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Requested by the ECON committee

Monetary Dialogue Papers, June 2021

European Parliament

Low for Long: Side Effects of Negative Interest Rates

Policy Department for Economic, Scientific and Quality of Life Policies
Directorate-General for Internal Policies
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PE 662.920 - June 2021

EN

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Abstract

Policy rate cuts in negative territory have increased credit supply and improved the macroeconomic environment similar to cuts in positive territory. Dreaded disruptions to the monetary policy transmission channels as well as adverse side effects on bank profitability have so far largely failed to materialise. Thus, the evidence available today shows that the negative interest rate policy is an effective policy tool. However, systemic risks, including in the non-bank sector, should be closely monitored as negative rates are expected to remain low for longer.

This paper was provided by the Policy Department for Economic, Scientific and Quality of Life Policies at the request of the committee on Economic and Monetary Affairs (ECON) ahead of the Monetary Dialogue with the ECB President on 21 June 2021.

This document was requested by the European Parliament's committee on Economic and Monetary Affairs (ECON).

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Original: EN

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Manuscript completed: June 2021
Date of publication: June 2021

This document was prepared as part of a series on "Low for Longer: Effects of Prolonged Negative Interest Rates", available on the internet at:
https://www.europarl.europa.eu/committees/en/econ/econ-policies/monetary-dialogue

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For citation purposes, the publication should be referenced as: Inhoffen, J., Pekanov, A., Url, T., *Low for Long: Side Effects of Negative Interest Rates*, Publication for the committee on Economic and Monetary Affairs, Policy Department for Economic, Scientific and Quality of Life Policies, European Parliament, Luxembourg, 2021.

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LIST OF ABBREVIATIONS

APP	Asset purchase programme
CMP	Conventional monetary policy
DFR	Deposit facility rate
DSGE	Dynamic stochastic general equilibrium
ECB	European Central Bank
ESCB	European System of Central Banks
EU	European Union
MFI	Monetary financial institutions
NIM	Net interest rate margins
NIRP	Negative interest rate policy
NMFI	Non-monetary financial institutions
TFP	Total factor productivity
TLTRO	Targeted longer-term refinancing operations
UMP	Unconventional monetary policy
VAR	Vector autoregression

EXECUTIVE SUMMARY

- **Negative interest rate policies (NIRPs) have been introduced in a number of advanced economies in recent years as central banks have aimed at addressing the low inflation environment with unconventional monetary policy tools.** The entry into negative territory raised several concerns about its effects on the transmission of monetary policy and possible side effects.
- **The decade-long decline in the natural rate of interest suggests that a low interest rate environment may be here to stay for a prolonged period in advanced economies.** This trend may necessitate the more often usage of NIRP after significant macroeconomic shocks.
- **Policy rate cuts in negative territory have successfully eased financial conditions in largely similar ways as standard interest rate cuts.** The *interest rate channel* of transmission was effective as evidenced by prevalent money market rates and a downward shift of the government bond yield curve. Market participants' expectations of future short-term interest rates were successfully steered towards negative territory. The *credit channel* effectively raised credit growth to households and the non-financial sector.
- **Concerns of a muted policy rate pass-through towards bank clients only partly realised.** Banks were expected not to charge negative rates from clients, which could disrupt policy transmission and severely impact profitability. While this did occur for deposit rates of households, it did not for non-financial corporates. Causal evidence of the negative effect on credit supply for banks most reliant on deposits and consequently most exposed to NIRP is inconclusive.
- **There are several systemic risks associated with NIRP:** it may reduce bank profitability by eroding the interest rate income of banks, may create asset price bubbles, or hurt the yield on pension savings. In search for yield, banks can lend to riskier counterparties, invest in riskier assets, and thereby endanger financial stability.
- **Evidence suggests that banks prevented severe adverse effects on their profitability by modifying their business strategies and have benefited from other factors not guaranteed to persist in the long run.** Empirical evidence suggests that clients did not significantly withdraw their deposits which would endanger bank funding. Further, banks realised gains on their fixed income assets, against which they could also borrow more on wholesale markets, and decrease their loan loss provisions.
- **While the impact of monetary policy rates on real estate prices is an important transmission channel, housing is also a crucial part of households' wealth and consumption spending.** From a consumer perspective, asset price inflation affects the decision to acquire home ownership and rental rates. International evidence suggests that a one percentage point decrease in the interest rate will cause an increase in real estate prices of 6% to 8% over the following three years.
- **NIRP may adversely affect non-monetary financial intermediaries (NFMI)**. A protracted low interest rate will hit the solvency status of NMFIs and plan sponsors depending on the extent to which they guaranteed minimum returns. NMFIs may implement riskier strategies to meet their obligations. Beneficiaries of non-guaranteed pension products will have to bear the low return on assets. Due to limited available data, there is little evidence on effects on NFMIs.
- **The evidence points towards cautious optimism regarding NIRP as a monetary policy instrument. So far, it cannot be associated with significant adverse effects.** The empirical assessment suggests that it has delivered on its objectives and has worked similarly to standard

nominal interest rate cuts. The main adverse effects of NIRP, i.e. the disruption of monetary policy transmission as well as financial fragility arising from low bank profitability and an excessive pressure for cash hoarding, have not yet materialised in the euro area.

- **Ongoing assessment is needed to understand whether market participants can continue to cope with the pressure on profitability in negative territory when policy rates decrease further and/or remain on this level for years to come.** In the face of considerable uncertainty, the risks of pushing rates too low should not be underestimated since non-linear effects may materialise at some point. Some increasingly crucial elements of the financial system, the non-bank financial intermediaries, are poorly understood, yet their response could introduce material risks.

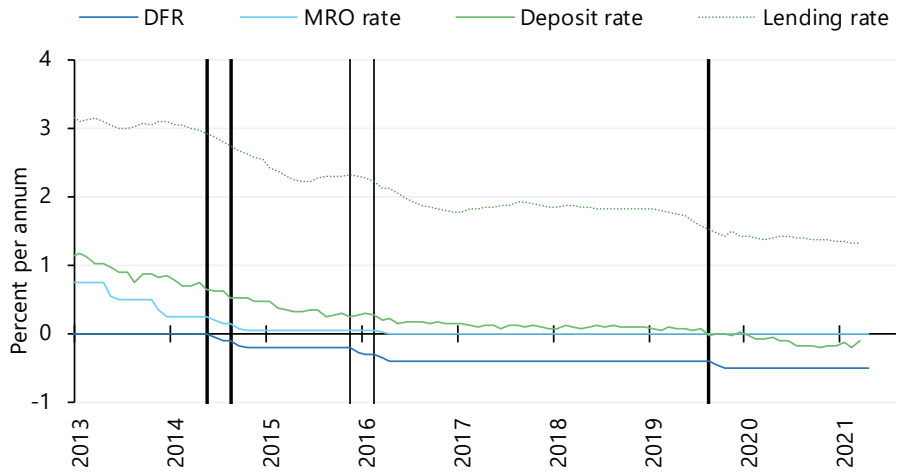
1. INTRODUCTION

Negative interest rate policies (NIRPs) have been introduced in many advanced economies in the aftermath of the global financial crisis, as central banks have aimed at addressing the low inflation environment and sluggish growth with unconventional monetary policy tools. For a long time, it was assumed that policy interest rates had a natural lower bound of zero. It was a widely held view that they could not go negative or that interest rate cuts in negative territory could lead to significant problems.[1] More recently, however, economists have argued that the zero lower bound can be overcome using various measures, policies or instruments[2].

The entry into negative territory raised several concerns about the effectiveness of monetary policy in inducing inflation and output growth. In the absence of experience with NIRP in a large economy before 2014, there was considerable uncertainty about how financial intermediaries, which are of crucial importance for policy transmission, would respond strategically to pressures on profitability. This could not only disrupt pass-through channels of interest rates on prices but could induce systemic risks to financial markets. The evidence in the countries which have introduced NIRP during the recent years suggests that the suspected adverse effects have not materialised. The effective lower bound on interest rates seems to be well below zero and a negative interest rate policy appears to be feasible, at least in the short term, although it is not yet clear whether it is optimal and how far policy rates can and should go into negative territory (Tenreyro, 2021). This paper discusses both the traditional effects of NIRP, as well as the additional side effects it can have.

The European Central Bank (ECB) was the first of the major central banks in advanced economies to introduce negative interest rates by lowering the deposit facility rate (DFR) below zero in 2014 (Figure 1). It has since continued this policy in small increments until it reached the current level of -0.5% in September 2019, although in combination with a two-tier system for remunerating excess reserves at the central bank. Other countries which have also introduced NIRP over the last decade have been Denmark (2012), Sweden (2014-2019), Japan (2016) and Switzerland (2014) (Tenreyro, 2021).

Figure 1: Developments in policy rates and bank lending rates



Source: Boucinha and Burlon (2020), ECB and ECB calculations.

Note: The vertical black lines indicate the five cuts in the DFR into negative territory between June 2014 and September 2019.

[1] See Mankiw (2003) and Woodford (2003) for standard textbooks explaining that the zero lower bound can be a hard constraint on monetary policy.

