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Consumer savings behaviour at low and negative interest rates

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Abstract: *We study interest rates transmission to savings at low and negative rates. Exploiting cohorts of consumers from a data-rich multi-country survey, we show how the strength of interest rate transmission to savings varies with the level of nominal interest rates. This response is positive when interest rates are high but declines steadily at lower levels. At very low levels, there is evidence that the savings response may even reverse sign. Such a "savings' reversal" is consistent with the behavioural evidence on money illusion as well as with a negative signalling effect from policy announcements in a liquidity trap and may weaken the direct stimulatory effects from very low and negative rates. Consistent with this, the reversal appears to be causally related to central bank information shocks and concentrated among older consumers and consumers with lower educational attainment.*

Keywords: Savings, Nominal Interest Rates, Consumer Survey, Liquidity Trap, Euro Area

JEL: D12, D84, E21, E31, E52

Non-technical summary

For almost a decade after the Great Recession of 2008-2009, nominal interest rates in many advanced economies were at unprecedented low levels. In the case of the euro area, in June 2014, the ECB was the first major central bank to cut one of its key policy rates into negative territory to provide more monetary easing and encourage banks to stimulate credit to the economy. Although the prevalence of negative nominal interest rates on household savings remains low, during this period household rates have on average been persistently at very low levels, often close to zero. This environment has provoked considerable empirical analysis of the effects of low and negative nominal interest rates on bank profitability and lending and firm borrowing and risk-taking behaviour. However, we know far less about the possible implications of this very low and negative interest rate environment for households or consumers and their savings.

In this paper, we address this gap, focusing on two related and important empirical questions: Firstly, what can the micro evidence tell us about how households' take interest rates into account when they change their savings behavior? And, second, does the nature of the household savings response to interest rates depend on the level of interest rates? These questions are central to discussions of monetary transmission and they take on an added relevance during the above period where central banks have lowered policy rates to very low and even negative levels putting increased pressure on the financial system to pass these low rates onto the rates offered on household deposits and savings accounts.

Concerning the first question, the microdata data overwhelmingly suggests that consumers do not take their savings decisions in purely real terms. Although consumers' subjective expectations about future inflation certainly influence the savings decision, nominal interest rates appear to be more relevant both on average and in absolute terms. As a result, the simple real rates model of interest rate transmission - typical of most conventional macroeconomic models - is found to be strongly rejected by the data. This finding is in line with a large body of experimental evidence emphasizing the importance of nominal representations in consumer decisions. Regarding the second question, the micro evidence also strongly demonstrates how the strength and even the sign of interest rate transmission to savings may depend on the level of nominal interest rates. At relatively high levels of nominal rates, the response of savings to interest rate changes is positive in line with the assumptions embedded in most mainstream economic models. However, the magnitude of the savings response to interest rates declines steadily as the level of nominal rates declines. Such a result suggests that the level of nominal rates may alter the relative weight of income versus substitution effects as drivers of savings behavior. Moreover, for very low levels of nominal rates (e.g. below 0.5%) there is some evidence of a "saving's reversal" where savings starts to increase in response to further reductions in nominal rates. Such a reversal may reflect an enhanced role for target wealth in driving savings whereby risk-averse savers respond to lower rates by increasing their level of active savings as a way to provide for future retirement or consumption needs. This pattern is also consistent with possible contractionary effects of interest rate reductions in the presence of a confidence-driven liquidity trap, where income effects dominate substitution effects reflecting the persistence of consumers' expectations on the future state of the economy. We also find evidence of this "news" channel by employing exogenous central bank information shocks, which identify a reversal in the response of savings to interest rates changes below a nominal rate level of 0.5%.

The evidence on the importance of the level of nominal - as opposed to real - rates for understanding interest rate transmission to households raises important questions for policy. In the first instance, the direct stimulus to demand and household consumption from reductions in nominal interest rates is likely to diminish in potency as interest rates decline. Moreover, reductions in nominal rates to very low levels may potentially give rise to upward pressure on consumer savings as households strive to compensate for the associated decline in nominal interest income. However, our results do not imply that ultra-low household deposit rates driven by negative policy rates would necessarily imply an overall contractionary impact on the economy. This is because our findings largely pertain to the direct impact effects on savings linked to changes in nominal rates, while the full general equilibrium effects of interest rate changes will include other indirect channels of transmission via expected future income, employment as well as changes in uncertainty, asset prices and effects associated with the possible re-allocation of household wealth across different asset classes. However, the non-linearities that are uncovered in the microdata certainly suggest scope to improve the public's understanding about the reasons for interest rate changes and the importance of real interest rate considerations in economic decisions. The finding that central bank information shocks play a role in triggering a savings reversal at low rates suggests a need to emphasize more the benefits of lower rates for future household incomes in central bank communication. Importantly, our evidence suggests that the decline in the response of savings associated with the level of nominal rates is not driven by specific consumer groups but is a quite generalized phenomenon in the population. However, the significance of the reversal in the response of savings to interest rates appears to be predominantly driven by older consumers and consumers with lower educational attainment who may have lower levels of overall financial literacy. This suggests that the savings reversal need not be taken as an immutable "fact of life" but instead it may be influenced by households' ability to gradually learn over time. For this reason, public policies aimed at enhancing levels of financial literacy, knowledge about inflation as well as the reasons behind low and negative nominal interest rate policies may be particularly important in enhancing policy effectiveness in a low interest rate environment.

1. Introduction

In the decade following the Great Recession of 2008-2009, nominal interest rates in many advanced economies were lowered to exceptionally low and even unprecedented levels. In the case of the euro area, in June 2014, the ECB was the first major central bank to cut one of its key policy rates into negative territory to provide more monetary easing and encourage banks to stimulate credit to the economy. Although the prevalence of negative nominal interest rates on household savings remained very low, household rates were on average persistently at very low levels, often close to zero.[1] This environment has provoked considerable empirical analysis of the effects of low and negative nominal interest rates on bank profitability and lending and firm borrowing and risk-taking behaviour; see, for example, Altavilla et al. (2021), Abildgren and Kuchler (2020), Amzallag et al. (2019), Bubeck et al. (2020) and Heider et al. (2019).

We know far less about the possible implications of this experience of very low and negative interest rates for households or consumers and their savings. The textbook behaviour underlying the above low interest rate policies is that the propensity to save declines with a reduction in interest rates, thereby exerting a stimulatory impact on the economy. However, there are plausible grounds to expect a possible change in the household savings response to interest rates at very low or negative levels such that further reductions in interest rates could become contractionary and boost rather than decrease households' propensity to save. Several

[1] Individual bank-level data, discussed in Schnabel (2020), show that in September 2020 a non-trivial share of household sector deposits across the euro area MFIs were earning a small negative rate of interest. Moreover, in such an environment, even if banks offer a zero or marginally positive rate, administrative fees on savings products can often mean that the *effective* nominal interest rate will be below zero.

arguments have been advanced for such a "savings reversal". For example, a low level of interest rates may alter the relative weight attached to intertemporal substitution and income effects in the savings decision, particularly in a situation characterised by a liquidity trap due to the lower bound on nominal interest rates. Bilbiie (2018) discusses how in a confidence-driven liquidity trap, of the type analysed in Schmitt-Grohé and Uribe (2017), interest rate decreases may be contractionary. This reflects the predominance of the income effect over intertemporal substitution and high persistence and news amplification regarding the future state of the economy and inflation. Such information channels, which can have opposite real effects to traditional monetary policy shocks, have recently been shown to be an important feature of monetary transmission particularly in the euro area (see, Jarociński and Karadi, 2020). Another related idea is that low or negative rates may engender a greater role for target wealth considerations and precautionary savings. *In extremis*, as discussed in Nabar (2011) if target wealth considerations dominate, the response of savings to an interest rate decrease can reverse sign and become positive. In line with this idea, Bayer et al. (2020) link a reversal in the sign of the savings response to the generosity of social security systems. In their model, when interest rates are low, less generous social security systems may encourage households to increase current savings in response to a decline in interest rates to meet goals for retirement consumption.[2] Similarly, Greenwald et al. (2021) develop a heterogeneous agent model where

[2] McKay and Wieland (2019) show how lumpy durable goods consumption is associated with a weakening of the consumption-savings response to interest rates because households do not need to subsequently acquire even more durable goods when interest rates decline even further. This argument implies only a weakening of interest rate transmission as the level of rates declines and not a reversal in the sign of the response.

the presence of target future consumption considerations prompts individuals with substantial financial wealth to increase savings in a low-rate environment.

The above ideas for changes in savings behaviour at low levels of the interest rates apply - at least in principle - to the *real* rate that is adjusted for expected inflation. However, while the real rate features prominently in most conventional economic models, as discussed in Sapienza and Zingales (2013), how economists think and how the public thinks may be far from being in perfect alignment. In this respect, the importance of nominal concepts in influencing household decisions, encapsulated in the concept of "money illusion" (Patinkin, 1965), may limit households' ability to appropriately internalise the future benefits of low interest rates policies for their future income and consumption.[3] There is already a considerable body of behavioural evidence (e.g. Shafir et al., 1997; Fehr and Tyran, 2001 and Fehr and Tyran, 2014) showing that a high degree of money illusion may underpin household decisions. Shafir et al. (1997) highlight how the ease and salience of nominal concepts may make them more important for economic decisions. The existence of a savings' reversal would imply that a change in nominal interest income from say EUR 500 to EUR 400 could elicit a different sign of the savings response to a change from EUR 100 to EUR 0 (or from 0 to EUR-100). The latter implies a very salient reduction to zero (or loss) of the nominal interest income on any savings held in term deposits. In such a context, the behavioural evidence, e.g. from prospect theory as reviewed in Barbereis (2013), stresses the potential importance of asymmetric responses (Fehr and Tyran, 2014) due to loss aversion or, as in Bracha (2020) and Prelec and Loewenstein (1998), the "pain of paying". The associated perceptions by households of increased risk to their future wealth accumulation and consumption could incentivise an

[3] Borio and Hofmann (2017) also highlight how money illusion may be relevant for understanding the household response to low or negative levels of the nominal interest rate.

increase in current savings in response to interest rate declines. In this vein, Kőszegi and Rabin (2009) introduce ideas from prospect theory into a dynamic model of consumption that incorporates a precautionary savings motive aimed at avoiding the expected pain of lower future consumption.

Patterns in euro area macroeconomic aggregates as depicted in Figure 1 lend some support to the potential relevance of nominal rates *per se* and for changes in consumer behaviour at particularly low levels. For example, although reductions in nominal rates following the Great Recession and subsequent euro area sovereign debt crisis were associated with a clear decline in the household savings ratio, consistent with a strong intertemporal substitution effect, the subsequent period of ultra-low interest rates was associated with a steady increase in the household savings ratio over the period 2017-2019. In this paper we draw on the power of micro data to study empirically the implications of this low nominal rate environment for consumer savings. Due to its unique and persistent experience of low and negative policy rates, the euro area provides an ideal case study to identify possible changes in the interest rate responsiveness of savings. Although several recent papers, including van den End et al. (2020), Borio and Hofmann (2017), Aizenman et al. (2019) have provided macro evidence about how interest rate transmission may weaken or even change sign as the level of interest rates falls, to our knowledge the issue has thus far not been comprehensively or explicitly studied at the micro level. Our work relates to the broader empirical research on household savings, as previously surveyed in Browning and Lusardi (1996), as well as to the more recent and growing empirical literature on household expectations and behaviour using survey-based measurement. This literature, recently surveyed in Coibion et al. (2018), has highlighted sharp inconsistencies with the traditional rational paradigm that is assumed in many formal economic models. We make a new empirical contribution to this literature by providing microeconomic evidence on possible non-linearities and asymmetries in interest rate transmission to savings.

