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Negative interest rates, COVID-19, and the finances of listed euro firms

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Aim: The paper measures the impact of negative interest rates on listed firms in the original euro zone countries. It also measures the impact of the first COVID-19 year.

Design / research methods: The paper uses panel data to measure the influence of the short-term ECB deposit rate and the 10-years German bond yield on short-term and long-term firm variables. Cross section fixed effects are applied to first differences and dummy variables. For liquidity and non-liquid assets the effects are also measured for small and large companies, for sectors, and for countries.

Conclusions / findings: Corporate liquidity ratios and creditor ratios decline when short-term ECB-rates fall. If ECB rates are negative, liquidity ratios are further reduced by 0.6 percentage points. Declining long-term German government bond yields increase non-liquid assets, while negative yields boost these assets by 4.5% extra. In the first COVID-19 year, the investments in non-liquid assets were 7.6% smaller, while liquidity ratios increased by 2.3 percentage points.

Originality / value of the article: Papers on the influence of negative interest rates and of COVID-19 on European firms are unavailable. This makes the paper relevant for firm managers and policy makers and a benchmark for future research.

Implications of the research: Because the issues addressed are new, further research is valuable. One may think of comparable studies for different countries. Many other suggestions for further research are given in the conclusions.

Keywords: Negative interest rates, European Central Bank, German government bond yields, short-term firm financing, liquidity ratios, debtor ratios, creditor ratios, dividends, long-term borrowing cash flows, non-liquid investments, corona crisis, COVID-19.
JEL: E22, E31, E32, E58, G31, G35.

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1. Introduction

Some financial innovations are man-made, like bitcoin, financial derivatives, and special-purpose acquisition companies (SPACs). Negative interest rates are only partly man-made, because they are set by Central Banks, while they are followed by financial markets.

Until deep in the 20th century it would have been unimaginable that interest rates would be negative.[1] Nevertheless, negative interest rates apply nowadays in major developed countries, like Germany, France, and Japan, but also in smaller ones like Switzerland, The Netherlands, Finland, Sweden, and Denmark. Negative interest rates may be set by the central bank. For example, in Denmark there is already a policy of negative interest rates in effect since 2012 (Krogstrup et al. 2020) and the European Central Bank started with a negative interest rate of -0,1% on its deposit facility in 2014.[2] As a result, also private banks turned to invoke negative interest rates and firms (and later also private customers) were only able to leave their excess liquidity in deposits with banks if they were prepared to pay for it. In the sequel also solvent governments issued long-term debt at low or negative interest rates.[3]

Negative interest rates change the economic environment of firms and investors and may have pervasive effects on them. An analysis of the impact of such negative interest rates on corporate finance and corporate finance policies may thus be truly relevant.[4] In this paper I go into consequences of nominal interest rates for listed

[1] The first instance that I am aware of is Japan, where the T-bill rate became negative at the end of 1998 (Jørgensen, Risberg 2012). That such negative nominal rates may not be that strange for consumers and firms is discussed shortly by Thornton (1999).

[2] https://www.ecb.europa.eu/stats/policy_and_exchange_rates/key_ecb_interest_rates/html/index.en.html [18.06.2021].

[3] The Central Bureau of Statistics (2020) of The Netherlands identified at the end of June 2020 nine European countries for which sovereign debt rates were negative.

[4] There are other important questions related to the impact of low or negative (real) interest rates in economics and finance. For example, how do negative interest rates affect preferences and the discounting anomalies (Frederick et al. 2002)? What can investment institutions do to earn more to keep the spending at the desired level (Perold 2012)? In the same vein: how can pension funds and life insurers keep the value of assets equal to the value of discounted future promised payments (Antolin et al. 2011)? How to cope with risky discounted values for the distant future if interest rates are low (Newell, Pizer 2003), and how to address the negative values arising from the use of the Gordon growth model (Gordon 1959) at negative interest rates?

euro-zone firms. First, I focus on short-term measures, namely liquidity-, debtor- and creditor-ratios and their reactions to ECB rates. Second, I address longer term aspects like cash dividends, long-term borrowing cash flows and non-liquid investments and their sensitivity to long-term interest rates. Besides the impact of interest rates on these finance variables I also study if there is an additional effect when those rates are negative.

While doing so, there was also an opportunity to measure the impact of the corona crisis year 2020 (being the first year with a world-wide pandemic since the Spanish flue). The spread of the corona virus (COVID-19) had far-reaching consequences in many countries. Not only for mortality,[5] long-term illness, and overpopulated hospitals but also because of the pervasive measures taken by the governments in the form of lock downs, social distancing requirements, and economic assistance provided.[6] It is interesting to learn what influence the first year of this world-wide pandemic had on short- and long-term finances of firms.

In section 2, I go into the background of negative interest rates and in section 3, I present the data and the methodology. Section 4 shows the results of cross-sectional fixed effects regressions for short-term financial variables and structural financial variables of the firms. In section 5, I provide more detailed evidence by size, sector, and country for the two most important variables. Finally, section 6 presents the conclusions and gives suggestions for further research.

[5] The World Health Organization reported October 11, 2021 4,842,716 deaths (https://covid19.who.int/).

[6] A survey of the socioeconomic consequences of the corona epidemy, like labor, health, gender, discrimination, the environment, and public policy responses is provided by Brodeur et al. (2021). Donthu and Gustafsson (2020) summarize a special issue of the "Journal of Business Research" on the corona crisis.

