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## Do firms behave differently when nominal interest rates are below zero?

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# DANMARKS NATIONALBANK

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## Do firms behave differently when nominal interest rates are below zero?

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## Do firms behave differently when nominal interest rates are below zero?

### Abstract

Yes they do! We examine the case of Denmark – the first country in the world to move its key monetary policy rate below zero. Using rich microdata and an event-study framework, we find that firms exposed to negative deposit rates to a higher degree than other firms increase their fixed investments and employment – after due control for changes in the level of interest rates. They also tend to rebalance their portfolio of liquid assets away from bank deposits and reduce their degree of leverage. These findings are suggestive of an additional monetary transmission channel operating as nominal interest rates cross zero and become negative. Although we identify a causal effect of facing negative deposit rates, the causal mechanism is more open to interpretation. The transmission channel might imply that firms become more aware of their portfolio composition and alternative opportunities when deposit rates cross zero and become negative.

### Resume

Danmark var det første land i verden, hvor den pengepolitiske nøglerente blev negativ, og mange danske erhvervsvirksomheder har fået negativ rente på deres bankindsud. Analysen viser, at de øger deres investeringer i nyt produktionsapparat og etablerer flere nye arbejdspladser sammenlignet med virksomheder, som ikke betaler negativ rente. Der er tale om et eventstudie baseret på omfattende mikrodata, og der tages højde for ændringer i renteniveauet. Virksomhederne ændrer også deres portefølje af likvide aktiver væk fra bankindsud og reducerer deres gearing, når de udsættes for negativ indlånsrente. Disse resultater indikerer eksistensen af en ekstra transmissionskanal fra de pengepolitiske renter til realøkonomien, når renterne bliver negative. Vi identificerer en kausal effekt af negative indlånsrenter, men mekanismen er mere åben for fortolkning. Resultaterne kan afspejle, at virksomhederne bliver mere opmærksomme på deres porteføljesammensætning og alternative muligheder, når indlånsrenterne bliver negative.

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### Key words

Negative interest rates; Monetary transmission; Firm behavior.

### JEL classification

D22; E43; E52; G21.

### Acknowledgements

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## 1. Introduction

Natural real interest rates have declined considerably over the past decades (Holston, Laubach and Williams, 2017; Bielecki, Brzoza-Brzezina and Kolasa, 2020). A concomitant decline in inflation and increase in the risk of deflation in the aftermath of the global financial crisis has resulted in exceptionally low central-bank policy rates in many economies. This has constrained the monetary policy space, even though the traditional view on the existence of a "zero lower bound" (ZLB) on nominal interest rates has been challenged. There seem rather to be an "effective lower bound" (ELB) on nominal interest rates which might be quite substantially below zero. As policy rates approached zero or became negative, several central banks also turned to unconventional monetary policy instruments such as forward guidance and quantitative easing via large-scale bond purchases to drive down the risk premium in the longer end of the yield curve (Bernanke, 2020; Bounie, 2020). Furthermore, the move towards negative interest rates has turned out to be quite persistent. This has fuelled a wider and more general discussion on whether and to what extent negative interest rates stimulate the economy (Rogoff, 2017; Brunnermeier and Koby, 2018; Eggertsson *et al.*, 2019; Adolfson and Spange, 2020; Andersson and Jonung, 2020; Repullo, 2020). The issue seems especially important since low and negative interest rates have raised concerns in relation to banks' profitability and the stability of the financial system (Borio, Gambacorta and Hofmann, 2017; Lucas *et al.*, 2017; Altavilla, Boucinha and Peydró, 2018; Chaudron, 2018; Claessens, Coleman and Donnelly, 2018; Heider, Saidi and Schepens, 2019; Lopez, Rose and Spiegel, 2020).

Danmarks Nationalbank was the first central bank in the world to move its key monetary policy interest rate below zero (Jørgensen and Risbjerg, 2012; Arteta *et al.*, 2018; Danthine, 2018; Eisenschmidt and Smets, 2019). This happened already in mid-2012 with a fast pass-through to money market rates. Later banks' retail deposit rates also became negative. As a result, many Danish non-financial firms have faced negative interest rates on their bank deposits for several years. Furthermore, Denmark is a country with high-quality microdata in administrative and statistical registers and ample opportunities to link granular information from the various registers at a firm level. This makes Denmark an interesting case to consider when it comes to tracing the effects of negative interest rates to the real economy.

In this paper, we study the impact of the introduction of negative deposit rates on non-financial Danish firms' portfolio behaviour and decisions regarding employment and real investments. As long as the nominal interest rate is above the ELB, it might be argued that there is no *a priori* reason to expect that just crossing the zero interest rate threshold would induce any change in firms' decisions to a larger extent than a similar sized change in interest rates in the positive territory. However, following the line of reasoning within behavioural economics (Kahneman and Tversky, 1984), there might be a psychological difference between facing positive and negative nominal interest rates, for instance if a switch to negative interest rates on bank deposits increases risk-taking among firms in an attempt to "search for yield" or increases the (perceived) cost of holding liquidity. Crossing the zero threshold may also make firms more aware of their portfolio

composition and opportunities regarding fixed investment and employment. One reason to expect this is that, according to news media, banks often contact their corporate clients when they take the step of moving deposit rates below zero, cf. for example Bitsch and Brahm (2019). This is also reflected in the following quote from a news release issued by Denmark's largest bank regarding negative interest on deposit accounts for corporate customers:

"We already do a lot of talking to our customers about alternatives to larger amounts in deposit accounts, and we will of course continue to do so. In some cases, for example, it will make more sense for the customer to settle debts, and in other cases the money can be invested profitably."  
[Quotation from Danske Bank (2020), authors' translation]

We have access to rich and previously unexplored confidential microdata covering all non-financial Danish firms and are able to link the firms to their bank connections through third-party reported information obtained from the Danish Tax Agency. After controlling for changes in the level of interest rates, we find that the introduction of negative interest rates on firms' bank deposits is associated with an increase in their fixed investment and employment. They also tend to reduce their degree of leverage and rebalance their portfolio of liquid assets towards other types of liquid assets, e.g. stocks, bonds or cash. These findings are suggestive of an additional monetary transmission channel operating as nominal interest rates cross zero and become negative.

It is conceivable that negative deposit rates more fundamentally affect companies' sentiment in line with the reasoning behind "animal spirits" effects (Pigou, 1927; Keynes, 1936; Akerlof and Shiller, 2009; Shiller, 2015). For example, negative deposit rates could be seen by the companies concerned as a very direct signal of the easy monetary conditions, which stimulates the economy and potentially increases demand for the firm's products and services. Negative deposit rates could also serve as a strong signal which is interpreted by the firm as an increase in the probability that interest rates would be "low for long" and thus provide the firm with low financing costs over many years to come. These direct signals may induce a firm faced with negative deposit rates to invest more and hire more employees than other firms.

To shed further light on such mechanisms, and to validate that firms' reactions can indeed be ascribed to the introduction of negative deposit rates, we take a closer look at firms' expectations as well as developments in bank-firm links. We find limited impacts of negative deposit rates on firms' expectations regarding future production, turnover and employment. However, firms in the service industry facing negative deposit rates tend to become less pessimistic about future turnover and employment. In addition, we find that firms exposed to negative deposit rates are more likely to engage in new banking relationships and rebalance their bank deposits towards banks that have not (yet) introduced negative deposit rates. These findings indicate that firms are indeed very much aware of the introduction of negative deposit rates on their bank accounts, therefore also strengthening our claim that the behavioural changes we identify are related to the event of deposit rates becoming negative.

The behaviour of non-financial firms in a negative interest rate environment is an area with relatively few contributions in the literature. In one of the few existing studies, Altavilla *et al.* (2020) have previously found that firms with large cash holdings which are exposed to negative rates on deposits tend to decrease their short-term assets and increase their fixed investments. Our paper also relates to the literature on a complementary signalling channel of moving into the negative nominal interest rate territory. Within this strand of research, negative monetary policy interest rates are seen as a credible signal that zero is not the lower bound for nominal interest rates and thereby an indication of the future path of interest rates (for example Czudaj, 2020). At a more general level, our paper complements previous research on monetary transmission in a negative interest rate environment, cf. Kyriazis, Papadamou and Siriopoulos (2020) for a recent survey.

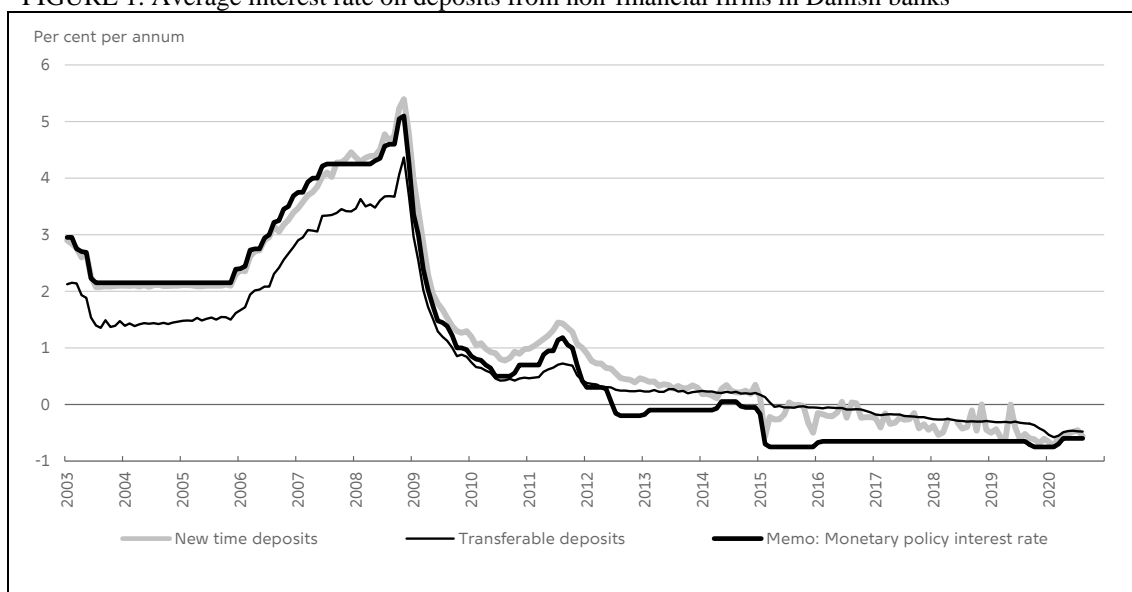
The transmission mechanisms that we suggest in this paper are basically of a behavioural nature and imply that firms are not fully rational and have limited information. While a formalised theoretical model is outside the scope of this paper, our findings speak to the emerging research paradigm of how bounded rationality affects monetary policy within the framework of New Keynesian Models, cf. Woodford (2013) and Gabaix (2020) for surveys of the literature.

