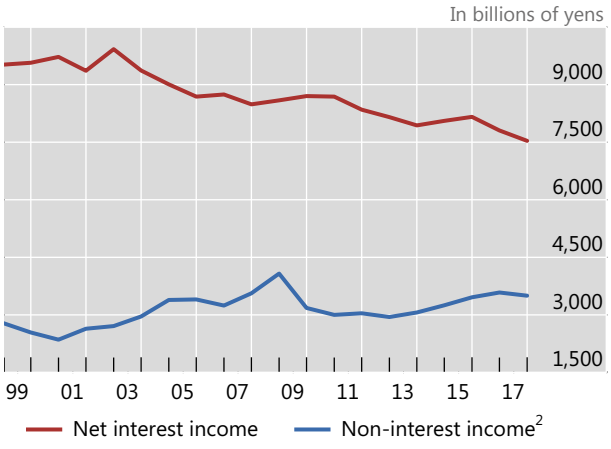
Japanese banks' risk-taking

Graph 8

Assets of Japanese domestically licensed banks



Source of income[1]



[1] Annual data for fiscal year ending March 31. [2] Non-interest income is fees, commissions and trading income.

Source: Bank of Japan, *Flow of Funds Account*; Japanese Bankers Association.

Graph 7.[20] At the same time, the credit quality of euro area banks' debt securities holdings has improved slightly (right-hand panel of Graph 7) and banks also continued to reduce their portfolio of hard-to-value (step 3) assets, although some banks still retain significant exposures. However, supervisors have recently found a pickup in maturity transformation and duration exposure at German (and Swiss) banks, which have increased their holdings of unhedged fixed-rate assets.[21]

In Japan, interest rates have remained very low since the late 1990s and net interest margins have declined from their already low levels. Nonetheless, evidence based on aggregate data suggests that, in general, risk-taking by banks has not been excessive. Banking system assets stagnated for more than a decade (Graph 8) and asset composition tilted away from loans and equities and towards government bonds until about 2012. After 2013 quantitative easing catalysed the resumption of loan growth, and banks have been increasing their holdings of riskier assets such as investment trusts and foreign bonds, including overseas credit products. Relative to total banking system assets this increase has been quite small (about 2 percent) and it has been most pronounced among regional banks. Some regional banks also increased interest rate risk by extending the average maturity of domestic bonds (IMF 2017). In recent years there are signs that the banking system may have taken additional credit risk in extending loans, although this might also reflect intensified competition in lending (and the effects of monetary easing) in addition to pressures from low NIMs.[22] Finally, some of the larger banks have expanded their international operations, but generally in relatively safe advanced-economy (primarily North American) markets.

Analytical evidence. As detailed in Annex IV, the effects of interest rates on soundness indicators (including the measures shown in Graph 6) are estimated for a large panel of banks over the 2005–15 period. The results for AE banks, including and excluding the United States, are summarised in Table 6 and show little evidence of risk-taking in a low rate environment: more often than not, the estimated coefficients suggest that lower rates are associated with improved bank soundness. For example, lower short-term rates in AEs and EMEs are associated with a higher ratio of regulatory capital to risk-weighted assets. An important caveat is that these regressions do not control for regulatory changes over the sample period, which ought to have supported bank soundness, irrespective of the path of interest rates. In addition, some studies that use less comprehensive but more granular data find that bank risk-taking increases when interest rates decline.[23]

Two further empirical investigations are presented in Annex IV. The first, a bank-level analysis of maturity transformation – defined as the difference between the average tenor of a bank's assets and liabilities – suggests that banks extend the maturity of their assets when short-term rates decline. However, they increase the maturity of their liabilities to a larger extent. The net effect is that banks perform slightly less maturity transformation when short-term rates decline. The second exercise, a probit analysis,

[20] The global charge indicator is a measure of risk relative to the size of exposures that allows comparisons between portfolios evaluated under the standardised and Internal-Ratings-Based (IRB) approaches to regulatory capital.

[21] See Bundesbank, *Financial Stability Review*, 2016, and Swiss National Bank, *Financial Stability Report*, 2017.

[22] See Bank of Japan, *Financial System Report*, April 2018.

[23] See, for example, Ioannidou et al (2009), Maddaloni and Peydró (2011), Jimenez et al (2014), Altunbas et al (2014), Kandrac and Schlusche (2016), Morais et al (2017), Dell'Ariccia et al (2017), Aramonte et al (2015), and Lee et al (2017).

Summary of estimated impact of lower rates on bank soundness Table 6

	AEs		Memo: AEs excl. United States	
	Short-term rate	Slope	Short-term rate	Slope
Loans to deposits and short-term funds	–*	+*	–*	+*
Liquid assets to total assets	+	–*	+	–*
Nonperforming loans to gross loans	+	+*	+*	–*
Loan loss provisions to gross loans	+	+*	+*	–
Charge-offs to gross loans	+	+*	+	+*
Regulatory capital to risk-weighted assets	–*	–	–*	–
Residential mortgages to gross loans	–	+	–	–

Signs indicate direction and asterisks statistical significance.

which models the probability of reaching high levels of NPL ratios, finds that declines in either short-term rates or the slope reduce the probability of exceeding such a threshold, the opposite of what might be expected if lower rates incentivised risk-taking. In both cases, these results provide further evidence that is broadly consistent with a lack of significant deterioration in bank soundness as rates decline.

2.4 Impact of a snapback after prolonged low rates

A period of prolonged and historically low interest rates poses the risk that these rates may revert sharply and unexpectedly to higher levels, especially if the factors causing the initial low-for-long scenario are not well understood. The snapback scenario described in Chapter 1 would represent a substantial shock: short-term rates rise by 300 basis points and longer-term interest rates rise even more, leading to a recession. Even if banks had not adjusted their portfolios and business models to low interest rates in the years before the snapback, they would be challenged by valuation losses on their longer-term securities, higher funding costs, increased delinquencies on their loans and reduced credit growth. As emphasised by the analysis of Swiss banks (Box B), in the event of a sharp snapback, these losses could exceed the benefits to banks of higher net interest margins.[24]

Although the WG found little evidence of a generalised rise in risk-taking in the low-interest-rate years following the GFC, banks have taken measures to offset reductions in net interest margins that could raise their exposure to interest rate snapbacks, including lengthening the maturity of their assets and raising their exposure to real estate loans. Our review of stress tests (Box A), the simulation exercise on Swiss banks (Box B), and the US experience with rising rates since the GFC (Box C) suggest that banks may be putting themselves at more risk should interest rates rise abruptly, especially smaller banks that do not hedge their interest rate positions. Moreover, should interest rates remain low for a prolonged further period, and especially should supervisory and regulatory constraints loosen, more overt forms of risk-taking may become more prevalent.

[24] It should be noted that projecting the estimated relationship between interest rate levels and bank profitability of Section 2.2.2 using the snapback scenario in Chapter 1 would fail to account for the non-linearity of the costs. Specifically, since this approach does not capture well the repricing of assets and mark-to-market losses, the snapback scenario would imply immediate improvements in bank profitability, which is likely to be misleading.

Box C

Rising rates and bank losses in the United States

This box considers the effect of recent increases in interest rates on US banks' capital, focusing on losses from the available-for-sale securities (AFS) portfolio of banks and on banks' self-assessments of interest rate exposure.① Overall, our analysis suggests that US banks' interest rate exposures are well contained.

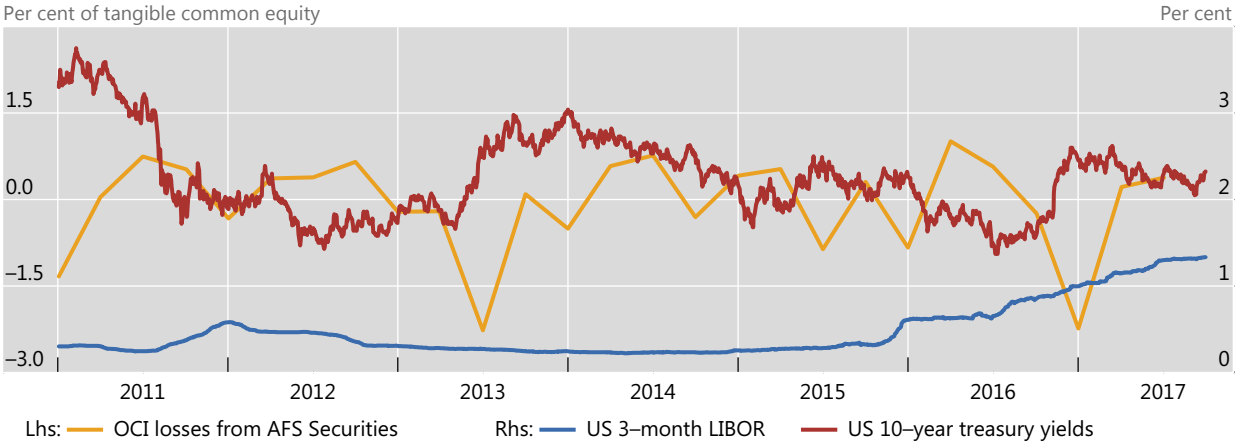
"**Taper tantrum" and post-election "reflation trade" periods**. Since 2011, sudden and significant spikes in 10-year Treasury yields have occurred twice: (i) an approximately 100 basis point increase dubbed the "taper tantrum" and (ii) an approximately 70 basis point increase experienced after the US presidential election in 2016 reflecting the market's reflation expectations. Graph C shows that both of these episodes resulted in capital losses averaging about 2.3%, primarily from repricing of investment securities. Across banks, outcomes ranged from very modest losses to over 7% of tangible common equity. No large bank breached minimum capital requirements due to valuation losses.

Panel regression. For 26 large US financial institutions, the impact of quarterly changes in the three-month LIBOR rate and the 10 year Treasury yield on quarterly other comprehensive income (OCI) relative to tangible equity was estimated, controlling for business models as an indicator of the balance sheet exposures through securities portfolios.

Gains and losses from AFS securities were driven by long-term yield movements, with an implied average effect of 2.5% of capital losses from the 100 basis point increase in 10-year rates. Impacts vary depending on each firm's interest rate risk positioning and strategies, but show greater risks for custody banks that maintain a highest portion of the balance sheet in high-quality securities and weaker risks for broker-dealers that have more risk-neutral positions. Changes in short-term rates are not found to have significant impact on quarterly OCI.

US Treasury yields, LIBOR and OCI losses from AFS securities

Graph C



Source: National sources.

Interest rate risk assessment through analysis of economic value of equity: Most US banks are required to model and estimate the economic value of equity (EVE) under different interest rate scenarios. Based on the public disclosures from the bank holding companies with assets greater than $50 billion, these assessments indicate that US banks would face capital losses that are material but manageable if yield curves were to experience a parallel and instantaneous shift by +200 basis points, with some firms even estimating potential gains under such a scenario. Additionally, firms often set their own risk limits on maximum losses ranging from 12% to 20% in most cases. As of Q3 2017, all firms that voluntarily disclosed EVE estimates and limits were operating well within the risk limits.

① Recently, more securities have been booked in banks' Hold-to-Maturity portfolios than had been previously.

In addition, to the extent that snapbacks are typically associated with a broad repricing of assets, these market moves could also generate significant costs for banks. The Swiss exercise highlighted costs coming from a sharp housing market correction. For US institutions, repricing of investment securities led to large losses for some firms during the taper tantrum. Other losses could occur were institutions to encounter liquidity bottlenecks if their matured short-term liabilities were not renewed or if they were unable to liquidate assets to fulfil their payment obligations. Moreover, although historically deposit rates have tended to increase slowly, higher interest rates could potentially push banks' funding costs up faster than assets can reprice. This could lead, at least temporarily, to a decline in NIMs. Indeed, the immediate impact of higher rates on bank lending costs is an issue of considerable uncertainty, given the unprecedented length of the preceding low rate environment as well as new regulations that make deposit funding more attractive.

2.5 Summary and financial stability implications

The evidence presented in this chapter suggests that low interest rates depress net interest margins, especially where banking markets are very concentrated and if the level of short term rates is already relatively close to zero. At the same time, econometric evidence and the experience of recent years suggest that, on average, banks have found ways to shield overall return-on-assets from prolonged low interest rates. In consequence, while a low-for-long scenario would likely depress NIMs to a material extent, RoAs for much of the banking system seem likely to be less affected. However, the profitability of some banks or even some banking systems could suffer more considerably in a low-for-long scenario, depending on their business models, balance sheets and competitive environments.

The WG found only limited evidence to support the view that prolonged low interest rates would induce a substantial degree of additional risk-taking. Aggregate measures of bank soundness generally have not deteriorated to a marked extent, including in the euro area and Japan, where interest rates have fallen especially low.

That said, it is difficult to identify comprehensive and reliable measures of risk-taking behaviour. Moreover, it is possible that the subdued extent of risk-taking in recent years may reflect greater supervisory and regulatory restraint in the wake of the GFC. There is also some evidence of banks stretching the duration of their assets and increasing their exposures to housing markets, both of which would increase their vulnerability to a sharp increase in interest rates.

Even in the absence of a prior increase in bank risk-taking, a sharp snapback in interest rates would likely entail valuation losses on longer-term securities holdings, increased delinquencies on loans, and reduced credit growth, potentially overwhelming any profitability benefit from higher net interest margins. If banks did adjust to low interest rates through riskier loans, greater duration mismatches and greater investments in interest-sensitive sectors such as housing, the adverse consequences of a snapback would be worse. The rises in yields that occurred in recent years were well handled by US banks. However, as illustrated by the case study of Swiss banks, sharper rate increases associated with major asset price corrections would likely have more dire consequences. If deposit rates were to rise faster than they have done in past cycles, their increase might outpace that of yields on assets, thus depressing – rather than boosting – NIMs.

Box D

Takeaways from industry roundtable – banks

To augment its research, the WG also engaged in outreach with financial sector representatives. In general, low interest rates were viewed as presenting significant challenges for banks, but there were both positives and negatives. On the positive side, low interest rates were seen as spurring demand for credit, lowering funding costs, reducing default risks and increasing capital gains. These benefits were weighed against the impact of lower rates on net interest margins, the possibility of deposit outflows as customers sought higher returns and greater risks of asset price bubbles.

Representatives pointed to steps their institutions were taking to maintain profits, such as reduced reliance on more costly wholesale funding sources. In Europe, this has included a higher share of funding coming from retail deposits and ECB liquidity. In addition, banks have taken measures to increase fee income, with varying degrees of success.

Other adjustments by banks may increase their risk. In a number of countries, real estate loans have picked up as a source of higher return, especially for smaller regional banks. Banks also have sought higher returns by switching increasingly from issuing variable to issuing fixed rate mortgages. While the stresses of the euro area crisis have led some European banks to reduce their international footprint, other banks, particularly in Japan, have looked to foreign assets and a greater presence abroad to boost their returns. Greater engagement in foreign lending by advanced-economy institutions was viewed as providing some stability to emerging market banking systems, cheaper financing and enhanced efficiency, but at the risk of fuelling bubbles that could then turn into destabilising credit outflows. Finally, a few of the representatives highlighted concerns that some of the steps banks were taking to boost return in the low interest rate environment would make them vulnerable should interest rates snap back and assets prices adjust accordingly.

3. Impact of low rates on banks: an EME perspective

3.1 Channels

As noted above, EME banks have largely avoided the disruptions and pressures experienced by advanced economy banks. Despite low interest rates at home and abroad, net interest margins and overall profitability in EMEs have generally held up well, notwithstanding some declines since the GFC. This good performance likely reflects solid economic growth, rapid credit expansion, low international funding costs and strong capitalisation.

Thus, the prospects for EME banks in a low-for-long scenario have not received much attention. However, were interest rates to remain subdued for a prolonged period, risks to financial stability in EME banking systems might become more evident.

Persistently low interest rates could affect the stability of EME financial institutions in four important ways. First, for those EMEs that experience historically low domestic interest rates under the scenarios in Section 1, low profitability of EME banks may threaten solvency and induce risk-taking. Chapter 2 documented that the depressive effect of low interest rates on net interest margins was even greater in EMEs than in AEs. Although little impact was found on the overall return-on-assets, profits could fall if rates remain low for long enough.

Second, sustained low interest rates in AEs may encourage borrowing by EME financial institutions by reducing the cost of foreign financing and increasing the flow

of funding, a standard "spillover" channel.[25] Cheap foreign financing could reduce financial stability risks by increasing the profitability of EME banks, but it could also lead to problems if lending became excessive or unduly risky, or if access to global markets were suddenly cut off. Problems could also arise if funding were denominated in foreign currency, as EME corporations with unhedged exposures may experience repayment difficulties in the event of a local depreciation.

Third, low interest rates and low profitability for AE banks domestically could motivate them to shift more activities into EMEs. Such a shift could bolster efficiency, innovation, and stability in the host EME financial systems but it could also reduce the profitability of EME domestic institutions, leading to greater risk-taking and possible stresses. It is also possible that even without AE banks shifting into EMEs, EME bank profitability could be harmed if, as described in the previous paragraph, low AE rates led EME corporations to seek cheap funding abroad, putting downward pressure on EME bank margins.

Finally, low interest rates in AEs might also support broader capital flows to EMEs, pushing up EME asset prices and reducing household and business borrowing spreads. Booms in equities, property, or credit engendered by low AE interest rates could pose financial stability risks, as might reversals of EME capital flows such as might take place in a "snapback" scenario for AE rates.

Chapter 2 presented an analysis of the effects of persistently low domestic interest rates on bank performance, including in EMEs. The remainder of this chapter addresses the possible effects of spillovers from advanced economy financial conditions.

3.2 Spillover of advanced economy interest rates to EME banks

To assess the net effect of spillovers of low AE interest rates on EME banks, the econometric models shown in Table 1 and Table 2 for EME bank-level data were augmented to include, as explanatory variables, the average of three-month interest rates and the average of yield curve slopes in the three major AEs: the euro area, Japan and the United States. Also included were a wide array of global macroeconomic control variables, including AE GDP growth, AE inflation, global oil and commodity prices and an index of EM exchange rates against the U.S. dollar. (Not shown; see Annex II for more details).

The results of this analysis are shown in Table 7. AE interest rates exert a positive and significant effect on EME bank NIMs (column (1)).[26] This suggests that loans linked to AE interest rates compete with those offered by EME banks, so that declines in AE rates diminish EME bank margins: this effect could be exacerbated if EME banks' FX deposits are subject to an effective lower bound, while rates on their FX loans are not. With a parameter estimate of about the same magnitude, column (2) suggests that the impact of AE interest rates on NIMs carries through to EME bank RoAs, with the caveat that this coefficient is imprecisely estimated.

[25] Gambacorta et al (2017) show that banks' funding from abroad is sensitive to domestic/foreign interest rate differentials.

[26] The decomposition of NIMs suggests that the sensitivity of interest income to AE rates is slightly higher than the sensitivity of interest expense; however, neither can be precisely estimated (see Annex IV).

Spillovers of AE interest rates to EM bank profitability Table 7

	Bank-level analysis	
	NIM	RoA
	(1)	(2)
Lagged dep. Variable	0.32***	0.10***
Home-country short-term rate	0.08**	0.01
Home country yield curve slope	0.01	–0.09**
Home-country inflation	0.01	0.01
Home-country GDP growth	–0.04*	0.01
AE short-term rate	0.15*	0.18
AE yield curve slope	–0.03	0.12
Number of observations	4988	4988
Number of countries	20	20
Number of banks	583	583

***/**/* denotes results significant at the 1/5/10% level.

All told, the empirical findings described above suggest that low AEs rates reduce EME bank margins, adding to downward pressure on these margins coming from low domestic interest rates. Thus, in a low-for-long scenario, NIMs might be even more depressed, relative to the baseline, than depicted in Graph 4 above. In regard to overall bank profitability, the results shown in Table 7 suggest that a low-for-long scenario in AEs might also depress RoAs to some extent, although the relevant coefficient was not statistically significant.

It should be noted that this is the first analysis the WG is aware of that directly assesses the impact of AE interest rates on EME bank profitability. Accordingly, these results merit further investigation, especially given the relative imprecision of the estimates.

3.3 Impact of snapback on banks in EMEs

Section 2.4 discussed the adverse implications of a snapback in interest rates for banks, both in advanced and EMEs, including capital losses on longer-duration assets, losses associated with falls in property and real estate prices and increased non-performing loans. Such effects would likely be magnified if banks had taken on riskier and/or longer-duration exposures when interest rates were low.

For EMEs, interest rates could rise sharply for domestic reasons, such as a surge in inflation or an expanding fiscal deficit, or the trigger could be a snapback in AE interest rates that would likely push up EME interest rates and be associated with a pullback from EMEs by AE investors. In previous decades, such snapbacks led to considerable turbulence in emerging financial markets. More recently, solid domestic economic growth, a more resilient financial sector, strengthened borrower balance sheets, strengthened institutions and more stable policy frameworks have reduced the vulnerability of many EMEs to external shocks. In consequence, spillovers to EMEs from the GFC in 2008 and the taper tantrum in 2013, while disruptive, were less severe and prolonged than earlier episodes. Box E reviews the EME experience with the taper tantrum.

Nevertheless, an extended further period of low global interest rates could see a further widening of imbalances already evident in some EMEs, including rising corporate indebtedness and stretched asset valuations. Therefore, even with the progress EMEs have made in bolstering their economic resilience and developing policy frameworks in recent decades, a snapback following an extended period of low rates could be quite challenging.

3.4 Summary and financial stability implications

Low domestic interest rates present challenges for local banks' profitability, regardless of whether these financial institutions are based in EMEs or AEs. In addition, EME banks experience spillovers related to low interest rates in AEs. These spillovers can make EME banks more vulnerable to financial stability risks in several ways. Low rates in AEs can encourage borrowing by EME banks, potentially resulting in excessive local credit expansion. At the same time, low AE rates could pose competitive pressures for EME banks, both by inducing AE banks to shift more of their activities to EMEs, and by reducing borrowing costs for local firms that access global capital markets. Finally, low local rates in AEs could support broader capital flows to EMEs, pushing up asset prices and reducing credit spreads.

Econometric evidence reinforced the view that low AE rates may put pressure on EME bank margins, thereby compounding the effect of low local rates. The implications for EME banks' RoAs were less clear-cut.

Stresses on EME financial sectors would likely be greater should a period of low rates at home or in the AEs be followed by a snapback in interest rates. Although progress made by EMEs in bolstering their economic resilience and policy frameworks in recent decades should mitigate such risks, a snapback after a further prolonged period of low global rates – which could further widen imbalances in EMEs – could still present EMEs with challenges, as underscored by the taper tantrum experience in 2013.

Box E

Spillovers to EMEs in the 2013 taper tantrum

The taper tantrum of mid-2013, which drove long-term interest rates higher and roiled financial markets, especially in EMEs, serves as an example of how a snapback in long-term interest rates in AEs could spill over to EMEs.① The analysis in this box will concentrate on 10 EMEs representing various regions (Brazil, China, Hong Kong SAR, Hungary, India, Mexico, Poland, Singapore, South Korea and Turkey).

In general, the impact on EME financial conditions was sharp and negative. Long-term interest rates in many EMEs rose as much or more than did US Treasury yields, highlighting the sensitivity of EME asset prices to AE financial developments (Graph E, top left-hand panel). (Note that during this episode, US yields rose roughly 100 basis points, whereas in the snapback scenario described in Chapter 1, they rise more than 300 basis points.)

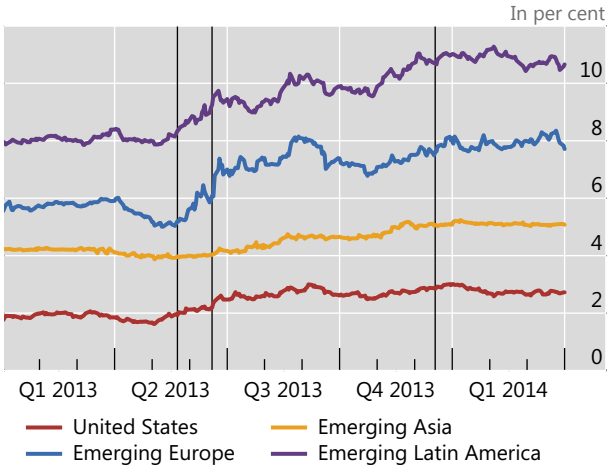
EME bank stock prices fell sharply and stayed weak, in contrast to those in the United States (Graph E, top right-hand panel).

Cross-border interbank flows to EMEs declined (Graph E, bottom left-hand panel). This contraction was relatively pronounced for those EMEs with large US dollar liability exposures, as higher US interest rates raised the refinancing costs of US dollar-denominated debt. Moreover, the depreciation of the currencies of these EMEs increased the value of debt in local currencies.

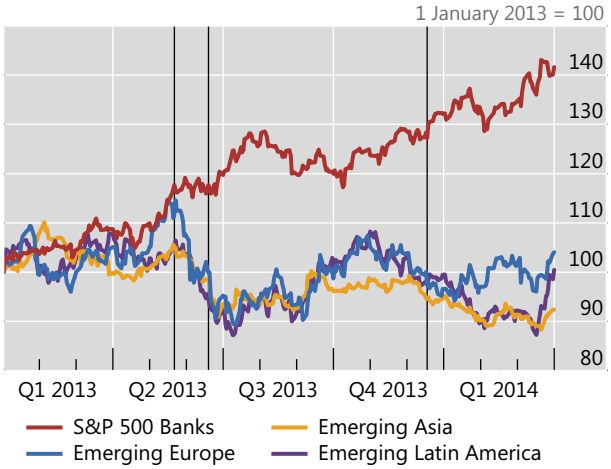
Spillovers to EMEs in the 2013 "Taper Tantrum"

Graph E

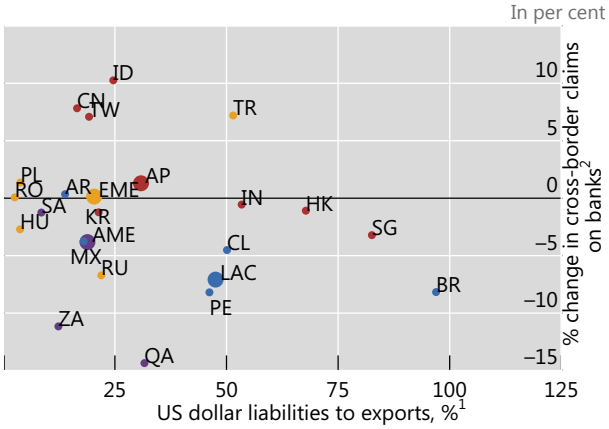
10–year government bond yields, Jan 2013–Mar 2014



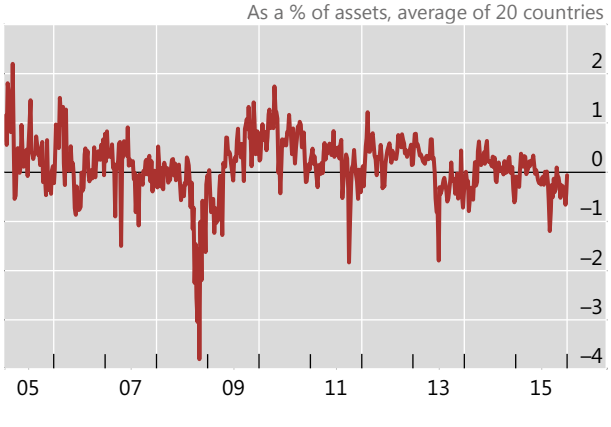
Bank stock indices



Cross-border banking activity in EMEs



Weekly inflows to EME bond mutual funds



The vertical lines in the top panels indicate: 22 May 2013, Federal Reserve Chairman Ben Bernanke states that the FOMC could envisage reducing the pace of asset purchases; 19 June 2013, Bernanke emphasised that the envisaged slowdown of asset purchases should be consistent with the unemployment rate decreasing to 7% by mid-2014; 18 December 2013, Federal Reserve announced its intention to begin tapering by $10 billion per month starting in January 2014.

Emerging Europe: Hungary, Poland and Turkey. Emerging Asia: China, Hong Kong SAR, India, Korea and Singapore. Emerging Latin America: Brazil and Mexico. Emerging regions banks indices calculated as a capitalisation-weighted average of bank stock index of each country.

Sources: IMF, *Direction of Trade Statistics*; Bloomberg; Datastream; EPFR; BIS locational banking statistics by residence..

There was a sharp retrenchment in portfolio flows to EMEs (Graph E, bottom right-hand panel). Research on the determinants of these flows undertaken by the WG confirm that movements in the US 10-year Treasury yield are the most important factor in the likelihood of strong capital outflows.

The taper tantrum also led to a retrenchment in lending by EME banks. Using detailed data at bank-firm level, research by this WG shows that Brazilian commercial banks with larger dependence on foreign funding cut their lending disproportionately more than non-exposed banks in the aftermath of the taper tantrum (see Barbone Gonzalez et al (2018)).

① For a more detailed analysis of the taper tantrum and its impact on EME financial markets, see, eg Mishra et al (2014), Eichengreen and Gupta (2015), Aizenman et al (2016) and Chari et al (2017).

4. Impact of low rates on ICPFs

This chapter analyses the impact of low rates on life insurance companies (IC) and defined benefit pension funds (PF). It begins by describing the solvency and liquidity channels through which rates impact ICPFs. It then provides an impact assessment based on the interest rate scenarios described in Chapter 1, taking into account changes in firms' risk-taking incentives. The final sections discuss implications for financial stability and provide a summary of the main messages.

4.1 Channels

The balance sheets of ICPFs are sensitive to prolonged periods of low interest rates mainly because their liabilities tend to be of longer duration than their assets, resulting in *negative duration gaps*. A negative duration gap implies that low discount rates boost the value of liabilities to a greater extent than the value of assets, undermining solvency (solvency channel). The existence of surrender options on some life insurance contracts can create additional vulnerabilities. Exercising these options becomes more attractive if a period of low interest rates ends with a sudden snapback of rates, potentially draining ICs' liquidity (liquidity channel).

Negative duration gaps arise both because these firms commit to making future payments over very long horizons and because future payments are relatively insensitive to interest rates. In general, the payouts of defined benefit PFs do not change with interest rates, although funds can (and do) reduce or suspend inflation indexation when faced with challenges such as falling interest rates (conditional indexation). Similarly, payouts associated with guaranteed life IC products may not fall as much as interest rates when these fall below guaranteed minimum levels.

