Discussion Papers
Department of Economics
University of Copenhagen

No. 16-14

Money Illusion and Household Finance

Thomas A. Stephens

Jean-Robert Tyran

Øster Farimagsgade 5, Building 26, DK-1353 Copenhagen K., Denmark
Tel.: +45 35 32 30 01 – Fax: +45 35 32 30 00
http://www.econ.ku.dk

ISSN: 1601-2461 (E)

Money Illusion and Household Finance

Thomas A. Stephens and Jean-Robert Tyran*

November 13, 2016

Abstract

We elicit money illusion and match it with financial and sociodemographic data from official registers on a quasi-representative sample of the Danish population. We find that people who are more prone to money illusion hold more of their gross wealth in nominal assets, including bank deposits and bonds, and less in real assets, including real estate and stocks. This bias is robust to controls for education, income, cognitive ability and other relevant characteristics. We further find that money illusion is a costly bias: 10-year portfolio returns are about 10 percentage points lower for individuals with high money illusion.

JEL: C91, D03, D14, E21, G11

Keywords: money illusion, loss aversion, household finance

---

* Stephens: Department of Economics, WU Vienna University of Economics and Business, Vienna, Austria; thomas.alexander.stephens@wu.ac.at. Tyran: Department of Economics, University of Vienna, Vienna, Austria Department of Economics, University of Vienna, Vienna, Austria; Department of Economics, University of Copenhagen, Copenhagen, Denmark; CEPR, London, United Kingdom; jean-robert.tyran@univie.ac.at. Tyran thanks the Carlsberg Foundation and the Austrian Science Fund (FWF) under project I2027-G16 for financial support.

1 Introduction

Money illusion was banned from economists' research agendas for decades, but has received renewed interest in recent years. The lack of interest in money illusion to late 1990s was driven by the view that it is incompatible with basic notions of optimization. To many economists, it seemed implausible that money illusion could have any economically significant effects, particularly in high-stakes settings such as financial markets. Even today, economists largely ignore money illusion, devoting little attention to it in the training of economics students. The typical economics student is confronted with money illusion only once, in an introductory course where the *assumption* of its complete absence is introduced. This assumption is often introduced by a thought experiment: imagine your income doubles and all prices also double. Rational decision makers will not change their consumption or investment plans in such a situation. This thought experiment seem quite convincing to most economists but it is not to all regular people.[1]

Now consider a slightly different version of that thought experiment. Is a 2 percent nominal wage cut with no inflation worse than a 2 percent nominal wage increase with 4 percent inflation? Again, the answer given by those trained in economics differs from that given by members of the general public.[2] Intuitions vary not only across groups that are more or less trained in economics, but also over time. For example, Irving Fisher (1928) devoted an entire book to the topic, and prior to the 1970s, economists regularly invoked money illusion as a plausible factor in economic behavior. But with the advent of the rational expectations revolution in the 1970s, money illusion became anathema to economists. More recently, money illusion has received renewed interest, at least in some circles. Various papers have addressed the existence and potential consequences of money illusion, such as nominal inertia, coordination failure, and bubbles in financial and housing markets. Money illusion has also been appeared in works targeting general audiences. Akerlof and Shiller (2009, chap. 6), for example, write,

---

[1] Van Rooij, Lusardi, and Alessie (2011) find in a representative sample of the Dutch population that about 22 percent of the respondents fail to correctly answer the following question (p. 452): "Suppose that in the year 2010, your income has doubled and prices of all goods have doubled too. In 2010, how much will you be able to buy with your income?"

[2] Kahneman, Knetsch, and Thaler (1986) find that 62 percent of respondents judge a 7 percent nominal wage cut with no inflation as unfair but only 22 percent hold the same view of a 5 percent nominal increase with 12 percent inflation. Similarly, Agell and Bennmarker (2003) find that Swedish human resource managers think 94 percent of workers would find a 5 percent nominal wage cut at no inflation unacceptable, but that only 50 percent would view a 5 percent wage increase with 10 percent inflation in the same way.

"Money illusion is another cornerstone of our theory. The public is confused by inflation and deflation and does not reason through its effects."