The remainder of this paper is organised as follows. Section 2 offers an overview of developments in negative interest rates in Denmark and contains a description of our data set and sample selection. This is followed by an analysis in section 3 of the effect of negative deposit rates on firms' balance sheets and real economic decisions. In section 4, we look at developments in firms' bank relationships and their expectations regarding future production, turnover and employment. Section 5 contains some robustness checks and section 6 concludes the paper.

## **2. Context, data and descriptive statistics**

The key monetary policy interest rate in Denmark has been in negative territory during most of the period since mid-2012, and it was still -0.60 per cent in August 2020. As a result, many non-financial Danish firms have faced negative interest rates on their bank deposits for several years, cf. Figure 1. In February 2020, around 77 per cent of the total outstanding amount of deposits in Danish banks from non-financial firms earned negative interest rates, cf. Figure 2.

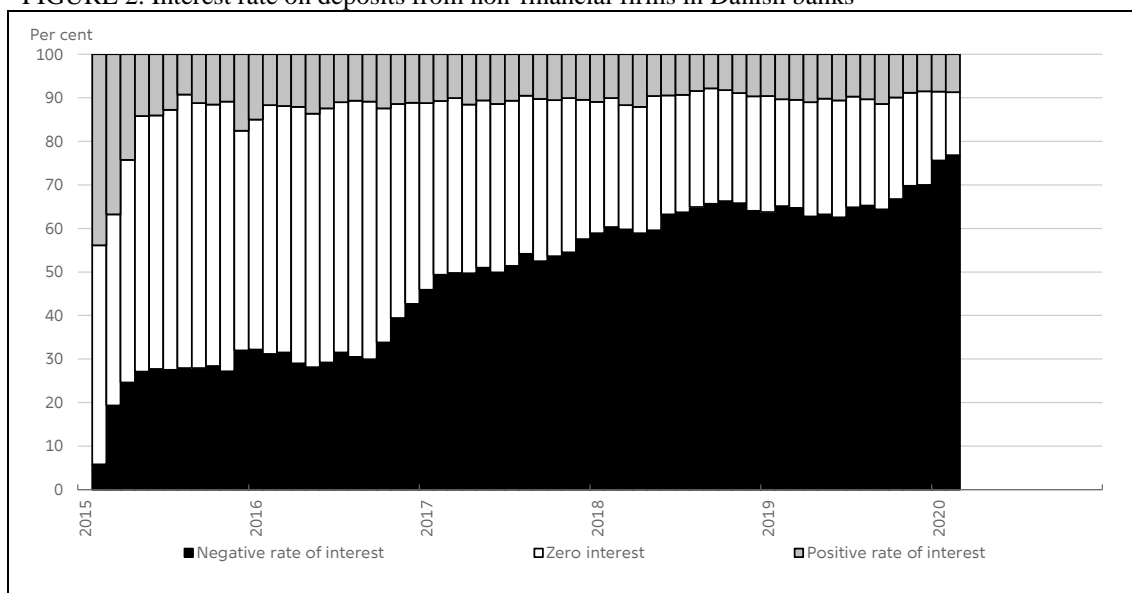
FIGURE 1. Average interest rate on deposits from non-financial firms in Danish banks



Note: The monetary policy interest rate is the rate on Danmarks Nationalbank's certificates of deposits. Last observation: August 2020.

Source: Danmarks Nationalbank.

FIGURE 2. Interest rate on deposits from non-financial firms in Danish banks



Notes: Share of outstanding amount of deposits. Last observation: February 2020.

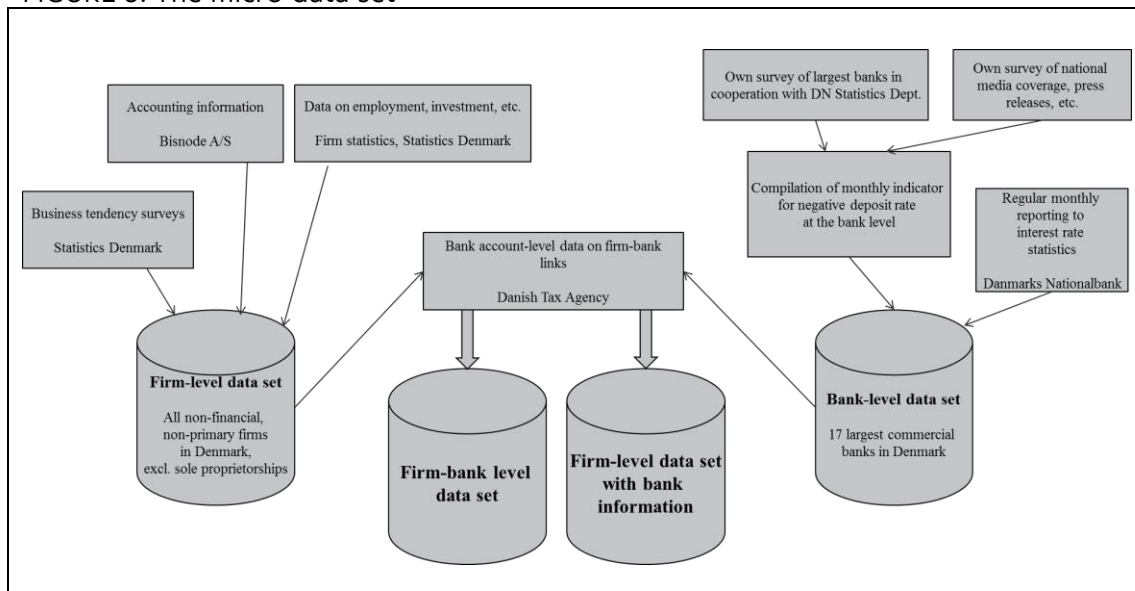
Source: Danmarks Nationalbank.

The core of our data set consists of firm-level accounting data from a private data vendor, Bisnode. The data set covers all non-financial firms in Denmark, excluding sole proprietorships, in the period 2014-2018. We merge the accounting data at the firm level using the business registration number (CVR number) with

register data on employment, fixed investments, value added, etc. from Statistics Denmark's Firm Statistics, which are available for the period 2014-2017. We retain only active firms that appear in both datasets and have a registered employment of more than one full-time equivalent.

We link the individual firms to their bank connections through a data set obtained from the Danish Tax Agency, cf. Figure 3. This data set contains annual information on deposit balances for all firms in Denmark. We can therefore identify the firms' bank relationships as well as observe the firms' actual deposits with each bank. These data are reported by banks on behalf of firms and are audited. They are therefore assumed to be of high quality. Our bank-level information on the average interest rate on firms' bank deposits comes from the banks' reporting to Danmarks Nationalbank's interest rate statistics.

FIGURE 3. The micro data set



Notes: Share of outstanding amount of deposits. DN denotes Danmarks Nationalbank. Non-financial non-primary firms refer to the non-financial private business sector, excluding agriculture, etc., energy and water supply and parts of the transport sector (ports, etc. and rail and bus transport).

Source: Danmarks Nationalbank.

We also make use of firm-level responses to the Danish part of the monthly EU-harmonised business tendency surveys conducted by Statistics Denmark for the manufacturing, construction, retail and services industries. Since Statistics Denmark knows the identity of the participating firms, we are able to link the survey responses to the register data described above. We use survey data for 2014-2018.

To establish a measure of whether a given firm has been exposed to negative interest rates on their bank deposits, we have in cooperation with the Statistical Department of Danmarks Nationalbank surveyed the largest individual banks in Denmark. In particular, we have asked banks at what point in time they introduced negative interest rates on deposits from various types of non-financial firms. The survey results



were supplemented with coverage in national news media regarding the introduction of negative interest rates on deposits from firms by individual banks. Based on this information, we have compiled monthly bank-level indicators for the introduction of negative interest rates on deposits from large customers and/or all customers.

From the tax authorities we have, as mentioned, information on firms' bank connections. We define firms with average deposits during 2014-2018 exceeding DKK 750,000 as having been exposed to negative deposit rates if any of the firm's bank connections have introduced negative interest rates for large customers. Similarly, firms with average deposits up to and including DKK 750,000 are defined as having been exposed to negative deposit rates if any of their bank connections have introduced negative interest rates for all customers.