For an ICPF with assets and liabilities that include streams of receipts and payments that stretch out into the future, assessing solvency dependss crucially on the discount rate used. In most cases, prudential regulation of ICPFs use discount rates linked in some way to a market interest rate, but the details vary significantly across jurisdiction (see tables in Annex VI).[27] Solvency metrics can also be risk-based.[28]

New evidence collected by the WG on the basis of a survey among CGFS members provides a sense of the magnitude of the negative duration gaps (Graph 9, left-hand panel). ICs in the Netherlands and Sweden and PFs in Luxembourg all had duration gaps of more than 10 years in 2016. To the extent that these positions are not hedged, a fall in interest rates by 1% would bring about a decline in the funding

[27] The majority of insurers across CGFS jurisdictions apply such a mark-to-market approach. Canada, Hong Kong SAR, Japan, Singapore and the United States employ a more diverse set of valuation approaches (Annex VI). The picture for corporate pension funds is reversed, with only a handful of jurisdictions – the Netherlands, Sweden, and the United Kingdom – discounting liabilities at market rates (Annex VI). It is also possible that different approaches be applied within the same jurisdiction. In Canada, for example, only a subset of funds (those subject to solvency funding rules) mark liabilities to market.

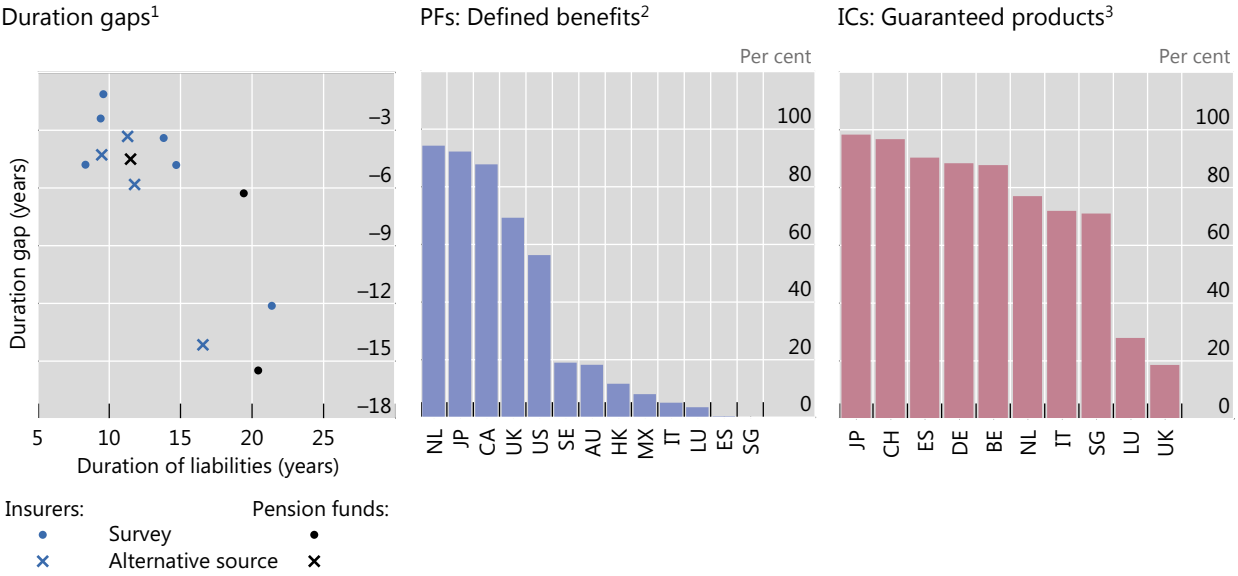
[28] For instance, under Solvency II (the prudential supervisory framework for ICs in the European Economic Area) a firm is solvent if it can weather large asset price shocks without failing with a sufficiently high probability. The framework employs a risk-based metric defined as the ratio of own capital to "required capital", a risk-based buffer calibrated to ensure that future payment promises can be covered in the event of large adverse asset price shocks with a sufficiently large probability.

ratio in excess of 10%.[29] In practice, ICPFs are likely to hedge part of their duration gap although precise information on this is not readily available.[30] Similarly, despite the growth of defined contribution (DC) pension plans (which have a more flexible liability structure), defined benefit (DB) schemes have consistently accounted for approximately 90% of pension funds' assets in Canada, the Netherlands and Japan, and to a lesser extent in the United Kingdom (Graph 9, centre panel). Guaranteed return products represent the majority of claims against life insurers. In Belgium, Germany, Japan, Spain and Switzerland, their share has consistently exceeded 80% of insurers' assets since 2010 (Graph 9, right-hand panel).

Although ICPFs are less connected to the rest of the financial system than banks, distress and failure of individual ICPFs could still have systemic consequences (on a jurisdiction by jurisdiction basis), especially given some of the adjustments undertaken by firms in a low interest rate environment. Financial stability implications are discussed in Section 4.5 below.

ICPFs: duration gaps, return guarantees and defined benefits

Graph 9



[1] Difference between asset and liability duration. Asset duration is a weighted duration of fixed-income and other assets. Durations are based on 2016 figures or, if not available, on recent years prior to 2016. [2] As share of total pension fund assets. The remainder is made up by defined contribution and hybrid schemes. [3] As a share of total life insurer liabilities. Includes capital guarantees, as these are essentially "minimum zero return" guarantees. Shares are based on 2016 data for all countries except Germany, for which 2015 data are used instead.

Sources: WG survey, EIOPA stress test, US Life Insurers Fact Book.

[29] The funding ratio is the ratio of the current value of assets to the present value of the firm's liabilities (see Annex V for a more detailed definition).

[30] In Spain, for example, life insurers structure their balance sheets to achieve (close to) full cashflow matching of assets to liabilities (ie NCFs close to zero in each period), thereby reducing the FR sensitivity to interest rate fluctuations. According to Netherlands Bank (2009), Dutch pension funds hedge on average about one third of the interest rate risk that could generate volatility in the FR.

Despite many similarities, there are also significant differences between ICs and PFs. From a financial stability perspective, the most relevant difference relates to the vulnerability of life insurers to runs because their products may include surrender options, that is, the option to liquidate early but often at some cost.[31] In addition, PFs are restricted to providing a single product (ie a pension contract) while some life ICs are part of diversified multiline insurers and therefore have greater scope for adjustment in a low interest rate environment. Lastly, the prudential supervisory regimes applied to these institutions differ, with ICs typically facing a risk-based framework, unlike most PFs.

4.2 Performance

4.2.1 Trends in ICPF performance since the GFC

As in the case of banks, the performance of ICPFs can be assessed by the return-on-assets (RoA) which captures the efficiency of assets in generating net income. ICPFs' RoAs took a hit during the GFC but have since (partially) recovered. Insurers' RoAs have stabilised, albeit at levels below those registered pre-crisis (Graph 10, left-hand panel). Valuation metrics such as the market-to-book ratio – the ratio of the market value of a firm to the book value of its equity – have also improved, particularly for US firms (Graph 10, centre panel). This suggests greater optimism about the outlook for insurers, as investors are willing to pay more for equity stakes in these firms. Investment returns for PFs exhibit a similar dynamic – recovery following a large hit during the GFC. PFs' returns (Graph 11, left-hand panel) have, however, been more volatile than those of ICs (Graph 10, right-hand panel), reflecting their higher risk profile.

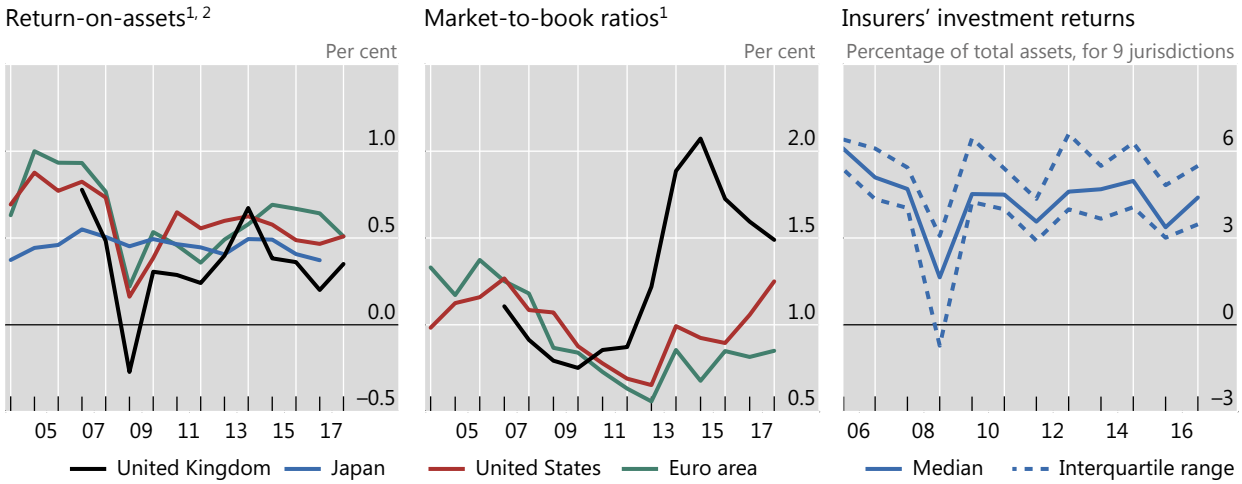
That said, the investment performance of ICPFs in recent years of falling rates may not be a good predictor of future performance if interest rates remain *persistently* low. This is because falling interest rates may depress interest income but they also create capital gains. Once rates bottom out, however, this positive effect disappears, reducing net cash flows. There are reports that some plan sponsors may have already begun experiencing difficulties, and signs that pension fund deficits may have contributed to sponsor bankruptcies.[32]

[31] Surrender-driven runs on insurance companies have occurred in the past. For example, two US-based firms, Executive Life and Mutual Benefit, failed in the early 1990s after policyholder runs were sparked by losses on investments. AIG experienced a spike of policy surrenders in 2008. Outside the United States, in 2008 the Belgian insurer Ethias faced a severe surrender-driven liquidity crisis, ignited by crisis-driven losses on assets and compounded by inadequate surrender penalties (ESRB (2015)). In the wake of the Asian financial crisis in 1998, Korean life insurers also experienced an upsurge in surrenders that resulted in asset fire sales (Geneva Association (2012)). Run risk is typically more relevant for ICs than PFs. However, some DB plans could face withdrawals spurred by concerns about sponsor insolvency. For instance, the Dallas Fire and Police pension plan experienced a run in 2016. To the extent that they hold derivative contracts with margin requirements, ICPFs are also subject to some liquidity risk, to meet short-term, mark-to-market payments embedded in derivative exposures. If an ICPF's creditworthiness is perceived to be deteriorating, it will likely experience margin calls.

[32] Large pension fund deficits are thought to have played a significant role in bankrupting their sponsor (eg city of Detroit, government of Puerto Rico).

ICs: returns and market to book ratios

Graph 10



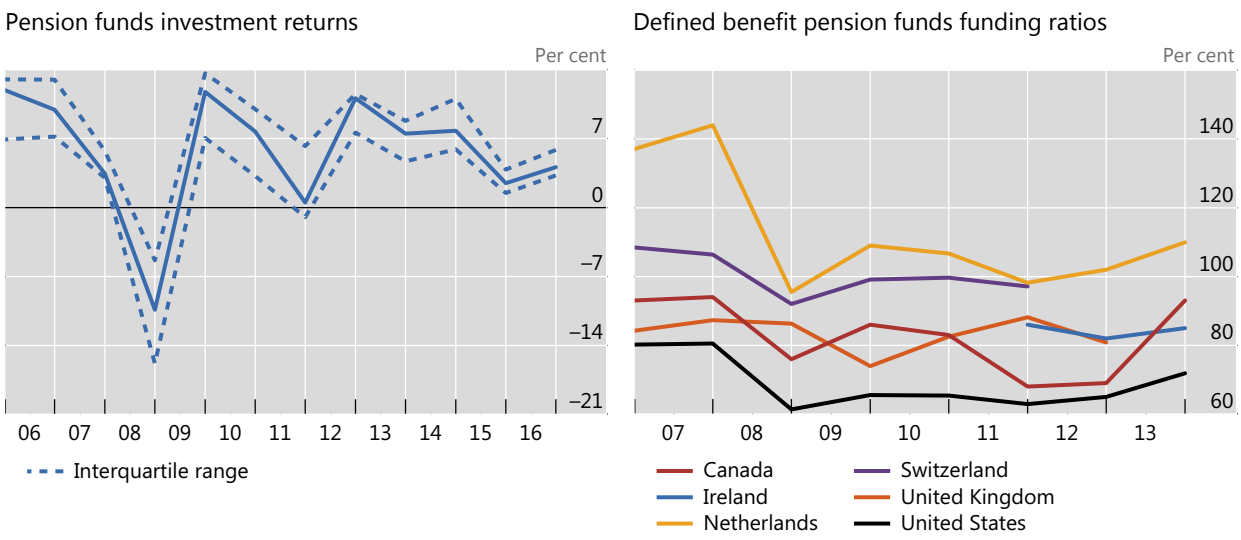
[1] The series for the euro area, United Kingdom and the United States are medians of firm-level data. [2] The RoA series for Japan reports the median for four major insurers.

Sources: OECD; Bloomberg; S&P Capital IQ; The Life Insurance Association of Japan; WG survey.

Given the subdued rate outlook, even in the baseline scenario, discussed in Chapter 1, the pickup in investment performance has not been large enough to assuage concerns about ICPFs' solvency (see also the results of industry outreach, Box G).[33] Evidence about PF funding ratios (albeit limited in scope to a handful of countries), which measure the present value of assets relative to liabilities, is no more benign, with funding ratios mainly below 100 in the post-crisis period (Graph 11, right-hand panel).

Pension funds returns and funding ratios

Graph 11



Sources: OECD, *Business and Financial Outlook* (2015); WG survey.

[33] See ESRB (2016), IMF (2017a, 2017b), IAIS (2017), and Moody's (2017).

4.2.2 Simulating the impact of low rate scenarios

The methodology used to investigate the impact of low interest rates on ICPFs' cash flows and funding ratios is based on model simulations, in contrast to the regression-based approach employed in the study of banks presented in Chapters 2 and 3. The approach involves simulating measures of profitability for an ICPF with a typical balance sheet that offers long-term savings and retirement products. Simulations can capture the cumulative impact of rates and investment returns over the full horizon of these products, whereas regression analysis would focus only on their contemporaneous links.

The simulations-based approach consists of two steps. First, a balance sheet is constructed to be broadly representative of a life insurance company – in terms of asset allocation, duration, approach to liabilities valuation, accumulation period, minimum guarantees and operational costs. Its initial balance sheet is calibrated for a negative duration gap (seven years), toward the upper end of the range for euro area insurers, in order to capture the impact of scenarios on firms with relatively high sensitivity to interest rates.[34] The dynamics of this stylised balance sheet (and of the corresponding stream of cash flows) are then tracked through the different interest rate scenarios presented in Chapter 1, with a number of extensions.[35] Model details are presented in Annex V. There are two important caveats. First, the model assumes that the firm has one business line – life insurance. In practice, larger ICs typically offer a diversified portfolio of products (e.g. property and casualty insurance), which reduces their exposure to interest rates. Second, the model does not incorporate the possibility of surrenders and the consequent liquidity risk.

The two solvency metrics used in the simulation analysis are Net Cash Flows (NCFs) and the Funding Ratio (FR).[36] The NCF is a flow measure that reports the difference between investment income (ie interest received and realised capital gains, net of administrative costs) and (lump sum) payments to policyholders in any period of time period. Changes in interest rates impact the NCF through investment income and through the value of payments to policyholders, which is affected by the presence of return guarantees. A positive NCF can add to the equity buffer (a cash reserve) of the firm, while a negative NCF can deplete this buffer.[37] The FR is a stock measure, defined as the ratio between the market value of the IC's financial assets to the value of policyholders' claims cumulated to date.[38] Changes in interest rates impact the FR

[34] The (modified) duration of assets – that is, the percentage change in the value of assets associated with a one percentage point change in rates – is equal to eight years, consistent with duration values typically displayed by euro area life insurers. A (modified) liability duration of about 15 years is far enough into the upper the tail of the distribution (without being an outlier) to capture a maximum impact benchmark (see, for instance, Figure 78 in EIOPA (2014)). By this reasoning, the more vulnerable life insurers in the euro area have a duration gap of about 7 years. Regarding the liability side: modified duration of 15 years represents the more vulnerable IC's in the EA.

[35] To account for the long horizons of ICPFs, scenarios were extended to cover a total of 30 years (rather than 10). As ICPFs typically hold equities and corporate bonds in addition to sovereign bonds, the set of variables covered by the scenarios was augmented with equity returns and corporate credit spreads. Extension assumptions are discussed in Annex V.

[36] See Annex V for a more detailed discussion of the two metrics and their relationship.

[37] More precisely, if the NCF is positive, a share is retained by the firm and is added to a cash reserve. The remainder is paid out.

[38] Financial assets include the cash reserve but do not include claims to future premiums. Consistently, the calculation of liabilities only includes policyholders' claims that have been accumulated to date. The FR

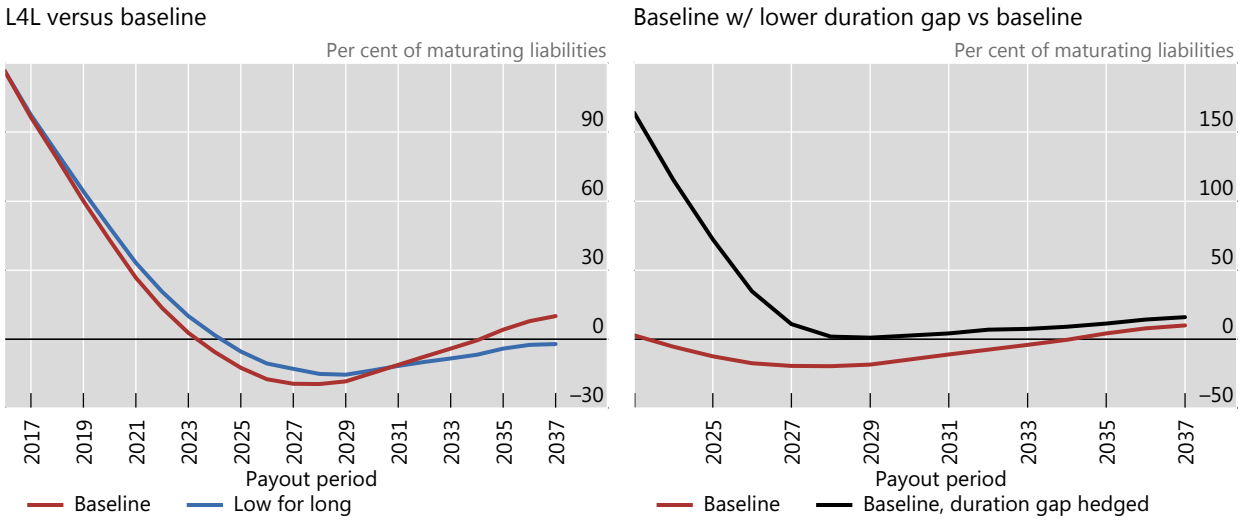
because they affect the value of assets and of liabilities, which are marked to market. If the FR falls below one – or 100 in percentage terms – the IC is underfunded.

Results for this life insurer reveal a considerable drop in NCFs in the baseline scenario (Graph 12, left-hand panel). By 2023, NCFs are negative, because investment returns have fallen so much that the firm can no longer cover the difference between cash outlays associated with legacy return-guaranteed liabilities and investment returns without dipping into equity. NCFs bottom out around 2028 and in the very long run (from 2034 onwards), they return into positive territory as interest rates recover and legacy liabilities are replaced by new liabilities with lower return guarantees.

After a small initial dip, the FR recovers to its initial level by 2027, and it continues to improve on the back of rising asset values (Graph 13, left-hand and centre panels). Liabilities decline throughout the simulation horizon, both because of rising interest rates and because no new payment promises are made after 2028, so the balance sheet starts to unwind. Assets fall until 2027, and initially at a faster pace than liabilities – in spite of what may be expected given a negative duration gap – because capital losses are compounded by losses from negative NCFs. Assets start rising after 2027, as by this point interest rates have stabilised and NCFs begin to recover (growth in NCFs turns positive around 2028), compensating for the decline in premiums.[39]

As a preview for a more fully fledged discussion of behavioural adaptations to come in Section 4.3, the simulation also showcases how this hypothetical firm would have benefited from longer-duration assets. This IC is assumed to have a (modified) duration of assets close to eight years in 2016. Had it instead had double that asset

Scenario analysis: net cash flows (L4L) Graph 12



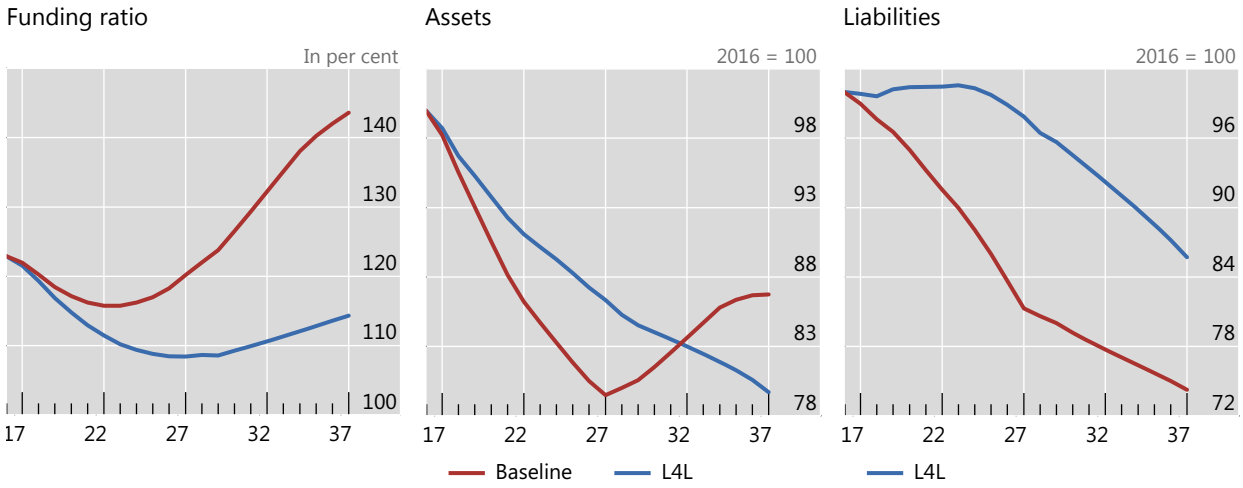
Source: WG

measure employed in the simulations is thus different from measures typically employed by ICs (and reported in the WG's survey) to estimate duration gaps, which do include projected premium payments.

[39] To draw inferences about the hypothetical firm's solvency, it is necessary to make assumptions about the distribution of NCFs. For instance, had the positive NCFs experienced by the IC in the medium run been wholly retained as cash reserves, the firm would have been more likely to be solvent (at any point in time) than if they had been entirely paid out (the value of assets would be larger). In this example, the firm is assumed to retain about half of positive NCFs.

Scenario analysis: funding ratios (L4L)

L4L vs baseline Graph 13



Source: WG.

duration, it would still have experienced a period of low NCFs, but it would not have needed to dip into equity (Graph 12, right-hand panel).

A comparison of the evolution of NCFs under L4L and baseline (Graph 12, left-hand panel) suggests that an important issue in assessing the impact of low interest rates on the NCFs of ICPFs is the extent to which the impact of low rates on investment returns through interest income is offset by their impact through valuation changes. The stylised IC does initially better under L4L than under baseline (ie in the period 2016-2031), because the scenarios feature a significantly faster pick up in rates under baseline than under L4L. The less rapid rate pickup in L4L results in smaller capital losses that boost NCFs relative to baseline. However, these capital losses disappear after rates have stabilised under each scenario, and since interest income is smaller in L4L (because rates stabilise at a lower level) the ICPF begins to do worse in L4L than in baseline.

Despite the small impact of L4L on NCFs relative to baseline, the negative impact on the FR is significant (Graph 13, left-hand panel). It falls for longer, reaching its trough in 2027 as opposed to 2023 as in baseline, and it does not recover as quickly. The FR is still below its initial value by the end of the simulation horizon. The dynamics of the FR can be better understood by looking at the value of assets (the numerator, centre panel of Graph 13) and of liabilities (the denominator, right-hand panel of Graph 13). While asset values begin to recover after 2027 in the baseline, they remain on a downward trajectory throughout the simulation period in L4L, even after rates have stabilised. This is because in baseline investment returns are large enough to more than offset the decline in premium growth by driving up NCFs (growth in NCFs turns positive around 2028). In L4L, instead, returns are lower, resulting in NCFs recovering too slowly to offset declining premiums. Because interest rates do not rise as rapidly in L4L as they do in baseline after 2016, liabilities decline at a slower rate in L4L. That said, differences in liabilities across the two scenarios are larger than differences in assets, making developments on the liabilities side the primary driver of the negative impact on the FR.

Box F

Impact of adverse scenarios: evidence from EIOPA stress tests

The European Insurance and Occupational Pension Authority (EIOPA) conducts stress tests on a regular basis for insurers and pension funds.

The 2016 insurance company exercise (EIOPA (2016)) included 236 individual companies from 30 countries. One of the scenarios it considered was a low-for-long scenario, which contemplated a decline in the euro swap curve to levels below 0.5% for maturities up to 15 years and a drop of the ultimate forward rate (the discounting rate for long-term liabilities) to 2%. Consistent with the scenario analysis in this report, prolonged low interest rates in the EIOPA stress tests result in a deterioration of funding rates because the negative duration gap in insurers' balance sheets means that the increase in the value of liabilities is larger than that of the assets.

EIOPA 2016 insurance company scenarios: aggregate results

Table F

	Low-for-long		
	Change in assets	Change in liabilities	Change in excess of assets over liabilities
EUR bn	282.4	381.5	–99.1
%	+4.5%	+6.7%	–18.0%

Source: EIOPA (2016).

Box G

Takeaways from industry roundtable – ICPFs

Representatives from ICPFs involved in the WG's outreach noted that the negative effect of low rates on solvency and profitability is strongest for ICPFs with "hard" liabilities (defined benefit schemes and guaranteed life insurance products) and large duration gaps. The impact also depends on the regulatory framework including solvency requirements, reporting standards and the methods used to value assets and liabilities (eg mark-to-market).

Higher interest rates would in principle benefit ICPFs' solvency but mainly if they were to materialise gradually. A snapback scenario could be problematic because of liquidity risks to the firms, including risks that arise from the behavioural responses of policyholders (surrenders). In addition, firms that have increased their investments in credit risky and alternative asset classes in their search for yield could see the value of their holdings decline if a snapback is associated with a downturn.

Despite having a long-term investment horizon, ICPFs also need to have sufficient liquid assets. Holding illiquid assets limits the ability to rebalance their portfolio, and cash is needed for settling hedging instruments such as derivatives, swaps, and repos, especially in stressed market scenarios.

Rigid solvency regimes combined with mark-to-market valuations may reduce ICPFs' scope to take long-term investment risks and act in a countercyclical manner. At the same time, accounting and regulatory constraints can create incentives for PFs to increase asset duration by replacing equities with long-term fixed-income securities rather than short-term bonds.

Participants emphasised the need to address L4L not only through changes on the asset side (eg extending duration and boost investment returns) but also through adjustments on the liability side of their balance sheet. Among other things, ICPFs have raised premiums or revised down guarantees. ICs are shifting towards more unit-linked products and lower guarantees; PFs move to DC for new employees and reduce indexation of liabilities. Risks are therefore transferred to households. In a rising yield environment, PFs may also have a stronger incentive to shift longevity risk to insurance companies by buying annuities for retiring plan members.

Contrary to what many believe, defined contribution plans tend to take more risk than defined benefit plans. In addition, as investments in defined contribution plans tend to be more procyclical than in defined benefit plans, they might exacerbate asset price movements in market downturns.

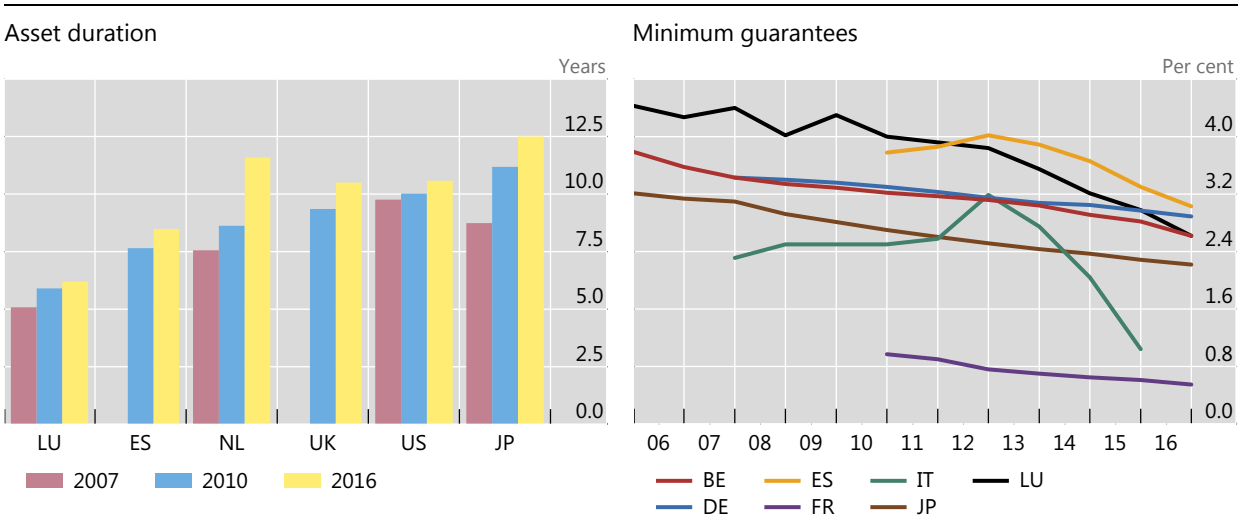
4.3 Risk-taking and other adaptations to low interest rates

ICPFs made several adaptations to the low interest rate environment. Some of these have been marginal adjustments to the current business model involving shifts in asset composition and small changes to product specifications. Others represent more radical shifts towards a new business model that would exhibit a lower sensitivity to interest rates primarily because of changes in the nature of liabilities.

ICPFs that see lower rates weigh down their funding ratios and shrink their buffers against liquidity risk face a trade-off in their choice of asset allocations. On the one hand, reducing the near-term risks to solvency requires a more conservative investment strategy that reduces the volatility of returns. On the other hand, rebuilding buffers in a world of higher liability valuations over the medium term requires higher-yielding investments, which typically entail taking higher risk. The evidence on firms' adaptations reflects this trade-off.

One way of reducing an ICPF's solvency risk is by lengthening its asset duration thus reducing the gap with the duration of liabilities. This would support NCFs and cushion FRs in an environment of falling interest rates as well as reduce the impact of additional falls in rates, but at the cost of realising smaller capital gains in case of a snapback. Survey-based evidence suggests that ICs appear to have lengthened asset durations in the 2007–16 period, including in the Netherlands, Japan, Spain and the United Kingdom (Graph 14, left-hand panel), although to some extent this increase might have been a mechanical consequence of the decline in rates themselves.[40]

Life insurers' asset duration and minimum guarantees — Graph 14



Source: WG survey.