2. Negative interest rates

Causes for the negative interest rates are not in all countries completely similar. For many countries, the abundancy of liquidity provided by Central Banks aimed at getting inflation at an adequate level (often assumed to be 2%) contributed to it. Besides this traditional task, a second aim of Central Banks is to assist governments in reducing unemployment by buying longer-term securities in the open market (Quantitative Easing: QE). This may reduce interest rates and stimulate investments. QE may, additionally, also assist local governments in preventing them to become bankrupt. This was relevant for the southern euro-zone countries and for Ireland during the euro-crisis from the end of 2009 until deep in 2012. In these countries sovereign interest rates soared because of bankruptcy fears caused by large government debt ratios. A fourth reason for keeping interest rates low is the wish to fight a possible appreciation of the local currency (Denmark).[7]

The discussion above applies to nominal interest rates. In fact, it may be amazing that the nominal interest rates are negative when there is an extremely large supply of liquidity. Many researchers assume that the abundant liquidity generated by Central Banks may not be withdrawn that quickly when inflation increases above 2% and that it may then result in soaring nominal interest rates. However, even if the nominal rates would rise, real interest rates may still stay negative if the rise in nominal interest rates will lag the rise of actual inflation. For these reasons negative real[8] interest rates may prevail for a long time.[9,10]

[7] Of course, a country may also indicate to keep interest rates low for one official reason (fighting unemployment), but also have the side-benefits of fighting appreciation (e.g. Switzerland).

[8] Graphically Borio et al. (2017: 10) show four periods with negative sort-term and long-term real interest rates "globally", though such periods occur in individual countries more often (Borio et al. 2017: 28, 46). From 1870 till now there have been four such periods, namely in World War I, around World War II, around 1975 (only for short-term real rates) and after about 2010 (long-term real rates about after 2015). Borio et al. (2017) also investigate several determinants of real interest rates, and they conclude that not only real factors, like GDP growth, life expectancy, and percentage of dependent population are important explanatory variables, but also monetary policy periods, like the Gold standard period, the Bretton Woods period, and the inflation targeting period.

[9] In a Reuters Poll amongst fixed investment specialists, many of them expect that real rates on government bonds will remain negative the forthcoming year and that pre-corona real sovereign bond returns might not be expected soon (Karunakar 2020).

A major discussion amongst economists is the question whether negative nominal interest rates of a Central bank will be transferred to other sectors in the economy.[11] The investment trap already suggests that lowering interest rates below a certain point will not increase economic activity. Moreover, negative interest rates might reduce the supply of funds to banks thereby diminishing the supply of funds to firms. Finally, bank profits would decline and thereby make it less interesting to lend. In that sense, negative interest rates could be a "black hole", by distorting economic laws. However, others argue that negative interest rates are just "business as usual". In a recent paper Altavilla et al. (online July 1st, 2021) show that negative interest rates in the euro zone did not make monetary policy ineffective. In fact, bank deposits did not decline, also because firms' liquidity increased during the period of negative interest rates. When confronted with negative interest rates, firms do invest more and increase their liquidity balances less. From now on the results of Altavilla et al. (2021) are assumed to hold, meaning that deposit rates will be transferred to bank lending rates.

In this paper, I study the impact of nominal interest rates to see if corporate liquidity holdings indeed decline and non-liquid investments do increase. Table 1 shows the ECB depository rates at the end of the year and the minimum and maximum of the annual 10-years German government bond yields, as well as the average of the two. I use the German government bonds for our calculations of the influence of long-term rates, as their yields are in many euro countries a benchmark for firms, also because they are often used in capital budgeting calculations as approximations of risk-free rates.

[10] Schmelzing (2019) even finds that there is a structural decline in real interest rates taking place for more than seven centuries. If this decline continues, negative real interest rates become a phenomenon which with firms (and economists) need to deal with for a long time.

[11] Ulate (2019) finds that at negative rates monetary policy is less effective. Altavilla et al. (2021) find that negative Central Bank interest rates are transmitted to other sectors of the economy. It can, however, be doubted if small firms (and individuals) will ever be paid for borrowing money (Bromley 2020).

Table 1. ECB deposit facility rates at the end of the year and the minimum, maximum and mean ten-year German government bond yields during the year (GGBYs), 2011–2020

1	2	3	4	5
Year	ECB Rate	Minimum GGB Yield	Maximum GGB yield	Mean GGB yield
2011	0.250	1.690	3.497	2.594
2012	0.000	1.162	2.050	1.606
2013	0.000	1.168	2.041	1.605
2014	-0.200	0.540	1.946	1.243
2015	-0.300	0.077	0.990	0.534
2016	-0.400	-0.184	0.629	0.223
2017	-0.400	0.154	0.604	0.379
2018	-0.400	0.220	0.768	0.494
2019	-0.500	-0.718	0.260	-0.229
2020	-0.500	-0.840	-0.188	-0.514

Sources: ECB Rate Is the Deposit Facility Rate at the End of the Year, https://www.ecb.europa.eu/stats/policy_and_exchange_rates/key_ecb_interest_rates/html/index.en.html [18.06.2021]; GGB Yield Is the German 10-years Annual (Minimum, Maximum, and Mean of these two) Government Bond Yield, http://www.worldgovernmentbonds.com/bond-historical-data/germany/10-years/ [18.06.2021].

It proves that the ECB rate was negative for the first time at the end of 2014 and that it stayed negative during the following six years. The minimum German government bond yields followed in 2016 and in 2020 the maximum yield on such bonds even proved to be negative.

Negative interest rates and short-term firm finances. If a deposit with a bank makes losses with negative interest rates, it may not be attractive for firms to hold such deposits. Instead, they might hold cash. At the current small negative interest rates, it is not likely that firms will switch all bank deposits into cash (Jensen, Spange 2015). The prevention of the loss of income via a negative interest-bearing deposit will not outweigh the relatively high costs of holding cash at the firm (or elsewhere in a storage room), while there are in addition high costs in transferring banknotes physically. Nevertheless, there may be marginal effects. Treasury

managers may not be willing to accumulate depository holdings further. Instead, they may now accept that more cash is held. In principle, however, these shifts between bank deposits and cash holdings would not necessarily mean that a firm's overall liquidity changes. With excess bank deposits caused by negative interest rates, a firm could of course also try to pay its creditors quicker. Another option to reduce excess bank deposits would be to soften credit policies and thereby increase its accounts receivables. For these reasons, not only the impact of the interest rates on liquidity, but also the impact on debtors and creditors is studied here.