Our measure of firms' exposure to negative interest rates on bank deposits is thus a measure of exposure vis-à-vis banks that have introduced negative interest rates on deposits from non-financial firms rather than a measure of whether a firm actually has incurred negative interest income from its bank deposits. Some firms may have been able to circumvent negative interest rates by for example reducing their deposits, negotiating with the bank, or adjusting their deposit portfolios across banks. This type of behaviour is a reaction to negative rates that we should measure as an outcome. If we had measured exposure to negative interest rates based on whether firms had actually incurred negative interest income or not, we might not have captured the full behavioural effect of introducing negative interest rates.

The share of firms that according to our definition is exposed to negative interest rates on bank deposits increases gradually over the sample period in line with the aggregate share of deposits carrying negative interest rates according to Danmarks Nationalbank's official statistical survey of banks' introduction of negative interest rates, cf. Table 1. This serves as an important quality check of our measure. Larger firms were generally exposed to negative interest rates earlier than smaller firms, partly because they have larger deposit balances (and in general banks first introduced negative interest rates vis-à-vis large customers) and partly because they have a larger number of bank connections in comparison to smaller firms. This is not a major issue in relation to our analyses. There is a substantial time variation in banks' introduction of negative deposit rates, so at a given firm and bank size class and point in time there is sufficient variation in the exposure to negative interest rates to enable a comparison between firms that were exposed to negative rates and firms that were not. In addition, we use firm fixed effects in most of our regressions, thereby controlling for all potential time-invariant confounders, including selection of firms into specific banks. Still, it is reassuring that firms that became subject to negative interest rates in different years are similar in terms of for example liquidity and leverage ratios, cf. the last part of Table 1.

**Table 1: Banks' introduction of negative interest rates for non-financial firms**

	2014	2015	2016	2017	2018
<i>Details and indicators from own bank-level survey</i>					
No. of banks that have introduced negative interest rates on their deposits for <i>large depositors</i>	0	5	8	9	11
- Of which: Large banks <sup>1</sup>	0	3	6	6	6
No. of banks that have introduced negative interest rates on their deposits for <i>all depositors</i>	0	1	2	5	8
- Of which: Large banks <sup>1</sup>	0	0	1	3	4
Total no. of banks in survey	17	17	17	17	17
- Of which: Large banks <sup>1</sup>	6	6	6	6	6
% of bank-firm links in which the bank has introduced negative interest rates for firms in the given size class <sup>2</sup>	0.0	20.1	37.8	45.9	57.3
% of firms exposed to negative interest rates on deposits from <i>any</i> of their bank connections <sup>2</sup>	0.0	37.6	53.8	59.8	68.0
<i>Benchmark series<sup>3</sup></i>					
% of total deposits carrying negative interest rates, end of year	0.0	32.0	42.7	57.5	64.0
<i>Characteristics of firms that were exposed to negative interest rates for the first time</i>					
No. of employees (median)	-	9.5	7.6	5.6	-
Liquidity ratio (median)	-	23.1	24.9	23.1	26.8
Leverage ratio (median)	-	52.0	51.6	53.6	50.7
No. of firms in sample	47,500	48,970	42,994	45,018	42,815

Notes: <sup>1</sup>Large banks refer to banks in Group 1 defined by the Danish Financial Supervisory Authority, as well as branches of foreign banks with a similar sized balance sheet.

<sup>2</sup>Based on firms with an average deposit balance of more than DKK 750,000.

<sup>3</sup>Source: Danmarks Nationalbank's official statistical survey on banks' introduction of negative interest rates. Sources: Own compilations based on own bank-level survey, Danmarks Nationalbank's official statistical survey on banks' introduction of negative interest rates and microdata from the Danish Tax Agency, Statistics Denmark and Bisnode.

Descriptive statistics are provided in Table 2. Our sample consists of nearly 200,000 firm-year observations over the period 2014-2018. Data on fixed investment and employment are only available for the period 2014-2017. Data on fixed investment are collected by Statistics Denmark through surveys and tax reporting for a sample of firms and imputed by Statistics Denmark for the remaining firms. When considering fixed investments, we exclude all observations for which any data on fixed investments or value added are imputed.

**Table 2:** Descriptive statistics

Variable	Definition	Source	Mean	Std. dev.	1st quartile	Median	3rd quartile	N
Negative interest rate	Negative interest rate on deposits introduced by any of the firm's bank connections (dummy)	Own survey, Danish Tax Agency	0.43	0.50	0.00	0.00	1.00	197,530
Deposit balance	Firm's total bank deposits, DKK	Danish Tax Agency	1,736,273	3,675,000	138,942	559,900	1,655,490	197,209
Interest rate - largest bank	Average interest rate (per cent) on deposits at the bank connection with which the firm has the largest amount of deposits	Danmarks Nationalbank (Interest rate statistics)	0.02	0.22	-0.14	-0.04	0.16	197,530
Deposits to total assets	Ratio of deposits to total assets, per cent	Danish Tax Agency, Bisnode	20.37	21.92	2.34	12.57	31.94	157,001
Liquidity ratio	Liquid assets / total assets, per cent	Bisnode	23.11	23.32	3.13	15.51	36.97	156,987
Leverage ratio	Debt / total assets, per cent	Bisnode	61.98	34.05	40.49	59.07	77.79	155,522
Investment rate	Net fixed investment / value added, per cent	Statistics Denmark (Firm statistics)	4.86	12.01	0.00	0.58	4.77	99,892
Employment	No. of employees (full time equivalents)	Statistics Denmark (Firm statistics)	14.11	28.45	2.75	5.62	13.02	161,171

Notes: N denotes the number of firm-year observations. Liquid assets cover cash, bank deposits, shares, bonds and mutual fund shares. Investment rate and employment are available for the period 2014-2017. Remaining variables are available for the period 2014-2018.

### 3. The effect of negative deposit rates on firms' balance sheets and real economic decisions

To investigate the extent to which the introduction of negative interest rates on firms' bank deposits has had an impact on firms' portfolio behaviour and decisions regarding real investments or employment, we estimate the following event study specification

$$y_{it} = \alpha_i + \beta E_{it} + \gamma T_t + \theta \Delta i_{it} + \delta x_{it} + \varepsilon_{it} \quad (1)$$

where  $y_{it}$  is the outcome variable (deposits to total assets, liquidity ratio, leverage ratio, investment rate or employment),  $\alpha_i$  is a firm fixed effect,  $E_{it}$  is a vector of dummy variables indicating the number of years before and after the first introduction of negative interest rates on deposits at any of the firm's bank connections,  $T_t$  is a vector of time fixed effects,  $\Delta i_{it}$  is the change in the deposit rate at the firm's main bank connection from year  $t-1$  to year  $t$  and  $x_{it}$  is a vector of control variables (in our main specifications  $x_{it}$  consists of firm-size fixed effects only).

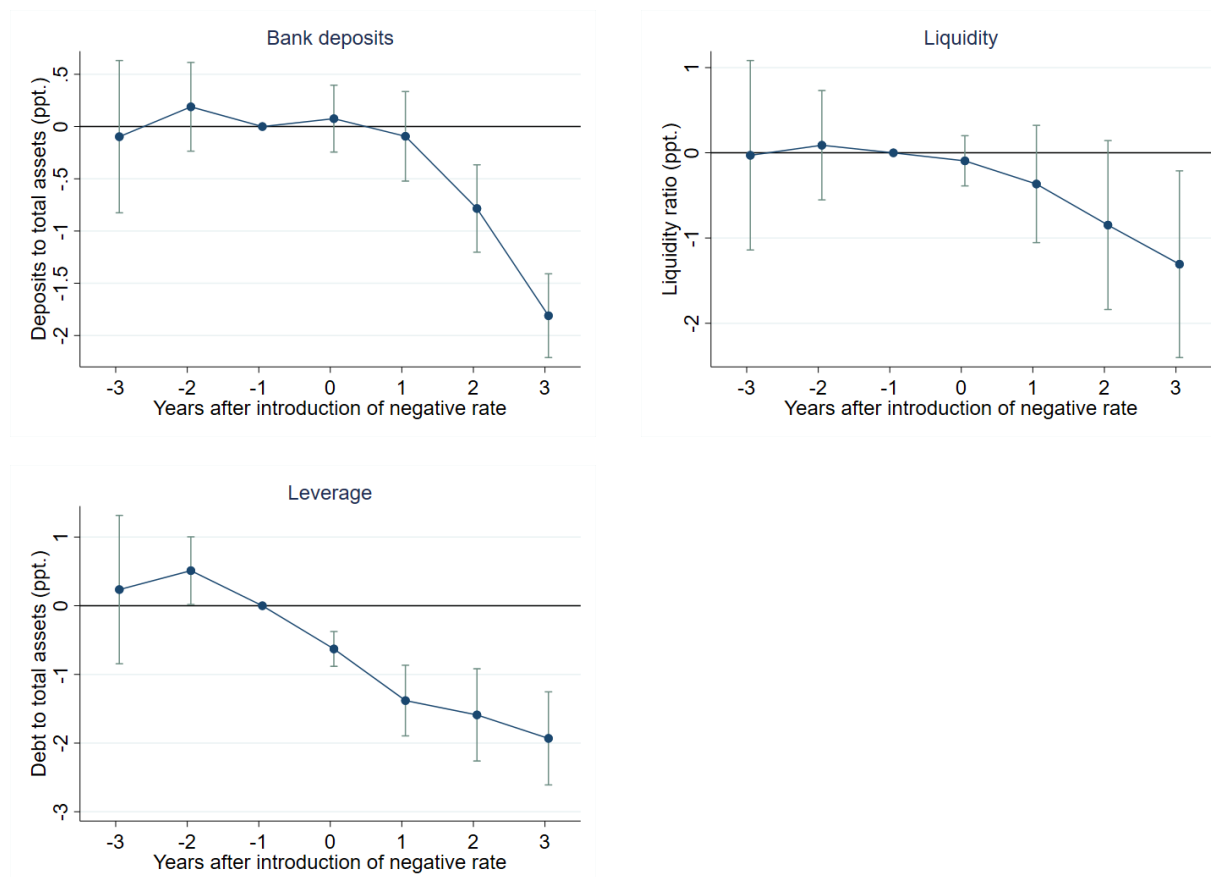
The inclusion of firm fixed effects implies that the estimation is based on variation within firms and that we thereby control for all potential time invariant confounders. Most importantly, the inclusion of firm fixed effects reduces concerns about the selection of specific types of firms in specific types of banks. Furthermore, only firms that are exposed to negative interest rates on deposits at some point during the sample period are included in the estimation sample. This allows us to abstract from potential biases coming from unobserved differences between firms that are exposed to negative interest rates and firms that are not. However, our results are not sensitive to this approach, cf. the robustness check in section 5.