[40] Fixed-income valuations exhibit convexity with respect to interest rates. This means that the duration of a security increases as rates fall. In addition, some lengthening could also have happened because of the need to match changes in the duration of liabilities, at least in some jurisdictions (eg the Netherlands).

The survey evidence is mixed when it comes to the issue of ICPFs changing the risk profile of their asset portfolio, with responses indicating that while some firms attempt to reduce interest rate risk, others seek to boost returns to maintain a sufficiently robust growth profile as to be able to meet future obligations. This is consistent with evidence pointing to a rise in shares of alternative investments (such as real estate) in aggregate PFs' assets over the 2007–17 period (from about 4% to about 25%), although the trend is not evident in all jurisdictions (Tower Watson (2018)). Other sources concur that DB funds' portfolios do seem to include a greater share of risky assets, although the change may not be as large (OECD (2015)). Evidence for the insurance sector is similarly mixed. On some accounts, ICs do not seem to have taken on more risk (IMF (2016, 2017a)), but others find that these firms do search for yield in choosing their investments, at least in the corporate bond market (Becker and Ivashina (2015)).[41]

The low interest rate environment has also likely pushed ICPFs to make changes to their liabilities so as to better align the interest sensitivity of their payment commitments with the interest sensitivity of their returns. Survey-results indicate that life insurers have been reducing minimum yields on newly-issued guaranteed products, to replace costly legacy liability over time (Graph 14, right-hand panel). In addition, they have shifted from guaranteed to unit-linked products – such that most investment risk is borne by the customer – and non-life insurance (eg healthcare) in several jurisdictions (eg Belgium, Canada, France, the Netherlands, Sweden and the United Kingdom). This shift has been an important adjustment tool for Japanese insurers in the past two decades (Box I). Some German insurers have responded to narrowing margins by discontinuing new business and decreasing the extent of *profit-sharing* – the practice whereby policyholders benefit from investment returns beyond guaranteed minimums.[42] In Belgium, some ICs have been experimenting with liabilities buy-backs, whereby a firm pays an "exit" premium to policyholders who surrender their policies.[43]

Pension funds in the Netherlands and some funds in Canada have suspended inflation indexation of benefits, or cut benefits altogether. The EIOPA stress tests of pension funds (EIOPA (2017)) concluded that participating funds in Belgium, Italy and the Netherlands would have to resort to benefit reductions to restore compliance with funding requirements in an adverse scenario. In addition, low rates have also likely accelerated the trend away from DB to DC corporate pension contracts, as sponsoring firms seek to reduce exposure to pension plans. In some jurisdictions, including Canada and the United Kingdom, some DB schemes have been closed to new participants.

It should be noted, however, that these major adjustments to the products offered by ICPFs to reduce the exposure of these firms to interest rate and other investment risks do not eliminate these risks, but merely shift them on to their claimholders.

[41] Assessing risk-taking in a comprehensive manner is complicated by a lack of historical or sufficiently granular data (for example, about derivative positions) and because ICPFs' rebalance slowly, so trends surface only over long periods of time. For evidence of behavioural adjustment by euro area ICPFs, see EIOPA (2017).

[42] See Bundesbank (2017) for a detailed treatment of German life insurers.

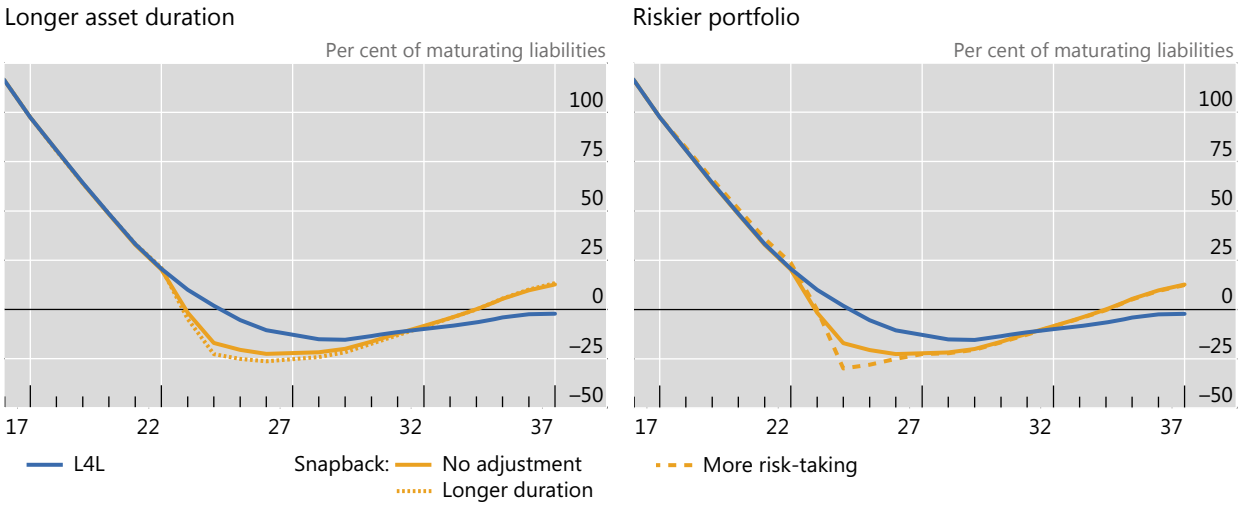
[43] Belgian insurers offered large surrender incentives, with exit premiums of 25%.

4.4 Impact of a snapback after prolonged low rates

Because of their typically negative duration gaps, ICPFs could in principle benefit from a snapback in rates, as this would improve FRs. However, the fact that these firms have been adapting to the low interest rate environment by lengthening asset durations suggests – insofar as negative duration gaps remain – that the sector stands to gain less from a snapback in rates than it would have done absent adjustments. At the same time, if a snapback were accompanied by a collapse in the valuations of risky assets, additional risk-taking in the low interest rate environment would likely cause FRs to deteriorate. In addition, ICs may experience a spike in policy surrenders (early withdrawals) and ensuing liquidity issues.

The analysis of a snapback with behavioural adaptations by ICPFs suggests that their impact on NCFs is small. The simulation approach outlined in Section 4.2.2 can be applied to the snapback scenario, as shown in Graph 15. For the purpose of these simulations, the snapback scenario has been adapted to be accompanied by a collapse in equity prices and a widening of credit spreads that results in both capital and credit losses on corporate bonds held by the insurer. The solid yellow line in both panels shows the evolution of NCFs in the snapback scenario absent behavioural adjustments. Compared with the L4L scenario (blue line), cash flows in the snapback initially dip lower, reflecting capital losses from the rise in interest rates, before rising above the L4L path as interest rates flatten out and the insurer enjoys higher returns. The dotted yellow line in the left-hand panel shows the impact of a snapback on NCFs assuming that the hypothetical IC increases the duration of its assets, from 2018 onwards, by substituting longer-dated corporate bonds for the corporate bonds on its portfolio. The dashed yellow line in the right-hand panel, instead, assumes that this virtual firm tilts its portfolio so as to increase the share of risky assets, also from

Scenario analysis: simulated NCFs (snapback) Graph 15



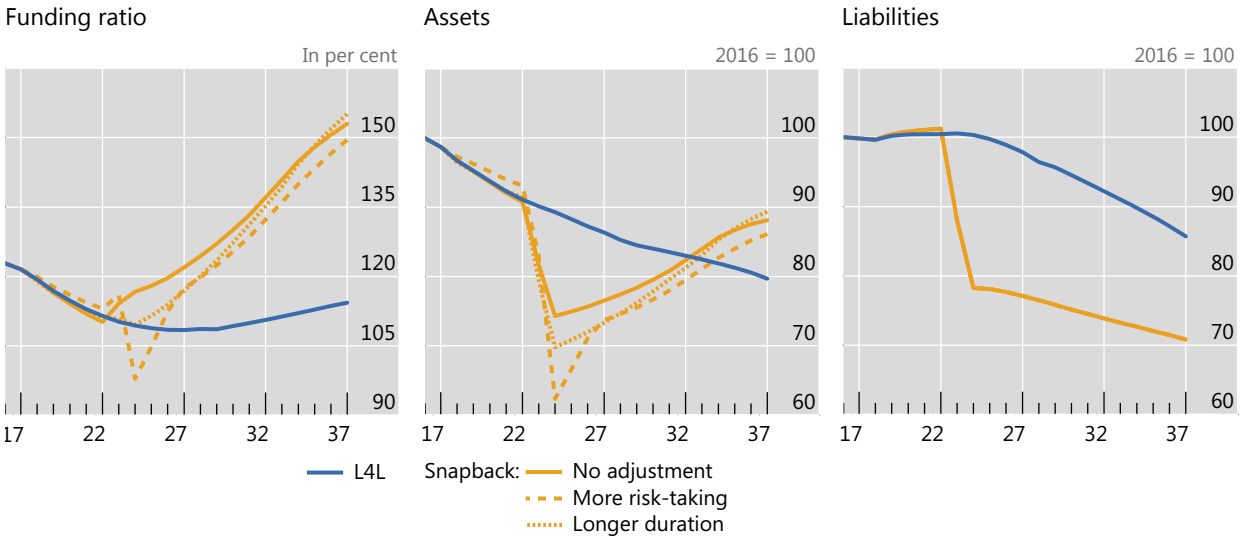
Source: WG.

2018 onwards.[44] Taking on more interest rate risk (left-hand panel) or more market risk (right-hand panel) does not materially affect NCFs, although the IC does a little worse with behavioural adjustments than without.

Behavioural adaptations make a larger difference to the FR (Graph 16). As anticipated, because of the negative duration gap between assets and liabilities, the funded status of the IC improves under snapback relative to L4L absent adjustments (left-hand panel, continuous yellow line). The jump in rates depresses both the value of assets and the value of liabilities, but because of the negative duration gap, liabilities fall more (right-hand panel), improving the funding ratio relative to L4L. Also as anticipated, if the virtual firm increases asset duration (dotted yellow line), it still does better under snapback than L4L, but the improvement is not as marked (the duration gap is still negative but smaller in absolute value). Finally, if the firm adapts to the low interest rate environment by tilting its portfolio to risky assets whose valuations collapse upon snapback (dashed yellow line), the FR – which starts off higher than absent behavioural changes, because of higher returns – suffers a sharp decline after a snapback, falling below its level in L4L before eventually recovering. As the insurer experiences both capital and credit losses on its portfolio after a snapback (centre panel), though, the value of assets is pushed permanently below its counterpart in the scenario with no behavioural adjustments (Graph 16, centre panel), driving the FR lower than its counterpart. Even so, funding ratios in all three examples end up well above the L4L path.

Scenario analysis: funding ratios (snapback)

Snapback vs L4L — Graph 16



Source: WG.

[44] Absent behavioural adjustments, the hypothetical insurer is assumed to hold the following portfolio: 10 percent equity, 30% euro area sovereign bonds and 60% corporate bonds. All bonds in the portfolio are assumed to have a nine-year maturity, which returns an approximate asset duration of eight years. The IC takes on more interest risk by swapping 11-year bonds for its nine-year bonds from 2018 onwards. It takes on more market risk by switching to a portfolio with a 20% share of equities and an 80% fthshare of corporate bonds, also from 2018 onwards.

In addition to the solvency issues explored in the simulations, a snapback scenario could also trigger liquidity problems for ICPFs. First, as discussed in Box H, rising interest rates can induce insurance policyholders to withdraw their funds ahead of maturity (surrenders). This could be motivated by concerns about solvency (which

Box H

Estimating the risk of a policyholder 'run' on life-insurers – a case study for Germany

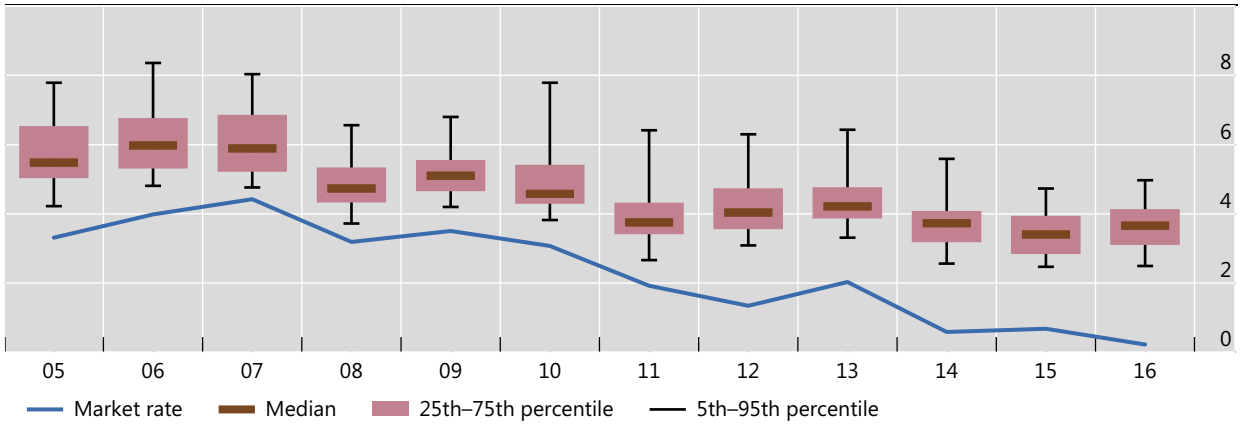
Surrender options allow policyholders to liquidate their investments early and receive the policy's surrender value. Surrender values are typically computed by compounding paid-in premiums at a guaranteed rate of return, and adding a share of past excess investment returns (profit participation). Crucially, surrender values do not depend on current or expected future market interest rates.

Surrender options can engender liquidity problems for insurers in an environment of rising interest rates. When rates increase above a certain level, the incentive for policyholders to surrender their policies and reinvest the proceeds at a higher yield increases.① At the same time, the value of assets on insurers' portfolios falls. If rates rose to sufficiently high levels, asset valuations could also fall short of the outlays insurers would need to cover if all policyholders surrendered at the same time. Such a situation might indeed trigger a run on insurers (Chen and Förstemann (2018)).

Graph H presents Bundesbank estimates of the distribution of firm-specific threshold yields of the 10-year German government bond above which surrender values would cease to be fully funded. The critical thresholds have declined in the period 2006–16, partly because insurers have increased the duration of their assets making valuations more sensitive to a rise in market yields.

Critical interest rate level for life insurers given an upsurge in policy lapses[1]

In per cent, year-end data — Graph H



① Yields on bunds with a residual maturity of 10 years, above which an upsurge in policy lapses could impair life insurers' stability. The analysis covered the approximately 55 largest German life insurance companies with a premium reserve of more than EUR 1 billion each and for which data are available until 2016.

Source: Deutsche Bundesbank.

These results suggest that the most vulnerable 5% of German life insurers would have faced policyholder runs if market rates had jumped from 0.2 to 2.5% in 2016. The snapback scenario assumes that in 2023 the 10-year rate jumps from 1.2% (a level close to the market rates prevailing in 2012) to 2.8% (Graph A.I.6.6 in Annex I). On the basis of the simulations, a jump of this size could represent stress from policyholder runs for the most exposed insurers.

① If surrender values were allowed to vary with interest rates, policyholders would have less incentive to surrender, thereby decreasing the likelihood of surrender runs.

Box I

Japanese life insurers' experience with low interest rates

Japanese life insurers have been confronted with low interest rates for a much longer period than ICs in other jurisdictions covered in this report. This box provides a brief summary of the sector's ensuing solvency problem, the behavioural adaptations and the associated systemic implications.

Failures in the late 1990s: a negative margin problem

In the mid- to late 1980s, Japanese life insurers funded an expansion in their balance sheets by selling guaranteed products characterised by high minimum returns (up to 9%), partly in response to competitive pressures from GSEs (eg postal life insurance) and agricultural cooperatives. Interest rates started on a trend decline in the early 1990s (see Graph I, left-hand panel) and pushed investment returns below the guaranteed minimum (negative margins). Short asset durations (about five years on average) contributed to the quick onset of the negative margin problem, as maturing assets were replaced by new, lower-return assets. In addition, the legal framework of the time (set out in the Insurance Business Act of 1996 and later revised in 2003) prevented insurers from unilaterally lowering guaranteed yields on existing policies.

As a result of these pressures, several firms that represented about 10% of total assets of the life insurance sector went bankrupt between 1997 and 2001, with the cost of resolution borne primarily by policyholders and by an industry-funded "Policyholder Protection Fund". Bankrupt firms' assets were acquired by other insurance companies (both domestic and foreign), with support from the Policyholder Protection Fund. These buyers took on the failed firms' liabilities with a haircut. Policyholders with claims on failed firms lost on average between 8 and 10% of their savings and their minimum yield guarantees were substantially reduced (from about 5% to 1.5%). These measures limited the broader consequences of these insurers' bankruptcies.

Japanese life insurers' responses to sustained low interest rates since 2000

Japanese life insurers have made efforts to safeguard both profitability and solvency in a low interest rate environment. On the asset side, they have purchased super-long JGBs, Japanese government bonds with maturities of at least 15 years (Graph I, centre panel), replacing in part loans to Japanese firms. As a result of this portfolio shift, the average asset duration of Japanese insurers has increased to about 12.5 years (Graph I, left-hand panel). The shift was motivated not only by profitability considerations, but also by the need to hedge against interest rate fluctuations by better matching the duration of assets to that of liabilities. Accounting changes implemented in 2000 provided insurers with further incentives to buy super-long JGBs, by allowing bonds purchased to match the duration of liabilities (so-called "policy-reserve-matching" bonds) to be valued in the same manner as liabilities (ie not marked to market).①

Investment in super-long JGBs has also boosted investment returns, as has an increased portfolio share of foreign bonds driven by a large return differential relative to domestic bonds. About 70% of foreign bond holdings are currency-hedged to limit foreign exchange risk.

On the liability side, life insurers have shifted from savings-type products toward protection-type products, due in part also to a more favourable regulatory environment (a ban on life insurers' participation in medical insurance began to be gradually lifted in 2001). Premiums on protection-type products – which are less sensitive to interest rates than savings-type products because they are non-refundable and do not offer long-term saving options– have been on the rise since the early 2000s. A 2003 revision in the law allowed life insurers to renegotiate with policyholders lower guaranteed returns on existing contracts, provided they face a high probability of bankruptcy.

As a result of these efforts, the interest margins of major Japanese life insurers have turned positive in 2013 (Graph I, right-hand panel).

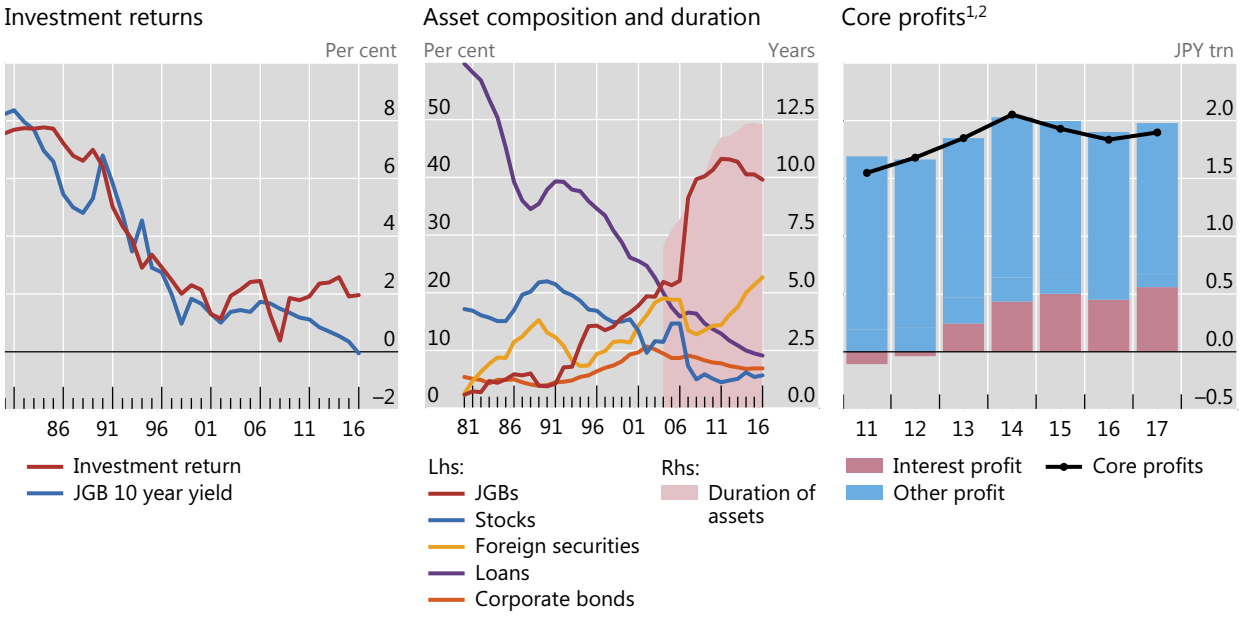
Implications for financial stability

The distress or failure of life insurers associated with prolonged low interest rates could, in principle, have broader systemic consequences. However, the interconnectedness of the life insurance companies with other parts of the financial sector appears to be limited (see IMF's FSAP technical note on Japanese insurance sector (2017)). For example, Japanese life insurers have been cutting back on the subordinated loans that they have traditionally provided to banks. On balance, the evidence points to counterparty risks not being a source of concern.

Additionally, the changes to the accounting framework discussed above imply that insurers are partially immunised from changes in asset valuations induced by changes in interest rates. As a result, the firms have a smaller incentive to tilt their portfolios to risky assets than if the assets had been marked to market. Moreover, because they have extended duration by outright purchases of long-dated JGBs rather than through interest rate swaps, they are less exposed to liquidity risk in a snapback. At the same time, improved profitability has contributed to the build-up of an equity cushion that would reduce the need to liquidate assets in response to the market volatility that might arise from a snapback in rates (Graph I, right-hand panel). Furthermore, surrender rates have been relatively low and, while this has admittedly been in an environment where interest rates have remained low, it may also reflect renewed focus on post-sales services by insurers (eg special bonuses to employees who successfully discourage surrenders).

Japanese life insurers in a low interest rate environment

Graph I



[1] The data for fiscal 2017 are as at the first half of fiscal 2017 (annualised). [2] Covers four major life insurance companies.

Sources: Bank of Japan; Published accounts of each company.

① For a more detailed discussion, see Washimi et al (2017).

seem supported by the simulation results in the variant with increased risk-taking) or by the fact that policyholders can now earn a better return by pursuing alternative investment opportunities. Specific features of life insurance contracts (such as surrender penalties or returns above the minimum guarantee) can dissuade surrenders, but these may prove insufficient deterrents in the case of a large snapback if returns do not increase enough, or if penalties are too low (as they could be in some jurisdictions, see Moody's (2017)). Were surrenders to occur on a large enough scale, ICs may be forced to liquidate assets and realise losses.

Heightened liquidity needs may also arise because of the impact of snapback on the marked-to-market value of derivative contracts (eg interest rate swaps used to increase asset duration). ICPFs typically enter these agreements as receivers of fixed rate payments, both to better match the interest sensitivity of asset returns and of the service cost of liabilities (minimise funding volatility) and to protect against declining rates (Klingler and Sundaresan (2018)). Such firms would therefore stand to lose from a snapback in rates, which would reduce the value of the contract. As a result, they may be required by counterparties to post more collateral, draining liquidity.

4.5 Summary and financial stability implications

This Chapter has discussed how alternative interest rates scenarios may affect financial stability because of their impact on ICPFs. A simulation model of a hypothetical life insurance company confirmed that because of the negative duration gaps in ICPF balance sheets, a low-for-long scenario would lead to depressed net cash flows and funding ratios, and thus greater risk of insolvency, relative to baseline performance.

The discussion then moved to the effects of a snapback in interest rates following a prolonged period of low interest rates. By and large, the simulation analysis shows that higher interest rates in the context of negative duration gaps should lead to an improvement in the financial position of ICPFs relative to a continuation of the low-for-long scenario. Nevertheless, adaptations that ICPFs may implement in a low interest rate environment – eg lengthening asset durations and, even more so, tilting portfolios away from safe assets – could reduce the gains from a snapback in rates, and possibly lead to more adverse outcomes, if the snapback were to be accompanied by a sharp contraction in valuations of risky assets. Longer asset duration implies a smaller duration gap, and thus a smaller improvement in the funding ratio as rates increase. Riskier portfolios generate higher returns when rates are low, but they also result in larger losses upon snapback. In addition to solvency issues, ICPFs may experience liquidity problems in a snapback. ICs would likely face a spike in policy surrenders, while both ICs and PFs may face additional collateral demands driven by losses on their derivative positions.

This Chapter concludes with a review of possible systemic consequences arising from the impact of low rates on ICPFs. Distress or outright failures of ICPFs could be transmitted to the rest of the financial system (and to the broader economy) through an exposure channel and a market channel.[45]

The exposure channel refers to the possibility that distress or failure of particular ICPFs can spill over to others, both counterparties in the financial sector (eg banks, asset managers and other ICPFs) and stakeholders in the non-financial sector (eg households, corporate sponsors).[46] As discussed in Section 4.3, ICPFs respond to a prolonged period of low interest rates by lengthening the maturity of their assets. Being, however, limited by the availability of long-dated bonds, they often resort to using derivatives (eg interest rate swaps) to obtain the desired interest sensitivity (CGFS (2011)) thereby resulting in counterparty risk for the financial institutions on the other side of the transaction. The move toward central clearing of derivatives since the GFC has significantly reduced counterparty exposures between ICPFs and the rest of the financial sector. That said, collateralised positions entail asset encumbrance, which could exacerbate risks if an ICPF faced a liquidity crunch.

[45] See also IAIS (2016). There is also a critical function channel but this seems to be less specific to L4L.

[46] Alves et al (2015) find European insurers' connectedness with banks and other financial institutions is low relative to the interconnectedness of banks. However, other studies find connectedness through credit default swaps and securities lending (Cummins and Weiss (2014). Dungey at al (2014), Pierce (2014)) or through interest rate derivatives (Fiedor et al (2017), Abad et al (2016)). Households' claims on ICPFs can also be seen as a component of this transmission channel (Bank of England (2015)).

The market channel, by contrast, involves the impact of ICPFs on asset valuations. First, it is possible that a prolonged period of lower interest rates may impair ICPFs' capacity to exert countercyclical effects on asset prices. ICPFs' investment strategies require periodic re-balancing to maintain a constant (strategic) asset allocation. As a result, these firms should (in theory) buy securities when valuations are low and sell securities when valuations are high, resulting in countercyclical pressure on valuations.[47] Deviations from strategic asset allocations induced by solvency concerns – for instance, in search of yield – may undermine this stabilising capacity (Jones (2016)). Second, as discussed in Section 4.4 above, a prolonged period of lower interest rates may result in liquidity issues for ICPFs, triggered by concerns about solvency or other factors. Unanticipated liquidity withdrawals (eg driven by policy surrenders or margin calls) may generate asset liquidations and fire sales, thereby spilling over to other markets and institutions.[48] Existing survey evidence (EIOPA (2016)) suggests that insurers prefer not to fire-sell assets during market corrections, as they first pursue alternatives such as raising capital, reviewing guarantees and changing the product mix. Whether insurers would refrain from fire sales in a future distress event, however, remains uncertain.

5. Conclusion and policy messages

5.1 Assessment of risks and caveats

The analysis conducted by the WG focused on two main questions: how would prolonged low interest rates affect the financial performance of banks and ICPFs, and to what extent would these institutions respond by adapting riskier practices in order to increase returns?

Starting with the first question, the analysis suggests that banks should generally be able to cope with solvency challenges in a low-for-long scenario. Net margins would be depressed, but most banks would likely be able to make adaptations to maintain overall profitability, including by cutting costs, shifting to fee-based activities, and increasing the riskiness and duration of assets.[49] Conversely, ICPFs would be more vulnerable to a low-for-long scenario. Because of their negative duration gaps, falling interest rates would push up the present value of their liabilities more than that of their assets, leading some ICPFs to experience more pronounced reductions in profitability and balance sheet positions. Nevertheless, these challenges would most likely play out over a longer time period – as a result of the long maturities of their liabilities, ICPFs have long horizons, as highlighted by the simulations presented in Chapter 4 – providing greater room for orderly adaptation.

[47] Evidence on ICPF countercyclical behaviour during major market events and over the long run is mixed. Some studies also found evidence of herding behaviour among ICPFs. See eg Jones (2016), Blake et al (2015), Duijm and Steins Bisschop (2015), BOE (2014), Papaioannou et al (2013), Ang and Kjaer (2011). Regulatory constraints may significantly affect ICPFs ability to behave in a contrarian manner (see Box G on roundtable takeaways).

[48] For example, Dutch pension funds had to liquidate assets in the fourth quarter of 2008 because they needed liquidity to settle USD-EUR currency swaps (see Netherlands Bank (2009)).

[49] At the banking sector level cost efficiency under certain conditions can also be improved by mergers between institutions.

Similarly, the WG identified only a relatively limited amount of additional risk-taking undertaken by banks and ICPFs in response to the low interest rates of recent years. Both banks and ICPFs have increased the duration of their assets to some extent, and banks have shifted more loans to the interest-sensitive housing sector. But there was little evidence of more exuberant risk-taking (eg substantial reductions in bank loan quality or shifts to equity or corporate bonds by ICPFs). Moreover, as described in Chapter 2, there has been little systematic correlation between movements in interest rates and measures of bank soundness or risk-taking.

Nevertheless, a low-for-long scenario could still engender material risks to financial stability. First, even if banks in the aggregate manage to maintain adequate profitability, some banks or even national banking sectors are likely to come under strain. The analysis described in Chapter 2 suggests that bank profits are more likely to be depressed by low interest rates when banks focus on retail lending and deposit activities, when they hold fewer fixed rate loans, when they operate in competitive markets, and when interest rates are already at very low levels. Moreover, it is possible that the WG's multi-country analysis underestimates the damage that low rates could cause, compared with more focused analyses such as the one of the Swiss banking sector described in Chapter 2, Box B. All told, the WG reached the view that, even if a prolongation of low interest rates would not engender a global surge in bank distress, it could certainly create problems for some banks.

Second, relatively restrained risk-taking by financial institutions in recent years may reflect tighter regulation and de-risking following the GFC. Such restraint might erode over time if interest rates remain low and continue to put downward pressure on returns and profitability.

Third, although the adverse effects of low interest rates on the profitability and balance sheets of ICPFs would likely play out gradually, so that problems could be addressed in an orderly manner, it is possible that some firms might not find ways to adapt and as a result experience solvency and/or liquidity problems, with knock-on effects to other parts of the financial system.