Negative interest rates and long-term firm finances. For the long-term finances of firms, I study the impact of interest rates on cash dividends, the increase in long-term borrowing cash flows,[12] and the investments measured by the increase in the natural logarithm of total assets minus cash and cash equivalents. I assume that these more structural finance characteristics will be influenced most by longer term interest rates, for which I use the mean of the maximum and the minimum of the ten years German government bond yields (Table 1, column 5). For the dividends paid it is not set in advance whether the impact of interest rates will be negative or positive. A larger interest rate may result in more interest income on bank deposits and commercial paper, which might be transferred to investors via additional dividends. However, it may also result in lower dividends if the debt needs more servicing and the higher interest costs make less cash available to investors.

Low or negative interest rates should make the borrowing costs lower and decreased the borrowing cash flows if the firms do not finance themselves with additional cheaper debt. In the latter case, the impact of lower interest rates will be the combined effect of lowering cash flows per unit of debt but of increasing cash flows for more units of debt.

Finally, for investments the relationships are theoretical quite unidirectional. Lower cost of financing (including lower cost do debt) will make it possible for

[12] I study this variable instead of the leverage ratios itself, since then the leverage rate could not be used as an independent variable too, while it is used as an explanatory variable in the other equations. Moreover, an interesting phenomenon of declining and negative interest rates is that the debt servicing outlays may be reduced when the leverage increases. Such a phenomenon may occur with solvent governments (in non-Covod-19 times), and I considered it interesting to see if this also happened to the firms.

firms to invest more. This is also one of the assumptions of Central Banks if they apply QE for getting lower interest rates.

3. Data and methodology

I study the data for listed firms in the EU-15 countries[13] that have the euro as its currency. This means that the United Kingdom (no EU country anymore), Denmark and Sweden are excluded, as they have their own currencies. I focus on listed firms, because these are on average more advanced than non-listed firms and because they may be under more scrutiny of investors. These characteristics imply that these firms may react sharply to changes in the economic environment, the financial sector, and interest rates. Data come from the Orbis database that gives recent data for 10 years, which nicely fits the period around which the interest rates in the euro-zone became negative, as shown in Table 1. I, finally, exclude financial firms (SIC codes 6000-6999) and utilities (SIC codes 4900-4949). This results in 1224 firms in the sample.

Short-term data. I first focus on short-term firm finances, namely on cash and equivalents (liquidity) holdings, the debtors, and the creditors. These data are transformed into ratios by dividing by total assets. Table 2 shows the development of the averages of these ratios between 2011 and 2020.

[13] EU-15 refers to the number of member countries in the European Union prior to the accession of ten additional candidate countries on May 1, 2004.

Table 2. Annual ratios of the main variables and differences between 2011 and 2020

	1	2	3	4	5	6
Year	Liquidity-ratio	Debtor ratio	Creditor ratio	Cash dividend ratio	Increase in long-term borrowing ratio	Non-liquid invest-ments
2011	0.121	0.163	0.120	0.027	-0.014	n.a.
2012	0.120	0.158	0.118	0.026	-0.003	0.044
2013	0.131	0.153	0.118	0.027	-0.005	0.010
2014	0.134	0.147	0.116	0.026	-0.004	0.067
2015	0.134	0.142	0.116	0.026	0.008	0.100
2016	0.129	0.140	0.115	0.024	-0.004	0.102
2017	0.132	0.140	0.117	0.026	-0.001	0.068
2018	0.129	0.134	0.115	0.028	0.001	0.078
2019	0.124	0.120	0.105	0.025	0.007	0.125
2020	0.150	0.107	0.098	0.019	0.011	0.004
# of Obs.	11,039	11,145	11,137	7,858	6,522	9,788
Dif (2019-2012)	0.004	-0.038	-0.013	-0.001	0.010	0.080
PDif (2019-2012)	(0.464)	(0.000)	(0.001)	(0.501)	(0.237)	(0.000)
Dif (2020-2012)	0.030	-0.052	-0.021	-0.007	0.014	-0.041
PDif (2020-2012)	(0.000)	(0.000)	(0.000)	(0.000)	(0.100)	(0.000)

Source: author's own elaboration.

The table presents in columns 1 till 5 the average ratios of Cash and equivalents, Debtors, Creditors, Cash dividends and the Increase in long-term borrowing respectively, all scaled by total assets. Column 6 gives the change in the natural logarithm of the total assets minus cash and cash equivalents. All the variables are presented by Year . The number of observations is calculated over all available years. Dif (2019–2012) presents the difference between 2019 and 2012 and Dif (2020–2012) the difference between 2020 and 2012. Between these differences are the two-sided P-values for the differences based on unequal variances (between parentheses).

The table reveals that the liquidity ratio (column 1) is rather stable over time, but that it increased suddenly in the corona year 2020.[14] This can also be seen from the P-values from the bottom of Table 2. Between 2012 (used as benchmark year,

[14] It should be noted here that the number of observations is not equal in each year. When downloading the data (June 16, 2021) there was a smaller number of firms available for 2020 then for earlier years. This will have biased the results. Nevertheless, for the liquidity ratio it is unlikely that the smaller number of firms will have contributed to the increase, because larger firms generally report earlier and thus arrive earlier in databases, while they also often have lower liquidity ratios.

because all observations were available for all variables for this year) and 2019 there is no significant difference (P value = 0.464). However, between 2012 and 2020 there is (P-value=0.000). Table 2 also reveals that the debtor ratio (column 2) is always larger than the creditor ratio (column 3). This is logical, as the firm adds value to its goods bought, and when one assumes similar payable policies for goods bought and sold, debtor ratios should be larger. Both debtor- and creditor ratios decline over time between 2011 and 2020, which is clear from the highly significant changes between 2012 and 2019/2020. Given the decline in interest rates over the investigated period, it is not strange that creditors are paid faster, the more so when interest rates become negative. At the same time the firm's customers seem to have done the same, as debtor ratios declined even stronger.