Such non-linear effects are inherently difficult to identify in practice reflecting their relatively low frequency of occurrence. However, our novel empirical strategy is able to overcome these limitations by combining variation in savings behaviour across similar cohorts of consumers with cross-country variation in household deposit rates to identify interest rate transmission over interest rate regimes that are well supported in our dataset. The analysis exploits a very rich and powerful consumer microdata set across 19 euro area countries and exploits consumers' subjective inflation expectations with matched horizon term-deposit rates to help distinguish real from nominal channels of interest rate transmission. Most importantly, fixed effect instrumental variables estimation using exogenous monetary policy and central bank information shocks identified with high frequency data helps control for the potentially important sources of heterogeneity and conveys a causal interpretation on our identified interest rate transmission. By focussing on savings variation for different cohorts of consumers, our method allows us to propose a new disagreement-based measure of consumer's uncertainty about their future financial situation that can be used to control for a precautionary savings motive. As it is based on the disagreement *within* groups of consumers that share similar characteristics, it is also akin to a peer group uncertainty effect (see, for example, Bailey et al., 2018), an aspect which – to our knowledge – has also not yet featured in the literature examining the measurement and transmission of uncertainty (as surveyed, for example, in Bloom, 2014).

The layout of the remainder of the paper is as follows. In Section 2, we describe the underlying data sources and the construction of the panel. In Section 3 we outline the econometric methods used to study the transmission of interest rates to savings. Section 4 reports all our empirical results and explores their robustness across various dimensions. Section 5 summarises and discusses the policy implications of the paper's findings. The supplementary material in Appendix I provides additional information on the underlying data sources used, while

Appendix II provides additional robustness checks, including tests of their generality across different consumer groups such as the retired, those with lower educational attainment, financially better-off consumers or consumers from the relatively high-saving northern European economies.

2. A Multi-Country Panel of Consumer Cohorts

Our primary data source combines the microdata from the EU Business and Consumer Survey with data on the monthly nominal interest rates offered on one-year household deposits in financial intermediaries across 19 euro area countries. The microdata in the EU Consumer Survey is also collected at a monthly frequency and has the major advantage of large and highly representative samples that are surveyed on a comparable basis and in a highly synchronised manner across all euro area countries. The Consumer Survey data is described in more detail in Arioli et al. (2017) and in Appendix I. A key feature of the data is that it is available as a repeated cross section with a new set of random respondents sampled every month in each euro area country. To accurately model savings, it would be preferable to track consumer behaviour over time to facilitate the identification of interest rate transmission whilst also controlling for time-invariant sources of unobserved consumer heterogeneity. To do so we follow the approach advocated in Deaton (1985) to construct a panel dataset at the level of the "pseudo" individual (see also Verbeek, 2008). In this section we document the construction of this panel and explore the information it contains about the key forces that shape savings.

2.1 Savings

To measure savings we exploit over 2,850,000 individual survey responses collected for 19 euro area countries over the period May 2003 to March 2019. The main focus of our analysis is survey data on the likelihood that a consumer will save over the next 12 months:

Over the next 12 months, how likely is it that you save any money? It is (i) very likely, (ii) fairly likely, (iii) not likely, (iv) not at all likely, (v) don't know

Given that the EU Consumer Survey is constructed as a repeated cross-section it is convenient to aggregate responses to groups of "pseudo" individuals or cohorts sharing a predefined set of characteristics. Such a cohort-level analysis allows us to track responses over time and thereby also control for unobserved time-invariant characteristics that may influence savings behavior at the cohort level. To do so, we aggregate the actual individual replies ($s_{n,t}$) to the pseudo individual or cohort level ($S_{i,t}$) based on a four-dimensional array of directly observed consumer characteristics. The selected characteristics include country of residence, gender, age and level of educational attainment as also exploited in Duca-Radu, Kenny and Reuter (2021). The set of N pseudo respondents are thus defined by this four-dimensional vector of characteristics:

Pseudo respondent "i" = [Country, Gender, Age, Educational Attainment]

The cross-sectional dimension of the panel reflects the richness of the underlying data from 19 euro area countries, two gender classifications (Female, Male), four age groups (16-29, 30-49, 50-64, 65+) and three classifications for the level of educational attainment (Primary, Secondary, Higher). From this four-dimensional vector of characteristics, a possible total of N =19 x 2 x 4 x 3 or 456 "pseudo" individuals emerges. However, to limit the impact of estimation uncertainty, we focus only on those cohorts with at least 30 individual members available in the repeated cross section. This yields a cross section of N=363 pseudo observations with a variable number of time series observations per cohort (106 monthly time series observations on average). The resulting unbalanced panel dataset comprises a total of 38,616 observations. A measure of savings propensity ($S_{i,t}$) for each pseudo individual is then constructed from the above survey question on the likelihood of savings and measures the fraction of individual survey respondents in each cohort who respond that they are either "*very likely*" or "*fairly likely*" to save:

$$S_{i,t} = \sum_{n=1}^{\widetilde{m}} w_{n,t} s_{n,t} \tag{2.1}$$

where,

$$s_{n,t} = \begin{cases} 1 & if = \text{"Very Likely" or "Fairly Likely"} \\ 0 & Otherwise \end{cases}$$

In the estimation of $S_{i,t}$, the individual survey weights ($w_{n,t}$) ensure that the aggregation of all pseudo individual responses is representative of the overall population in each of the euro area countries, while $\widetilde{m}$ represents the total number of individual respondents included in a given cohort. This can vary from survey round to survey round and from cohort to cohort reflecting random sampling fluctuations in the survey fieldwork (as mentioned above observations are discarded whenever $\widetilde{m} < 30$). To ensure that the aggregation of individual replies represents the weighted share of consumers who are likely to save within each cohort, the weights are normalised to sum to 1 within each cohort, i.e. $\sum_{n=1}^{\widetilde{m}} w_{n,t} = 1$. The derived measure of savings has a clear positive correlation with macroeconomic estimates of the household savings ratio across the main euro area countries. Based on a linear least-squares fitted regression line (see Figure 2a), the correlation is estimated at 0.4173 which is highly significant (P-value < 0.0001).

2.2 Income and uncertainty

Fluctuations in income as well as uncertainty about future income and economic prospects are traditionally seen as key drivers of savings. In general, one expects a positive effect of income on savings, primarily reflecting inertia and habit persistence in consumption behaviour. To proxy income at the level of the pseudo individual, we exploit the following question from the EU Consumer Survey on the recent change in the financial situation of households:

How has the financial situation of your household changed over the last 12 months? It has i) got a lot better, ii) got a little better, iii) stayed the same, iv) got a little worse, v) got a lot worse and vi) don't know.

From the individual survey responses, a normalised measures of changes in consumers' financial situation can be constructed by coding individual responses $(y_{n,t})$ in each of the response categories i) to v) as +2, +1, 0, -1, - 2.[4] As in the construction of the measure of savings above, a proxy for income fluctuations $(Y_{i,t})$ at the level of the pseudo individual is then constructed by aggregating over each $\widetilde{m}$ members of the individual pseudo cohort:

$$Y_{i,t} = \sum_{n=1}^{\widetilde{m}} w_{n,t} \; y_{n,t} \tag{2.2}$$

where,

$$y_{n,t} = \begin{cases} 2 & if \ \text{"get a lot better"} \\ 1 & if \ \text{"get a little better"} \\ 0 & if \ \text{"stayed the same"} \\ -1 & if \ \text{"got a little worse"} \\ -2 & if \ \text{"got a lot worse"} \end{cases}$$

Figure 2b presents a bin scatter of the percentiles of this normalised income proxy (x-axis) together with the corresponding percentiles for the measure of savings for each pseudo individual, $S_{i,t}$. In line with theoretical predictions, we observe a very strong and tight positive

[4] Strictly speaking, as the survey question refers to changes in the financial situation of households, it can be interpreted as referring to changes in wealth rather than income *per se*. Of course, for many consumers, changes in their wealth and income are likely to be strongly positively correlated.

association between the income proxy and the likelihood that consumers will save. Such a strong positive association is in line with a high degree of persistence in consumption and that consumers have a strong propensity to save out of past increase in income (or wealth). As well as controlling for the effects of income, any analysis of interest rate transmission to saving must also consider the effects of uncertainty. To do so, and to reflect the important forward-looking dimension of the precautionary savings motive, we exploit a similar but forward-looking question about future changes in consumers' own financial position *over the next 12 months*:

> *Q2: How do you expect the financial position of your household to change over the next 12 months? It will i) get a lot better; ii) get a little better; iii) stay the same; iv) get a little worse; v) get a lot worse and vi) don't know.*

As with past changes in the financial position, a normalised measure of expected income can be constructed from the individual survey responses in our dataset, again aggregating over each $\widetilde{m}$ members of the cohort:

$$Y_{i,t}^{e} = \sum_{n=1}^{\widetilde{m}} w_{n,t}\, y_{n,t}^{e} \tag{2.3}$$

where,

$$y_{n,t}^{e} = \begin{cases} 2 & \text{if } y_{n,t}^{e} \text{ get a lot better} \\ 1 & \text{if } y_{n,t}^{e} \text{ get a little better} \\ 0 & \text{if } y_{n,t}^{e} \text{ stay the same} \\ -1 & \text{if } y_{n,t}^{e} \text{ get a little worse} \\ -2 & \text{if } y_{n,t}^{e} \text{ get a lot worse} \end{cases}$$

For the analysis of how uncertainty might transmit to savings our interest is less in the expected change in a consumer's financial position ($Y_{i,t}^{e}$) but more in a measure of its variability, $\sigma_{i,t}(Y_{i,t}^{e})$. To construct such a measure, we propose a dispersion-based indicator that captures the *within* cohort disagreement about the expected future financial position. The idea that disagreement can serve as a useful proxy for uncertainty goes back at least to Zarnowitz and Lambros (1987). Our proposal to focus on within cohort disagreement captures the intuition that the disagreement amongst agents with similar characteristics may have a strong influence on agents' perceptions of uncertainty. This approach captures the idea that individuals may extrapolate from their peer group when forming estimates about aggregate outcomes. Such peer group effects have been recently studied in Bailey et al. (2018) and Knell and Stix (2019) in relation to the housing market expectations and activity, though to our knowledge we are the first to link the idea of peer group disagreement and the transmission of uncertainty to households. In our application, we focus on an asymmetric or semi-variance measure of dispersion that captures the dispersion that is particularly linked to the risk of future *downside* outcomes, in line with the belief that it is precisely such negative future developments that can incentivise precautionary behaviour:

$$\sigma_{i,t}(Y_{i,t}^{e}) \; = \left[\sum_{n=1}^{\widetilde{m}} I_{n,t}\right]^{-1} \sum_{n=1}^{\widetilde{m}} [Y_{i,t}^{e} - y_{n,t}^{e}\,]^{2} \cdot I_{n,t} \tag{2.4}$$

where,

$$I_{n,t} = \begin{cases} 1 & if\ y_{n,t}^{e} = -2 \\ 1 & if\ y_{n,t}^{e} = -1 \\ 0 & Otherwise \end{cases}$$

$\sigma_{i,t}(Y_{i,t}^{e})$ thus measures the within cohort disagreement about the expected change in consumers' future financial position. When the disagreement among individual responses indicating that the expected future financial situation may deteriorate relative to the cohort mean expected financial position is high (low), the proposed measure of uncertainty will be large (small). Hence, our measure captures uncertainty related to the risk of worse outcomes in the future. This is in line with recent evidence which identifies a close link between overall uncertainty and negative skewness or augmented risks of downside outcomes - see, for example, Barrero and Bloom (2020). Semi-variances are extensively used in finance for similar reasons: intuitively, investors view negatively downside volatility but not upside volatility and empirically models based on semi-variances tend to perform better (Ballestero, 2005; Estrada, 2007). Importantly, if all group members agree - either that the expected financial situation will get a lot worse or get a lot better - the proposed measure is minimized at zero. Figure 2c presents the bin scatter linking our measures of savings to the derived measure of uncertainty. In contrast to the previous plots, in Figure 2c we focus on the fluctuations in savings after controlling also for past changes in income ($Y_{i,t}$), as well as for individual fixed effects and monthly time fixed effects. In line with theoretical predictions that a stronger precautionary motive boosts consumer savings, we observe a clear positive association between savings and our proposed asymmetric dispersion-based uncertainty measure in the scatter plot. These graphical results suggest that the proposed measure proxies well for precautionary effects.