Fourth, even in the absence of greater risk-taking, a future snapback in interest rates following a period of prolonged low rates could be challenging for financial institutions, although the types of challenge would be different across banks and ICPFs. Because of valuation losses on long-duration assets and credit losses on loans, banks without sufficient capital buffers could experience solvency issues, particularly if deposit rates were to increase more rapidly with market rates than they have historically and erode the profitability gains from higher rates. Adaptations to maintain profitability during low-interest rate periods, such as lengthening asset maturities and shifting loans to the interest-sensitive real estate sector, would exacerbate the effects of a subsequent snapback, as evidenced by the simulation analysis for Swiss banks. Banks in EMEs might face even greater challenges if sharply higher interest rates in AEs triggered a reversal of capital flows and sharp sell-off in EME assets. Conversely, ICPFs, with their negative duration gaps, would likely see improvements in solvency ratios in the event of a snapback. Nevertheless, these firms could face liquidity problems: a surge in interest rates could cause losses on derivative positions that triggered additional collateral demands, and higher interest rates might also lead policyholders to surrender their insurance contracts, as discussed in Box H.

Finally, three other risks, which have sometimes been associated with a low-for-long scenario, were beyond the scope of the WG's report. There could be some chance that prolonged low interest rates might encourage asset bubbles and

subsequent crashes, although the theoretical and empirical backing for this possibility is controversial. And, it is possible that low rates might encourage excessive risk-taking in the market-based intermediation sector, other than by banks and ICPFs. Finally, disruptions originating in other institutions or asset markets, as well as spill-overs between ICPFs and banks, could create system-wide stress.

5.2 Policy recommendations and considerations

To guard against the risks described above, the first line of defence by prudential authorities should be to continue to build resilience in the financial system by encouraging adequate capital, liquidity, and risk management. Strong and resilient banks, insurers, and pension funds will be better positioned to weather a wide range of adverse shocks, including the low-for-long and snapback scenarios explored in this paper.

At the same time, consideration might be given to policies that both advance the general objective of bolstering financial-sector resilience and also address more specific concerns posed by low-for-long and snapback scenarios. Such policies include the following.

Enhanced monitoring of financial institutions' exposure to low-for-long and snapback risks, especially through stress tests. Stress tests should be designed to address both low-for-long and snapback scenarios, and might consider the implications of possible behavioural adaptations to low rates by firms, such as increasing risk or duration. Behavioural adaptations might be considered on a sector-wide basis, as the outcome of a single institution moving into a particular business may be different than it would be if all institutions were to do so. In addition, because low-for-long may exert its effects over long time periods, regulators and supervisors might consider longer horizons for their exercises, particularly for ICPFs. In designing stress tests intended to assess the vulnerability of ICPFs to interest rate risk, authorities should adopt a consistent valuation approach across assets and liabilities. Moreover, the valuation approach should reflect the objective of the exercise, and a mark-to-market approach may best capture challenges to economic solvency and liquidity from changes in interest rates, even in jurisdictions where other measurement approaches are used in prudential standards. Finally, it would be important to ensure that stress-tests and other reviews of risk-taking are carried out at a high enough frequency to identify potential issues rapidly.

Collection and analysis of appropriate firm-level data to monitor exposures and risks. One challenge is that firms' financial statements may not provide enough detail to accurately identify common trends, vulnerabilities and possibly spill-overs across jurisdictions. While more detailed data are available in some jurisdictions, they are not available in others, and steps to collect such data would be desirable.[50] Similarly, it would also be desirable to collect comprehensive and comparable data on derivative positions, which are essential for assessing the exposures and balance sheet positions of both banks and ICPFs, but especially difficult to access. Such work

[50] US banks are required to file detailed financial reports to the FFIEC and larger banks that are subject to the CCAR and Dodd Frank Act independent supervisory stress tests report detailed data on their key risk positions to the Federal Reserve. The larger euro area banks annually report to the EBA detailed data on capital positions, risk exposure amounts, leverage exposures and asset quality. Financial reporting for US insurers is collected in the NAIC's Financial Data Repository.

could be undertaken on a coordinated basis, although jurisdictions undertaking such analysis separately would also be of value.

Adoption of appropriate resolution strategies. Appropriate rules and procedures to resolve failing financial firms represent a key element in the resilience of financial systems to shocks. The need for resolution procedures for banks is widely understood, but given that ICPFs are found to be relatively more vulnerable to low-for-long scenarios than most banks, authorities should prepare for the possibility that some life insurers may come under enough stress to eventually fail, as was the case in Japan in the late 1990s. Concretely, they should consider whether their resolution regimes are capable of allowing insolvent insurers to be resolved without systemic disruption.[51]

Finally, the WG discussed two policy suggestions addressing issues specific to ICPFs that might be considered by the relevant authorities. The first suggestion stems from the fact that ICPF' solvency risks play out over a long horizon in the low-for-long scenario. Accordingly, prudential authorities might provide firms facing financial shortfalls with adequate time for them to rebuild their balance sheets to required norms, thereby not encouraging procyclical or disruptive actions by the affected firms. The second suggestion refers to liquidity risk associated with the possibility of mass surrenders during a snapback (Box H). Prudential measures might be designed to mitigate this risk by reducing early termination incentives (eg by imposing larger surrender penalties), or suspending surrenders altogether, although some argue the latter policy might lead runs to occur earlier.[52] However, the WG endorsed neither of these policy suggestions, as there was not scope in the project to fully assess their costs and benefits.

[51] For a detailed discussion of resolution regimes for insurers, see FSB (2014).

[52] The French macro-prudential authority can regulate profit participation, ie the amount of investment returns that is incorporated into the surrender value of the policy. It can also impose a temporary ban on surrenders in case of a crisis.

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Annex I. Scenarios

The WG developed three scenarios, referred to as "baseline", "low-for-long" (or L4L) and "snapback". As the names suggest, the L4L scenario features interest rates remaining lower than in the baseline for an extended period of time. The snapback scenario features interest rates remaining lower than in the baseline for a number of years before rapidly adjusting back to more historically normal levels.

Relative to the descriptions of the scenarios given in Chapter 1 of this report, this annex provides details of the considerations that went in to specifying the scenarios and presents the scenarios themselves. This Annex is organised as follows. As background, section A.1 discusses drivers of short- and long-term yields. These factors are discussed here these factors because they inform the scenario specification. Section A.2 presents the basic parameters for the three scenarios; that is, their jurisdictional coverage, their variable coverage, their time-horizon and their frequency. Section A.3 then describes the WG's approach to specifying the baseline scenario and recaps the developments of key variables in this scenario. Sections 3.3 and 3.4 do the same for the L4L scenario and snapback scenario, respectively.

A.I.1 Drivers of nominal interest rates

The determinants of short-term nominal rates

While in the short-run short-term nominal interest rates are influenced by monetary policy, on a more sustained basis short-term nominal yields are determined by the inflation target and the natural rate, r*. r* is defined as real interest rate that equates savings and investment after economic shocks have worked their way through the system, so actual output equals potential output and inflation equals its target rate (see, inter alia, Holston et al (2017)).

In recent years, persistently low levels of interest rates have sparked a debate about their drivers. Some economists argue that the transition to the long-run, when r* is the main determinant of short-term nominal rates, is taking longer than normal in the aftermath of the GFC (eg Lo and Rogoff (2015); Ravn and Sterk (2016); Borio et al (2017)). In this perspective, parts of the global economy have yet to recover, although eventually they will, so interest rates will return to more historically typical levels. Proponents of this hypothesis believe that low rates are transient.

Others contend that interest rates are low because r* has fallen on the back of structural changes that alter the balance between savings and investment. These changes include a slower pace of technological innovation and economic growth (eg Gordon (2016)); adverse demographic trends (eg Carvalho et al (2016)); rising wealth and income inequality (eg Summers (2014)); reduced capital intensity of production; falling (relative) prices for investment goods; rising savings rates in emerging economies and a global scarcity of safe assets (eg Bernanke (2005)). Supporters of this position view the fall in rates as persistent.

The determinants of term premiums and long-term nominal rates

Long-term nominal interest rates are the sum of short-term nominal rates over the maturity- period of the long-term bond and a term premium, that is, the compensation required by investors to bear interest rate risk.

Term premiums may be compressed in a low interest rate environment. One theory links premium compression to investors' preferences. If investors care about yield levels – rather than expected returns, for example because they have to satisfy return guarantees – a fall in short-term nominal rates leads them to rebalance their asset holdings toward longer-term bonds so as to prevent their overall yield from declining too much. As a result of this buying pressure the price of long-term bonds increases, lowering long-term yields and the term premium (Hanson and Stein (2015)). Similarly, if investors are concerned about a widening negative duration gap in a low interest rates environment (eg ICPFs), they will attempt to rebalance by shifting to long-term bonds so as to increase asset duration (Domanski et al (2015)).

Other theories contend that the quantity of interest rate risk falls following a decrease in interest rates, thereby lowering the compensation required to bear it, at least temporarily. In the US, for instance, a fall in interest rates may lower interest rate risk by increasing expected mortgage refinancing, which reduces the duration of MBSs (Malkhozov et al (2016)). More generally, some attribute the decline in term premiums to a switch by investors from concerns about excessive inflation to concerns about bouts of deflation.

A.I.2 Scenario specification

The parameters for the WG's three scenarios were informed by the quantitative assessments planned by the work streams studying banks, insurance companies and pension funds. These parameters are the scenarios' jurisdictional coverage, variable coverage, time-horizon, and frequency.

Jurisdictional coverage

The scenarios are specified for all CGFS jurisdictions – with the exception of Luxembourg and Singapore – as well as for three additional EMEs – Hungary, Poland, and Turkey. The rationale for excluding Luxembourg and Singapore is that financial firms in these two countries are global institutions. As a result, they face financial conditions that are more likely driven by global rather than local factors. Hungary, Poland and Turkey were included so the WG could consider a wider range of issues affecting EMEs as a result of the low interest rate environment than would have been permitted had the analysis been restricted to EMEs that are part of the CGFS (China, India, Brazil and Mexico).

Variable coverage

Each scenario comprises paths for the yield curve (three-month and 10-year yields), GDP growth and consumer price inflation. The WG included variables other than interest rates because economic fundamentals driving interest-rate developments also have a significant impact on the profitability and behaviour of financial firms (eg economic activity).

Horizon and frequency

The scenarios cover a 10-year horizon – that is, 2017 to 2027 – which is substantially longer than typically used in the stress tests used to inform banks' capital plans. There were several reasons for doing so. First, the WG agreed that a L4L scenario likely imposes slow-mounting stresses on financial institutions, so it would take longer than the typically assumed two to three years for them to materialise. Second, the types of

behavioural adjustments that financial firms might undertake in response to a low interest rate environment (eg changes in business models) would also likely play out over a longer horizon than applicable to capital plans, which can be adjusted more quickly. Third, the report focuses on both banks *and* insurance companies and pension funds, whose business models involve long horizon. Finally, other studies of policy issues relating to low-for-long interest rates also work with 10-year horizons.

The scenarios are specified at annual frequency. This is because, for many of the jurisdictions included in the study, financial institutions' balance sheet data are only available at annual frequency.

A.I.3 The baseline scenario

The International Monetary Fund's (IMF) October 2017 World Economic Outlook (WEO) projections are used as the basis for the baseline scenario. This scenario is intended to capture mainstream modal expectations of the outlook for the global economy, so using a single reputable source as the starting point for the scenario ensures that the paths of the variables reflect an internally consistent projection. The IMF WEO projections are also routinely used as the baseline in stress tests conducted by the IMF for its Financial Stability Assessment Program (FSAP) reviews of countries' financial systems, so the purpose for which they are being used by the WG matches with one of the purposes for which they have been generated and used by the IMF. A further appeal of using IMF WEO projections is the breadth of its coverage. For example, projections for three-month and 10-year sovereign yield are generated by the IMF for all countries, whereas Consensus Forecasts (one alternative baseline-scenario source that the WG considered) provides few short-rate projections and has incomplete coverage for long-rate projections. Additionally, the WEO contains projections for variables like output gaps, potential output growth and labour-force growth, which were helpful in calibrating the other two scenarios (see below).[53]

Because the IMF WEO projections only extend out five years – currently, to the end of 2022 – whereas the WG scenarios extend out to 2027, it was necessary to extend the WEO projections to 2027.

The general approach in constructing the extended portions of the baseline scenario was to pin down the value of the short *real* rate and inflation at the terminal date (2027). The economy is assumed to have reached a steady state with output at potential by that point, so the real three-month rate is equal to the natural rate, r*.[54] Central banks are assumed to have achieved their target inflation by this time, and thus the 2027 nominal three-month rate is equal to the sum of the natural rate and the inflation target.[55] The 10-year yield is then determined as the sum of the nominal

[53] Many of these ``additional'' variables are part of the IMF WEO internal database, and were generously shared on a restricted basis with the WG. WEO interest rate projections could not be shared for some countries (China, India, and Mexico).

[54] The natural (or Wicksellian) rate of interest r* is defined as the real rate of interest that would prevail in an economy where actual output equals potential output. In generating scenarios, the WG used the definition of the natural rate of interest that underpins the empirical measure used by Holston et al (2017).

[55] Not all countries in the sample have a point target for inflation. Accordingly, for those who use an interval target, the midpoint has been used. For those that have a "less than or equal to" type target, the upper bound on inflation has been used.

three-month rate plus a country-specific term spread, which in 2027 is set to be equal to the average term spread between 1999 and 2016.[56]

Between 2022 and 2027 the components of the yield curve (ie the short rate, the term spread and the long rate) are assumed to converge linearly from their last value in the WEO projection (in 2022) to their terminal value (see Graph 1, top panels, red line).

Similarly, the WEO projections for inflation and real GDP were extended beyond 2022 by closing, over the 2023 to 2027 period, any divergence between actual and target inflation and any divergence between actual and potential output that may still be present by 2022 (the end of the WEO's projection period). The gap between actual and target inflation was closed by adjusting the path of actual inflation so it would converge linearly to its terminal value. In closing any divergence between actual and potential GDP (both levels and growth rates) in 2022 the paths of actual GDP were adjusted (again, to obtain linear convergence), while the paths of potential GDP were not changed from those implied by the growth rates of potential GDP implied for 2022 by the WEO.

The natural rate

The value of r* plays a key role in determining the short real rate. For countries where the WEO projects the short real rate to have plateaued by 2022, r* is assumed to be equal to the 2022 WEO short real rate thereafter. This is because a flat short-term rate is interpreted as suggesting that the economy has converged to a steady state with inflation at target and real GDP at potential. This method was applied to the United States, Canada and most of the EMEs.

For the other AEs, where the WEO short rate path generally has not levelled out by 2022, the natural rate had to be estimated. r* is estimated as a function of the growth rate of potential GDP; consistent with economic theory, countries with higher potential growth are estimated to have higher values of r*. The growth rate of potential GDP is drawn from the IMF WEO projection for 2022, and is expected to stay at that rate thereafter. Specifically, r* is computed using the relation $r_t^* = q + mg_t^n$, where g_t^n denotes the growth rate of potential GDP.[57] The slope coefficient (m) is assumed to be 1/3, and the constant (q) is calibrated to a value of 0.1 that matches the values of r_t^* and g_t^n for both the US and Canada.[58]

[56] With this approach the spread between any euro area country 10-year yield and the German bund 10-year yield converges over the 2023 to 2027 period to the 1999 to 2016 average spread. Since this 1999 to 2016 average euro-area country to German bund spread might be a reasonable proxy for sovereign risk, the chosen approach for setting 10-year AE yields also means that any sovereign risk that should be reflected in 10-year euro area country yields is captured.

[57] This linear relation can be interpreted as an intertemporal optimality condition for households, pinning down the growth rate of consumption (hence, output) as a function of the real interest rate. The slope coefficient (m) varies inversely with the responsiveness of consumption growth to real interest rates (in technical terms it corresponds to the inverse of the elasticity of intertemporal substitution). The constant (q) varies inversely with the discount rate, which captures households' preference for consumption today versus consumption tomorrow. In practice, the cross-country empirical relationship between real GDP growth and real short-term interest rates is quite fragile, and the choice of coefficients was motivated in large part to yield plausible results.

[58] The assumed slope coefficient (m) falls within the range of estimates that can be obtained from cross country regressions between multi-year GDP growth rates and (estimated) real interest rates,

Graphs A.I.6.1 to A.I.6.22 report the paths of three-month sovereign yields, 10-year sovereign yields, GDP growth and inflation for the baseline scenario.

A.I.4 The low-for-long scenario

Relative to baseline, the low-for-long scenario (L4L, for short) projects a lower path for interest rates, GDP growth and inflation for the entire 2017—27 period, broadly consistent with secular stagnation.

In L4L, the path of r* is lower than in baseline, reflecting declines in potential GDP growth, population aging, increased headwinds to investment, higher savings preferences and other such factors usually associated with the secular stagnation hypothesis.[59]

Both the natural rate and the nominal short rate start off at the same level as in baseline in 2017, but stand 100 and 150 basis points lower than baseline by 2027, reflecting a 50 basis points undershooting of the inflation target at the terminal date. The divergence between the natural rate in the baseline and L4L opens gradually over the period, in part, to ensure that the path of the short nominal rate does not decline from its current level in economies that currently have very accommodative monetary policy (see Graph 1, top left-hand panel, blue line). The deviations from baseline of the nominal three-month yield is equal to the combined deviation of the natural rate and inflation throughout the projection horizon, so the difference between the real three-month yield and the r* (monetary stimulus) is the same as in the baseline scenario.

The 10-year yield is set so that the term spread converges linearly to a terminal value which is *half* the average slope between 1999 and 2016 (see Graph 1, top right-hand panel, gap between red and blue line). This is motivated by the possibility that low interest rate environments decrease term premiums, as discussed in A.1.

While potential growth is lower than in baseline, the path of the output gap is unchanged. This reflects the fact that monetary stimulus is constant across the two scenarios. The path of inflation is lower than in baseline, reflecting undershooting (see Graph 1, bottom panels).

Graphs A.I.6.1 to A.I.6.22 report the paths of three-month sovereign yields, 10-year sovereign yields, GDP growth and inflation for the L4L scenario.

A.I.5 The snapback scenario

The snapback scenario follows the L4L scenario until 2022 but then features a breakout of inflation that leads to a rapid increase in three-month nominal sovereign

although such estimates are not robust (as documented by Hamilton et al (2016)). For the two countries whose values for the natural rate and the growth rate of potential output were used to calculate the constant (q), Canada and the US, the WEO projects approximately equal values for the natural rate and the growth rate of potential output, at $r^* = .70$ and $g^n = 1.8$.

[59] GDP growth in the low-for-long scenario is assumed to fall by ½ percentage point in each economy. Given the 1.5 percentage point fall in r* in the L4L scenario relative to baseline, this represents a smaller decline in GDP growth than implied by the formula for computing r* described above for the baseline scenario. This is because the decline in r* in L4L is motivated not only by lower potential growth, but by other factors that affect r*, such as the demographic changes and reduced spending propensities noted in the text.

yields in 2023 and 2024 of the scenario and a steepening the yield curve, also in these years. The mechanism generating the increase in inflation is actual GDP exceeding potential GDP by a sizable magnitude, a nonlinear Phillips curve, and a reduced anchoring of inflation expectations.

In this scenario potential GDP growth is about ½ a percentage point slower than in the L4L scenario – due to a mix of slower productivity growth and slower labour force growth – but actual GDP growth is until 2022 the same as in the L4L scenario. This divergence in actual and potential GDP growth pushes the level of GDP materially above potential, although until 2022, this positive output gap leads to no discernible change in the inflation rate (relative to the L4L scenario) because the amount that actual GDP is above potential GDP still leaves the economy on a very flat portion of the scenario's assumed Phillips curve. In addition, inflation expectations are assumed to remain anchored. By 2023, however, actual GDP exceeds potential GDP by an amount that begins to generate higher inflation, reflecting the assumed nonlinearity in the Phillips curve. In addition, inflation expectations are assumed to become unanchored and start to rise, resulting in additional upward pressure in inflation. In total the result is a 100 basis points higher and a 200 basis points higher inflation rate in 2023 and 2024, respectively (relative to the L4L scenario), which is assumed to yield a rapid monetary policy response that pushes up short rates by 300 basis points (relative to the L4L scenario), where this increase is spread over 2023 and 2024. Short-term interest rates stay at this higher level for the next couple of years, as policymakers seek to reverse the rise in inflation. This tighter stance of monetary policy slows real GDP growth by about ¾ percentage points in 2024 and 1½ percentage points in 2025 and 2026, implying a mild recession in 2026. Inflation remains at its higher level until the last two years of the scenario, when GDP falls sufficiently below potential to put appreciable downward pressure on inflation.

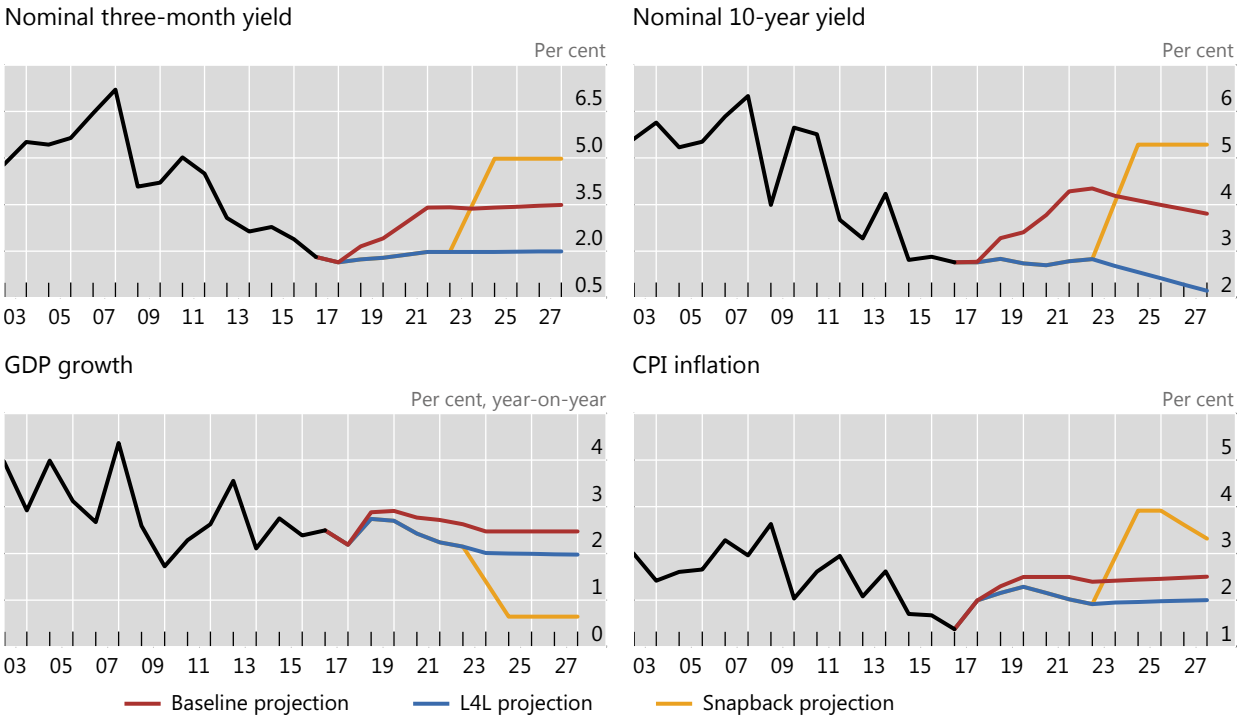
The paths of 10-year sovereign yields for each jurisdiction are then set by specifying that the implied spread between 10-year and three-month sovereign yields converges to their average level over the 1999 to 2016 period (as in the baseline scenario). This specification is consistent with the discussion in Section A.1 that suggests that a higher interest rates and higher inflation rates are associated with higher term premiums.

Graphs A.I.6.1 to A.I.6.22 report the paths of three-month sovereign yields, 10-year sovereign yields, GDP growth and inflation for the baseline scenario for the snapback scenario.

A.I.6 Scenarios by country

Interest rate scenarios: Australia

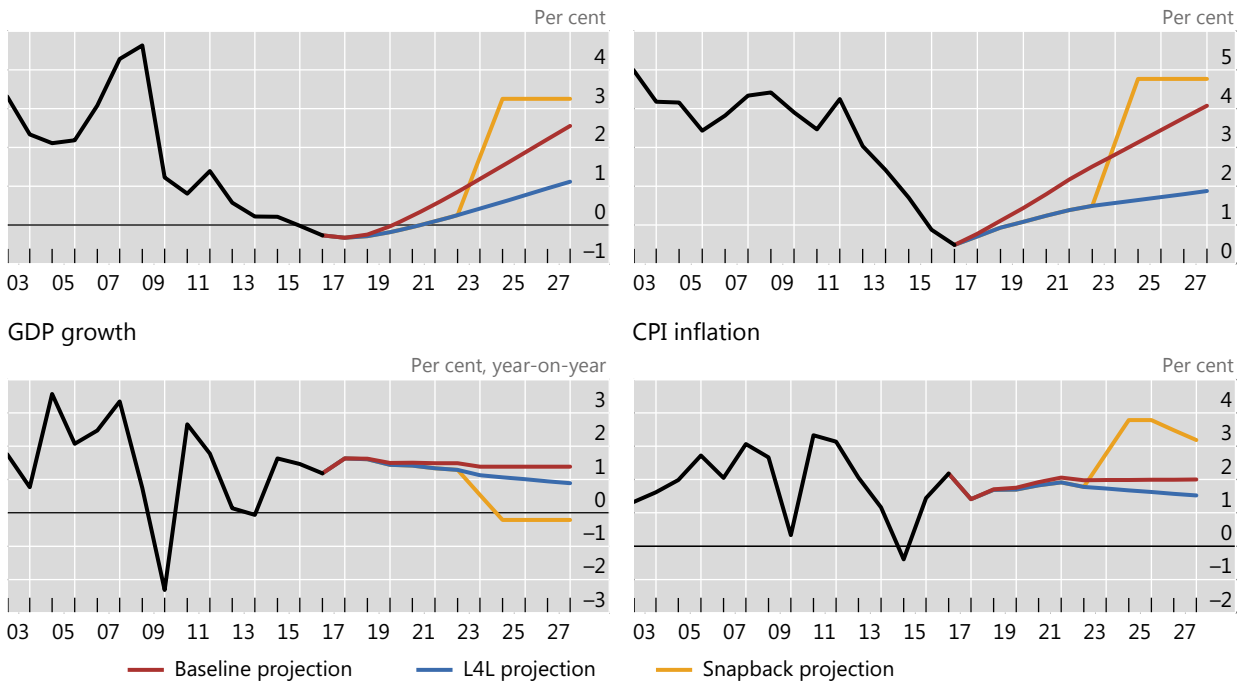
Graph A.I.6.1



Sources: IMF, *World Economic Outlook October 2017*; WG, scenarios workstream.

Interest rate scenarios: Belgium

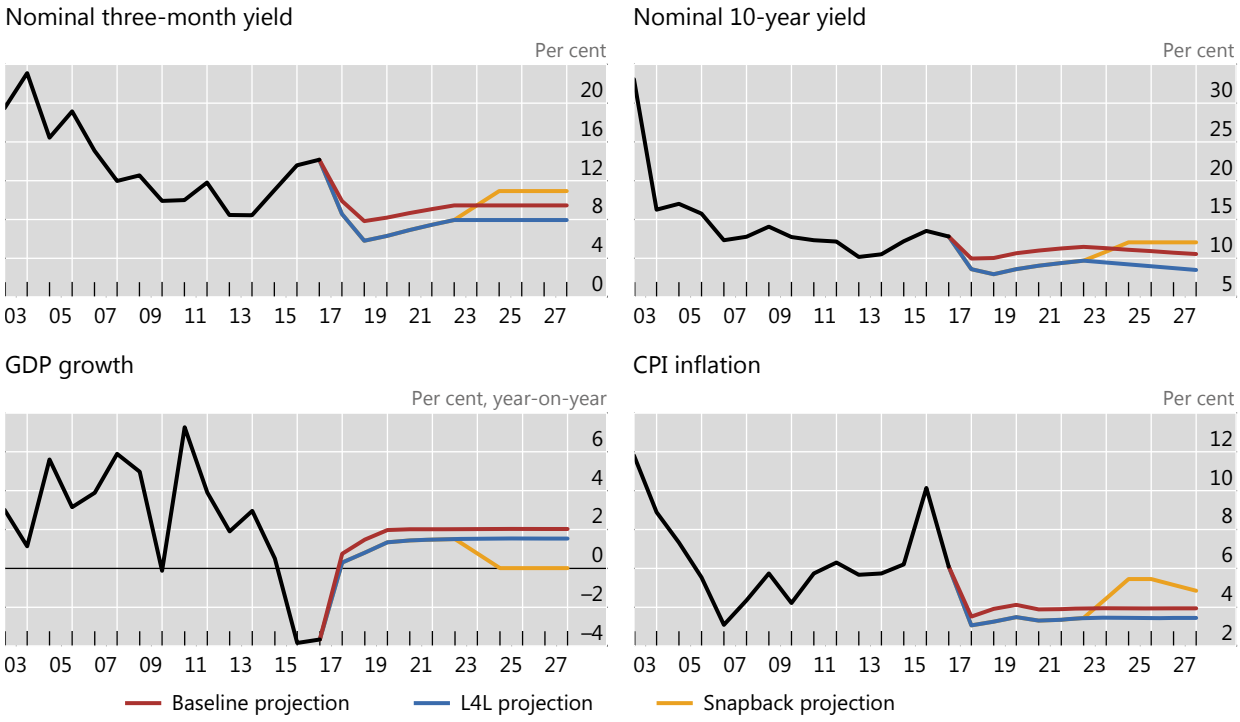
Graph A.I.6.2



Sources: IMF, *World Economic Outlook October 2017*; WG, scenarios workstream.