Our main research question is whether there is an effect on firms' behaviour once they are exposed to deposit rates below the zero threshold. There may of course also be an effect from the generally decreasing interest rate level during the sample period or from other macroeconomic developments. We control for common factors by the inclusion of time-fixed effects. Still, the size of the coefficients in  $\beta$  could be impacted by a decrease in the interest rate that comes at the same time as the switch to negative deposit rates. We therefore also control for the change in the level of the deposit rate at the firms' main bank connection,  $\Delta i_{it}$ , and the coefficients in  $\beta$  can thus be interpreted as the effect of exposure to negative interest rates on deposits in addition to the normal transmission of a change in the interest rate.

The results regarding balance sheet adjustments are reported in Figure 4. We start by noting that trends in the outcome variables before the introduction of negative interest rates seem to be reasonably similar for firms that were exposed to negative interest rates in year 0 and for firms that were not. With a few exceptions, the levels of the outcome variables do not differ significantly statistically in the treatment and control groups during the years before the introduction of negative interest rates. In particular, the outcome variables do not differ in years  $t-3$  and  $t-2$ . Firms may start to react already at the time when banks announce that they will impose negative interest rates on deposits, which in our annual data in some cases is the year before the switch to negative rates is implemented (i.e. year  $t-1$ ).

Firms' reaction to the introduction of negative interest rates – balance sheet indicators

Figure 4



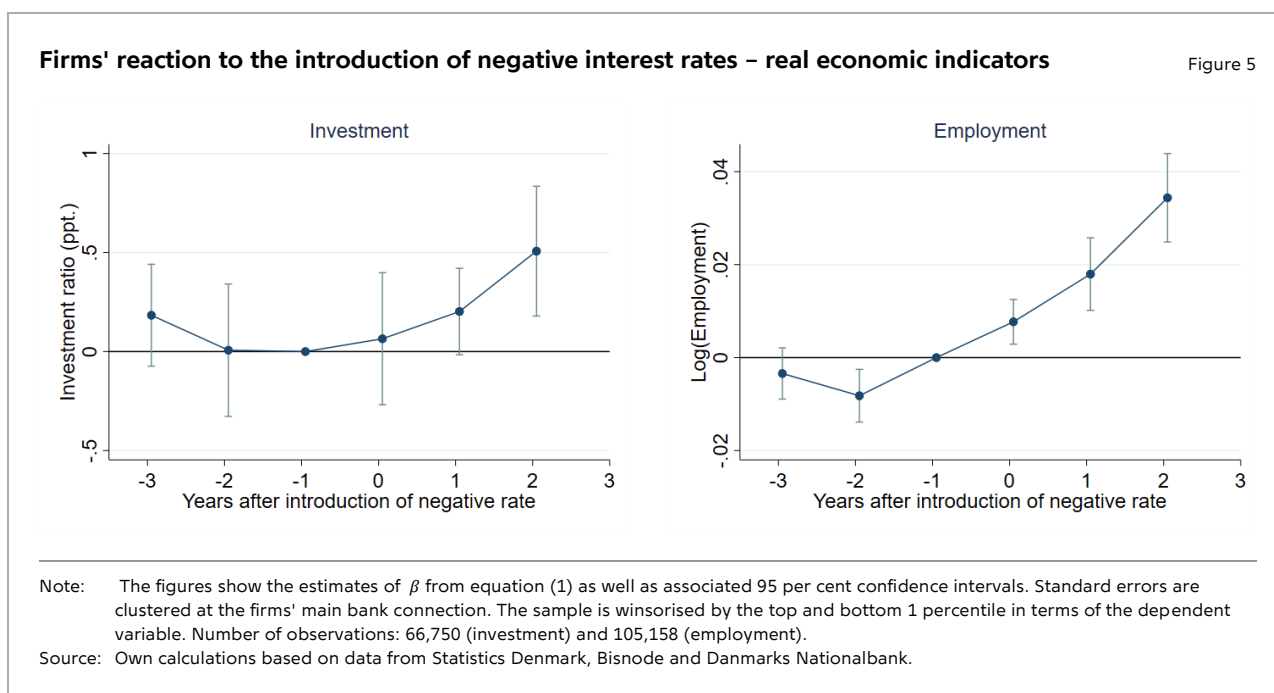
Note: The figures show the estimates of  $\beta$  from equation (1) as well as associated 95 per cent confidence intervals. Standard errors are clustered at the firms' main bank connection. The sample is winsorised by the top and bottom 1 percentile in terms of the level of and change in the dependent variables. The development in liquidity has not been adjusted for revaluation of securities holdings. Number of observations: 126,879 (deposits), 65,307 (liquidity and leverage).

Source: Own calculations based on data from Statistics Denmark, Bisnode and Danmarks Nationalbank.

Following the introduction of negative interest rates on deposits, firms reduced their bank deposits as a share of their balance sheet. We also find an effect on liquidity, although liquidity reacts slower than bank deposits. This might indicate that firms initially rebalance by substituting bank deposits into other types of liquid assets or deposit accounts in other countries. Furthermore, our results show that firms reduce their leverage when faced with negative interest rates on deposits. Such a balance sheet contraction could be a rational approach for firms with excess liquidity, in particular if it is possible to reduce the draw on for example revolving credit facilities without a concomitant reduction in drawing rights. The fact that firms reduce their liquidity when the cost of maintaining a liquidity reserve increases due to the introduction of negative deposit rates suggests that the introduction of negative deposit rates has not generally given rise to

concern about access to liquidity among the firms (Anderson and Carverhill, 2012; Boyle and Guthrie, 2003; Acharya, Almeida and Campello, 2007).

With respect to real economic outcomes, we find that firms exposed to negative deposit rates increase their fixed investments and employment more than other firms, cf. Figure 5. After two years, firms faced with negative interest rates have increased employment by 3 percentage points more than firms not exposed to negative interest rates. The investment rate is around 0.5 percentage point higher. The slower reaction of fixed investments compared to employment may reflect the fact that investments are typically planned for a longer horizon and therefore change at a slower pace. Firms might also view investments in fixed assets as being irreversible to a larger extent than increased employment. The Danish labour market is normally considered to be very flexible due to a so-called "flexicurity model" that combines flexible hiring and firing rules with a generous social safety net and active labour-market policies (Jespersen, Munch and Skipper, 2008; Andersen 2012, 2015).



The size of the estimated effects on fixed investments and employment is not trivial from an economic point of view. However, the economic impacts of central banks' unconventional monetary policy (non-interest policies) are usually also estimated to be quite substantial. Estimated shadow rates for the euro area suggest that the impact of the ECB's non-standard monetary policy measures corresponds to a decline in the short-term interest rate of around 4 to 5 percentage points (Hartmann and Smets, 2018). To put our findings into perspective, we can consider the effect after two years on employment and the investment rate of a 4.5

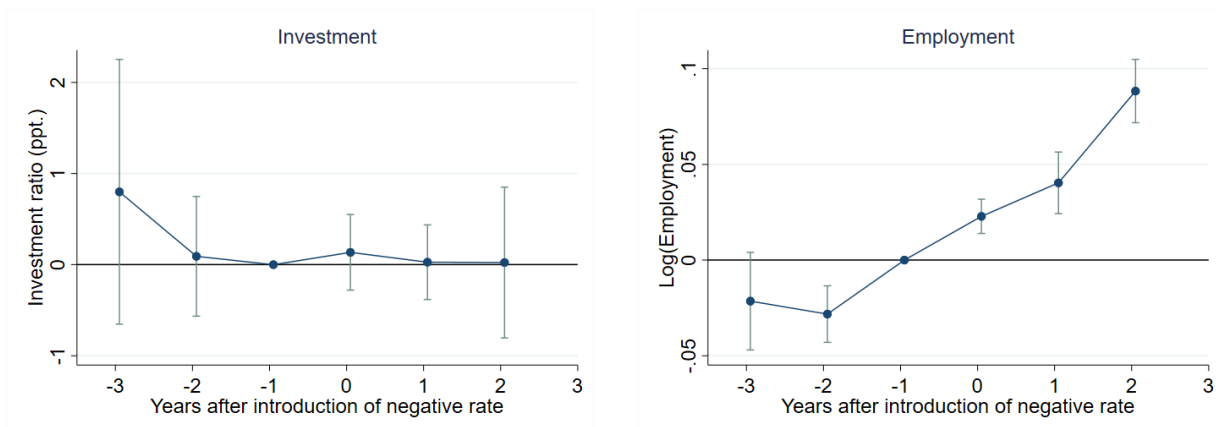
percentage point decline in interest rates according to the large-scale macroeconomic model of the Danish economy (Annual Danish Aggregate Model (ADAM)) developed and maintained by Statistics Denmark, see Knudsen (2013) for a description of the model. According to the multipliers of the June 2019 version of the model, employment will increase by an amount corresponding to 2.0 per cent of total private sector employment and the investment rate (defined as gross fixed capital formation in per cent of GDP) by 3.3 percentage points. Taking uncertainty and methodological differences into account, our findings based on firm-level data are therefore not implausible.