2.3 Expected inflation and real rates

A last step in the construction of our pseudo panel is the estimation of information on inflation expectations and the associated measures of real interest rates. The Consumer Survey includes a direct and quantitative question about consumers' subjective assessment of the expected change in prices:

> *By how many per cent do you expect consumer prices to go up/down in the next 12 months? Consumer prices will increase by __,__%/ decrease by __,__%.*

From the individual replies it is relatively straightforward to derive the corresponding inflation expectations for each cohort "*i*" as

$$\pi_{i,t}^{e} = \sum_{n=1}^{\widetilde{m}} w_{n,t}\pi_{n,t}^{e}$$

A corresponding expected real interest rate is then obtained as $r_{i,t}^{e} = R_{j,t}^{e} - \pi_{i,t}^{e}$ where $R_{j,t}^{e}$ is the matched-horizon nominal interest rate offered by financial institutions on household deposits for up to 1 year in country "j". Our analysis thus assumes that, in the absence of a direct survey measure of nominal interest rate expectations, consumers expect to receive the average nominal interest rate offered in each of the euro area countries. In the regression analysis that is discussed further below, this focus on the average nominal interest rates at the country level helps alleviate concerns about simultaneity. In particular, while interest rates and savings are likely to be simultaneously determined at the aggregate level, it would seem much more reasonable to expect causation would run from aggregate nominal rates to savings behaviour at the level of the pseudo individual and not *vice versa*.

Figure 2d, 2e and 2f reproduce scatter plots of savings on nominal interest rates, expected inflation and the ex-ante real interest rates for each cohort derived as above. In each case the scatters control for the effects of income and uncertainty on savings behaviour, as well as for time and individual fixed effects. For both the nominal and real interest rates, the expected positive association with savings likelihood is clearly observed. In other words, both higher nominal rates and higher real rates are associated with a higher share of individuals in each cohort that is likely to save. In the case of expected inflation, we observe a negative relation, i.e. cohorts who expect higher inflation tend in general to be comprised of consumers who are less likely to save. This is in line with the positive real interest rate relationship above and a positive effect of higher future inflation expectations on current consumption, as for example would be predicted by the consumption Euler equation reflecting an effect of intertemporal prices on consumption (see, for example, Bachmann, Berg and Sims, 2015).

Such basic graphical analysis leaves open, however, many important questions about the nature of interest rate transmission to savings. For example, in terms of their savings behaviour, all other things equal do consumers treat equally – in absolute terms - a 1.0 pp. rise in inflation as they would a 1.0 pp. decline in the nominal interest rate? Put differently, do nominal interest rates only have their effect on savings *via* their effect on real interest rates? Equally, does the effect of a change in nominal interest rates depend on the prevailing *level* of nominal interest rates at the time that interest rates change? In the next section, we lay out an empirical strategy to exploit the pseudo panel to address these specific questions.

3. Methodology and Hypotheses Tests

The central questions we wish to address relate to the transmission of interest rates to savings. In particular, whether consumers adapt more in response to a change in nominal interest rates compared with a change in real rates that take into account their own subjective expectations for inflation. In other words, when they consider the interest rate on their term deposits, do consumers see their savings choice more in nominal than in real terms and thus exhibit some form of "intrinsic money illusion"? Secondly, if nominal rates are special in this sense, we are equally interested in whether or not the prevailing level of nominal rates plays a role, i.e. if interest rate transmission is different in a very low as compared to a normal or relatively high interest rate environment that is further away from the zero lower bound. To shed light on these questions, we exploit a threshold regression with pseudo fixed effects that controls for unobserved but time-invariant heterogeneity at the level of the pseudo individual.

3.1 Threshold Regression with Pseudo Fixed Effects

Our basic reference model relates the share of individual respondents in each cohort who are likely to save $(S_{i,t})$ to a rich array of observables capturing the possible determinants of savings behaviour as described in Section 2 whilst also controlling for other time-invariant and time-varying un-observables:

$$S_{i,t} = \mu_i + \mu_t + \beta_R R^e_{j,t} + \beta_\pi \pi^e_{i,t} + \boldsymbol{\beta_{RD}} R^e_{j,t} \cdot \boldsymbol{D} + \boldsymbol{\beta_X X} + \varepsilon_{it} \qquad (3.1)$$

where μ_i represents pseudo individual fixed effects, μ_t represents monthly time fixed effects which control for high frequency aggregate shocks that simultaneously impact on savings behaviour of all agents and $\boldsymbol{X} = [\, Y_{it,}, \sigma_{i,t}(Y^e_{i,t})\, , \pi^p_{i,t}]$ captures the impact of time- and cross-sectional variation in consumers' past financial situation, uncertainty about consumers' expected future financial position as well as their perceptions about current inflation. ε_{it} is an individual specific error term that we cluster over time at the pseudo cohort level. The centre of our analysis are the parameters represented by β_R, β_π and the parameter vector $\boldsymbol{\beta_{RD}}$. β_R and β_π capture, respectively, the impact of the nominal interest rates and expected inflation on savings, while the vector of parameters $\boldsymbol{\beta_{RD}}$ allows the impact of nominal rates to vary with the level of nominal interest rates by interacting it with a vector of dummy variables $\boldsymbol{D} = [D_{4-3}, D_{3-2}, D_{2-1}, D_{1-0.5}, D_{0.5-0.25}, D_{<0.25}]$, identifying periods when the interest rate was located in specific intervals. These intervals range from relatively high levels of the nominal rate to the current exceptionally low levels and are defined as follows:

$$D_{4-3} = \begin{cases} 1 & if\ 4.0 \geq R^e_{j,t} > 3.0 \\ 0 & Otherwise \end{cases}$$

$$D_{3-2} = \begin{cases} 1 & if\ 3.0 \geq R^e_{j,t} > 2.0 \\ 0 & Otherwise \end{cases}$$

$$D_{2-1} = \begin{cases} 1 & if\ 2.0 \geq R^e_{j,t} > 1.0 \\ 0 & Otherwise \end{cases}$$

$$D_{1-0.5} = \begin{cases} 1 & if\ 1.0 \geq R^e_{j,t} > 0.5 \\ 0 & Otherwise \end{cases}$$

$$D_{0.5-0.25} = \begin{cases} 1 & if\ 0.5 \geq R^e_{j,t} > 0.25 \\ 0 & Otherwise \end{cases}$$

$$D_{<0.25} = \begin{cases} 1 & R^e_{j,t} \leq 0.25 \\ 0 & Otherwise \end{cases}$$

The selected intervals reflect the distribution of nominal interest rates both across time and countries that is observed in our data. Hence, to identify possible level effects from changes in nominal rates, the model will exploit variation in savings likelihood at the cohort level with cross-country and time variation in nominal interest rates on household 1-year term deposits. Figure 3 shows a time series plot illustrating the cross-country variation in nominal household deposit rates that can be exploited by this regression. While the chart highlights a clear co-movement of deposit interest rates with short-term policy interest rates in the euro area, it nonetheless also highlights substantial cross-country variation in the level of nominal interest rates at each point in time. For example, even in the more recent period when the rate on the ECB deposit facility has been negative, household deposit rates have varied persistently across countries ranging for zero to rates as high as 1.5%. Table 1 reports the number and respective share of month-country observations for the nominal interest rate variable. It highlights that the selected intervals are well supported in our dataset - a key requirement for any attempt to identify possible changes in the sensitivity of savings to interest rates for different interest rate levels. For example, the interval associated with nominal interest rates between 2% and 1% has the highest number of interest rate observations (1,024). However even at the extremities of the interest rate distribution, i.e. rates below 0.25% and above 4.0%, the sample has 280 and 276 observations respectively. In our empirical analysis, the vector of parameters $\boldsymbol{\beta_{RD}}$ captures any observed change in the responsiveness of savings to interest rates compared with the responsiveness in the reference interval, $R^e_{j,t} > 4.0$, which is given by the estimate of β_R.

3.2 Restricted Models and Hypothesis Tests

Equation (3.1) represents a general model of savings behaviour that nests several more restricted characterisations. A first such characterisation is that the interest sensitivity of savings is independent of the level of nominal rates, depending solely on the real interest rate:

$$S_{i,t} = \mu_i + \mu_t + \beta_r r^e_{i,t} + \boldsymbol{\beta_X X} + \varepsilon_{it} \tag{3.2}$$

(3.2) is typical of the way interest rate transmission to savings is captured in contemporary macroeconomic models. Comparing with (3.1), this specification requires that all elements of the parameter vector $\boldsymbol{\beta_{RD}}$ are equal to zero and that a change in the nominal rate has an equal but opposite effect to a change in expected inflation i.e. H$_o$: $\boldsymbol{\beta_{RD}} \equiv 0$ *and* $\beta_R = -\beta_\pi$. Such restrictions are consistent with the typical consumption Euler equation used in many macro models. We can test the consistency of this more restrictive "Real rates model" of savings with the data by use of a simple F-test. A second restrictive model of savings that we consider relaxes the assumption that savings responds only to the real interest rate and allows for a differential transmission of nominal interest rates and expected inflation. However unlike (3.1) it assumes that the impact of nominal interest rates is still independent of the level of interest rates, i.e.

$$S_{i,t} = \mu_i + \mu_t + \beta_R R^e_{j,t} + \beta_\pi \pi^e_{i,t} + \boldsymbol{\beta_X X} + \varepsilon_{it} \tag{3.3}$$

For example, if $\beta_R > -\beta_\pi$ consumers would tend to respond more strongly to a reduction in nominal interest rates than they would to an equivalent rise in expected inflation. Such a finding would be more in line with Fisher's (1922) conjecture that consumers tend to be "beguiled by", or simply pay more attention to, changes in nominal interest rates instead of equally taking into account their expectations about future inflation. Such a model of savings is also nested in Equation (3.1) and requires that all elements of $\boldsymbol{\beta_{RD}}$ are equal to zero, i.e. H$_o$: $\boldsymbol{\beta_{RD}} \equiv \mathbf{0}$, implying that there is no change in interest rate sensitivity of savings over any of the predetermined intervals included in $\boldsymbol{D}$. We can again test this "No threshold effect" hypothesis directly with the use of a simple F-test. Rejection of this null hypothesis would imply some dependence of the interest rate sensitivity on the level of nominal rates and the sign of each element of $\boldsymbol{\beta_{RD}}$ would offer insight on whether interest rate transmission strengthens or declines with the level of nominal rates. For example, if interest rate transmission declines with the level of nominal interest rates, we would expect some elements of $\boldsymbol{\beta_{RD}}$ to be statistically significant and negative. The next section presents empirical evidence on the plausibility of these two more restricted representations of savings behaviour relative to the general threshold model in equation (3.1).

4. Micro Evidence

This section presents empirical results analysing the key determinants of savings in the euro area using the pseudo panel dataset constructed in Section 2. In section 4.1 we present empirical estimates of the two restricted models given by (3.2) and (3.3). In section 4.2 we then examine the evidence on whether and how interest rate transmission to savings depends on the level of nominal rates using the general fixed effects threshold regression model (3.1) before providing in section 4.3 the results of hypotheses tests yielding direct evidence on whether the estimated interest rate level effects are important features of the data. Finally, section 4.4 discusses whether the results can be given a causal interpretation linked to the assumed exogeneity of the nominal rate in the baseline regression model.

4.1 Restricted Model Results

Table 2 presents the regression results for the two restricted models represented by equations (3.2) and (3.3). In column (1) the coefficient estimates from the real rate model of savings are reported. At first pass, the model appears to offer an economically coherent account of the determinants of savings. The variable capturing fluctuations in income has the strongest impact on the likelihood of savings while uncertainty about downside developments in households' expected financial situation has a more muted but still statistically significant positive effect on savings. The coefficient on the real interest rate is also positive in line with conventional economic theory and statistically significant at the 5% level, though compared with the other savings determinants it has the smallest overall economic effect.

Column (2) in Table 2 instead reports the estimated coefficients for the model which relaxes the assumption that savings are driven by real rates but instead allows for separate effects of nominal interest rates and expected inflation. All estimated coefficients in this model again point in the expected direction, in line also with the previous graphical evidence in Section 2. However, in this specification, the coefficient on nominal rates is almost four times higher in absolute terms compared with the coefficient on expected inflation. According to the estimated parameters, a 1.0 pp. rise in expected inflation would increase the average share of consumers likely to save in each cohort by less than by 0.5 percentage point (pp.) while an equivalent change in the nominal rate would raise this share by more than 1.7 pp.s. An F-test of the hypothesis that $\beta_R = -\beta_\pi$ has a value of 22.81 and thus strongly implies that this restriction is not consistent with the data (P-value <0.0001). These results imply that consumers do not take saving decisions purely in real terms but instead they appear to be on average much more sensitive to fluctuations in nominal rates. This first evidence is also consistent with the hypothesis of some form of money illusion linked to a greater importance of nominal concepts as determinants of savings.