Interest rate scenarios: Brazil

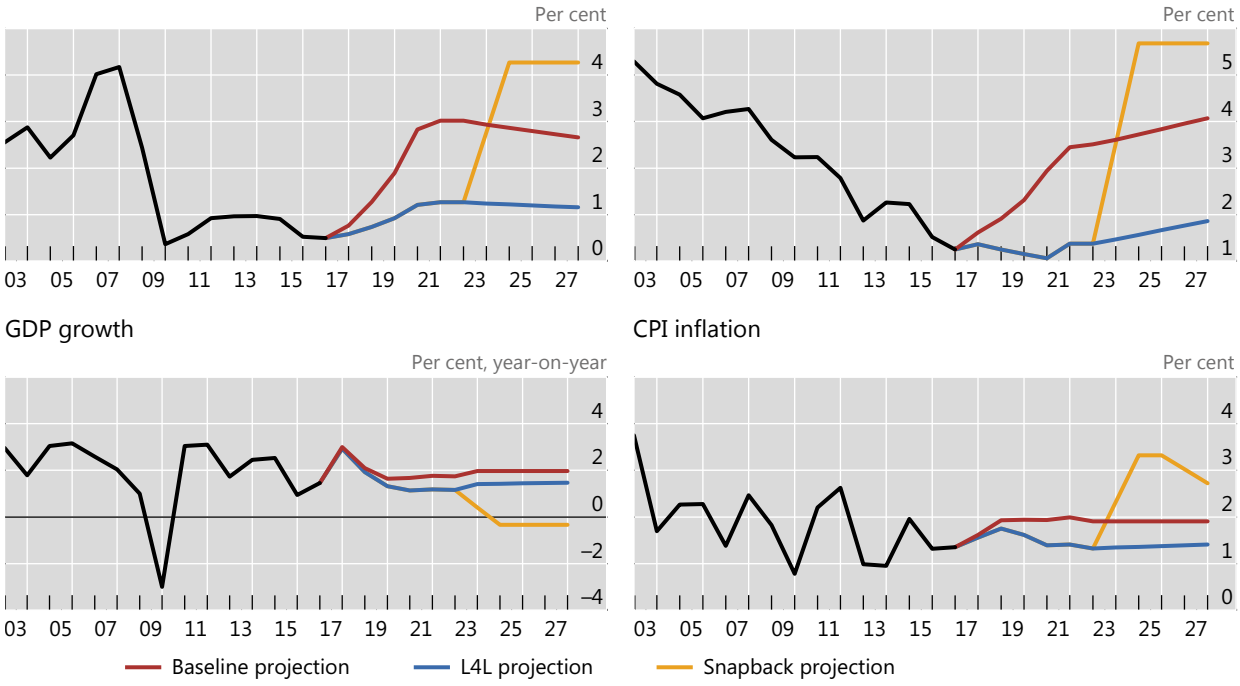
Graph A.I.6.3



Sources: IMF, *World Economic Outlook October 2017*; WG, scenarios workstream.

Interest rate scenarios: Canada

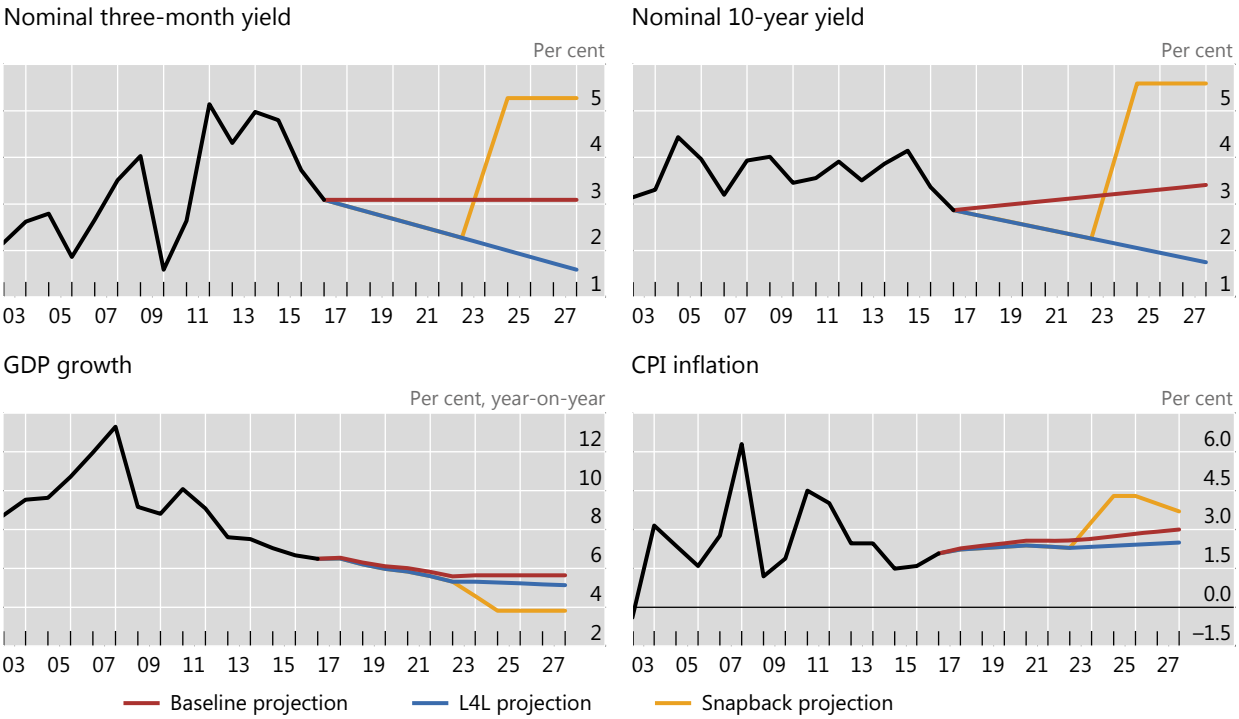
Graph A.I.6.4



Sources: IMF, *World Economic Outlook October 2017*; WG, scenarios workstream.

Interest rate scenarios: China

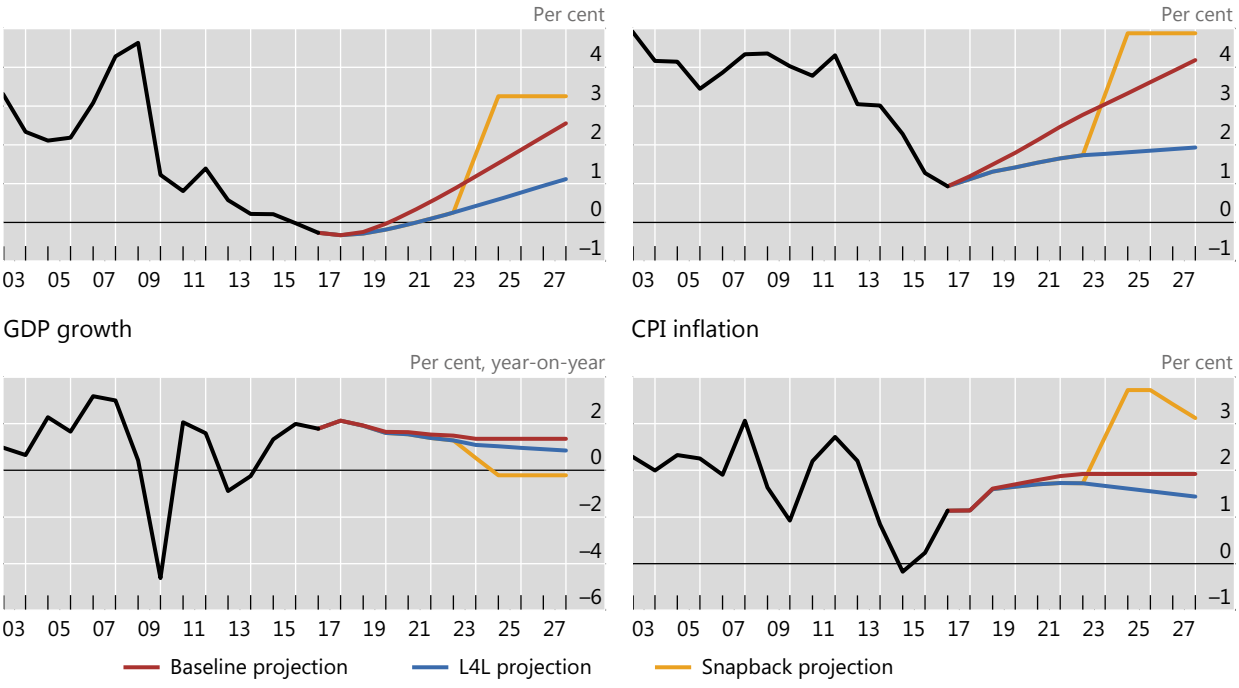
Graph A.I.6.5



Sources: IMF, *World Economic Outlook October 2017*; WG, scenarios workstream.

Interest rate scenarios: Euro area

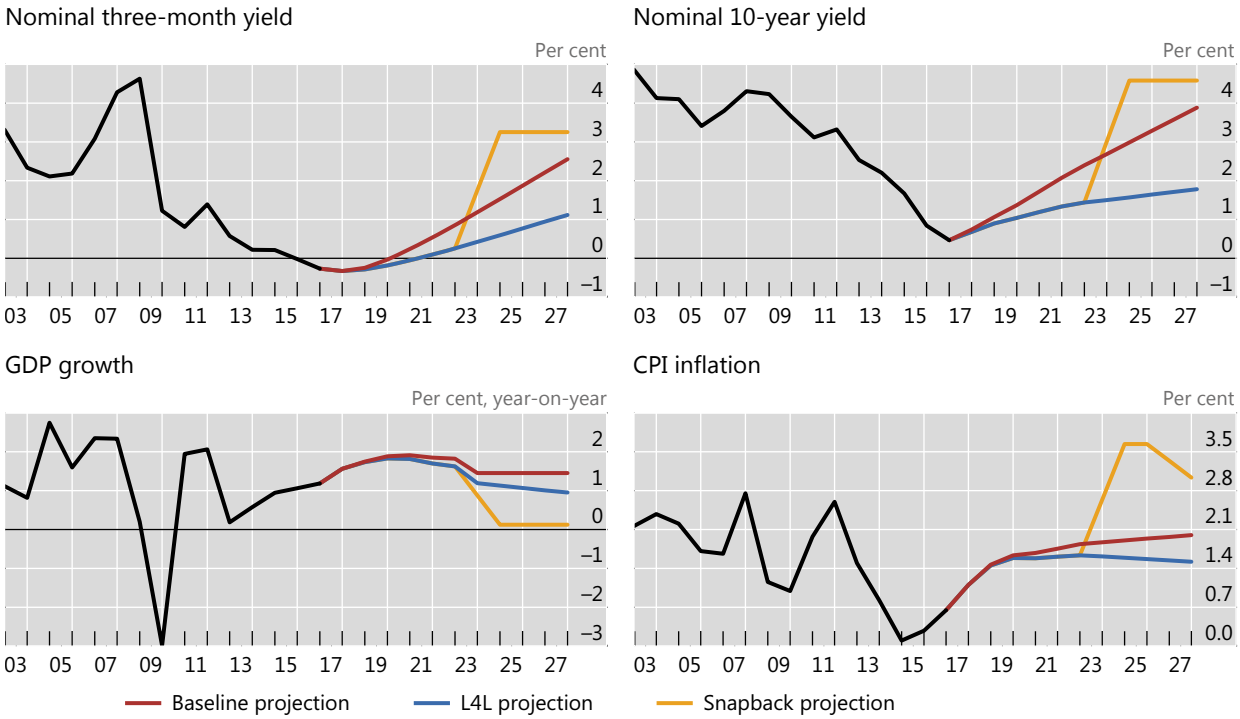
Graph A.I.6.6



Sources: IMF, *World Economic Outlook October 2017*; WG, scenarios workstream.

Interest rate scenarios: France

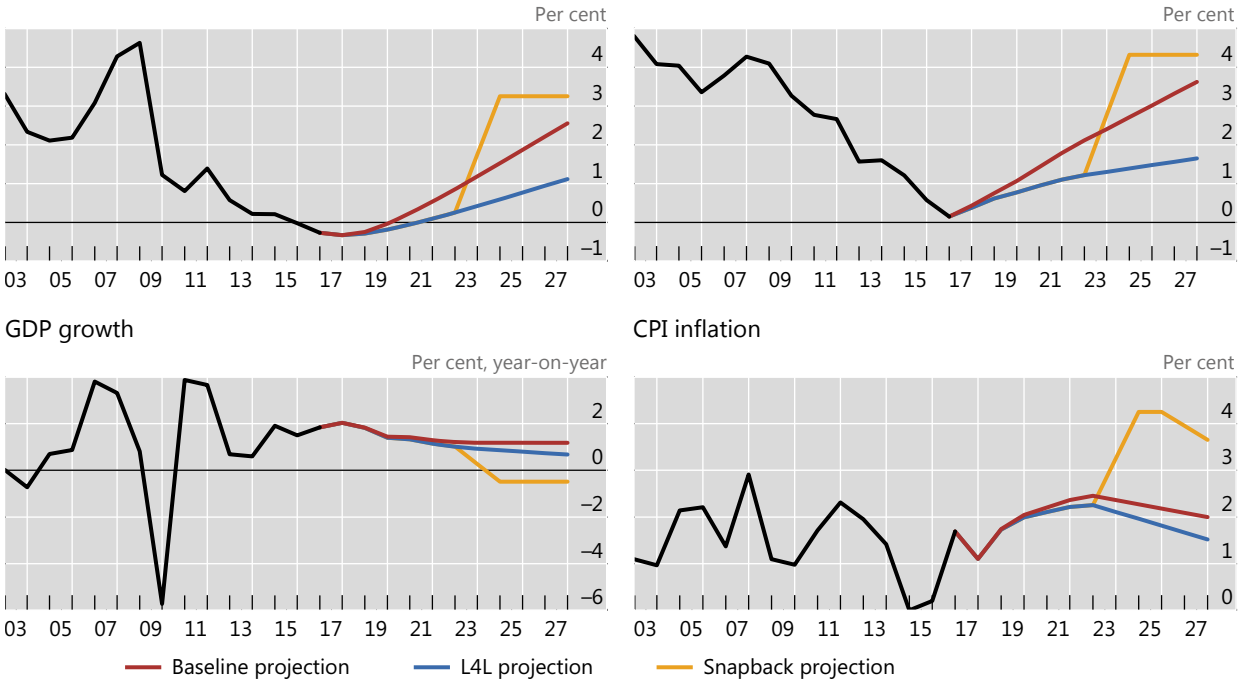
Graph A.I.6.7



Sources: IMF, *World Economic Outlook October 2017*; WG, scenarios workstream.

Interest rate scenarios: Germany

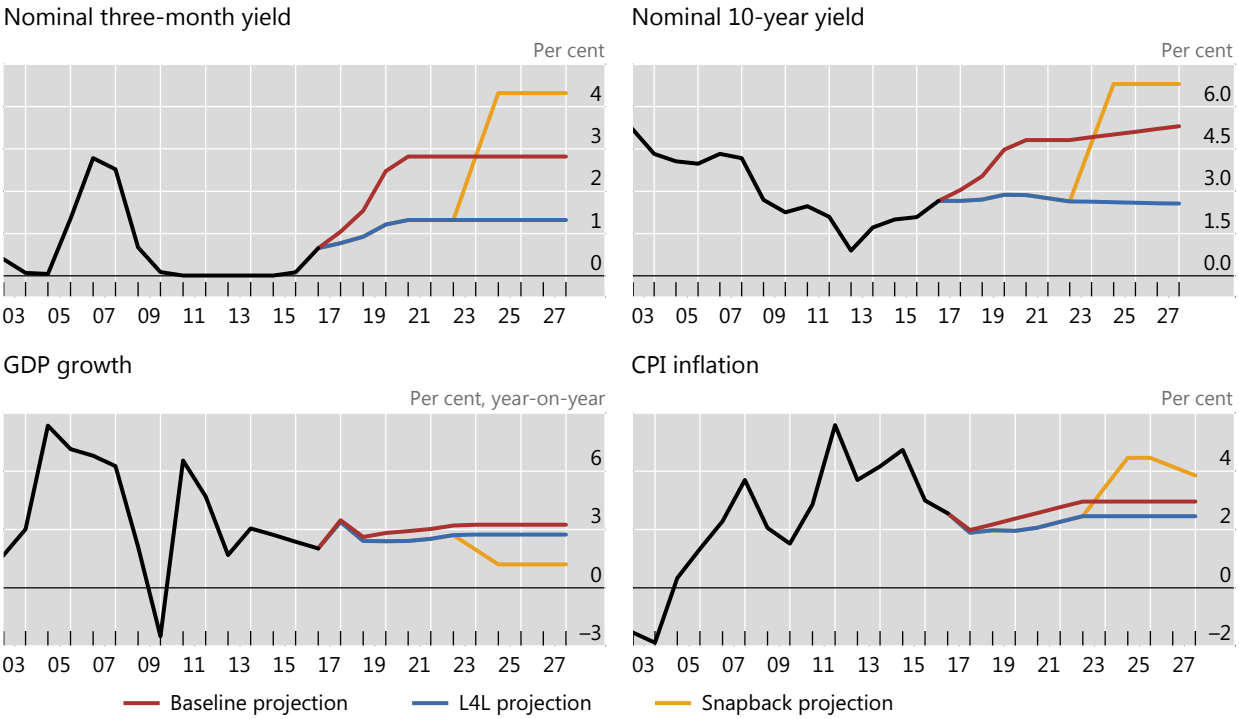
Graph A.I.6.8



Sources: IMF, *World Economic Outlook October 2017*; WG, scenarios workstream.

Interest rate scenarios: Hong Kong SAR

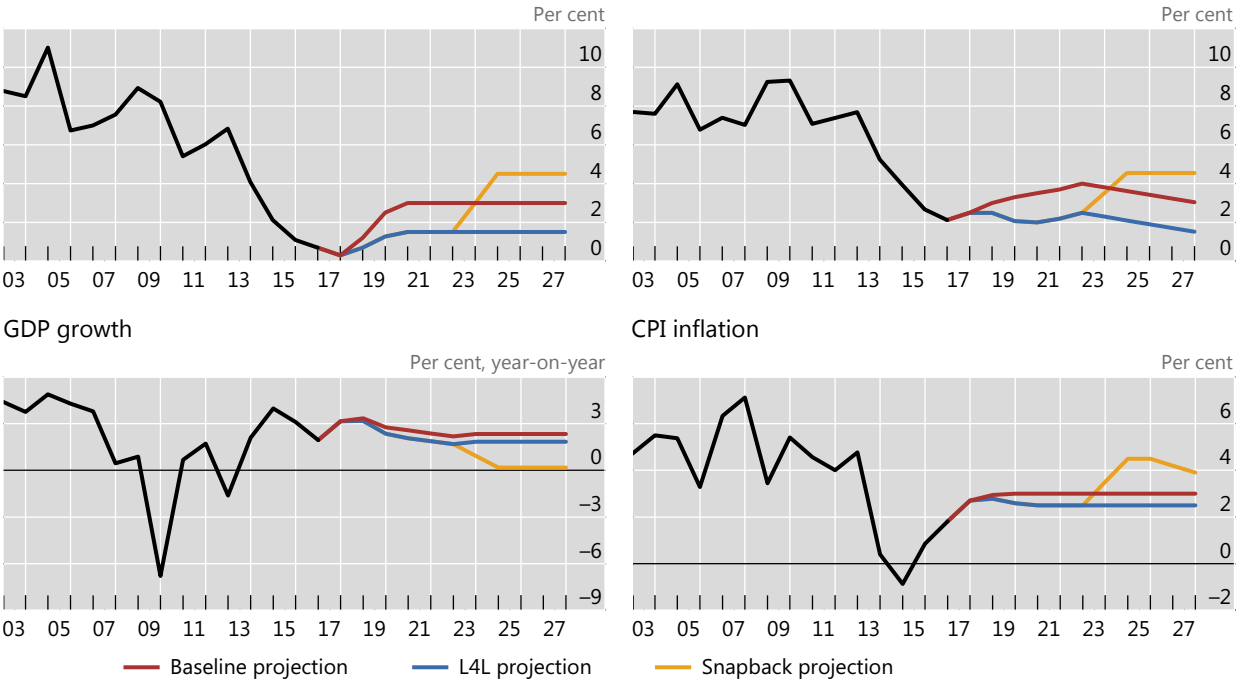
Graph A.I.6.9



Sources: IMF, *World Economic Outlook October 2017*; WG, scenarios workstream.

Interest rate scenarios: Hungary

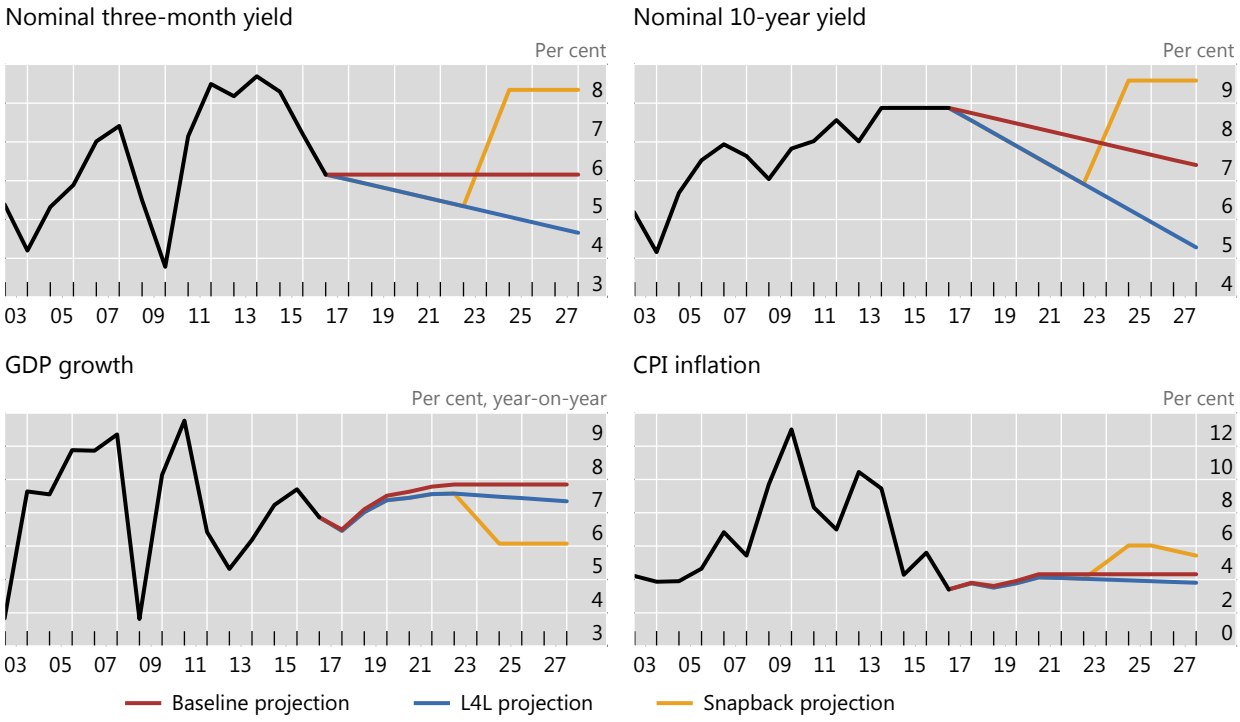
Graph A.I.6.10



Sources: IMF, *World Economic Outlook October 2017*; WG, scenarios workstream.

Interest rate scenarios: India

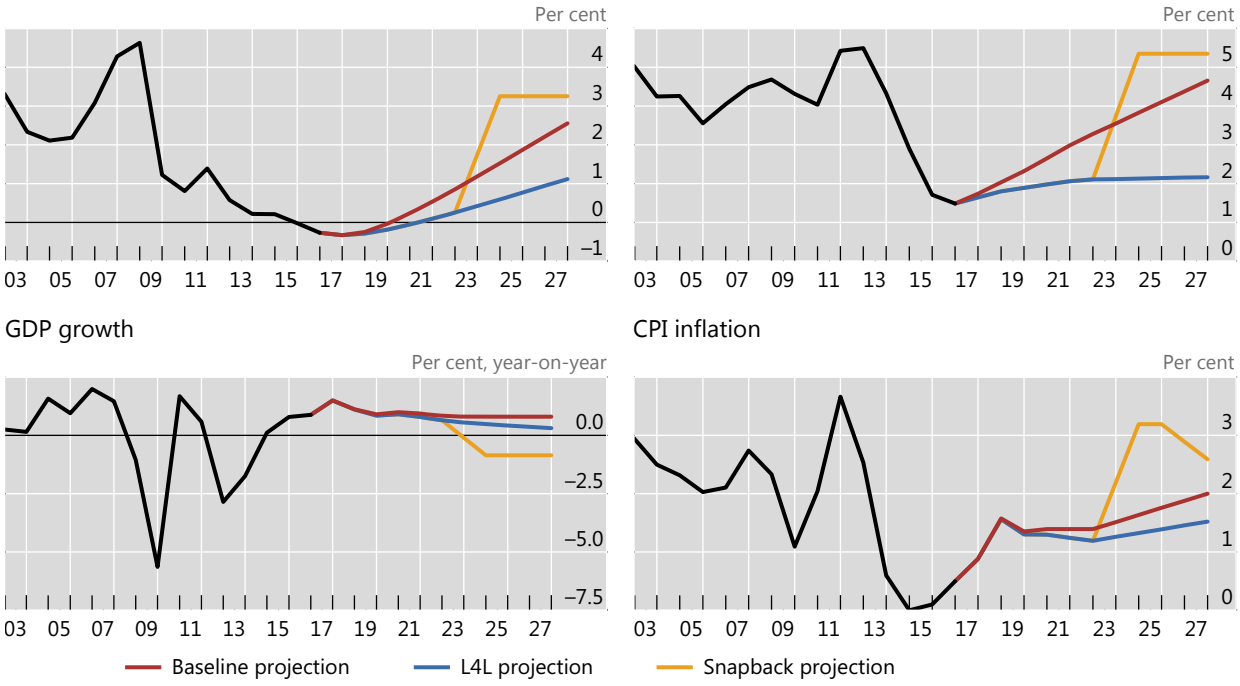
Graph A.I.6.11



Sources: IMF, *World Economic Outlook October 2017*; WG, scenarios workstream.

Interest rate scenarios: Italy

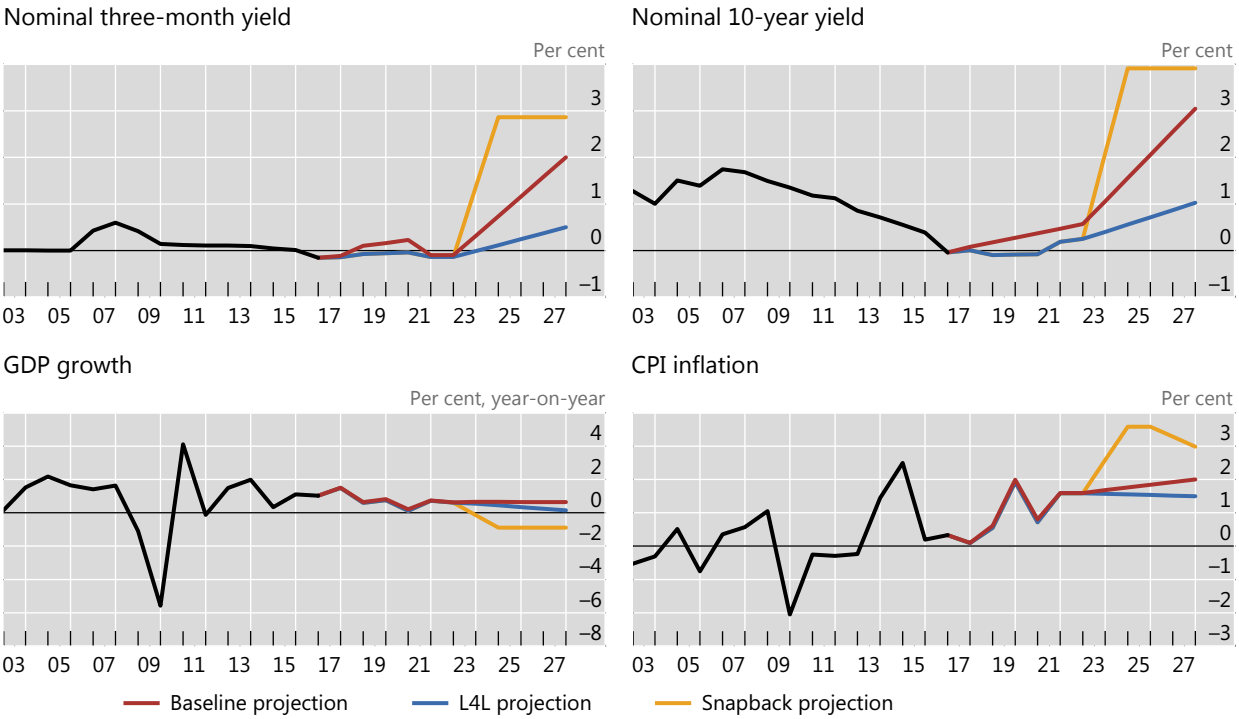
Graph A.I.6.12



Sources: IMF, *World Economic Outlook October 2017*; WG, scenarios workstream.

Interest rate scenarios: Japan

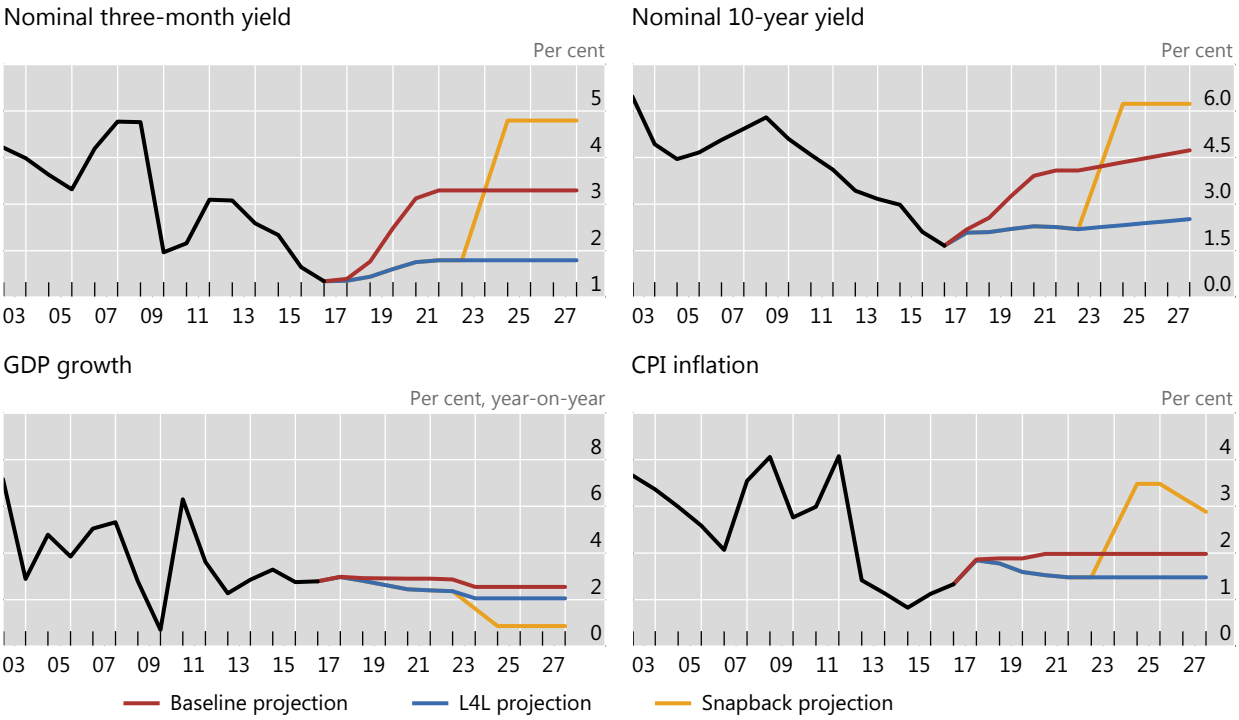
Graph A.I.6.13



Sources: IMF, *World Economic Outlook October 2017*; WG, scenarios workstream.