In Figure 6, we split the sample by firm age. The effects on investment are driven by more established firms, while the effect on employment is stronger among the younger firms. Generally, older firms are more capital intensive than younger firms, and that may be one reason why the effect on investment only seems to be present among the older firms. The larger employment effect for younger firms should be seen in light of these firms having a higher baseline growth in employment (average employment growth for young firms is 19 per cent compared to 3 per cent for older firms in the estimation sample).

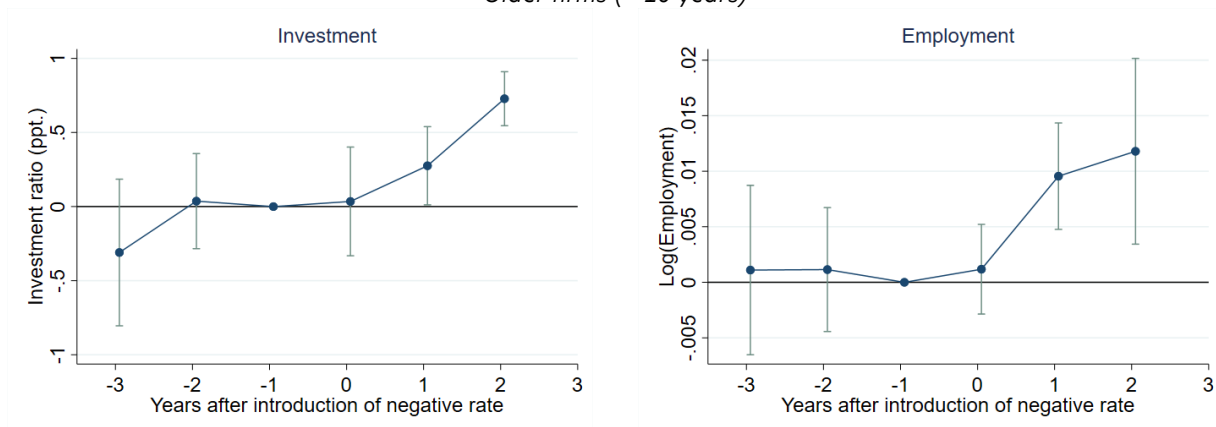
Real economic impacts of negative interest rates: Split by firm age

Figure 6

Younger firms (< 10 years)



Older firms (≥ 10 years)



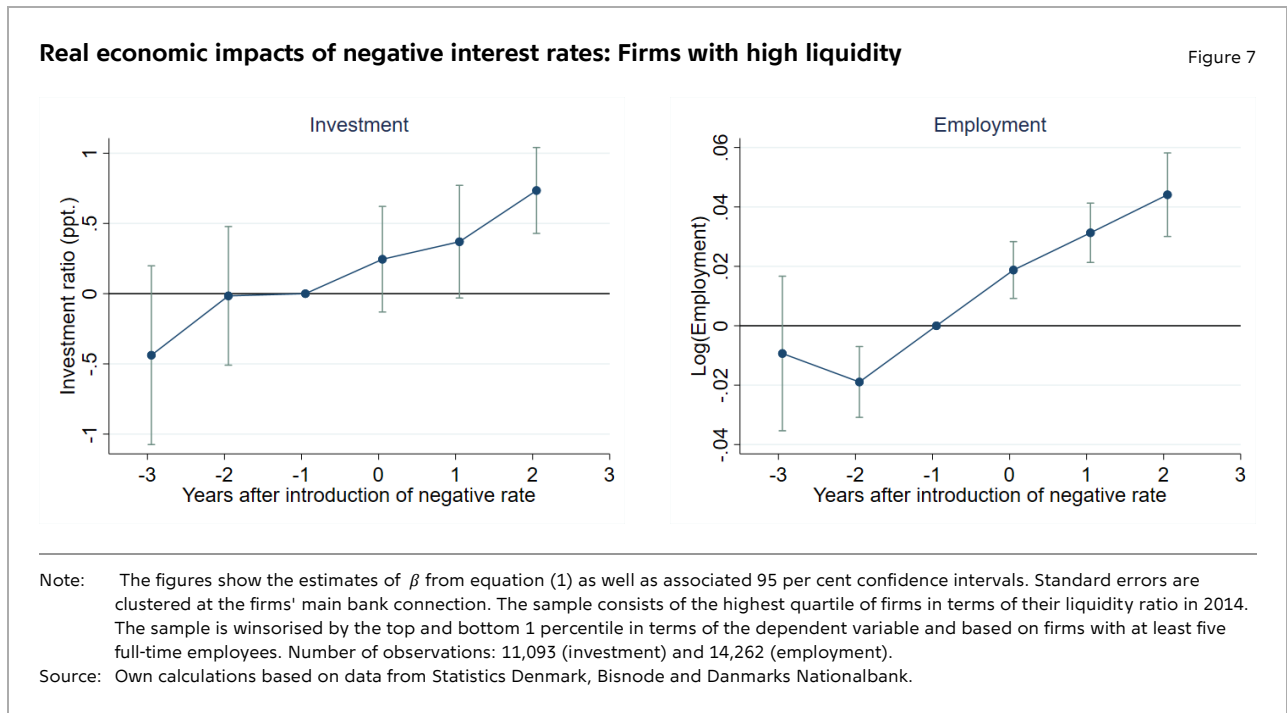
Note: The figures show the estimates of  $\beta$  from equation (1) as well as associated 95 per cent confidence intervals. Standard errors are clustered at the firms' main bank connection. Age is measured in the first year in which the negative interest rate was introduced by one of the firm's bank connections.

Source: Own calculations based on data from Statistics Denmark, Bisnode and Danmarks Nationalbank.

Next, we investigate whether firms with high liquidity exhibit stronger reactions to negative interest rates than other firms. This could be expected since the costs of negative interest rates are larger relative to other costs for firms with high liquidity. In Figure 7, we report results for firms with a liquidity ratio in the highest quartile. Results are qualitatively similar to those for the full sample. The reaction to negative deposit rates seems somewhat stronger for firms with high liquidity holdings than our overall estimate, but the difference is not statistically significant. Finally, we investigate an additional dimension of potentially important



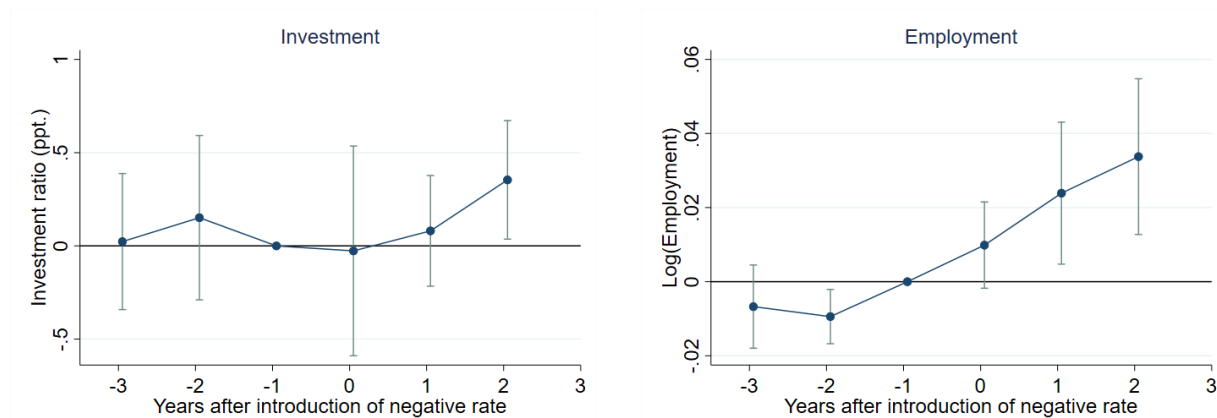
heterogeneity, namely industry. We find that the reaction in investment and employment is present in both the manufacturing and services industries, cf. Figure 8.



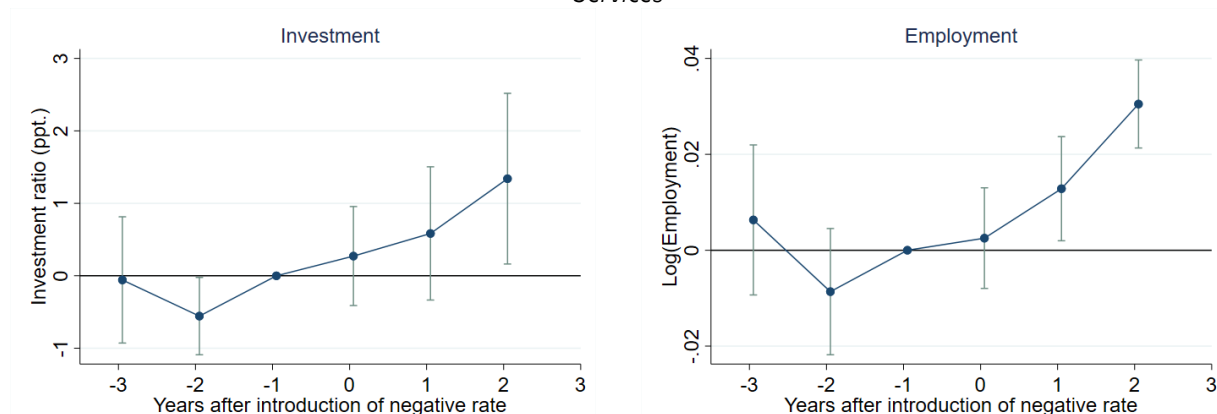
## Real economic impacts of negative interest rates: Split by industry

Figure 8

### Manufacturing, trade and transport



### Services



Note: The figures show the estimates of  $\beta$  from equation (1) as well as associated 95 per cent confidence intervals. Standard errors are clustered at the firms' main bank connection.