4.2 Threshold Regression Results

Column (1) of Table 4 presents the estimation results for the full threshold regression model (3.1). The parameter estimates related to income and uncertainty are very close to the corresponding estimates from the two more restricted models discussed above. In particular, the threshold regression also implies a strong positive and significant effect of income on savings. Also, the effect of uncertainty is considerably more muted than income though it is still highly significant in line with an important role for downside income risk in driving precautionary savings. The effect of nominal interest rates for the reference interval at relatively high levels (above 4.0%) is also positive in line with conventional views on the response of savings to interest rates. According to the estimated parameter, a 1.0 pp. increase in the nominal interest rate would be associated with a 1.65 pp. rise in the share of consumers that are likely to save in each cohort. This relatively large and significant effect dominates a much smaller 0.43 pp. effect from expected inflation – a result which is again in line with the evidence reported in Section 4.1. However, we observe that the interactions with all interest rate thresholds are highly significant, implying a strong dependence of the interest rate elasticity of savings on the level of nominal rates.

The key pattern we observe is the negative sign and gradual increase in the absolute magnitude of the interaction coefficient as we move towards lower values of the nominal rate. This result implies that interest rate transmission to savings is declining in the level of the nominal rate. Column (1) of Table 6 reports the overall response of savings to nominal interest rates at different levels of the nominal rate i.e. the reference response plus any change in the response associated with a given threshold. According to the estimates, an increase in the nominal rate is associated with a positive savings response when $R_{j,t}^{e}$ is above 2%. In the intervals between 2.0% and 1.0% and 1.0% and 0.5%, respectively, the response though still positive is not significantly different from zero. Of particular note is the observed change in the sign of the response of savings to interest rates at exceptionally low levels of the nominal rate. When $R_{j,t}^{e}$ is below 0.5%, we observe a substantial negative response of savings while for interest rate levels below 0.25% the estimated magnitude of this negative response is even stronger. Figure

4 gives a graphical illustration of the estimated responses over different thresholds. At ultra-low levels of the nominal rate (e.g. below 0.25%) the model implies a very strong increase in savings in response to any further interest rate reductions. At -0.0773 the estimated coefficient implies a savings response that is considerably stronger than the estimated effects of uncertainty and close to half the magnitude of the income coefficient in absolute terms. Overall, our results imply a very strong dependence of the savings response to interest rates on their level and a quite dramatic reversal of the direction of conventional interest rate transmission at ultra-low levels of the nominal rate. As a further check on this result, Appendix II reports further model estimations whilst excluding specific consumer groups from the estimation. The results from these estimations suggest that the decline in the response of savings associated with the level of nominal rates is not driven by particular groups but is a quite generalized phenomenon in the population. However, the significance of the reversal in the response of savings to interest rates appears to be predominantly driven by older consumers and consumers with lower educational attainment who may have lower levels of overall financial literacy. In Section 5 we discuss the potential policy implications of this heterogeneity.

4.3 Hypotheses tests

Table 3 presents the results of hypotheses tests that provide direct evidence on whether or not the data support the more restricted models of savings that are nested within the threshold model that lets the interest rate sensitivity of savings depend on the level of interest rates. The first row of Table 3 tests the restrictions $\boldsymbol{\beta_{RD}} \equiv 0 \textit{ and } \beta_R \equiv -\beta_\pi$ implied by the real rates model from column (1) of Table 2. The second row of Table 3 tests the less restrictive model (3.3), which allows for differential effects of nominal rates and expected inflation but excludes threshold effects associated with the level of nominal rates. Though both models exhibit highly plausible economic effects, in each case we strongly reject each of them in favour of the general threshold regression model given by (3.1). The results of these hypotheses test therefore offer further evidence against the idea that consumers make their savings choice simply in real terms. Instead the evidence strongly suggests that the level of nominal interest rates and the associated nominal interest rate thresholds, are important for understanding the savings response to changes in interest rates.

4.4 A causal interpretation?

Although our use of microdata for a cross-section of consumer cohorts as well as estimation with pseudo fixed effects using cross-country variation in *aggregate* nominal interest rates should limit concerns about endogeneity as a driver of our results, it is useful to check the overall robustness of the findings to the assumed exogeneity of $R^e_{j,t}$. Taking account of the potential endogeneity of $R^e_{j,t}$ in the fixed-effects threshold regressions requires at least seven instrumental variables: one instrument for the reference rate and one for each of its interactions with the six threshold dummies. We consider four separate IV regressions to examine the overall robustness of our results with respect to endogeneity concerns. In all IV models, we apply a two-stage least squares estimator with heteroscedasticity robust standard errors, clustered at the level of the pseudo-individual (Schaffer, 2010).

IV with lags of $R^e_{j,t}$ as instruments

A first IV specification uses $R^e_{j,t-1}$ and its interaction with the set of threshold dummies, $R^e_{j,t-1} \cdot \boldsymbol{D}$, as instrumental variables. This choice reflects the idea that the lagged nominal rate is a plausible source of more exogenous variation in the deposit interest rates that is highly correlated with $R^e_{j,t}$ but as it is temporally exogeneous should not be correlated with ε_{it}. A second proposed IV specification builds on similar logic and uses both the first and second lags of the nominal rate, $R^e_{j,t-1}$ and $R^e_{j,t-2}$, as well as their interactions with the threshold dummies, $R^{e}_{j,t-1} \cdot \boldsymbol{D}$ and $R^{e}_{j,t-2} \cdot \boldsymbol{D}$, as instrumental variables. The results from these IV specifications are reported in columns (2) and (3) of Table 4, with the corresponding estimated effect of the nominal rate at different thresholds reported in columns (2) and (3) of Table 6 and panels a and b of Figure 5. All the estimated IV models have coefficients for the other main covariates (inflation expectations, income and uncertainty) that are very close to the baseline estimation. The adjusted within R-squared is also comparable. Both instrumental variable models are clearly relevant, with very large first-stage F statistics (since for each IV model there is one F statistic for each of the seven variables that are instrumented, we report only the smallest one). For the model in column (3) of Table 4, where we have more instruments than variables instrumented, we can also perform a test of overidentifying restrictions. The corresponding Hansen J statistic is small, indicating that we cannot reject the null hypothesis that the instruments are uncorrelated with the error term, providing additional confidence on instrument validity.

Given that these two IV models appear well specified and valid we now turn to a discussion of the estimated interest rate transmission. The IV models show a comparable pattern and a set of interest rate coefficients that are of a very similar magnitude to the baseline regression (reported for comparison in column (1) of Table 4 and, in terms of effects across intervals, in column (1) of Table 6). In particular, the IV estimations identify significant positive effects of the deposit rate on savings for relatively high levels of the deposit rate, but the savings response is consistently declining with the level of rates. Below 0.5% the estimated savings response also turns negative though the negative change in the response is marginally smaller in absolute terms in each of the IV regressions. As can be seen in Table 6, the savings reversal is therefore less precisely estimated compared with the baseline model. However, for the lowest threshold values of below 0.25% in the IV regression with both lags of the nominal deposit rate used as instruments we observe a negative effect of interest rates on savings that is significant at the 10% level (see also column (3) of Table 6).

IV with monetary policy and central bank information shocks

We rely on a further IV specification where we exploit for identification two exogenous shocks associated with central bank announcements for the euro area as derived by Jarociński and Karadi (2020). Using the high-frequency co-movement between stock prices and interest rates around central bank announcements, Jarociński and Karadi (2020) identify two different shocks associated with central bank announcements (henceforth "JK shocks"). The first of these captures conventional effects of monetary policy tightening and loosening and induces a negative correlation between stock prices and the interest rate. The second, in contrast, induces a positive correlation between stock prices and interest rates and is linked to central bank communication about the state of the economy.[5] As these shocks represent exogenous movements in policy rates that could plausibly transmit through to other interest rates in the economy, they represent valid and potentially relevant instrumental variables for household deposit rates. Importantly, as the JK shocks are at the euro area level, they are - on their own

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[5] To identify the two shocks, Jarociński and Karadi (2020) record surprises in the EONIA interest rate swaps with maturities of one month up to two years around the time of central bank announcements. Most of these announcements happen after the ECB Governing Council monetary policy meeting and consist of a press statement at 13:45 hours followed by a press conference at 14:30 hours that lasts about one hour. They then use a 30-minute window around press statements and a 90-minute window around press conferences, both starting 10 minutes before and ending 20 minutes after the event. In our IV regressions, we use the shocks identified in their baseline specification, based on this high frequency identification combined with sign restrictions.

- collinear with the year-month fixed effects included as a control for aggregate shocks. However, we can generate a total of twelve exogenous instruments based on the interactions of the first and second lags of, in turn, each of the JK shocks with the six threshold dummies which vary both over time and across countries. The results from these additional IV specifications are reported in columns (2) and (3) of Table 5, while the corresponding effects across intervals are reported in columns (4) and (5) of Table 6 and panels c and d of Figure 5. In this case too, the models have coefficients for the main covariates (inflation expectations, income and uncertainty) and adjusted R-squared statistics that are close to the baseline. The first stage F statistics again confirm the relevance of the instruments although they are lower compared to the IV models using the lagged nominal rates as instruments. In fact, while we report the lowest first-stage F statistic for each model in Table 5, the highest for the monetary policy shock is 89.61 and for the central bank information shock 206.29. A Hansen J statistic for the test of overidentifying restrictions is small for the monetary policy shock but relatively high for the central bank information shock. Although this empirically suggests that the latter set of instruments may not be valid, the use of high-frequency data around the time of central bank press conferences in the identification of these shocks strongly supports the assumed exogeneity.

Crucially, as with the baseline model, each shock allows to identify an effect at different levels of the nominal rate. The monetary policy shock identifies a positive effect of the nominal interest rate on the saving response, in line with a substitution effect, whenever the nominal rate is above 1%. The central bank information shock, on the other hand, identifies a negative effect of the nominal interest rate on the saving response, in line with an income effect, below a threshold of 0.5%. The magnitude of the estimated response is, in both cases, considerably larger than the baseline regression estimates. These results are particularly interesting in light of the liquidity trap considerations highlighted in the introduction. For example, Bilbiie (2018) suggests, as one of the tests to discriminate between a fundamental and a confidence-driven liquidity trap, to assess whether a decrease in the nominal interest rate is contractionary (confidence-driven) or expansionary (fundamental) in terms of the estimated consumption and inflation responses. We find that the savings response to a decrease in the nominal interest rate may be contractionary precisely at low levels of the nominal interest rate when a liquidity trap would be more likely to occur. Moreover, this effect is identified by an information shock, which is the precise channel that Bilbiie (2018) highlights as being dominant in a confidence driven liquidity trap.

Taken together, the IV results confirm the declining pattern of the effect of nominal interest rates observed in the baseline fixed-effects threshold regression, as well as providing further evidence of the existence of a savings reversal at ultra-low nominal interest rates. We impute the heterogeneity in coefficient estimates across IV models to differences in the relevance of the instruments. For instance, while more credibly exogenous, the monetary policy and central bank information shocks represented by the JK shocks might not be equally relevant to the nominal deposit rates in all countries, thereby generating quite different coefficients from those of the lagged nominal deposit rates which may be more easily observable by all households. In other words, the "compliers" (i.e. those exposed to the specific exogenous variation that we use) are different between the IV specifications. For the JK shocks, one possible explanation for the strong effect when the interest rate is at low levels is that compliers are more likely to pay attention to interest rates and central bank announcements in such an environment. Similarly, if the compliers are more likely to pay attention, they may also react more strongly - or indeed over-react - and this may help explain why the size of the effect using the JK shocks as instruments is greater than in the baseline specification.

5. Discussion and conclusions

In this paper, we have addressed two related and important empirical questions: Firstly, what can the micro evidence tell us about how households take interest rates into account when they change their savings behavior? And, second, does the nature of the household savings response to interest rates depend on their level? These questions are central to discussions of monetary transmission and they took on an added relevance during the recent period where central banks have lowered policy rates to very low and even negative levels putting increased pressure on the financial system to pass these low rates onto the rates offered on household deposits and savings accounts.

