WORKING paper

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Interest Rate Uncertainty and Firm Decisions

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ABSTRACT

We examine the effects of uncertainty regarding the path of interest rates on firms' decisions in the euro area. In the presence of heightened *short-term* interest rate uncertainty, firms tend to decrease their future investments and hiring activities. They also adopt a more cautious approach by hoarding cash and cutting dividend payments. Firm heterogeneity is crucial, as the negative effect on future investment is magnified when firms are ex-ante exposed to interest rate risk, face financial constraints or lack hedging strategies. These effects operate mainly through a financing and cash flow channel, highlighting the presence of a Finance-Interest-Rate-Uncertainty multiplier, whereby the effects of this uncertainty are amplified by the presence of financial constraints. Conversely, we find no significant effects of *long-term* interest rate uncertainty on firm decisions.

Keywords: Interest Rate Uncertainty, Firm Heterogeneity, Financial Constraints, Rollover Risk, Investment, Employment, Cash Holding, Euro Area

JEL classification: E43, E52, E22, G32

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NON-TECHNICAL SUMMARY

In recent years, central banks worldwide have faced the challenge of navigating interest rate uncertainty amidst rising inflation. This paper empirically studies the effect of uncertainty about the path of future interest rates on listed firms from the four largest euro area countries.

We measure interest rate uncertainty (IRU) following Istrefi and Mouabbi (2018), which reflects the uncertainty perceived by professional forecasters in the euro area about the future path of important benchmark rates: the 3-month Euribor rate and country-specific 10-year government bond rates. We refer to these measures as short- and long-term IRU, respectively.

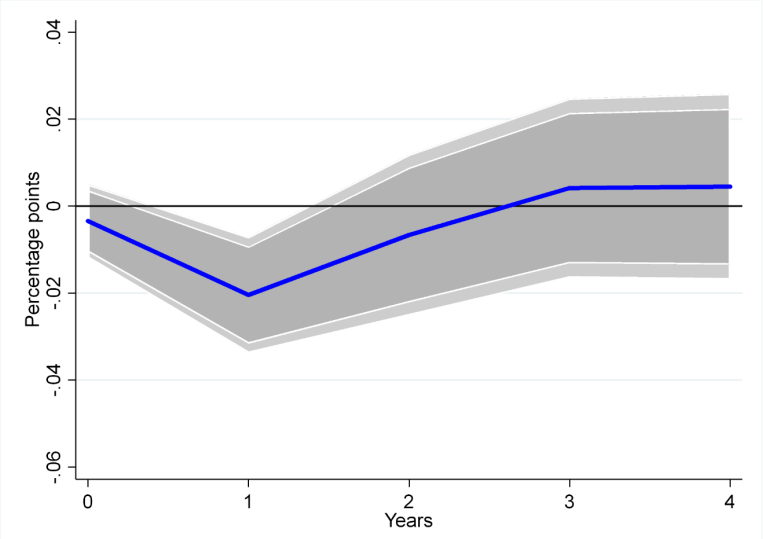
We show that euro area firms reduce their investment in response to interest rate uncertainty, despite the possibility of hedging such a risk. We find that short-term interest rate uncertainty has a stronger negative effect on corporate investment than long-term IRU. This could be due to the high share of floating rate debt in euro area firms' liabilities, which exposes firms to short-term interest rate fluctuations and makes them more vulnerable to IRU.

Beyond this average effect, the sensitivity to IRU varies considerably across firms. Firms with shorter debt maturities and firms whose cash flows are negatively correlated with rising interest rates are thus more sensitive to IRU. In addition, IRU has a disproportionately negative impact on the investment of firms facing real and financial constraints. While hedging against interest rate risk can partially mitigate the negative effects of IRU on investment, especially for financially constrained firms, it does not eliminate it.

In addition to investment, IRU also affects other firm decisions: firms tend to reduce sales, hiring, increase cash holdings, and reduce dividend payouts in response to increased IRU.

Overall, the paper highlights the importance of short-term IRU in influencing firm decisions and points to a broadly negative impact of monetary policy uncertainty on euro area firms. To the extent that uncertainty about short-term interest rates reflects uncertainty about the euro area's common monetary policy, our findings have important policy implications. Policymakers should remain vigilant to the effects of IRU, and the ECB and the Eurosystem can develop policies and operational frameworks aimed at mitigating such uncertainty.

Figure 1. Local Projections of Short-term IRU effects on Investment
Average firm-level investment response to short-term IRU shocks



Note: This figure reports the estimates of the effect of Short-term IRU on Investment across different horizons. Shaded areas represent 90 and 95 percent confidence bands. Clustered standard errors at firm level.

Incertitude des taux d'intérêt et décisions des entreprises

RÉSUMÉ

Nous examinons les effets de l'incertitude entourant la trajectoire future des taux d'intérêt sur les décisions des entreprises dans la zone euro. En présence d'une incertitude accrue sur les taux d'intérêt à court terme, les entreprises ont tendance à réduire leurs investissements futurs et leurs activités d'embauche. Elles adoptent également une approche plus prudente en augmentant leur liquidité et en réduisant les paiements de dividendes. L'hétérogénéité des entreprises est cruciale, car l'effet négatif sur les investissements futurs est amplifié lorsque les entreprises sont exposées ex-ante au risque de taux d'intérêt, qu'elles sont confrontées à des contraintes financières ou qu'elles ne disposent pas de stratégies de couverture. Ces effets passent principalement par le canal du financement et de « cashflow », ce qui met en évidence l'existence d'un multiplicateur Financier de l'incertitude des taux d'intérêt, par lequel les effets de cette incertitude sont amplifiés par la présence de contraintes financières. À l'inverse, nous ne trouvons pas d'effets significatifs de l'incertitude des taux d'intérêt à long terme sur les décisions des entreprises.

Mots-clés : incertitude des taux d'intérêt, hétérogénéité des entreprises, contraintes financières, investissement, emploi, détention de liquidités, zone euro

1 Introduction

After a decade of being constrained by the lower bound, major central banks have made bold adjustments to their policy rate, in response to rising inflation. Yet, these interest rate changes have been accompanied by significant uncertainty. Initially, identifying the underlying sources of inflation presented a challenge, and more recently, factoring in policy trade-offs such as concerns over financial stability and the possibility of a recession has contributed to the uncertainty surrounding interest rates. This uncertainty stands out from other types of uncertainties (e.g., macroeconomic, geopolitical or commodity-related): it has a direct impact on economic agents' financing costs, agents have the possibility to hedge against it, and policymakers have the ability to directly influence it. However, while there is a large literature assessing the effects of interest rates on the economy, studies on the effect of uncertainty about the interest rate are scarce.[1]

We contribute by studying the impact of uncertainty about the future path of interest rates on firm decisions in the euro area. The euro area provides a unique environment to explore the heterogeneous effects of interest rate uncertainty beyond standard firm characteristics. In this environment firms share a common monetary policy while being exposed to country-specific sovereign risks, affecting differently their term structure of interest rates and financing costs. Additionally, these firms face variations in financing structures, such as financial intermediaries (share of bank and corporate bond lending) and instruments (e.g., share of fixed and floating rates and their maturity) across countries. Our evidence on the significant effects of interest rate uncertainty highlights the importance of all these dimensions (policy, financial structures and firm characteristics).

We examine the impact of interest rate uncertainty on investment and financial decisions using a sample of 895 listed firms from the four largest euro area countries: France, Germany, Italy, and Spain. These firms constitute a substantial portion of the euro area economy, with their market capitalization representing approximately 42% of euro area GDP. Our analysis is based on firms' financial statements from 2005 to 2017, providing comprehensive information on various aspects of their operations, including tangible and intangible investment, employment, cash holdings, leverage, dividend payout and hedging activities. We measure interest rate uncertainty (IRU) following Istrefi and Mouabbi (2018), as uncertainty perceived by professional forecasters in the euro area regarding the future path of two significant benchmark rates: the 3-month Euribor rate and country-specific 10-year Government bond rates.[2] We refer to these measures as short- and

[1] The importance of this source of risk is also evident from a growing literature looking at the management of interest rate risk (Vickery, 2008; Chernenko and Faulkender, 2011; Jermann and Yue, 2018; Vuillemey, 2019). Existing literature on interest rate uncertainty focuses on macroeconomic effects (Istrefi and Mouabbi, 2018, for evidence on G7 countries) or US firm decisions (Bretscher, Schmid, and Vedolin, 2018).

[2] The Euribor rate serves as a key market reference rate for various financial instruments and contracts in the euro area, including floating-rate bank loans and interest rate swaps. On the other hand, the 10-year Government bond rate acts as a benchmark rate for long-term maturities.

long-term IRU, respectively. These measures are the sum of two components: the disagreement across forecasters, measured as the standard deviation of point forecasts, and the perceived variability of future aggregate shocks, measured as the conditional variance of mean forecast errors.

