

Negative Interest Rates

Taking Stock of the Experience So Far

*Prepared by Luís Brandão-Marques,
Marco Casiraghi, Gaston Gelos,
Güneş Kamber, and Roland Meeks*

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Executive Summary

Starting in 2012 several central banks introduced negative interest rate policies (NIRP) that brought up many important questions: To what extent would negative policy rates be transmitted to other interest rates? Would there be counterproductive effects, with economic agents hoarding cash and financial intermediaries reducing lending? Would the introduction of NIRP bring about disruptions in the functioning of money markets? Moreover, NIRP was and remains politically controversial, partly because it is often misunderstood. Because the COVID-19 crisis emerged in an environment wherein many central banks lack conventional monetary policy space, NIRP is back in the forefront.

This departmental paper aims to take stock of the experience with NIRP so far. It summarizes the evidence accumulated since the discussion in IMF (2017) and complements several existing surveys of unconventional monetary policies. This paper focuses on NIRP and covers a broad range of its effects, with a detailed discussion of findings in the academic literature and of broader country experiences.

The transmission of NIRP has been effective in money market rates, long-term yields, and bank rates. In particular, NIRP has contributed significantly to the fall in longer-term yields following the initial rounds of cuts pushing policy rates below zero. Rates on corporate deposits have dropped more than those on retail deposits because it is costlier for companies to switch into cash. Bank customers have not markedly shifted to cash.

Bank lending volumes have generally increased, and overall, bank profits have so far not significantly deteriorated. In jurisdictions where banks increased lending, introduced fees on deposit accounts, or benefited from capital gains, bank profits have not suffered. It is conceivable, however, that the absence of a significant impact on profitability mostly reflects shorter-term effects,

which could potentially be reversed over time. And for banking systems with a heavier reliance on deposit funding and larger holdings of very liquid assets, or with smaller and more specialized banks, the impact of NIRP on lending has been weaker, and the negative impact on profitability larger.

NIRP has likely supported growth and inflation. The effects of NIRP on inflation and output may be comparable to those of conventional interest rate cuts or of other unconventional monetary policies. It remains an open question how much further interest rates could go negative before seriously impairing financial intermediation or inducing other negative side effects. However, since there is no evidence that the negative interest rates implemented thus far have triggered these problematic effects, there may well be latitude to push interest rates more negative.

Although a low-for-long environment creates significant financial stability concerns, NIRP per se does not appear to have compounded the problem. The accommodative monetary policy reaction to a lower equilibrium real rate (r^* , which itself is driven by structural factors) tends to induce a search for yield and lower bank profitability. The evidence so far does not indicate that NIRP as such exacerbates these effects. However, these side effects may still arise if NIRP remains in place for a long time or policy rates go even more negative.

The reasons why some central banks adopt NIRP while others resist it are likely related to institutional and other country characteristics. First, institutional and legal constraints may play a role (for example, some central banks may not have the authority to charge interest on bank reserves). Second, specific aspects of the financial system may heighten financial stability concerns related to NIRP. Finally, from a political economy point of view, it is likely to be difficult to introduce or deepen NIRP in economies with important constituencies that may stand to lose—in reality or in perception—from negative nominal interest rates.

The evidence so far also suggests that central banks should not rule out NIRP and keep it as part of their toolkit, even if they are unlikely to use it. If markets internalize that rates can be cut below zero, the shift in market expectations is likely to induce declines in longer horizon yields. This suggests a greater loosening effect of NIRP for countries that currently have low but positive rates. Ultimately, given the low level of the neutral real interest rates, many central banks may be forced to consider NIRP sooner or later, even if there are material adverse side effects.

Glossary

AE	advanced economy
APP	asset purchase program
AUM	assets under management
CGFS	Committee on the Global Financial System
CNAV	constant net asset value
DFR	deposit facility rate
DN	Danmarks Nationalbank
ECB	European Central Bank
ELB	effective lower bound
EMDE	emerging market and developing economy
EME	emerging market economy
FXI	foreign exchange intervention
GFSR	Global Financial Stability Report
IT	inflation targeting
MFI	monetary financial institution
MMF	money market fund
NAV	net asset value
NIM	net interest margin
NIRP	negative interest rate policy
QE	quantitative easing
QQE	quantitative and qualitative easing
SNB	Swiss National Bank

TLTRO	targeted longer-term refinancing operations
UMP	unconventional monetary policy
YCC	yield curve control
ZLB	zero lower bound

Introduction

Starting in 2012 several central banks introduced negative interest rate policies (NIRP) that brought up many important questions. Central banks in Denmark, the euro area, Japan, Sweden, and Switzerland turned to NIRP as their economies faced cyclical headwinds and, in the cases of Denmark and Switzerland, strong upward pressure on their currencies even after short-term policy rates had been pushed to about zero. These moves were accompanied by many questions. To what extent would negative policy rates be transmitted to deposit and lending rates? Might the effects be counterproductive, with financial intermediaries reducing lending? Would banks, companies, and households switch massively to cash holdings? What would be the effects on the yield curve as a whole? Would the introduction of NIRP bring about disruptions in the functioning of money markets? Concerns were also raised about financial stability implications stemming from a potentially significant shift to risky assets by financial intermediaries. Beyond these concerns, NIRP was and remains politically controversial, partly since it is novel, counterintuitive, and often misunderstood. The economic effects of the COVID-19 crisis, and associated prospects of a protracted recovery in an environment where many central banks have exhausted conventional monetary policy space, have brought the issue back to the forefront.

This paper aims to take stock of the experience with NIRP so far. It summarizes the evidence accumulated since the discussion in IMF (2017). Several existing good surveys also cover NIRP as part of broader assessments. These either discuss the effects of unconventional monetary policies (UMP) more generally, including quantitative easing (QE) and forward guidance (Bhattarai and Neely 2016; Dell’Ariccia, Rabanal, and Sandri 2018; and CGFS 2019), cover low interest rates more broadly (CGFS 2018), or zoom in on one aspect of NIRP (for example, Brown [2020] on NIRP and bank lending). However, the specific aspects of NIRP deserve a deeper discussion, and an overall assessment of the effectiveness or desirability of NIRP should be based

on its effects on the decisions of households, banks, and firms, in addition to asset prices and the overall economy. Hence, in contrast to other surveys, this paper focuses on NIRP, and covers a broad range of its effects. It comprises both a discussion of detailed findings in the academic literature and of broader country experiences, and points to open issues.

Overall, NIRP has likely supported growth and inflation. The evidence on the macroeconomic effects of NIRP remains sparse, partly because it is challenging to separate the effects of NIRP from those of other concurrent UMP measures. Still, for the euro area, NIRP seems to have had small but positive effects on inflation and growth (Rostagno and others 2019) and boosted corporate investment (Altavilla and others 2019b). In addition, in Japan, NIRP may have supported the economy through the exchange rate channel (Honda and Inoue 2019). Overall, the available evidence so far suggests that effects of NIRP on inflation and output may be comparable to those of conventional interest rate cuts or of other unconventional monetary policy.

The transmission of NIRP has been most visible in money market rates, but long-term yields have also responded. Across jurisdictions, money market rates have tracked policy rates closely as the latter moved below zero (Eisenschmidt and Smets 2019). NIRP also has contributed to the fall in longer-term yields, especially following the initial rounds of cuts pushing policy rates below zero, though some of the decline in long yields probably also reflects the coincident implementation of asset purchase programs (APPs) and enhanced forward guidance. No substantial disruption in money markets have been observed to date.

Deposit rates for non-retail customers and some lending rates have also fallen. In Denmark, the euro area and Sweden, where central banks cut interest rates multiple times into negative territory, these rates slowly dropped following each easing round. The decline in deposit rates has been more pronounced for corporate deposits, in line with the notion that, compared to retail depositors, it is costlier for companies to switch into cash (CGFS 2019). However, banks reacted by raising fees on retail deposits. There also is evidence that these cuts have helped to lower lending rates in the euro area and Switzerland, even if it is difficult to measure the effects because of many confounding factors (for example, the simultaneous announcement of targeted longer-term refinancing operations [TLTROs] in the euro area).

For the most part, bank lending volumes have also responded positively. However, for banking systems with a heavier reliance on deposit funding and larger holdings of very liquid assets, the impact of NIRP is weakened. This implies less stimulus to investment, consumption, and economic activity in general.

In general, bank profits have not significantly deteriorated. This is due to an increase in lending, the introduction of fees on deposit accounts, and the realization of capital gains. However, the evidence is not fully conclusive, since smaller and more specialized banks appear to have been adversely affected and some uncertainty about the effects of NIRP over the long term persists. That being said, the fact that NIRP has now been in place for five or more years without significant adverse effects on bank profitability is reassuring.

So far, there has not been a marked shift toward cash, although euro area banks have increased their cash-in-vault holdings. All in all, there is no evidence of a widespread increase in the use of cash in countries that have implemented NIRPs. Moreover, there is no clear indication that the introduction of NIRPs has been followed by an increase in vault cash in most countries. One exception, however, is the euro area, where vault cash held by monetary financial institutions (MFIs) remained stable during initial NIRPs announcement but started to rise significantly from 2016 when the European Central Bank (ECB) lowered a key policy interest rate to -40 basis points.¹

Overall, NIRP appears to have been effective, but it remains unclear how much further negative rates could go before inducing adverse effects. Estimates of how low policy rates can be before encouraging a wholesale switch to cash (typically referred to as the effective lower bound, ELB) have been revised downward across countries. In addition, the limit on NIRP after which financial intermediation by banks becomes seriously impaired (often referred to as the reversal rate) is still unknown. However, differences across countries in the structure of their financial systems play an important role in determining the degree to which NIRP can be deepened (Tenreyro 2021). For example, the scope for reducing rates further in negative territory will be more limited in banking systems with more retail-oriented deposit funding, given that retail deposit rates, especially those held by households, appear to have a zero lower bound (ZLB). And politically, introducing or deepening NIRP in financial systems with an important presence of financial intermediaries that may stand to lose from nominal interest rates becoming negative (for example, money market funds) is likely to be more difficult.

Although a low-for-long environment creates significant financial stability concerns, NIRP per se does not appear to have compounded the problem. The accommodative monetary policy reaction to a lower equilibrium real rate (r^* , which itself is driven by structural factors) tends to induce a search for yield and lower bank profitability. The evidence so far does not indicate that NIRP as such exacerbates these effects.

¹Vault cash has been increasing in the United States as well, despite the fact that policy rates have remained in positive territory.

The evidence so far also underscores the notion that central banks should not rule out NIRP and should keep it as part of their toolkit. This is true even if they are unlikely to use it: when markets internalize that rates can be cut below zero, this is likely to translate into declines in longer horizon yields. This would suggest a greater loosening effect of NIRP for countries that currently have low but positive rates. Ultimately, given the low level of the neutral interest rate, many central banks may be forced to consider NIRP sooner or later, even if there are material adverse side effects.

The paper first discusses the conceptual underpinnings of NIRP and then, based on those, summarizes the existing empirical evidence and discusses specific implementation challenges. In Chapter 1, the paper attempts to derive a set of predictions about the effects of NIRP. Focusing on recent results, Chapter 2 reviews the fast-growing academic literature that attempts to quantify the effects of NIRP. Chapter 3 covers two operational challenges of NIRP: reserve tiering and communication. The concluding chapter identifies the shortcomings in the existing empirical evidence and suggests directions for future work. Details on country experiences are provided in the Annex 1.

Conceptual Issues

Negative Interest Rates as a Policy Option

Why Seek Negative Policy Rates?

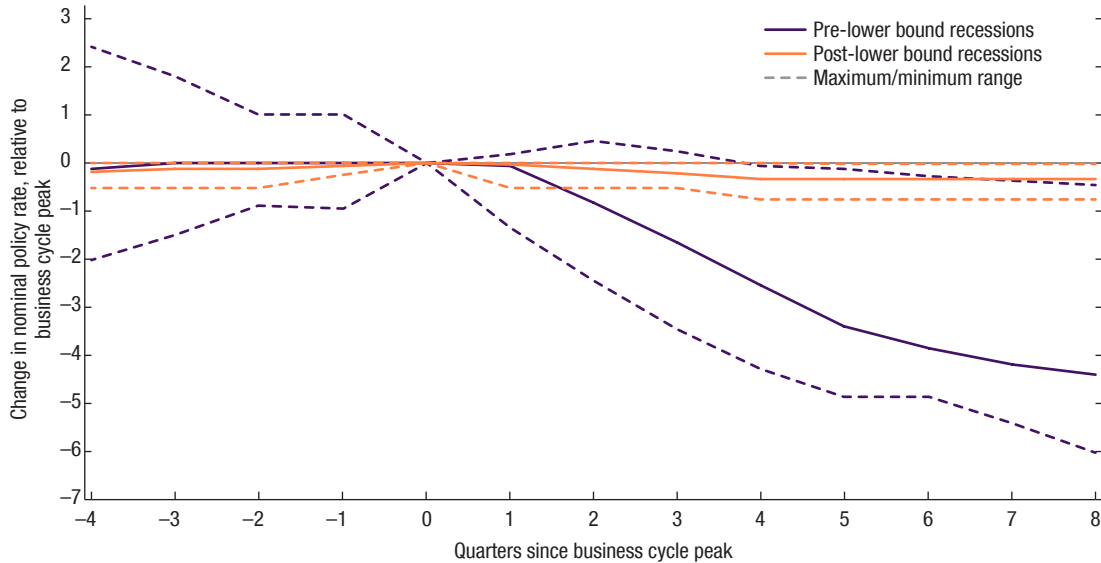
Central banks adopted NIRP against the backdrop of low neutral real interest rates, when the room for conventional policy easing had been exhausted. The neutral real rate of interest—the level of real rates at which demand equals potential output, and therefore there are no inflationary or deflationary pressures—has been declining globally, and in many advanced economies (AEs) is estimated to be close to zero (among others, see Del Negro and others 2019).¹ With inflation targets of about 2 percent, this has resulted in very low nominal interest rates as well. Whereas the median policy easing for AEs prior to the global financial crisis, after which neutral rates declined markedly was about 5 percentage points, in the following decade central banks implemented only small cuts when recessions struck (Figure 1). Achieving sufficient stimulus when neutral rates are low can require policy rates to be set below zero. Therefore, central banks turned to NIRP as part of a range of unconventional policy measures (Dell’Ariccia and others 2018).

NIRP and Other Unconventional Policies

An attractive characteristic of NIRP: it can reinforce the effects of forward guidance. Unconventional monetary policies such as forward guidance and APPs have frequently been deployed in concert with NIRP. One of the reasons is that these measures may often have mutually reinforcing effects,

¹The average level of the neutral rate over long periods is thought to be influenced principally by real economic forces—in particular, the economy’s rate of technological progress, demographic trends, and factors affecting the global balance of saving and investment. Monetary policy itself is not thought to be a principal determinant of the neutral real rate.

Figure 1. Median Policy Easing during AE Recessions, 1990–2019
(Percentage points)



Source: Haver Analytics; IMF staff.

Note: The figure shows changes (median, minimum, maximum) in policy interest rates around business cycle peaks between 1990 and 2019, for Canada, euro area (Germany until 1999), Japan, the United Kingdom, and the United States. Business cycle peaks (according to jurisdictional business cycle dating committees): Canada = 1990:Q1, 2008:Q4; EA = 1992:Q1, 2008:Q1, 2011:Q3; Japan = 1991:Q1, 1997:Q2, 2000:Q4, 2008:Q1, 2012:Q1; UK = 1990:Q2, 2008:Q1; US = 1990:Q3, 2001:Q1, 2007:Q4. “Pre-lower bound” recessions are taken to be those prior to 2009, aside from Japan, for recessions prior to 1999.

even if this was not always clear at first. The complementarity in the case of forward guidance is particularly direct, as both policies influence beliefs about the path of interest rates. By influencing beliefs about the lower bound of interest rates (Grise, Krogstrup, and Schumacher 2017), NIRP reinforces the effect of forward guidance announcements that aim to lower long-term yields. By reducing the perceived asymmetry in possible future interest rate paths—through indicating that rates can go lower as well as higher—NIRP can lower the expected path of future rates and so long rates.²

NIRP can also be seen as a substitute for forward guidance when the credibility of the latter is imperfect. Forward guidance has been deployed when private sector expectations for rate hikes were running ahead of policymakers’ own expectations, with announcements inducing a flattening of the yield curve. The efficacy of these announcements hinges on their credibility, which is not observable. NIRP, however, is an observable action and could be more credible and, thus, more effective (Sims and Wu 2020). Furthermore, forward guidance is often viewed as a way to overcome the ZLB and NIRP, by allow-

²The Federal Reserve Board’s August 9, 2011 announcement had precisely this effect (FOMC 2011).

ing the central bank to track more closely the natural rate of interest, in part removes the need for such forward guidance (Rognlie 2016).

The interaction between NIRP and APPs is likely to be more complex. Just like NIRP, APPs also work through a “signaling channel” (Krishnamurthy and Vissing-Jorgensen 2011).³ Therefore, to the extent that the signaling channel of NIRP is material, negative rates may reinforce the effectiveness of APPs in the same manner that they reinforce that of forward guidance. In addition, since APP flattens the yield curve, NIRP may mitigate APP’s negative effect on bank profits from maturity transformation by removing the ZLB constraint on policy rates, as long as they remain above the reversal rate. However, there are circumstances under which APPs may detract from NIRP. This is because APPs increase the amount of bank reserves and, hence, the burden of NIRP on bank profits. Thus, for a sufficiently large central bank balance sheet, the contractionary bank lending channel may offset the expansionary signaling channel of NIRP (Sims and Wu, 2020).

What Are the Limits to Negative Policy Rates?

The Effective Lower Bound

The existence of cash means that zero is a special number for nominal, but not for real, returns. Real interest rates routinely fall below zero, often because inflation is higher than expected. Consequently, in general, zero has no special status when it comes to real rates of return on assets (Bernanke 2016). But a negative return in nominal terms is special thanks to the existence of physical cash, which is technologically constrained to maintain a constant face value.⁴ This constraint means that the return on cash dominates the return on assets that are close substitutes, such as central bank reserves and bank deposits, and pay negative nominal interest rates. Hicks (1937) used this observation to argue that the existence of cash placed a lower bound of zero on nominal rates, and the same basic assumption has been embedded in much subsequent analysis. However, storage and insurance costs mean that the nominal return to large amounts of cash can be negative.

³In this view, financial markets may in part interpret APPs as a commitment by the central bank to keep policy rates low. The signal is credible, so the argument goes, because raising rates while holding a large portfolio of long-duration assets would lead the central bank to take losses, which may lead to political or reputational costs.