To address these questions, we focus on the unique and persistent experience of low and negative policy rates in the euro area and build a panel of cohorts of consumers sharing similar characteristics and then exploit cross-country and within variation in consumer savings behavior for these cohorts to identify the interest rate effects of interest. Importantly, our adopted approach is able to identify a net effect of interest rates after controlling for other key savings determinants, most notably fluctuations in consumers' current financial situation and their uncertainty related to their expected financial situation in the future as well as other aggregate shocks, key demographic characteristics and sources of unobserved consumer heterogeneity. Concerning the first question, the microdata data overwhelmingly suggest that consumers do not take their savings decisions in purely real terms. Although consumers' subjective expectations about future inflation certainly influence the savings decision in line with the expected effect of intertemporal prices, nominal interest rates appear to be more relevant both on average and in absolute terms. As a result, the simple real rates model of interest rate transmission - typical of most conventional macroeconomic models - which is nested within our general framework is found to be strongly rejected by the data. This finding is in line with a large body of experimental evidence emphasizing the importance of nominal representations in consumer decisions.

Regarding the second question, the micro evidence also strongly demonstrates how the strength and even the sign of interest rate transmission to savings depends on the level of nominal interest rates. At relatively high levels of nominal rates, the response of savings to interest rate changes is positive in line with the assumptions embedded in most mainstream economic models. However, the magnitude of the savings response to interest rates declines steadily as the level of nominal rates declines. Such a result suggests that the level of nominal rates may alter the relative weight of income versus substitution effects as drivers of savings behavior. Moreover, for very low levels of nominal rates (e.g. below 0.5%) we find some evidence of a saving's reversal where savings starts to increase in response to further reductions in nominal rates. Such a reversal may reflect an enhanced role for target wealth in driving savings whereby risk-averse savers respond to lower rates by increasing their level of active savings in order to provide for future retirement or consumption needs. This pattern is also consistent with possible contractionary effects of interest rate reductions in the presence of a confidence-driven liquidity trap, where income effects dominate substitution effects through the persistence of consumers' expectations on the future state of the economy. We also find evidence of this "news" channel by employing exogenous central bank information shocks, which identify a reversal in the response of savings to interest rates below a nominal rate level of 0.5%. While such a reversal in interest rate transmission has been prominently discussed in relation to banks loans (Brunnermeier and Koby, 2018; Repullo, 2020), some more recent empirical studies have also documented its potential relevance for macroeconomic aggregates (van den End et al., 2020; Colciago et. al, 2019; Borio and Hofmann, 2017; Nabar, 2011 and Aizenman et al., 2019)). However, our paper makes an important further contribution by identifying more precisely the nature of these nonlinearities by using the power of micro data to test their empirical and causal relevance.

This evidence on the importance of the level of nominal - as opposed to real - rates for understanding interest rate transmission to households raises important questions for policy. In the first instance, the direct stimulus to demand and household consumption from reductions in nominal interest rates is likely to diminish in potency as interest rates decline. Moreover, reductions in nominal rates to very low levels may potentially give rise to upward pressure on consumer savings as households strive to compensate for the associated decline in nominal interest income. However, our results do not imply that ultra-low household deposit rates driven by negative policy rates would necessarily imply an overall contractionary impact on the economy. This is because our findings largely pertain to the direct impact effects on savings linked to changes in nominal rates, while the full general equilibrium effects of interest rate changes will include other indirect channels of transmission via expected future income, employment as well as changes in uncertainty, asset prices and effects associated with the possible re-allocation of household wealth across different asset classes. However, the non-linearities that are uncovered in the microdata certainly suggest scope to improve the public's understanding about the reasons for interest rate changes and the importance of real interest rate considerations in economic decisions. The finding that central bank information shocks may play a role in triggering a savings reversal at low rates suggests a need to emphasize more the benefits of lower rates for future household incomes in central bank communication. Importantly, our evidence suggests that the decline in the response of savings associated with the level of nominal rates is not driven by particular groups but is a quite generalized phenomenon in the population. However, the significance of the reversal in the response of savings to interest rates appears to be predominantly driven by older consumers and consumers with lower educational attainment who may have lower levels of overall financial literacy. This suggests that the savings reversal need not be taken as an immutable "fact of life" but instead it may be influenced by households' ability to gradually learn over time. For this reason, as discussed, for example, in Lusardi and Mitchell (2014), public policies aimed at enhancing levels of financial literacy, knowledge about inflation as well as the reasons behind low and negative nominal interest rate policies may be particularly important in enhancing policy effectiveness in a low interest rate environment.

Our evidence also points to the need for further research to better understand the general equilibrium implications of the influence of nominal as opposed to real rates on the consumer savings as well as the economic mechanisms - both behavioral and non-behavioral - that may explain the non-linearities in the transmission of nominal rates that we have identified. One particularly important aspect that we have not addressed here relates to the composition of household savings and whether lower rates can stimulate a shift of households into more risky asset classes. Although traditionally, and especially in Europe, a very high share of households have shown a strong aversion to direct exposure to stock markets and other risky asset classes (see, for example, Guiso et al. 2003), such risk-taking behavior can help stimulate economic activity by increasing investment and employment and thereby offset any contractionary effects associated with a short-term rise in savings in response to ultra-low nominal rates. On the other hand, ultra-low or negative nominal interest rates may also encourage some households to take on risks that they are less well-equipped to manage or assess, thus raising potentially important financial stability considerations.

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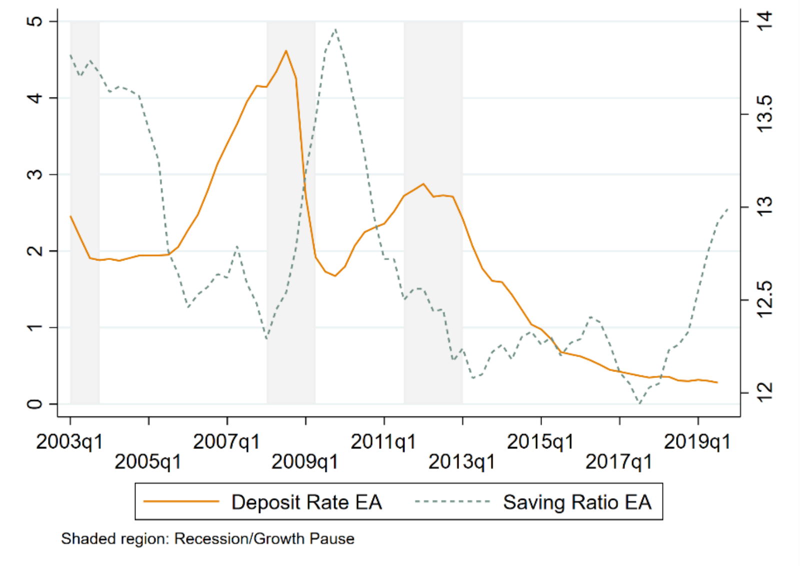
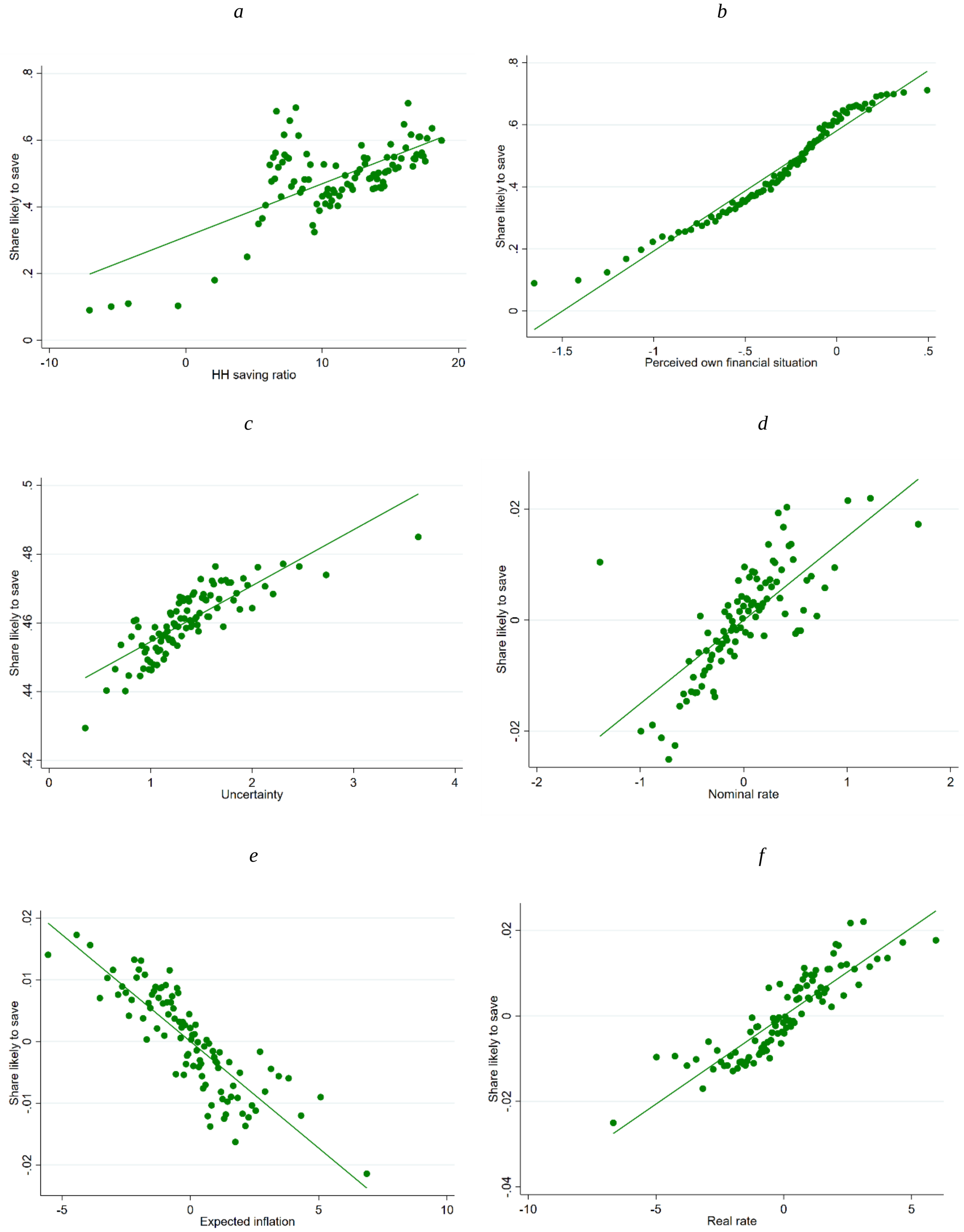
Tables and charts

Figure 1: Euro area household nominal deposit rate and the household saving ratio



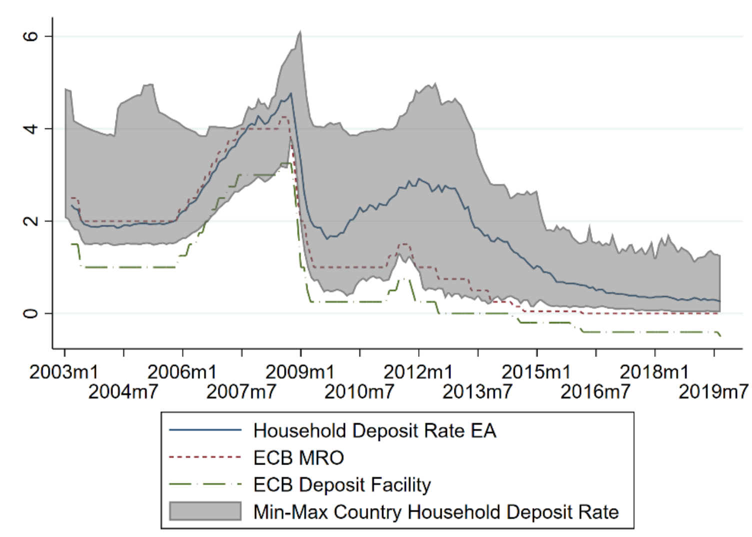
Note: The euro area deposit rate (left axis) is the average annualised agreed rate on household deposits with maturity of up to 1 year. The euro area saving ratio (right axis) is the gross saving of households as a ratio of adjusted gross disposable income. Recession/growth pause as defined by the CEPR business cycle dating committee.