[2] See Buiter (2009) or Kimball (2015).

Policy rate cuts generally stimulate price developments and the macroeconomy through various channels. Most importantly, they decrease the short end of the yield curve as well as the long end if market participants' expectations of future short-term rates are successfully steered (de Groot and Haas, 2020). When nominal rates are sluggish, real interest rates decrease which induces demand for credit and investment. Further, banks should increase their supply of credit in response to the effects on a range of components of their business. One immediate peculiarity of negative rates is that commercial banks' holdings of excess reserves are penalised which incentivises them to increase loan issuance.

There are, however, several risks associated with negative interest rate policies. They may induce excessive cash hoarding, reduce bank profitability by eroding the interest rate income of banks, may create asset price bubbles, or hurt the yield on pension savings. Lower profitability in their conventional credit business may induce banks to take on higher risk investments. The first effect may occur if, after the introduction of NIRP, investors decide to transfer their deposits into cash holdings rather than into riskier or long-term assets. If negative interest rates transmit to retail deposits, this can endanger bank profitability and start to have a reverse effect on bank lending, which instead of expanding could contract (Eggertsson et al., 2017). While the initial steps into negative territory have so far not shown signs of such adverse impacts, it is not certain that the effects will be non-linear. In that line, the concept of the reversal interest rate has been introduced by Brunnermeier and Koby (2018).

The current empirical assessment of the effects of NIRP, however, suggests that NIRP has been an effective tool to reduce money market rates as well as yields on longer-dated assets, to expand the supply of loans, thereby stimulating inflation and output growth, while it has not so far been connected with significant adverse effects. NIRPs have in general worked similar to standard nominal interest rates cuts and have delivered on their objectives (Bottero et al., 2019; Demiralp et al., 2019; Rostagno et al., 2019; Schnabel, 2020). Negative interest rates have contributed to expanding lending volumes, which have partly compensated the pressure on bank profitability from lower interest rate margins. Even though the evidence points towards the overall benefits and the effective transmission of nominal interest rates, it is hard to distinguish the individual contribution of NIRP towards the effective monetary policy transmission mechanism from other tools of unconventional monetary policy (UMP) such as forward guidance, the introduction of a two-tier system and the implementation of targeted longer-term refinancing operations (TLTROs). Furthermore, the initial macroeconomic response to NIRPs can change if rates go further into negative territory – a non-linear response may emerge, especially if banks' profitability starts to suffer after passing the reversal interest rate.

2. THE NATURAL RATE OF INTEREST

The introduction of negative nominal interest rates has been partly determined by the fact that the estimated natural interest rate as well as real rates have been on a decline for the past three decades (Jordà et al., 2020; Constâncio 2016; Yellen, 2017). With an inflation target of 2%, low real rates imply low nominal rates. Following the global financial crisis, the combination of the long-term decline in the real interest rate and the natural interest rate has meant that the policy space of central banks with regard to conventional nominal interest rate cuts has become limited. It is often argued that structural factors such as an ageing society have lowered the equilibrium interest rate and thus contributed significantly to the current low interest rate environment (Rachel and Summers, 2019).[3] Rachel and Smith (2017) predict a "world" equilibrium interest rate of around 1% for the next decades. If indeed, very low natural interest rates are here to stay, this will result in monetary policy space being constrained and therefore requiring steps into negative territory more often to counteract big macroeconomic shocks.[4] In any case, if that tendency holds for the future, it entails the danger that even after the normalisation of policy rates, nominal rates will most probably stay at low levels, thus reducing the space for monetary policy to counteract any significant shocks if and when they occur.

The natural rate of interest is a key notion for the efficient decision-making processes of modern central banks and acts as one of the underlying concepts in monetary economics today. It builds upon the concept that there is a unique short-term interest rate which ensures that the potential output level will be reached with stable inflation at the given target.[5] This natural interest rate, also known as the equilibrium interest rate, plays a key role for central banks with an inflation targeting framework, as it guides their assessment for the appropriate stance of monetary policy at different points of the business cycle. Therefore, the equilibrium interest rate acts as an anchor for long-term interest rate expectations, but is also a central component of Taylor-type rules, which central banks use for guiding their short-term nominal interest rate decisions (Taylor, 1993). As any unobserved variable, the estimation of the equilibrium interest rate involves a number of methodological challenges. Most importantly for the current implementation of monetary policy, many studies have highlighted a secular decline throughout the past three decades of the natural interest rate in most developed countries. This has important repercussions for the space of monetary policy to stabilise the economy after significant macroeconomic shocks even in normal times. Even after an economy has fully recovered after a recession, nominal interest rates start from a low level and therefore can reach negative territory much faster.

By definition, the natural real interest rate is determined by real economic factors that affect desired savings and investment. Similarly to the idea of a steady state in canonical growth models, in the neo-Wicksellian framework popular today, real economic factors can put the economy on a path where output grows at the potential output growth rate and inflation is stable. The equilibrium interest rate, often marked as r*, is the short-term interest rate in this situation. In the classical theory of Wicksell (1898), the equilibrium interest rate determines prices through the marginal productivity of capital and market interest rates. If market rates are below the equilibrium, there will be an acceleration in price dynamics and vice versa. Similar dynamics underpin the current framework in which the natural interest rate is used to assess whether monetary policy is too expansionary, too contractionary or

[3] See (Vlieghe, 2016) for a detailed explanation.

[4] Or alternatively, if assumed that the effective lower bound on nominal interest rates is binding, it will be hit much harder and much more often than previously anticipated if monetary accommodation is used fully to stabilise aggregate demand, as some analysis have pointed out (Dordal-i-Carreras et al., 2016; Kiley and Roberts, 2017). Using the standard models of the Federal Reserve, Kiley and Roberts (2017) show for example that in such a low interest rate environment, policy rates would be constrained by the zero lower bound by about one-third of the time, making it very hard to reach the 2% inflation target.

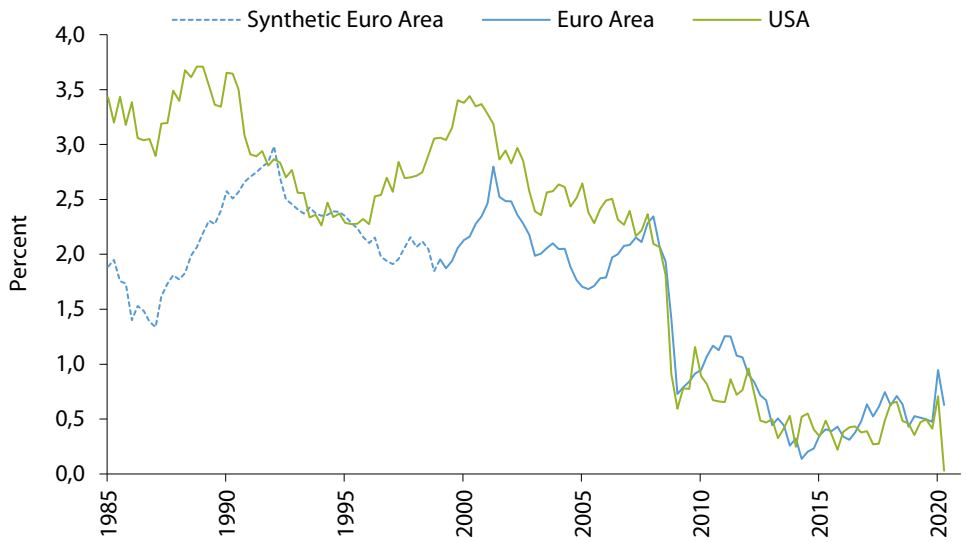
[5] It was first developed by the renowned Swedish economist Knut Wicksell in (Wicksell, 1898).

adequate. The natural interest rate is now an indivisible part of monetary theory, as well as of central bank's decision-making. Over the past decades, many central banks have disregarded the previous paradigm of targeting the money supply aggregate and have switched to an explicit or implicit inflation target as a more efficient method of securing long-term growth by having the objective of price stability as their central mandate (Bernanke et al., 2001). Interest rates, rather than changes of monetary aggregates, hold promise to reach this goal. One of the main reasons for this enhanced efficiency of using interest rate rules to aim at specific inflation targets is that this makes the interest rate setting process transparent and can ensure the anchoring of expectations about the future path of interest rates and prices, thus better solving the time-consistency and commitment problems (Bernanke et al., 2001; Williams, 2016a).

Therefore, to be able to assess the proper level of the short-run nominal interest rate at a point of the business cycle, besides an inflation target, the central bank needs to know the equilibrium interest rate. The concept is essential, as it gives a central bank a target, an anchor in terms of an interest rate r*, where a neutral stance is reached. This natural real interest rate plus the inflation results in the nominal short-term interest rate which gives a neutral stance on monetary policy and at which the output gap should be closed at the steady state level.