⁴Various schemes have been suggested to relax the technological constraint on constant face value through varieties of tax or other administrative measures, or by the abolition of physical cash itself, including through the adoption of central bank digital currencies (Rogoff 2017a, 2017b; Assenmacher and Krogstrup 2018; and Agarwal and Kimball 2019). If successful, such schemes would lower the ELB, but this paper does not evaluate them.

Negative rates may induce banks to move reserve holdings to cash in vaults. Banks demand central bank reserves because they need it to settle transactions, and in some jurisdictions because of regulation.⁵ An overnight deposit with the central bank is an extremely close substitute for cash: both are liabilities of the central bank; are riskless in nominal terms; and are liquid, in the sense of being immediately available. Indeed, central banks typically guarantee the convertibility of central bank reserves into cash. This very close substitutability means that a policy rate below zero generates an incentive for banks to switch from central bank deposits into cash.⁶ However, the incentive for banks to switch out of reserves as nominal rates fall below zero is tempered by the practical difficulties of a wholesale move into cash. For example, shifting to cash settlement on the scale needed in large economies would be a vast logistical undertaking.

Negative rates would also make cash attractive for some households and firms. However, bank deposits offer obvious advantages over cash: deposits offer the convenience of electronic payments and holding large quantities of cash securely is costly. But for households and firms with smaller liquid asset balances, and less-frequent needs to make larger transactions, deposits may be flightier. Nonlinear effects may be conceivable, with massive cash withdrawals occurring if rates become sufficiently negative (IMF 2007).

Therefore, interest rates cannot be reduced below a technical minimum, known as the ELB, which may be below zero in many economies. The ELB is the interest rate below which there would be a move away from assets that carry nominal interest charges into cash, which is always redeemable at its nominal face value. Its primary determinant is generally taken to be the cost of storing and holding physical cash, which, given a zero nominal return, locates the ELB at or below zero interest rates in AEs,⁷ although it could be higher in emerging market and developing economies (EMDEs).⁸ So far no

⁵In a system with reserve requirements (a minimum ratio of reserves to certain types of commercial bank deposit), those requirements may be met with vault cash rather than deposits in some jurisdictions. This was mostly the case in the United States prior to the global financial crisis, for example. But in other important jurisdictions, such as the euro area, cash is ineligible for meeting reserve requirements. Recent liquidity regulation means that banks must hold “high quality liquid assets: such as reserves and government bills in proportion to certain short-term wholesale liabilities. When policy rates are negative, the rates on government bills are likely to be negative too.

⁶For example, Federal Reserve Board staff estimated that short-term rates could not be driven below –30/–35 basis points without triggering large withdrawals of reserves by banks (Burke and others 2010).

⁷Although this cost has likely remained stable over time, financial innovation may cause to fluctuate. For example, the dissemination of privately sponsored digital currencies as an alternative to cash could raise the ELB.

⁸For example, the Central Bank of Chile recently stated that the “technical minimum for its policy rate was 50 basis points.” See Central Bank of Chile (2020).

Table 1. Estimates of the Effective Lower Bound

Country	Estimate (percent)	Source
Canada	–0.25 to –0.75	Witmer and Yang (2015)
Czech Republic	–0.2 to –0.6	Kocunová and Havránek (2018)
Denmark	–1.5	Rostagno and others (2016)
Euro area	–0.7	Rostagno and others (2016)
Sweden	–1.6	Rostagno and others (2016)
Switzerland	–0.5	Rostagno and others (2016)
United States	–0.35	Burke and others (2010)

Source: IMF staff.

jurisdiction appears to have set a rate low enough to precipitate a material shift into cash.⁹

Estimates of the ELB vary and reflect different assumptions about storage, transportation, and insurance costs associated with holding large amounts of currency. The costs associated with holding and using cash are likely to vary across countries. For instance, storage costs depend on the largest denomination banknote available in each jurisdiction during the implementation of NIRP. Estimates for Canada, for example, imply an ELB between –25 and –75 basis points, with a midpoint estimate of –50 basis points.¹⁰ Similar estimates hold for the Czech Republic, euro area, and the United States and are somewhat lower for Denmark and Switzerland (Table 1).

The Effective Lower Bound in Emerging Market and Developing Economies

In EMDEs, policy could be constrained by a positive ELB. There are a few reasons why the ELB in EMDEs may be positive. First, emerging market economies are typically more exposed to higher risks of currency substitution and capital flight, with investors demanding a risk premium on domestic currency assets (that is, in this context, the relevant concept of ELB is not the switch to banknotes but to foreign currencies). Second, financial inclusion is lower, cash usage more common, and households may more readily move away from bank deposits into domestic cash (that is, a higher ELB).¹¹ Therefore, despite low inflation and subdued economic activity, emerging mar-

⁹Since, as mentioned above, retail deposits may be flightier the lower bound for these deposits may be higher than the lower bound on reserves.

¹⁰Witmer and Yang (2015) look at data on the costs to store and insure precious metals and find that the cost of holding cash ranges between 25 and 50 basis points. If cash is used to settle payments twice a month, the same authors estimate that transportation costs would amount to 25 basis points.

¹¹It is usually accepted that efforts consisting in lowering the usage of cash and promoting access to financial products are important to boost financial inclusion and limit informality. NIRPs could be counterproduc-

kets' central banks may be willing to keep a positive interest rate differential with AEs' interest rates. This, in turn, could prevent emerging markets from adopting NIRP.¹²

Reversal Rates and Other Technical Minima

Even above the ELB, central banks may be unwilling to cut rates below a certain level for fear of adverse effects on financial intermediaries and credit dynamics. The interest rate below which these adverse effects could seriously impair or even reverse the pass-through of policy rates to lending and deposit rates is the “reversal rate.”¹³ The reversal rate may lie above, at, or below the ELB.¹⁴ Unlike the ELB, the reversal rate depends on the composition of financial intermediaries' balance sheets and income, including their capitalization (Darracq Pariès, Kok, and Rottner 2020). Consequently, policy measures that affect the structure of intermediaries' balance sheets (for example, micro- and macroprudential regulations) or the marginal returns to lending, such as TLTRO, as well as implementation details, such as tiering, contribute to determining the location of the reversal rate. For example, for jurisdictions wherein a material share of credit is provided by banks that rely heavily on retail deposits (which are thought to be sticky at zero), NIRP may have adverse effects on bank profitability, thus increasing the reversal rate. Such arguments were made for the UK case when interest rates there were cut to 50 basis points in 2009. However, the reversal rate may well be subject to change as the financial positions of key intermediaries change, as illustrated by the Bank of England's subsequent reduction in rates to 10 basis points in the wake of the 2016 Brexit referendum.

The terms ELB and reversal rate are often used interchangeably, even in central bank communications. As discussed, the ELB and the reversal rate represent two different economic concepts. The confusion between the two hinders an informed debate regarding how low policy rates can go in negative territory. The term ELB is often used to denote a threshold below which the

tive in this context since they may increase the role of cash as a store of value and lower the opportunity cost of tax evasion.

¹²Another reason could be that most EMDEs are running persistent current account deficits and need to attract capital flows to finance these deficits. Notably, so far, countries that have implemented NIRPs have been AEs with current account surpluses.

¹³In principle, the reversal rate could be positive, although this appears to be unlikely in practice for jurisdictions currently implementing NIRP. However, in EMDEs, the reversal rate could be positive (that is, there could be a positive interest rate below which monetary easing can be contractionary) because of the way capital flows and collateral constraints interact (Cavallino and Sandri 2020).

¹⁴That is, central banks may estimate that they will reach the reversal rate before reaching the “technical” minimum represented by the ELB. Alternatively, the reversal rate may be so low as to be unreachable (as policy would lose traction because of a shift to cash before hitting it).

central bank deems it undesirable, rather than infeasible, to cut policy rates beyond, which is instead the *reversal rate*. However, central banks usually refer only to the ELB, without distinguishing between technical minima, and “reversal” rates.

The Expected Effects of Negative Interest Rates

NIRP is expected to provide substantial monetary accommodation and to boost aggregate demand. NIRP supports economic activity and inflation through the same channels as conventional interest rate cuts. However, NIRP may induce discontinuities in the behavior of households, firms, and financial intermediaries which may yield different effects compared to rate cuts above zero. One example is the increased demand for cash by the private sector, which was discussed above. Other potential discontinuities are discussed next.

Effects on The Yield Curve, Bank Rates, and Exchange Rates

Central banks can affect the entire term structure of interest rates by changing the expectations of future short-term interest rates or by influencing term premiums. Indeed, long-term rates reflect expectations about future short-term rates and the level of risk premiums, which amount to the compensation that investors demand for holding a nominal bond with an uncertain payoff. Changes in the central bank’s policy rate (a very short-term rate) will affect interest rates at longer maturities to the extent that they are interpreted to be persistent and, thus, affect market expectations about the future path for policy rates.¹⁵ Unconventional monetary policy, through forward guidance and other unconventional measures, can also affect term premiums.

If term premiums are positive, the presence of a lower bound on short-term nominal interest rates places a similar constraint on interest rates all along the term structure. But IMF estimates show that since 1998, across the major bond markets, term premiums, at their lowest point, have fallen to about –1 percent (IMF 2019, Figure 1.2). Therefore, longer-term bond yields would likely remain in positive territory if the long-term nominal neutral rate is above (positive) 2–3 percent. At the same time, with a natural rate below this threshold, long-term nominal rates may fall below zero even without policy rates going negative.

¹⁵There is the possibility that central banks reduce uncertainty about future policy rates through forward guidance and, as a consequence, reduce the term premium (Bundick, Herriford, and Smith 2017). Conversely, if the reductions in term premiums achieved via quantitative easing-induced portfolio rebalance affect the economic outlook, they can also affect the expected path of future policy rates (Bernanke 2020).

A one-time revision in investor beliefs about negative rates could produce an outsized effect on long-term yields. If an announcement of negative policy rates causes investors' expectations of future rates to be revised down, longer-term yields will tend to fall too. The extent of the fall naturally depends on how long policy rates were expected to be at their lower bound. But where the removal (or reduction) of the bound is unexpected, and causes expectations of the path of rates to be materially lower over the medium term, the impact is likely to be stronger and likely be felt further along the term structure (Grise, Krogstrup, and Schumacher 2017; de Groot and Haas 2020).

The degree of pass-through of negative policy interest rates to bank lending and deposit rates is likely to differ from country to country. In theory, pass-through should depend on a host of factors, including the relative importance of retail and wholesale deposits for bank funding, the competitive environment in which banks operate (for example, the degree of contestability of the markets for bank deposits and loans), the degree of adjustment costs, the prevalence of fixed-rate relative to variable rate loans, and the elasticities of demand for loans and deposits (Cottarelli and Kourelis 1994, Borio and Fritz 1995, van Leuvensteijn and others 2013). The speed and extent of pass-through will also tend to change over time as those factors vary (Hristov, Hülsewig, and Wollmershäuser 2014).

Generally, exchange rates are expected to respond to interest rate cuts below zero as they do when interest rates are positive. However, it is possible that the sensitivity of the exchange rate to interest rate differentials increases when rates become negative. One reason could be that the adoption of NIRP affects not only the level but also the distribution of the expected policy rates over the medium term.¹⁶ Another reason could be that “preferred habitat” effects (Vayanos and Vila 2009) cause exchange rates to behave differently once central banks adopt NIRP: suppose that only cross-border flows by mutual funds and other institutional investors are sensitive to interest rate differentials when rates are positive. However, when central banks adopt NIRP, it may be the case that a broader class of cross-border flows, including bank flows, also become sensitive to interest rate differentials. If these assumptions were true, they would imply an increased sensitivity of cross-border flows and exchange rates to interest rate differentials once rates become negative.

However, the literature seems to have largely overlooked the role of NIRP in the context of monetary regimes that target exchange rates. By contrast, a growing number of papers study whether central banks that hit the ELB can

¹⁶Rostagno and others (2019) find that a similar mechanism can contribute to explaining the increased effectiveness of forward guidance in the euro area.

resort to foreign exchange intervention (FXI) to provide additional monetary stimulus (for example, Svensson 2003, Adrian and others 2020). These findings further support the view that FXI and NIRP could work as substitutes.¹⁷

How Might Negative Nominal Rates Affect Households' Portfolio Choices?

The introduction of negative nominal rates may induce discontinuities in households' behavior. Households may suffer from some degree of money illusion (confusing real and nominal quantities), or be extremely uncertain over the rate of inflation, which will make them dislike negative nominal rates more than negative real rates.¹⁸ Or they may see an explicit and visible “penalty,” in the form of negative rates, as unfair in a way that a more obscure “fee” or “charge” on their bank deposit or mutual fund is not. Such attitudes may combine with preferences that are not in line with standard expected utility theory. One example of such preferences is given by prospect theory (Kahneman and Tversky 1979) whereby the response to losses is more intense than the response to gains—in this case nominal losses and gains—a situation known as “loss aversion.” Another related example is aspiration-level theory whereby individuals want to reduce the probability of losses (that is, not meeting a level of aspiration)—a behavior called “loss probability aversion” (Diecidue and Van de Ven 2008). Under both theories, the introduction of negative rates could induce a sudden shift in household portfolios (for example, into more risky assets).¹⁹

¹⁷However, these results may not necessarily apply for countries where, for instance, the monetary regime differs from inflation targeting.

¹⁸In surveys of household inflation expectations, sizable proportions of respondents choose “Don't know” as a response to questions about near-term inflation rates (for example, Coibion, Gorodnichenko, and Weber 2019).

¹⁹In both prospect theory and aspiration-level theory, zero is a special number—a reference point—for portfolio allocation. Both theories predict large changes in the composition of portfolios—risky vs. safe assets—for small changes of the risk-free rate around the reference point. However, prospect theory would require a high level of loss aversion (that is, a much steeper value function for losses than for gains) to generate significant changes in portfolio allocations once risk-free rates turn slightly negative. Alternatively, aspiration-level theory can produce large shifts in allocations by introducing a discontinuity in the value function around the reference point. Although similar, these two theories have slightly different implications: while prospect theory predicts the effect of interest rate cuts on portfolio choice to be the same when going from positive to negative and from negative to further negative, aspiration-level theory predicts the first cut into negative territory to have the largest effect. In contrast, under expected utility theory, a decline in the risk-free interest rate could discourage risk-taking via wealth effects.

How Might Negative Nominal Rates Affect Commercial Bank Profits and Lending?

Banks' net interest margins (NIM) may suffer. If bank reserves pay a negative nominal interest rate, then bank income will decline if they cannot pass on the cost to their own depositors. Banks typically have some market power because retail customers value the safety and convenience of bank deposits, and because switching accounts to take advantage of better rates is seen as troublesome.²⁰ But if retail customers are strongly resistant to negative rates, for the reasons discussed above, banks that wish to maintain deposit funding must accept lower profits.²¹

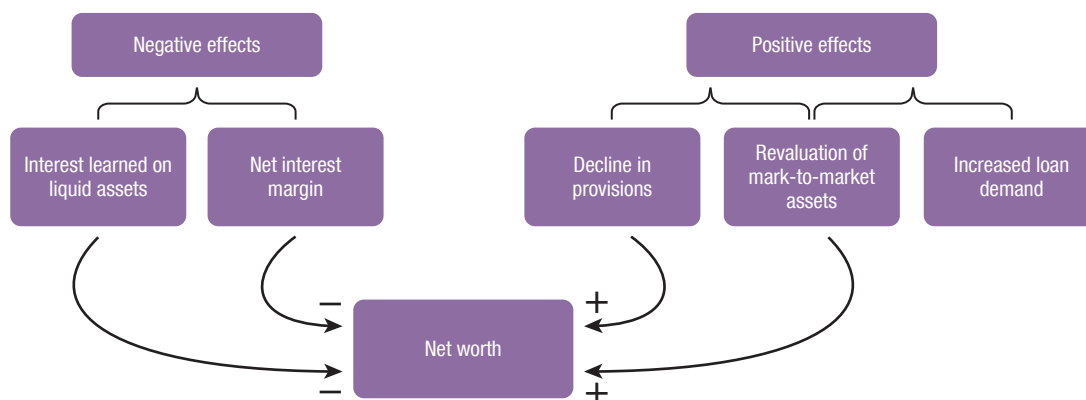
On the other hand, negative rates may support banks' net worth by boosting asset values and improving loan quality. The direct impact of NIRP on banks' NIM may be offset by positive effects on other sources of income. If NIRP has the intended effect of easing economic conditions, the extent of provisioning charges declines along with borrowers' improved ability to repay their loans. For tradeable assets, a similar revaluation may occur, and is reflected in mark-to-market gains. The equity value of the bank is potentially improved through both of these channels. But this benefit is transitory—capital gains are a one-off, and new loans will be priced to reflect better conditions.

When the negative net income effect outweighs the positive net worth effect, cuts in rates may hurt lending (Figure 2). A rich literature examines how incentive problems of various types can constrain the extent to which bank creditors are willing to fund their activities (see for example, Kashyap and Stein 1995, and Holmström and Tirole 1997). More recently, Brunnermeier and Koby (2019) have developed a simple model in which optimizing banks may respond to rate cuts with higher (rather than lower) loan rates, causing credit volumes to fall rather than to rise. The effect comes about because banks face constraints on their leverage and on their holdings of liquid assets. If negative rates cause bank net worth to decline too much, that leverage constraint becomes binding.²² To increase profits, banks then optimally choose

²⁰In many jurisdictions, some form of deposit insurance scheme provides safety to retail depositors.

²¹An alternative action on the part of banks would be to allow deposit funding to flow out. When deposits are transferred from one bank to another, reserve balances shift along with them, leaving the aggregate amount unchanged. Allowing deposits to leave would therefore allow the bank, but not the banking sector as a whole, to save on the costs associated with reserves that pay negative rates. In countries where reserves are abundant, such as the United States, such a policy may be feasible (for an individual bank, although not for banks as a whole) but probably not desirable. Liquidity regulations such as the Basel III Liquidity Coverage Ratio require banks to hold high-quality liquid assets in proportion to certain types of market funding, and reserves are preferred by large banks as they provide the most readily available form of liquidity.

²²The link between bank net worth and policy rates drives this bank-capital channel of monetary policy (Van den Heuvel 2001, Disyatat 2011). When rates are not too low and as long as banks have positive duration gaps (that is, the duration of their assets is longer than that of their liabilities), rate cuts should increase banks' mar-

Figure 2. Potential Effects on Bank Net Worth

Source: IMF staff.

to charge a higher rate than otherwise on the marginal loan. At the same time, a binding liquidity constraint leads them to choose a higher deposit rate than otherwise, reflecting the elevated shadow value of liquid assets.