Figure 2: Household savings propensity and key variables of interest



Note: Panels *a* to *f* present binned scatter plots (Stepner, 2013) of the share of consumers likely to save for each consumer cohort as obtained from the survey (y axis) and six key variables of interest. The binned scatter plots are created by grouping each variable in 100 equally-sized bins and then computing the mean within each bin. Panel *a* is first aggregated at the country-quarter level. Panel *c* controls for the income measure and for time and pseudo-individual fixed effects. Panels *d* to *f* control additionally for the uncertainty measure.

Figure 3: ECB policy rates and household deposit rates in the euro area



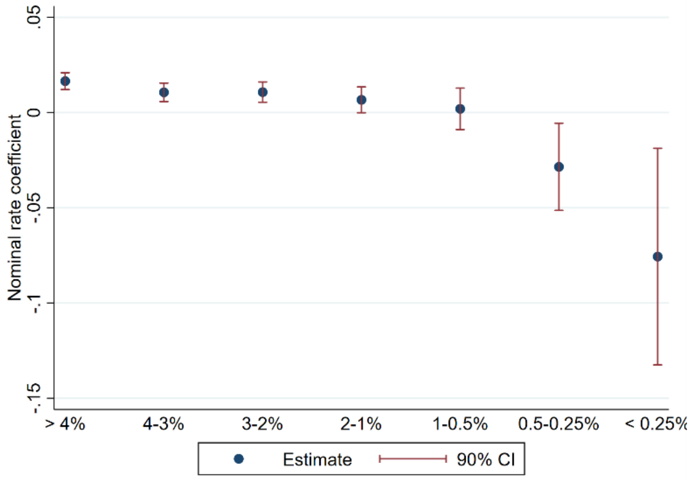
Note: The euro area household deposit rate is the average annualised agreed rate on household deposits with maturity of up to 1 year, while the shaded area represents the corresponding range at the country level. The MRO (Main Refinancing Operation) rate and the Deposit Facility rate are European Central Bank official rates.

Table 1: Shares of observations for different levels of the household nominal deposit rate

Interval	Observations	Share
$> 4\%$	276	0.085
4-3%	276	0.085
3-2%	631	0.194
2-1%	1024	0.315
1-0.5%	415	0.128
0.5-0.25%	348	0.107
$< 0.25\%$	280	0.086
Total	3250	1

Note: The table reports the number of observations and shares for each interval of the nominal rate. The nominal rate is the average annualised agreed rate on household deposits with maturity of up to 1 year.

Figure 4: Savings response to nominal deposit rates over different intervals



Note: For each interval of the nominal rate, the reported estimates are the effect of the nominal rate from model 3.1 (Baseline) and its 90% confidence interval.

Table 2: Linear models of savings behaviour

	(1)	(2)
$r^e_{i,t}$	0.00537***	
	(0.000708)	
$R^e_{j,t}$		0.0171***
		(0.00255)
$\pi^e_{i,t}$		-0.00433***
		(0.000739)
$Y_{i,t}$	0.151***	0.158***
	(0.00739)	(0.00748)
$\sigma_{i,t}(Y^e_{i,t})$	0.0152***	0.0162***
	(0.00186)	(0.00193)
Observations	38616	38616
Adj. within R-squared	0.240	0.244
Individual FE	YES	YES
Time FE	YES	YES

Note: The table reports the results for two restricted and linear models of the savings propensity without thresholds. Model (1) corresponds to equation 3.2 and model (2) to equation 3.3. The test of the restriction that $\beta_R = -\beta_\pi$ for model (2) has an $F_{1,362}$ statistic of 22.81***. Standard errors in parentheses, clustered over time at the pseudo-individual level. Additional controls not reported: $\pi^p_{i,t}$. * p < 0.10, ** p < 0.05, *** p < 0.01.

Table 3: Tests of the relevance of the real interest rate model and nominal interest rate thresholds

H_0	Restrictions	F Stat	P-value
(1) Real rates model	$\beta_{RD} \equiv 0$ and $\beta_R \equiv -\beta_\pi$	$F_{7,362} = 13.93$	< 0.0001
(2) No threshold effect	$\beta_{RD} \equiv 0$	$F_{6,362} = 9.07$	< 0.0001

Note: The hypotheses tests refer to restrictions to model 3.1, comparing it to models 3.2 (Hypothesis 1) and 3.3 (Hypothesis 2) respectively.

Table 4: Baseline and IV savings models with interest rate thresholds

	(1) Baseline	(2) 1st lag	(3) 1st-2nd lag
$R^e_{j,t}$	0.0165***	0.0179***	0.0182***
	(0.00269)	(0.00299)	(0.00299)
$R^e_{j,t} \cdot D_{4-3}$	-0.00587***	-0.00592***	-0.00558***
	(0.000956)	(0.000989)	(0.000986)
$R^e_{j,t} \cdot D_{3-2}$	-0.00578***	-0.00525***	-0.00521***
	(0.00150)	(0.00163)	(0.00162)
$R^e_{j,t} \cdot D_{2-1}$	-0.00982***	-0.00861***	-0.00872***
	(0.00242)	(0.00283)	(0.00280)
$R^e_{j,t} \cdot D_{1-0.5}$	-0.0145***	-0.0112*	-0.0117*
	(0.00515)	(0.00629)	(0.00621)
$R^e_{j,t} \cdot D_{0.5-0.25}$	-0.0450***	-0.0351**	-0.0361***
	(0.0129)	(0.0139)	(0.0137)
$R^e_{j,t} \cdot D_{0.25}$	-0.0921***	-0.0675**	-0.0738**
	(0.0341)	(0.0306)	(0.0315)
$\pi^e_{i,t}$	-0.00434***	-0.00437***	-0.00433***
	(0.000744)	(0.000753)	(0.000760)
$Y_{i,t}$	0.157***	0.158***	0.158***
	(0.00737)	(0.00742)	(0.00744)
$\sigma_{i,t}(Y^e_{i,t})$	0.0162***	0.0163***	0.0163***
	(0.00191)	(0.00191)	(0.00192)
Observations	38616	38376	38161
Adj. within R-squared	0.246	0.240	0.241
Individual FE	YES	YES	YES
Time FE	YES	YES	YES
Hansen J	-	-	10.36
Min first stage F Stat	-	2098.58***	1522.45***

Note: The model in column (1) is the baseline, while column (2) and (3) are instrumental variable models where we instrument with, in turn, the first lag of the nominal rate and the first and second lag of the nominal rate, each interacted with the threshold dummies. Standard errors in parentheses, clustered over time at the pseudo-individual level. Additional controls not reported: $\pi^p_{i,t}$. * p < 0.10, ** p < 0.05, *** p < 0.01.

Table 5: Baseline and IV savings model with interest rate thresholds

	(1) Baseline	(2) Monetary shock	(3) Information shock
$R^e_{j,t}$	0.0165***	0.0432***	-0.00253
	(0.00269)	(0.0150)	(0.0109)
$R^e_{j,t} \cdot D_{4-3}$	-0.00587***	0.00191	-0.00684**
	(0.000956)	(0.00665)	(0.00339)
$R^e_{j,t} \cdot D_{3-2}$	-0.00578***	0.0159	-0.00944
	(0.00150)	(0.0125)	(0.00777)
$R^e_{j,t} \cdot D_{2-1}$	-0.00982***	0.0414	-0.0238
	(0.00242)	(0.0314)	(0.0165)
$R^e_{j,t} \cdot D_{1-0.5}$	-0.0145***	0.00691	-0.0531
	(0.00515)	(0.0416)	(0.0350)
$R^e_{j,t} \cdot D_{0.5-0.25}$	-0.0450***	-0.158	-0.226***
	(0.0129)	(0.163)	(0.0861)
$R^e_{j,t} \cdot D_{0.25}$	-0.0921***	-0.0527	-0.391**
	(0.0341)	(0.189)	(0.168)
$\pi^e_{i,t}$	-0.00434***	-0.00484***	-0.00418***
	(0.000744)	(0.000911)	(0.000783)
$Y_{i,t}$	0.157***	0.191***	0.152***
	(0.00737)	(0.0165)	(0.0106)
$\sigma_{i,t}(Y^e_{i,t})$	0.0162***	0.0160***	0.0153***
	(0.00191)	(0.00236)	(0.00193)
Observations	38616	38601	38601
Adj. within R-squared	0.246	0.117	0.220
Individual FE	YES	YES	YES
Time FE	YES	YES	YES
Hansen J	-	3.96	15.29***
Min first stage F Stat	-	10.76***	19.34***

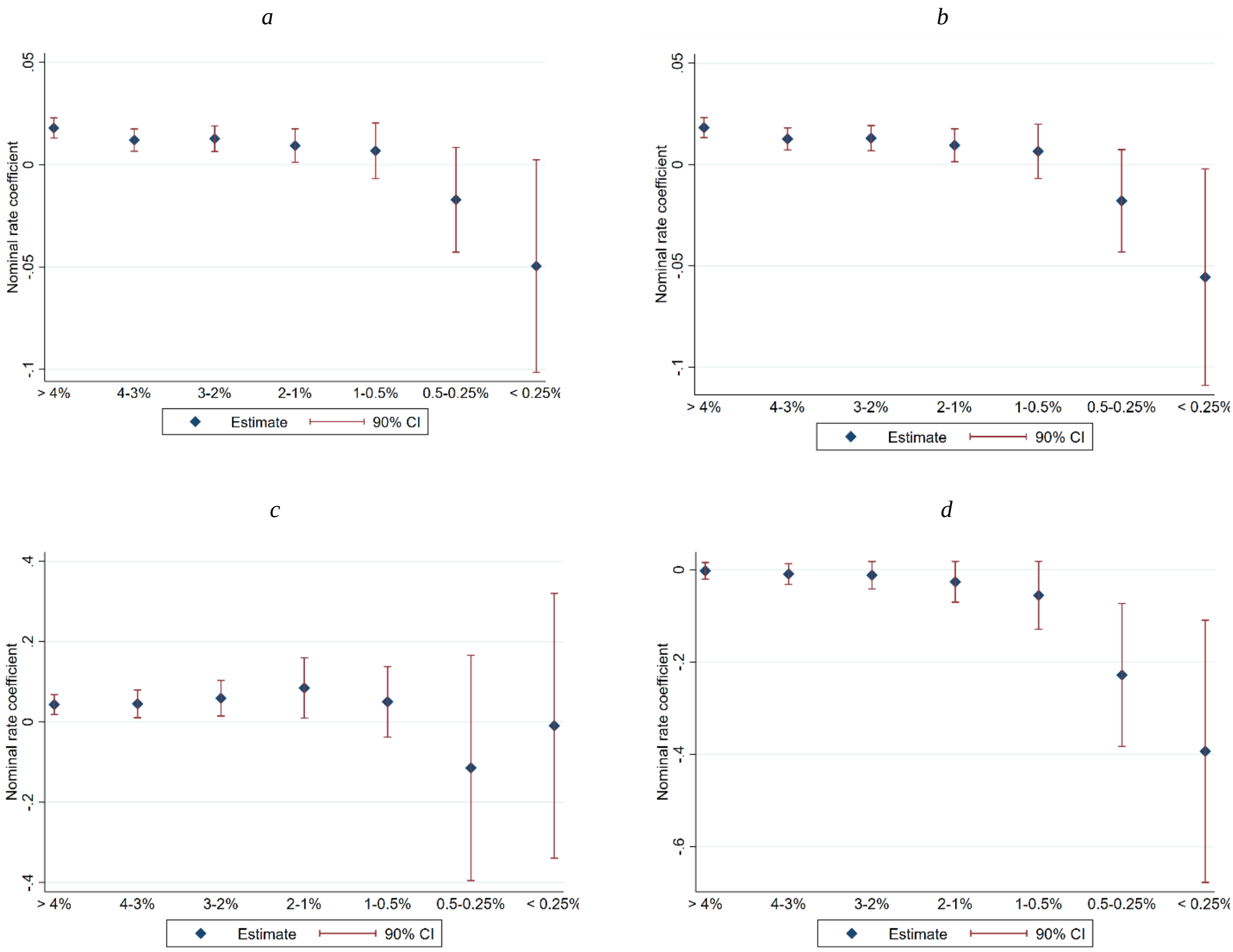
Note: The model in column (1) is the baseline, while column (2) and (3) are instrumental variable models where we instrument the nominal rate and its interactions with the thresholds with, in turn, the monetary policy shock lagged one and two months, and the central bank information shock lagged one and two months. Standard errors in parentheses, clustered over time at the pseudo-individual level. Additional controls not reported: $\pi^p_{i,t}$. * p < 0.10, ** p < 0.05, *** p < 0.01.