A growing body of evidence from surveys (Shafir, Diamond, and Tversky 1997), economic experiments (Thaler et al. 1997; Fehr and Tyran 2001; 2005; 2007; 2008), and neuroscience studies (Weber et al. 2009) points to the existence of money illusion. A less settled question is whether money illusion affects high stakes issues of particular interest to economists, such as saving and investment decisions by individuals and households. There is some evidence that it does, both in housing (Genesove and Mayer 2001; Einiö, Kaustia, and Puttonen 2008, Brunnermeier and Julliard 2008) and stock markets (Campbell and Vuolteenaho 2004; Cohen, Polk, and Vuolteenaho 2005; Schmeling and Schrimpf 2011). While there is a vibrant literature studying household finance and the various biases that seem to plague such choices (Campbell 2006; Guiso and Sodini 2013; Andersen et al. 2015), we seem to be the first to address the issue of how money illusion shapes household finance. We proceed in four steps.

First, we elicit individual-level money illusion in a quasi-representative sample of the adult population in Denmark. The measure we use, a *money illusion index* (MI index), is based on work by Shafir, Diamond, and Tversky (1997) and Weber et al. (2009), and elicits perceptions of the advantageousness of housing transactions at different levels of inflation. The index is built on the intuition (see Benartzi and Thaler 1995) that money illusion has particularly strong effects under prospect theory (Kahneman and Tversky 1979). In the presence of inflation, money illusion can offer the illusion of certain gains, even when the underlying reality is a real loss.

In the second step, we match the MI index with two sets of data. The first comprises various psychometric and experimental measures we elicit ourselves, including cognitive ability as measured by part of a standard IQ test (Liepmann et al. 2001) and cognitive reflection (Frederick 2005). The second set of data includes detailed financial and sociodemographic data from official Danish registers. The usual suspects like income and education are included, but what is crucial for our analysis is the inclusion of data on wealth. We have information on total assets and liabilities, as well as the allocation of assets to the major asset classes, including stocks, bonds, real estate, and bank deposits. We group these four classes into two broad categories, *nominal* assets and *real* assets. We define nominal assets, including bank deposits and bonds, as those that are defined in money terms, with a nominal face value and a nominal income stream. Real assets, including real estate and stocks, are defined as those that lack nominal face

values and where income streams are tied to real economic variables such as real profit and the real value of imputed rents. Under normal conditions, nominal assets offer certain *nominal* gains (in the case of bonds, if held to maturity), but these apparent gains are sometimes real losses that are hidden by inflation. In contrast, fluctuations in market values of real assets frequently produce both nominal and real losses (whether realized or not).[3] That is, nominal assets are nominally safe. As the name suggests, real estate is a real asset. However, the degree to which property owners observe nominal losses varies considerably by country. As we will show in detail, the Danish residential real estate market has long been characterized by high volatility, leading to frequent nominal losses and underscoring the "real" nature of real estate in Denmark.[4]

In the third step, we estimate the relation between money illusion and shares of wealth invested in nominal and real assets. We focus on bank deposits and real estate because these are the two most relevant asset classes for households, both in the U.S. (see Campbell 2006; Guiso and Sodini 2013) and even more so in Denmark. In our sample, the average individual holds 56 percent of his or her gross wealth in real estate and 35 percent in bank deposits. The remaining 10 percent is divided between stocks (6 percent) and bonds (4 percent).

We find that money illusion is strongly correlated with individual asset allocation. People with above-average money illusion invest on average 10 percentage points less in real assets than those below average (60 percent versus 70 percent). This difference is highly significant and of similar magnitude to the effect of above- vs. below-average education (11 percentage points). Regression analysis confirms the strength of the relation between money illusion and asset allocation, and demonstrates its robustness. An increase of one standard deviation in the MI index is equivalent to two to three fewer years of education or a reduction in annual income of about $10,000. Particularly remarkable is the finding that the MI index remains significantly correlated with the share invested in real assets in specifications including the length and type of education from register data, as well as our measures of cognitive ability and cognitive reflection. Although the MI index is correlated with education and cognitive measures, it does not simply capture general cognitive ability or mathematical education, which have been shown to

---

[3] "Normal" conditions imply weakly positive nominal interest rates and, in the case of government bonds, the absence of default risk.