However, other mechanisms may lead banks to lend more or make riskier loans in response to shrinking profitability and low policy rates. On the one hand, when banks have significant market power (the key ingredient of a “deposits channel of monetary policy”), they may respond to lower intermediation margins caused by a policy rate cut by increasing lending (Drechsler, Savov, and Schnabl 2017, 2018).²³ On the other hand, banks may increase risk-taking and lend to riskier borrowers if NIRP reduces banks’ net worth (see Dell’Ariccia, Laeven, and Marquez 2014).²⁴

Therefore, the net effect of negative rates on bank profits and lending is mostly an empirical question. The impact of NIRP on banks should be greater, the larger the retail deposits in overall liabilities, the greater the overall dependence on net interest income, the larger their share of liquid assets, and the lower the pricing power. On the other hand, banks should benefit from higher asset values and improved loan performance. The balance of

ket value of equity and, consequently, their ability to lend. This may be reversed, however, when rates are below the reversal rates, as previously discussed.

²³The effect of NIRP on this deposits channel of monetary policy hinges on banks maintaining market power over depositors and facing an inelastic supply of deposits. However, a ZLB on retail deposit rates suggests some weakening of banks’ market power and of the deposits channel under NIRP (Brown 2020).

²⁴Dell’Ariccia, Laeven, and Marquez’s (2014) risk-shifting argument applies to interest rate hikes because those are perceived as having adverse effects on bank profitability. However, the argument also applies to NIRP (but not necessarily to low-but positive rates) if indeed it reduces bank profits.

these effects is uncertain, with more extended periods below zero tending to raise the likelihood that profitability could suffer.

What Could Be the Effects on Nonbank Financial Intermediaries?

Negative rates could potentially induce large outflows from money market funds (MMFs). Just like for banks, negative nominal interest rates are special for MMFs. This is because, in many jurisdictions, MMFs are in fact a form of narrow banks that issue short-term liquid liabilities and invest in liquid safe assets. Thus, like commercial banks, MMFs face the risk of redemptions when interest rates near the effective cost of holding cash. However, unlike commercial banks, MMFs work with very narrow interest margins because they have a limited ability to tilt the composition of their assets toward riskier, illiquid higher-yield assets.²⁵ A further complication arises for MMFs that offer constant net asset value or CNAV (for example, a constant 1 euro per share) with negative rates: such MMF models are either not sustainable, or forced to recur to share-cancelling mechanisms.²⁶ Finally, NIRP can encourage MMF exits because of the effect it may have on fund manager compensation, especially if management fees are a percentage of fund gross yields and these remain negative for a long time (Dwyer and others 2008).

Importantly, MMFs are likely to evolve and adapt their business model if interest rates become very negative and remain so for long. Faced with the risk of mass withdrawals, MMFs may start searching for yield to preserve their profitability and attractiveness to investors. Within the constraints set by regulation, MMFs will be able to adjust the composition of their portfolio and restructure the remuneration of their liabilities instead of exiting the market. This could in principle transform the industry, potentially making these intermediaries less liquid and riskier than they are now. These considerations are of primary importance in countries such as the United States, where MMFs represent a cornerstone of the financial system; a significant change in their balance sheet structure toward less-safe assets could threaten financial stability.²⁷ For instance, the functioning of short-term credit and Treasury markets could be affected if MMFs modified their business model.

²⁵This limited ability to reach for yield could either be because of regulatory and supervisory action or because of market discipline, whereby end investors redeem their MMF shares if they believe they have become too risky. However, this is not really a problem solely of NIRP but more generally of low interest rates (Di Maggio and Kacperczyk 2017).

²⁶CNAV funds are now disallowed in many jurisdictions, including the European Union. In the United States, CNAVs are not allowed for prime MMFs, but are still allowed for retail and Treasury-only MMFs (McAndrews 2015).

²⁷These funds are relatively more important in the United States and significant outflows could trigger funding disruptions for the financial and nonfinancial sectors (Burke and others 2010).

NIRP could exacerbate the search for yield and associated risk-taking by other nonbank financial institutions. In particular, life insurance companies and other institutional investors may have an incentive to increase risk-taking because of guaranteed positive nominal returns to their policyholders and requirements to hold a certain fraction of their assets as liquid (potentially negative yielding) government securities. It is not clear, however, that this would imply a discontinuity at negative rates in the behavior of these investors, rather than being a problem with low interest rates in general. In addition, especially for liability-driven investors such as life insurance companies, low and negative yields may have the opposite effect and cause them to increase their demand for negative-yielding safe assets (even to the detriment of cash) as they try to hedge duration risk (Domanski, Shin, and Sushko 2017; Shin 2017).

Cross-Border Spillovers

As with other unconventional monetary policies, NIRPs could have cross-border spillover effects. Unconventional monetary policies in AEs support the world economy by boosting asset prices globally and benefit trade via increased economic activity. At the same time, as they create a low return environment for investors, they could also cause excessive capital flows into emerging markets, appreciating their currencies and easing financial conditions. These effects could, in turn, lower the competitiveness of recipient countries and, at the same time, threaten their financial stability by fueling an excessive buildup of leverage.

The nature and channels of international spillovers could be different when interest rates are negative. One potential reason why NIRPs could have a different spillover effect is the possibility that the behavior and the sensitivity of capital flows and exchange rates to interest rate differentials could be different than when interest rates are positive, as mentioned previously. Alternatively, the different nature and combination of shocks that lead to the adoption of NIRP could influence the nature of spillovers. Cross-border bank lending may also be impacted by NIRP, if, for example, it leads to a decline in banks' lending activities, including cross-border bank lending. These effects could depend in part, however, on the currency denomination of international banking flows. For instance, although euro area and Japanese banks play an active role in extending credit to emerging markets, they mainly do so in US dollars (IMF 2019). Negative rates in jurisdictions such as the euro area or Japan could create an incentive to switch from US dollar-denominated foreign debt instruments issued in emerging markets to euro- or yen-denominated ones. This effect could be potentially stronger

if NIRPs tended to increase the interest rate differential between US dollar assets and those denominated in other major currencies.

Summary

All in all, several frictions could cause the adoption of NIRP to have different effects from those observed when rates are cut in positive territory. As illustrated earlier, the existence of cash and financial constraints of various nature could induce agents in the economy to react differently when facing negative nominal interest rates. Bounded rationality may also imply that household change their behavior when nominal rates turn negative. In other words, the adoption of NIRP and further rate cuts below zero could have nonlinear effects on a vast set of financial and macroeconomic variables.

The potential adverse side effects of negative rates may intensify over time. It is possible that the erosion of bank profits is gradual because potential losses in net interest income are initially compensated by trading and fee income. In addition, firms and households may be slow in switching out of bank deposits into cash. Thus, the benefit of the policy may be outweighed by its cost as time passes by (see Balloch and Koby 2020).²⁸ Consequently, NIRP would likely be seen as temporary, and therefore less effective.

The empirical question is whether these effects have materialized in the economies where central banks have adopted NIRP. Box 1 reports a summary of key potential implementation problems of NIRP.

²⁸In addition, the circumstances that cause the need for monetary easing may themselves be short-lived (for example, see Lane (2020) on the use of NIRP to counteract the COVID shock), even if this is not exclusive to NIRP.

Box 1. Potential Implementation Problems

Interest rate cuts into (or in) negative territory may produce responses in output and inflation that are different to those in conventional (positive) territory. Differences in the transmission of NIRP may occur for the following main reasons.

1. Agents, including households and banks, may avoid paying negative interest rates by increasing their use of physical cash. This may happen at rates not far below zero, limiting the implementation of negative rates.
2. Banks may be unwilling to pass negative rates on to depositors or borrowers.
3. Bank interest margins may shrink, and balance sheets may weaken over time.
4. The response of households and firms to rate cuts may be weaker than with cuts in positive territory, particularly if bank lending is materially affected.
5. There may be a reversal rate at which policy rate cuts become contractionary for bank lending; the reversal rate may lie above, or below, the ELB.
6. A prolonged period of negative interest rates may amplify financial stability concerns (for example, excessive risk-taking by financial intermediaries or exit of MMFs).
7. The effect of the first rate cut below zero on the yield curve may be larger than the effect of subsequent cuts to the extent that the introduction of negative rates caused agents to revise down their beliefs about the policy path.
8. The effects on the exchange rate may be stronger than rate cuts in positive territory.

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Overview of Empirical and Quantitative Evidence

This chapter provides an overview of the quantitative evidence on NIRP in Denmark, the euro area, Japan, Sweden, and Switzerland.¹ It covers several academic studies that try to quantify the effects of NIRP on cash usage, financial variables, the behavior of households, nonfinancial firms, banks, and MMFs, as well as on output and inflation. It also draws on the descriptive analysis of raw data and on technical studies published in policy reports.

The quantification of the effects of NIRP on financial variables and the macroeconomy is difficult for a variety of reasons. First, it is difficult to disentangle the effect of NIRP from other UMP measures. This is because almost all NIRP announcements have been accompanied by other UMP measures. Second, there are not many instances of policy rate changes in or into negative territory, which reduces the power of empirical approaches. Third, identification of causal effects is difficult. Those studies that allow clean identification (for example, by examining the high-frequency response of asset prices or using micro data) only provide indirect evidence. By contrast, studies that try to measure aggregate effects directly face important identification challenges. Fourth, the analysis of NIRP suffers from a selection problem: if countries that expect high costs from NIRP do not implement it and only economies that expect low costs do, empirical studies may underestimate potential side effects. Finally, NIRP has only been adopted in high-income economies with deep financial markets, which limits the scope for exploiting cross-country heterogeneity to identify the role of structural factors in shaping the transmission of NIRP.

¹These are the only countries so far wherein a key monetary policy rate has turned negative. Other central bank rates, but not key policy rates, have been at times negative in other countries (for example, Hungary) but these do not constitute examples of NIRP (see Jobst and Lin 2016).

Cash Usage

There is no evidence of a widespread increase in the use of cash in countries that have implemented NIRPs. In some countries the use of cash has grown over the last two decades, but there is no indication that these increases coincide with the introduction of NIRPs (Figure 3). In the euro area and Japan, the ratios of banknotes in circulation to nominal GDP have been trending up over the last two decades.² Sweden, by contrast, has seen a significant downward trend driven by a shift to digital transactions.³ In Denmark, the ratio has been stable but started to decline recently, driven by the fall in the highest denomination banknotes. In Switzerland, there had been an increase in the use of cash starting 2008, but the trend has reversed recently. Trends in the usage of cash have not shown significant changes in countries that have not adopted NIRP.

In most countries, the introduction of NIRP has not been followed by an increase in the vault cash (Figure 4). However, in the euro area, vault cash held by MFIs remained stable during the initial NIRP announcement but increased significantly after 2016 when the ECB lowered interest rates to –0.40 percent. However, this was mostly driven by German MFIs (ECB 2018). Vault cash has been increasing in the United States as well, despite the fact that policy rates have remained in positive territory.

Financial Variables

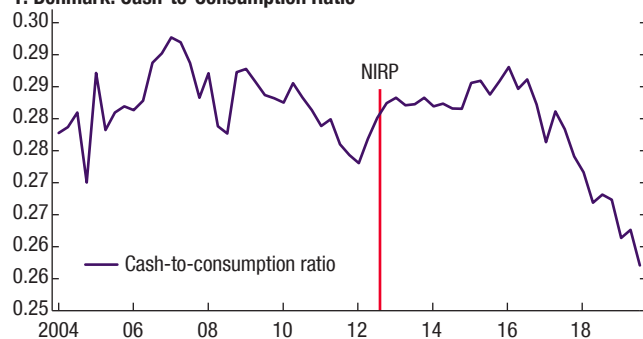
Have the effects of monetary policy on the price of financial assets become different when central banks adopt NIRP? In the presence of a properly functioning transmission mechanism, changes in monetary policy rates are reflected in short-term money market rates and passed from there to the entire yield curve of risk-free rates. The term structure, in turn, works as a benchmark to price risky assets, stocks, and corporate bonds. Despite many confounding factors, the data can provide clues as to whether NIRP involves significant changes in monetary policy spillovers to financial assets. This is discussed next.

Money Market Rates

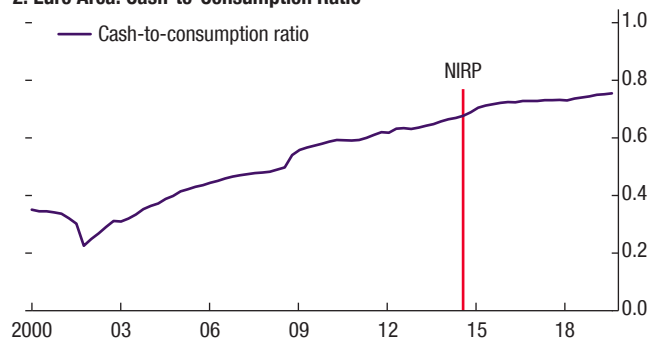
The impact of NIRP has been most visible in short-term money market rates. Across jurisdictions, they have tracked policy rates closely as the latter moved into negative territory (Figure 5 and Bech and Malkhozov 2016). NIRP

²The fall in 500 euro notes may be driven by the decision to discontinue issuance by the end of 2018.

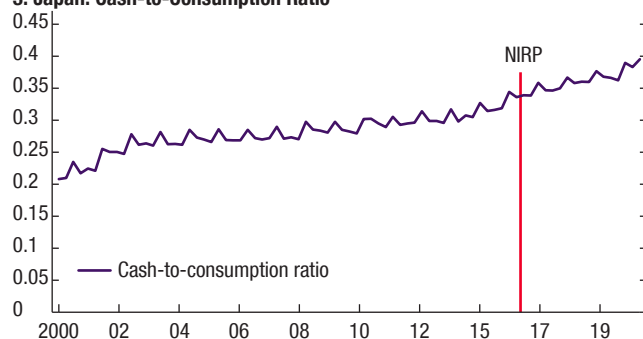
³A recent rise in banknote usage was related to the end of the banknote and coin changeover initiative that took place between 2015 and in 2017 and had depressed cash usage (Armeliuss, Claussen, and Reslow 2020).

Figure 3. Cash-to-Consumption Ratio**1. Denmark: Cash-to-Consumption Ratio**

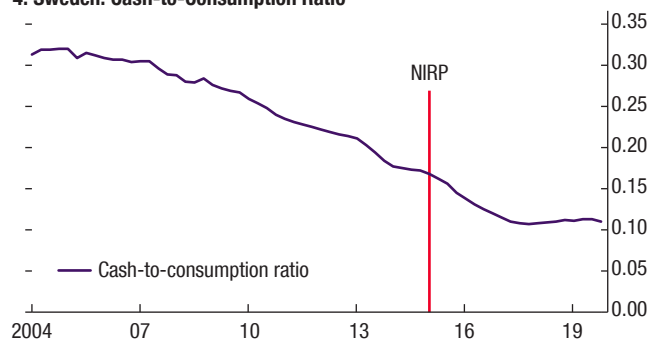
Sources: Danmarks Nationalbank; and Haver Analytics.

2. Euro Area: Cash-to-Consumption Ratio

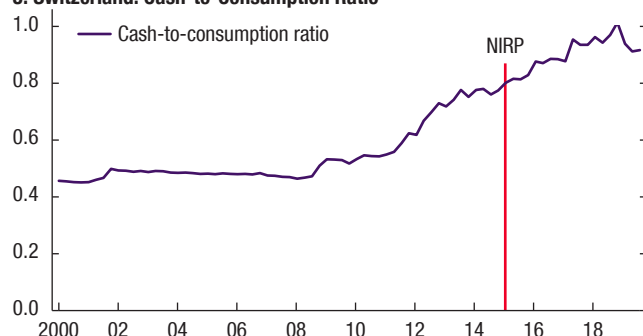
Sources: European Central Bank; and Haver Analytics.

3. Japan: Cash-to-Consumption Ratio

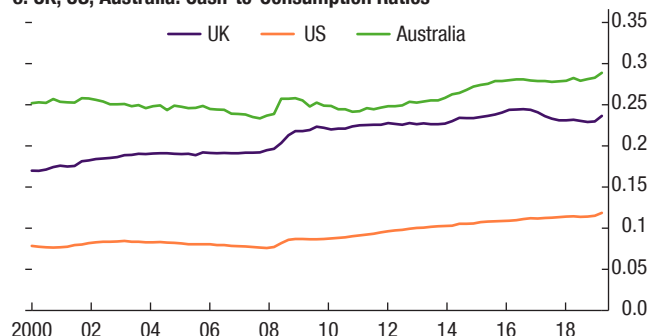
Source: Haver Analytics.

4. Sweden: Cash-to-Consumption Ratio

Sources: Sveriges Riksbank; and Haver Analytics.

5. Switzerland: Cash-to-Consumption Ratio

Sources: Swiss National Bank; and Haver Analytics.

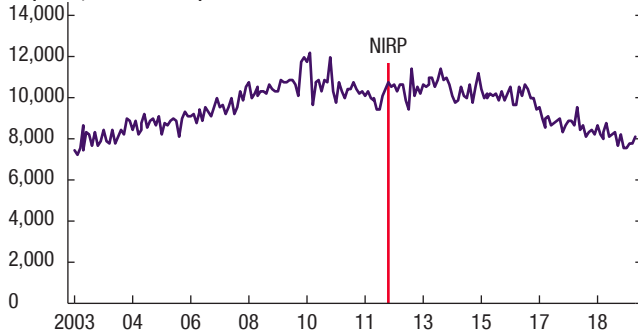
6. UK, US, Australia: Cash-to-Consumption Ratios

Source: Haver Analytics.

has not weakened the pass-through of policy rates to money market rates in Denmark (Jensen and Spange 2015), the euro area (Eisenschmidt and Smets 2018), Japan, Sweden (Angrick and Nemoto 2017), and Switzerland (Grisse and Schumacher 2018).

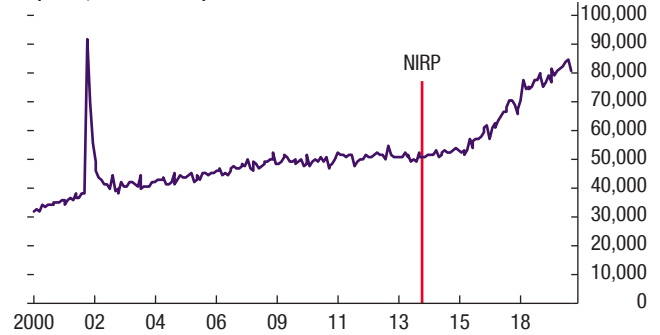
Figure 4. Vault Cash Held by Monetary and Financial Institutions (MFIs)

1. Denmark: MFI Vault Cash
(value, DKK millions)



Sources: Danmarks Nationalbank; and Haver Analytics.