We document a significant effect of uncertainty regarding the path of *short-term* interest rates on firms operating in the euro area, above and beyond the level of interest rates, monetary policy surprises, the state of the economy, measures of economic policy uncertainty and financial volatility and firm-related characteristics. Specifically, we observe that heightened short-term IRU is associated with a decrease in firms' future tangible investments. In our sample, the investment growth rate of the average firm is 4%. Our findings show that, on average, a one standard deviation increase in short-term IRU corresponds to a 1.5 percentage point reduction in the investment growth rate. Moreover, our sample includes episodes of IRU rising by over three standard deviations (such as the period between the Great Recession and the European Sovereign Debt Crisis), suggesting significant contractions in firms' investment rate.[3]

Firm heterogeneity is crucial. First, we show that pre-defined characteristics that relate to firms' exposure to interest rate risk (e.g., debt maturity or natural hedge to interest rate risk) are important for the sensitivity of investment to short-term IRU. On average, a one standard deviation increase in short-term IRU corresponds to a reduction in the investment growth rate of up to 3 percentage points for exposed firms. Second, there is a stronger negative relationship between investment and short-term IRU for firms facing capital and financial constraints (firm size, collateral), whereby the investment growth rate drops between 1.5-1.9 percentage points compared to unconstrained ones. Third, hedging is important as the negative effects of short-term IRU on investment are stronger for non-hedging firms and more so for firms with high rollover risk.

The negative effects of short-term IRU on firms go beyond investment decisions. We find that an increase in short-term IRU is associated a contraction in sales, hiring and dividend payouts and an increase in cash holdings. Overall, our results suggest that short-term interest rate (Euribor) uncertainty is important for the average firm's real and financial decisions.

The term structure of interest rate uncertainty is also important. In contrast to short-term IRU, we find no significant effects of long-term IRU on firm decisions. When considering the level of interest rates, we document only a weak negative effect of long-term interest rates on investment. The importance of short-term IRU (relative to long-term IRU and the level of interest rates) is supported by the following debt financing characteristics of euro-area firms. The primary source of their funding are bank loans, and more than half of these loans mature or have an interest rate reset within 12 months (i.e., short-term debt or long term debt with floating rates, Holm-Hadulla, Musso, Nicoletti, and Tujula, 2022). For instance, the proportion of loans carrying floating interest

[3]The effects of IRU remain significant when controlling for the Great Recession episode.

rates ranges from approximately 40% in Germany to 75% in Italy.[4] Typically, the benchmark rate for these loans is the Euribor rate with a maturity of 3 or 6 months (Dalla Fontana, Holz auf der Heide, Pelizzon, and Scheicher, 2019). This direct exposure of euro-area firms to the Euribor renders them highly vulnerable to fluctuations in short-term IRU, primarily due to rollover risk, rather than to long-term IRU.

Overall, our findings highlight the important role of interest rate uncertainty on real and financial decisions of firms, reflecting its direct link to firms' financing. They suggest a multi-faceted dimension of IRU, operating beyond the standard real options channel of uncertainty (Bernanke, 1983; Bloom, 2009). Notably, we document and quantify the importance of a financing and a cash flow channel of interest rate uncertainty, whereby constrained firms, further cut future investment when facing such uncertainty. Moreover, firms driven by a precautionary savings motive adopt a more cautious approach, increasing cash holdings and reducing dividend payouts. These findings are consistent with the presence of a Finance-Interest-Rate-Uncertainty (FIRU) multiplier, whereby the effects of IRU are amplified by financial constraints.[5]

To the extent that Euribor uncertainty reflects uncertainty about the *common* euro-area monetary policy, our findings have important policy implications.[6] They point to a broad-based adverse effect of monetary policy uncertainty across euro-area firms. They suggest that high IRU may reinforce the effects of a monetary tightening and counteract those of a monetary loosening. Nevertheless, the latter effect might have been more muted in the second half of our sample, as short-term IRU has been very low post Great Recession, due to the reach of the lower bound and the ECB's forward guidance on interest rates. Against this backdrop, the ECB and the Eurosystem can develop strategies and operational frameworks aimed at mitigating such uncertainty.

We primarily contribute to the literature that studies the effects of uncertainty on firm decisions, focusing on idiosyncratic and aggregate uncertainties. For example, at the idiosyncratic level, Bloom, Bond, and Van-Reenen (2007) and Alfaro, Bloom, and Lin (2023) show that in the US, firm-level uncertainty reduces firms' investment. A similar effect is found on US firm investment in response to Economic Policy Uncertainty (EPU) (Baker, Bloom, and Davis, 2016), to interest rate uncertainty (Bretscher, Schmid, and Vedolin, 2018) and to trade policy uncertainty

[4]For statistics on the proportion of bank loans with floating rates in total bank loans to NFCs in the euro area refer to De Fiore, Raudsaar, McCann, Carluccio, Horny, Finaldi Russo, Caruana Briffa, Metzemakers, van der Veer, Herman, and Kar (2013), page 37.

[5]Gilchrist, Sim, and Zakrajsek (2014) and Alfaro, Bloom, and Lin (2023) examine the interaction between US firm-level stock-return volatility and financial constraints, and show that financial frictions amplify the impact of uncertainty shocks on firms' real and financial outcomes.

[6]With a Taylor-rule specification in mind, short-term interest rate uncertainty might reflect uncertainty about the reaction function of the central bank and about the economic fundamentals (e.g., inflation). The latter also depend on policy itself. For interest rate maturities beyond the direct control of the central bank, uncertainty may also relate to financial uncertainty. In this paper, we focus on the effects of this uncertainty on firm decisions rather than taking a stance on its exact source.

(Caldara, Iacoviello, Molligo, Prestipino, and Raffo, 2020). In addition, Kumar, Gorodnichenko, and Coibion (2022) show that firms in New Zealand reduce their prices, employment, and investment when facing higher macroeconomic uncertainty. We contribute by exploring the heterogeneous effects of interest rate uncertainty across firm characteristics and interest rate maturity in a monetary union with country-specific fiscal policies. We show that short-term interest rate uncertainty explains firm investment above and beyond the EPU, the VSTOXX and business cycle indicators. Moreover, in line with US findings (Bretscher, Schmid, and Vedolin, 2018), we show that firms in the euro area also reduce investment in response to interest rate uncertainty, despite the possibility to hedge such a risk.[7]

Moreover, we relate to the literature that studies the effect of monetary policy on firm decisions or firm dynamics. For instance, studies for US firms (Ippolito, Ozdagli, and Perez-Orive, 2018; Ottonello and Winberry, 2020; Gurkaynak, Karasoy-Can, and Lee, 2022; Jungherr, Meier, Reinelt, and Schott, 2022; Cloyne, Ferreira, Froemel, and Surico, 2023) and euro area firms (Durante, Ferrando, and Vermeulen, 2022; Ferrando, Popov, and Udell, 2022) show that monetary policy surprises (measured using the high-frequency event-study approach) have heterogeneous effects depending on firms characteristics. Regarding firm dynamics, Fasani, Mumtaz, and Rossi (2023) show that US monetary policy uncertainty (a newspaper text-based measure) is recessionary and that firm entry-exit amplifies its effects. Importantly, for euro area firms, we find that it is the uncertainty about the short-term interest rate (Euribor) that matters for future firm investment rather than its level or monetary policy surprises (measured as in Altavilla, Brugnolini, Gurkaynak, Motto, and Ragusa, 2019), and that firm heterogeneity is important.

Finally, our results speak to the literature on risk management and firm decisions (Vickery, 2008; Chernenko and Faulkender, 2011; Bretscher, Schmid, and Vedolin, 2018). For instance, the latter study the swap usage of US firms, providing evidence that small and constrained ones are left exposed to interest rate risk even after hedging. These firms reduce more their investment facing such risk. They relate this result mainly on firms' reliance on bank and floating rate debt. We show that negative effects of short-term interest rate uncertainty are stronger even for large firms when they do not hedge, and more so when financially constrained. Similarly, the prevalence of bank and floating rate debt in the euro area seem to support our results with regard to the significant effects of short-term IRU and to the muted effects of long-term IRU.

The paper is structured as follows. Section 2 describes our data and Section 3 presents our empirical findings. Finally, we conclude in Section 4.

[7] Bretscher, Schmid, and Vedolin (2018) focus on US firms and measure interest rate uncertainty as the implied volatility index extracted from 1-month options written on 30-year US Treasury futures. In contrast, Istrefi and Mouabbi (2018)'s measures are based on surveys of professional forecasters and, thus, not prone to market imperfections (e.g., liquidity risk).

2 Data

The following section provides a summary of the data used in our analysis. We first describe the measures of interest rate uncertainty and their evolution across the four largest euro-area countries: France, Germany, Italy and Spain, for the period 2005 to 2017. Subsequently, we present our firm- and country-level data.

2.1 Interest rate uncertainty

Our measures of interest rate uncertainty (IRU) are constructed following Istrefi and Mouabbi (2018). They are based on Consensus Economics (CE) surveys of professional forecasters in France, Germany, Italy and Spain and reflect the uncertainty about the future path of interest rates. Forecasters are predominantly large banks but also include some corporations and independent consultants. Moreover, forecasters are specific to each country, ensuring coherence in expectations formation and firm decision-making, making our approach suitable for a multi-country analysis.

IRU measures reflect the uncertainty of professional forecasters in the euro area about the future path of two important benchmark rates: the 3-month Euribor rate and country-specific 10-year Government bond rates. These measures are constructed as the sum of disagreement across forecasters (measured as the standard deviation of point forecasts) and the perceived variability of future aggregate shocks (measured as the conditional variance of mean forecast errors).[8] For further details about the construction of IRU measures, refer to Istrefi and Mouabbi (2018).