Long-term data. The columns 5 till 7 of Table 2 give the development in the longer-term variables. There is hardly any change in the ratio of cash dividends paid (column 4), except for the decline in the last year 2020. Between 2012 and 2019 there was no significant effect (P-value of the difference is 0.501), but between 2012 and 2020 there was (P-value 0.000). The long-term borrowing cash flows (column 5) declined the first years of the observations but increased afterwards. However, the change between 2012 and 2019 and between 2012 and 2020 is not significant. Finally, there seems to be a trending increase in non-liquid investments (column 6) with a significant P-value (of 0.000) for the 8.0% increase, but this trend was broken in the corona year 2020 with a significant decline between 2012 and 2020 of 4.1% (P-value also 0.000). For information on the variables used I refer to Table A1 and for their descriptive statistics to Table A2 in the Appendix.

Methodology. Because the ECB rates and the German government bond yields are declining over time and the dependent and independent variables could trend over time too, I take the first differences per year. These first differences are analyzed with cross section fixed effect regression analyses, with cluster robust standard errors.

The first focal variable is the change in the interest rates (either the ECB deposit facility rate or the German bond yields). The second variable is a dummy, taking the value of 1 if the rate (or yield) is negative, and else zero. The third variable is a dummy variable, which takes the value of 1 in the corona year (2020) and zero in

other years. Besides the focal variables, I use four control variables: the change in the natural logarithm of operating revenue "D-LN(OPR)", the change in the return on assets "D-ROA", the change in the long-term debt ratio "D-LTDR", and, finally, the change in the tangible assets ratio "D-TAR".

I checked for multicollinearity by measuring the correlation coefficients between the independent variables. There was a high correlation (0.782) for the change in the ECB rate and the change in the government bond yield.[15] This is not a problem, because these variables are not used in the same regression equation. Because the other variables have a correlation below a threshold of 0.7, there is no major problem of multicollinearity. I then use a cross-section fixed effects model to estimate the relations.[16]

4. Interest rates and COVID-19 effects

Table 3 shows the relation between the ECB rates, the ECB rates being negative, and the impact of the first corona year on short term finances of the firm. It proves that declining ECB rates reduce both liquidity holdings and creditor ratios significantly, as the sign of ECB rate is positive for those dependent variables.

[15] This is an indication that the short-term ECB rates are indeed (partially) transmitted to other parties in the economy; in this case to the German government and its 10-year bond yields. Similar results are found by Jensen and Spange (2015).

[16] The technique used is state of the art as can also be seen from the recent paper of Altavilla et al. (2021) who use the same technique with addition of time fixed effects. Inclusion of the latter would make interest rate collinear and then these focal effects would disappear from the regression. Therefore, time fixed these were left out. The benefits of cross-section fixed effects are in comparison with OLS less omitted variable bias and, in comparison to a random effects model better consistency. Non-stationarity is already coped with through first differences, so an error correction model is not needed. Because there are no lagged dependent variables included in the regression, Arellano Blundell Bover Bond techniques are not needed.

Table 3. The impact of changes in ECB rates, of negative ECB rates and of the corona year on changes in liquidity variables

	(1)	(2)	(3)
Variables	Liquidity ratio changes D-LIQR	Debtor ratio changes D-DEBTR	Creditor ratio changes D-CREDR
D-ECBR	0.018**	0.006	0.014***
	(0.009)	(0.005)	(0.004)
ECB-	-0.006***	-0.001	-0.001
	(0.002)	(0.001)	(0.001)
CORONA	0.023***	-0.007***	-0.005***
	(0.003)	(0.001)	(0.001)
D-LN(OPR)	-0.024***	0.009***	0.007***
	(0.002)	(0.001)	(0.001)
D-ROA	0.087***	-0.007**	-0.039***
	(0.006)	(0.003)	(0.003)
D-LTDR	-0.001	-0.004	0.010***
	(0.005)	(0.003)	(0.003)
D-TAR	-0.274***	0.006	0.042***
	(0.015)	(0.008)	(0.007)
Constant	0.007***	-0.004***	-0.000
	(0.002)	(0.001)	(0.001)
Obs.	9,705	9,737	9,728
R-squared	0.095	0.014	0.039
Number of Firms	1,215	1,216	1,215

Source: author's own elaboration.
The table shows the cross section fixed effects regression results. All variables are annual changes except for the dummies for the negative ECB interest rates and for the Corona crisis year. The dependent variables are the annual change in liquidity ratios (liquidity divided by total assets) in column 1, the annual change in the ratio of debtors to total assets (column 2) and the annual change in the ratio of creditors to total assets (column 3). The explanatory variables are presented in Appendix A1. Cluster robust standard errors are shown between parentheses below the coefficients. *** p<0.01, ** p<0.05, * p<0.1

The positive sign of ECB rates on the liquidity ratio was not expected, as Shirai and Sugandi (2019) find that there exists in most countries a negative relation between cash holdings in the economy and central bank interest rates. A probable reason for the different result is that I focus on firms, while firms have generally less

cash in hand than the public and firms have more cash equivalents, like bank deposits. Because the listed firms are amongst the largest firms in the economy, they react quickly to negative interest rates on their cash equivalents. This means that these firms search for alternative, more profitable investments in the short-term finances. This can for example be done by paying creditors quickly and getting a better reputation with them or by enhancing the reputation with debtors by softening the payment requirements. Of course, such investments can also be done in long-term finances like -as will be seen later- investments in non-liquid assets.

The positive sign for the creditors could be expected. It is an indication that excess liquidity holdings (given declining interest rates) can be reduced by paying creditors faster. Nevertheless, there is no other effect of negative ECB rates per se (ECB-) on the other liquidity measures; neither by increasing the debtor ratios, nor by reducing the creditor ratios.

Finally, the corona crisis increased liquidity ratios significantly, but reduced debtor and creditor ratios. For the liquidity and creditor ratio, these are quite unexpected significant signs, as the corona crisis could require firms to withdraw from their liquidity balances[17] and to slow down paying creditors. That firms' debtors paid less in the first corona year might be expected.[18]

Table 4 shows the relation between the (German) government bond yields and these yields being negative as well as the impact of the first corona year on long-term finances of the firm. The (marginal significant) positive sign of the bond yields on cash dividends, indicates that with such yields declining, also cash dividends decline. A much stronger (negative) significant effect of government bond yields is found for the non-liquid investments of firms. Reduced government bond yields do increase investments.