2. Euro Area: MFI Vault Cash
(value, EUR millions)



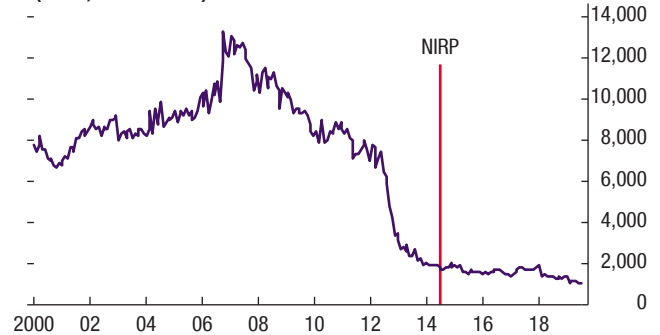
Source: ECB Statistical Data Warehouse.

3. Japan: MFI Vault Cash
(value, JPY 100 millions)



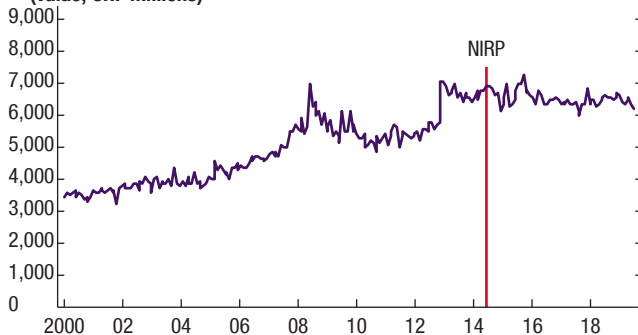
Source: Haver Analytics.

4. Sweden: MFI Vault Cash
(value, SEK millions)



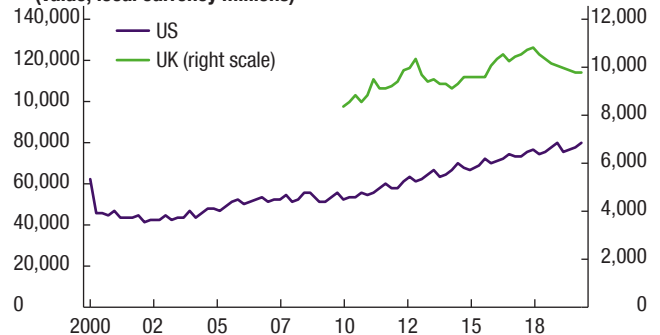
Source: Haver Analytics.

5. Switzerland: MFI Vault Cash
(value, CHF millions)



Source: Haver Analytics.

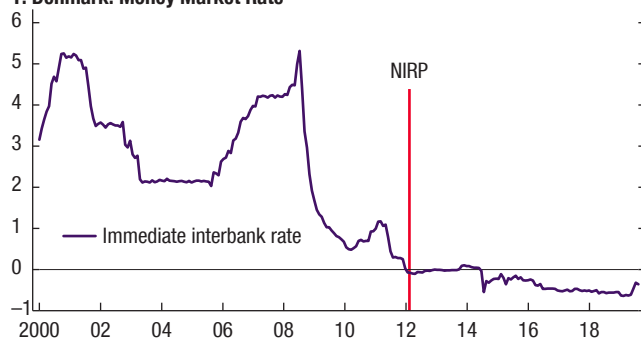
6. UK and US: MFI Vault Cash
(value, local currency millions)



Sources: FRED; and Haver Analytics.

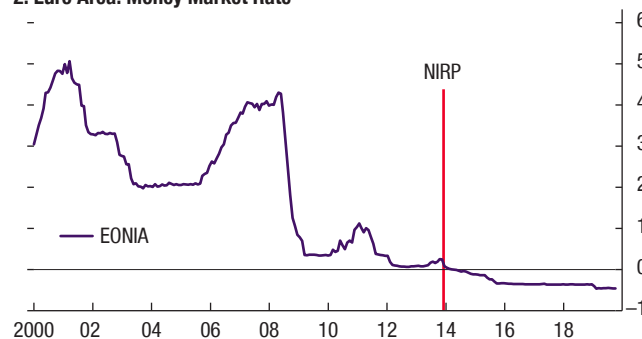
Figure 5. Money Market Rates

1. Denmark: Money Market Rate



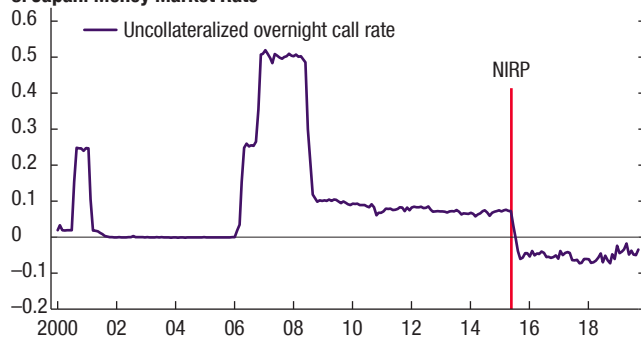
Source: OECD.

2. Euro Area: Money Market Rate



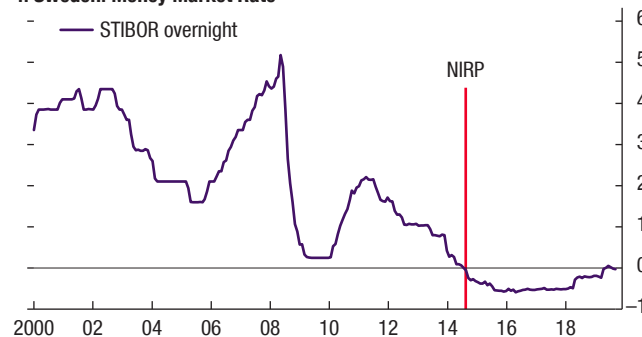
Sources: European Central Bank; and Haver Analytics.
Note: EONIA = Euro overnight index average.

3. Japan: Money Market Rate



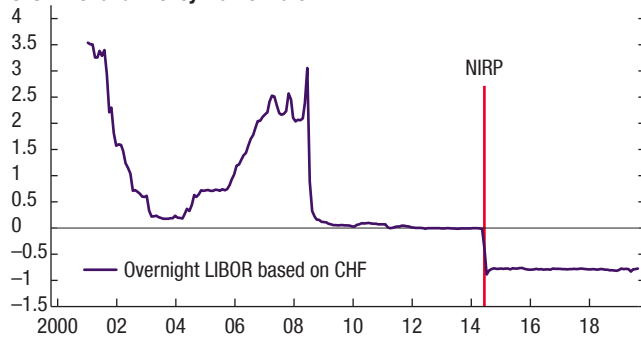
Sources: Bank of Japan; and Haver Analytics.

4. Sweden: Money Market Rate



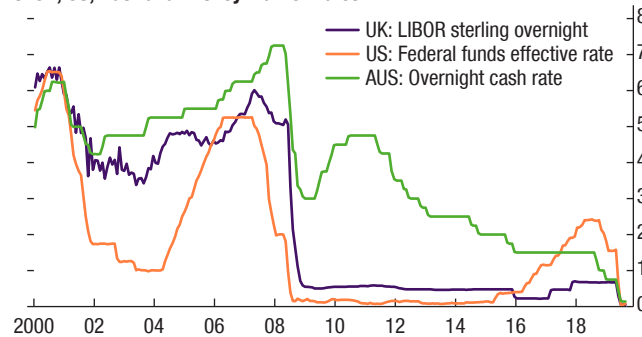
Sources: Sveriges Riksbank; and Haver Analytics.

5. Switzerland: Money Market Rate



Source: Haver Analytics.

6. UK, US, Australia: Money Market Rates



Source: Haver Analytics.

Yield Curves

Yield curves have shifted downward after NIRP announcements (Figure 6). Government bond yields tend to exhibit an immediate and persistent negative response to the introduction of NIRP (Christensen 2019). Moreover, since the introduction of negative interest rates, a large amount of short- and medium-term government bond yields have turned negative, consistent with investors revising down their beliefs about the ELB. Similarly, Arteta and others (2016), in a cross-country event study analysis, find that both short- and long-term yields dropped significantly after policy announcements, with the maximum effects of NIRP occurring on two-year yields. The case of Japan, however, seems to have been somewhat different, with NIRP leading to a significant flattening of the yield curve, and explains the subsequent adoption of yield curve control (YCC) by the Bank of Japan (Westelius 2020).⁴

Once rates are negative, the impact of interest rate cuts on the yield curve appears to be similar to interest rate cuts in positive territory. The response of the yield curve in the euro area to changes in the policy rates before and after NIRP was qualitatively similar (Arteta and others 2016), especially in the short end of the yield curve (Wu and Xia 2020). Wu and Xia also suggest that successive cuts of already negative rates affect medium-term yields more strongly, possibly because of the use of forward guidance. Alternatively, the smaller effect of initial policy rate cuts on medium- and long-term yields when compared to later cuts could also reflect changing market expectations about the duration of NIRP.⁵

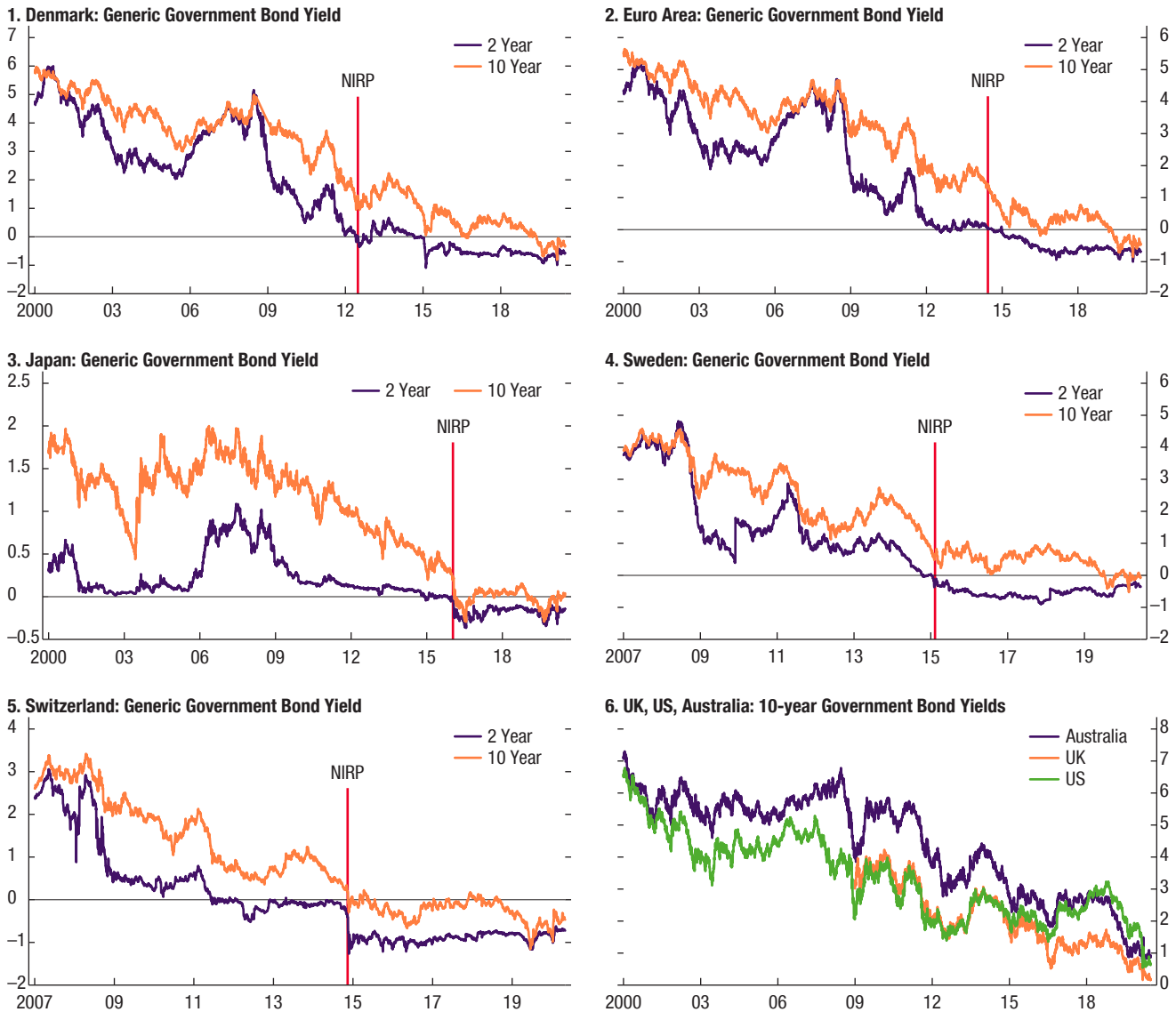
Exchange Rates

The empirical studies regarding the effects of NIRP on exchange rates find mixed evidence. Some argue that the impact of NIRP on exchange rates appears to have been short-lived because other domestic and international developments dominated the evolution of exchange rates (Arteta and others 2016; Hameed and Rose 2018; and Viñals, Gray, and Eckhold 2016). Others conclude that negative interest rates did not have any substantial impact on the behavior of exchange rates (Hameed and Rose 2018). However, Thornton and Vasilakis (2019) found NIRP to have contributed to weaker currencies and reduced exchange rate volatility. Moreover, the data on both the Danish krona and the Swiss franc suggest that NIRP contributed to depreciating

⁴YCC aims to shape the yield curve by targeting both short-term and long-term interest rates.

⁵A similar argument explains the reduced sensitivity of medium- and long-term yields to macroeconomic news after 2011 (Swanson and Williams 2014a).

Figure 6. Government Bond Yields



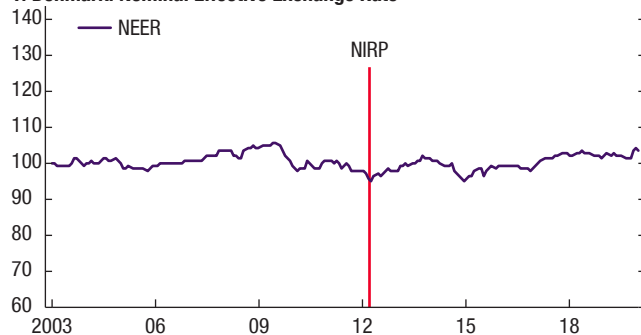
Source: Bloomberg Finance L.P.

the exchange rate, allowing central banks to reduce their reliance on FXI (Figure 7).⁶

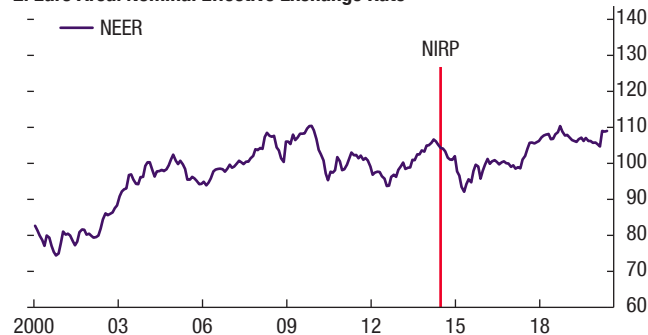
⁶Faced with the challenge of avoiding appreciation, the Danmarks Nationalbank (DN) and the Swiss National Bank (SNB) intervened in the FX market after 2010. Although FXI was successful in ensuring exchange rate stability, the required size of these interventions turned out to be very large, which increased the size the central banks' balance sheet and their exposure to exchange risk. The DN—which was able to maintain the peg with the euro—and the SNB eventually decided to adopt NIRP and reduce the size of its FXI.

Figure 7. Exchange Rates

1. Denmark: Nominal Effective Exchange Rate



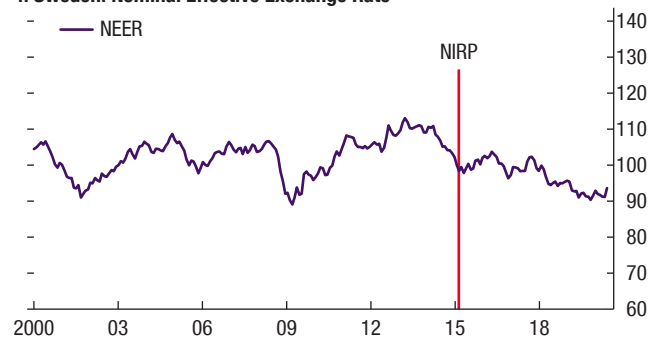
2. Euro Area: Nominal Effective Exchange Rate



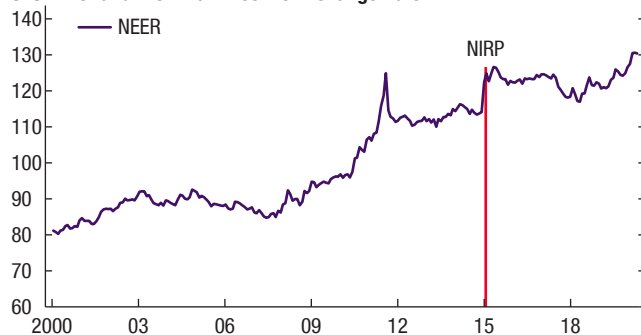
3. Japan: Nominal Effective Exchange Rate



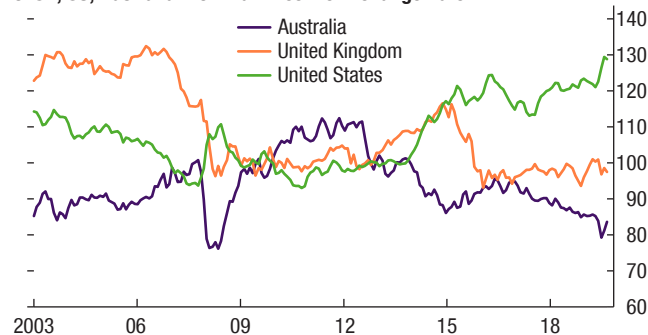
4. Sweden: Nominal Effective Exchange Rate



5. Switzerland: Nominal Effective Exchange Rate



6. UK, US, Australia: Nominal Effective Exchange Rate



Source: IMF, International Financial Statistics.

NIRP may have increased the sensitivity of exchange rates to interest rate differentials by changing the investor base in currency markets. Some country-specific studies suggest a greater sensitivity of exchanges rates to interest rates under NIRP. In particular, Lane (2019) presents evidence that the sensitivity of the euro/dollar exchange rate to monetary policy expectations has risen since the introduction of NIRP in the euro area (see also

references in Eisenschmidt and Smets 2019).⁷ In Denmark, NIRP may have led to higher banking outflows and depreciation pressures, as banks switch to holding more foreign assets to offset the costs of their reserves receiving negative interest rates (Khayat 2018). Moreover, the adoption of NIRP seems to have provided domestic banks in Switzerland with an incentive to raise their foreign currency exposure (Basten and Mariathasan 2018).