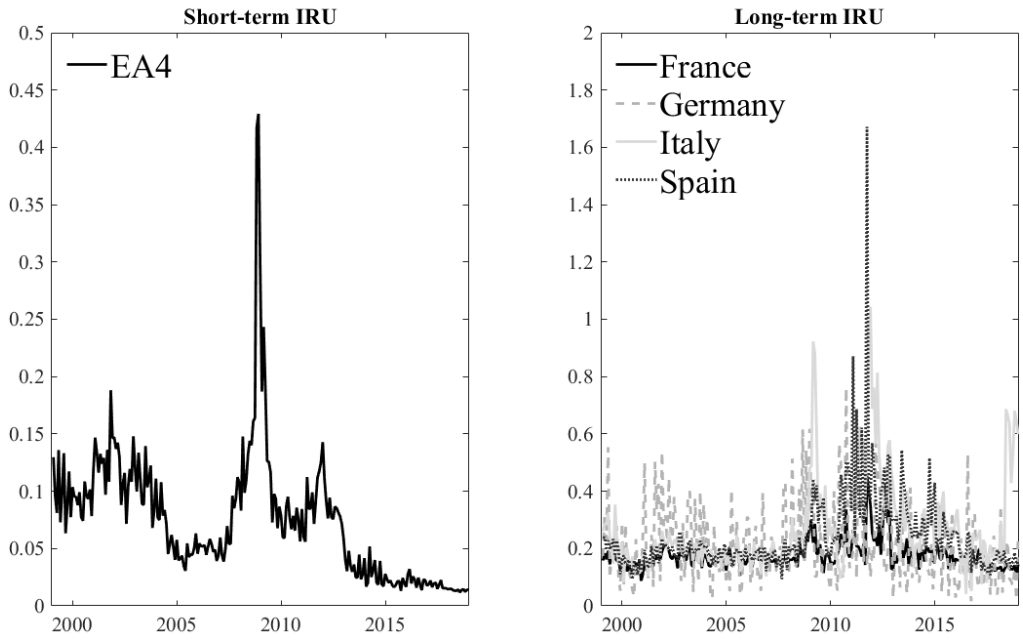
The Euribor is a key market reference rate for a variety of financial instruments and contracts in the euro area (including floating-rate bank loans and interest rate swaps) while the 10-year Government bond rate is a benchmark rate for long-term maturities. To the extent that the 3 month Euribor relates to monetary policy, the short-term IRU relates to the uncertainty about *common* euro-area monetary policy as well while the long-term IRU reflects *country-specific* sovereign risk. Note, the latter may also reflect uncertainty about monetary policy to the extent that unconventional policies, through asset purchases, and central bank communication affect the long-end of the yield curve and euro-area fragmentation. These IRU measures are increasingly used in the literature, along other well-known proxies of uncertainty, and often as a proxy for monetary policy uncertainty (Jondeau, Mojon, and Sahuc, 2020; Tillmann, 2020; Cascaldi-Garcia, Sarisoy, Londono, Sun, Datta, Ferreira, Grishchenko, Jahan-Parvar, Loria, Ma, Rodriguez, Zer, and Rogers, 2023).[9]

[8] These measures are built in line with Lahiri and Sheng (2010). In contrast to them, Istrefi and Mouabbi (2018) enhance the estimation of the second component by using a stochastic volatility model rather than a GARCH-type model. This allows the perceived variability of future aggregate shocks to be time-varying and stochastic.

[9] Note that our interest rate uncertainty measures are different in nature from a variety of other uncertainty proxies, such as the implied volatility of the EUROSTOXX50 (VSTOXX) and the European Economic Policy Uncertainty (EPU) index of Baker, Bloom, and Davis (2016). In our sample, the VSTOXX mostly covaries with short-term IRUs

Figure 1 illustrates IRU measures for all countries, for the 3-month (left panel) and 10-year (right panel) interest rates, at a three-month forecasting horizon. Both measures vary considerably over time. With the introduction of the ECB's Forward Guidance in July 2013, the short-term IRU has reached its all-time low, reflecting the Governing Council's communication for the policy rate to remain low for long and expectations that rates are close to their effective lower bound. Larger differences appear on the long-term IRU measures, which reflect more country-specific variations, especially during the European sovereign debt crisis in 2011-2013.

Figure 1: Short- and long-term IRU, as in Istrefi and Mouabbi (2018)



Notes: The left-hand side panel displays the short-term IRU on the common 3-month Euribor, where EA4 denotes the equally-weighted average of the interest rate uncertainty for the four largest countries of the euro area. The right-hand side panel shows the long-term IRU on country-specific 10-year Government bonds. Both measures are at a three-month forecasting horizon.

The underlying rates of IRU measures (3-month Euribor and the 10-year Government bond rates) are highly correlated with the cost of external financing that firms in these countries face. During our sample period, we observe correlations between the 3-month Euribor rate and bank loan rates with maturities below 1 year ranging from 0.65 in Spain to 1 in Germany. Additionally, the correlation between the 3-month Euribor rate and bank loan rates with maturities exceeding 5 years ranges from 0.89 in Spain to 0.97 in Italy. Interestingly, in Italy and Spain, long-term bank loan rates exhibit a higher correlation with the Euribor rate compared to their respective short-term bank loan rates. This can be attributed to two factors: (i) firms in these countries heavily rely on

(correlations of up to 0.6), while correlations with the euro area EPU are low.

overdrafts, and (ii) they hold a significant proportion of long-term bank debt with floating rates. For example, based on data up to 2012, approximately 40% of Germany and France's bank loans to non-financial corporations were at a floating rate.These statistics range between 60% and 80% for Spain and Italy, respectively (see De Fiore, Raudsaar, McCann, Carluccio, Horny, Finaldi Russo, Caruana Briffa, Metzemakers, van der Veer, Herman, and Kar, 2013).

Looking into longer term maturities, the correlation between 10-year Government bond rates and bank loan rates with a maturity over 5 years ranges between 0.40 for Italy and 0.95 for Germany. Moreover, to the extent that firms use corporate bond financing, bond rates are highly correlated with Government bond rates of respective countries (between 0.83 for Spain and 0.96 for France, for the sample period 2008-2017).[10] Note that most bond finance consists of long-term financing at a fixed rate, which ought to be less sensitive to uncertainty about interest rates.

2.2 Firm-level data

We use firm-level data for selected euro area countries, provided by Worldscope (Refinitiv), spanning the period 2005-2017. Our sample comprises of 895 listed Non-Financial Corporations (NFCs) in France, Germany, Italy and Spain. We exploit annual financial statements to obtain information on their real and financial activities, including tangible and intangible investment, employment, sales, cash holdings, leverage, dividend payout and hedging practices. We remove utilities and financial firms as well as firms not listed in their domestic country. We also exclude firms with missing or negative assets or sales, negative capital expenditures, negative debt and fiscal year of less than 12 months. All firm characteristics are winsorized at the 1st and 99th percentile.

Table 1 reports descriptive statistics on key firm-level variables in our sample. We present more details on our variable definitions on Table A.1 in the Appendix. The average firm in our sample has an investment growth rate of 4% and 5.7 bn EUR in total assets. The average leverage ratio is 0.24. About 50% of the firms in our sample operate in the *Manufacturing* sector while about 25% belong to the *Information and Communication Technologies* sector.

2.3 Country-level variables

In our analysis, we include several macroeconomic variables that are targeted to isolate interest rate uncertainty effects from important macroeconomic confounders. First, we add the level of the 3-month Euribor and 10-year Government rates in our regressions. Our aim is to isolate effects stemming from *second-order* moments of interest rates (i.e., IRU), by controlling for their

[10]The source for bank loan rates, Government bond rates and corporate bond rates are from the ECB's SDW database, Datastream and the Gilchrist and Mojon (2018) database, respectively. In the latter database, corporate bond rates start in 2008, possibly due to lack of market depth in earlier years.

Table 1: Descriptive statistics for firm-level variables

	Mean	p25	Median	p75	Std.Dev.	Nb.Obs.
Investment	0.04	-0.05	0.02	0.11	0.25	8,328
Total Assets in EUR M	5,749	109	398	2,203	20,516	8,328
Tobin Q	1.72	1.06	1.33	1.83	1.80	8,328
Leverage (% of total assets)	0.24	0.10	0.22	0.35	0.18	8,328
Short-term debt (% of total debt)	0.38	0.15	0.32	0.57	0.30	8,328
PP&E (% of total assets)	0.22	0.07	0.17	0.32	0.18	8,328

Notes: Investment is the growth rate in capital investment, defined as the change in the log of fixed capital, with capital being the net property plant & equipment (i.e. net of depreciation). Tobin's Q is the one-year lagged Market-to-Book value measured at the end of the fiscal year. Leverage is $Financial\ debt_t / Total\ assets_{t-1}$ and Short-term debt is any outstanding debt with remaining maturity of less than year as a proportion of total debt. PP&E is $Property,\ plant\ \&\ equipment / Total\ assets_{t-1}$.

level (i.e., *first-order* moments). Second, we control for country-specific business cycle characteristics such as GDP growth, inflation and unemployment. Third, we control for other standard measures of uncertainty, such as financial volatility (VSTOXX) and country-specific Economic Policy Uncertainty indices (EPU) of Baker, Bloom, and Davis (2016). The VSTOXX is a 30-day option-implied volatility, and is commonly used as a measure of the stock market's expectation of volatility. Conversely, the EPU is a news-based measure and relates to uncertainty about different economic policies (e.g., fiscal, monetary, regulatory) without a specific horizon.