[17] Table 4 analyzes if there are longer term financing effects of the corona crisis that may have influenced the liquidity ratios, like lower dividends during the corona crisis or less non-cash investments.

[18] The significant coefficients of the control variables will not be discussed here, but generally they have the signs that could be expected.

Table 4. The impact of changes in 10-years German government bond yields, of negative German government bond yields and of the corona year on changes in structural firm variables

	(1)	(2)	(3)
Variables	Cash dividend ratio changes D-CADIR	Increase in long-term borrowing ratio D-LTBCF	Non-liquid investment changes D-LN(NCA)
D-GGBY	0.002*	-0.003	-0.021***
	(0.001)	(0.004)	(0.007)
GGBY-	-0.002	0.008	0.045***
	(0.001)	(0.005)	(0.008)
CORONA	-0.003*	0.004	-0.076***
	(0.002)	(0.007)	(0.011)
D-LN(OPR)	0.002	0.015***	0.283***
	(0.002)	(0.005)	(0.007)
D-ROA	0.053***	0.024**	-0.030
	(0.004)	(0.011)	(0.020)
D-LTDR	-0.004	0.098***	0.099***
	(0.006)	(0.009)	(0.018)
D-TAR	0.032***	-0.099***	-0.017
	(0.010)	(0.029)	(0.049)
Constant	0.000	-0.004*	0.042***
	(0.001)	(0.002)	(0.003)
Obs.	6,613	5,834	9,702
R-squared	0.037	0.028	0.184
Number of Firms	1,000	872	1,215

Source: author's own elaboration.

The table shows the cross section fixed effects regression results. All variables are annual changes except for the dummies for the negative German government bond yields and for the Corona crisis year. The dependent variables are the annual change in cash dividends divided by total assets (column 1), the annual increase in long-term borrowing divided by total assets (column 2) and the annual change in the natural logarithm of non-liquid assets (column 3). The explanatory variables are presented in Appendix A1. Cluster robust standard errors are shown between parentheses below the coefficients. *** p<0.01, ** p<0.05, * p<0.1

If the government bond yield is negative (GGBY-), there is only a significant and strong effect on the non-liquid investments, as these increase by 4.5%. When combining the liquidity holdings results in Table 3 and the non-liquid investment results of Table 4, one may conclude that in the listed euro-zone firms negative (ECB) interest rates make liquidity holdings to decline, while negative long-term

government bond yields make non-liquid investments to increase. These results are in line with the findings of Altavilla et al. (2021).[19]

Finally, the corona crisis reduced cash dividends (only marginally significantly so) and the non-liquid investments. Both effects could have contributed to the corona-induced increase in liquidity ratios of Table 3, though the non-liquid investment results are much stronger (namely -7.6%).

5. Effects for size, sector, and country

It is relevant to see if the results differ for small and large firms. I focus on the liquidity ratios and the non-liquid investments because the liquidity holdings are the prime variable to look at for the interest rate sensitivity of the short-term finances of the firm. And the non-liquid investments are likely to be influenced (even targeted so by monetary policies) by the longer-term interest rate changes. Moreover, these variables showed the largest R-squares for the short-term effects (Table 3) and the long-term effects (Table 4).

I measured the median of operating revenue of all observations (547.995 million euros) and then selected firms below and above the median (small and large firms). However, some firms were not always small or large. For that reason, I selected firms that were permanently small during all years, and firms that were permanently large. This procedure makes that there are less observations for the combined small and large firms in Table 5, than the numbers shown for all firms in Tables 3 and 4.

Table 5 presents the results for the permanently small and large firms. It proves that the positive interest rate sensitivity for the liquidity ratios found in Table 3 is caused by the small firms. Large firms do not react significantly with their liquidity holdings to ECB rate changes. This implies that the small firms' treasury managers actively manage their firm's liquidity based on interest rates, while larger firms do

[19] There are no significant effects of interest rates on the increases of long-term debt cash flows; probably because of counteracting effects of lower interest rates and increases in debt. Nevertheless, I consider the signs to be interesting.

not directly do so. Both types of firms, however, reduce their liquidity ratios when the ECB rate becomes negative.

Table 5. Liquidity ratios and investment effects by firm size

	(1)	(2)	(3)	(4)
Variables	Liquidity ratios small firms D-LIQR	Liquidity ratios Large firms D-LIQR	Non-liquid investments small firms D-LN(NCA)	Non-liquid investments large firms D-LN(NCA)
ECBDR / GGBY	0.031*	-0.002	-0.009	-0.015**
	(0.017)	(0.009)	(0.013)	(0.007)
ECB- / GGBY-	-0.006*	-0.005***	0.050***	0.039***
	(0.003)	(0.002)	(0.015)	(0.008)
CORONA	0.020***	0.025***	-0.063***	-0.080***
	(0.005)	(0.003)	(0.020)	(0.011)
D-LN(OPR)	-0.024***	-0.035***	0.261***	0.373***
	(0.003)	(0.005)	(0.010)	(0.016)
D-ROA	0.093***	0.101***	0.033	-0.340***
	(0.009)	(0.009)	(0.030)	(0.029)
D-LTDR	-0.001	0.016	0.093***	0.234***
	(0.007)	(0.011)	(0.024)	(0.034)
D-TAR	-0.291***	-0.235***	0.184**	-0.479***
	(0.023)	(0.022)	(0.075)	(0.066)
Constant	0.008**	0.004**	0.056***	0.026***
	(0.004)	(0.002)	(0.006)	(0.003)
Obs.	4,021	4,160	4,018	4,160
R-squared	0.102	0.103	0.167	0.206
# of firms	531	492	531	492

Source: author's own elaboration.