Source: Own calculations based on data from Statistics Denmark, Bisnode and Danmarks Nationalbank.

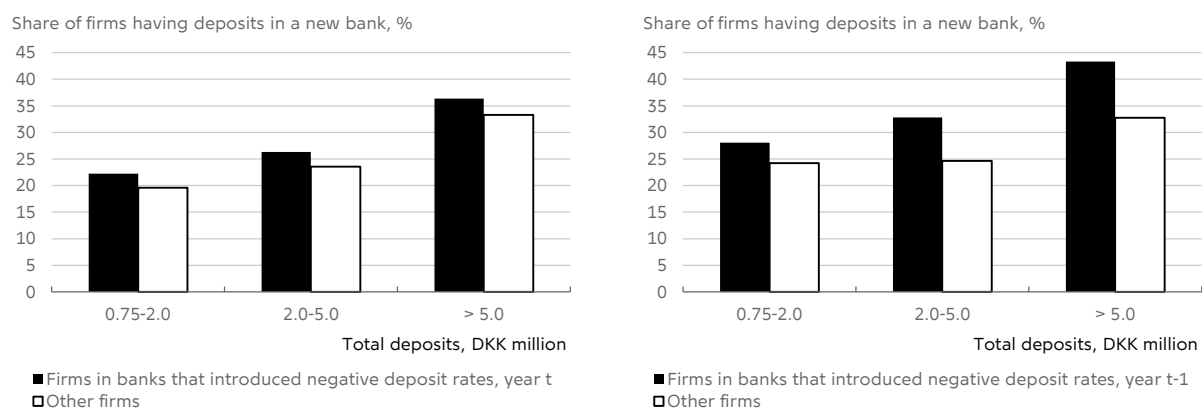
## 4. Bank relationships and expectations regarding future production, turnover and employment

The results in the previous section indicate that the introduction of negative interest rates is associated with changes in firms' behaviour. In this section, we present a number of supplementary results supporting the interpretation that the changes in behaviour we identify are indeed related to the introduction of negative interest rates.

As a starting point, we consider firms' reaction to being exposed to negative interest rates on their bank deposits both in the extensive margin (i.e. firms' tendency to establish new bank relationships) and the intensive margin (i.e. to which extent firms adjust their deposit balance across existing bank connections).

### Firms exposed to negative interest rates are more likely to establish new bank relationships

Figure 9



Note: Firms are assigned to the black group if at least one of their bank connections has introduced negative interest rates on deposits for that group of customers (based on total deposits in that bank).

Source: Own calculations based on data from Statistics Denmark and the Danish Tax Agency.

First, we note that firms that were customers in a bank that introduced negative interest rates were more likely to become a customer of a new bank during that year, or the year after, cf. Figure 9. To evaluate firms' response to negative interest rates at the extensive margin more formally, we estimate two different logistic regression models, cf. Table 3. Model (1) is a standard logistic regression model. The results show that the probability of having a new bank connection during a given year is 7.2 percentage points higher if at least one of the firm's existing bank connections has introduced negative deposit rates compared to a firm which does not face negative deposit rates at any of their existing bank connections. This effect is sizeable, since the baseline probability of having a new bank connection was 29 per cent. The coefficient of the lagged indicator for negative rates requires careful interpretation. During the estimation period, some banks have introduced negative interest rates on deposits, but no banks have moved away from negative interest rates again. Hence, if a bank had negative deposit rates in year  $t-1$ , it also has them in year  $t$ . The interpretation of the coefficient of the lagged indicator for negative rates is thus the additional increase in the probability of having a new bank connection if the bank also had negative deposit rates in the previous year, compared to a situation in which the bank only had introduced negative deposit rates in the current year. We find this effect to be insignificant in model (1). This indicates that firms respond relatively quickly (within the same year in our annual data set) to being exposed to negative interest rates on their deposits.

**Table 3:** Firms reaction to the introduction of negative interest rates on deposits: Extensive and intensive margin

	(1)	(2)	(3)	(4)
Dependent variable	New bank connection	New bank connection	$\Delta$ no. of bank connections	Growth rate in deposits (in %)
Negative deposit rate $i_{i,t}$	0.0719*** (0.0168)	0.0691*** (0.0189)	0.137*** (0.0207)	
Negative deposit rate $i_{i,t-1}$	0.00979 (0.0177)	0.0291** (0.0137)	-0.0421*** (0.0134)	
Negative deposit rate $i_{j,t}$				-0.782 (1.519)
Negative deposit rate $i_{j,t-1}$				-6.330*** (1.204)
Negative deposit rate $i_{j^-,t}$				-0.154 (1.461)
Negative deposit rate $i_{j^-,t-1}$				2.686* (1.423)
Number of observations	34,654	15,027	34,654	24,226
Table displays	Marginal effects	Marginal effects	Coefficient estimates	Coefficient estimates
Firm-bank fixed effects	-	-	-	Yes
Firm fixed effects	No	Yes	No	-
Year fixed effects	Yes	Yes	Yes	Yes
Method	Logit	Conditional fixed effects logit	OLS	Fixed effects
Estimation level	Firm-year	Firm-year	Firm-year	Firm-bank-year

Notes: Standard errors in brackets. Standard errors are clustered at the level of firms' main bank connection in the previous year (model (1) and (3)). Significance: \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ . Only firms/firm bank pairs with deposits exceeding DKK 750,000 are included. This reduces the risk that shifts of deposits across banks are driven by a wish to be covered by the depositor guarantee scheme (which covers deposits up to EUR 100,000 at bank level, i.e. approximately DKK 750,000) rather than considerations regarding negative interest rates. All models include control for the change in interest rates at the firm's main bank connection. Models (1) and (3) include controls for the level of deposits, and model (3) includes control for the lagged number of bank connections. Subscripts refer to firm  $i$ , bank  $j$  and year  $t$ .  $j^-$  refers to a firm's bank connections other than the current bank. Model (4) is based on firm-bank-year observations with a growth in deposits between -50 per cent and +200 per cent.

To take potential unobserved heterogeneity into account, we also estimate a fixed effects logistic regression model (model (2)). Identification in the fixed effects model comes from variation within firms, and the model is therefore only based on the firms which experience a shift from non-negative to negative deposit rates at some point during our sample period. We find an effect in year  $t$  similar to that found in model (1), but also a marginally significant additional effect of having been exposed to negative deposit rates in year  $t-1$  of 2.9 percentage points. Hence, a firm is 6.9 percentage points more likely to establish a new

bank connection in the first year in which deposit rates were negative, and 9.8 percentage points (6.9+2.9) more likely in the subsequent year compared to firms that have not (yet) faced negative interest rates on any of their deposit accounts.

The tendency of firms to establish new bank connections following the introduction of negative deposit rates at one of their existing bank connections could reflect the fact that firms change their main bank connection and/or that they increase the number of bank connections. In Table 3, column (3), we regress the change in the number of active bank connections on the indicators for negative interest rates at the firms' bank connections. The tendency of firms to establish new bank connections when they are faced with negative interest rates on their deposit accounts is reflected in the positive coefficient of the indicator for negative deposit rates at one of the firms' bank connections. Hence, firms increase the number of bank connections when they are faced with negative deposit rates. The coefficient of the lagged indicator for negative interest rates is negative, indicating that firms reduce the number of bank connections the year after the introduction of negative interest rates. This is likely to reflect the fact that it often takes time for a firm to close an existing bank relation once it has decided to do so. The sum of the two coefficients is positive and statistically significant, indicating that firms increase the number of bank connections when they are faced with negative interest rates on their deposit accounts – even when we allow for an adjustment period of at least one year.

Considering firms' reactions to negative interest rates on the intensive margin, we turn to data at the firm-bank-year level. We regress the growth in deposits on indicators for whether the bank has introduced negative interest rates on deposits in year  $t$  or  $t-1$ , as well as indicators for whether a firm's other existing bank connections have introduced negative interest rates on deposits in year  $t$  or  $t-1$ . We also include firm-bank-year fixed effects, and the estimation is thus based on variation over time in firms' deposits with a given bank. The results are presented in Table 3, column (4). In general, the level and growth rate of a firm's bank deposits from year to year are highly volatile and reflect a number of different factors not necessarily completely under the firm's control. We do, however, find that the growth rate from year  $t-1$  to  $t$  in firms' deposits with banks that introduced negative interest rates in year  $t-1$  was 6.3 percentage points lower than the growth rate of firms' deposits with other banks. Furthermore, results indicate that the growth rate in a firm's deposits with a given bank was 2.7 percentage points higher if *other* existing bank connections have introduced negative interest rates on deposits during year  $t-1$ . Overall, these results indicate that firms actively attempt to avoid paying negative interest rates on their deposits once these are introduced by banks – both by establishing new bank connections and by rebalancing the distribution of deposits across existing bank connections towards banks that have not introduced negative interest rates.