Even though the concept has such a big importance, it is still facing significant measurement challenges. Like other unobservable variables, the estimation of the natural interest rate requires important assumptions. Estimates of r* can be obtained either through statistical and econometric methods to extrapolate the equilibrium interest rate from data using filters (e.g. a Kalman filter) or semi-structural models or can be computed using a more theoretical dynamic stochastic general equilibrium (DSGE) model. Different methodological approaches, as well as the number of different factors that affect r*, may lead to uncertainties around the estimation of the interest rate (Taylor and Wieland, 2016), leading some policymakers to warn against their increased use as a measure for the policy stance (Michaelis and Wieland, 2017). More realistic medium and large-scale models with nominal rigidities and frictions such as the canonical (Smets and Wouters, 2007) DSGE-model can present a well-defined framework to model and estimate r* using the estimation with macroeconomic data. In a similar setting based on the *Smets – Wouters* model combined with financial friction à la Bernanke et al. (1999) and Del Negro et al. (2017) estimate the natural rate of interest r* as the real return to a safe asset in a counterfactual economy without nominal rigidities. It is with such models that proper optimal monetary policy rules can be derived and r* is a crucial input in these rules. The most well-known approach to estimate r* has been developed by Laubach and Williams (2003) and revolves around estimating reduced form equations, derived from a standard New Keynesian model – a New Keynesian Philips curve with inflation expectations and an intertemporal IS equation. This allows the natural rate of interest to be affected by low-frequency nonstationary processes. A more recent version of these estimations is presented in Holston et al. (2017*)*. Most importantly, both Holston et al. (2017) and Del Negro et al. (2017), as well as a number of vector autoregression (VAR) studies using interest rate trends, have pointed to a significant decline in r* throughout the past decades (Figure 2). In the case of the US e.g., the estimated r* has reached a value from 4% in 1980, to 2% before the financial crisis, to a value of around 0%-1% in recent years. In addition to structural as well as empirical estimates, a practical proxy for the natural rate of interest is the long-term government bond yield. They should approximate the long-term interest rate on a safe asset, such as government bonds, and have a long maturity that embeds the prospects regarding interest rate return beyond the current point of the business cycle. As Figure 3 shows, this indicator also points to a steady downward trend in the selected countries over the past decades.

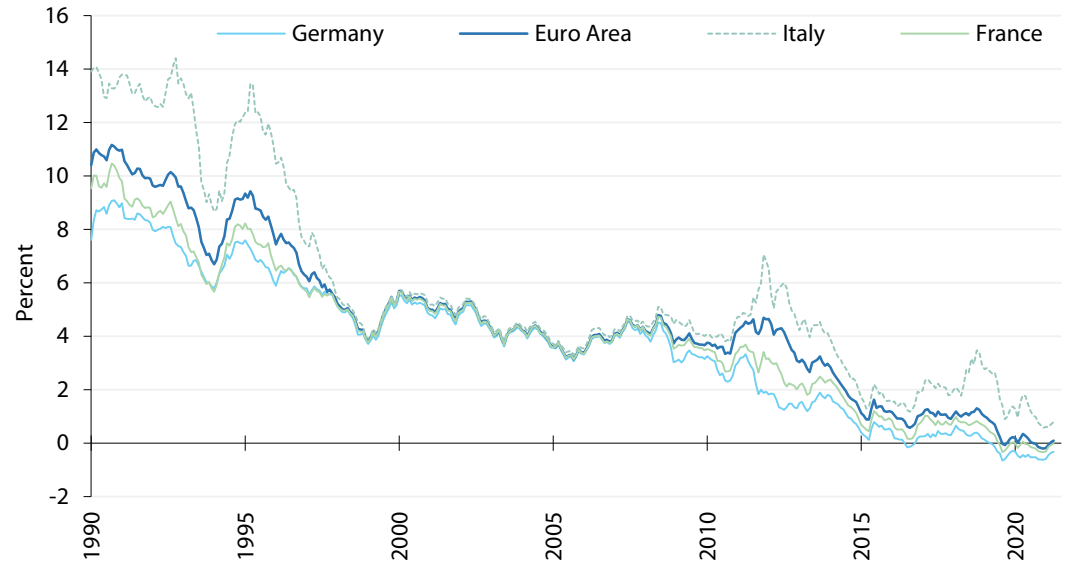
Figure 2: Holston-Laubach and Williams estimates of the natural interest rate



Source: Holston-Laubach-Williams, Federal Reserve Bank of New York, Measuring the Natural Rate of Interest, (https://www.newyorkfed.org/research/policy/rstar/overview).

Note : Euro area before 1999 is based on calculations of synthetic euro area aggregate. Final data point: Q2 2020.

Figure 3: Long term government bond yields



Source: Eurostat, Macrobond.

Even when taking into account the uncertainties around its estimation, there has been a notable and unprecedented decline in natural interest rates over the past three decades across developed countries (Furman, 2016; Holston et al., 2017). The exact causes for such a decline are still under discussion. There are a number of different factors that can affect the equilibrium interest rate. A growing literature deals with the question whether this decline in r* is connected to secular developments in the economy such as demographics and aging (Gagnon et al., 2016), a secular stagnation phenomenon (Summers, 2015; Eggertsson et al., 2016) or is due just to cyclical conditions and an unfinished recovery of the global economy (Holston et al., 2017; Gourinchas and Rey, 2016). Del Negro et al. (2018) argue that indeed this

was a secular trend caused by low economic growth and increased demand for safety and liquidity – a so-called convenience yield for safe/liquid assets, as discussed in Krishnamurthy and Vissing-Jorgensen (2012). The global "savings glut" hypothesis of increased global aggregate savings as a cause for low interest rates has been famously discussed also by Bernanke (2005). This explanation can also be connected to the documented fall in the global equilibrium interest rate (Rachel and Smith, 2017), besides the decline in country-specific r*. The decline of such a global equilibrium interest rate can be connected to the significant downward revision on growth and productivity expectations after the global financial crisis (along the secular stagnation hypothesis), but a big contribution to this development also comes from a change in preferences regarding savings (Rachel and Smith, 2015).

3. NEGATIVE INTEREST RATES EFFECTIVELY EASED FINANCIAL CONDITIONS

The transmission of monetary policy to the real economy relies profoundly on financial intermediation by the banking sector and operates through a number of channels. While these are well-established for the positive range, the literature on policy effectiveness in the negative range was only of theoretical nature due to a lack of data for big economies prior to 2014 (for an overview, see Beyer et al., 2017, Figure 1). In this section, we discuss how channels were expected to operate under NIRP and review recent empirical studies to reassess our understanding of their effectiveness. We then focus on adverse side effects that created some of the reservations against entering negative territory and pursuing further rate cuts, particularly in terms of bank profitability and financial stability.

3.1. Monetary policy transmission

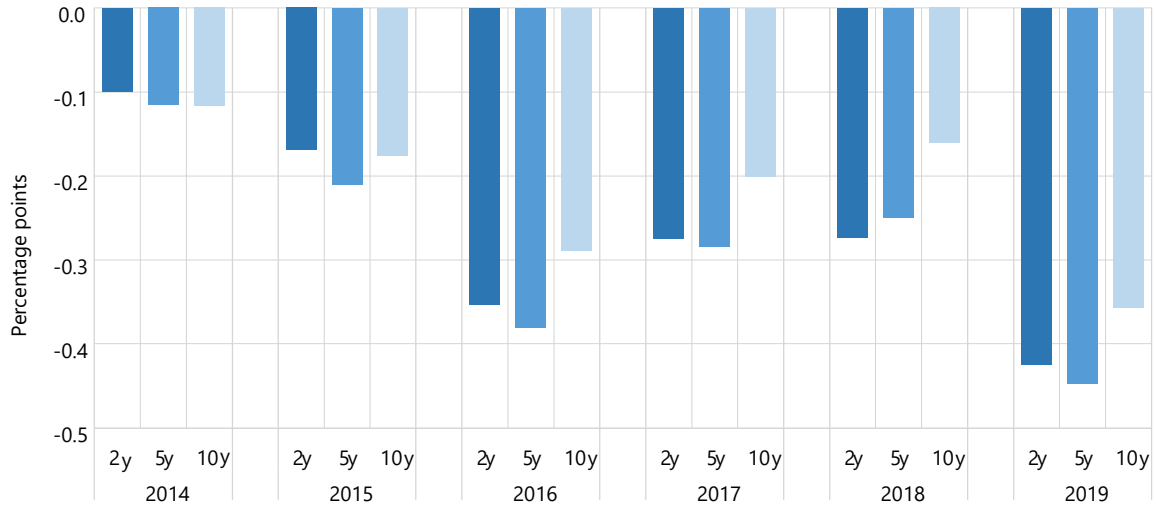
Overall, policy rate cuts in negative territory have eased financial conditions and operated in similar ways as standard interest rate cuts, however additional channels affected the transmission (Boucinha and Burlon, 2020; Altavilla et al., 2019). Empirical analyses of NIRP suggest that transmission was most effective via the *interest rate* and *bank lending channel* which we discuss in the following. Empirical studies on macroeconomic effects, though, in particular for the period in question, should be weighed against the econometric difficulty to establish causality because a range of UMP measures – in particular the large scale asset purchasing programs (APP), forward guidance, and targeted longer-term refinancing operations (TLTRO) – could have introduced confounding factors and interaction effects. Moreover, discrete fiscal policy measures also interacted with monetary policy.