The table shows the cross section fixed effects regression results for firms that permanently have operating revenues below the median and firms that have them permanently above the median. All variables are annual changes except for the dummies for the negative ECB interest rates (ECB-) used in the liquidity ratio regressions, the negative German government bond yield (GGBY-) used in the non-liquid investments and for the pandemic crisis year (CORONA) used in all four regressions. The dependent variables are the annual change in liquidity ratios (liquidity divided by total assets) in columns 1 and 2, and the annual change in the natural logarithm of non-liquid assets (columns 3 and 4). The explanatory variables are presented in Appendix A1. Cluster robust standard errors are shown between parentheses below the coefficients. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Interestingly, the large firms do react significantly with their non-liquid investments to long-term interest rates, while small firms do not. Large firms invest significantly more if the German government bond yields are declining. Though small firms do not react significantly to changes in long-term bond yields, that behavior changes if those yields are negative. Then they start investing by 5%. In addition, large firms also invest significantly 3.9% more if the long-term bond yields are negative.

Finally, the corona pandemic increased the liquidity ratios for small and large firms significantly, probably related to the concomitant strong decline in non-liquid investments for both size groups.

Table 6 presents the impact for major sectors of Manufacturing and Services, as well as for the remaining (Other) sectors combined. The liquidity ratios of manufacturing firms do not react in any way significantly to the ECB rates. The liquidity holdings in the services sector, however, do react strongly to ECB rates, and decline with smaller ECB rates. To a lesser extent, liquidity ratios in the Other sectors get smaller too when ECB rates diminish. Also, the liquidity ratios in the Services sector react positively to negative ECB rates, while the Manufacturing and the Other sectors do not.

Services sector firms' non-liquid investments do not react to long-term government bond yields per se, but they react strongly when the government bond yields are negative. The firms of the Manufacturing sector increase their investments when government bond yields decline, but they do not show an additional effect of negative government bond yields. The Other sector(s) do react to both the government bond yields per se, as well as to those yields being negative.

Finally, all three major sectors do react significantly to the corona crisis. Liquidity ratios increased and non-liquid investments declined. Both effects were strongest in the services sector.

Table 6. Effects by sector for liquidity ratios and non-liquid investments

	(1)	(2)	(3)	(4)	(5)	(6)
	Liquidity ratio changes D-LIQR			Non-liquid investments changes D-LN(NCA)		
Variables	Manufact.	Services	Other	Manufact.	Services	Other
ECBDR / GGBY	0.004	0.078***	0.035**	-0.028***	-0.002	-0.024**
	(0.012)	(0.025)	(0.017)	(0.009)	(0.020)	(0.012)
ECB- / GGBY-	-0.004	0.020*	0.009	0.017	0.085***	0.064***
	(0.005)	(0.010)	(0.007)	(0.010)	(0.023)	(0.014)
CORONA	0.025***	0.039***	0.022***	-0.065***	-0.100***	-0.070***
	(0.004)	(0.007)	(0.005)	(0.014)	(0.031)	(0.019)
D-LN(OPR)	-0.016***	-0.029***	-0.033***	0.236***	0.390***	0.307***
	(0.003)	(0.006)	(0.003)	(0.009)	(0.023)	(0.010)
D-ROA	0.089***	0.114***	0.034***	-0.092***	-0.119***	0.150***
	(0.010)	(0.011)	(0.012)	(0.031)	(0.039)	(0.037)
D-LTDR	-0.026**	0.015*	0.010	0.215***	0.029	0.176***
	(0.012)	(0.008)	(0.015)	(0.039)	(0.028)	(0.049)
D-TAR	-0.365***	-0.340***	-0.182***	-0.219***	0.041	0.117*
	(0.023)	(0.043)	(0.021)	(0.074)	(0.154)	(0.066)
Constant	0.006***	0.006	0.003	0.035***	0.077***	0.024***
	(0.002)	(0.004)	(0.003)	(0.004)	(0.010)	(0.006)
Obs.	5,042	1,962	2,701	5,042	1,959	2,701
R-squared	0.102	0.125	0.089	0.153	0.167	0.299
# of firms	615	257	343	615	257	343

Source: author's own elaboration.

The table shows cross section fixed effects regression coefficients. The dependent variables are the annual change in liquidity holdings (columns 1 till 3) and annual non-liquid investments (columns 4 till 6). The table distinguishes between manufacturing firms (first SIC codes 2 and 3), service sector firms (first SIC codes 7 and 8), and Other firms (remaining SIC codes exclusive of Financial firms and Utilities). All variables are annual changes except for the dummies for the negative ECB interest rates (ECB-), the negative German government bond yield (GGBY-) and the pandemic crisis year (CORONA). The ECB rate and the negative ECB rate (ECB-) are used in the regressions for the liquidity ratios, and the German government bond yield (GGBY) and that yield being negative on average (GGBY-) are used in the non-liquid investment equations. The other explanatory variables are presented in Appendix A1. Cluster robust standard errors between parentheses are shown below the coefficients. *** p<0.01, ** p<0.05, * p<0.1