Other Assets

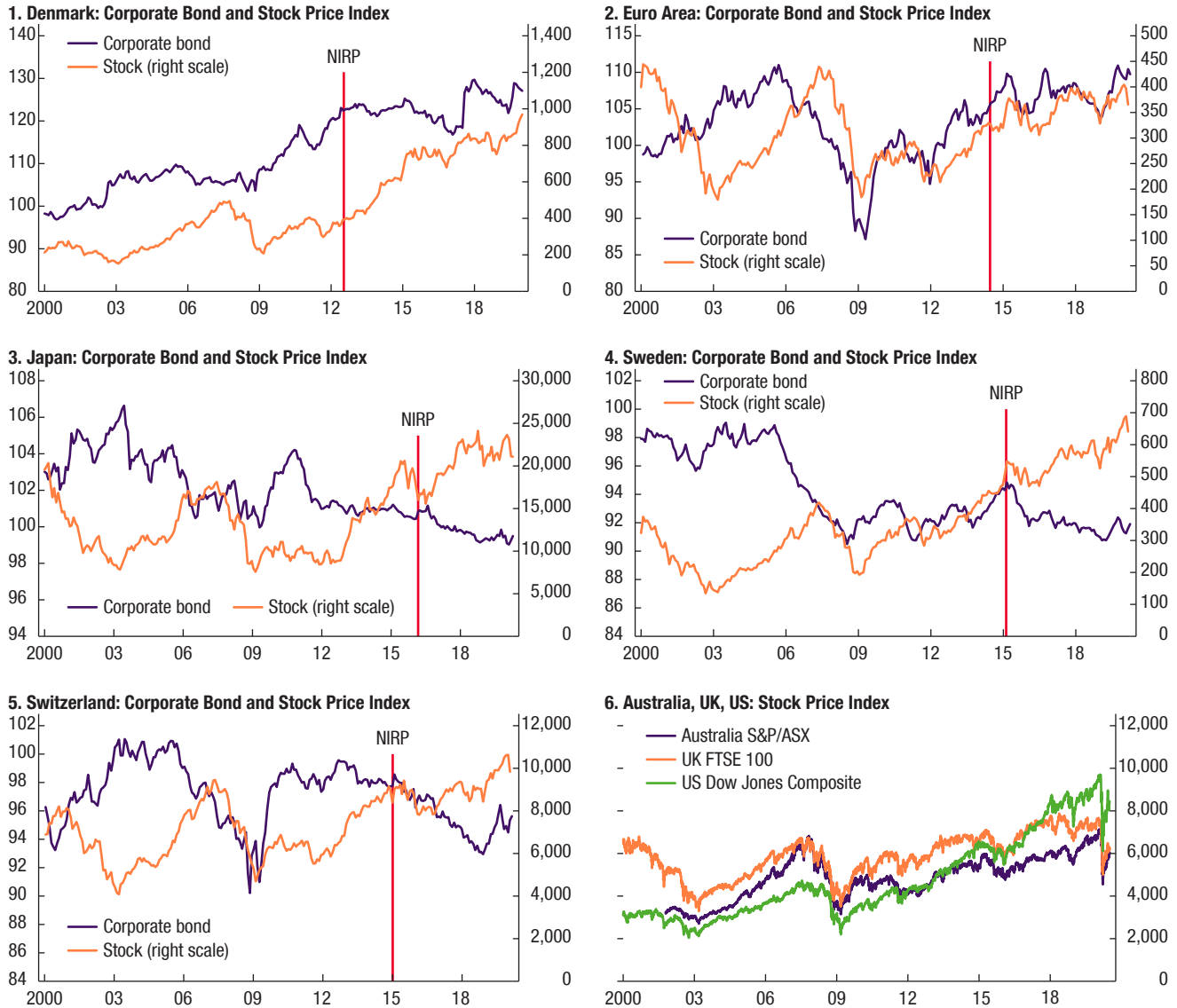
NIRP does not seem to have had a significant impact on equity prices in general, but bank equities may have suffered. Stock market indexes kept rising after policy rate cuts in negative territory (Figure 8). However, while reporting an overall positive reaction of stock prices to NIRP in Japan, Hong and Kandrac (2018) find the opposite for Japanese banks' stocks. For the euro area, while announcements of UMP (including NIRP) on average benefited banks by increasing their stock prices and reducing their credit default swap (CDS) spreads (Altavilla and others 2018), there is some evidence that the effects of policy rate cuts on bank equity prices have turned negative since official rates went to or below zero (Ampudia and Van den Heuvel 2018; Heider, Saidi, and Schepens 2019; Balloch and Koby 2020; Bats, Giuliadori, and Houben 2020).⁸ Importantly, the more banks rely on deposit funding, the more their stock prices suffer from rate cuts in low or negative territory. This suggests that markets perceive the existence of a ZLB on deposits rates as harming bank profitability and provides indirect support for the reversal rate hypothesis.

The evidence on corporate bonds is mixed. In some countries, price indices on investment grade corporate bonds stopped rising or even started falling following the introduction of NIRP. Besides the caveats listed above, it is important to stress how these indices suffer from composition effects. If, within the investment grade category, the relative weight of firms with a low rating increases, the overall quality and thus the price of bonds in the index

⁷There is evidence that with low interest rates, the exchange rates of major currencies became more sensitive to changes in monetary policy expectations already before rates became negative (see Ferrari, Kearns, and Schrimpf 2017) and at least since the 2007–09 crisis (Curcuru 2017). Also, Swanson and Williams (2014b) found that the exchange rates of the euro and British pound against the dollar were not constrained by the ZLB.

⁸Ampudia and Van den Heuvel (2018) use intraday, tick-by-tick data on interest rate swaps, sovereign bond yields, and individual bank stock prices to estimate the effects of monetary policy in the euro area. Altavilla, Boucinha, and Peydró (2018) also use bank-level data to estimate the reaction of bank equity prices and CDS spreads to conventional and unconventional monetary policy, but do not look at the effects of NIRP in isolation. Based on aggregate data, Varghese and Zhang (2018) also find significant effects on sovereign CDS spreads, equity and bank equity, government bond yields, exchange rate, and inflation swap rates.

Figure 8. Corporate Bond and Equity Prices



Source: Haver Analytics; Refinitiv Eikon.

falls. This is likely to happen because one of the intermediate objectives of NIRP is to incentivize firm access to capital markets for external funding.

Household and Firm Behavior

Empirical studies of the response of household savings and portfolio choices to NIRP are largely absent. The authors are not aware of any empirical study

of changes in investor behavior using microdata. At the macro level, Aizenman Cheung, and Ito (2019) find that the effect of low real interest rates on private savings could be negative, depending on economic and structural factors (for example, output volatility, old-age dependency ratio, and financial development) but their study is not specifically about NIRP.

Experimental evidence of the effects of NIRP on household saving and investment decisions is mixed. At least one study in which investors can choose between a risk-free and a risky asset, reductions in the risk-free rate can cause investors to increase the share of risky assets in their portfolios when rates turn negative, but a similar reduction does not occur when rates remain positive (Baars, Cordes, and Mohrschladt 2020). However, Bracha (2020) finds no change in risk-taking behavior in a similar experiment. Furthermore, experiments where investors can choose to withdraw (and spend) or keep a bank deposit with a negative nominal return suggest that investors seem tolerant of negative interest rates (Efendic and others 2019, Corneille and others 2020). Tolerance for negative rates seems to decline with the size of the deposit, the time horizon, and the size of negative rates. Tolerance for negative rates seems to be higher for regular savers or when savers know that interest rates will become positive later.

The evidence on how NIRP affects firm behavior is also mixed. On the one hand, in the euro area, firms with relationships with banks that pass through negative interest rates to corporate deposits increase their fixed investment (Altavilla and others 2019b). This effect comes mostly from firms with high cash holdings. Moreover, a survey by Commerzbank (2019) suggests that nonfinancial companies tend to change their (fixed and financial) investment strategies when interest rates turn negative: 37 percent of respondents said that they would switch to other types of assets, and 32 percent responded that they would increase (fixed) investment in their own company. Also, in Denmark, nonfinancial firms more exposed to negative deposit rates increase fixed investment and employment and reduce their leverage and bank deposit holdings (Abildgren and Kuchler 2020).⁹ On the other hand, micro-evidence for Japan suggests that nonfinancial firms curtail investment if they borrow from banks with greater exposure to negative rates (Inoue, Nakashima, and Takahashi 2019). In addition, a 2017 survey by the ifo Institute found that about 30 percent of firms affected by negative deposit interest rates reallocated their financial portfolios to other investments and repaid loans, but only 11 percent increased their fixed investment (Hainz, Marjenko, and Wildgruber 2017).

⁹In Denmark, at least initially, firms did not lower their total bank deposit holdings but shifted away from demand deposits into higher-yielding time deposits (Jensen and Spange 2015).

Bank Behavior

Overall, the evidence suggests that the effects of rate cuts below zero on bank lending and bank lending rates largely resemble those of cuts in positive territory. Although the magnitude of the effects depends on the intensity of NIRP, the responses of bank credit are qualitatively similar across banks. This notion applies in particular to volumes, while the response of lending rates is less clear cut. However, the impact of NIRP on bank funding costs appears different from that of conventional monetary policy: particularly for households, banks tend to raise fees and commissions rather than impose negative rates. However, there is some (but not conclusive) evidence that the impact of NIRP on lending is weakened for banking systems with a heavier reliance on deposit funding and larger holdings of very liquid assets. For such banking systems, NIRP would be less stimulative for investment, consumption, and economic activity in general.

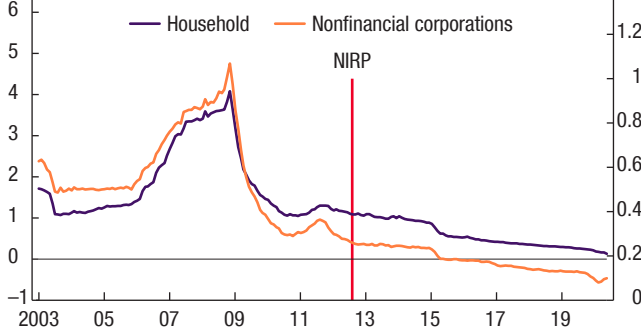
Deposit and Lending Rates

Banks seem to respond to NIRP by increasing fees on retail deposits, while passing on negative rates partly to firms. For retail customers, banks try to overcome the ZLB on deposit rates and reduce their interest expenses by charging higher fees and commissions on retail depositors (Arce and others 2018, Bottero and others 2019 for the euro area; Basten and Mariathasan 2019 for Switzerland). In contrast, for corporate customers, negative rates are transmitted to rates on firm deposits (Altavilla and others 2019b; Deutsche Bundesbank 2020). For European banks, Klein (2020) finds no evidence for a nonlinear relation between policy and deposit rates at negative policy rates, or for a slower pass-through, contrary to what is expected in the presence of a ZLB for retail deposit rates.

The responsiveness of bank deposit rates to successive policy rate cuts after NIRP does not seem to have changed significantly. Deposit rates generally adjust slowly to lower policy rates. A substantial body of evidence shows that this was the case in the euro area prior to the 2007–09 financial crisis (Andries and Billon 2016). This may also be true for rate cuts below zero, as Figure 9 suggests (that is, successive rounds of rate cuts have produced smaller and slower reductions in deposit rates). There is little evidence that the short-term pass-through from policy to deposit rates slowed after the adoption of NIRP in Denmark and Sweden (Madaschi and Pablos-Nuevo 2017). The authors of this departmental paper do not find that the association between policy rates and deposit rates has changed after the adoption of NIRP in any of the countries surveyed here, except perhaps for Denmark (Box 2).

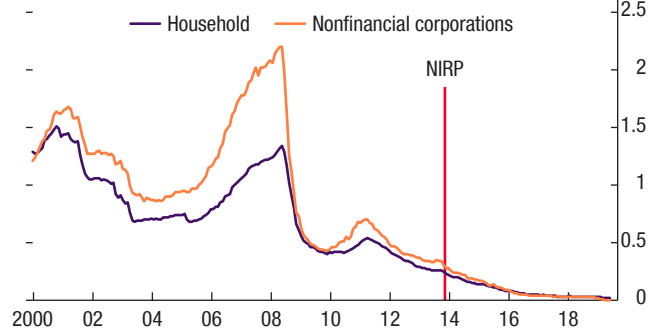
Figure 9. Bank Deposit Rates

1. Denmark: Bank Deposit Rates



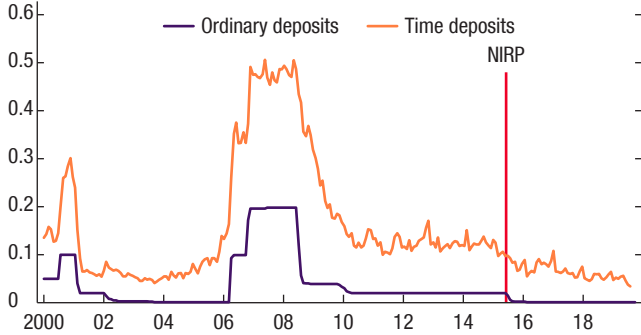
Sources: Danmarks Nationalbank; and Haver Analytics.

2. Euro Area: Bank Deposit Rates



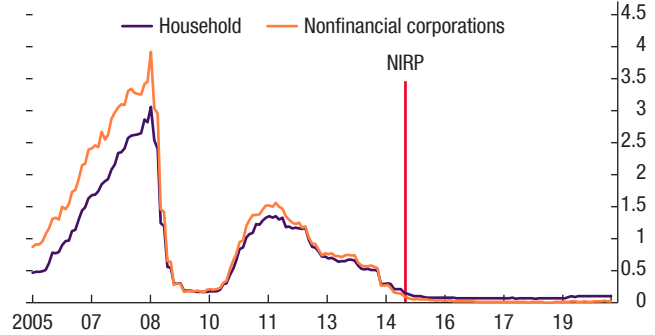
Sources: European Central Bank; and Haver Analytics.

3. Japan: Bank Deposit Rates



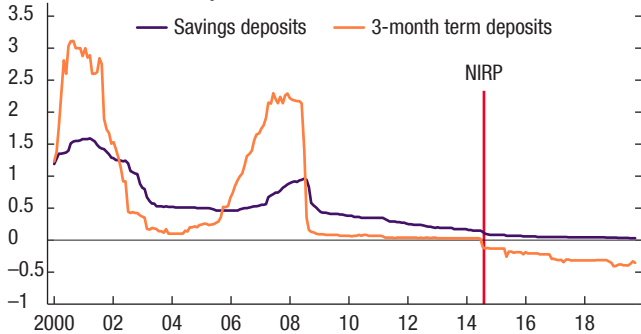
Sources: Bank of Japan; and Haver Analytics.

4. Sweden: Bank Deposit Rates



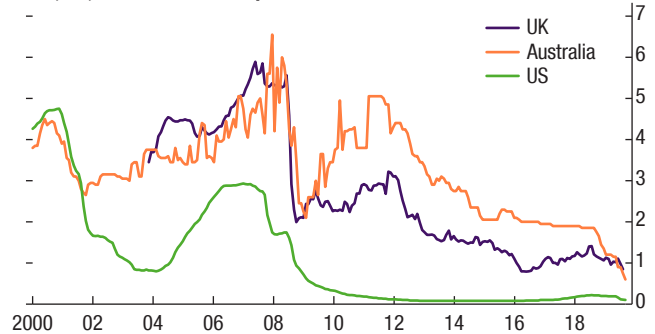
Sources: Sveriges Riksbank; and Haver Analytics.

5. Switzerland: Bank Deposit Rates



Source: Swiss National Bank.

6. UK, US, Australia: Bank Deposit Rates



Source: Haver Analytics.

NIRP seems to have lowered interest rates on new mortgages and corporate loans. Bank lending rates fell in Denmark after the NIRP, even if the immediate pass-through from policy rates may have declined (see Adolfsen and Spange 2020). Still, it is not clear whether the lower pass-through to lend-

ing rates in Denmark is due to NIRP or to the aftermath of the 2007–09 financial crisis, and Madaschi and Pablos-Nuevo (2017) do not corroborate such a decline in pass-through following NIRP for Denmark or Sweden. Floating rate mortgage rates fell substantially across the euro area and Sweden after policy rates turned negative (Figure 10). Similarly, new corporate lending rates in the euro area dropped sharply after the ECB cut the deposit facility rate (DFR) into negative territory. The pass-through to corporate lending rates from the ECB’s first 10 basis point rate cut was more than 30 basis points after three months; however, the cut was accompanied by the announcement of TLTROs, which clouded the picture. A simple analysis does not support the notion that the association between policy rates and average bank lending rates in the countries covered in this survey has changed after the adoption of NIRP (Box 2).

There is substantial heterogeneity across banks in the effects of NIRP on lending rates. Bottero and others (2019) report that NIRP did lower loan rates amongst Italian banks and increased lending—particularly among banks holding larger shares of liquid assets. Similar results have been obtained for Switzerland by Basten and Mariathasan (2018), although they are at odds with Danthine (2018). In Denmark, there is no evidence that banks theoretically more exposed to NIRP (that is, with a higher reliance on deposit funding) responded differently than other banks (Adolfson and Spange 2020). By contrast, Italian banks with a relatively high reliance on retail deposits tend to increase rates on loans to the nonfinancial private sector (Amzallag and others 2019), while Japanese banks that are more exposed to NIRP did not lower lending rates as much as other banks (Hong and Kandrac 2018).

Bank Profits

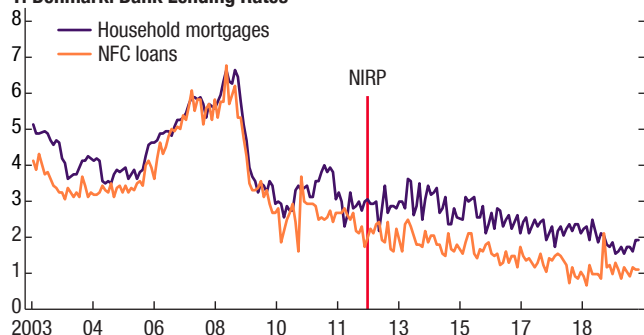
On average, bank profits have not significantly deteriorated, thanks to an increase in lending, the introduction of fees on deposit accounts, and the realization of capital gains.¹⁰ For banks in the European Union, Japan, and Switzerland, NIRP only had a small overall effect on profitability because losses in interest income were offset by gains in non-interest income, such as fees, capital gains, and insurance income (Lopez, Rose, and Spiegel 2020), or because of lower loan-loss provisions (see Urbschat 2019 for evidence on German banks).¹¹ Larger were also likely to have made use of hedging strategies to protect margins (IMF 2020). Other studies find that overall bank profitability in the euro area has been largely unaffected by the introduc-

¹⁰Before NIRP, the literature on the effects of monetary easing on bank profitability found that interest rate cuts depressed bank profits (for example, Hancock 1985).