Next, we consider the extent to which firms' expectations regarding future production, turnover and employment are influenced by the introduction of negative deposit rates by their banks. For this exercise we use the monthly business tendency surveys conducted by Statistics Denmark for the manufacturing,

construction, retail and services industries. Questionnaires and sample sizes differ across the four surveys. The survey for the services industry is by far the largest in terms of sample size, consisting of around 2,000 firms per month. This allows us to study the response of these firms' expectations to the introduction of negative interest rates on their deposits. The surveys for the manufacturing, construction and retail industries also cover around 2,000 firms in total per month. Questions regarding activity and employment are relatively similar across these three surveys, and due to sample size considerations we pool the responses from these surveys, allowing us to also estimate the impact on non-service firms' expectations. Firms in the manufacturing industry are asked about their expectations regarding future production, while firms in the remaining industries are asked about their expectations regarding future turnover. All firms are asked about their expectations regarding future employment. All questions have three response options (decrease/unchanged/increase) and are asked at a three-month horizon.

As in the previous section, we use an event study specification, namely

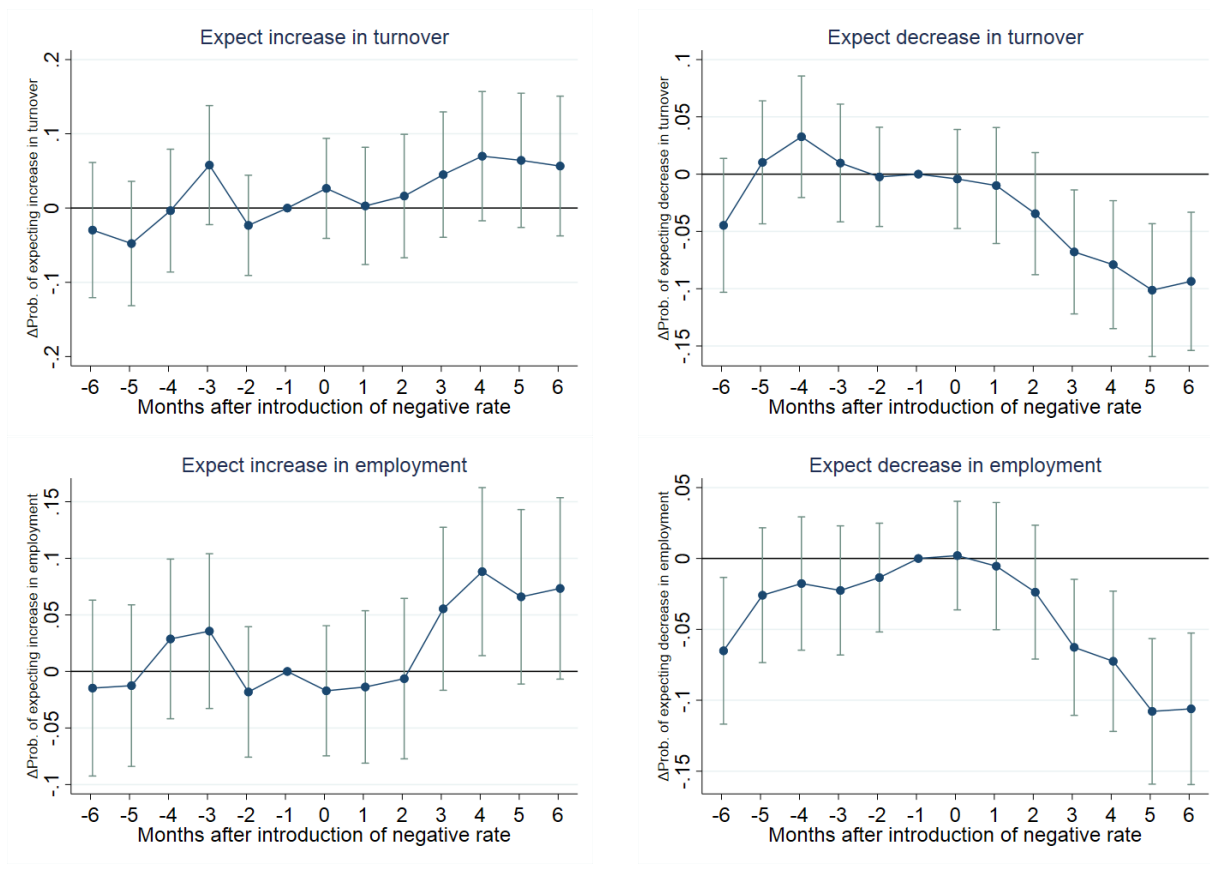
$$P(Y = a)_{it} = \alpha + \beta E_{it} + \beta T_t + \delta x_{it} + \varepsilon_{it} \quad (2)$$

in which we model the probability that a firm expects  $Y$  (production, turnover or employment) to move in direction  $a$  (increase or decrease) as a (linear) function of  $E_{it}$ , a vector of dummy variables indicating the number of months after the first introduction of negative interest rates on deposits at any of the firm's bank connections,  $T_t$ , time (month) fixed effects and  $x_{it}$ , a vector of control variables (firm size and industry fixed effects). The inclusion of time (month) fixed effects picks up any macroeconomic shocks, and also the aggregate effect on expectations (i.e. the effect on all firms) of for example news about banks introducing negative interest rates for their customers.  $\beta$  is therefore a measure of the effect on firms' expectations of the actual introduction of negative interest rates on deposits at one of their bank connections, compared to contemporary expectations of firms for which negative interest rates were not introduced (at that point in time).

We find only a limited impact on firms' expectations regarding future production/turnover and employment of actually being faced with a switch to negative interest rates on bank deposits. Firms in the service industries are significantly less likely to expect a decrease in turnover and employment starting from three months after the first introduction of negative interest rates on their deposit accounts, cf. Figure 10. Similarly, the switch to negative interest rates seems to be correlated with a gradual increase in the probability of expecting an increase in employment (significant at the 10 per cent level). For firms in manufacturing, construction and retail, there is no significant effect on expectations of a switch to negative interest rates on their deposits, cf. Figure 11.

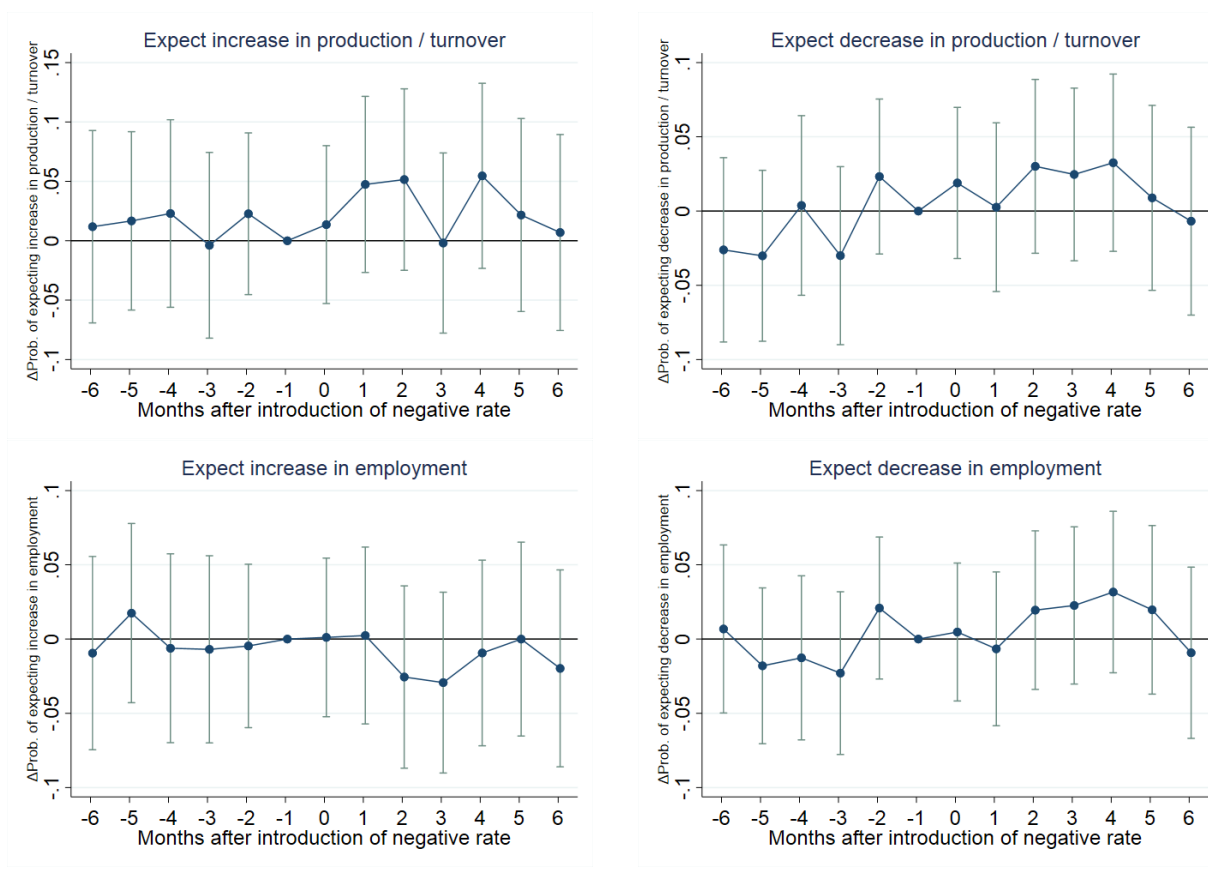
Negative interest rates and firms' expectations – service industries

Figure 10



Note: The figures show estimates of  $\beta$  from equation (2) as well as associated 95 per cent confidence intervals. Firms in the manufacturing industry report expectations regarding production, whereas other firms report expectations regarding turnover. The results are based on 12,944 observations from 1,167 firms.

Source: Own calculations based on data from Statistics Denmark and Danmarks Nationalbank.