3 Interest rate uncertainty and firm decisions

We proceed in investigating the effect of interest rate uncertainty on firm decisions of the four largest countries in the euro area, across two dimensions. The first pertains to the real activities of firms, represented by tangible and intangible investment, employment and sales. The second dimension revolves around financial activities and covers the cash holdings and dividend payouts of firms. These dimensions allow us to study the co-movement between interest rate uncertainty and firm decisions and conjecture on the possible channels through which they relate, e.g., "real options" channel (Bernanke, 1983; Bloom, 2009) and a financing channel.[11] We further explore whether interest rate uncertainty effects are heterogeneous across firm-characteristics, including financial constraints, size, hedging activities.

[11] Previous work by Opler, Pinkowitz, Stulz, and Williamson (1999), Bates, Kahle, and Stulz (2009) and Alfaro, Bloom, and Lin (2023) suggests that, under adverse financial conditions, a precautionary motive could induce firms to take a more cautious position and increase cash holdings (i.e., "cash-hoarding" motive).

3.1 Empirical strategy

To examine the impact of short-term and long-term interest rate uncertainty at the firm-level, we estimate the following baseline specifications, over the period 2005-2017, at an annual frequency:

$$Y_{i,c,t} = \beta^S \text{IRU}_{t-1} + \gamma^S \text{Euribor}_{t-1} + \gamma^S 10\text{YRate}_{c,t-1} + \Theta^{S\prime} X_{c,t-1} + \Gamma^{S\prime} Z_{i,c,t-1} + \alpha_i^S + \alpha_q^S + \varepsilon_{i,c,t}^S \quad (1)$$

$$Y_{i,c,t} = \beta^L \text{IRU}_{c,t-1} + \gamma^L \text{Euribor}_{t-1} + \gamma^L 10\text{YRate}_{c,t-1} + \Theta^{L\prime} X_{c,t-1} + \Gamma^{L\prime} Z_{i,c,t-1} + \alpha_i^L + \alpha_{s,t}^L + \varepsilon_{i,c,t}^L \quad (2)$$

where $Y_{i,c,t}$ is the outcome variable of firm i in country c at the end of the fiscal year t, *IRU* is the equally-weighted average of the short-term interest rate uncertainty of the four countries in Eq. 1 and the country-specific long-term interest rate uncertainty in Eq. 2, *Euribor* denotes the 3-month Euribor rate, $10YRate$ denotes the country-specific 10-year Government bond rate, X is a vector of country-specific macroeconomic controls, Z is a vector of firm covariates, α_i^S and α_i^L are firm fixed effects that capture permanent differences in the outcome variable across firms i, α_q^S is a fiscal quarter indicator that captures seasonality as firms close their balance sheet at different points in time for a given year (where q represents fiscal quarters), and $\alpha_{s,t}^L$ denotes sector-by-year fixed effects capturing differences in how broad sectors s (industry is defined at the NAICS 2-digit level) are exposed to aggregate shocks that may simultaneously affect interest rate uncertainty and investment. IRU measures are as in Istrefi and Mouabbi (2018), and are estimated at a monthly frequency. To go from the high-frequency to yearly measures of interest rate uncertainty, we aggregate monthly figures by averaging them within a fiscal year t.

Our main outcome of interest is the growth rate in capital of firm i, defined as the change in the log of fixed capital ($\Delta \log k_{i,t+1}$), with capital being the net property plant & equipment (i.e., net of depreciation). All explanatory variables are lagged by one year to reduce concerns about endogeneity and to align with natural delays expected in the implementation of decisions. Explanatory variables are standardized over the entire sample. Standard errors are clustered at the firm level.

Our coefficient of interest, β^S (β^L), captures the semi elasticity of investment to a one standard deviation in short-term (long-term) IRU, after having controlled for observed and unobserved firm characteristics and country-specific economic conditions. As described above, the macroeconomic controls are GDP growth, inflation and the unemployment rate, to account for country-specific business cycles, and the country-specific EPU indices by Baker, Bloom, and Davis (2016). In addition, we include the level of the underlying rate of our IRU metric to control for first-order moment effects. The list of firm covariates is comprised of firm size, Tobin's Q, leverage, sales growth and cash flows. Lagged investment is also included as a control as firms' planned investment at the beginning of a year generally explains a large part of the variation in actual investment.

We estimate conditional correlation between firm decisions and IRU, and address a number of potential endogeneity issues that may arise when estimating the specification in Eq. (1) and Eq. (2). First, note that because of the survey nature of our IRU measures, within a given period, there is a temporal ordering in our macro variables, with the IRU measures being constructed with information available at the beginning of the period. By construction, the CE forecasters information set at a given month when surveys are filled out includes only past realizations of macroeconomic data (e.g., industrial production, prices, unemployment) and economic indicators based on monthly surveys of firms (e.g., Purchasing Managers' Index, Business Confidence surveys). CE forecasts are generally made within the first 10 days of the month. During this period, contemporaneous monthly data on economic activity are not known. For instance, based on the Eurostat Release Calendar for Euro indicators, the earliest releases are for the flash estimate of inflation and confidence indicators at the end of the month.

Second, our regression includes macroeconomic variables (level of interest rates and country-specific business cycle indicators) that are targeted to isolate interest rate uncertainty effects from important macroeconomic confounders.

Third, the granularity of our data allows us to enrich the specification with multiple sets of fixed effects. We control for time-invariant unobserved heterogeneity across firms that might affect their investment behavior by including firm fixed effects. We cannot control for country-by-time fixed effects as our time-varying IRU measure would be perfectly collinear with it. Instead, we use an industry-by-time fixed effect. This allows us to only exploit cross-country differences in IRU for firms belonging to the same industry and, to control for time-varying unobserved differences in how various industries respond to economic shocks.

3.2 Firm investment

Table 2 examines how short-term interest rate uncertainty affects future firm investment. We find that firms tend to invest less when short-term IRU is high. Short-term IRU explains the future investment growth rate above and beyond the level of interest rates, the state of the economy (GDP growth, inflation, unemployment), measures of economic policy uncertainty (such as the EPU) and financial volatility (VSTOXX) and firms' unobserved time invariant characteristics as well as observed characteristics, such as investment opportunities, firm size and financial health and fixed effects. Indeed, this finding suggests that IRU reflects an important type of uncertainty that matters for firms through its direct link to the financing of their investment. With regard to other controls, as expected, higher future investment correlates positively with better firm investment opportunities and financial health, and negatively with economic conditions, such as inflation and unemployment.

Table 2: Firm investment and IRU: Baseline

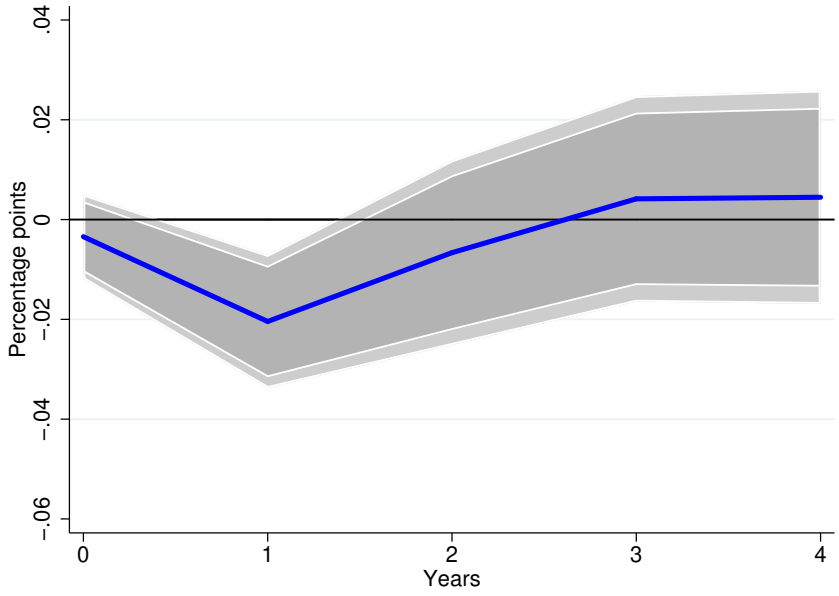
	Short-term IRU								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
IRU	-0.033***	-0.016***	-0.015***	-0.015***	-0.019***	-0.022***	-0.015***	-0.015***	-0.011*
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.008)	(0.004)	(0.004)	(0.006)
IRU x Crisis									-0.008
									(0.008)
3M Euribor rate	0.023***	0.011**	0.011*	0.013***	0.006	0.007	0.000	0.000	-0.003
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)	(0.006)	(0.006)	(0.009)
10Y rate	0.008	-0.001	-0.001	0.001	0.005	0.006	0.001	0.002	-0.001
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.007)
GDP growth			0.001						
			(0.004)						
Inflation				-0.006*					
				(0.004)					
Unemployment rate					-0.004**	-0.004**	-0.004**	-0.004**	-0.004**
					(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
VStoxx						0.003			
						(0.006)			
Country EPU							-0.012**	-0.012**	-0.012**
							(0.005)	(0.005)	(0.005)
GFC									0.029
									(0.026)
TobinQ		0.064***	0.064***	0.064***	0.062***	0.063***	0.062***	0.061***	0.061***
		(0.009)	(0.010)	(0.009)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
Size		-0.095***	-0.095***	-0.091***	-0.099***	-0.099***	-0.092***	-0.093***	-0.094***
		(0.031)	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)
Cashflow		0.044***	0.044***	0.043***	0.044***	0.043***	0.043***	0.043***	0.043***
		(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Sales growth		0.014***	0.014**	0.015***	0.014***	0.014***	0.014***	0.014***	0.014***
		(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Leverage		-0.042***	-0.042***	-0.042***	-0.042***	-0.042***	-0.043***	-0.043***	-0.043***
		(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.008)	(0.008)
Lagged Inv.								0.002	0.002
								(0.006)	(0.006)
Firm FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Fiscal quarter FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
N firm clusters	891	891	891	891	891	891	891	891	891
N	8319	8319	8319	8319	8319	8319	8319	8319	8319
Adj-R^2	0.09	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15