Policy rate cuts are known to have a positive effect on credit *demand* via the *interest rate channel*. If transmission works properly, money market rates, that is interbank lending rates, directly reflect changes in policy rates due to arbitrage opportunities. If the policy rate adjusts market participants' expectations of future short-term rates, nominal rates on longer maturities decrease as well.[6] As a result, the yield curve shifts downwards, corporate borrowing costs in real terms fall and this induces demand for credit to finance additional investment.

There is strong evidence that the pass-through by money market rates was effective, irrespective of the jurisdiction (euro area: Eisenschmidt and Smets, 2018; Denmark: Jensen and Spange, 2015, Sweden: Angrick and Nemoto, 2017; Switzerland: Grisse and Schumacher, 2018). Figure 4 shows that as a response, negative interest rates in every maturity bucket significantly reduced government bond yields in the euro area (Rostagno et al, 2019). Prior to 2014, market participants did not expect future short-term rates to become negative, this suggests that the policy successfully steered perceptions through the *signaling channel* of monetary policy. The *signaling channel* of monetary policy works by manipulating market participants' expectations about the future stance of monetary policy and can thus also change expectations on long-term rates (De Groot and Haas, 2019). Studies suggest that the overall response of the yield curve was similar in negative compared to positive territory (Arteta et al., 2016; Wu and Xia, 2020).

[6] This is based on the expectations hypothesis of the term structure according to which the return on a long-term instrument is a function of a series of short-term instruments.

Figure 4: Effects of NIRP on sovereign bond yields

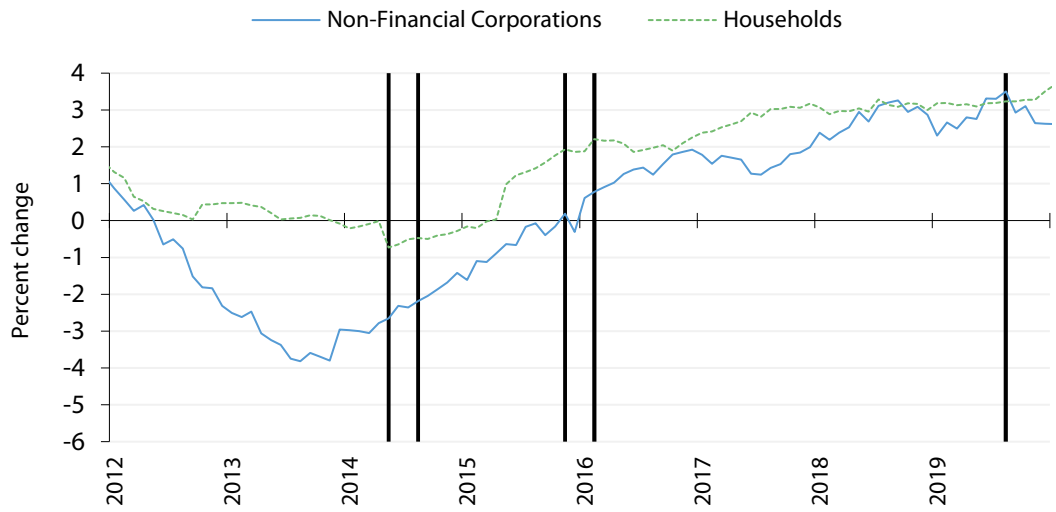


Source: Boucinha and Burlon (2020) with updated data from Rostagno et al. (2019).

Note: The chart illustrates the impact of NIRP on sovereign yields (weighted average of German, French, Italian and Spanish sovereign bond yields), which works primarily via the short-term rate and the OIS forward curve.

The *credit channel* raises the *supply* of credit. While aggregate data on loan growth in the euro area suggests an effective functioning (see Figure 5), we focus on individual components of this channel: the *bank lending* and *bank balance sheet channel*. In the traditional *bank lending channel*, lower policy rates are passed on to banks' customers lowering their funding costs and reducing their external finance premium - as a consequence of a more favorable net worth - and enables higher lending volumes (Bernanke et al., 1999; Disyatat, 2011). NIRP can be expected to further encourage lending since a negative remuneration of excess liquidity incentivises banks to supply loans.

Figure 5: Loan growth of euro area commercial banks

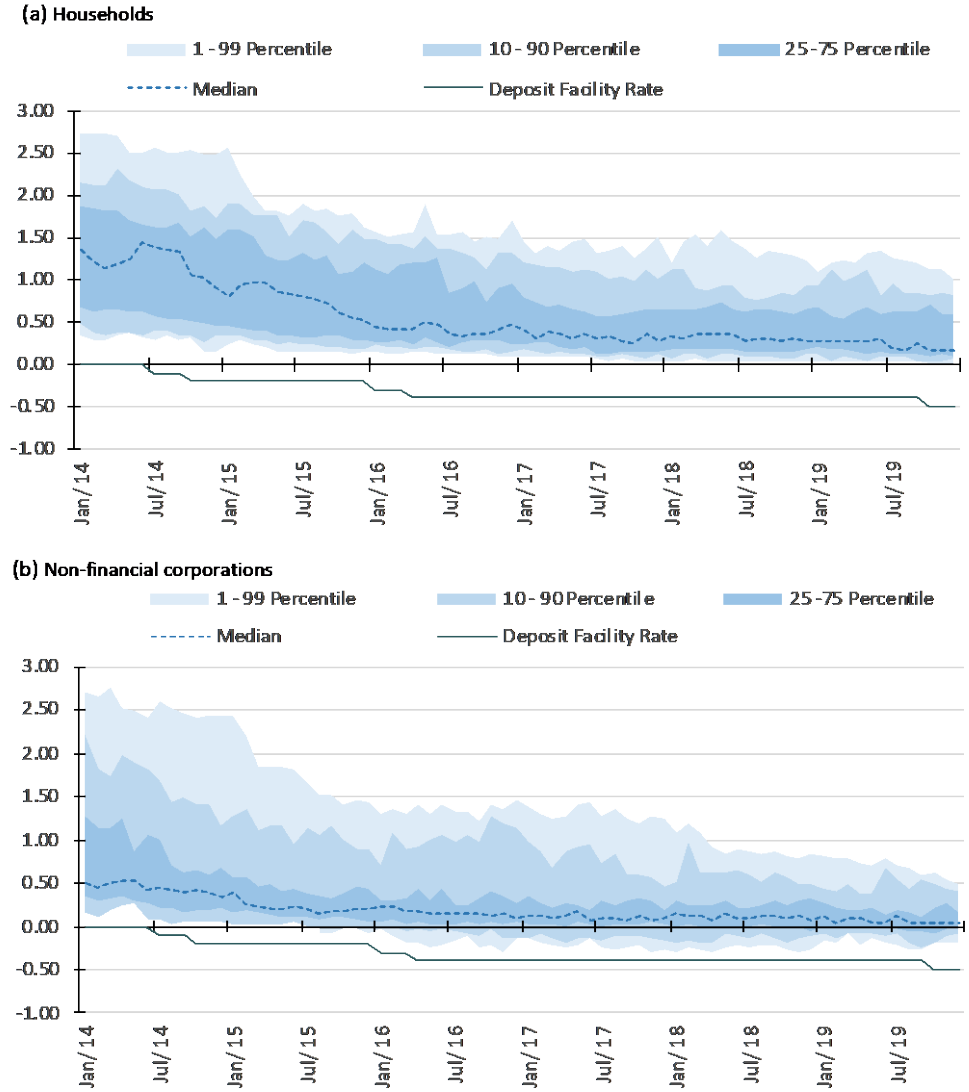


Source: ECB Statistical Data Warehouse, Macrobond.

Note: This graph shows the year-on-year growth of loans extended to households and non-financial corporates by MFIs (excluding the ESCB reporting sector). The five vertical black lines indicate the months of cuts in the deposit facility rate in negative territory between June 2014 and September 2019.

Before NIRP was introduced, many economists shared the concern that monetary policy transmission could be disturbed since banks become increasingly reluctant to pass on rate cuts as the deposit facility rate approaches and eventually crosses the zero lower bound. A range of factors can be expected to drive this disruption: for example, the degree of competition for deposits between banks, the share of fixed versus floating rate loans, and the fear that clients would switch into cash or interest-bearing bonds. In some euro area Member States, legal restrictions may also prevent banks to pass on rate cuts below zero. Consequently, banks' net interest margins (NIM) – the difference between the interest they earn and pay for a unit of currency they intermediate – would decrease and banks' ability to supply loans may eventually be reduced or even overcompensated by higher solvency requirements.

Figure 6: Deposit interest rates paid by commercial banks in the euro area



Source: ECB Statistical Data Warehouse.

Note: This figure shows selected percentile bands of annualised interest rates in percent that commercial banks pay on deposits with a maturity up to 1 year. In subfigure (a), the counterparties are households for subfigure (b) those are non-financial corporations. The sample consists of average interest rates from all euro area Member States.