Table 7. Effects by country for liquidity ratios and non-liquid investments

	(1)	(2)	(3)	(4)	(5)	(6)
	Liquidity ratio changes D-LIQR			Non-liquid investment changes D-LN(NCA)		
Country	D-ECBR	ECB-	CORONA	D-GGBY	GGBY-	CORONA
Austria	0.073	0.006	0.027*	-0.014	0.027	0.051
	(0.057)	(0.012)	(0.015)	(0.025)	(0.031)	(0.043)
Belgium	-0.031	0.001	0.031**	-0.018	0.052	-0.148***
	(0.044)	(0.009)	(0.014)	(0.032)	(0.038)	(0.053)
Finland	0.079*	-0.016*	0.013	-0.023	0.067**	-0.094**
	(0.045)	(0.009)	(0.012)	(0.025)	(0.030)	(0.040)
France	-0.008	-0.003	0.038***	-0.008	0.029**	-0.078***
	(0.016)	(0.003)	(0.005)	(0.012)	(0.014)	(0.020)
Germany	0.032*	-0.008**	0.013***	-0.020	0.024	-0.076***
	(0.018)	(0.004)	(0.005)	(0.013)	(0.015)	(0.020)
Greece	0.004	-0.011	0.016	0.005	0.100***	-0.072*
	(0.033)	(0.007)	(0.012)	(0.020)	(0.026)	(0.038)
Ireland	0.073	0.006	0.027*	-0.254***	-0.209***	0.037
	(0.057)	(0.012)	(0.015)	(0.052)	(0.060)	(0.077)
Italy	-0.002	-0.000	0.011	-0.013	0.072***	-0.010
	(0.027)	(0.006)	(0.007)	(0.023)	(0.026)	(0.033)
Luxemburg	-0.070*	0.000	0.041***	-0.004	0.033	-0.088*
	(0.041)	(0.009)	(0.012)	(0.031)	(0.034)	(0.045)
Netherlands	0.052	-0.026***	0.041***	-0.045	-0.001	-0.044
	(0.046)	(0.009)	(0.012)	(0.037)	(0.042)	(0.054)
Portugal	0.025	0.006	0.025*	0.000	0.082***	-0.136***
	(0.041)	(0.008)	(0.015)	(0.023)	(0.029)	(0.044)
Spain	0.081**	-0.009	0.013	0.015	0.121***	-0.099***
	(0.032)	(0.007)	(0.009)	(0.023)	(0.027)	(0.035)

Source: author's own elaboration.

The table shows cross section fixed effects regression coefficients. The dependent variables are the annual change in liquidity to assets ratios (columns 1 till 3) and annual non-liquid investments (columns 4 till 6). All variables are annual changes except for the dummies for the negative ECB interest rates (ECB-), the negative German government bond yield (GGBY-) and the pandemic crisis year (CORONA). Column 1 shows the coefficients of the change in the ECB rate on the change in liquidity ratios and column 2 of negative ECB rates on liquidity ratios. Columns 3 and 6 show the impact of the Corona-year on liquidity ratios and non-liquid investments, respectively. Column 4 presents the impact of changes in mean German 10-years government bond yields on non-liquid investments and column 5 of that yield being negative on non-liquid investments. Control variables (like in Tables 3 and 4) were used in the equations but omitted for presentation reasons in this table. Cluster robust standard errors between parentheses are shown below the coefficients. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 7 shows the results for the coefficients of the interest rates and the corona year by country. These coefficients originate from a full fixed effect regression analysis that included the other control variables.

For the liquidity holdings, Germany and Spain show signs of the ECB rate (column 1) that are at least marginally significant and positive, like in the analysis for all countries together. Only for Luxemburg there is a marginally significant negative coefficient. In Finland, Germany, and The Netherlands negative ECB rates (column 2) reduce the liquidity holdings (in line with the results of Table 3). For these countries, my findings confirm the results of Altavilla et al. (2021). However, I do not find such significant negative effects in all countries, which implies that their results are not uniform over the euro-zone. Finally, in eight of the twelve countries studied, the corona year increased the liquidity holdings significantly or marginally so (column 3), namely in Austria, Belgium, Germany, France, Ireland, Luxemburg, The Netherlands, and Portugal (also in line with the results found in Table 3).

For the investments, only one country has a significant effect of the 10-years mean (German) government bond yields (column 4), namely Ireland. That sign is in line with what was expected and with the sign found in Table 4, meaning that a decline in that interest rate increased investments. In that same country, however, there is an unexpected negative effect of the negative 10-years mean (German) government bond yields (column 5) on investments. In six countries the impact of that government bond yield being negative had the expected significant positive sign. This was found for all four South-European countries (Spain, Greece, Italy, and Portugal), as well as for Finland and France. Again, in some countries the results of Altavilla et al. (2021) do hold, but not in all of them. In line with the results in Table 4, the impact of the corona year (column 6) resulted in (marginally) significant negative investments in most countries, namely in Belgium, Denmark, Spain, Finland, France, Greece, Luxemburg, and Portugal.

6. Conclusions

Negative interest rates are a new phenomenon in Europe. In this paper I test if short-term finances and long-term finances of listed firms in the euro zone react to short- or long-term interest changes. In addition, I test if there is an additional effect of such rates being negative. If the structural decline in nominal interest rates prevails, other countries may be confronted with negative rates as well, and firms in other countries can learn from what happened to their counterparts in the euro zone. The major findings are that the liquidity ratios and creditor ratios decline with declining short-term interest rates. Moreover, liquidity ratios show an additional negative effect when the short-term rates are negative. For the long-term variables, the non-liquid investments increase if (German) government bond yields decline and that they get an additional impulse if the long-term yields are negative. The findings of the impact of negative interest rates (yields) on liquidity ratios and on non-liquid investments are in line with the recent findings of Altavilla et al. (2021).

I also measure the impact of the interest rates on liquidity holdings and non-liquid investments for firms with different sizes, for different sectors and for the different countries. Overall, the results are similar, though I neither find sensitivity of liquidity ratios for large firms nor for manufacturing firms. Also, non-liquid investments of small firms and of service firms do not significantly react to long-term German government bond yields. Finally, differences between countries for the interest sensitivity of liquidity ratios and non-liquid investments remain.

For the corona year 2020, non-liquid investments dropped severely, while – despite of the crisis – the liquidity ratios increased significantly. Also, debtor-, creditor- and cash dividend ratios declined during the crisis. Liquidity ratios increased for small and large firms, for the three sectors distinguished, and for most countries significantly during the corona crisis year. Finally non-liquid investments declined for large and small firms, for the three sectors, and for most of the countries in the crisis year.

Because many of the issues addressed here are quite new, further research is valuable. Besides aspects indicated in footnote 4 one might think of the following research on (negative) nominal interest rates on macro-economic and firm variables.

If, for example negative interest rates prevail, will then the negative effect on liquidity ratios pertain, or not? Will then non-liquid investments remain to be increasing, or not? And will the increased level of non-liquid investments caused by negative bond yields also result in additional growth for the firms that invested, or will these investments have been subject to agency costs and not have added value? Moreover, I assumed that the relations would be linear, but Gao et al. (2021) suggest that it may not always be so. Finally, it may also be relevant to see what effects real interest rates have on firm variables.