Notes: This table reports panel regressions with firms' investment growth rates as a dependent variable. IRU refers to the short-term interest rate uncertainty; GFC refers to a dummy variable which takes values of 1 during the period 2008-2009 and 0 otherwise, the Euribor refers to the 3-month rate maturity, the 10Y rate, GDP growth, inflation, unemployment rate and EPU of Baker, Bloom, and Davis (2016) are at country level, VSTOXX is the implied volatility of the EUROSTOXX50. Tobin's Q is the one-year lagged Market-to-Book value measured at the end of the fiscal year; Size is the log of a firm's total assets; Cashflow is the cash flows defined as the ratio of $Net\ income\ plus\ Depreciation\ and\ amortization_t / Total\ assets_{t-1}$; Sales growth is the one-year lagged log difference in yearly sales, Leverage is $Financial\ debt_t / Total\ assets_{t-1}$. Standard errors are clustered at the firm level. The sample period runs from 2005 to 2017.

These effects are economically important. In our sample, the investment growth rate of the average firm is 4%. Quantitatively, depending on the regression specification, a one standard

deviation increase in the short-term IRU reduces the investment growth rate of the average firm by 1.1 to 3.3 percentage points (Column 1 to 9). This negative effect can be economically sizable in periods of high short-term IRU. For instance, between the Global Financial Crisis (GFC) and the European Sovereign Debt Crisis, this uncertainty increased by more than three standard deviations, implying a threefold drop in the investment rate. Importantly, despite the peak in IRU during the GFC, the average effect on investment is not driven by this episode (Column 9).

Figure 2: Local Projections of short-term IRU effects on investment



Notes: This figure reports the estimates of the effect of short-term IRU on investment (baseline regression, column 7, Eq.(1)), across different horizons.

Figure 2 depicts the dynamic effect of short-term IRU on investment, across different horizons up to 4 years. We observe that the peak effect occurs at a 1-year horizon and fades within two years. Note that our baselines results are robust to alternative definitions of investment, such as the growth in net Property, Plant and Equipment (PP&E), the ratio of Capital Expenditures over lagged Total Assets, or Capital Expenditures over lagged net PP&E (Columns 1 to 3, in Table A.3). Moreover, results are robust to (i) a filtered measure of short-term IRU, controlling for VSTOXX and euro area EPU and to a short-term IRU constructed using a 12-month forecast horizon (Columns 4 and 5, Table A.3). In contrast, firms' investment does not react to long-term IRU across horizons (refer to Table A.2 and Figure A.2 in the Appendix). Moreover, Column 10 of Table A.2 presents results on the effect of long-term IRU on investment using the same specification as in Eq. (1), that controls for fiscal quarters instead of time and industry fixed effects. Results remain unchanged, suggesting that the absence of a significant effect for long-term IRU (compared to that found for

short-term IRU), is not due to the use of a finer set of fixed effects.

3.2.1 Controlling for monetary policy surprises

We showed that short-term IRU explains the future investment growth rate above and beyond the level of interest rates (3-month Euribor and 10-year Government rates). In the following we further control for monetary policy high-frequency surprises as reflected in the changes of 3-month and 2-year Overnight Indexed Swaps (OIS) around policy announcements (Altavilla, Brugnolini, Gurkaynak, Motto, and Ragusa, 2019). As standard in the literature, we aggregate them at an annual frequency by constructing 12-month rolling sums of these surprises. We match this sum with the fiscal year of each individual firm across time. As in the case of short-term IRU, these surprises are common to all firms in our sample.

Table 3: Firm investment, monetary policy surprises and IRU

	Short-term IRU		Long-term IRU	
	(1)	(2)	(3)	(4)
IRU	-0.013***	-0.018***	-0.005	-0.006
	(0.005)	(0.004)	(0.004)	(0.004)
MP surprise (3M OIS)	-0.001		-0.001***	
	(0.001)		(0.001)	
MP surprise (2Y OIS)		-0.001		-0.000
		(0.001)		(0.001)
3M Euribor rate	0.004	-0.002	0.001	-0.008
	(0.006)	(0.006)	(0.006)	(0.005)
10Y rate	-0.006	-0.000	-0.014*	-0.002
	(0.008)	(0.006)	(0.008)	(0.007)
Firm FE	Y	Y	Y	Y
Fiscal quarter FE	Y	Y	Y	Y
Covariates	Y	Y	Y	Y
N firm clusters	891	891	891	891
N	8178	8178	8178	8178
Adj-R^2	0.15	0.15	0.15	0.15

Notes: This table reports panel regressions with firms' investment growth rate as a dependent variable. IRU refers to interest rate uncertainty, Interest Rate refers to the 3-month Euribor (for the short-term IRU) and to the 10-year government bond rate (for the long-term IRU), MP surprise refer to monetary policy surprise for the 3M OIS and 2Y OIS from Altavilla, Brugnolini, Gurkaynak, Motto, and Ragusa (2019). The sample period runs from 2005 to 2017.

Table 3 reports these results and shows that the explanatory power of short-term IRU on investment holds when controlling for first-order moment effects stemming from both the level of interest rates and monetary policy surprises (Columns 1 and 2). The magnitudes of the effect continue to

be economically important. In our sample, a one standard deviation increase in the short-term IRU is associated with a decrease on the investment rate by 1.3 to 1.8 percentage points. As in the baseline specification, long-term IRU has no significant effect (Columns 3 and 4). Importantly, over our sample, we find that it is the uncertainty about the Euribor that matters for future firm investment rather than its level or monetary policy surprises (see Columns 1 and 2). The two latter matter only when using 3-month OIS surprises and controlling for long-term IRU (as opposed to short-term IRU), as reported in Column 3.

To put our results into perspective, we compare them with the effects from the related literature on firm investment and monetary policy surprises (identified with high-frequency movements on interest rates). For instance, Cloyne, Ferreira, Froemel, and Surico (2023) find for US firms that, a one standard deviation increase in the interest rate surprise, decreases the investment rate by 0.5 percentage points (peak effect). Durante, Ferrando, and Vermeulen (2022) find for euro area (listed and unlisted) firms that a one standard deviation upward interest rate declines the investment rate by 2.7 percentage points. When we repeat our exercise using the same definition of the investment rate as in Cloyne, Ferreira, Froemel, and Surico (2023), we find that a one standard deviation rise in short-term IRU has a 0.4 percentage point negative effect on the investment rate (Column 3 of Table A.3). Similarly, for a comparable definition of the investment rate with Durante, Ferrando, and Vermeulen (2022), we find that, in the context of listed firms in the euro area, a one standard deviation rise in short-term IRU has a 1.6 percentage point negative effect on the investment rate (Column 1 of Table A.3).

These findings suggests that the contractionary effects of the short-term IRU may reinforce the effects of a monetary tightening and counteract those of a monetary loosening. Nevertheless, the latter effect might have been more muted in the second half of our sample, as short-term IRU has been very low post Great Recession, due to the reach of the lower bound and the ECB's forward guidance on interest rates.

3.2.2 Do firm characteristics matter?

In the following, we study whether interest rate uncertainty has heterogeneous effects across firms' characteristics. More precisely, to pinpoint the IRU channel, we first evaluate differences among firms' responses to IRU conditional on some pre-defined characteristics that relate to their exposure to interest rate risk or to uncertainty in general.

We augment our regression specification to include interaction terms between IRU and firm characteristics. In addition, this specification allows us to control for common industry-level shocks, with industry-year fixed-effects in the short-term IRU specification.[12]

[12]Note that in this set up, we can control for industry shocks using sector x time fixed effect in both short- and long-term IRU specifications.

Ex-ante exposure to IRU. In what follows, we implement tests building on cross-sectional variation in firms' exposure to interest rate risk through three channels: a financing, a cash flow, and a real options channel. To this aim, we investigate structural features of firms, including their debt composition and the nature of their cash flows and investment.