Indeed, descriptive statistics of interest rates paid on deposits in euro area Member States suggest that there is a zero lower bound for household clients, however not for non-financial corporate clients (see

Figure 6). While all plotted aggregates of the former seem to react strongly to NIRP, they converge but never cross the zero threshold. Only Denmark experienced negative interest rates on deposits from private households from 2019 onwards (see Table 1). This is consistent with (Brandao-Marques et al., 2021) who find a structural break in the correlation between policy rates and deposit rates. This could also explain why significant deposit volumes were not withdrawn from clients as evidenced by relatively stable deposit shares in banks' funding mix even after introduction of NIRP.[7] On the other hand, the negative policy rate seems to be passed on to corporate clients: all descriptive statistics show a downward trend with the 10% lowest average rates crossing into negative territory in early 2016. While this does not establish causality, it suggests that transmission may indeed be compromised in negative territory, though more pronounced for retail compared to corporate deposits. Consequently, numerous analyses confirm the hypothesis that NIMs decrease after the introduction of NIRP (for example, Alessandri and Nelson, 2015; Borio et al., 2017).

This reasoning raises the expectation that banks which rely more heavily on deposits compared to wholesale funding, contribute more to the disruption of policy transmission. Empirically, there is a strong heterogeneity in deposit shares of banks' liabilities: Brandao-Marques et al. (2021) document that deposits of the non-financial private sector contribute 15% to banks' liabilities while this figure is 70% in Japan (and 40% for the euro area).

Causal evidence of the effects of bank funding on policy transmission is, however, inconclusive. Using contract-level loan data, Heider et al. (2019) compare lending volume and counterparty risk before and after the introduction of NIRP and find support for the hypothesis: high deposit banks reduced lending by 35% relative to low deposit banks. Other studies find contradicting results: Tan (2019) finds that high-deposit banks expand credit by 17% while Schelling and Towbin (2020) find the expansion was significantly weaker compared to low deposit banks.

The *bank balance sheet channel* raises banks' net worth and reduces external financing costs to eventually increase loan volumes. Bottero et al. (2019) measure the degree of exposure to NIRP in term of banks' reliance on short-term funding, that is the difference between short-term interbank liabilities and assets. Inconsistent with expectation, they show that banks relatively more exposed to NIRP rebalance their portfolio away from liquid assets to credit and thereby expand supply.

3.2. The reversal interest rate

After monetary policy rates passed the zero lower bound, the question surfaced whether there exists an effective lower bound for target rates below zero and consequently also for money market rates and interest rates on deposits or credits. The possibility for households and firms to withdraw assets from bank accounts and move into cash creates a theoretical limit for negative interest rates, yet in practice holding large amounts of money in cash creates storing costs and runs the risk of theft. Thus, low levels of negative interest rates on household deposits appear possible. Corneille et al. (2021) identify additional factors fostering the tolerance of negative interest rates on deposits in an online experiment. The higher the amount on the deposit account, the lower is the tolerance of negative rate, and a longer period of negative interest rates decreases the tolerance of private households. Savers with regular savings payments are more likely to tolerate a negative interest rate as compared to irregular lump sum savers. Finally, savers are more willing to accept a negative interest rate if they expect them to be replaced by positive interest rates in the future.

[7] In Brandao-Marques et al. (2021), see Box 2 for the econometric analysis of the association between deposit rates and policy rates and see Figure 11 for descriptive statistics of average commercial banks' deposit to total liabilities ratio.

Table 1: Interest rates on new deposits from households and non-financial corporations, March 2021

	Private households		Non-financial corporations[1]	
	Up to 1 year	More than 2 years	Up to 1 year	More than 2 years
Austria	0,15	0,45	-0,30	0,14
Belgium	0,19	0,57	-0,17	0,20
Bulgaria	0,05	0,59	0,00	0,00
Croatia	0,07	0,22	0,04	0,02
Cyprus	0,08	-	0,08	-
Czech Republic	0,26	1,30	0,12	1,41
Germany	0,06	0,41	-0,12	0,24
Denmark	-0,19	-0,15	-0,51	-0,24
Estonia	0,55	1,32	0,26	10,39
Euro area	0,18	0,60	-0,11	0,22
Spain	0,01	0,10	-0,31	0,46
Finland	0,15	0,43	0,02	-0,12
France	0,35	0,68	0,04	0,20
United Kingdom	0,30	0,64	0,06	0,10
Greece	0,16	-	0,07	-
Hungary	0,34	0,56	0,52	0,64
Ireland	0,11	0,05	-0,46	-
Italy	0,82	0,81	0,31	-0,11
Lithuania	0,06	0,49	0,00	0,65
Luxembourg	0,07	0,16	-0,20	0,00
Latvia	0,40	1,05	0,00	0,00
Malta	0,47	1,51	0,59	2,68
Netherlands	0,93	1,02	-0,22	0,75
Poland	0,05	0,07	0,06	0,19
Portugal	0,40	0,86	0,03	0,80
Romania	0,40	0,86	0,03	0,80
Sweden	0,12	0,54	0,00	0,06
Slovenia	0,44	0,95	-0,14	1,19

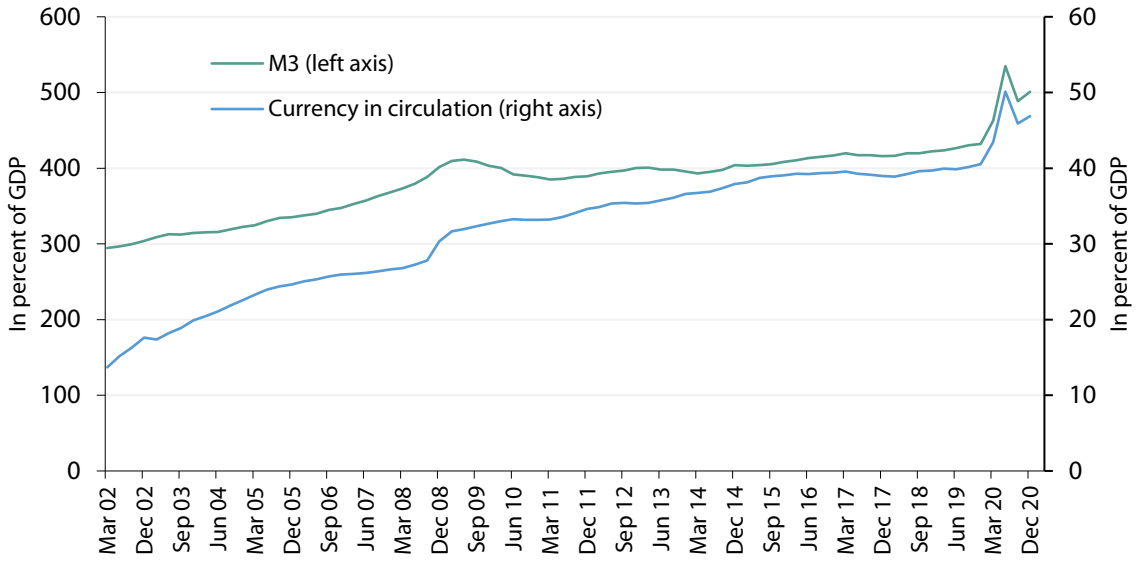
Source: ECB.

Note: [1]Values are from March 2021 or last available value.

At the moment, only banks in Denmark charge negative interest rates on accounts from private household (since 2019) and the threshold for charging negative interest rates has been lowered to DKR

100.000 in February 2021[8]. Around 35% of deposits were subject to negative rates in February 2021. Table 1 shows that negative interest rates on household accounts are still seldom throughout the euro area, while negative interest rates on corporate accounts are widespread. It is yet unknown, how low negative interest rates can go in practice. The recent experience indicates some willingness to accept a negative interest rate as a kind of fee for the convenience provided by liquid deposits with low loss potential. Nevertheless, steeply increasing real estate price, booming equity prices, high raw material prices (e. g. gold), and record levels of circulating cash (see Figure 7) show that agents respond to the low interest rate environment by restructuring their portfolios away from deposits.

Figure 7: Development of the currency in circulation and M3 in the euro area



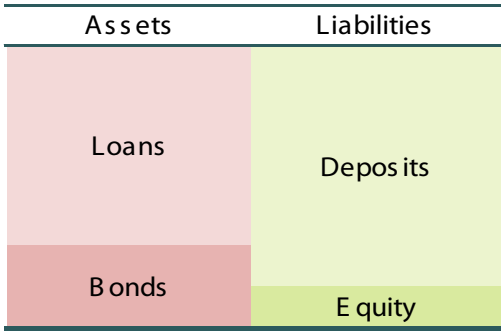
Source: ECB, Eurostat.

Note: Seasonally and calendar-adjusted data, euro area (changing composition).