Table 6: Savings response to nominal deposit rates over different intervals

	(1) Baseline	(2) 1st lag	(3) 1st-2nd lag	(4) Monetary shock	(5) Information shock
Interval					
$> 4\%$	0.0165***	0.0179***	0.0182***	0.0432***	-0.00253
	(0.00269)	(0.00299)	(0.00299)	(0.0150)	(0.0109)
$4 - 3\%$	0.0106***	0.0120***	0.0127***	0.0451**	-0.00937
	(0.00293)	(0.00330)	(0.00330)	(0.0209)	(0.0136)
$3 - 2\%$	0.0107***	0.0127***	0.0130***	0.0590**	-0.0120
	(0.00323)	(0.00378)	(0.00376)	(0.0269)	(0.0180)
$2 - 1\%$	0.0067	0.0093*	0.0095*	0.0846*	-0.0263
	(0.00411)	(0.00496)	(0.00492)	(0.0455)	(0.0268)
$1 - 0.5\%$	0.0019	0.0068	0.0065	0.0501	-0.0556
	(0.00660)	(0.00824)	(0.00814)	(0.0533)	(0.0446)
$0.5 - 0.25\%$	-0.0285**	-0.0172	-0.0179	-0.1146	-0.2282**
	(0.0139)	(0.0155)	(0.0153)	(0.1702)	(0.0939)
$< 0.25\%$	-0.0757**	-0.0496	-0.0556*	-0.00957	-0.3935**
	(0.0345)	(0.0315)	(0.0324)	(0.2000)	(0.1723)

Note: For each interval of the nominal deposit rate, the reported estimates are the effect of the nominal rate on savings behaviour for the baseline model in column (1), for the IV regressions using the first lag of the nominal rate in column (2), the first and second lag of the nominal rate in column (3), for the first and second lag of the monetary policy shock in column (4) and the first and second lag of the central bank information shock in column (5).

Figure 5: IV estimate of the savings response to nominal deposit rates over different interest rate intervals



Note: For each interval of the nominal rate, the reported estimates are the effect of the nominal rate instrumented by the first lag of the nominal rate (panel *a*), the first and second lag of the nominal rate (panel *b*), the first and second lag of the monetary policy shock (panel *c*) and the first and second lag of the central bank information shock (panel d).

Appendix I: Further details on data sources

Most of the data used in this study comes from the EU Consumer Survey of the European Commission, complemented by additional macroeconomic time-series. Both sources are described more in detail below.

Consumer Survey: The Consumer Survey collects individual level data under the framework of the Joint Harmonised EU Programme of Business and Consumer Surveys (BCS). The surveys are conducted by the Directorate General for Economic and Financial Affairs (DG ECFIN) of the European Commission (EC). The consumer component of the survey is the largest of its kind, covering all of the EU member states. In the current application, to the euro area (EA) countries, the survey comprises approximately 26,440 individual responses collected monthly. Equivalent surveys for the US, such as the University of Michigan Consumer Survey, or the Federal Reserve Bank of New York Survey of Consumer Expectations (SCE), include 500 and 1300 respondents respectively. The BCS was launched as early as 1962 for the manufacturing sector, with the consumer part added in 1972. The surveys are carried out at a national level by partner institutes, which retain ownership of the data and can be contacted directly for access. Specifically, the dataset we use is a subset of the BCS focusing on quantitative inflation perceptions and expectations, and it is described in Duca-Radu, Kenny and Reuter (2021) and Arioli et al. (2017). The underlying microdata is provided to the ECB by DG ECFIN for joint research purposes on the agreement with all national partner institutes. The complete pseudo panel dataset used in this study can be obtained from the authors upon request. Our sample is limited in time and scope as compared to the entire BCS: it starts in May 2003, the first month in which quantitative questions on inflation perceptions and expectations were introduced, and ends in March 2019.

Inflation perceptions: In addition to the survey questions included in the main text, we also use one additional question on inflation perceptions:

By how many per cent do you think that consumer prices have gone up/down over the past 12 months? (Please give a single figure estimate). Consumer prices have increased by ___,_ % / decreased by ___,_ %.

1-year deposit rate (EA and by country): Annualised agreed rate (AAR) on household deposits with an agreed maturity of 1 year/ Narrowly defined effective rate (NDER). Credit and other institutions (MFI except MMFs and central banks) reporting sector. Deposits with agreed maturity up to 1 year, new business coverage. Households and non-profit institutions serving the households sector, denominated in Euro**.** Monthly frequency**.** Source: ECB Statistical Data Warehouse MFI Interest Rate Statistics.

Households savings ratio (EA): Gross saving of households as a ratio of adjusted gross disposable income**.** Households and non-profit institutions serving households (NPISH) reporting sector. Current prices, domestic currency (including conversion to current currency made using a fixed parity). Ratio to the annual moving sum of sector specific gross disposable income, adjusted for change in net equity of households in pension funds reserves. Neither seasonally adjusted nor calendar adjusted. Quarterly frequency. Source: ECB Statistical Data Warehouse ESA2010 quarterly financial and non-financial sector accounts.

Main Refinancing Operations (MRO): Fixed rate tenders rate (from October 2008 onwards) and variable rate tenders minimum bid rate (before October 2008) combined. Source: Key ECB interest rates (https://www.ecb.europa.eu/stats/policy_and_exchange_rates/key_ecb_interest_rates/html/index.en.html).

Deposit Facility: Rate on overnight deposits with the Eurosystem. Source: Key ECB interest rates (https://www.ecb.europa.eu/stats/policy_and_exchange_rates/key_ecb_interest_rates/html/index.en.html).

Appendix II: Robustness and Heterogeneity across Consumer Groups

Logit model estimated on individual data

To examine the robustness of the results of Section 4 and especially for the exogeneity of the nominal rate, we adapt specifications 3.1 to 3.3 to the repeated cross-section of individual level data. Indeed, the case to give a causal interpretation to the savings response to country-level aggregate nominal interest rates may be even stronger at the level of individual consumers than for the consumer cohorts used in the fixed-effects estimation. Given the categorical nature of the outcome variable $s_{n,t}$, representing the likelihood to save at the individual level:

$$s_{n,t} = \begin{cases} 1 & if = "Very\ Likely"\ or\ "Fairly\ Likely" \\ 0 & Otherwise \end{cases}$$

we estimate three binomial logit models. The observed likelihood to save $s_{n,t}$ can be thought of as determined by a continuous measure of the likelihood to save $s^*_{n,t}$ that is latent, in the form:

$$s^*_{n,t} = \mu_t + \beta_R R^e_{j,t} + \beta_\pi \pi^e_{n,t} + \boldsymbol{\beta_{RD}} R^e_{j,t} \cdot \boldsymbol{D} + \boldsymbol{\beta_X X} + \varepsilon_{n,t}$$

(A1.1)

$$s^*_{n,t} = \mu_t + \beta_r r^e_{n,t} + \boldsymbol{\beta_X X} + \varepsilon_{n,t}$$

(A1.2)

$$s^*_{n,t} = \mu_t + \beta_R R^e_{j,t} + \beta_\pi \pi^e_{n,t} + \boldsymbol{\beta_X X} + \varepsilon_{n,t}$$

(A1.3)

for the individual level equivalents of model 3.1, 3.2 and 3.3 respectively. The difference in covariates as compared to the pseudo-panel specifications lie in the inflation expectations $\pi^{e}_{n,t}$ and the real rate $r^{e}_{n,t}$, which are now at the individual level, and in the vector $\boldsymbol{X}$, where the income measure and inflation perceptions are now at the individual level and the variables used to compose the pseudo panel (gender, age, educational attainment and country of residence), are added as control variables. The measure of uncertainty is instead the same as in the aggregate models, so that individuals, in each time period, have an uncertainty corresponding to that of the cohort to which they belong. This response of individual savings to group level uncertainty offers additional evidence for a peer group uncertainty effect on individual savings as discussed in the main body of the paper.

When $s^{*}_{n,t}$ crosses a certain threshold, say 0 without loss of generality, the observed likelihood to save $s_{n,t}$ switches from 0 to 1, that is:

$$s_{n,t} = \begin{cases} 0 & if\ \ s^{*}_{n,t} < 0 \\ 1 & if\ s^{*}_{n,t} \geq 0 \end{cases}$$

Then the corresponding probabilities will be (let $\boldsymbol{M}_{n.t}$ represent the matrix of all variables in the model):

$$P\big(s_{n,t} = 1 \mid \boldsymbol{M}_{n.t}\big) = P\big(\boldsymbol{M}_{n.t}\beta_{M} + \varepsilon_{n,t} \geq 0\big) =$$

$$= P\big(\varepsilon_{n,t} \geq -\boldsymbol{M}_{n.t}\beta_{M}\big) = P\big(\varepsilon_{n,t} \leq \boldsymbol{M}_{n.t}\beta_{M}\big) = F(\boldsymbol{M}_{n.t}\beta_{M})$$

and

$$P\big(s_{n,t} = 0 \mid \boldsymbol{M}_{n.t}\big) = P\big(\boldsymbol{M}_{n.t}\beta_{M} + \varepsilon_{n,t} < 0\big) =$$

$$= P\big(\varepsilon_{n,t} < -\boldsymbol{M}_{n.t}\beta_{M}\big) = 1 - F(\boldsymbol{M}_{n.t}\beta_{M})$$

F needs to be a monotone and increasing function bounded by 0 and 1 at its extremes, and in our case takes the form of the logistic function. As we do not have a linear relationship, we cannot use ordinary least squares but must resort instead to maximum likelihood estimation. This amounts to maximizing the log-likelihood function $lnL(\beta_M)$:

$$\frac{1}{NT} lnL(\beta_M) = \frac{1}{NT}\sum_{n=1}^{N}\sum_{t=1}^{T}[s_{n,t} lnF(\boldsymbol{M}_{n.t}\beta_M) + (1 - s_{n,t})ln(1 - F(\boldsymbol{M}_{n.t}\beta_M))]$$

In the estimation, we use survey weights ($w_{n,t}$) to ensure representativeness within each euro area country and heteroscedasticity-robust standard errors.

We are particularly interested in the marginal effect of the nominal rate on the likelihood to save, including within each interval. In the model with no thresholds (A1.3), the marginal effect of nominal interest rates will be:

$$\frac{\partial P(s_{n,t} = 1 \mid \boldsymbol{M}_{n.t})}{\partial R_{j,t}^{e}} = F'(\boldsymbol{M}_{n.t}\beta_M)\beta_R$$

While in the general model with thresholds (A1.1) it is given by:

$$\frac{\partial P(s_{n,t} = 1 \mid \boldsymbol{M}_{n.t})}{\partial R_{j,t}^{e}} = F'(\boldsymbol{M}_{n.t}\beta_M)(\beta_R + \boldsymbol{\beta_{RD}} \cdot \boldsymbol{D})$$

Which in the logistic case takes the form:

$$\frac{\partial P(s_{n,t} = 1 \mid \boldsymbol{M}_{n.t})}{\partial R_{j,t}^{e}} = \frac{\exp\,(\boldsymbol{M}_{n.t}\beta_M)}{[1 + \exp(\boldsymbol{M}_{n.t}\beta_M)]^2}\beta_R$$

And

$$\frac{\partial P(s_{n,t} = 1 \mid \boldsymbol{M}_{n.t})}{\partial R_{j,t}^{e}} = \frac{\exp\,(\boldsymbol{M}_{n.t}\beta_M)}{[1 + \exp(\boldsymbol{M}_{n.t}\beta_M)]^2}(\beta_R + \boldsymbol{\beta_{RD}} \cdot \boldsymbol{D})$$

Those reported in the tables are sample averages of the marginal effects, or

$$ME_R = \frac{1}{NT}\sum_n \sum_t F'(\boldsymbol{M}_{n.t}\hat{\beta}_M)\hat{\beta}_R$$

And $ME_R = \frac{1}{NT}\sum_n \sum_t F'(\boldsymbol{M}_{n.t}\hat{\beta}_M)(\hat{\beta}_R + \widehat{\boldsymbol{\beta}}_{\boldsymbol{RD}} \cdot \boldsymbol{D})$

Table A1 reports the results. Table A2, finally, reports the tests on the restrictions that nest models A1.2 and A1.3 in model A1.1. Instead of the simple F-statistic used in Table 3, the test of joint restrictions on coefficients in the logistic model can be implemented with a likelihood ratio test that takes the form of a χ^2 statistic.