With regard to debt composition, firms with a higher proportion of short-term debt are more likely to refinance it, and thus more exposed to interest rate risk (rollover risk). Therefore, one would expect a higher sensitivity of these firms to interest rate uncertainty, reflecting a financing channel of IRU. In financial statements, we observe total debt and total long-term debt, which we difference in order to obtain the percentage of total debt payments due within one year (i.e., this includes short-term debt and the portion of long-term debt obligations that is due within one year). For simplicity, we refer to this variable as short-term debt. To avoid capturing annual variations that would be induced by the profile of the amortization of long-term debt, we classify a firm as having a high short-term debt share when its average ratio of short-term debt over the period is above the sample median.

With regard to the nature of cash flows, we investigate the natural hedge hypothesis following Vickery (2008), whereby industries in which output or cash flows co-vary positively with interest rates have a natural hedge against shifts in short-term interest rates.[13] We do so to understand whether industries that do not benefit from this natural hedge are more sensitive to IRU.

In line with Vickery (2008), this exercise involves two steps. First, we estimate the correlation between industry cash flows and interest rates using 2-digit industry data for the sample period. For each industry, the log of cash flow is regressed on interest rates (either the 3-month Euribor or the 10y Government bond rates) over the sample period, at the industry level for 45 industries (NAICS 2 digit level), with a firm and time fixed effect. Second, we consider firms as naturally hedged if they operate in an industry with a significant positive correlation between its cash flow and interest rates, and *exposed* to interest rate risk otherwise.[14]

With regard to the nature of investment, we explore the real options channel where costly capital reversibility creates incentives for firms to delay investment in presence of uncertainty. Costs associated with redeploying assets are an important source of investment irreversibility. As frictions in redeploying assets make firms cautious about investment decisions, firms operating in a low redeployability industry are expected to be more sensitive to uncertainty. As a measure of capital irreversibility, we apply the US industry-level redeployability index, built by Kim and Kung (2017), to European industries. This measure is computed with an asset-level redeployability score which combines the specificity of the asset (proportion of firms/industries by which a given asset is

[13] Vickery (2008) exploits the natural hedge hypothesis to examine the relationship between fixed- and adjustable-rate loans and firm financial constraints in the US, with a focus on small firms.

[14] We have 68 industries at the NAICS 2-digit level and we impose the industry to have at least 5 firms per year, reducing the sample to 45 industries.

used), the financial constraints of potential buyers, and the correlation of output within industries. Scores are then aggregated at the industry level. We use Kim and Kung (2017)'s measure over the 2005-2015 period and classify a firm as operating in a low-redeployability industry, if its sector has a below median redeployability of assets.

Table 4: Heterogeneous effect of IRU on firm investment: Ex- ante exposure

	Short-term IRU			Long-term IRU		
	(1) Financing	(2) Cashflow	(3) Real option	(4) Financing	(5) Cashflow	(6) Real option
IRU x High short-term debt	-0.020***			-0.007		
	(0.007)			(0.007)		
Interest rate x High short-term debt	0.010			-0.005		
	(0.008)			(0.012)		
IRU x Exposed		-0.031**			0.023	
		(0.013)			(0.023)	
Interest rate x Exposed		0.002			-0.070***	
		(0.018)			(0.025)	
IRU x Low redeployability			-0.002			-0.008
			(0.006)			(0.008)
Interest rate x Low redeployability			-0.003			-0.009
			(0.003)			(0.014)
IRU				0.005	-0.021	0.004
				(0.006)	(0.023)	(0.007)
Covariates	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y
Industry x time FE	Y			Y	Y	Y
Time FE		Y	Y			
N firm clusters	890	840	844	890	840	844
N	8324	7887	7929	8324	7874	7916
Adj-R^2	0.16	0.15	0.15	0.16	0.17	0.16

Notes: This table reports panel regressions with firms' investment growth rate as a dependent variable. IRU refers to interest rate uncertainty, Interest Rate refers to the 3-month Euribor (for the short-term IRU) and to the 10-year government bond rate (for the long-term IRU), *High short-term Debt* takes a value of 1 when the average ratio of short-term debt over the period is above the sample median. *Exposed* (no natural hedge) takes a value of 0 when a firm operates in an industry with a significant positive correlation between its cash flow and interest rates and 1 otherwise. *Low-Redeployability* takes a value of 1 when a firm operates in a below median low-redeployability industry. Financing, Cashflow and Real option refer to propagation channels of IRU. Standard errors are clustered at the firm level. The sample period runs from 2005 to 2017.

The specifications as in Eq. (1) and Eq. (2) now include an interaction term between covariates and the three new dummy variables: high short-term debt, being in an exposed industry and having low redeployability of investment. We present the results of these estimations in Table 4. We find that firms with a larger share of short-term debt contract investment more when short-term IRU is high (Column 1). This result supports a financing channel of interest rate uncertainty. In addition, investment falls more for exposed firms (i.e., no natural hedge, Column 2). Finally, firms with

low redeployability of investment decrease their investments, though this result is not statistically significant (Column 3). First, this finding could reflect that our redeployability measure is tailored to US industries. Second, it may also reflect the nature of uncertainty under investigation, which is not a general measure of economic uncertainty but rather one that directly relates to the funding of firms through the financing and cash flow channel.

With regard to long-term IRU, we do not observe heterogeneous effects on investment stemming from ex-ante exposures of firms (Column 4 to 6). We find that the financing channel of interest rate uncertainty is operating rather through the short-end of the term structure of the IRU (Column 1 and 4). With regard to the redeployability (the real options channel), the same arguments as for the short-term IRU apply (Column 3 and 6). Instead, exposed firms are associated with lower investment when the level rather than the uncertainty of long-term interest rates is high (Column 5), as typically financing with long-term interest rates is of fixed nature.

Overall, we find that pre-defined characteristics that relate to firms' exposure to interest rate risk are important for sensitivity of investment to interest rate uncertainty, predominantly through the financing and cash flow channel. Below, we explore further firm characteristics that relate to potential difficulties in accessing external financing, which in turn affect a firm's ability to produce and invest.

Financial constraints. To analyze the response of firms' investment to IRU conditional on financing constraints, we use the following characteristics that capture a firm's relative ease in accessing external financing: size, collateral and capital constraints.

We use yearly balance sheet information to build time varying firm size and collateral proxies. We classify firms based on their position in the distribution of the variable of interest in the year preceding the one at which investment effect is measured. In the case of size, a firm is classified as being *Small* (indicator takes the value of 1) when its log of total assets is below the fourth quartile of the cross-sectional distribution in the preceding year. For collateral we use tangible assets over total assets to reflect the amount of pledgeable assets, which could support more borrowing. The *Low Collateral* indicator takes the value 1 if the firm's ratio of tangible assets over total assets is below the median of the cross-sectional distribution in the preceding year. To capture the extent to which firms may be capital constrained, we use the marginal revenue products of capital (MRPK). In a standard model of production, misallocation of capital operates as a wedge on the price of capital. Bau and Matray (2023) show that, under mild assumptions, MRPK is proportional to this wedge and therefore firms with high MRPK are more capital constrained. Following Bau and Matray (2023), we compute the within-industry MRPK as the sales to capital ratio, where industry is defined at the 3-digit level. A firm has a *High MRPK*, if its average MRPK over the sample period is above the industry median.

Table 5 reports results on the effects of IRU on investment when accounting for firm size,

collateral and capital constraints. Columns 1 to 3 show that high short-term IRU is associated with lower investments for financially constrained firms relative to the baseline result for the average firm (refer to Table 2). As above, we do not observe heterogeneous effects of long-term IRU on investment stemming from financial constraints of firms (Column 4 to 6).

Table 5: Heterogeneous effect of IRU on firm investment: Financial constraints

	Short-term IRU			Long-term IRU		
	(1) Size	(2) Collateral	(3) Capital Constraint	(4) Size	(5) Collateral	(6) Capital Constraint
IRU x Small	-0.019***			-0.002		
	(0.007)			(0.006)		
Interest Rate x Small	0.010			0.001		
	(0.008)			(0.007)		
IRU x Low Collateral		-0.016**			0.004	
		(0.008)			(0.007)	
Interest Rate x Low Collateral		0.002			-0.009	
		(0.009)			(0.008)	
IRU x High MRPK			-0.015**			0.001
			(0.007)			(0.006)
Interest Rate x High MRPK			-0.001			-0.014*
			(0.008)			(0.007)
IRU				0.003	-0.001	0.000
				(0.006)	(0.005)	(0.005)
Covariates	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y
Industry x time FE	Y	Y	Y	Y	Y	Y
N firm clusters	890	890	890	890	890	890
N	8324	8324	8324	8324	8324	8324
Adj-R^2	0.16	0.18	0.16	0.16	0.18	0.16

Notes: This table reports panel regressions with firms' investment as a dependent variable. IRU refers to interest rate uncertainty, Interest Rate refers to the 3-month Euribor (for the short-term IRU) and to the 10-year government bond rate (for the long-term IRU). *Small* takes a value of 1 when a firm's log of total assets is below the top quartile of the cross-sectional distribution in the preceding year. *Low Collateral* indicator takes the value of 1 if the firm's ratio of fixed assets over total assets is below the median of the cross-sectional distribution in the preceding year. *High MRPK* takes a value of 1 when a firm's averaged within-industry MRPK (i.e., the sales to capital ratio) is above the industry median. Standard errors are clustered at the firm level. The sample period runs from 2005 to 2017.