¹¹In relative terms, the income of large banks and those that rely relatively less on deposits performs better under NIRP.

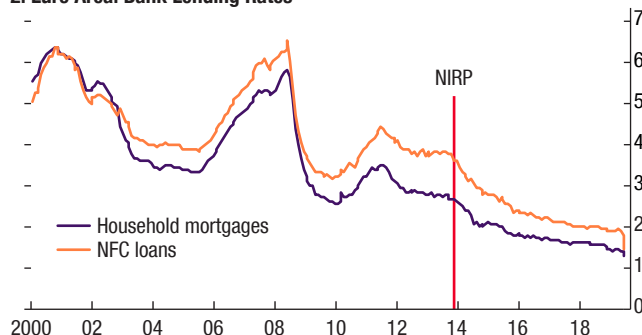
Figure 10. Bank Lending Rates

1. Denmark: Bank Lending Rates



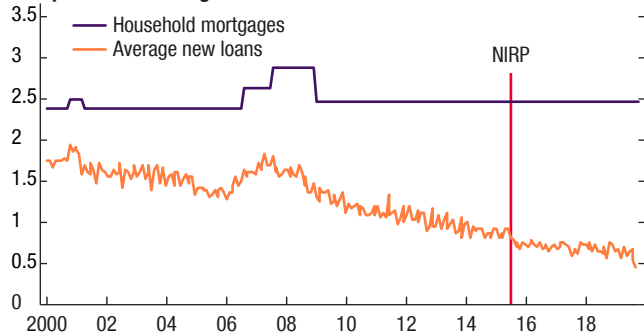
Sources: Danmarks Nationalbank; and Haver Analytics.

2. Euro Area: Bank Lending Rates



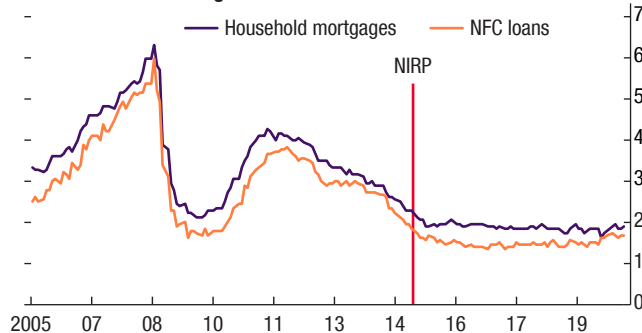
Sources: European Central Bank; and Haver Analytics.

3. Japan: Bank Lending Rates



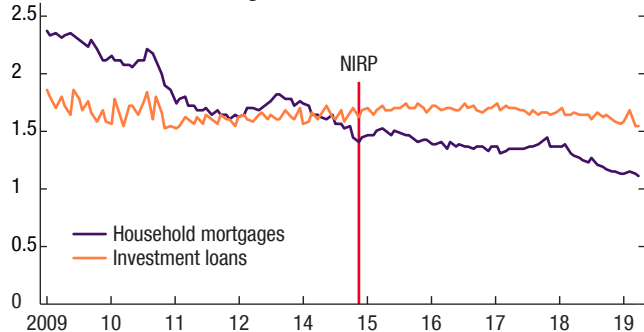
Source: Haver Analytics.

4. Sweden: Bank Lending Rates



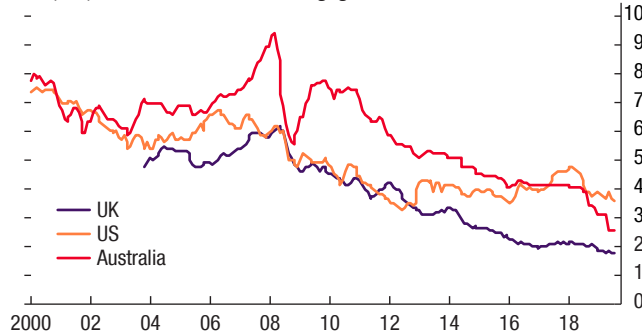
Sources: Sveriges Riksbank; and Haver Analytics.

5. Switzerland: Bank Lending Rates



Source: Swiss National Bank.

6. UK, US, Australia: Household Mortgage Rates



Source: Haver Analytics.

tion of NIRP once the total effects of this policy on asset quality are taken into account (Hong and Kandrac 2018, Altavilla and others 2019a, Stráský and Hwang 2019).

However, the evidence is not conclusive, and it could be capturing only the short-term effects of NIRP, which may be reversed over time. For positive interest rates, Alessandri and Nelson (2015) and English, van den Heuvel, and Zakrajšek (2018) find evidence that rate cuts initially increase bank NIM and profits, but after some time the effect is reversed, consistent with loan pricing frictions. In line with this finding, at least one study shows that NIRP squeezed bank profits through a significant contraction in the NIM, which more than offset capital gains on security holdings (Molyneux, Reghezza, and Xie 2019). Also, Klein (2020) finds that a policy rate cut in negative territory implies a larger drop in NIM for European banks than an equivalent cut above zero. Finally, the expectation of large adverse medium- to long-term effects on bank profitability, potentially offsetting any temporary increase in profits, could explain the evidence discussed earlier on bank stock prices falling after NIRP.

Still, smaller and more specialized banks appear to have been adversely affected.¹² In particular, banks that are small, are not engaged in cross-border lending, face significant competition, are real estate and mortgage specialists, or operate in countries where floating loan rates predominate, see the biggest declines in profits and NIM after the introduction of NIRP (Molyneux, Reghezza, and Xie 2019).¹³ However, Coleman and Stebunovs (2019) find that NIRP adversely affected the profitability of all euro area banks, regardless of their business models, but this policy seems to have accounted for only a small fraction of the difference in profitability between US and European banks.

Lending Volumes and Asset Quality

According to some studies, banks with more liquid assets and greater access to wholesale funding are able to increase lending more after NIRP. Studies that use different cross-sectional characteristics to measure the exposure to NIRP find a stronger increase in lending by banks with a larger share of liquid assets (Bottero and others 2019) and more excess reserves with the central bank (Basten and Mariathasan 2019). Moreover, banks with a lower share

¹²Several studies have used bank heterogeneity to better identify the effects of NIRP on banks' net interest income and profitability. Some have relied on exploiting exogeneity in banks' reliance on retail deposits to make inferences on the importance of the ELB for NIRP. Similarly, many researchers have used the amount of cash-like assets as a proxy for how banks are affected by NIRP. Other approaches classify banks based on their size, business model, or responses to dedicated surveys. Finally, some studies simply compare the impact of cuts in official rates to low, but still positive, levels with that of cuts in negative territory.

¹³The literature offers conflicting findings relating bank capital and the effect of rate cuts on bank profits. For example, Molyneux, Reghezza, and Xie (2019) find that well-capitalized banks see bigger declines in profits, but Arce and others (2018) find that the net interest revenue of banks with low capital is more adversely affected.

of deposit funding increase their supply of credit more (Heider, Saidi, and Schepens 2019; Lopez, Rose, and Spiegel 2020) or as much as (Bottero and others 2019) other banks.¹⁴ In addition, Inoue, Nakashima, and Takahashi (2019) and Eggertson and others (2019) find that in Japan and Sweden, respectively, a larger share of retail deposits is actually associated with lower lending.^{15, 16} The finding that banks that rely more on wholesale funding increase lending more than those that depend more on deposits is in line with the bank lending channel.

Some other studies, however, find that banks that rely more on deposits increase their lending as much, and often more so, than their peers with lower shares of deposit funding. For example, Tan (2019) and Schelling and Towbin (2020) find that banks increase lending, but the effect is stronger for banks with high deposit ratios and which rely more on retail deposits. One explanation for this finding is that banks try to compensate the decline in interest income by increasing lending volumes (Klein 2020),¹⁷ which would be consistent with Drechsler, Savov, and Schnabl's (2017) deposits channel of monetary policy.

Banks take on more (but not necessarily excessive) risk following the adoption of NIRP. This result holds in particular for loans (Basten and Mariathan 2019; Bottero and others 2019; and Heider, Saidi, and Schepens 2019), with some evidence pointing to banks terming out loans (IMF 2020), but also for securities (Bubeck, Maddaloni, and Peydró 2020). Furthermore, smaller banks that are more reliant on deposits for funding seem to become riskier (Nucera and others 2017; Heider, Saidi, and Schepens 2019; Schelling and Towbin 2020), as do those banks with lower capital ratios (Inoue,

¹⁴The only study that ranks banks in terms of retail deposits and excess liquidity simultaneously also finds a positive impact of NIRP on lending (Demiralp, Eisenschmidt, and Vlassopoulos 2019).

¹⁵Eggertson and others (2019) describe a theoretical model of the transmission of monetary policy through the banking system. In their model, banks may respond to negative policy rates by raising the spread between their lending and borrowing rates. The wider spread tends to depress output and inflation, rather than stimulating them as intended. However, this result rests on assumptions that (1) there is one type of liability (deposits) subject to the ELB, (2) the marginal benefit to holding reserves in terms of reduced intermediation costs can be driven to zero, (3) the marginal cost of issuing loans rises as bank profits fall, and (4) the central bank attempts to set a policy rate below the ELB. The consequence is that when the central bank sets rates below -0.01 percent, the assumed ELB, it causes bank profits to be lower, and so leads to a contraction in loan supply. See also Ulate (2021) for a similar exercise that reaches very different conclusions.

¹⁶There is only one study that does not find any effect of NIRP on bank lending growth (Michail 2019).

¹⁷Klein (2020) finds that the positive relationship between NIM and new lending to the nonfinancial private sector disappears in the presence of NIRP. In line with this finding, Hong and Kandrak (2018) find that banks more adversely exposed to NIRP (based on stock price reactions) increased lending more. But, according to Arce, Rose, and Spiegel (2018), the behavior of banks that identify themselves as negatively affected by NIRP is not different from the response of other banks.

Nakashima, and Takahashi 2019)¹⁸ or with stocks that have experienced larger drops in prices following the adoption of NIRP (Hong and Kandrac 2018). These findings are consistent with Dell’Ariccia, Laeven, and Marquez’s (2014) risk-taking channel of monetary policy. However, the increase in ex ante risk-taking does not translate into higher nonperforming loans (ex post risk) and is probably not excessive. This is consistent with additional lending by banks to financially constrained firms which lack access to credit but are otherwise profitable (Bottero and others 2019), but it can also be consistent with NIRP improving the ex post creditworthiness of borrowers, or simply with nonperforming loans being a lagged indicator of credit quality.

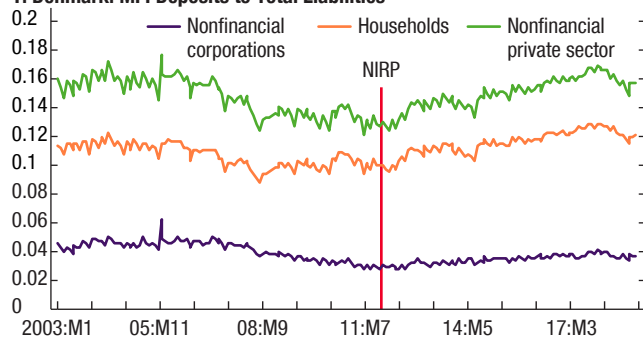
Bank Funding Structure

Countries differ sharply in terms of the importance of retail deposits as a source of bank funding. The country-level heterogeneity in the funding structure of banking sectors matters because the degree of reliance on retail deposits plays a key role in determining the effects of NIRP. Figure 11 shows the evolution of the share in bank deposits held by the nonfinancial private sector in total bank liabilities over the last two decades for the five economies where NIRP was implemented. The figure also reports the dynamics of household and firm deposits separately, because these two types of agents may respond differently to NIRP in terms of portfolio decisions. At the time of the introduction of NIRP, the share of deposits held by the nonfinancial sector ranged from 15 percent in Denmark to nearly 70 percent in Japan. Thus, the effects and transmission of NIRP in Scandinavian and euro area countries are more likely to resemble the impact of conventional cuts than in Japan or Switzerland.

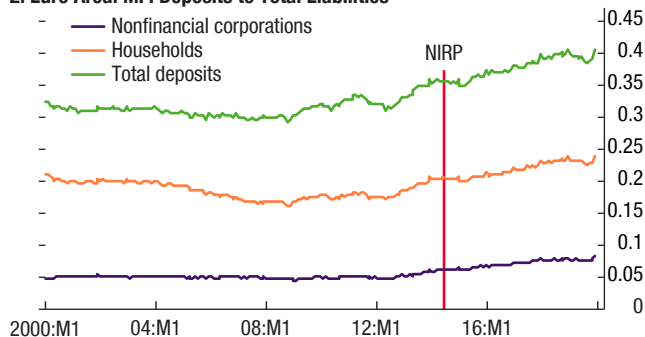
NIRP does not seem to have affected bank reliance on retail deposits. Specifically, the share of household or nonfinancial corporation deposits over total liabilities has not fallen in any of the relevant economies following the adoption of NIRP. In some cases, for instance the euro area, the reliance on this source of funding has even risen since the policy rate moved into negative territory (Eisenschmidt and Smets 2019, Deutsche Bundesbank 2019). This is also found by Lopez, Rose, and Spiegel (2020) for banks in economies that have adopted NIRP.

However, many confounding factors may be at work. Among other factors, the evolution of deposits may reflect the adoption of unconventional monetary policy measures, such as QE. When the central bank purchases assets directly from households or firms, this mechanically causes an increase in

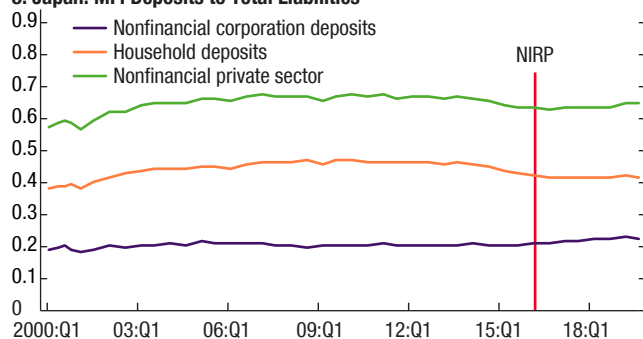
¹⁸However, Arce and others (2020) find the opposite for euro banks in general and Spanish banks in particular: banks with NIM more adversely affected by NIRP reduce risk-taking in lending to shore up their capital.

Figure 11. Bank Funding**1. Denmark: MFI Deposits to Total Liabilities**

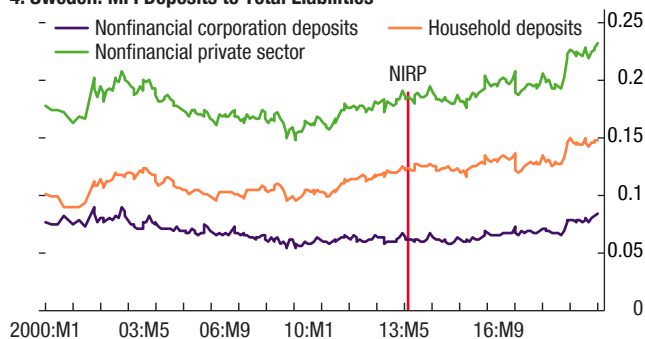
Sources: Denmark's Nationalbank; and Haver Analytics.

2. Euro Area: MFI Deposits to Total Liabilities

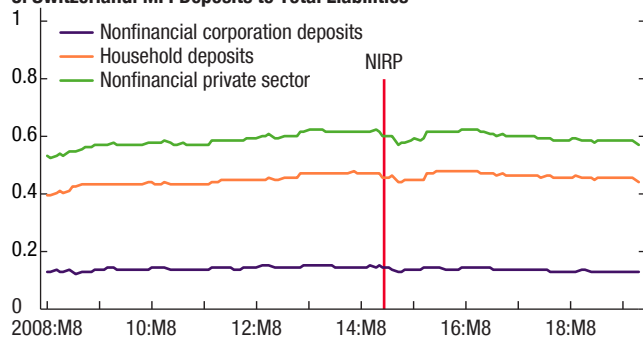
Sources: ECB Statistical Data Warehouse; and Haver Analytics.

3. Japan: MFI Deposits to Total Liabilities

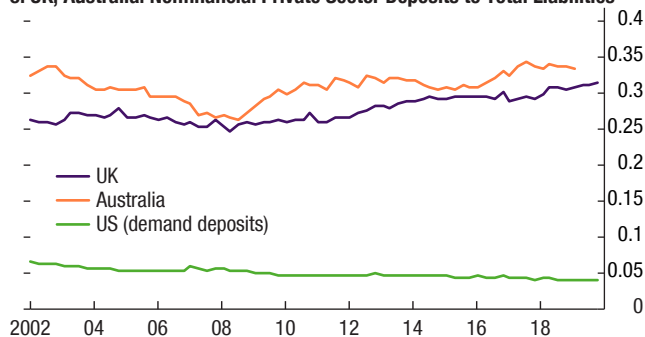
Sources: Bank of Japan; and Haver Analytics.

4. Sweden: MFI Deposits to Total Liabilities

Sources: Sveriges Riksbank; and Haver Analytics.

5. Switzerland: MFI Deposits to Total Liabilities

Source: Swiss National Bank.

6. UK, Australia: Nonfinancial Private Sector Deposits to Total Liabilities

Sources: Bank of England; Federal Reserve; Reserve Bank of Australia; Haver Analytics.

bank deposits held by these sectors. However, this descriptive evidence suggests that neither households nor nonfinancial firms have significantly rebalanced their portfolios away from bank deposits.

Money Market Funds

Overall, MMFs have weathered NIRP relatively well. Although MMFs saw an increase in MMF redemptions following the introduction of NIRP, at least for the euro area, assets under management (AUM) by MMF recovered quickly (ECB 2015). And, because the assets held by MMFs were generally safe and liquid, redemption-induced liquidations were not disruptive to funding markets. Moreover, the empirical evidence suggests that the level of policy rates is not the key driver of MMF performance. In fact, the profitability of MMFs mainly depends on the difference between the rate on the central bank deposit facility and the yield on short-term debt securities, which typically represent a large share of MMF holdings (see Bua, Dunne, and Sorbo 2019 for evidence on Irish funds). These results point to the importance of the policy mix, since the gap between the relevant policy rates and short-term government bond yields is influenced by other unconventional monetary policy measures, such as QE.