Heterogeneity across Different Consumer Groups

The preceding analysis has largely focussed on average interest rate transmission for the population in general. However, there is considerable theoretical grounds and growing empirical evidence suggesting that interest rate transmission may be quite heterogeneous across the population (see, for example, Kaplan, Moll and Violante, 2018). In line with this, some of the theoretical and behavioural arguments for dependence of interest rate transmission on the level of rates may pertain more strongly, or even only, to specific groups. In this section, to test the broader generality of our findings, we therefore present the threshold regressions but excluding specific groups of consumers. We consider four specific groups to exclude: older age groups above 65 years in age that are likely in or close to retirement, consumers from northern countries (Germany, Netherlands, Finland) who traditionally have a very strong average propensity to save, consumers with higher average income growth who are likely to have a higher share of liquid wealth and accumulated savings and those consumers with the lowest level of educational attainment (i.e. primary education only). [6]

Table A3 reports the results for equation 3.1 (Baseline) in the first column, as well as the equivalent models when excluding, in turn, each of the four groups discussed above. For the nominal rate, Table A4 reports the total average effect over the different interest rate intervals. In line with the baseline model results, the response of savings to nominal interest rates tends to be positive and significant for relatively high levels of the nominal rate (above 1%) across each of the models that exclude the above specific groups. However, in line with the baseline model, when the level of the nominal rates declines the responsiveness of savings to interest rate also declines and then, for levels of interest rates between 1.0% and 0.5%, becomes not significantly different from zero. Across all models, the estimated response of savings also tends to be negative for levels of the nominal rate that are exceptionally low (e.g. below 0.5%). However, the reversal in the effect of $R^e_{j,t}$ is not as precisely estimated compared with the baseline model which benefits from a larger sample size. Nonetheless for the intervals between 0.5% and 0.25% and below 0.25%, we estimate a reversal in the sign of interest rate transmission that is significant in the model excluding the Northern economies at the 5% level of significance suggesting that it is not just the relatively high-saving German, Dutch and Finnish consumers driving this key result. Similarly, the savings reversal appears significant in the models that exclude consumers from the top quartile of the income distribution. However, once we exclude consumers with only a primary education or older consumers above 65 years of age, the significance of the savings reversal is lost. These results suggest that reversal in the

[6] Consumers with higher average income growth are defined to be those cohorts whose time-averaged income measure $\bar{Y}_i = T^{-1} \sum_t^T Y_{i,t}$ belongs to the top quartile of the distribution of $\bar{Y}_i$ across the pseudo panel.

sign of the savings response to interest rates maybe particularly driven by these two groups. The importance of the older consumers is highly intuitive given their greater closeness to retirement, larger reliance on interest income and likely weaker incentives to invest in risk assets. The relevance of those with lower educational attainment in driving the savings reversal also points to a possible role for communication strategies and policies to promote higher levels of financial literacy. Such policies if appropriately designed and clear might help mitigate the observed reversal in the savings response identified in the baseline model estimates; for instance, Bholat et al. (2019) find, in an experimental setting, that central bank communication can be made more effective by simplifying the language used and by making the content more relatable to people's lives.[7] Importantly, however, the general result that the response of savings to a change in interest rates declines with the level of rates appears not to be driven by any of the four specific groups considered.

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Bholat, David, Nida Broughton, Janna Ter Meer, and Eryk Walczak, "Enhancing central bank communications using simple and relatable information," *Journal of Monetary Economics* 108 (2019), 1-15.

[7] As specific example of such policies, Stantcheva (2020) highlights how individuals' understanding and support for economic policy are affected by instructional videos that emphasise explanation of how policies work and what effect they have on economic agents.

Duca-Radu, Ioana, Geoff Kenny, and Andreas Reuter, "Inflation expectations, consumption and the lower bound: Micro evidence from a large multi-country survey," *Journal of Monetary Economics* 118 (2021), 120-134.

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Tables

Table A1: Savings models at the individual level

	(1) Real Rate	(2) No threshold	(3) Baseline	(4) Lagged
$r^e_{n,t}$	0.00346***			
	(0.0000520)			
R^e_j		0.0213***		
		(0.000682)		
Interval				
$> 4\%$			0.01999***	0.02233***
			(0.0007911)	(0.0007491)
4-3%			0.01344***	0.01558***
			(0.0008668)	(0.0007932)
3-2%			0.01312***	0.01619***
			(0.0010196)	(0.0008836)
2-1%			0.00803***	0.01192***
			(0.0013256)	(0.001085)
1-0.5%			-0.00167	0.00635***
			(0.0024824)	(0.0018802)
0.5-0.25%			-0.03238***	-0.01139***
			(0.0048985)	(0.0035305)
$< 0.25\%$			-0.07854***	-0.03805***
			(0.0071746)	(0.0066372)
$\pi^e_{n,t}$		-0.00338***	-0.00338***	-0.00338***
		(0.0000520)	(0.0000520)	(0.0000523)
$Y_{n,t}$	0.180***	0.190***	0.189***	0.190***
	(0.00146)	(0.00149)	(0.00151)	(0.00152)
$\sigma_{i,t}(Y^e_{i,t})$	0.0155***	0.0164***	0.0163***	0.0164***
	(0.000638)	(0.000641)	(0.000641)	(0.000643)
Observations	2854510	2854510	2854510	2837162
Pseudo R-squared	0.1410	0.1413	0.1414	0.1413
Time FE	YES	YES	YES	YES
Country FE	YES	YES	YES	YES

Note: Model (1) corresponds to equation A1.2 and model (2) to equation A1.3. Models (3) and (4) correspond to equation A1.1 using, respectively, the contemporaneous nominal rate and the nominal rate lagged by one month. All values reported refer to marginal effects. Standard errors (in parentheses), are heteroscedasticity robust. Additional controls not reported: $\pi^p_{n,t}$, demographic controls for gender, age group and level of educational attainment. *p < 0.10, ** p < 0.05, *** p < 0.01.

Table A2: Tests of the real interest rate model and nominal interest rate thresholds

H_0	Restrictions	χ Stat	P-value
(1) Real rates model	$\beta_{RD} \equiv 0$ and $\beta_R \equiv -\beta_\pi$	$\chi_7 = 933.98$	< 0.0001
(2) No threshold effect	$\beta_{RD} \equiv 0$	$\chi_6 = 244.37$	< 0.0001

Note: The hypotheses tests refer to restrictions to model A1.1, comparing it to models A1.2 (Hypothesis 1) and A1.3 (Hypothesis 2) respectively. The χ^2 statistic is derived from a likelihood-ratio test.

Table A3: Baseline savings model estimates excluding specific groups of consumers

	(1) Baseline	(2) w/o +65	(3) w/o North	(4) w/o High Inc.	(5) w/o Primary Ed.
$R^e_{j,t}$	0.0165***	0.0151***	0.0196***	0.0196***	0.0149***
	(0.00269)	(0.00314)	(0.00286)	(0.00291)	(0.00321)
$R^e_{j,t} \cdot D_{4-3}$	-0.00587***	-0.00579***	-0.00692***	-0.00660***	-0.00713***
	(0.000956)	(0.00110)	(0.00100)	(0.00102)	(0.00115)
$R^e_{j,t} \cdot D_{3-2}$	-0.00578***	-0.00591***	-0.00665***	-0.00575***	-0.00658***
	(0.00150)	(0.00167)	(0.00158)	(0.00160)	(0.00185)
$R^e_{j,t} \cdot D_{2-1}$	-0.00982***	-0.0119***	-0.0103***	-0.0106***	-0.0128***
	(0.00242)	(0.00275)	(0.00272)	(0.00276)	(0.00306)
$R^e_{j,t} \cdot D_{1-0.5}$	-0.0145***	-0.0214***	-0.0176***	-0.0164***	-0.0149**
	(0.00515)	(0.00625)	(0.00588)	(0.00593)	(0.00636)
$R^e_{j,t} \cdot D_{0.5-0.25}$	-0.0450***	-0.0420***	-0.0544***	-0.0557***	-0.0364**
	(0.0129)	(0.0154)	(0.0154)	(0.0162)	(0.0147)
$R^e_{j,t} \cdot D_{0.25}$	-0.0921***	-0.0768*	-0.114***	-0.0965**	-0.0636
	(0.0341)	(0.0414)	(0.0370)	(0.0412)	(0.0394)
$\pi^e_{i,t}$	-0.00434***	-0.00431***	-0.00415***	-0.00415***	-0.00556***
	(0.000744)	(0.000871)	(0.000790)	(0.000807)	(0.000898)
$Y_{i,t}$	0.157***	0.163***	0.159***	0.158***	0.174***
	(0.00737)	(0.00823)	(0.00823)	(0.00800)	(0.00783)
$\sigma_{i,t}(Y^e_{i,t})$	0.0162***	0.0149***	0.0195***	0.0222***	0.0130***
	(0.00191)	(0.00202)	(0.00232)	(0.00243)	(0.00203)
Observations	38616	29957	31047	31835	28110
Adj. within R-squared	0.246	0.267	0.268	0.266	0.276
Individual FE	YES	YES	YES	YES	YES
Time FE	YES	YES	YES	YES	YES

Note: The Baseline corresponds to equation 3.1. Columns (2) to (5) refer to equation 3.1 estimated excluding, in order, those above the age of 65, those in Northern countries, those belonging to the top quartile of the income measure and finally those with only primary education. Standard errors in parentheses, clustered over time at the pseudo-individual level. Additional controls not reported: $\pi^p_{i,t}$. * p < 0.10, ** p < 0.05, *** p < 0.01.

Table A4: Savings response to household deposit rates over different interest rate intervals

	(1) Baseline	(2) w/o +65	(3) w/o North	(4) w/o High Inc.	(5) w/o Primary Ed.
Interval					
$> 4\%$	0.0165***	0.0151***	0.0196***	0.0196***	0.0149***
	(0.00269)	(0.00314)	(0.00286)	(0.00291)	(0.00321)
$4 - 3\%$	0.0106***	0.0093***	0.0127***	0.0130***	0.0078**
	(0.00293)	(0.00344)	(0.00311)	(0.00318)	(0.00354)
$3 - 2\%$	0.0107***	0.0092**	0.0130***	0.0138***	0.0083**
	(0.00323)	(0.00371)	(0.00352)	(0.00357)	(0.00392)
$2 - 1\%$	0.0067	0.0032	0.0094**	0.0090*	0.0021
	(0.00411)	(0.00477)	(0.00463)	(0.00473)	(0.00513)
$1 - 0.5\%$	0.0019	-0.0063	0.0020	0.0032	0.00004
	(0.00660)	(0.00794)	(0.0075)	(0.00763)	(0.00821)
$0.5 - 0.25\%$	-0.0285**	-0.0270	-0.0348**	-0.0361**	-0.0215
	(0.01388)	(0.01669)	(0.01628)	(0.01705)	(0.01632)
$< 0.25\%$	-0.0757**	-0.0617	-0.0948**	-0.0769*	-0.0487
	(0.03448)	(0.0420)	(0.03735)	(0.04146)	(0.04002)

Note: For each interval of the nominal rate, the reported estimates are the effect of the nominal rate for the baseline model in column (1), excluding those above the age of 65 in column (2), excluding those in Northern countries in column (3), excluding those belonging to the top quartile of the income measure in column (4) and excluding those with only primary education in column (5).

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