Besides practical limits to move out of deposits and the willingness to switch into alternative financial and real assets, there are also theoretical reasons to expect the existence of an effective lower bound on interest rates. This bound is characterised by a reversal of the effect of expansionary monetary policy on bank lending. Usually, expansive monetary policy lowers the financial constraints for banks by providing additional liquidity and it lowers the interest rate at which banks can refinance their lending to the corporate and household sector, respectively. In the regular case, expansionary monetary policy expands lending. If the monetary policy target rate crosses the effective lower bound, additional monetary impulses will have a contractionary effect on credit provision by the banking sector. The reason is that lower monetary policy target rates reduce the interest income of the banking sector going forward, i. e. all new contracts and all contracts on variable terms will carry the lower interest rate. This negative effect on future income may be compensated by valuation gains on the holdings of fixed-interest securities by banks, but these gains are one-off and if the episode of low rates is long enough, the negative effect on interest income is likely to dominate.

[8] Reuters. (2021). "Enough is enough: Danish minister cries foul at banks' negative rates". 27 April. https://www.reuters.com/article/denmark-banks-idUSL8N2MK3S7.

Figure 8: Stylised bank balance sheet



Source: Brunnermeier and Koby (2018).

Brunnermeier and Koby (2018) illustrate the mechanism starting from a very simple bank balance sheet, containing only loans and fixed interest government bonds as assets, and the clients' deposits and own equity of the bank as liabilities (see Figure 8). The important feature is the high leverage of the banking sector in combination with the request for regulatory solvency capital by supervisory agencies. A successful expansionary policy will create additional lending from the banking sector, but this also requires at the same time the provision of more solvency capital. In the simple bank balance sheet of Figure 8, the earning capacity of banks depends on three interest rates:

- the interest rate on government bonds, r^g
- the interest rate on deposits, r^d
- the interest rate on loans, r^l

and the spreads between interest rate being structured in the following way $r^d < r^g < r^l$. Figure 8 shows that due to this ranking of the interest rates, even a proportional reduction in interest rates will result in lower net interest earning by banks, i. e. the reversal rate does not depend on the stickiness of deposits rates, rather it depends on the maturity transformation inherent in the banking business. Lower banking earnings in turn reduce the ability to provide additional solvency capital and thus restrict future credit expansion by diverting investment into government bonds. Because one-off valuation gains on mark-to-market assets or reduced loan-loss provisions alleviate the negative short-term effect on the ability of banks to provide loans only at the beginning of an interest rate cycle, it is obvious that a low for long interest rate cycle becomes less effective over time in inducing more lending. Brunnermeier and Koby (2018) prove the existence of the reversal interest rate if the gains from the maturity mismatch, i. e. the financing of long-term loans with short-term deposits, are sufficiently small. If banks reach the binding solvency capital constraint, the monetary policy rate hits the reversal rate because further interest rate cuts reduce profits and consequently the ability to provide additional solvency capital out of the current cashflow. Their calibrated value for the reversal rate of the euro area in 2018 was -1%, but they stress that the reversal rate is time variable and depends on the following key determinants:

- The amount of fixed interest government bonds held by the bank. The more fixed interest government bonds a bank holds, the bigger is the maturity mismatch between assets and liabilities, and consequently valuation gains are bigger in case of an interest rate cut. This increases the reversal interest rate.

- Low initial equity capitalisation of banks (higher leverage) implies that the constraint on solvency capital will be binding sooner after the drop in the interest rate. This effect amplifies the loss in net interest income and further decreases the reversal interest rate.
- A restrictive capital constraint, e. g. a high cyclical capital puffer, implies that the constraint on solvency capital will be binding sooner after the drop in the interest rate. From this point onwards, banks are forced to invest in fixed interest government bonds rather than loans. This decreases the reversal interest rate.
- If the deposit supply elasticity of private households with respect to the interest rate is already high or further increases after a rate cut, banks' profitability will decrease faster after a rate cut. A higher interest elasticity may result from private household awareness of spreads to other asset classes or from cash competition. This increases the reversal interest rate.
- High dividend payments by banks, based on valuation gains after an interest rate cut, will reduce the ability to provide additional solvency capital. This increases the reversal interest rate.
- A strong initial increase in loan demand after an interest rate cut, will improve net interest earnings by banks but also creates more strain on the solvency capital. In general equilibrium the reversal rate still exists.
- Already low nominal monetary policy rates reduce the effectiveness of further expansive monetary policy steps.

The unconventional monetary policy measures like the long-term refinancing operations have alleviated the reversal interest rate effects on bank profit margin by offering cheap access of funds to banks.

A similar argument for an effective lower bound has been put forward by Kiyotaki et al. (2021). They use a non-exclusivity constraint which restricts the entrepreneur's borrowing capacity to near-horizon profits, i.e. entrepreneurs will receive only short-term credit contracts from banks. Based on the maturity mismatch between the long-term costs of gross fixed capital investment and the short-term share in gross revenues that can be credibly pledged by the entrepreneur, a permanent fall in the real interest rate reduces the present value of the investment project and consequently the borrowing capacity of the entrepreneur. Overall, domestic investment can fall with a reduction in the interest rate.

4. ADVERSE SIDE EFFECTS OF NEGATIVE INTEREST RATES

4.1. On bank profitability

In negative territory, the credit channel is subject to a discontinuity: once policy rates become sufficiently low, banks are reluctant to pass on the policy rate cuts to their depositors, particularly households. As banks internalise the impact of decreasing NIMs, they need to generate profits elsewhere by adjusting their strategy. This seems to have been the case since a range of studies using bank-level data suggest that profits did not deteriorate significantly, some suggest even slight improvements (Lopez et al., 2020; Turk, 2016; Altavilla et al., 2019).

In search for a partial or even full compensation of lower interest income, banks have a number of options. In search for yield, one option for banks is to lend to riskier counterparties and thus raising loan rates. Indeed, (Bottero et al., 2019) find that banks relatively more exposed to NIRP increase their loan supply to ex-ante riskier and smaller firms. This finding is consistent with the results of other studies. Eggertsson et al. (2019) find for Swedish banks that policy and lending rates disconnect once the policy rate entered into sufficiently negative territory. Heider et al. (2019) document that banks in the euro area that are deposit reliant, seem to increase lending to firms with higher return-on-assets volatility. It could be considered surprising that Bottero et al. (2019) find that higher risk profiles do not translate to a significantly higher share of non-performing loans. However, the absence of borrowers' bankruptcies could be partly driven by overall improved macroeconomic conditions spurred by NIRP, UMP and expansionary fiscal policy measures.

To compensate for profitability, banks seem to have turned to alternative revenue sources. Arce et al. (2020), Basten and Mariathasan (2020) and Bottero et al. (2019) find that banks charge higher fees on interbank deposits. Altavilla et al. (2019) document that the current low-interest rate environment in the euro area has led to higher non-interest income and had reduced loan loss provisions, while also improving bond and stock valuations and therefore resulting in capital gains.

Apart from pursuing other revenue sources, banks profited from rate cuts in negative territory in a mechanical way (Tan, 2019). First, banks realise a revaluation gain on their fixed income assets since the discount factor increases as the safe interest rates becomes negative. Second, banks' provisions for potential loan defaults decreases due to a stimulated macroeconomy. Third, banks' holdings of safe securities eligible for collateralised transactions increases due to the revaluation such that their borrowing constraints ease.

Overall, the evidence suggests that banks prevented severe adverse effects on their profitability by implementing a range of modifications to their business strategies and have benefited from other factors not guaranteed to persist in the long-run. Deposits are usually slow to react to changes in the financial environment such that the clients' portfolio rebalancing into safe bonds remains a risk. Also, the fact that the non-performing loans ratio has not changed significantly in response to relatively higher risk profiles, cannot be a predictor for the future since other factors and policies could have contributed to the absence of a larger share of non-performing loans.

4.2. On non-bank intermediaries

In this section we discuss primarily non-monetary financial institutions (NMFI) from the insurance and pension fund industries. NMFIs feel the effects of low or negative interest rates on both sides of their balance sheet. The non-life insurance industry is likely to experience a weaker effect because most of its business is short-tail, i.e. the current premium intake is used to pay current claims. Cross-subsidising the technical result by high investment returns, however, becomes impossible during a negative

interest rate period. This implies upward pressure on insurance tariffs throughout all lines of the non-life business.

In the following, we will concentrate on the life insurance business and pension funds. Both industries collect premiums and invest the premium intake (net of transaction costs and taxes) until the life insurance contract expires or the client retires and starts to receive an annuity. This type of business regularly suffers from a maturity mismatch because there are only few assets covering exactly the time horizon between the premium intake and the annuity payment.

Life insurance companies and pension funds are both long-term investors with a portfolio balancing the trade-off between risk and return of a financial investment. Additionally, supervisory authorities closely monitor the riskiness of the portfolio decision to protect the plan beneficiaries from potential revaluation losses of risky investment strategies. This limits the scope of investment opportunities for NMFIs depending on the obligations fixed in the insurance contract or the occupational pension plan. NMFIs have to apply the mark-to-market principle in their balance sheet statement, consequently, they reveal revaluation gains and losses annually.

An effective monetary policy rate cut – particularly in combination with quantitative easing – will shift the whole yield curve downwards, i. e. the interest rate will decrease at all maturities. This creates revaluation gains for NMFIs on impact but reduces the re-investment returns on their fixed-income portfolio. Pension funds operating defined-benefit plans and life insurance companies with high-return guarantees in their product portfolio may run into difficulties fulfilling these promises. By contrast, pension funds operating defined-contribution plans and life insurance companies selling mainly unit- and index-linked contracts will have no liabilities with respect to their customers. In these cases, the customers fully bear the risk of low returns: Their future annuity will be equivalently smaller.