There were, however, some changes in behavior. As interest rates and yields turned negative in the euro area, several MMF managers waived managements fees and the extended maturities of their investments.¹⁹ Initially, CNAV funds in Europe also used the so-called Reverse Distribution Mechanism—whereby shares are cancelled and then distributed across remaining shares—to maintain a unit share price when interest rates are negative. This practice has now been halted by the European Securities and Markets Authority.²⁰ However, these changes in behavior are not exclusive to NIRP. In fact, in response to policies that kept money market rates close to or at zero for a long period of time, MMFs in the United States have also reached for yield, reduced fees, or exited the market (Di Maggio and Kacperczyk 2017).

However, if policy rates were allowed to go below the ELB, the ensuing flight for cash would be detrimental not just to banks but also to MMFs. The evidence so far on the absence of important redemption pressures or many MMF closures under NIRP may be the outcome of policy rates remaining only mildly negative. The same is true for bank profits' observed resilience to NIRP being specific to the current environment of moderately negative interest rates. It is possible, therefore, that both industries are significantly disrupted if policy rates become very negative.

¹⁹These changes were not without precedent. Between August and November 2003, repo rates in the United States were sometimes negative and low rates remained low (but positive) even for uncollateralized lending until 2004. As a consequence, MMF yields fell and AUM by MMFs fell by about 15 percent during 2003–04. However, the decline was very gradual and did not disrupt funding markets (Dwyer and others 2008).

²⁰The EU adopted a far-reaching reform of its money market regulation (Regulation (EU) 2017/1131, fully implemented in March 2019), further confounding the analysis of the effects of NIRP on the MMF industry.

Other Nonbank Financial Institutions

There are very few studies of how life insurance companies and pension funds have fared after the introduction of NIRP. In Denmark, they have seen their profit margins fall since 2012 (Danmarks Nationalbank 2018). This could be because NIRP depresses current interest income,²¹ or because legacy policies with significantly positive guaranteed returns have dragged down profitability in a low-return environment.²² However, in Switzerland, where a majority of pension funds pay negative interest on their bank deposits, the negative effect of NIRP on current interest income has been outweighed by the positive effects on capital gains in fixed income, equity, and real estate (Bauer, Bee, and Weisser 2019). And, in Japan, following the introduction of NIRP investment in foreign securities by insurers and pension funds experienced a large increase (Honda and Inoue 2019).

Impact on Inflation and Output

Judging by its effect on long-term yields, there is some indication that NIRP stimulated economic activity and inflation. For example, Rostagno and others (2019) find a large impact of negative interest rates on macroeconomic outcomes in the euro area. Those authors separately identify the effects of NIRP, forward guidance, and asset purchase programs and find that the cumulative impact of negative interest rates on the yield curve has been almost one to one across the maturity structure. This is substantially more than the estimates of the effect of conventional policy rate cuts (that is, in positive territory) on long-term yields for the United States (−42 basis points for a 100 basis point policy rate cut; Hanson and Stein 2015), the euro area (−17 to −45 basis points; Brand, Buncic, and Turunen 2010), and Japan (−40 basis points; Braun and Shioji 2006). Moreover, it compares well with the effect on 5-year yields of QE between 2008 and 2012: −130 basis points for the United States, −90 for the United Kingdom, −25 for Japan, and −13 for the euro area (Hausken and Ncube 2013).²³

²¹There are two reasons for this. First, banks have increasingly passed on negative rates to insurers and pension funds' deposits, and to a much larger extent than to nonfinancial corporations or households. Second, among domestic investors, Danish life insurers and pension funds are only second to banks as holders of Danish mortgage bonds, and these bonds compose 33 and 44 percent of their assets, respectively. Returns on investment for life insurers and pension funds, since January 2018 has been between −1.10 and 1.86 percent. For Danish krone-denominated mortgage bonds, return on investment has been between −0.09 and 0.66 (data from Danmarks Nationalbank Statbank).

²²Bloomberg Law. 2019. "A \$440 Billion Pension Market Sounds Alarm as Liabilities Swell." October 7. <https://news.bloomberglaw.com/employee-benefits/a-440-billion-pension-market-sounds-alarm-as-liabilities-swell>.

²³These estimates are similar to those of D'Amico and others (2012) and Christensen and Rudebusch (2012) for the United States and the United Kingdom. The size of ECB purchases relative to GDP (3.5 percent) was

Still, direct evidence on the overall effects of NIRP on inflation and output is scarce. On the one hand, Rostagno and others (2019) report that unconventional monetary policies have had a substantial combined effect on output and inflation over the period 2015–18 (about 2.7 percent on GDP and one-third of a percentage point on inflation). Further, their decomposition of the effects of various unconventional policies assigns about a fifth of the overall impact to NIRP. This suggests that a staggered 50 basis point rate cut yields about 0.5 percent increase in GDP and 0.07 percent point increase in inflation. Boucinha and Burlon (2020) corroborate these findings. For Japan, Honda and Inoue (2019) present evidence that NIRP may have supported the economy through the exchange rate channel. On the other hand, Michail (2019) uses a counterfactual estimation technique and finds that the impact of NIRP did not have a significant effect on inflation in Denmark, Sweden, and Switzerland.

The estimated effect of interest rate cuts on output under NIRP is comparable to those of conventional policy rate cuts and quantitative easing, but the effects on inflation may have been modest. The estimates of the effect of a 100 basis point policy rate cut based on pre-GFC data (that is, away from the ZLB) suggest an increase in output of 0.5–1 percent in the United States (Ramey 2016) and the United Kingdom (Cloyne and Hurtgen 2016), 0.3–0.7 percent in the euro area (van Els and others 2003), and 0.7–0.8 percent in Japan (Miyao 2002).²⁴ In addition, the effect of a 100 basis point drop in long-term rates caused by QE is estimated to have been a rise of 1.1–1.4 percent in GDP and of 0.9–1.5 percent in CPI in the United States, a 2.5–3 and 1.5–4.2 percent rise in GDP and CPI, respectively, in the United Kingdom, and a 0.75–1 percent increase in GDP and 0.35–0.6 rise in CPI in select euro area countries (Kapetanios and others 2012; Baumeister and Benati 2013; Altavilla, Giannone, and Lenza 2016; and Weale and Wieladek 2016).²⁵ Overall, these results suggest that all countries that have implemented NIRP have yet to reach the reversal rate, which may be at or below –1 percent (see Darracq Pariès, Kok, and Rottner 2020).

Cross-Border Spillovers

Few studies have examined cross-border spillovers of NIRP, and no comprehensive, systematic assessment exists. For example, the authors were not

much smaller than that of the Federal Reserve, Bank of Japan, and Bank of England (22.1, 37.3, and 26.3 percent, respectively; Fawley and Neely 2013).

²⁴Ulate (2021) uses a DSGE model to conclude that the relative efficiency of a 100 basis point cut into negative rate territory in welfare terms is between 60 and 90 percent of that of the same sized cut in conventional positive territory.

²⁵See Dell’Ariccia, Rabanal, and Sandri (2018) for a summary of these effects.

able to find any empirical study on the effect of NIRP on cross-border flows to and from non-NIRP economies. Still, there is some evidence that NIRP in Japan had positive spillovers to equity markets in other Asian countries (Fukuda 2018). In addition, the adoption of NIRP by the ECB had significant positive spillovers to financial markets in the Czech Republic, Poland, Romania, and Sweden (Varghese and Zhang 2018) and to bond yields in Asia (Feldkircher, Huber, and Punzi 2020). However, Arteta and others (2016) find that, although the adoption of NIRP by central banks in AEs had positive spillovers to asset prices in EMDEs, they were in line with those of other expansionary monetary policy announcements.

Box 2. Pass-Through of Policy Rate Changes to Bank Rates

The authors tested the hypothesis that the association between monetary policy rate changes and changes in bank deposit or lending rates has changed after the adoption of NIRP. For this purpose, they ran a regression of changes in the policy rate on changes in the bank rate as follows:

$$\Delta i_t^b = \beta_0 + \beta_1 \Delta i_t^p + \beta_2 \Delta i_{t-1}^p + \beta_3 \Delta i_{t-2}^p + \varepsilon_t$$

in which i_t^b is either a bank deposit or lending rate, i_t^p is the policy rate (premeasured with a very short-term money market rate, which is the operational target of the central bank), and t denotes the month. The authors included lagged values of the explanatory variable as there may be some inertia in the transmission of changes in policy rates to deposit and lending rates. The authors then tested whether the coefficients on changes in policy rates are stable over the sample using Ploberger and Krämer's (1992) CUSUM test. The table here shows the dates for which the test rejects the null of no structural break.

Deposit Rates		Lending Rates	
Nonfinancial Firms	Households	Nonfinancial Firms	Households
Denmark	..	Oct/07-Nov/08, May/09-Aug/09, Jul/12-Feb/13	..
Euro area	Oct-08	Dec-11	..
Japan
Sweden
Switzerland

Source: IMF staff.

Note: “..” means the null of hypothesis of no structural break is never rejected at the 5 percent significance level. The test statistic is that of Ploberger and Krämer's (1992) CUSUM test based on OLS residuals. Deposit rates for Japan and Switzerland are not available by sector of the borrower. See Annex 2 for data sources.

The results point to the existence of structural breaks in the pass-through of policy rates to bank rates only in Denmark and the euro area. Among these, only the break that goes from July 2012 to February 2013 in Denmark occurred after the adoption of NIRP (July 2012).

All in all, the estimates do not support the notion that NIRP is associated with a structural break in the transmission of policy rates to bank rates. However, the results must be taken as suggestive for two reasons. First, they do not control for potential confounding factors, including the fact that rate cuts, especially after the adoption of NIRP, were often taken in conjunction with UMP measures. Second, they do not imply causality and simply measure association.

3 Implementation Issues

Tiering Reserve Regimes

Several central banks have introduced a tiering reserve regime to mitigate the impact of NIRP on bank profitability.¹ This system consists of remunerating a share of reserves at a rate higher than the marginal policy rate. In practice, central banks have implemented tiering in slightly different ways (see Annex 1). The size of the exemption is usually based on banking-system characteristics. For instance, the exemption is sometimes proportional to reserve requirements or reflects the activity on money markets. In terms of remuneration, the interest rate on exempt reserves can be zero (as in the euro area and Switzerland). As of today, Japan is the only case of a 3-tier system, in which central bank reserves are divided in three different categories with three different remunerations (a positive rate on the basic balance, a zero rate for the macro add-on balance, and a negative rate for the policy-rate balance).

When choosing the level of exemption, central banks face a trade-off between shielding bank profitability and ensuring a full transmission of monetary policy. On the one hand, the share of exempt reserves needs to be large enough to significantly lower the average cost of holding them. On the other hand, the exemption cannot be too large—otherwise the relevant money market rates will drift away from the (negative) marginal policy rate toward the rate at which the exempt reserves are remunerated (among others, see Whitesell 2006).²

¹The adverse effect of NIRP on bank profitability is exacerbated by the amount of excess reserves in the system (for example, because of FXI or APPs). See Chapter 2.

²To ensure that very short-term money market rates are close to the floor of the interest rate corridor, the amount of excess liquidity remunerated at the deposit facility rate needs to be sufficiently large. Intuitively, if all excess reserves were exempted from negative rates, the cost of holding liquidity would stop being negative.

All in all, the experience with tiering reserve regimes seems positive. Exempting a share of reserves has not hindered the monetary transmission mechanism, while it has provided support to the bank interest rate margin, potentially reducing the reversal rate. Counterfactual evidence for Japan suggests a small but beneficial effect on bank lending (Balloch and Koby 2020). At the same time, the trade-off between preserving the transmission mechanism and sustaining bank profitability may become more difficult to manage as excess reserves keep growing as a result of unconventional measures, such as QE.

Communications

The adoption of NIRP involves significant communication challenges. As for other UMP measures, central banks need to clearly justify the use of negative rates and explain their expected effects and the channel through which they work. In other words, central bank communication should establish a direct and sound link between NIRP, the macroeconomic outlook, and the central bank's objectives. For UMP in general, and for NIRP in particular, this communication is made more difficult because of the uncertainty surrounding its effects, the potential implications for financial stability, and the public perceptions about its distributional effects.³

Still, at some level, the communication of NIRP may be easier than for other UMP because the transmission channels are better understood. All in all, communication may benefit from the fact that the theory and implementation of NIRP are well established, while suffering from a high degree of uncertainty on its empirical effects.⁴ Indeed, negative rates are the most conventional among UMPs in several respects—in principle rate cuts below zero are not so different than cuts above zero, and its limits—the existence of the ZLB and reversal rates, as discussed earlier—are also well understood. Central banks can monitor the key variables that proxy for the intensity of negative side effects, for instance the use of cash or banks' reliance on retail deposits. Nevertheless, the levels of the reversal rate and, to a lesser extent, of the ELB are difficult to estimate with precision, also because they depend on characteristics of the banking sector that may vary over time and can be influenced by regulation.

³Although monetary policy may have distributional effects, the literature suggests that monetary policy easing has a net beneficial albeit small effect on inequality, mostly because it lowers unemployment (Coibion and others 2017). However, the evidence on unconventional monetary policy measures is inconclusive (Amaral 2017). Furthermore, there is a substantial gap between the public perceptions of the distributional effects of monetary policy and the best quantitative estimates of them (Haldane 2018).

⁴This is essentially the opposite case from QE, as captured by former Federal Reserve Chairman Bernanke's famous statement that "the problem with quantitative easing is that it works in practice, but it doesn't work in theory." See Brookings Institution (2014).

Central bank communication has emphasized different aspects of NIRP to support the decision to adopt or reject it. For example, the ECB has reiterated that negative rates should not be viewed as extraordinary, highlighted its positive effects especially when adopted as part of a broad package of UMPs, and shown confidence in its ability to counteract drawbacks should they become quantitatively significant. These arguments have typically been backed by analytical work. By contrast, some central banks have been reluctant to disclose the analysis underpinning their assessments of NIRP where this has rested on market-sensitive information, such as confidential supervisory and regulatory data. For instance, the Federal Reserve and the Bank of England refrained from introducing negative rates during the Great Recession on the grounds of potential damage to the proper functioning of financial markets with associated heightened risks to financial stability.

Several lessons can be drawn on how to design communication in preparation and during the implementation of NIRP. First, central banks should clearly explain the expected benefits of adopting NIRP and the likelihood and size of potential side effects of modestly negative rates. Central banks should push back against the notion that there exists a “red line” at zero, which is too risky to cross.⁵ Second, central banks need to stress that they will continuously and closely monitor the pass-through of policy rates to deposit and lending rates, as well as potential side effects and act to alleviate them with adequate instruments (for example, the adoption of a tiering reserve regime). Finally, communication should highlight the difference between nominal and real interest rates, reiterating the prominence of the latter in affecting macroeconomic conditions. To this end, central banks should put additional effort into explaining the rationale underlying negative rates—including the use of “tiered” or “targeted” communications geared toward stakeholders with differing levels of economic literacy.

⁵The need for clear communication on whether negative rates are in the toolbox, even when not used, has the added benefit of allowing financial system to prepare. This may also be important for the distribution of expected future interest rates.

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Conclusions

This paper sheds light on the cross-country experience with NIRP so far. To conclude, the authors briefly summarize what they have learned, what remains to be better understood, and why, given the evidence so far, central banks have been somewhat hesitant in adopting or deepening NIRP.

What Do We Know About the Effects of NIRP?

Overall, most of the theoretical negative side effects associated with NIRP have failed to materialize or have turned out to be less relevant than expected. Economists and policymakers have identified a number of potential drawbacks of NIRP, but none of them have emerged with such an intensity as to tilt the cost-benefit analysis in favor of removing this instrument from the central bank toolbox. For instance, the transmission mechanism of monetary policy does not appear to change significantly when official rates become negative. Moreover, overall, bank profitability has not significantly suffered so far. In other words, the reversal rate remains a theoretical concept which has not been empirically validated and, most likely, not yet breached (Arce and others 2020; Tenreyro 2021), and banks do not appear to have engaged in excessive risk-taking. Of course, these side effects may still arise if NIRP remains in place for a long time or policy rates go even more negative, approaching the reversal rate.

What Do We Not Yet Know About the Effects of NIRP?

The literature so far has largely overlooked the impact of negative interest rates on financial intermediaries other than banks. Although pension funds and insurance companies do not typically offer overnight deposits and thus the constraint on lowering the corresponding rates below zero is not an issue,

other non-linearities may arise when market rates become negative. Among others, legal or behavioral constraints to offering negative nominal returns could affect the profitability of nonbanks. Given the importance of these institutions for the financial system, the absence of empirical evidence on the impact of negative rates on their behavior is surprising.

The role of bank competition in shaping outcomes is not yet well understood. As highlighted in IMF (2017), absent competition from other intermediaries or capital markets, the transmission of negative policy rates to bank lending rates will be weaker, as banks would try and preserve their intermediation margin. To the best of our knowledge, no study has tested this hypothesis, despite the availability of relevant data.

Another interesting direction for future research is to further study the determinants of the corporate channel identified by Altavilla and others (2019b). According to this channel, cash-rich firms with relationships with banks that charge negative rates on deposits are more likely to use their liquidity to increase investment. What drives this channel is still unclear. For instance, the role of multiple bank relationships could be investigated. If cash-rich firms can easily move their liquidity across financial institutions (including nonbanks), then negative rates on corporate deposit may simply lead these firms to reallocate their liquidity across intermediaries, without any significant impact on investment. By contrast, frictions that prevent firms from easily establish new bank relationships, and thus move their funds around, could induce a reallocation from corporate deposits to other less liquid assets, such as fixed capital.

Why Have Central Banks Not Resorted to NIRP More Often?

NIRP may not be a first-choice policy option for many central banks because they have other unconventional policy options.¹ The need for monetary policy accommodation when central banks' main policy rates are close to zero can be met with in a variety of ways. For example, quantitative easing, credit easing, funding-for-lending schemes, and YCC have all been actively used by AE central banks, but not many have ever used NIRP. A reasonable inference is that those central banks judge that the least costly means of meeting their

¹Coordinated action among monetary, prudential, and fiscal policies may also reduce the need for NIRP. That is, monetary policy measures are not the only game in town. For jurisdictions wherein fiscal buffers are available, a shock to aggregate demand can be met with deficit spending. For example, the Norges Bank statements highlight Norway's room for fiscal maneuver (Olsen 2019). Similarly, the release of macroprudential buffers can provide a measure of support to the financial system in the event of a crisis, and thereby buttress conventional monetary policies (Bank of England 2020).

objectives does not involve NIRP.² For example, NIRP may be perceived as costly in jurisdictions that allow CNAV MMFs, at least in the short term.

Specific institutional constraints are likely to have also played a role. In some jurisdictions, central banks may lack the authority to set negative rates (Swoboda 2018). In others, they may be unable to easily enact other forms of unconventional monetary policy. One example is the potential constraints on the ECB's ability to undertake purchases of government securities arising from the prohibitions on monetary finance written into European treaties. Such constraints may make the commitment to undertake unlimited purchases that underpin YCC harder to support, although recent announcements make clear that the ECB can conduct very sizeable operations if needed (ECB 2020).