Further research on the corona crisis will also be interesting. Now the corona virus is still rampaging in many countries and a "fourth wave" happens to occur in the euro countries. When sticking to the findings here, it would be interesting to study why the negative non-liquid investment was less in the corona year in countries like Austria, Ireland, Italy, and The Netherlands? Are these the special types of firms in the country, the government subsidies, or the structure of the economy, or (a combination of these and) other factors. Moreover, firms in disaster-prone countries chose to have less leverage (Elnahas et al. 2018). Are firms in these countries less affected by the corona crisis? Moreover, did firms with large growth potential feel less need to reduce non-liquid investments? And if they kept investing, did they then access long-term borrowing or (seasoned) equity? Finally, did non-listed firms react quite differently to the crises, or not?

For the aftermath of the crisis, it will be interesting to learn what kind of impact the drop in investments in the corona year 2020 has for the growth of the impacted firms and for their countries. And what will the firms do with the liquidity holdings when they experienced a significant increase in the liquidity ratios during the corona crisis? Will the liquidity be used for catching up investments, will it be retrieved for risk reduction or as a buffer for future crises, or will it be paid out?

Appendix

Table A1. Mnemonics, meaning, and sources for the variables used in the regression equations

Mnemonic	Meaning	Source
D-ECBR	The annual change in the ECB deposit facility rate at the end of the year.	Table 1
ECBR-	A dummy variable: 1 in the years that the ECB deposit facility rate is negative; else 0.	Table 1
D-GGBY	The annual change in the mean German 10-years government bond yield.	Table 1
GGBY-	A dummy variable: 1 in the years that the German 10-years mean government bond yield is negative; else 0.	Table 1
D-LIQR	The annual change in Cash and cash equivalents (Liquidity) divided by total assets	Orbis
D-DEBTR	The annual change in Debtors divided by total assets	Orbis
D-CREDR	The annual change in Creditors divided by total assets	Orbis
D-CADIR	The annual change in Cash dividends divided by total assets	Orbis
D-LTBCF	Increase/Decrease in long-term borrowing cash flows	Orbis
D-LN(NCA)	The annual change the natural logarithm of total assets minus cash and equivalents divided by total assets	Orbis
CORONA	A dummy variable, zero in all years, but 1 in 2020	
D-LN(OPR)	The annual change in the natural logarithm of Operating revenue	Orbis
D-ROA	The annual change in Net profits divided by total assets	Orbis
D-LTDR	The annual change in the Long-term debt ratio divided by total assets	Orbis
D-TAR	The annual change in Tangible assets divided by total assets	Orbis

Table A2. Descriptive statistics

Panel A gives information on the ratios (measured to total assets) and the change in the long-term borrowing cash flows and the change in the natural logarithm for the non-liquid assets. Panel B gives the dependent variables used in the regression equation, which are the first annual differences from panel A (except for the increase in long-term borrowing cash flows (D-LTBCF) and the annual change in the natural logarithm of non-liquid total assets (D-LN(NCA)). Panel C provides the independent variables from the regressions. The meaning of the mnemonics is found in Table A1.

Variable	# of Obs.	Mean	Median	Std. dev.	Min	Max
Panel A: Ratios (or changes indicated by the prefix D)						
LIQR	11,039	0.130	0.095	0.129	0.000	1.104
DEBTR	11,145	0.140	0.124	0.105	-0.152	0.880
CREDR	11,137	0.114	0.091	0.093	0.000	0.727
CADIR	7,858	0.025	0.016	0.037	-0.094	0.926
D-LTBCF	6,522	0.000	-0.001	0.137	-4.411	1.590
D-LN(NCA)	9,788	0.069	0.033	0.329	-4.181	9.035
Panel B: Dependent Regression Variables (First annual differences indicated by the prefix D)						
D-LIQR	9,792	0.002	0.001	0.074	-0.918	0.857
D-DEBTR	9,910	-0.006	-0.002	0.040	-0.833	0.512
D-CREDR	9,901	-0.002	-0.001	0.037	-0.574	0.411
D-CADIR	6,669	-0.001	0.000	0.031	-0.890	0.914
D-LTBCF	6,522	0.000	-0.001	0.137	-4.411	1.590
D-LN(NCA)	9,788	0.069	0.033	0.329	-4.181	9.035
Panel C: Independent Regression variables (Dummy variables or first annual differences indicated by the prefix D)						
D-ECBR	11,016	-0.083	-0.100	0.088	-0.250	0.000
ECBR-	12,240	0.700	1.000	0.458	0.000	1.000
D-GGBY	11,016	-0.345	-0.311	0.376	-0.988	0.157
GGBY-	12,240	0.200	0.000	0.400	0.000	1.000
CORONA	12,240	0.100	0.000	0.300	0.000	1.000
D-LN(OPR)	9,858	0.040	0.035	0.403	-8.329	10.007
D-ROA	9,828	0.001	-0.001	0.509	-31.901	31.982
D-LTDR	9,817	0.005	0.000	0.150	-11.899	1.775
D-TAR	9,901	-0.003	-0.001	0.051	-0.934	0.823

Source: author's own elaboration.

Table A3. Correlation coefficients between the independent variables

The meaning of the mnemonics is found in Table A1.

	D-ECBR	ECB-	D-GGBY	GGB-	CORONA	D-LN(OPR)	D-ROA	D-LTDR	D-TAR
D-ECBR	1.000								
ECB-	0.235	1.000							
D-GGBY	0.782	0.194	1.000						
GGB-	0.162	0.270	-0.269	1.000					
CORONA	0.312	0.167	0.046	0.620	1.000				
D-LN(OPR)	-0.022	0.024	-0.001	-0.059	-0.100	1.000			
D-ROA	-0.018	0.011	0.008	-0.041	-0.026	0.097	1.000		
D-LTDR	0.023	0.002	-0.015	0.055	0.027	0.018	-0.301	1.000	
D-TAR	-0.046	-0.022	-0.039	-0.035	-0.074	0.025	-0.069	0.068	1.000

Source: author's own elaboration.

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