Interest rate scenarios: Korea

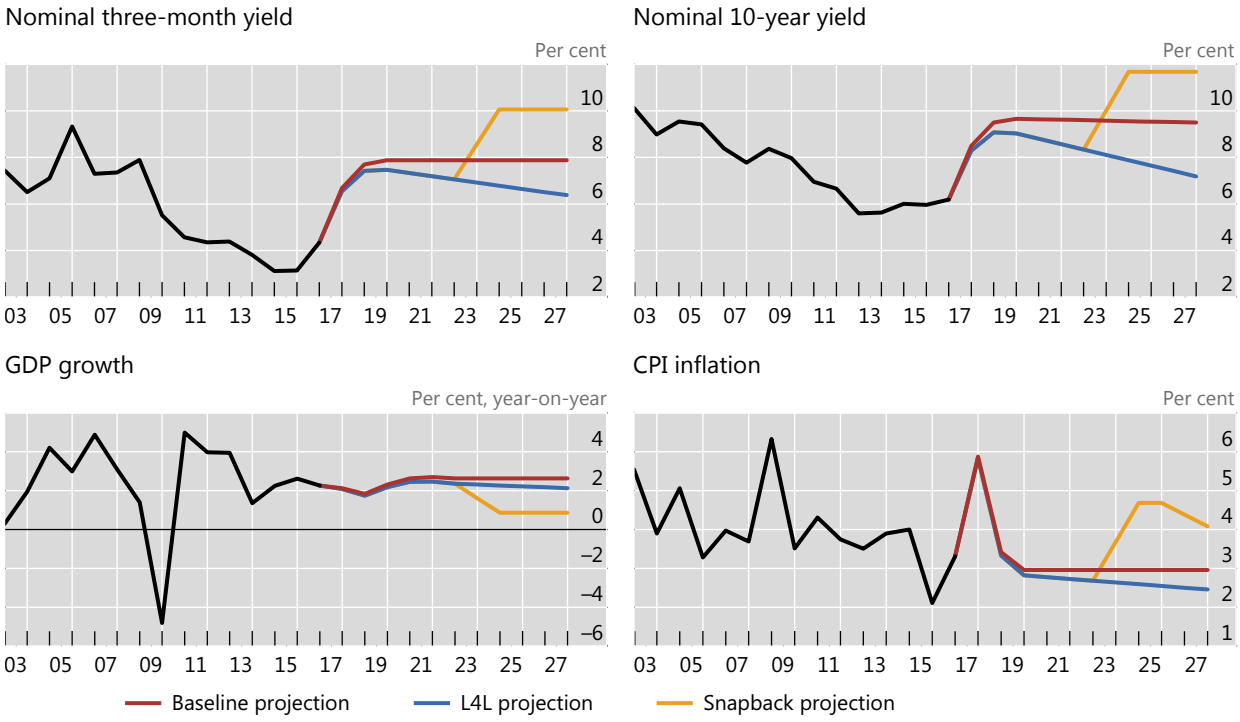
Graph A.I.6.14



Sources: IMF, *World Economic Outlook October 2017*; WG, scenarios workstream.

Interest rate scenarios: Mexico

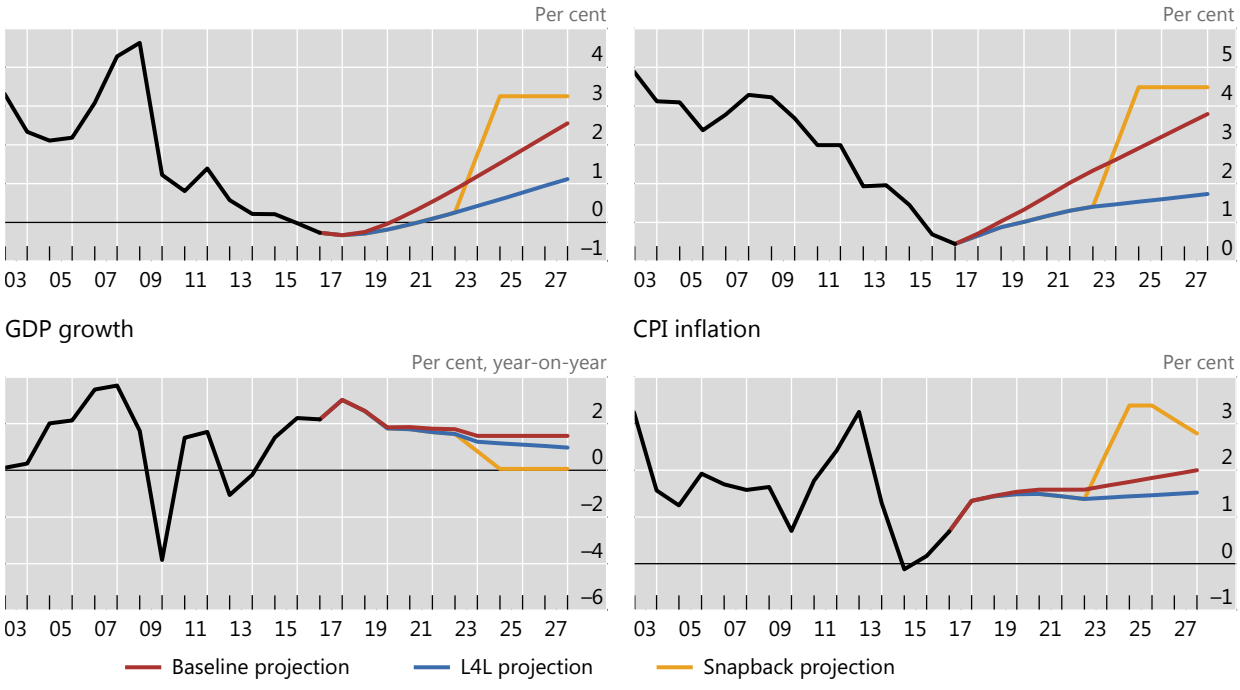
Graph A.I.6.15



Sources: IMF, *World Economic Outlook October 2017*; WG, scenarios workstream.

Interest rate scenarios: Netherlands

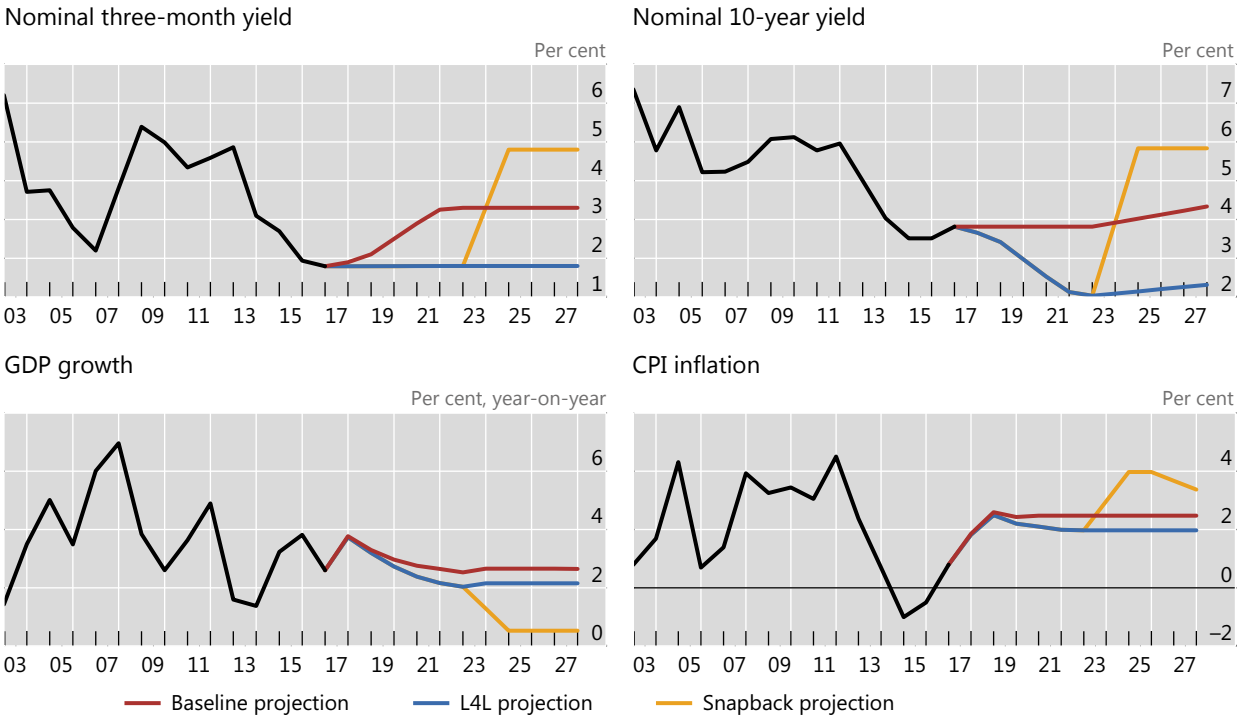
Graph A.I.6.16



Sources: IMF, *World Economic Outlook October 2017*; WG, scenarios workstream.

Interest rate scenarios: Poland

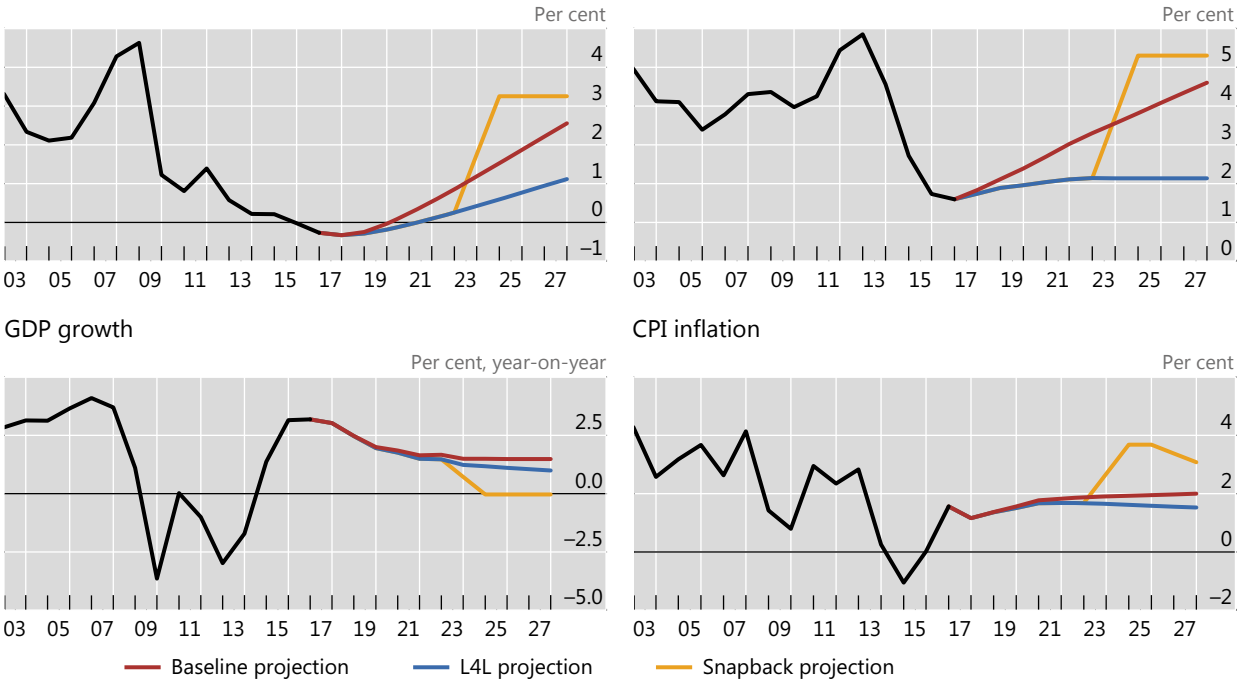
Graph A.I.6.17



Sources: IMF, *World Economic Outlook October 2017*; WG, scenarios workstream.

Interest rate scenarios: Spain

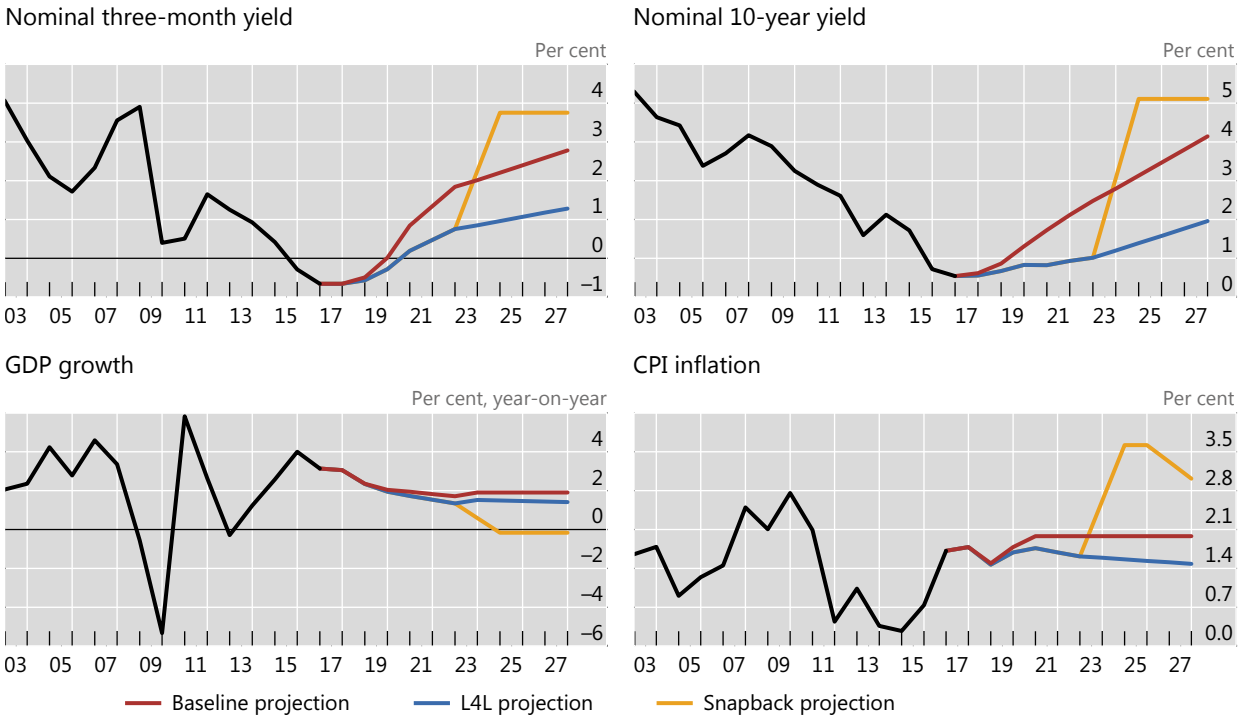
Graph A.I.6.18



Sources: IMF, *World Economic Outlook October 2017*; WG, scenarios workstream.

Interest rate scenarios: Sweden

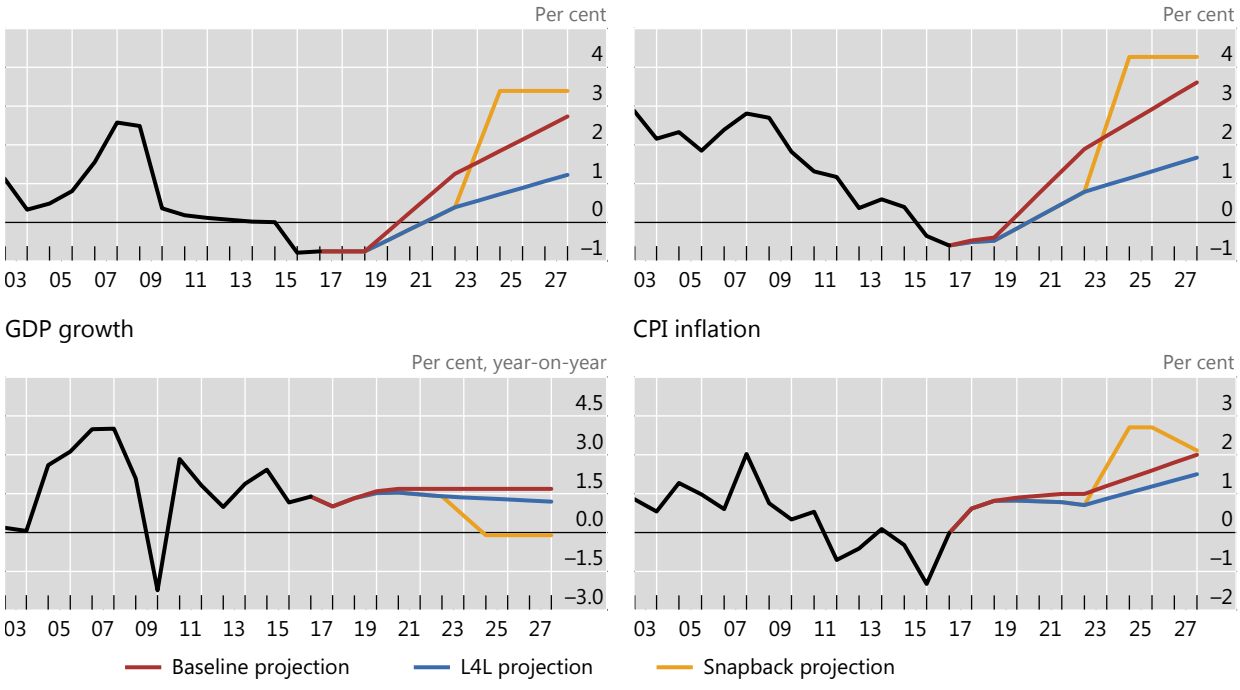
Graph A.I.6.19



Sources: IMF, *World Economic Outlook October 2017*; WG, scenarios workstream.

Interest rate scenarios: Switzerland

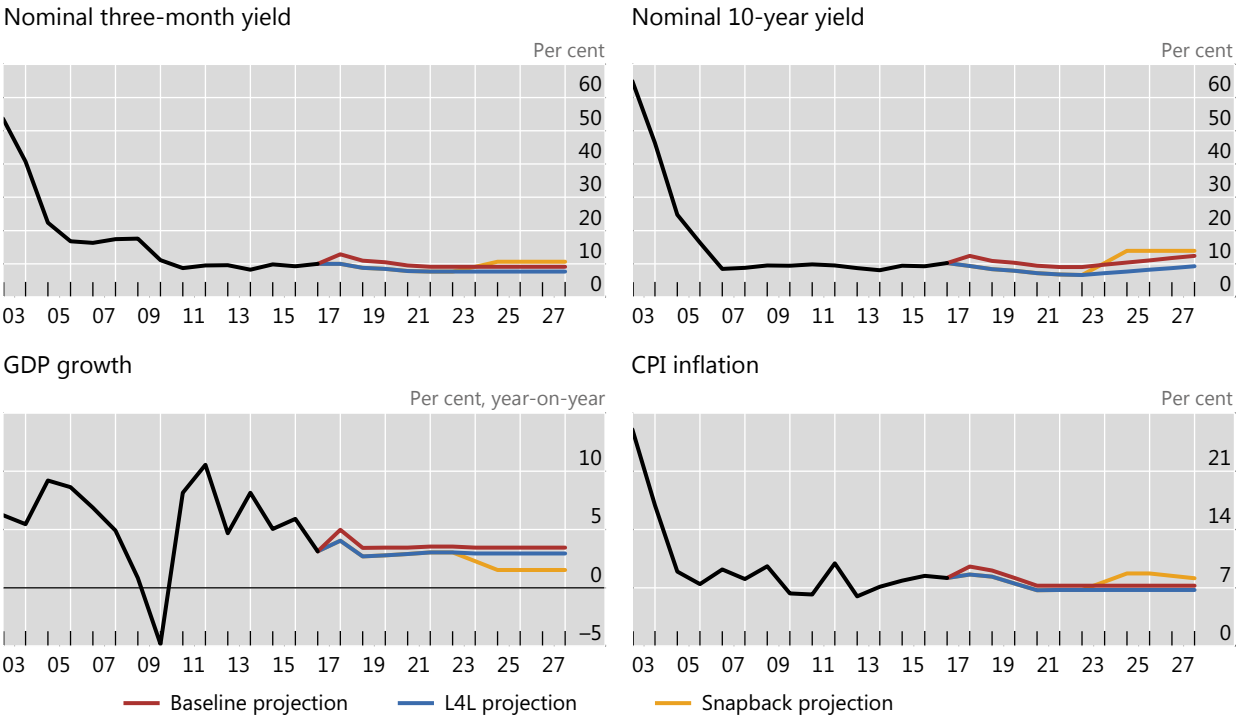
Graph A.I.6.20



Sources: IMF, *World Economic Outlook October 2017*; WG, scenarios workstream.

Interest rate scenarios: Turkey

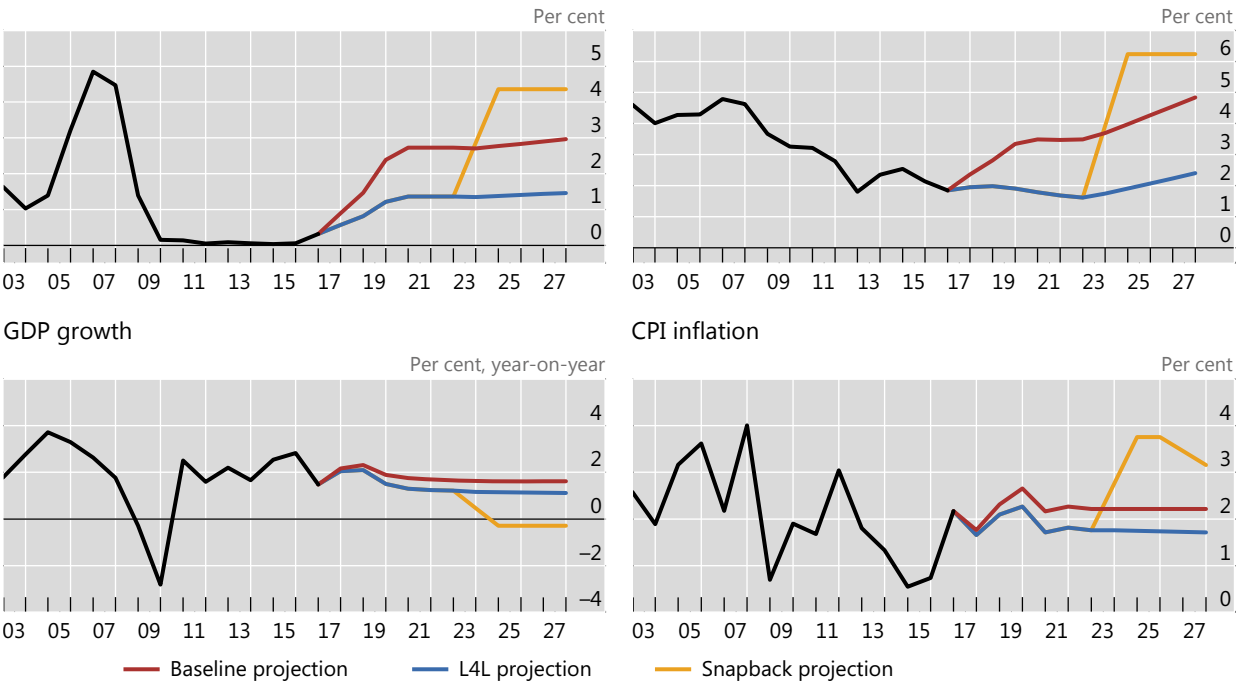
Graph A.I.6.21



Sources: IMF, *World Economic Outlook October 2017*; WG, scenarios workstream.

Interest rate scenarios: United States

Graph A.I.6.22



Sources: IMF, *World Economic Outlook October 2017*; WG, scenarios workstream.

Annex II: Methodology for the analysis of country-level bank data

To assess the impact of interest rates on net interest margins and return-on-assets, a dynamic modelling approach is employed to account for the potential time persistence of profitability and its components. The baseline specification is estimated in levels and includes one lag of our dependent variable (Y_{it}; ie the relevant income component as a ratio of total assets), the short term rate, the slope of the yield curve (measured as the difference between the 10-year government bonds and the short term rate) and several control variables.

$$Y_{jt} = \gamma_{jt} + \delta Y_{jt-1} + \alpha_1 r_{j,t} + \beta_1 \theta_{j,t} + \beta_3 CRISIS + \Psi' X_{jt} + \zeta_j + \varepsilon_{j,t}$$

- Dependent variables: Y_{it} = Income Component (NIM, RoA)
- Macro control variables: X_{jt} = (Real annual GDP growth rate, inflation)
- Banking system controls: γ_{jt} = (Loans to total assets, deposits to total liabilities, equity to total liabilities)
- Country fixed effects: ζ_j
- Banking crisis Dummy: $CRISIS$ (equal 1 in Year 2007 and 2008)

The models are estimated using panel techniques. As robustness, the baseline specifications are also estimated using Generalised Method of Moments (S-GMM) panel approach and the Least Square Dummy Variable approach (Bruno 2005). These additional estimations corroborate the original results.

The data cover an unbalanced panel of 19 countries between 2000 and 2016 (Table AII.1).[60] The measures of bank profitability are from the CGFS WG database and proxies for banking market structures - such as concentration in the domestic financial sectors - are drawn from the World Bank GFDD. The summary statistics of the variables are presented in Table AII.2.

Finally Table AII.3 presents the detailed results from the country-level model already discussed in section 2.2.

[60] For more on the Global Financial Development Database, see Cihak et al (2012).

Table A.II.1 Country coverage

Country	CGFS Country and Time Coverage	Number of observations in baseline model	Number of years with low =1
Australia	2000-2016	16	0
Belgium	2000-2016	16	7
Brazil	2000-2016	16	0
Canada	2000-2016	16	8
Switzerland	2000-2016	16	12
China	2001-2015	14	0
Germany	2000-2016	16	7
Spain	2000-2016	16	7
France	2000-2016	16	7
Hong Kong	2000-2016	16	12
India	2002-2016	14	0
Italy	2000-2016	16	7
Japan	2000-2016	16	17
Korea	2000-2016	16	0
Mexico	2000-2016	16	0
Netherlands	2000-2016	16	7
Sweden	2000-2016	16	6
United Kingdom	2005-2016	11	8
United States	2000-2016	16	9

Table A.II.2 Variable selection

Variable	Mean	St Deviation	Max	Min	Median
Net interest margin	2.25	1.67	8.86	0.56	1.66
RoA	0.68	0.58	2.67	–1.35	0.62
Short-term rate	3.03	3.55	23.08	–0.78	2.18
Slope of yield curve	1.35	1.47	13.61	–6.82	1.29
Inflation	2.38	2.15	13	–3.61	2.08
Real GDP growth	2.44	2.91	13.28	–5.72	2.17
Bank concentration	63.92	18.98	100	23.07	63.84
Deposit to total funding	61.52	20.26	98.89	7.25	64.17
Equity to total funding	7.94	4.61	24.54	0.58	6.98
Loan to total assets	57	13.29	82.06	27.79	58.92

Table A.II.3 Detailed results for NIM and RoA

	Dependent variables:					
Explanatory variables	NIM		NIM and banking system concentration	RoA: profit before taxes to total assets		RoA and banking system concentration
	(I)	(II)	(III)	(IV)	(V)	(VI)
Lagged dependent variable	**0.82*** **	**0.81*** **	**0.76*** **	**0.48*** **	**0.41*** **	**0.47*** **
Short term rate	**0.06***	**0.06***	**0.09*** **	0.02	0.01	**0.02** **
Short term rate *Concentration			**–0.07*** **			**–0.02**
Slope	**0.05*** **	**0.05*** **	**0.06*** **	0	0	**0**
Slope*Concentration			**–0.06*** **			**0.00**
Inflation	–0.01	–0.01	–0.01	0.00	0	–0.00
GDP growth	0.01	0.01	0.01	**0.05*** **	**0.05*** **	0.05***
Crisis dummy	–0.03	–0.03	–0.09	–0.23	**–0.21** **	–0.24***
Deposits to total liabilities		0.00			–0.01*	
Equity to total liabilities		0.02			0.00	
Loan to assets		–0.00			0.00	
Concentration			0.26***			–0.03
Constant	0.14	0.03	0.2	0.22**	0.64	0.28***
Countries	19	18	19	19	18	19
Observations	295	267	272	295	267	272
R-squared	0.78	0.78	0.79	0.36	0.37	0.38

Annex III: Stress tests results

Characteristics of interest rate-focused stress tests[1]

Table A.III.1

Regulatory authority (year of test)	Exercise type	Interest rate scenario	Scenario for other key variables	Sample of banks	Impact of interest rate change on profitability	Other factors influencing the results	Impact of interest rate change on financial stability
Bank of England (2017)	Bottom-up stress tests	Policy rate at zero and other rates little changed (L4L)	- Competitive pressures from Fintech lead to fall in lending and deposit margins - Cross-border banking falls - Business lending shrinks	Seven largest banks	- Headline RoE increases to 8.3% from 0% - Underlying RoE increases to 8.5% from 5.0% - NIM falls by 35bp - Non-interest income increase by 26% - Operating costs decrease by 14%		- Banks compensate for the lower NIM by loan growth. This could increase their IR maturity gap and thus vulnerability to a snapback scenario - Share of mortgage is projected to increase as a result of banks' reaction to low interest rates, possibly raising households' indebtedness
Bundesbank/BaFin (2017)	Bottom-up sensitivity analysis	1. Unchanged interest rates (L4L) 2. 100 bp fall across the curve 3. 200 bp rise across the curve 4. Inverse turn scenario	None	1,555 (smaller) credit institutions	1. RoA decreases by 16% with dynamic balance sheet and 41% with static balance sheet 2. RoA decreases by 41% with dynamic balance sheet and 60% with static balance sheet 3. RoA increase by 7% 4. RoA decrease by 38%	Effect of low interest rates stronger when competition is high	- Banks envisage mergers to face depressed returns - Balance sheet shift toward assets with higher risk weights

Characteristics of interest rate– focused stress tests[1] (continued) Table A.III.1

Regulatory authority (year of test)	Exercise type	Interest rate scenario	Scenario for other key variables	Sample of banks	Impact of interest rate change on profitability	Other factors influencing the results	Impact of interest rate change on financial stability
ECB IRRBB (2017)	Bottom-up sensitivity analysis	1. Unchanged interest rates (L4L) 2. 100 bp across the curve 3. 200 bp across the curve 4. Steepener 5. Flattener 6. Back to end-2010	None	111 significant institutions	1. NII falls by around 7.5% 2. NII increases by around 10% 3. NII falls by around 30% 4. NII falls by around 7.5% 5. NII falls by around 7.5% 6. NII increases by around 10%	Banks with ling asset duration (eg fixed rate mortgage) show a more negative impact of higher interest rates on profitability	- Important model risk that banks underestimate their exposure to higher interest rates - Most banks use IR derivatives to reach a target IR profile. These derivatives are associated with certain risks and situations of over-hedging have been observed.
Federal Reserve (2013, 2014, 2015)	Bottom-up stress tests. These adverse scenarios were considered as part of the Dodd Frank Act Stress Tests.	Max. difference from baseline: 2013: 10y-3m slope 1 p.p. flatter from 3m rate 2½ p.p. and 10y yield 1½ p.p. higher. 2014: 10y-3m slope 2½ p.p. steeper from 10y yield 2½ p.p. higher. 2015: 10y-3m ¾ p.p. flatter from 3m rate 2¼ p.p. and 10y yield 1½ p.p. higher.	The adverse scenario also features a mild-to-moderate recession.	2013: 18 BHCs 2014: 30 BHCs 2015: 31 BHCs	2013: Results not disclosed for the adverse scenario. 2014 and 2015: Results disclosed for individual BHCs to the detail of pre-provision net revenue (PPNR) and other comprehensive income (OCI) 2014: PPNR bolstered by high projected NII, driven in part by increasing long-term interest rates and the yield curve steepening. Higher long-term interest rates and wider credit spreads result in -$103B of OCI over the 9 quarters of the planning horizon for the advanced approaches BHCs.	Several other variables affect PPNR, which also includes non-interest income and expenses, and other variables, such as credit spreads, also affect OCI.	2013: Results not disclosed for the adverse scenario. 2014 and 2015: Results used the Federal Reserve's projections of the balance sheet for each BHC. Any new loan balance implied by the balance sheet projections were assumed to have the same risk characteristics as loans held at the start of the scenario.