The structure of funding markets may also discourage some central banks from pursuing NIRP. This may be the case, for instance, in economies where banks rely extensively on retail deposits. It could also apply to economies where MMFs intermediate a significant fraction of savings, especially if most of those funds have constant or stable NAV. However, the experiences and evidence surveyed in this paper should dampen these concerns, at least for moderately negative rates.

However, central banks should not rule out NIRP and keep as part of its toolkit, even if they are unlikely to use it. Allowing for the possibility of temporary cuts into negative territory by not ruling out NIRP could still shift expectations and be effective in lowering long-term rates. If markets internalize the concept that rates can be cut below zero or below what was previously seen as their effective minimum, the shift in market expectations is likely to produce declines in longer horizon yields—even if the move is initially seen as temporary. This would suggest a greater loosening effect of NIRP for countries that currently have low but positive rates.

Finally, there may still exist some room for central banks to cut rates further. The absence of a flight to cash at moderately negative interest rates could mean that the ELB is deeply negative, probably below the estimates of about -0.5 to -0.75 percent from many older studies (Table 1) and perhaps as low as -2 percent (Lilley and Rogoff 2019).³ Deeply negative rates could be effective as a temporary tool in extreme situations, and may be required given that AE central banks, on average, cut policy rates by 500 basis points in typical recessions. Still, there is considerable uncertainty about how negative rates

²Alternatively, it could reflect a greater aversion to cross-sectional variation in consumption relative to intertemporal inequality (Jung 2019).

³Implementing even more negative rates may require more extreme measures such as taxes on cash or the elimination of large denomination bills (for example, Agarwal and Kimball 2019, Lilley and Rogoff 2019).

can become, before significant adverse effects on bank lending become apparent. And prolonged periods of negative rates could elicit a strong pushback from households and certain segments of the financial sector (for example, money market funds).

Annex 1. Country Case Studies

Denmark

Background

In July 2012, the Danish central bank was the first country to cut its main official policy interest rate—the interest rate on bank certificates of deposit—into negative territory.^{1,2} This was done as a means of defending the Danish krone's peg with the euro. The Danmarks Nationalbank (DN) has been successful in keeping the krone closely aligned with euro. However, as with other central banks that were focused on preventing an excessive appreciation of their currencies, at least initially, there were serious doubts about the transmission of negative rates to other interest rates, output, and prices (IMF 2017).

Effects

Since 2017, there is mounting evidence that negative rates are increasingly being transmitted to both deposit and lending rates. For example, several commercial banks are now charging the central bank's benchmark rate (–0.75 percent) on corporate and moderate-size retail deposits,³ and 10-year

¹Danmarks Nationalbank's interest rate on reserves—the current account deposits rate—has been close to zero since July 2012. However, Danish banks can hold only a limited amount of reserves, with excess liquidity being converted to negative-interest-bearing certificates of deposit (Angrick and Nemoto 2017). When the text refers to negative central bank rates in Denmark, it means a negative rate on DN certificates of deposit.

²Although the Riksbank, Sweden's central bank, lowered its overnight deposit rate to –0.25 in July 2009, this is not the Riksbank's official policy rate.

³Reuters. 2019. “UPDATE 1-Denmark's Jyske Bank Lowers Its Negative Rates on Deposits.” September 20. <https://www.reuters.com/article/denmark-rates-jyske-bank/update-1-denmarks-jyske-bank-lowers-its-negative-rates-on-deposits-idUSL5N26B1AA>.

mortgages are being issued at rates as low as -0.5 percent.⁴ In addition, interest rates on short-term bank loans to nonfinancial corporations have been close to zero since at least mid-2018. However, the successful transmission of negative rates to lending rates is, to some extent, the result of Denmark's unique mortgage market where mortgage originators (banks and mortgage companies) collect fees from financing and refinancing but then securitize the loans.⁵

Despite having to live with negative interest rates for most of the last eight years, bank profits in Denmark have not suffered. The resilience of bank profits stems partly from their ability to adapt business models and to rely more on fee income. There is also little evidence that negative rates have encouraged zombie lending. Lending to mature firms with negative interest coverage ratios (ICR)⁶ as a share of total lending has declined since 2011 (Danmarks Nationalbank 2019).

Euro Area

Background

The European Central Bank (ECB) introduced NIRP in June 2014, when it lowered the interest rate on its deposit facility to -0.10 percent. Since then, the ECB has cut the deposit facility rate four more times, always in steps of 10 basis points. As a result, the rate on the deposit facility has been standing at -0.50 percent since September 2019. Crucially, the deposit rate has been the relevant ECB policy rate since the onset of the sovereign debt crisis. Owing to the adoption of other unconventional measures, such as targeted and non-targeted longer-term refinancing operations and assets purchase programs, banks in the euro area hold a large amount of excess liquidity. Therefore, even before the adoption of NIRP, the cost of depositing reserves at the central bank rather than the rate on refinancing operations was determining the overnight unsecured rate, which is the ECB's (implicit) operational target and the effective marginal policy rate.

The main reason to adopt NIRP was to provide additional monetary stimulus in a context characterized by strong disinflationary pressures. Given the lack of consensus on launching a large-scale asset purchase program, the Governing Council of ECB opted for lowering the deposit rate below zero to

⁴Schartzkopff, Frances. 2019. "Negative Rates are a Cash Cow for Denmark's Mortgage Lenders." *Bloomberg*, September 4. <https://www.bloomberg.com/news/articles/2019-09-04/negative-rates-are-a-cash-cow-for-denmark-s-mortgage-lenders>.

⁵Ibid.

⁶The ICR is the ratio of earnings before interest and taxes to net interest expenses, provided the latter are positive.

maintain price stability. However, other reasons may have played an important role. For instance, a reduction in the deposit rate allows for the interest rate corridor to widen, providing incentives to participate in the interbank market. A wider corridor incentivizes banks that need liquidity to tap money markets instead of borrowing from the central bank. Symmetrically, the increased cost of holding reserves creates a “hot potato” effect. By providing incentives to borrow and lend out reserves in the interbank market, the ECB aimed at reducing segmentation, as the distribution of excess liquidity was highly uneven across countries and financial institution.

Effects

Data on macro-financial variables suggest that the transmission of negative rates has been fast and effective. The exchange rate has depreciated significantly after the introduction of NIRP, contributing to boosting exports and economic activity.⁷ Bank lending rates have declined for both households and firms, with their dispersion across countries falling as well. This reduction in the cost of credit has supported credit growth and investment. The transmission to deposit rates has also been quick, even if it seems to have slowed down as they approach the ZLB. Despite the widespread decline in deposit rates, the use of cash does not seem to have grown. Boucinha and Burlon (2020) corroborate these findings by providing evidence that negative interest rates have supported economic activity and ultimately contributed to price stability.

While recognizing NIRP’s contribution in delivering the needed monetary accommodation, the ECB has become increasingly concerned about the potential negative impact of negative policy rates on bank profitability. To partially offset the fall in banks’ net interest margin, in September 2019 the ECB introduced a multi-tier regime, similar to those already adopted by other central banks. In particular, the ECB has chosen a two-tier system for reserve remuneration, in which liquidity up to six times the reserve requirement is remunerated at zero percent rather than at the deposit facility rate. Both the multiplier on reserve requirement and the interest rate can be changed over time. This system reflects the necessity to weaken the side effects of NIRP on bank profitability in a context where the distribution of excess liquidity is highly heterogeneous. The adoption of a two-tier system also aims to increase the average return on reserves, disincentivizing their substitution with cash.

⁷The empirical evidence suggests that monetary policy accommodation, including that from negative interest rates, improves the trade balance (for example, Ca’ Zorzi and others 2020).

In March 2020, the ECB decided to lower the interest rate on the funds borrowed through TLTROs to negative territory. Specifically, banks that met determined thresholds in terms of lending to the nonfinancial private sector were charged an interest rate 0.5 percent below the average rate on the deposit facility prevailing between June 2020 and June 2021, and in any case not higher than –1 percent. Although this decision may appear as a further step toward reaching the ELB, the effects are very different from those of a cut in official rates. As explained earlier, NIRP is typically considered a nonstandard measure mainly because it potentially involves an asymmetric impact on banks' assets and liabilities, possibly harming their probability. In the case of TLTROs, the ECB reduces the rate on funds borrowed from the central bank, thus lowering the cost of funding of financial intermediaries. By reducing the spread between the average return on bank assets and liabilities, this monetary policy decision softens, rather than exacerbates, the potential side effects associated with NIRP.

Japan

Background

The Bank of Japan (BOJ) announced on January 29, 2016, that a negative interest rate on excess reserves would be implemented on February 16, 2016. This was nearly three years after the introduction of quantitative and qualitative easing (QQE). After its deployment, the QQE framework helped boost economic activity, inflation, and inflation expectations (BOJ 2016, Hattori and Yetman 2017). Nonetheless, inflation persistently stayed below the 2 percent target of BOJ, and by the summer of 2015 both the domestic and global outlooks started to weaken. Amid intensifying financial turbulence in emerging markets, an appreciating yen, and falling oil prices during late 2015, economic activity in Japan softened, equity markets contracted sharply, and inflation started to decline.

The BOJ complemented QQE with negative interest rates to further lower the short end of the yield curve and reinforce its commitment to an inflation target of 2 percent. Since the price stability target had not been achieved for a long period in Japan, the backward component of inflation expectations in Japan was high, and stronger than in other large economies. Moreover, BOJ's own analysis suggested that the improvement in the output gap brought about by a unit decline in the real interest rate at each maturity tranche was largest at maturities of 1–2 years, but gradually became smaller the longer the maturity (BOJ 2016).

Effects

Following the introduction of NIRP, interest rates across the entire yield curve fell to such a degree that the yield curve flattened. The large drop in longer maturities was in part due to NIRP being accompanied by continuing Japanese government bond (JGB) purchases by the BOJ, compressing risk premiums. In addition, intensified search for positive yield by financial institutions drove up the demand for assets with a positive interest rate, driving down super-long-term JGB yields (BOJ 2016).

Lending and deposit rates also fell, compressing lending margins, but without evidence that financial institutions' functioning as intermediaries has been impaired. This may have been in part due to the three-tier reserve deposit system that the BOJ introduced to mitigate the direct impact on financial institutions' profits (IMF 2017). In addition, NIRP has translated into a fall on corporate yields as well, triggering a pickup, in particular, in the issuance of very long-term corporate bonds.

Overall, NIRP in Japan has stimulated activity and inflation, but has been insufficient considering the Bank of Japan's price stability objectives. Survey and market-based inflation expectations continued to slide down and economic activity remained tepid. In response, the BOJ introduced a new policy framework (Quantitative and Qualitative Monetary Easing with Yield Curve Control) on September 2016, which aimed to control both short-term and long-term interest rates to directly target the slope of the yield curve to better calibrate the monetary policy stimulus and alleviate the burden of low interest rates on financial intermediaries. Within the new framework, BOJ has also committed to overshoot its inflation target until the year-over-year rate of increase in the observed consumer price index exceeds the price stability target of 2 percent and stays above the target in a stable manner (BOJ 2016). Since then, macroeconomic outcomes have somewhat improved, though actual and expected inflation remain below the inflation target (Westelius 2020).

Sweden

Background

In July 2009, Sweden was in the midst of the downturn that had spread across its trading partners following the global financial shocks of the fall of 2008. The Riksbank—Sweden's central bank—lowered its main policy rate, the repo rate, to 25 basis points and its deposit rate to –25 basis points. With this action, the Riksbank became the first central bank to cut one of its policy rates (albeit not the main one, which in Sweden is the repo rate)

below zero.⁸ The period of negative rates did not last long. By the middle of the following year, rates started to move upward as the central bank became increasingly concerned with building financial imbalances.⁹

At the time of its 2009 decision, the Riksbank Executive Board judged that 25 basis points was the lower limit of its repo rate “in practice.”¹⁰ But as other central banks have found, what is taken to be a lower limit can change over time. Declining inflation expectations and weak demand conditions through 2012–14 led the Riksbank to ease policy once again, and in February 2015 it set its main repo rate below zero for the first time, at –10 basis points. A further sequence of cuts followed, bringing the repo rate to –50 basis points between February 2016 and January 2019.

As in other countries, NIRP was enacted alongside an asset purchase program and forward guidance. These three elements of unconventional policy combined produced substantial policy easing (see IMF 2015, paragraphs 14–19). Further discussion of how NIRP can reinforce other measures appears in Chapter 2.

In December 2018, the Riksbank announced that it would start to raise its repo rate, while maintaining the size of its asset purchase program. The following December, it became the first central bank to announce its exit from NIRP, when it increased the repo rate back to zero, while citing an inflation rate close to the 2 percent target and an expansion in economic activity. As of January 2021, the deposit rate remains negative at –10 basis points.

Effects

There is evidence that the Riksbank’s negative rate policy resulted in Swedish banks cutting both deposit and lending rates (see Erikson and Vestin 2019). But as Chapter 3 discusses, the pass-through to deposit rates looks to have weakened with successive cuts. Some research has pointed toward small negative effects, or even slightly positive effects, on lending rates from NIRP (Eggertsson and others 2019).¹¹ However, more than three years after NIRP

⁸The Riksbank’s market operations meant that, in practice, overnight rates remained positive and the deposit rate being negative was of no consequence (Burke and others 2010).

⁹Macroprudential policy is usually better suited to dealing with issues of financial stability (IMF 2015). But at that time, Sweden lacked an institutional framework for macroprudential policymaking.

¹⁰Riksbank. 2009. *Monetary Policy Report*. July. The report states (p. 21, emphasis added): “Although one can in principle consider even a negative repo rate to be possible, it is the Riksbank’s assessment that the repo rate, after the cut made now, *will have in practice reached its lower limit*, and that it is not appropriate to cut the rate further than to 0.25 percent.”

¹¹As noted before, in Eggertsson and others’ (2019) model of the transmission of monetary policy, banks may respond to negative policy rates by raising the spread between their lending and borrowing rates, which

was introduced, Swedish banks continued to report strong profitability (IMF 2019). More context on the pass-through of negative rates, and their potential effects on bank profitability, is given in Chapter 3.

Switzerland

Background

The Swiss National Bank (SNB) adopted negative rates on commercial bank deposits to keep Swiss interest rates below those of the euro (Danthine 2018). This, in turn, was enacted to stem a capital inflow surge (exacerbated by its safe-haven status) and thus prevent an excessive appreciation of the Swiss franc and associated deflationary pressure (Jordan 2020).¹²

Following QE by ECB in August 2011, the three-month interest rate differential between the Swiss franc and the euro basically vanished. Ruling out the possibility of implementing QE because of a small domestic capital market (Jordan 2020), the SNB responded by imposing a floor on the franc/euro exchange rate. The floor lasted until January 2015, after which the SNB cut the deposit rate to -0.75 and a negative interest rate differential returned. The SNB complemented the negative interest rate policy with the announcement that it would remain active in the FX market if necessary. The FX interventions ultimately led to a large expansion of its balance sheet (Danthine 2018).

Effects

Pass-through to bank lending rates was initially low, suggesting the relevant transmission channel was the exchange rate. Although the rate cuts into negative territory produced a level shift in the yield curve and have not weakened the transmission of short rate cuts along the curve (Grise and Schumacher 2018), Swiss banks did not initially reduce the rates they charge on their lending, including on mortgage lending (Danthine 2018). This could have been because of their inability to reduce funding costs, given the low pass-through to customer deposit rates, because of market power in lending markets, or simply reflect rising credit risk associated with overstretched valuations. More recently, shorter-term lending rates in particular have seen some sizeable declines.

depresses output and inflation. However, this is a consequence of the central bank setting a policy rate below the ELB (calibrated at -0.01 percent), among other assumptions.

¹²In small open economies that do not have safe haven status (unlike Switzerland), low interest rates in large AEs do not effectively constrain their monetary policy because they have a positive currency risk premium.

Low pass-through of negative rates to deposit rates at commercial banks has meant that the risk of cash hoarding by depositors is still low. The SNB has gone farther than any other central bank in setting a negative interest rate. However, significant exemptions have meant that the average rate on deposits at the SNB is significantly higher than the marginal rate. Furthermore, since commercial banks have refrained from passing on negative rates to small depositors,¹³ the ZLB still holds for these deposits. Therefore, the SNB may still have room to cut the marginal deposit rate further (Jordan 2020), at least based on market-implied beliefs (Grisse and Schumacher 2018).

¹³Several Swiss banks are now charging interest on large deposits (for example, Revill and Hirt 2019).

Annex 2. Tests of Structural Breaks after NIRP

Denmark	
Policy rate	Interbank rate “Tomorrow/Next”
Bank rate on household deposits	Interest rate on domestic deposits in DKK held by households
Bank rate on NFCs deposits	Interest rate on domestic deposits in DKK held by nonfinancial corporations
Bank rate on mortgages to households	Interest rates on new loans to households for house purchase
Bank rate on loans to NFCs	Interest rates on new loans to nonfinancial corporations (Including repos)
Euro area	
Policy rate	EONIA
Bank rate on household deposits	Interest rates on new overnight deposits held by households
Bank rate on NFCs deposits	Interest rates on new overnight deposits held by nonfinancial corporations
Bank rate on mortgages to households	Interest rates on new loans to households for house purchase with initial maturity up to one year
Bank rate on loans to NFCs	Interest rates on new loans to nonfinancial corporations with initial maturity up to one year (excluding revolving lines)
Japan	
Policy rate	Uncollateralized overnight interbank rate
Bank rate on deposits	Interest rate on ordinary deposits
Bank rate on time deposits	Average interest rate on time deposits
Bank rate on mortgages to households	Interest rate on housing loans with floating rates by city banks
Bank rate on loans to NFCs	Interest rates on new short-term loans
Sweden	
Policy rate	STIBOR “Tomorrow/Next”
Bank rate on household deposits	New bank deposit rates for households
Bank rate on NFCs deposits	New bank deposit rates for nonfinancial corporations
Bank rate on mortgages to households	New bank loans to households for housing
Bank rate on loans to NFCs	New MFI loans to nonfinancial corporations
Switzerland	
Policy rate	Swiss three-month LIBOR ¹
Bank rate on deposits	Interest rate on savings deposits for private clients
Bank rate on mortgages to households	Interest rate on mortgages with fixed interest rates
Bank rate on loans to NFCs	Interest rate on investment loans with fixed interest rates

¹As of June 13, 2019, the SNB policy rate replaced the target range for the three-month Swiss franc LIBOR previously used in the SNB’s monetary policy strategy.

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