In terms of business opportunities for NMFIs, a low for long interest rate scenario may significantly reduce the demand for life insurance and pension fund products. At the same time, the increasing life expectancy magnifies the negative consequences from low interest rates on the solvency status of insurance companies and thus may reduce the supply of annuity products as well. The negative interest rate environment deteriorates or even eliminates possible gains resulting from the extension of the duration of their assets or from switching towards inflation-linked bonds.

For NMFIs offering defined benefit plans or guaranteed insurance contracts the liability side of the balance sheet is also affected. Corresponding to the one-time revaluation gain, the liabilities of the insurance company, the pension fund, or the plan sponsor increases on impact. This can create a feedback loop from the financial sector to the real sector of the economy, if plan sponsors have to make additional payments into the funds, to make up the shortfall. Again, the liability side of NMFIs offering few contracts with minimum return guarantees is insulated from the interest rate shock because plan beneficiaries bear the risk of low returns in the form of lower expected annuity payments.

Except NMFIs without guaranteed products, a protracted low interest rate will hit the solvency status of NMFIs and plan sponsors. NMFIs may be unable to recover to their pre-financial market crisis solvency status because investment returns on save assets are too low (Berdin and Gründl, 2015). NMFIs may try to avoid low investment returns by rebalancing their portfolio towards more risky assets. Boubaker et al. (2018) show for US pension funds that they rebalanced their investment portfolio after a monetary policy rate cut. Lower Federal Reserve target interest rates lead to a substantial increase of equity in the pension fund portfolio. Moreover, during periods when the Federal Reserve used unconventional monetary policy tools, pension funds shifted their allocation more aggressively from bonds to equity. Boubaker et al. (2018) also present a positive correlation between pension fund risk-taking, low interest rates, and the decline in Treasury yields across both well-funded and underfunded

public pension plans. On the other hand, Defau and Moor (2021) use a sample of 890 pension funds throughout North America, Europe, Australia and New Zealand and find a significant rebalancing towards alternative assets (real estate, private equity, hedge funds) between 2000 and 2015; but pension funds seem to move more quickly into alternative assets when interest rates are high.

If minimum return guarantees feature an automatic feedback rule to market interest rates, the impact on solvency will be more subdued. Alternatively, life insurers may withdraw the supply of guaranteed products or reduce the guarantee level, thus shifting the investment risk to the beneficiary and avoiding solvency problems. Although Antolin et al. (2011) recommend regular monitoring and stress testing of NMFIs in a low interest rate environment, they also warn against excessive pressure by policy makers to correct the funding deficit of a plan quickly. In defined contribution pension plans, more flexibility with respect to the retirement date may help to avoid the lock-in of bad returns into a permanently low annuity payment.

4.3. On asset price inflation in the real estate sector

The impact of monetary policy rates on real estate prices is only one of several channels how monetary policy affects asset prices, but housing is an important part of private households' wealth and consumption spending. Rising real estate prices will finally have effects on the rental housing market as well because the real estate price is related to the present value of future rental payments and the expected future price development of a house. Poterba (1984) shows theoretically in an asset pricing model that interest rates can have a big impact on real estate prices. Himmelberg et al. (2005) extend this model. The elasticities derived from asset price-based models tend to be high because these models ignore real world phenomena like search and transaction costs, taxes and other types of costs associated with buying and selling decisions in the real estate market. If the standards for obtaining a credit are relaxed or hardened, this would change credit constraints and consequently the real estate price development may deviate from the prediction made by the asset price model. Furthermore, the discount rate used by private households may deviate from the market rate, particularly if private households expect interest rates to converge towards their historical mean (Glaeser et al., 2013). In this case, expansionary monetary policy shocks will not cause an immediate downward revision of the individual discount rate, and consequently, the present value of future rents and price increases will remain constant. Finally, the asset price model ignores the supply side of the real estate market completely. If supply responds quickly to rising real estate prices, then prices should be pinned down by building costs and land prices (Glaeser et al., 2008).

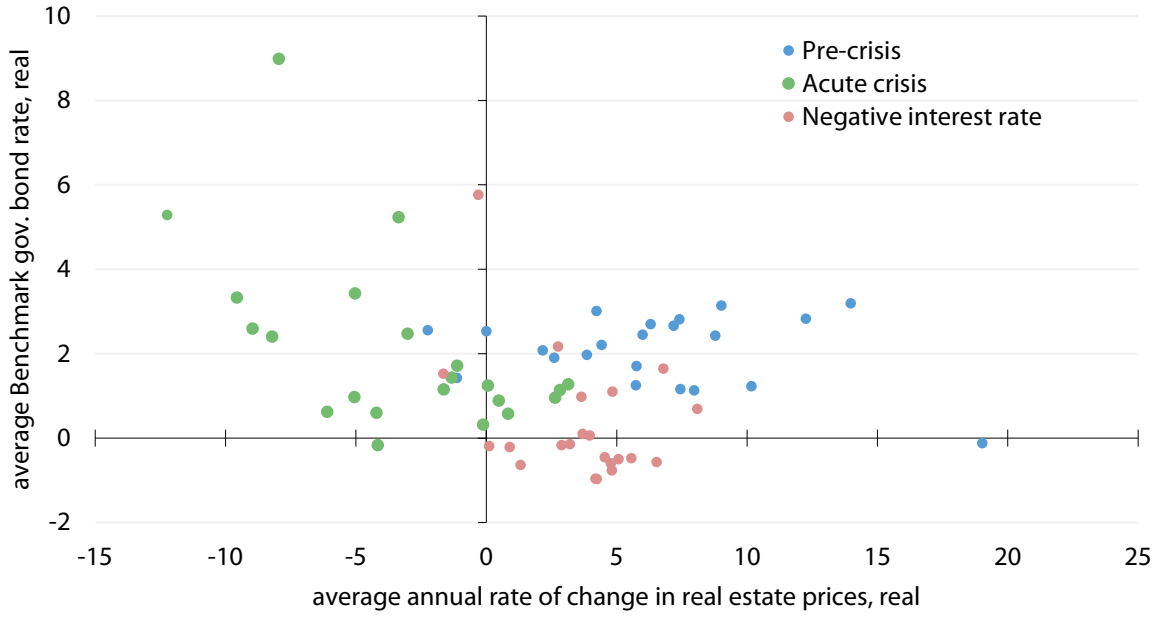
Economic theory suggests a time variable elasticity of real estate prices with respect to the interest rate. Himmelberg et al. (2005) show that if the interest rate is already low before a rate cut, then a further rate cut carries a higher response of real estate prices to a one percentage point reduction in interest rates. The non-linearity is due to the discount factor in the asset pricing model.

Figure 9 gives a first graphical illustration of the relation between real interest rates and house price inflation measured in real terms, i.e. after recognising consumer price inflation. The sample consists of all European Union (EU) Member States for which interest rates and real estate price are available between 2000 and 2020. We add Switzerland, the United Kingdom and the US to the sample and we distinguish three periods in Figure 9: the period before the financial market crisis from 2000 up to 2007 is marked by blue dots. The second period is marked by green dots and starts in 2008. The end of this period is country specific and depends on the year when negative interest rates have been introduced. For countries without a negative interest rate the second period runs until 2013, the year before the euro area switched towards negative interest rates. Finally, the third period covers the period of negative interest rates and it is marked by brown dots.

Figure 9: The relation between interest rates and real estate prices from 2000-2020

Short-term

Long-term



Source: Eurostat, OECD, OeNB.

Note: The sample consists of EU Member States for which data are completely available, Switzerland, United Kingdom, and the US with a total of 22 countries. Real interest rates and real estate prices are deflated by the consumer price index. The pre-crisis period runs from 2000 to 2007. The negative interest rate period is country specific, for Denmark (2013-2020), for Switzerland (2015-2020), for Sweden (2015-2019), and for the euro area and all other countries (2014-2020). The financial market crisis period starts in 2008 and ends with the introduction of negative interest rates.

During the pre-crisis period, the average real short- and long-term interest rates were almost everywhere positive and average real estate inflation varied substantially across countries. During the financial market crisis, short-term real interest rates were already negative for many countries while long-term interest rates remained remarkably high. This reflects the widening of spreads between German government bonds and the euro area periphery. Real estate inflation, however, was negative during the crisis in most of the countries. During the third period of negative policy rates, short-term rates were close to zero or lower everywhere, while real long-term interest rates remained positive in some of the countries. Real estate prices increased strongly during this period throughout the sample. Overall, the picture is not very clear for the relation between short-term real interest rates and real estate price inflation but in the lower panel, combining long-term real interest rates with house price inflation, a negative relation emerges.