Note: Figures show estimates of  $\beta$  from Equation (2) as well as associated 95%-confidence intervals. Firms in the manufacturing industry report expectations regarding production, whereas other firms report expectations regarding turnover. Results are based on 12,944 observations from 1,167 firms.

Source: Own calculations based on data from Statistics Denmark and Danmarks Nationalbank.

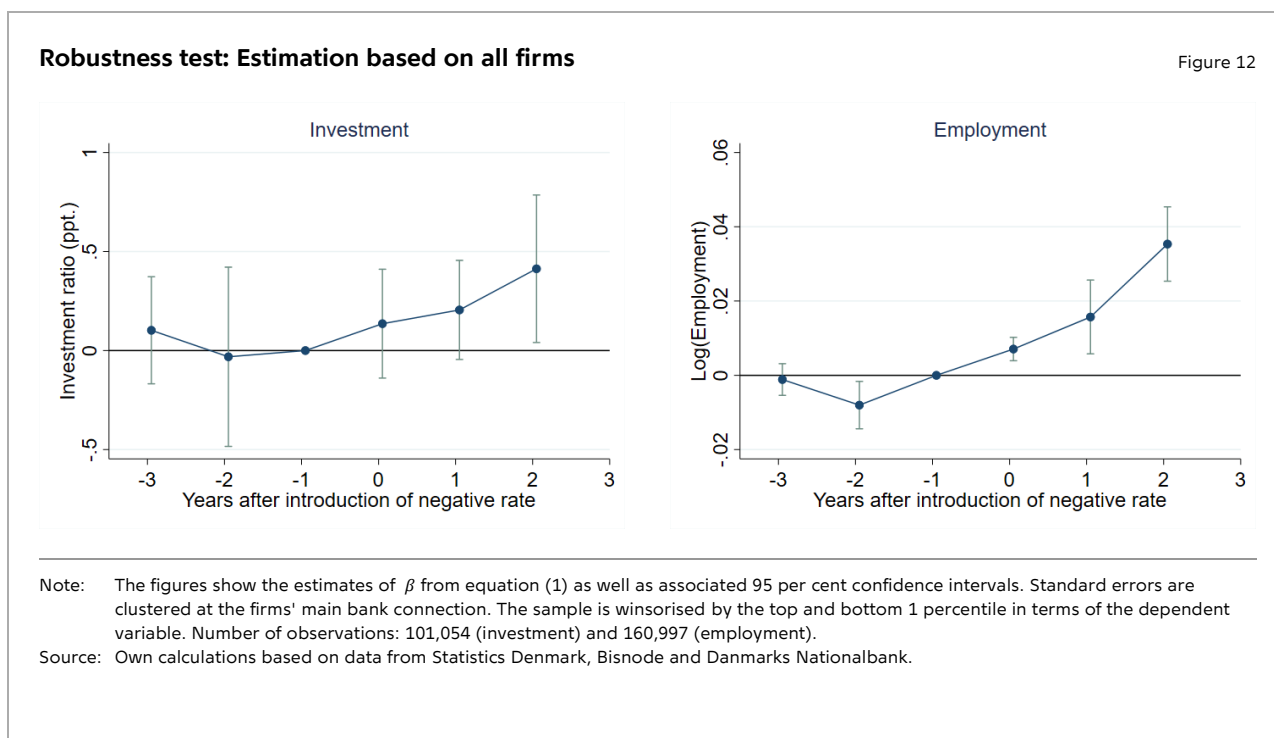
Overall, the findings presented in this section indicate that firms are very much aware of the introduction of negative deposit rates on their bank accounts, therefore also strengthening our claim that the behavioural changes we identify are indeed related to the event of deposit rates becoming negative. Even though the impact on firms' expectations in the short run seems limited, the fact that we are able to find statistically significant effects on expectations among a subsample of firms might indicate that "animal spirits" could play a role for some firms.



## 5. Robustness checks and further explorations

Before concluding, we show in this section that our results are not driven by our choice to only include firms in our estimation sample if they are exposed to negative deposit rates at some point during our sample period. We also discuss issues related to the estimation of the elasticity of investment and employment to changes in deposit rates when rates are in positive and negative territory.

First, as noted, our empirical approach implies that we base our estimation on firms that are exposed to negative deposit rates at some point during our sample period. The advantage of this approach is that it reduces concerns about unobserved differences between treatment and control groups. Firms that are exposed to negative deposit rates at different points in time are likely to be more comparable than firms that are exposed to negative rates and firms that are not exposed at all during the sample period. However, as a robustness check we also include those firms that are not exposed to negative deposit rates during the sample period. This does not impact the results in any important way, as presented in Figure 12.



In the regression results presented in section 3, we controlled for changes in the deposit rate to separate the effect of interest rates crossing zero from conventional monetary transmission. It is of course also of interest to explore whether the effect of interest rate changes on real economic outcomes is different in a negative interest rate environment. This effect is difficult to identify with the data at our disposal, however, since changes in deposit rates have been modest during our sample period – in particular changes in deposit rates in the negative territory. The short sample period also makes it difficult to identify the effect of changes in deposit rates with the appropriate time lags. Keeping these limitations in mind, Table 4 reports estimated

deposit rate elasticities (i.e. the marginal effect on investment and employment of a change in the deposit rate of 1 percentage point). Although the elasticities have the expected sign (row 1), they are not significantly different from zero at conventional confidence levels. Furthermore, the differences in elasticities between the positive and negative interest rate territory are not significantly different from zero (row 2).

**Table 4:** Estimated interest rate elasticities

	Investment	Employment
Interest rate	-0.526 (0.540)	-0.0284* (0.0150)
Interest rate * Negative	0.592 (0.632)	0.0192 (0.0144)
No of observations	66,377	104,705

Note: The table reports coefficients from a modified version of equation (1) that includes the deposit rate at the firm's main bank connection as well as an interaction term between this deposit rate and an indicator of whether the bank has introduced negative deposit rates for that group of customers. The results in the first row can be interpreted as a same-year interest rate elasticity of investment or employment when banks have not introduced negative deposit rates. The elasticity when banks have introduced negative deposit rates can be found as the sum of the coefficients in rows 1 and 2. Standard errors in brackets. Significance: \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .

## 6. Concluding remarks

So, do firms behave differently when nominal interest rates are below zero? According to our study, they do. Controlling for changes in interest rates, we have found that firms exposed to negative deposit rates to a higher degree than other firms increase their fixed investments and employment. These findings suggest that there is an additional monetary transmission channel when nominal interest rates cross zero and become negative.

Although we identify a causal effect of facing negative deposit rates, the causal mechanism is more open to interpretation. The transmission channel might imply that firms become more aware of their portfolio composition and alternative opportunities regarding fixed investment and employment when deposit rates cross zero and become negative. Such increased awareness might be induced by the firms' bank connections which have used the introduction of negative interest rates as an opportunity to contact their corporate customers and encourage them to reconsider their portfolio composition. This could be a particularly important transmission mechanism for smaller firms. However, our findings could also be related to "search for yield" or "animal spirits" if negative deposit rates affect the firms' degree of optimism.

## Research data statement

The research data set for this article has been constructed by the authors on the basis of confidential microdata from Statistics Denmark, the Danish Tax Agency and Danmarks Nationalbank as well as proprietary microdata from Bisnode. The data set is therefore not publicly available.

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# Low for long

Denmark was the first country to introduce negative monetary policy rates in 2012. Since then, Switzerland, Sweden, Japan and the euro area have followed suit.

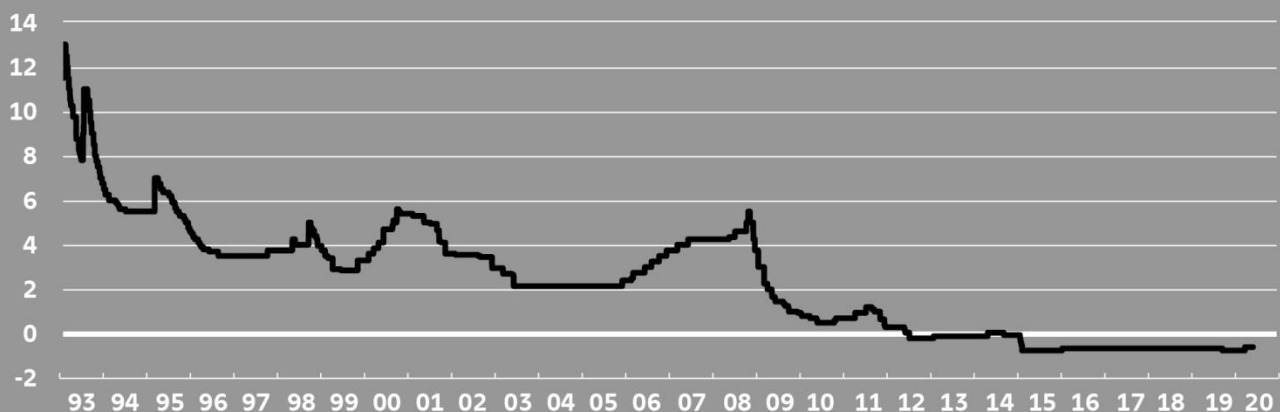
Very low and in some cases negative interest rates have characterised the past decade across the advanced economies. There are several reasons why interest rates have fallen to the current low levels. Low interest rates reflect the fact that inflation has been subdued in many countries, but structural changes in household and corporate savings and investment behaviour are also part of the explanation.

These developments have brought monetary policy and the economy into uncharted waters, which is why Danmarks Nationalbank will be issuing a series of publications on the topic of which this Working Paper is one.

## Danmarks Nationalbank's interest rate

Danmarks Nationalbank's key interest rate has been negative since the summer of 2012, with the exception of a brief period in 2014.

Per cent



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