Characteristics of interest rate– focused stress tests[1] (continued) Table A.III.1

Regulatory authority (year of test)	Exercise type	Interest rate scenario	Scenario for other key variables	Sample of banks	Impact of interest rate change on profitability	Other factors influencing the results	Impact of interest rate change on financial stability
Federal Reserve (2013, 2014, 2015) (continued)					2015: PPNR bolstered by high projected NII, driven in part by increasing interest rates. Higher long-term interest rates and wider credit spreads assumed in the scenario result in –$121B of OCI over the 9 quarters of the planning horizon for advanced approaches BHCs.		
SNB (2016)	Top-down sensitivity analysis	1. 200 bp rise in yields across the curve 2. 400 bp rise in yields across the curve	None	Domestically focused commercial banks	1. NIM increases by around 20% 2. NIM falls by 10%	- Size of the maturity gap in banks' portfolio - Banks' liquidity holdings (currently placed at negative rates) - Speed and adjustment of NMDs	- IR maturity mismatches have increased during the period of low interest rates - Changes in customer behaviour can lead to a rapid increase in banks' funding costs in a snapback scenario - If higher interest rates result from the unwinding of monetary stimulus, other impacts can be expected (eg banks' balance sheets can shrink as depositors redirect their savings toward securities released on the market by central banks)

[1] Stress tests shown here have a particular focus on the interest rate impact on bank profitability over other variables, such as economic growth or other asset price changes.
List of abbreviations: L4L low-for-long; IR interest rates; bp basis points; NII net interest income; RoA return-on-assets; RoE return-on-equity; NMDs non-maturity deposits.

Annex IV: Methodology and analysis of firm-level bank data

This annex describes the methodology used for the bank-level profitability regression results presented in Section 2.2 of Chapter 2. It also presents the risk-taking regression analysis and results that are summarised in the discussion in Section 2.3 of Chapter 2. The same methodology was used in Section 3.2 of Chapter 3.

A.IV.1 Methodology for estimated effects of interest rates on bank profitability

To investigate the effects of interest rates on bank profitability and soundness indicators using bank-level data, a panel regression approach is employed.[61] The bank balance sheet and income statement data are from Bankscope at an annual frequency for the 2005—15 period. The number of banks in the analysis varies across the variables of interest; at its peak, the sample contains over 10,000 banks from over 40 countries. Unconsolidated data are used to focus as closely as possible on the effect of a country's interest rate on only the bank's operations in that country. Observations are trimmed in cases where the data are found to be logically inconsistent.

A bank's indicator for each year is regressed on the average level of the three-month sovereign rate in that year, a common proxy for banks' marginal funding costs, controlling for the lag of the bank's indicator, other time-varying bank characteristics and a bank fixed effect, as well as GDP growth, inflation and the slope of the yield curve (the spread between the 10-year and three-month sovereign rates). Because the regressions control for each bank's fixed effects and its country's general economic conditions, the estimation results can be interpreted as the direct effects of a change in the short-term interest rate on banks' indicator holding these other factors constant. In the analysis of AE interest rate spillovers to EM bank profitability, additional variables are the simple average of short-term rates and slopes of the yield curve in AEs.

To explore differential effects of low yields, countries were grouped into advanced and emerging economies per the BIS definition and were classified each year as being in a low- or high-rate environment based on whether the interest rate on their three-month sovereign bond was below or above 1.25%. To study differential effects of characteristics of banking systems, the systems were sorted based on certain characteristics (bank concentration or mortgage loan contract types). Finally, to gauge differential effects of bank business models, banks were grouped by deciles of the distribution for a given bank characteristic (bank size, importance of retail and commercial lending, or reliance on wholesale funding).

[61] This analysis draws on Claessens, Coleman, and Donnelly (2017).

A.IV.2 Assessing profitability: impact of interest rates on net interest margins

Table A.IV.1 below delves further into the effects of interest rates on NIMs by looking at the effects of interest rates separately on banks' interest income and interest expense. Both of these components are strongly associated with short-term rates, but the sensitivity of interest income is higher, leading to the positive association of short rates and NIMs: while lower short-term interest rates reduce interest expenses through funding costs, the decline in interest income is larger.

Interest income and expenses over earning assets — Table A.IV.1

Explanatory variables	Bank-level analysis							
	Income				Expenses			
	All countries	AEs	EMEs	Memo: AEs excl United States	All countries	AEs	EMEs	Memo: AEs excl United States
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Lagged dep. variable	0.43***	0.46***	0.28***	0.46***	0.51***	0.57***	0.24*	0.44***
Short-term rate	0.44***	0.42***	0.32***	0.30***	0.34***	0.30***	0.22**	0.28***
Yield curve slope	0.19***	0.16*	0.30***	0.01	0.07	0.00	0.28***	–0.08
Inflation	0.03	0.06***	0.02	0.07	0.00	0.01	0.01	0.07
GDP growth	0.00	–0.02	0.05	0.00	0.00	–0.01	0.05	0.00
Deposits over liabilities	–0.01***	0.00*	–0.02*	0.00	–0.01***	–0.01***	–0.02***	0.00*
Equity over assets	0.02**	0.01**	0.03***	0.01	0.00	0.00	–0.01***	0.00
Securities over assets	–0.02***	–0.01***	–0.03***	0.00*	0.00**	0.00***	0.00	0.00
Number of observations	103495	98507	4988	23097	103495	98507	4988	23097
Number of countries	45	25	20	24	45	25	20	24
Number of banks	10018	9453	583	2442	10018	9435	583	2442

***/**/* denotes results significant at the 1/5/10% level.

A.IV.3 Assessing risk-taking: impact of interest rates on profitability in countries with fixed and variable interest rate mortgage loans

The countries are classified by mortgage loan type based on Cerutti et al (2015). Countries with mixed interest types are grouped with variable-rate countries in the regressions. Counterintuitively, for banks in the full set of AEs, the results suggest that bank NIMs are more sensitive to short rates in fixed-rate countries, but excluding US banks, the distinction disappears. The coefficients on the yield curve slope are higher for banks in fixed rate-countries, consistent with at least some of this fixed-rate lending being funded at shorter maturities.

NIM and RoA sensitivities and mortgage loan type

Table A.IV.2

	Country-level analysis		Bank-level analysis			
Explanatory variables	All countries with mostly variable rate mortgage loans	All countries with mostly fixed rate mortgage loans	AEs with mostly variable rate mortgage loans	AEs with mostly fixed rate mortgage loans	Memo: AEs excl United States, with mostly variable rate mortgage loans	Memo: AEs excl United States, with mostly fixed rate mortgage loans
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Net interest margins						
Short-term rate	0.02	0.09*	0.04***	0.09**	0.08	0.09**
Yield curve slope	0.01	0.08***	0.09***	0.16**	0.04	0.16**
Panel B: Return-on-assets						
Short-term rate	0.00	0.00	–0.01	0.04	0.02	0.04
Yield curve slope	–0.05	0.02	–0.09***	0.03	–0.04	0.03

Subset of economies with mostly variable rate mortgage loans also includes those with no prevalent interest rate type. Asterisks denote statistical significance.

***/**/* denotes results significant at the 1/5/10% level.

A.IV.4 Assessing risk-taking: impact of interest rates on bank soundness

Estimated effects of interest rates on soundness indicators are reported in Table A.IV.3 for a large panel of banks over the 2005–15 period. The results for AE banks, including and excluding the United States, are summarised in Table 6 and show little evidence of risk-taking in a low-rate environment: more often than not, the estimated coefficients suggest that lower rates are associated with improved bank soundness. For example, lower short-term rates in AEs and EMEs are associated with a higher ratio of regulatory capital to risk-weighted assets.

Impact of interest rates on select soundness indicators

Table A.IV.3

Panel I	Loans to deposits and short-term funds					Liquid assets to total assets				
	AEs		EMEs	Memo: AEs excl United States		AEs		EMEs	Memo: AEs excl United States	
Explanatory variables	All years	LYE years	All years	All years	LYE years	All years	LYE years	All years	All years	LYE years
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Lagged dep. variable	0.00	0.00	0.07***	0	0.00**	0.41***	0.35***	0.31***	0.34***	0.32***
Short-term rate	0.21	–5.10**	-0.19	–0.95	–5.64***	–0.72**	0.97	0.04	–0.13	1.74
Slope	–0.27	0.59***	–1.11***	0.48	2.31***	–0.63*	–1.14***	0.47	–0.98	–1.75*
Inflation	–0.02	–0.64***	0.19	–0.01	–0.21	0.03	0.50***	–0.09	0.16	0.12
GDP growth	–0.05	0.12*	–0.30*	0.03	–0.03	0.11*	–0.08	0.30***	0.031	0.01
Number of observations	92174	58463	4261	20813	13548	92055	62458	4433	21356	14777
Number of countries	25	20	20	24	19	25	21	20	24	20
Number of banks	9186	9005	567	2311	2196	9432	9334	570	2439	2341

***/**/* denotes results significant at the 1/5/10% level.

Panel II	Non-performing loans to gross loans					Loan loss provisions to gross loans				
	AEs		EMEs	Memo: AEs excl. United States		AEs		EMEs	Memo: AEs excl. United States	
Explanatory variables	All years	LYE years	All years	All years	LYE years	All years	LYE years	All years	All years	LYE years
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Lagged dep. variable	0.64***	0.51***	0.50***	0.79***	0.74***	0.58***	0.30***	-0.06	0.60***	0.30***
Short-term rate	0.10***	1.33	0.01	–0.1	1.14***	0.11***	0.13	0.00	0.06**	0.40***
Slope	0.44***	0.33*	0.18**	–0.04	–0.58***	0.17***	0.23***	0.09	–0.09	–0.10
Inflation	–0.02	0.08	–0.01	–0.05	–0.05**	–0.03***	–0.03	–0.01	–0.01	–0.07***
GDP growth	–0.11***	–0.09	–0.05	–0.00	0.05***	–0.05*	–0.04*	–0.05	–0.01	0.01
Number of observations	71462	51374	3902	11877	10128	96659	61776	2762	21642	14197
Number of countries	24	19	20	23	18	25	21	20	24	20
Number of banks	8736	8567	549	1962	1866	9404	9302	556	2419	2318

***/**/* denotes results significant at the 1/5/10% level.

Panel A.III	Charge-offs to gross loans					Regulatory capital to risk-weighted assets				
	AEs		EMEs	Memo: AEs excl. United States		AEs		EMEs	Memo: AEs excl. United States	
Explanatory variables	All years	LYE years	All years	All years	LYE years	All years	LYE years	All years	All years	LYE years
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Lagged dep. variable	0.27***	0.17***	0.20**	0.48***	0.49***	0.60***	0.51***	0.27***	0.48***	0.42***
Short-term rate	0.06***	0.81	–0.02	0.03	0.16	–0.20***	–1.17**	0.05	–0.49***	–0.59***
Slope	0.21***	0.19***	0.08*	0.09	0.15**	–0.10	–0.10	0.02	-0.10	-0.23
Inflation	–0.01*	0.04	0.01	–0.03	–0.07***	–0.01**	0.10***	0.09	-0.00	0.02
GDP growth	–0.04***	–0.04***	–0.02	0.02	0.03	0.07***	0.04**	–0.06	-0.04	0.01
Number of observations	79831	51508	1205	4819	3865	76138	49871	1390	7216	5609
Number of countries	21	17	18	20	16	24	20	16	23	19
Number of banks	8423	8300	222	1438	1316	8310	8144	210	1576	1463

***/**/* denotes results significant at the 1/5/10% level.

Impact of interest rates on select soundness indicators (cont'ed) Table A.IV.3

Panel IV	Residential mortgages to gross loans				
	AEs		EMEs	Memo: AEs excl United States	
Explanatory variables	All years (1)	LYE years (2)	All years (3)	All years (4)	LYE years (5)
Lagged dep. variable	0.51***	0.55***	0.75***	0.52***	0.54***
Short-term rate	–0.22*	–0.12	–0.01	–0.38**	–0.19
Slope	–0.02	0.10	–0.18	–0.13	–0.15
Inflation	–0.17	–0.17	–0.06**	–0.45*	–0.43
GDP growth	0.03	0.06***	0.10	0.05**	0.07***
Number of observations	8627	5792	711	6322	5252
Number of countries	21	17	16	20	16
Number of banks	1776	1165	158	1173	1165

***/**/* denotes results significant at the 1/5/10% level.

Using a similar regression specification, the effects of interest rates on bank soundness indicators of risk (discussed further in section 2.3), for many hundreds of banks from dozens of countries over the 2005–2015 period, are shown in Table A.IV.3 for seven soundness measures.[62] The results, overall, provide very little evidence of increased bank risk with lower rates or flatter yield curves, with the signs of the estimated coefficients more often pointing to improved bank soundness indicators accompanying lower rates or flatter yield curves.

A.IV.5 Effects of interest rates on a more-granular measure of maturity transformation

One statistically significant result shown in Panel I of Table A.IV.1 that does suggest potential financial stability risk from low rates is that, when the short-term interest rate reaches a very low level, loan-to-deposit ratios in the AEs are found to increase, suggesting increased maturity transformation by banks, all else equal. This possibility is explored further in Table A.IV.2, using a more granular measure that quantifies an estimate of maturity transformation based on the assignment of assets and liabilities to maturity buckets – available for some of the banks in the Bankscope data set. The transformation metric is defined as the difference between the estimated average maturities of a bank's assets and liabilities, respectively, measured in years. The table's columns (I) and (II) suggest that AE banks increase the maturity of their assets when short-term rates decline, particularly so in a low-yield environment. This finding is consistent with banks increasing their risk profile in response to low interest rates. However, as columns (VI) and (VII) show, AE banks extend the maturity of their liabilities even more, in particular in a low yield environment. This result is consistent with banks seeking to lock in cheaper long-term funding. The net effect – the difference between the tenor of assets and liabilities – is that banks perform less maturity transformation when short-term rates decline, in particular in a low-yield environment (although the effect is not precisely estimated). The magnitudes of the estimated coefficients are small, however, with a percentage point difference in rates translating to shifts in average maturities of just a few weeks. Similar analysis for EM banks suggests much weaker effects of rates on maturity transformation (not shown).

[62] The number of banks in regressions varies because of data availability. The number ranges from about 9000 banks in the analysis of non-performing loans to about 200 in the analysis of soundness indicators.

Impact of interest rates on maturity transformation

Table A.IV.4

	Country-level analysis				Bank-level analysis				Maturity gap			
	AEs		Memo: AEs excl United States		AEs		Memo: AEs excl United States		AEs		Memo: AEs excl United States	
Explanatory variables	All years	LYE years	All years	LYE years	All years	LYE years	All years	LYE years	All years	LYE years	All years	LYE years
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Lagged dep. variable	0.36***	0.26***	0.37***	0.24**	0.39***	0.32***	0.39***	0.31***	0.33***	0.31***	0.33***	0.30***
Short-term rate	–0.05***	–0.06**	–0.05**	–0.06***	–0.08***	–0.11***	–0.08***	–0.10***	0.04**	0.06	0.04**	0.06*
Yield curve slope	–0.01	–0.01***	0.01	–0.01	0.01	–0.01	0.01	–0.03	–0.01	0.00	–0.02	0.00
Inflation	–0.01	–0.01***	0.03	0.00	0.00	0.00	–0.01	0.01	–0.01	–0.01**	0.01	0.02
GDP growth	–0.01***	–0.01***	–0.02**	–0.01***	0.01**	0.01***	0.01**	0.01***	–0.02***	–0.02***	–0.02***	–0.02***
Number of obs	46247	41598	10703	6054	20779	16308	10969	6498	20062	15627	10436	6001
Number of countries	23	19	22	18	23	19	22	18	23	19	22	18
Number of banks	7866	7762	1555	1451	3914	3813	1692	1591	3742	3647	1538/	1443

Maturity is measured in years, interest rates in percent. Maturity gap is the difference between the maturity of assets and liabilities. Asterisks denote statistical significance.

***/**/* denotes results significant at the 1/5/10% level.

A.IV.6 Impact of interest rates on the probability of a high NPL ratio

One statistically significant result shown in Panel II of Table A.IV.3 that does not point to increased financial stability risk from low rates is that when the short-term interest rate reaches a very low level, NPL ratios in the AEs are found to decrease, suggesting that banks have not taken on more credit risk to compensate for profitability pressures. This is explored further in probit regressions that focus on the probability of non-performing loan ratios exceeding a critical threshold of 8%.[63] Estimated over the entire sample, the effect of short-term interest rates and the slope of the yield curve on probability of exceeding this threshold of is positive (Table A.IV.5). That is, an increase in either short-term rates or the slope boosts the probability that a bank's non-performing loan ratio exceeds the critical threshold. However, only the effect of changes in the short-term rate (the slope of the yield curve) is precisely estimated in the sample of AEs (the sample of EMEs).[64] In turn, an increase in real GDP growth reduces the probability. These results appear to indicate that borrower capacity to repay loans plays an important role: borrower capacity is likely higher when interest rates are lower and economic growth is higher.[65] Further analysis suggests that signs, magnitude and statistical significance patterns of the regression coefficients are generally similar across the two groups (columns II and IV). Analysis of predicted probabilities of exceeding the critical NPL ratio threshold illustrated the economic

[63] The threshold is from Moody's scorecard ratios.

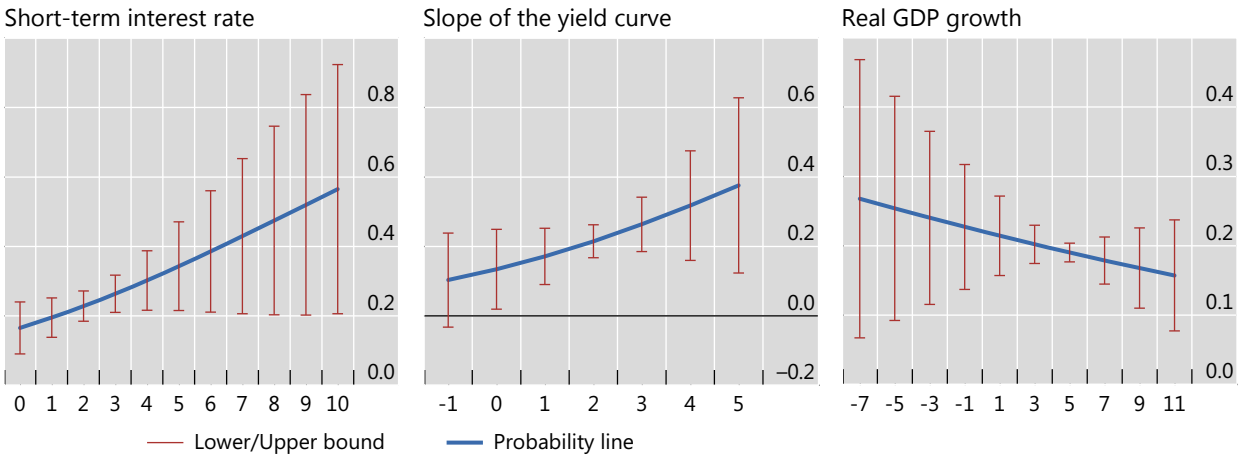
[64] In more sophisticated specifications, the regression coefficient on short-term interest rates is of the same sign and magnitude but is statistically significant.

[65] Separate preliminary analysis (not shown) suggests that these results are attributable primarily to years with low interest rates.

significance of the effects of interest rates and economic growth (Graph A.IV.1). While the effect of higher short-term interest rates on the probability is modest and very uncertain, the effects of a higher slope of the yield curve and higher economic growth are very pronounced and precisely estimated. Overall, being in a low-yield environment with relatively flat yield curves is supportive of bank soundness (as captured by non-performing loan ratios).

Predicted probabilities of excessing the critical NPL ratio threshold

Graph A.IV.1



Impact of interest rates on probability of exceeding critical NPL ratio threshold

Table A.IV.5

	Country-level analysis			Bank-level analysis	
	All countries economies	All countries economies	AEs	EMEs	Memo: AEs excl United States
	All years	All years	All years	All years	All years
Lagged explanatory variables		(1)	(2)	(3)	(4)
Short-term rate	0.07	0.11*	0.15*	0.04	0.20*
Slope	0.46***	0.16	0.21	0.26**	0.40***
Inflation	–0.29*	–0.02	–0.01	–0.01	0.13
GDP growth	–0.11	–0.02	–0.01	–0.06***	–0.03***
Number of observations	233	79516	78093	1423	7426
Number of countries	19	41	24	17	23

The critical threshold for NPL ratios is 8%. Asterisks denote statistical significance.

***/**/* denotes results significant at the 1/5/10% level.

Note. Based on the results in column (II) of Table A.IV.3. Probabilities evaluated holding all but one variable fixed at the sample means. 95% confidence intervals are shown.

A.IV.7 Assessing spill-overs: impact of AE interest rates on EME banks' NIMs

Table A.IV.6 below delves further into the effects of AE interest rates on EME NIMs by looking at the effects of interest rates separately on banks' interest income and interest expense. These coefficients have large positive point estimates, but they are too imprecisely estimated to be statistically significant.

Summary of estimated impact of lower rates on bank soundness — Table A.IV.6

Explanatory variable	Interest income	Interest expense
	(1)	(2)
Lagged dep. variables	0.28***	0.25*
Home-country short-term rate	0.25***	0.20*
Home-country yield curve slope	0.18**	0.21***
Home-country inflation	0.01	0.00
Home-country GDP growth	–0.07	–0.03
AE short-term rate	0.24	0.20
AE yield curve slope	0.37	0.58
Number of observations	4988	4988
Number of countries	20	20
Number of banks	583	583

***/**/* denotes results significant at the 1/5/10% level.

A.IV.8 Descriptive statistics: profitability indicators bank characteristics, and macroeconomic variables

Descriptive statistics for analysis in Tables 1 and 2 — Table A.IV.7

Panel I. All countries	Median	Mean	Standard deviation	Minimum	Maximum
Bank variables*					
Net interest margin, percent	3.67	3.66	1.40	–9.05	19.86
Return-on-assets, percent	0.70	0.71	1.03	–14.88	16.46
Interest income over interest bearing assets, percent	4.99	5.20	2.13	–2.94	26.41
Interest expense over interest bearing liabilities, percent	1.50	1.77	1.49	–6.49	15.44
Deposits over liabilities, percent	97.53	93.81	10.51	13.08	100.00
Equity over assets, percent	9.71	10.48	4.95	0.00	78.95
Securities over assets, percent	20.59	22.67	15.12	0.00	100.00
Loans over assets, percent	63.12	61.04	16.46	0.00	100.00
Total assets, $ millions	263	5991	64945	1	3126270
Macroeconomic variables					
Short-term rate, percent	2.74	3.50	3.63	–0.78	29.29
Yield curve slope, percentage point	1.58	1.69	1.42	–3.41	12.68
Inflation, percent	2.53	3.87	7.32	–4.48	109.68
GDP growth, percent	2.49	2.59	3.56	–9.13	15.24

*Number of bank-year observations is 103531

Descriptive statistics for analysis in Tables 1 and 2 (cont'ed)

Table A.IV.7

Panel II. AEs	Median	Mean	Standard deviation	Minimum	Maximum
Bank variables*					
Net interest margin, percent	3.65	3.57	1.21	–9.05	19.47
Return-on-assets, percent	0.68	0.67	0.97	–14.80	16.46
Interest income over interest bearing assets, percent	4.90	4.96	1.64	0.00	25.10
Interest expense over interest bearing liabilities, percent	1.40	1.60	1.13	0.00	14.12
Deposits over liabilities, percent	97.76	94.87	8.07	13.92	100.00
Equity over assets, percent	9.68	10.27	4.34	0.00	78.95
Securities over assets, percent	20.86	23.00	15.00	0.00	100.00
Loans over assets, percent	63.43	61.36	16.33	0.00	100.00
Total assets, $ millions	257	5782	66165	2	3126270
Macroeconomic variables					
Short-term rate, percent	1.23	1.97	2.19	–0.78	15.62
Yield curve slope, percentage point	1.43	1.68	1.48	–0.99	12.68
Inflation, percent	1.80	1.84	1.65	–4.48	10.93
GDP growth, percent	1.78	1.66	3.24	–9.13	15.24

*Number of bank-year observations is 98543

Panel A.III. EMEs	Median	Mean	Standard deviation	Minimum	Maximum
Bank variables*					
Net interest margin, percent	4.79	5.31	2.98	–8.33	19.86
Return-on-assets, percent	1.15	1.39	1.77	–14.88	14.51
Interest income over interest bearing assets, percent	9.87	10.09	3.99	–2.94	26.41
Interest expense over interest bearing liabilities, percent	5.17	5.24	2.79	–6.49	15.44
Deposits over liabilities, percent	80.19	72.78	23.26	13.08	100.00
Equity over assets, percent	11.42	14.69	10.87	0.00	76.98
Securities over assets, percent	12.52	16.20	15.96	0.00	95.95
Loans over assets, percent	57.62	54.57	17.70	0.00	95.07
Total assets, $ millions	718	10124	32242	1	707946
Macroeconomic variables					
Short-term rate, percent	4.89	5.57	4.13	–0.07	29.29
Yield curve slope, percentage point	1.73	1.72	1.35	–3.41	5.37
Inflation, percent	4.26	6.51	10.40	–1.42	109.68
GDP growth, percent	3.96	3.84	3.60	–7.82	14.25

*Number of bank-year observations is 4988

Descriptive statistics for analysis in Tables 1 and 2 (cont'ed) Table A.IV.7

Panel IV. AEs excluding the United States	Median	Mean	Standard deviation	Minimum	Maximum
Bank variables*					
Net interest margin, percent	2.25	2.24	0.91	–9.05	19.47
Return-on-assets, percent	0.25	0.33	0.73	–11.88	16.46
Interest income over interest bearing assets, percent	3.88	3.75	1.61	0.00	21.39
Interest expense over interest bearing liabilities, percent	1.56	1.61	1.23	0.00	14.12
Deposits over liabilities, percent	96.96	91.63	12.53	13.92	100.00
Equity over assets, percent	7.01	7.98	5.02	0.10	75.90
Securities over assets, percent	22.67	23.65	13.82	0.00	100.00
Loans over assets, percent	58.71	57.17	17.48	0.00	100.00
Total assets, $ millions	1238	15408	104081	8	3126270
Macroeconomic variables					
Short-term rate, percent	1.24	2.00	2.20	–0.78	15.62
Yield curve slope, percentage point	1.39	1.67	1.49	–0.99	12.68
Inflation, percent	1.79	1.83	1.66	–4.48	10.93
GDP growth, percent	1.73	1.66	3.30	–9.13	15.24

*Number of bank-year observations is 23133

A.IV.9 Descriptive statistics: soundness indicators

Descriptive statistics for analysis in Tables A.IV.3 Table A.IV.8

Panel I. All countries	Number of bank-year observations	Median	Mean	Standard deviation	Minimum	Maximum
Bank variables						
Asset duration	55783	1.00	1.48	1.12	0.25	5.00
Liability duration	27300	0.25	1.13	1.10	0.25	5.00
Maturity mismatch	26358	0.75	0.98	0.70	–3.94	4.52
Liquid assets to total assets	103529	8.59	12.14	11.44	–1.76	100.00
Nonperforming loans to gross loans	81603	1.75	3.16	4.01	0.05	44.90
Loan loss provisions to gross loans	100499	0.00	0.51	4.87	–1.50	850.00
Charge-offs to gross loans	83347	0.00	0.35	0.93	–1.00	20.00
Regulatory capital to risk-weighted assets	80341	13.77	14.80	4.76	3.00	30.00
Loans to deposits and short-term funds	96456	75.47	77.24	22.55	40.00	250.00

Descriptive statistics for analysis in Tables A.IV.3 (cont'ed)

Table A.IV.8

Panel II. AEs	Number of bank-year observations	Median	Mean	Standard deviation	Minimum	Maximum
Bank variables						
Asset duration	54681	1.00	1.47	1.12	0.25	5.00
Liability duration	26312	0.25	1.12	1.11	0.25	5.00
Maturity mismatch	25441	0.75	0.98	0.68	–3.94	4.52
Liquid assets to total assets	98541	8.25	11.50	10.70	0.00	100.00
Nonperforming loans to gross loans	77430	1.72	3.13	3.97	0.05	43.50
Loan loss provisions to gross loans	97379	0.00	0.49	4.94	–1.50	850.00
Charge-offs to gross loans	81921	0.00	0.35	0.92	–1.00	20.00
Regulatory capital to risk-weighted assets	78801	13.80	14.85	4.75	3.00	30.00
Loans to deposits and short-term funds	92192	75.20	76.20	20.25	40.00	250.00
Panel A.IV. EMEs	**Number of bank-year observations**	**Median**	**Mean**	**Standard deviation**	**Minimum**	**Maximum**
Bank variables						
Asset duration	1102	1.84	1.85	0.88	0.25	4.46
Liability duration	988	0.87	1.13	0.86	0.25	5.00
Maturity mismatch	917	0.75	0.79	1.02	–2.27	4.21
Liquid assets to total assets	4988	20.69	24.76	16.91	–1.76	100.00
Nonperforming loans to gross loans	4173	2.40	3.75	4.60	0.05	44.90
Loan loss provisions to gross loans	3120	0.63	1.09	1.69	–1.43	18.68
Charge-offs to gross loans	1426	0.29	0.71	1.40	–0.99	12.18
Regulatory capital to risk-weighted assets	1540	11.37	12.38	4.61	3.24	29.29
Loans to deposits and short-term funds	4264	84.77	99.58	46.04	40.03	249.67
Panel IV. AEs excluding the United States	**Number of bank-year observations**	**Median**	**Mean**	**Standard deviation**	**Minimum**	**Maximum**
Bank variables						
Asset duration	12611	3.71	3.27	1.09	0.25	5.00
Liability duration	12978	2.16	2.02	0.95	0.25	5.00
Maturity mismatch	12304	1.29	1.27	0.89	–3.94	4.52
Liquid assets to total assets	23131	13.56	17.28	13.99	0.00	99.46
Nonperforming loans to gross loans	13218	5.31	6.63	5.49	0.05	42.85
Loan loss provisions to gross loans	22250	0.38	0.80	10.18	–1.50	850.00
Charge-offs to gross loans	6797	0.00	0.19	1.00	–1.00	15.25
Regulatory capital to risk-weighted assets	8581	12.64	13.40	4.62	3.03	30.00
Loans to deposits and short-term funds	20825	69.57	75.28	27.85	40.00	250.00

Annex V: Simulation methodology for ICPFs

Stylised examples are used to simulate the impact of interest rate scenarios on ICPFs.