Our results suggest that there is a stronger negative relationship between investment and IRU for firms facing real and financial constraints. Hence, our findings suggest that, beyond the standard real options channel of uncertainty (Bernanke, 1983; Bloom, 2009), a financing and a cash flow channel are also at play.

3.2.3 Hedging

So far, we document that short-rate interest rate uncertainty is negatively associated with firm investment. We now study the exposure of firms to interest rate uncertainty through the lens of

firms' risk management practices, since they could hedge away their interest rate risks by trading financial derivatives. To this purpose, we use information on the overall derivative position of firms. This is possible because, since 2005, firms in the European Union (EU) are requested to report this information in their Financial Statements.[15]

Table 6: Heterogeneous effect of short-term IRU on firm investment: Hedging

	(1) All Firms	(2) High Rollover Risk	(3) Low Rollover Risk
IRU x Not Hedged	-0.021**	-0.033**	-0.006
	(0.009)	(0.015)	(0.010)
Interest Rate x Not Hedged	0.015	0.030	0.005
	(0.012)	(0.021)	(0.012)
Not Hedged	0.009	0.011	-0.003
	(0.012)	(0.020)	(0.016)
Covariates	Y	Y	Y
Firm FE	Y	Y	Y
Industry x time FE	Y	Y	Y
N firm clusters	890	443	444
N	8324	4151	4144
Adj-R^2	0.16	0.15	0.18

Notes: This table reports panel regressions with firms' investment as a dependent variable. IRU refers to short-term interest rate uncertainty. *Not Hedged* equals to 1 when a firm is not in the hedging category a year before, and zero otherwise. Standard errors are clustered at the firm level. *High Rollover Risk* refers to firms with short-term debt above the median of the cross-sectional distribution. *Low Rollover Risk* refers to firms with short-term debt below the median of the cross-sectional distribution. The sample period runs from 2005 to 2017.

We aggregate *Current* and *Non-Current Derivative Liabilities* in the *Hedging Supplemental* entries and classify a firm as a non-hedger if its aggregate is zero the year before. According to Reuters Fundamentals definition, these entries represent the negative fair value of financial instruments under contracts that have one or more underlying asset and one or more notional amounts. They are used for derivatives whose purpose is to limit the risk related to the volatility of market prices of goods sold by the company, or to significant changes in interest rates and foreign exchange rates. Therefore, our proxy captures risk management practices that do not pertain to interest rate risk only, and as such, results may be underestimating the effects of IRU on investment (if firms have hedged against other risks).

[15] In 2005, the EU introduced the fair value and hedging provision of the amended version of IAS 39. The *IAS 39 Financial Instruments: Recognition and Measurement* is an international accounting standard which outlines the requirements for the recognition and measurement of financial assets, financial liabilities and some contracts to buy or sell non-financial items.

Table 6 reports results on the effects of short-term IRU on investment when controlling for hedging. Focusing on the interaction term between *Not hedged* and IRU, we find that non-hedgers are more sensitive to short-term IRU (Column 1) as their future investment falls as IRU increases. In addition, we find that this negative effect is magnified for financially constrained firms (High Rollover Risk, Column 2). Conversely, firms that do not hedge and that have a low exposure to rollover risk are not significantly affected by short-term IRU (Low Rollover Risk, Column 3). Thus, financially constrained firms are the most exposed to short-term IRU. While this result implies that financially constrained firms would benefit most from hedging, such risk management practices are costly. Indeed, Bretscher, Schmid, and Vedolin (2018) show that incomplete hedging may be optimal in the presence of financial frictions.

3.3 Other real outcomes and financial decisions

We now proceed in investigating the effect of interest rate uncertainty on sales, employment and R&D investment, as well as financial decisions on cash holdings of firms and dividend payouts.

Table 7 shows that in the presence of higher uncertainty about the short-term interest rate, firms reduce sales (Column 1) and hiring (Column 4). The latter effect is in line with Bernanke (1983); Leduc and Liu (2016), whereby a firm may prefer to 'wait and see' instead of engaging in activities that are not easily reversed. Furthermore, such uncertainty, makes firms more cautious, by increasing cash holdings and cutting down on dividend payouts (Columns 2 and 3). Conversely, we do not find a statistically significant association between IRU and R&D investment. Finally, the effect of long-term IRU continues to be muted on real and financial outcomes for the average firm (Columns 6 to 10).

Table 7: Other real outcomes and financial decisions

	Short-term IRU					Long-term IRU				
	(1) Sales	(2) Cash holdings	(3) Payout	(4) Hiring	(5) R&D growth	(6) Sales	(7) Cash holdings	(8) Payout	(9) Hiring	(10) R&D growth
IRU	-0.015***	0.006***	-0.105***	-0.015***	0.013	0.005	0.001	0.001	0.000	0.023
	(0.005)	(0.001)	(0.012)	(0.003)	(0.017)	(0.006)	(0.001)	(0.019)	(0.004)	(0.037)
Covariates	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firm FE, Fiscal quarter FE	Y	Y	Y	Y	Y					
Firm FE, Industry x time FE						Y	Y	Y	Y	Y
N firm clusters	890	890	890	890	203	890	890	890	890	203
N	8323	8324	8324	8324	2122	8323	8324	8324	8324	2122
Adj-R^2	0.99	0.75	0.10	0.23	0.08	0.99	0.76	0.15	0.26	0.15

Notes: This table reports panel regressions with firms' Sales, Cash Holdings, Dividend Payout, Hiring and R&D investment growth as a dependent variable, respectively. IRU refers to interest rate uncertainty; Sales growth is the log difference in yearly sales. Cash holdings is $Cash\ and\ Liquid\ assets_t / Total\ assets_{t-1}$. Dividend Payout growth is defined as $g_t^D = (Dividend_t - Dividend_{t-1})/[0.5 \times (Dividend_t + Dividend_{t-1})]$. Hiring is defined as $g^H = (employment_t - employment_{t-1})/[0.5 \times (employment_t + employment_{t-1})]$. R&D growth rate is defined $g_t^{R\&D} = (R\&D_t - R\&D_{t-1})/[0.5 \times (R\&D_t + R\&D_{t-1})]$. Standard errors are clustered at the firm level. The sample period runs from 2005 to 2017.

4 Concluding remarks

This study documents a significant relationship between short-term (Euribor) interest rate uncertainty and real and financial decisions of euro-area firms for the period 2005-2017. We find that heightened interest rate uncertainty is associated with a decrease in firms' future tangible investments. When exploring the heterogeneous effects of interest rate uncertainty across firms, negative effects are magnified for firms that are *ex-ante* most exposed to interest rate risk, those that face financial constraints and those that do not hedge. Our findings suggest that, beyond the standard real options channel of uncertainty on investment and hiring, interest rate uncertainty affects firms through a financing and a cash flow channel. In our analysis, such channels are evident when assessing the effects of interest rate uncertainty on investment across firm characteristics and when studying the effects of interest rate uncertainty on cash flow and dividend payout decisions. In the presence of such uncertainty, the average euro-area firm tends to hoard cash and reduce dividend payouts to inhibit the potential impact of future adverse shocks.

Overall, our analysis provides empirical evidence on euro-area firms in support of a finance-uncertainty multiplier, as in Alfaro, Bloom, and Lin (2023), whereby the combination of a real options, financing and cash flow channel amplifies the effects of uncertainty on firm decisions. Importantly, our results speak to a Finance-Interest-Rate-Uncertainty (FIRU) multiplier, where uncertainty is common to all firms in the euro area and is associated with monetary policy.

We consider our estimates of the effect of short-term interest rate uncertainty on euro-area firms to be conservative. A large proportion of our sample is characterised by low interest rate uncertainty, as a consequence of historically low levels of interest rates and the ECB's forward guidance. Moreover, since 2008, the ECB has adopted other non-standard measures, such as unprecedented money-market support actions, special loan programs, and large-scale asset purchases, incentivizing bank lending and stimulating the real economy. Finally, our sample consists exclusively of listed firms, which tend to be larger and have access to various sources of external financing beyond bank loans. This includes options like corporate bonds and equity financing, which may provide additional avenues for managing the impact of interest rate uncertainty. We conjecture that the effects of interest rate uncertainty would have been more detrimental to Small and Medium-sized Enterprises (SMEs), as they have more limited access to external financing and may face greater challenges in obtaining bank loans, especially during periods of tighter financing conditions. We leave the investigation of how interest rate uncertainty affects SMEs for future research.