Table 2: Estimated effects of a plus one percentage point monetary policy shock after two years

International evidence	
Rae - Noord (2006)	-2,0
Assenmacher-Wesche - Gerlach (2008)	-10,8
Goodhart - Hofmann (2008)	-7,2
Iacoviello - Minetti (2008)	-8,8
Sá et al. (2011)	-7,8
Calza et al. (2013)	-2,3
Williams (2016b)	-8,2
US evidence	
Fratantoni - Schuh (2003)	-1,7
Himmelberg et al. (2005)	-19,0
Otrok - Terrones (2005)	-5,7
DelNegro - Otrok (2007)	-10,4
Taylor (2007)	-8,3
Jarocinski - Smets (2008)	-7,8
Eickmeier - Hofmann (2010)	-2,0
Glaeser et al. (2013)	-8,0
Ungerer (2015)	-7,2

Source: Williams (2016b) Table 1 and authors' own elaboration.

In contrast to simple scatter plots, which ignore too many potential explanatory variables, empirical models are more informative because they allow the estimated response of house prices to interest rate changes to depend on other explanatory factors. Most of the empirical evidence has been produced for the US real estate market but there are also some results based on international data sets. Table 2 shows an overview of estimates collected by Williams (2016b) and adds some further evidence

to it. Overall, the interest rate effect differs substantially across studies with the smallest (-1.7) and the largest (19.0) effect resulting from the analysis focusing on US data. Eickmeier and Hofmann (2010) show that the house prices response does not emerge immediately after the policy stimulus, rather real estate prices peak 10 to 16 quarters later. They also show that the estimated price response depends on the time series used to measure real estate prices. Models for the US which are based on the Case-Shiller price index tend to give higher elasticities as compared to models using the National Association of Realtors housing price index. Unlike real estate prices, stock and bond prices respond immediately to a monetary policy stimulus.

Most of the studies listed in Table 2 show values in a narrow range between -6 and -8, i.e. a one percentage point decrease in real interest rates will result in a real estate price increase between 6% and 8%. The mean response across the studies focusing on US data is around -8%. For all other countries considered, the mean price response is somewhat lower at around -7%.

4.4. On productivity growth

Together with the reduction in the natural rate, developed countries also experienced a substantial decline in total factor productivity (TFP) growth. Cette et al. (2016) show that the productivity slow-down in the US started already around the year 2005 and that TFP levels in major continental European countries lost touch to the US on the technology frontier mainly due to structural rigidities and the misallocation of capital during the low real interest rate period after the introduction of the euro. Teulings and Baldwin (2014) provide an early sum up of possible sources for the productivity decline.

The relation between interest rates and productivity is obvious in the conventional microeconomic optimisation model with homogenous firms: Due to decreasing returns of capital, an additional unit of capital will *ceteris paribus* produce a lower marginal product. In this basic model, investments will be undertaken until the marginal product equals the price of capital. Consequently, a lower interest rate will induce additional investment in a lower productivity activity.

In a macroeconomic context, variations in other inputs, productivity growth and firm heterogeneity change this logic but, in some cases, TFP will still decline within a low interest rate environment. If firms differ with respect to their financial constraints, their initial wealth, or their relative position as a market leader in an industry, lower interest rates may have adverse effects on TFP. Gopinath et al. (2017) start from the observation that real interest rates in Spain declined remarkably between 1999 and 2007. During this period foreign capital flowed into Spain and the return to capital across Spanish firms became more dispersed. In a data set of Spanish firms, Gopinath et al. (2017) found more dispersed returns across firms were accompanied by a decline in TFP. They explain this relation by a misallocation of capital towards firms with low financial constraints (large firms) rather than firms with productive short run investment opportunities. In a model with size-dependent financial constraints (lower for large firms) and adjustment costs, the decline in the real interest rate generates capital and debt accumulation by large firms, an increase in the dispersion of the marginal productivity of capital across firms, and a decline in TFP relative to its efficient level. TFP declines because capital is not allocated to its most efficient use as some productive but financially constrained firms with low net worth are not able to grow in the short run.

An alternative explanation for the widening productivity gap across firms has been developed by McGowan et al. (2017). They stress the role of "zombie" firms emerging in a prolonged period of low interest rates, which is accompanied by a policy of credit forbearance by banks and the persistence of crisis-induced support for small and medium sized enterprises. The capital sunk in nonviable zombie firms tends to crowd-out growth opportunities of healthy non-zombie firms because it reduces their ability to attract capital. Furthermore, this policy mix creates barriers to entry. A direct consequence of

zombie congestion is the tendency for a widening gap in TFP between firms, with young firms being more affected. Another type of heterogeneity results from incomplete competition. Liu et al. (2020) link the declining TFP growth over the last two decades to the increase in market concentration within US industries and the low interest rate environment. In their theoretical model, market leaders in an industry interact strategically with their followers. At very low interest rates, market leaders invest more aggressively in response to lower interest rates relative to their followers because they attempt to avoid neck-and-neck competition. Market followers, expecting this response in advance, become discouraged and invest less from the beginning. At sufficiently low interest rates the discouragement effect dominates, economy-wide measures of market concentration will rise and aggregate productivity growth will fall.

5. CONCLUSION

Negative interest rates have entered the unconventional monetary policy toolkit of modern central banks after the global financial crisis. While there has been previous scepticism towards their feasibility and practical use, given the low inflation environment and the active use of multiple unconventional monetary policy tools, several central banks have introduced NIRP. The evidence so far points towards cautious optimism regarding NIRP as a monetary policy instrument. In the euro area, NIRP has contributed to bank lending growth and has provided a macroeconomic impulse, similarly to the other unconventional monetary policy tools. Such positive impulses can also have additional, indirect effect by increasing banks' net worth, pushing long-term yields downwards, compressing risk premia and therefore helping borrowers' creditworthiness.

The main adverse effects of NIRP – negative impact on bank profitability and an excessive pressure for cash hoarding – have not yet materialised in the euro area according to most recent evaluations. What is more, the positive effects through the aggregate macroeconomic impulses from NIRP, combined with positive effects on the quantity of credit, as well as on banks asset prices, might have fully compensated for the negative effects on banks due to lower interest rate margins. So far, through the first years of its usage, financial stability dangers spurring from NIRP have also not materialised.

Further negative effects may affect non-monetary financial intermediaries like insurance companies and pension funds. Non-life insurance companies may have to increase their tariffs because revenues from investment income cannot be used to cross-finance the operating business. The effect on life insurance companies and pension funds depends on the volume of contracts with minimum return guarantees. The combination of low interest rates with minimum return guarantees may jeopardise their solvability because the guarantee may turn effective. Non-monetary financial intermediaries active in the old age provision business may alternatively implement riskier investment strategies. Plan sponsors may also have to pay additional contributions to the plan. If the beneficiaries bear the investment risk, lower investment returns will consequently reduce the annuity payments.

From a consumer perspective, possible asset price inflation in the real estate sector is important with respect to acquiring home ownership and its potential inflationary effects on rental rates. International evidence suggests that a one percentage point decrease in the interest rate will cause an increase in real estate prices of 6% to 8% over the following three years. Asset price models imply that real estate inflation rates grow in a non-linear way if the real interest rate becomes ever smaller.

In a long run perspective, low interest rates contribute to low total factor productivity growth by tilting access to external finance by firms towards large corporations, blocking funds in nonviable zombie firms and encouraging strategic investment by market leaders. On the other hand, green investments with low expected returns and long periods of amortization become more feasible.

The steady decline in the natural rate of interest throughout the past decade, partly driven by structural factors, however, determines that a low interest rate environment may be here to stay in advanced economies. Such a low interest rate environment would necessitate the more often usage of NIRP after significant macroeconomic shocks. The studies and evaluations discussed throughout this paper are documenting the effects of NIRP through its initial years. Further and ongoing assessment would be needed to see whether the adverse effects do not settle in in the long term – if the lower for longer environment does not lead to an increase in the negative side effects of NIRP. Furthermore, while first steps into negative territory might have been benevolent, it is possible that further interest rate decrease might show a non-linear effect. The risks of using NIRP very often or pushing rates too low into negative territory should not be underestimated. Central banks should assess such risks on an ongoing basis and provide evidence whether the nature of the transmission mechanism is not affected

as this unconventional monetary policy tool is used more frequently. While on average NIRP has been a useful tool so far, central banks should also monitor how it affects other sectors – especially the non-bank financial sectors, including pension funds, which might suffer significantly from a lower for longer interest rate environment.

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Policy rate cuts in negative territory have increased credit supply and improved the macroeconomic environment similar to cuts in positive territory. Dreaded disruptions to the monetary policy transmission channels as well as adverse side effects on bank profitability have so far largely failed to materialise. Thus, the evidence available today shows that the negative interest rate policy is an effective policy tool. However, systemic risks, including in the non-bank sector, should be closely monitored as negative rates are expected to remain low for longer.

This paper was provided by the Policy Department for Economic, Scientific and Quality of Life Policies at the request of the committee on Economic and Monetary Affairs (ECON) ahead of the Monetary Dialogue with the ECB President on 21 June 2021.

PE 662.920
IP/A/ECON/2021-22

PDF ISBN 978-92-846-8167-9 | doi:10.2861/980796 | QA-05-21-174-EN-N