A.V.1 Modelling the evolution of the balance sheet

The model is based on a cohort structure. Cohort i pays an annual premium $p_{i,t}$ in return for a lump-sum benefit at the end of a 30-year horizon, $b_{i,i+30}$. The first cohort begins paying premiums in 1975. The last cohort begins paying premiums in 2007. The cohort structure is illustrated in Table A.V.1 below. A cohort is active if it is either making or receiving payments. For instance, in 1977 the active cohorts are the 1975, 1976 and 1977 cohorts.

Table A.V.1

	Cohort 1, 1975	Cohort 2, 1976	Cohort 3, 1977	...	Cohort 33, 2007
1975	premium, $p_{75,75}$				
1976	premium, $p_{75,76}$	premium, $p_{76,76}$			
1977	...	premium, $p_{76,77}$	premium, $p_{77,77}$		
...	...	...	...		
2005	lump-sum, $b_{1975,05}$	premium	premium, $p_{77,05}$		
2006		lump-sum, $b_{76,06}$	premium, $p_{77,06}$		
2007			lump-sum,$b_{77,07}$		premium, $p_{07,07}$
...					...
2037					lump-sum, $b_{07,37}$

Inflows and outflows

In every year t, the firm receives premium payments from active cohorts (denoted by $P_t = \sum_{i:act.\ at\ t} p_{i,t}$, where $p_{i,t}$ is the premium paid by cohort i in year t) and returns on the non-cash asset portfolio (denoted by $V_{t-1}R_t$). Net returns (denoted by R_t) comprise both interest income and capital gains/losses. The insurer pays out lump-sum benefits to the cohort whose contract has reached maturity (denoted by $b_{t-T,t}$, since the policy of cohort $t-T$ matures in year t) and has to cover operating costs (denoted by Ψ_t). Premiums are invested. Outflows have to be covered by portfolio returns. Let net cash flows be defined as $NCF_t \equiv V_{t-1}R_t - b_{t-T,t} - \Psi_t$. If portfolio returns are large enough to cover outflows, $NCF_t \geq 0$, the firms retains a positive share γ_t smaller than 1 which goes into a cash reserve. The remainder is paid out. If portfolio returns are not large enough to cover outflows, NCF_t <0, the firm must liquidate assets. The cash reserve is liquidated first.

Assets and liabilities

The firm has two types of assets (whose combined value is denoted by A_t): cash (with value denoted by C_t) and non-cash (with value denoted by V_t). It maintains a constant allocation of the non-cash share of its portfolio to sovereign bonds, corporate bonds and equities. The cash share, C_t, is the accumulated balance of retained past positive NCFs. The asset portfolio (henceforth, assets) is marked to market. Assets do not

include future premium payments on existing contracts. Consistently, liabilities (whose value is denoted by L_t) are claims on the insurer based only on premium payments already accumulated.

Assets evolve as follows. The change in the cash reserve is $C_t - C_{t-1} = \gamma_t NCF_t$ if $NCF_t \geq 0$ and $C_t - C_{t-1} = NCF_t$ otherwise. Assets are then equal to $A_t = V_{t-1} + P_t + C_t$. Using the fact that $A_{t-1} = V_{t-1} + C_{t-1}$, asset growth is given by $A_t - A_{t-1} = P_t + C_t - C_{t-1}$. This expression shows that changes in assets are driven by premium payments and net cash flows.

Liabilities evolve as follows. Consider cohort i. In the first participation year $t = i$, this cohort pays a premium $p_{i,i}$, so $b_{i,i} = p_{i,i}$. In all years $t > i$ and $t < i + T$, the cohort's claim is given by $b_{i,t} = (1 + \rho_{i,t})p_{i,t-1} + p_{i,t}$, where $\rho_{i,t} = \underline{\rho}_{i,t}$ if $NCF_t \leq 0$ (minimum guaranteed return) and $\rho_{i,t} > \underline{\rho}_{i,t}$ if $NCF_t > 0$ (profit participation). Here, $\underline{\rho}_{i,t}$ denotes the minimum return guaranteed to cohort i in year t. In the payout year $t = i + T$, the claim is given by $b_{i,i+T} = (1 + \rho_{i,i+T})p_{i,i+T-1}$. Aggregating over cohorts active at time t and using the definition of liabilities returns $L_t = \sum_{i:act.\ at\ t} b_{i,t}$.

Assumptions

The model requires a number of assumptions summarised in the following table.

Table A.V.2

Parameter	Assumption	
Assets and allocation	Cash and non-cash Non-cash: sovereign bonds, corporate bonds, equities Non-cash allocation	
	Snapback w/ extra risk-taking (0%, 80%, 20%)	All other scenarios (30%, 60%, 10%)
Asset duration	Endogenous but calibrated to be about eight years in 2016	
Asset valuation	Marked to market using on a full yield curve interpolated as follows: Between three months and 10 years, the yield curve is a linear interpolation between these points; beyond 10 years it is assumed that the slope halves	
Liabilities duration	Endogenous but calibrated to be roughly equivalent to 15 years in 2016 if future premium payments on existing contracts were counted towards liabilities	
Liabilities valuation	Marked to market using the same yield curve as for assets	
Accumulation period	30 years	
Minimum guarantees	Vary according to a rule based on long-term averages of 10-year government bond yields. The rule approximately matches German data.	
Operational costs	Fixed percentage of premiums	
Share of NCF retained	$\gamma_t = 0$ if $t < 2016$ $\gamma_t = .4$ if $t \geq 2016$	

A.V.2 Scenario extensions

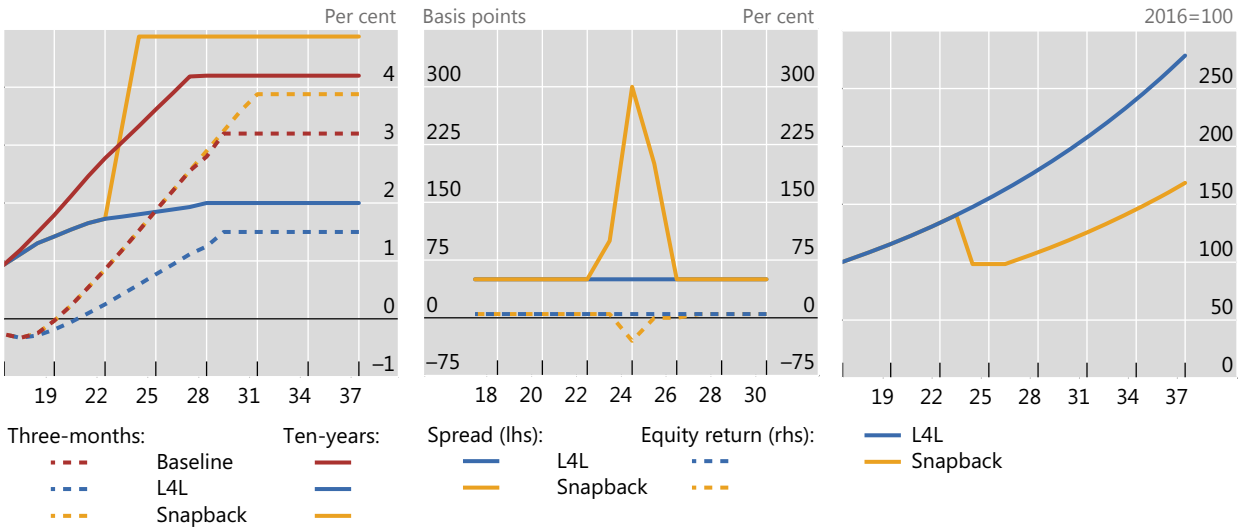
To simulate the impact of the (euro area) scenarios on the IC, it was necessary to (i) extend the paths of interest rates to 2037 and (ii) make additional assumptions about corporate bond spreads and equity returns. In baseline and L4L, corporate bonds spreads and returns on equities are based on historical euro area data. In snapback, there are three add-on assumptions, described below. All extensions are illustrated in Graph A.V.1.

A widening of credit spreads. In baseline and L4L, spread between the interest rate on corporate bonds and the risk-free rate is assumed to be 50 bp. In snapback, it increases temporarily by +100 bp in 2023, by 300 bp in 2024, by 200 bp in 2025 and by 100 bp in 2026.

Credit losses. In snapback, the insurer is assumed to book (one-off) losses from defaults on its credit exposure in 2024, equivalent to 3% of value of the corporate bond portfolio as of end-2023.

A crash in equity prices. In baseline and L4L, returns on euro area equities are used for the years up to and including 2017, while equity prices are assumed to increase by 5% each year from 2018 onwards. In snapback, equity prices are assumed to decline by 30% in 2024, to remain flat in the years 2025–2027 and to return to their pre-snapback growth rate of 5% in the subsequent years.

Scenario extension — Graph A.V.1



Source: WG

Annex VI: Survey

The WG has carried out a survey among CGFS members, to collect quantitative and qualitative information about insurers and pension funds, particularly on developments that are relevant to assessing vulnerabilities in a low-for-long scenario. The main quantitative results are presented in the tables below; the data are also used to illustrate developments and risks in the main text. The data come from different national sources, implying that in part of them are based on different definitions.

- The breakdown of assets is only presented for 2016; for most jurisdictions this breakdown has not changed much in previous years. One of the purposes is to show how much ICPFs invest in fixed-income assets. Because there are two broad categories that partly consist of fixed income, a range of minimum and maximum fixed-income exposures is presented.
- Investment returns are presented as a percentage of total assets.
- Durations are only available for a limited number of jurisdictions, particularly for pension funds. With two exceptions, durations of assets refer only to fixed-income assets. With one exception, it is not known to what extent durations take into account derivatives.
- The share of guaranteed products (insurers) is directly reported. The share of defined benefit schemes (pension funds) is 100% minus what is reported as defined contribution and hybrid schemes. Both are based in the amount of assets.
- Guarantees are only available for a few jurisdictions. With two exceptions, these are based on outstanding contracts.
- The overview of discount rates is based on descriptions by jurisdictions.

Life insurers: asset breakdown (2016)

Table A.VI.1

		(1)	(2)	(3)				(4)	(5)	(6)	(3)+(4)	(3), (4), (5), (6)	Total assets
		Equities	Real estate	Bonds	Government	Corporate	Foreign	Loans	Investment trusts	Others	Fixed-income (min)	Fixed-income (max)	USD bn
North America	US	6.8	0.7	50.4	11.9	28.8	9.6	9.3	23.4	9.5	59.7	92.5	6,764
	CA	2.9	1.7	29.3	—	—	—	6.6	43	16.5	35.9	95.4	1,048
	MX	12.2	1.4	82.2	62.6	16.7	2.9	2.8	—	1.4	85.0	86.4	49
Europe	BE	4.1	2.7	66.8	29.6	2.3	34.9	8.7	14.5	3.1	75.5	93.2	242
	DE	4.3	1.6	35.1	—	—	—	16.7	37.2	5.1	51.8	94.1	1,260
	ES	3.6	2.2	80.0	58.5	21.4	—	0.6	4.6	9.0	80.6	94.2	235
	FR	5.3	1.2	64.9	26.2	38.7	—	—	25.7	2.8	64.9	93.4	2,083
	IT	5.6	0.1	81.7	56.6	25.1	—	0.5	5.6	2.0	82.2	89.8	979
	LU	0.4	—	15.0	7.8	7.2	—	—	1.5	83.1	15.0	99.6	181
	NL	4.9	1.2	41.4	8.4	2.6	30.5	24.5	19.7	8.2	65.9	93.9	456
	SE	15.5	0.6	17.0	5.7	10.3	1.0	5.6	57.6	3.8	22.6	83.9	104
	UK	25.7	2.8	32.7	11.1	11.2	10.3	—	32.1	6.8	32.7	71.6	1,946
Asia & Oceania	AU	11.2	—	13.0	6.0	4.7	2.2	1.7	64.9	9.2	14.7	88.8	1,624
	CN	14.2	0.9	28.5	5.2	12.3	—	—	—	56.4	28.5	84.8	2,182
	HK	7.5	0.6	50.1	9.3	40.8	—	—	11.4	30.3	50.1	91.9	304
	JP	9.5	1.6	68.8	43.0	6.9	18.9	9.1	4.2	6.8	77.9	88.9	3,465
	SG	33.5	1.9	58.8	14.6	36.8	7.4	2.0	—	3.8	60.8	64.6	122

Note: For some countries, loans and unit-linked assets are included in others. For Canada, "investment trusts" include "segregated fund". Segregated funds, although similar to mutual funds, are sold as insurance contracts (including guarantees) and owned by the insurance policyholders.

Pension funds: asset breakdown (2016)

Table A.VI.2

		(1)	(2)	(3)				(4)	(5)	(6)	(3)+(4)	(3), (4), (5), (6)	Total assets
		Equities	Real estate	Bonds	Government	Corporate	Foreign	Loans	Investment trusts	Others	Fixed-income (min)	Fixed-income (max)	USD bn
North America	US	33.3	1.2	26.8	17.5	9.4	—	0.3	26.7	11.8	27.1	65.5	14,802
	CA	—	—	—	—	—	—	—	—	—	—	—	1,555
	MX	22.1	1.5	71.8	52.0	18.9	—	—	—	4.6	71.8	76.4	157
Europe	BE	8.9	0.5	12.5	7.9	4.6	—	0.8	69.8	7.6	13.3	90.7	31
	DE	3.4	5.6	34.6	—	—	—	4.9	47.1	4.4	39.5	91.0	679
	ES	11.1	0.1	50.5	34.3	16.2	—	0.0	17.8	20.4	50.5	88.7	112
	IT	13.5	1.8	43.4	17.5	0.9	—	—	11.1	30.2	43.4	84.7	137
	LU	18.6	—	53.6	—	—	—	—	4.1	23.7	53.6	81.4	204
	NL	13.6	0.6	24.1	3.8	0.9	—	1.5	51.6	8.7	25.6	85.8	1,525
	SE	23.9	1.5	26.0	6.2	12.1	—	3.2	43.3	2.0	29.2	74.6	452
	UK	16.0	2.0	32.7	22.0	4.9	—	—	27.7	21.6	32.7	82.0	2,122
Asia & Oceania	AU	51.5	—	10.3	2.5	3.4	—	0.3	11.1	26.9	10.5	48.5	1,440
	HK	59.0	—	22.3	—	—	—	—	—	17.2	22.3	39.6	122
	JP	17.4	—	33.0	20.4	1.0	11.7	3.0	8.7	37.8	36.0	82.6	1,192
	SG	0.2	—	94.0	93.7	0.3	0.0	1.0	—	4.8	95.0	99.8	240

Investment return insurers

Percentage of assets — Table A.VI.3

	2010	2011	2012	2013	2014	2015	2016
US	7.5%	3.4%	7.1%	8.6%	5.3%	2.8%	5.3%
BE	4.3%	2.8%	4.5%	4.4%	4.8%	5.1%	5.1%
DE	4.3%	4.1%	4.6%	4.7%	4.6%	4.5%	4.4%
ES	4.7%	4.8%	5.0%	5.0%	5.0%	4.5%	4.0%
FR	3.9%	3.0%	3.5%	3.5%	3.4%	3.4%	3.0%
IT	2.4%	1.4%	4.6%	3.8%	3.5%	3.2%	3.3%
NL	5.6%	4.6%	6.2%	2.8%	8.2%	3.2%	3.6%
UK	—	3.9%	8.8%	7.9%	9.8%	2.5%	13.9%
CN	4.8%	3.6%	3.4%	5.0%	6.3%	7.6%	5.7%
JP	2.6%	2.5%	2.5%	2.6%	2.7%	2.6%	2.6%

Investment return pension funds

Percentage of assets

	2010	2011	2012	2013	2014	2015	2016
US	7.7%	–1.0%	7.6%	12.6%	4.3%	–1.6%	4.5%
MX	11.6%	5.3%	14.4%	2.6%	9.3%	1.4%	2.7%
BE	8.6%	–2.3%	11.0%	6.2%	11.0%	3.9%	5.6%
ES	–0.2%	–0.7%	6.3%	8.2%	6.9%	1.8%	2.0%
IT	3.2%	0.5%	6.6%	4.7%	5.9%	3.6%	2.5%
NL	10.0%	6.2%	11.1%	3.2%	14.2%	1.5%	8.7%
UK	15.3%	12.9%	11.8%	7.5%	5.7%	4.9%	—
AU	4.0%	–1.9%	11.5%	15.1%	7.8%	5.1%	6.5%
JP	–0.5%	1.8%	11.2%	8.8%	11.1%	–0.9%	3.5%

Duration insurers

Fixed-income assets

Table A.VI.4

	2010	2011	2012	2013	2014	2015	2016
US	10.0	10.2	10.1	10.4	10.4	10.5	10.6
BE	—	—	—	—	8.3	7.9	8.3
DE[1]	—	—	—	—	9.9	—	—
ES[2]	7.7	7.7	7.7	7.9	8.3	8.2	8.5
FR	—	—	—	—	—	6.5b	—
IT	—	—	—	7.0	—	5.9b	—
LU	5.9	6.0	6.2	6.0	6.3	6.4	6.2
NL	8.6	8.5	8.5	8.6	10.6		11.6
SE	—	—	—	—	—	4.6b	—
UK	9.4	10.1	9.8	9.6	10.7	10.4	10.5
JP	11.2	11.7	11.8	12.1	12.2	12.5	12.5

[1] Duration based on total assets: [2] Based on data from the EIOPA (2016) stress test.

Liabilities

	2010	2011	2012	2013	2014	2015	2016
US	—	—	—	—	—	—	11.3[3]
BE	—	—	—	—	10.2	9.4	9.4
DE	—	—	—	—	14.7	—	—
ES	9.3	9.6	9.8	9.9	10.0	9.8	9.6
FR	—	—	—	—	—	—	12.5
IT	—	—	—	7.5	—	—	
LU	7.0	7.4	7.9	7.7	8.2	8.4	8.3
NL	14.9	16.3	16.3	15.5	21.4	—	—
SE	—	—	—	—	—	—	16.6[3]
JP	14.7	14.7	14.5	14.4	14.2	14.0	13.8

[3] Based on US Life Insurers Fact Book and data from the EIOPA (2016) stresstest.

Duration pension funds

Fixed-income assets

	2010	2011	2012	2013	2014	2015	2016
IT	—	3.7	4.5	4.6	6.3	—	5.9
LU	1.1	3.2	4.2	4.0	4.4	4.8	4.0
NL[4]	—	—	—	7.1	7.5	7.6	8.1
NL[5]	13.9	16.0	11.6	16.0	15.4	15.5	16.5

[4] Excluding derivatives positions. [5] Including derivatives positions.

Liabilities

	2010	2011	2012	2013	2014	2015	2016
LU	11.6	11.5	12.1	11.3	12.2	12.4	12.5
NL	16.8	17.8	17.7	17.2	18.8	18.9	19.4

Insurers: guaranteed products share

Percentage of total assets

Table A.VI.5

	2010	2011	2012	2013	2014	2015	2016
BE	89.6%	90.3%	88.3%	87.2%	86.4%	85.6%	87.8%
DE	87.8%	87.9%	88.2%	88.4%	88.5%	88.4%	—
ES	82.7%	86.3%	86.0%	88.2%	88.8%	89.4%	90.4%
IT	75.3%	76.8%	73.4%	76.3%	74.7%	67.7%	72.0%
LU	22.0%	23.0%	24.0%	25.0%	27.0%	27.0%	28.0%
NL	68.4%	71.0%	71.7%	71.3%	74.6%	74.5%	77.0%
UK	13.5%	15.3%	15.9%	14.9%	15.8%	18.3%	18.6%
CH	98.4%	—	—	99.4%	98.3%	97.2%	96.8%
JP	98.9%	98.9%	98.9%	98.8%	98.7%	98.5%	98.4%
SG	57.9%	62.4%	65.7%	64.5%	67.1%	67.6%	71.0%

Pension funds: share of defined benefit schemes

Percentage of total assets

	2010	2011	2012	2013	2014	2015	2016
US	59.2%	59.4%	58.7%	57.0%	56.9%	57.0%	56.3%
CA	92.0%	92.0%	92.0%	87.7%	86.7%	87.4%	87.8%
Hybrid:	5.2%	5.2%	5.2%	9.8%	11.0%	10.2%	9.7%
MX	15.2%	13.9%	12.3%	12.4%	10.4%	9.1%	8.1%
Hybrid:	6.0%	6.3%	6.2%	6.1%	6.1%	6.0%	6.0%
ES	0.4%	1.0%	1.0%	—	0.5%	0.5%	0.4%
Hybrid:	26.4%	26.0%	27.0%	27.1%	26.1%	24.5%	24.4%
IT	10.0%	8.6%	7.7%	6.8%	6.1%	5.7%	5.1%
LU	—	—	9.7%	8.9%	6.2%	3.8%	3.5%
Hybrid:	—	—	58.5%	57.7%	66.9%	66.7%	66.3%
NL	93.2%	94.2%	95.0%	95.1%	95.5%	94.7%	94.3%
Hybrid:	5.5%	4.6%	3.7%	3.6%	3.5%	4.3%	4.9%
SE	24.0%	27.0%	25.0%	22.0%	21.0%	20.0%	19.0%
UK	67.4%	69.9%	71.0%	70.2%	68.5%	69.3%	—
AU	17.6%	17.5%	17.3%	16.4%	0.0%	18.6%	18.2%
Hybrid:	—	—	—	—	—	6.1%	6.0%
HK	16.2%	17.1%	14.4%	13.8%	12.2%	12.4%	11.7%
JP	96.0%	95.2%	94.8%	94.0%	93.5%	93.0%	92.2%
SG	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Guaranteed rates insurers

Outstanding contracts

Table A.VI.6

	2010	2011	2012	2013	2014	2015	2016
BE	3.2%	3.2%	3.1%	3.0%	2.9%	2.8%	2.6%
DE	3.3%	3.2%	3.2%	3.1%	3.1%	3.0%	2.9%
New contracts:	2.3%	2.3%	1.8%	1.8%	1.8%	1.3%	1.3%
ES	3.8%	3.9%	4.0%	3.9%	3.7%	3.3%	3.0%
FR	1.0%	0.9%	0.8%	0.7%	0.7%	0.6%	0.6%
IT	2.5%	2.6%	3.2%	2.8%	2.0%	1.0%	—
LU	4.0%	2.8%	3.8%	3.6%	3.2%	3.0%	2.6%
New contracts:	2.3%	2.3%	1.8%	1.5%	1.5%	0.8%	0.8%
NL	2.7%	2.6%	2.5%	2.4%	2.4%	2.3%	2.2%
UK	1.5%	1.5%	1.5%	1.0%	1.0%	1.0%	1.0%
JP	3.2%	3.2%	3.1%	3.0%	2.9%	2.8%	2.6%
New contracts:	3.3%	3.2%	3.2%	3.1%	3.1%	3.0%	2.9%

Life insurers: discount rates

Table A.VI.7

		Discount rate	Description
North America	US	Fixed discount rate	General principle is present value of future benefits less present value of future premiums, including a margin for conservatism. Discount rates are set by product type at issue with reference to a set of corporate bond yield indices and remain fixed for the life of the policy. US GAAP accounting values liabilities in ways that more closely align with economic value, but many deviations remain.
	CA	Other	Prescribed by Canadian Institute of Actuaries, the Canadian Asset Liability Method is used to determine the value of insurance contract liabilities.
	MX	Market rate	Sovereign bonds (risk free rates).
Europe	BE DE ES FR IT LU NL SE UK	Market rate plus UFR-extrapolation	Risk-free market rate plus, from the last liquid point onwards, an add-on that converges to the UFR, set by EIOPA. The UFR was 4.2% in 2017, but will be decreased gradually to 3.65% in the coming years. The last liquid point depends on the currency that is used (20 years for EUR).
Asia & Oceania	AU	Market rate	Yields of Commonwealth Government Securities that relate to the term of the future liability.
	HK	Other	The discount rate is in essence based on the expected yield of the assets held, multiplied by 97.5% and reduced by the part of the yield representing default risk.
	JP	Fixed discount rate	Historical average of long-term JGB yields.
	SG	Other	Long-term risk free discount rates are used for valuation of liabilities. These are is calculated as 90% based on yields since inception of 15 and 20-Yr Singapore Government Securities, and 10 percent based on recent six months averages.

Pension funds: discount rates

Table A.VI.8

		Discount rate	Reference rate
North America	US	Other	Private and state and local government plans use AAA-rated corporate bond rate. Federal government plans use rates assumed by actuaries and reported in annual reports and statements. Actuarial liabilities of private and public pensions in the Financial Accounts are estimated based on annual estimates of pension entitlements produced by the Bureau of Economic Analysis (BEA). For private and State and local government pension plans, the BEA calculates pension fund liabilities using an accumulated benefit obligation (ABO) method, which measures the present value of earned future benefits calculated based on current salaries, tenure and life expectancy assumptions. For federal government pension plans, the BEA calculates liabilities using a projected benefit obligation (PBO) method, which incorporates projected future salary growth.
	CA	Market rate (solvency basis) Other (going concern basis)	Liabilities are calculated both on a solvency basis (SB) and on a going-concern basis (GC). A key methodological differences is the discount rate assumption. SB discount rates are based on a combination of effective discount rates used for pricing group annuity contracts issued by insurance companies and long term Government of Canada bonds plus a premium, as recommended by the Canadian Institute of Actuaries. GC discount rates, used for the plan's long-term funding, are set by the plan's actuary to reflect the long-term expected return-on-assets used to fund the promised benefits (different pension plans have different discount rates, depending on asset mix, plan size and other considerations).
	MX	Fixed discount rate	The value of liabilities of pension plans is calculated, taking into account a constant salary growth for the work life. Liabilities of most DB plans are valued using a fixed discount rate, generally taking as a reference sovereign yields.
Europe	BE	Other	Best estimate on ABO-basis (discounting of expected cash flows based on accrued benefits, with discount rate based on expected return-on-assets and/or risk free rate), plus a margin for negative deviations with respect to the parameters used.
	DE	Fixed discount rate	Liabilities are discounted with a technical interest rate equal to the guaranteed rate. An additional interest rate provision (Zinszusatzreserve) is imposed for a specific type of funds ("regulated Pensionskassen"). This provision is a constituent part of the premium reserve which companies must put in place for policies for which the reference interest rate – derived from the 10-year average of yields on zero-coupon euro interest rate swaps with a 10-year maturity – is lower than the original technical interest rate of relevance for the premium reserves.
	ES	Other	The maximum discount rate is determined annually by the supervisor and is currently the average Spanish public debt rate from the last quarter of the exercise (1.96% in 2015). In some cases, higher discount rates than the one provided by the supervisor is allowed, depending on the plan's profitability.
	IT	Other	Discount rates vary across DB plans and may depend on the expected returns on assets. Regulation imposes a cap on discount rates, currently set at 5 percent. The average discount rate at end-2016 is estimated at 3.4%.
	LU	Fixed discount rate	
	NL	Market rate plus UFR-extrapolation	Euro swap rates, for different maturities along the yield curve; beyond 20-year maturities extended by an add-on that converges to the UFR set by the Netherlands Bank, which is based on a 10-year moving average of the 20-year rate (2.5% end-2017).
	SE	Market rate plus UFR-extrapolation	A combination of market rate and ultimate forward rate (a structure).
	UK	Market rate	Long-term gilt yields.
Asia	JP	Expected returns	Liabilities are adjusted in line with expected return on asset (pension funding regulation).

Qualitative results of the survey:

Investment:

- Capitalisation insurers improved (AU/DE), partly by regulation (DE).
- Increasing use of ALM/LDI (CA, SG), pension funds hedge 50% of duration gap.
- Interconnectedness insurers and banks reduced (AU, DE, NL).

Changes within business model:

- Reduction guarantees (across the board), guaranteed products with more flexibility (BE). Suspension of indexation DB schemes (CA, NL). Guarantees practically zero (FR).
- Insurers introduce buy-back incentives, ie surrenders in low-rate environment (BE).

Shifts to other business model:

- Shift from DB to DC (SE, NL, UK, CA) and from non-linked to unit-linked (FR, NL, SE, UK, BE, CA). This shift has taken place for long time, not just due to low interest rates. Slow change in terms of total assets, but in terms of premiums unit-linked market share has increased rapidly (in FR premiums unit-linked higher than non-linked).
- Also shift from life insurance to protection (HK, JP).
- Most DB schemes closed, even for accruals existing members (UK). Almost 9% life business in run-off, which helps to reduce costs (DE). Buy-outs: insurer takes over pension business.

Regulation:

- Guaranteed rate capped (FR), in practice guarantees are zero.
- Macroprudential tool to suspend surrenders (FR).
- New regulatory framework Solvency 2 for insurers (EU), more market/risk-oriented. More risk-based framework (SG).
- Removal requirement to annuitise pension benefit (UK); IC loose annuity business but instead become more active taking over pension business.
- Stricter reserve requirements (DE).

Taxes:

- Various reductions in tax incentives (not necessarily related to low rates): SE has abolished tax deduction premiums for private pensions, AU has introduced a cap on tax-free pensions/annuities, NL has phased out tax-favoured mortgage products with life insurance component and capped tax deductibility pension premiums, BE has increased tax on life insurance products, CA has reduced tax exemption life insurance products.

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