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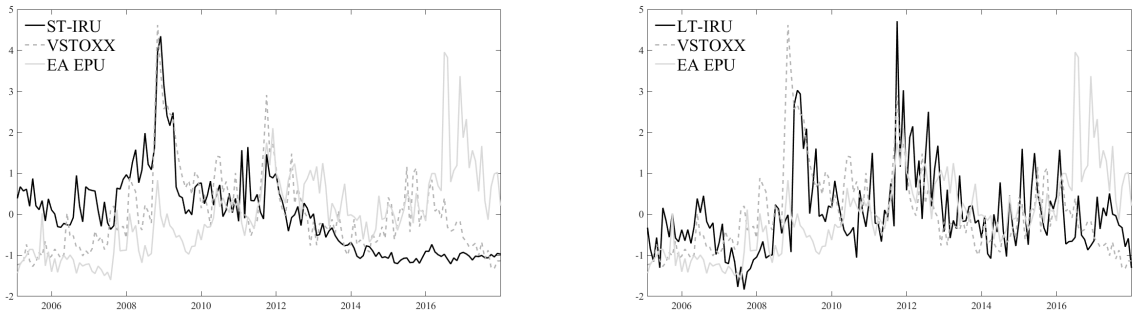
A Tables and Figures

Table A.1: Definitions of key firm-level variables

Sales growth	Log difference in yearly sales
Investment	The growth rate in capital investment, defined as the change in the log of fixed capital, with capital being the net property plant & equipment (i.e. net of depreciation)
TobinQ	Market Value to Book Value
Market Value	Book assets minus Book equity plus the product of share price at the end of the fiscal year by number of shares outstanding
Cash holdings	Cash and cash equivalent scaled by total assets
Cash flows	Net income plus Depreciation and amortization scaled by total assets
Book leverage	Financial debt scaled by total assets
Short-term debt	Short-term debt and the portion of long-term debt obligations that is due within one year scaled by total debt
Net worth	Market value minus book equity minus deferred taxes minus total Liabilities, scaled by total assets
Tangible assets	Property, plant and equipment scaled by total assets

Figure A.1: Comparison of IRU measures with other uncertainty proxies



Notes: The left-hand side panel displays the average short-term IRU (ST-IRU) on the 3-month Euribor, while the right-hand side panel shows the average long-term IRU (LT-IRU) on 10-year Government bonds. Both measures are at a one-year forecasting horizon and averages are computed by assigning equal weights on the measures for France, Germany, Italy and Spain. VSTOXX and EA EPU refer to the implied volatility of the EUROSTOXX50 and the European Economic Policy Uncertainty index of Baker, Bloom, and Davis (2016), respectively.

Table A.2: Firm investment and IRU: Baseline

	Long-term IRU									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
IRU	-0.004	0.002	0.002	0.002	0.002	0.004	0.003	0.003	0.001	-0.006
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.004)
3M Euribor rate	-0.021	-0.011	-0.018	-0.018	-0.016	-0.003	-0.015	-0.016	-0.017	-0.008
	(0.018)	(0.017)	(0.018)	(0.021)	(0.017)	(0.022)	(0.018)	(0.018)	(0.018)	(0.005)
10Y rate	-0.019*	-0.015	-0.010	-0.015	-0.005	-0.008	-0.006	-0.006	-0.009	-0.003
	(0.011)	(0.011)	(0.012)	(0.011)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.006)
Gdp growth			0.007							
			(0.007)							
Inflation				0.006						
				(0.009)						
Unemployment rate					-0.003	-0.002	-0.003	-0.002	-0.001	-0.002
					(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
VStoxx						-0.024				
						(0.018)				
Country EPU							-0.003	-0.003	-0.002	-0.014***
							(0.008)	(0.008)	(0.008)	(0.005)
TobinQ		0.061***	0.060***	0.060***	0.060***	0.060***	0.060***	0.060***	0.059***	0.065***
		(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.009)
Size		-0.100***	-0.099***	-0.102***	-0.103***	-0.103***	-0.103***	-0.104***	-0.098***	-0.092***
		(0.032)	(0.032)	(0.032)	(0.032)	(0.032)	(0.032)	(0.032)	(0.033)	(0.031)
CF		0.043***	0.043***	0.043***	0.043***	0.043***	0.043***	0.043***	0.042***	0.042***
		(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Sales growth		0.015***	0.015***	0.015***	0.015***	0.015***	0.015***	0.015***	0.015***	0.015***
		(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)	(0.005)	(0.005)
Leverage		-0.042***	-0.042***	-0.042***	-0.042***	-0.042***	-0.042***	-0.043***	-0.045***	-0.043***
		(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.008)	(0.007)	(0.008)
Lagged Inv.								0.002	0.001	0.002
								(0.006)	(0.006)	(0.006)
Firm FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y	Y	Y		
Industry-Time FE									Y	
Fiscal quarter FE										Y
N firm clusters	891	891	891	891	891	891	891	891	891	891
N	8319	8319	8319	8319	8319	8319	8319	8319	8318	8319
Adj-R^2	0.10	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.16	0.15

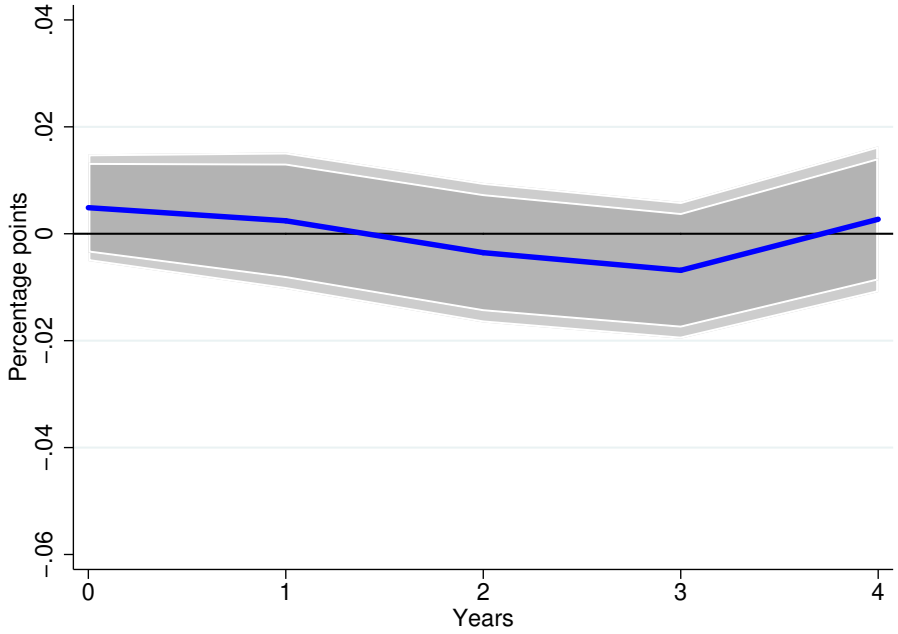
Notes: This table reports panel regressions with firms' investment growth rates as a dependent variable. IRU refers to the long-term interest rate uncertainty; 10Y Rate (10-year government bond rate), GDP growth, inflation, unemployment rate and EPU of Baker, Bloom, and Davis (2016) are at country level, VSTOXX is the implied volatility of the EUROSTOXX50. Tobin's Q is the one-year lagged Market-to-Book value measured at the end of the fiscal year; Size is the log of a firm's total assets; Cashflow is the cash flows defined as the ratio of $Net\ income\ plus\ Depreciation\ and\ amortization_t / Total\ assets_{t-1}$; Sales growth is the one-year lagged log difference in yearly sales, Leverage is $Financial\ debt_t / Total\ assets_{t-1}$. Standard errors are clustered at the firm level. The sample period runs from 2005 to 2017.

Table A.3: Firm investment and short-term IRU: Robustness

	(1) g(PP&E)	(2) CapEx/TA	(3) CapEx/PP&E	(4) ΔlogPP&E Filtered IRU	(5) ΔlogPP&E IRU 12-month
IRU	-0.016***	-0.030**	-0.004***	-0.017***	-0.020***
	(0.005)	(0.012)	(0.001)	(0.004)	(0.006)
Firm FE	Y	Y	Y	Y	Y
Fiscal quarter FE	Y	Y	Y	Y	Y
Firm covariates	Y	Y	Y	Y	Y
Macro covariates	891	891	891	891	891
N firm clusters	8319	8319	8319	8319	8319
N	0.22	0.81	0.70	0.24	0.24

Notes: This table reports panel regressions with firms' investment growth rates as a dependent variable. IRU refers to the short-term interest rate uncertainty. The table replicates our baseline specification (column 7 of Table 2 but using different definitions of investment as dependent variable (columns 1 to 3) and different measures of short-term IRU as independent variable (column 4 and 5). In column 1, investment is the growth rate in net Property, Plant and Equipment : $g_t^{PP\&E} = (PP\&E_t - PP\&E_{t-1})/[0.5 \times (PP\&E_t + PP\&E_{t-1})]$. In column 2 investment is equal to the ratio of Capital Expenditures over lagged Total Assets ; in column 3 investment is equal to the ratio of Capital Expenditures to lagged net PP&E. In column 4 we stick to our baseline estimation but replace short-term IRU with the residuals when regressing short-term IRU on VSTOXX and euro area EPU. In column 5 we use the short-term IRU at 12-month forecasting horizon instead of 3-months forecasting horizon as in the baseline. Standard errors are clustered at the firm level. The sample period runs from 2005 to 2017.

Figure A.2: Local Projections of long-term IRU effects on investment



Notes: This figure reports the estimates of the effect of long-term IRU on investment (baseline regression Eq.(2)), across different horizons.