[4] In this respect, the Danish housing market differs markedly from the U.S. housing market prior to the Great Recession. Former Federal Reserve Chairman Alan Greenspan's (2005) comment that, in the U.S., "nominal house prices in the aggregate have rarely fallen and certainly not by very much," could not have been made in Denmark, even before the crisis.

matter for household finance (see Lusardi and Mitchell 2014). Money illusion is clearly distinct from them.

Our fourth step is to estimate the cost of money illusion. Using aggregate quarterly data for Denmark, covering the period 1992 to 2016 and the four major asset classes, we compute approximate returns based on asset allocation at the time of the experiment. For the high money illusion group, the estimated 10-year real return averages 73.3 percent, versus 83.5 percent for the low group, a cost of about 10 percentage points.

Our study is closely related to the myopic loss aversion literature, and in particular to the seminal works by Benartzi and Thaler (1995) and Thaler et al. (1997), who propose myopic loss aversion as an explanation for the equity premium puzzle (Mehra and Prescott 1985), which refers to the inability of standard theory to explain the willingness of investors to hold bonds, when stocks have tended to offer much higher expected returns over typical investment horizons. The combination of loss aversion and narrow framing is central to this stream of literature, and these early contributions explicitly include money illusion. More recent literature, however, has tended to focus on narrow framing, both in terms of evaluation frequency (myopia) and in terms of evaluation of individual assets rather than integrated portfolios.[5] This focus on narrow framing has led to the abstraction of money illusion from most of the recent literature.[6] We extend this literature in two ways. First, we move beyond stocks and bonds to include the assets that dominate individual and household portfolios, namely bank deposits and real estate. Second, we test whether a simple measure of money illusion "predicts" variation in household asset allocation.

A key area where our study diverges from the myopic loss aversion literature is our focus on *household finance* rather than asset prices. In contrast to corporate finance and asset pricing, household finance as a standalone field is relatively new. In their review of the literature, Guiso and Sodini (2013) point to Campbell's 2006 Presidential Address to the American Financial

---

[5] Gneezy and Potters (1997) and Gneezy, Kapteyn, and Potters (2003), for example, show that more frequent portfolio evaluations and more information decrease risk taking, while Barberis and Huang (2001) find that investors are averse to losses on individual stocks, rather than to losses on their overall portfolios.

[6] Barberis and Huang (2008) omit the discussion of money illusion and inflation in their literature review, focusing instead on loss aversion and narrow framing. An exception, however, is He and Zhou (2014), who show that money illusion reduces the equity premium, provided that the reference point is not linked to the risk-free rate of return.

Association as the point when the term "household finance" was first used to refer to a distinct field. The field focuses on how households use financial markets to achieve their objectives, and although behavioral biases play a central role, money illusion has received almost no attention. For example, Guiso and Sodini (2013) discuss a number of behavioral biases that are relevant to household finance, but do not mention money illusion. Within the field of household finance, our study is related to the growing literature on *financial literacy*.[7] Indeed, the RAND American Life Panel survey used in some of the first discussions of financial literacy within the economics literature includes a question on money illusion (see Lusardi and Mitchell 2007; 2009; 2014). However, responses to the RAND question are either right or wrong, so it is not well suited to measuring money illusion of the form suggested by Shafir, Diamond, and Tversky (1997). Our approach, in contrast, allows for variation between the extremes, including some degree of bias towards nominal representations among those who may be able to answer the RAND question correctly.[8]

We proceed as follows. Section 2 explains how the interaction of money illusion and loss aversion biases investors towards nominal assets. Section 3 introduces our measure of money illusion and analyzes how it shapes household finance. Section 4 concludes.

2 Money Illusion, Inflation, and Investment Decisions

Money illusion implies that investors evaluate asset returns without fully accounting for inflation. In the presence of inflation, nominal and real returns will differ. If inflation is sufficiently high, real losses will become nominal gains. In an environment characterized by low inflation and sufficiently volatile stock and real estate prices, the combination of money illusion and loss aversion will bias investors away from stocks and real estate (real assets) and towards bank deposits and bonds (nominal assets). This may be the case even if nominal assets offer less attractive real returns, because real losses are obfuscated by inflation.

---

[7] The term "financial literacy" is also relatively new to the economics literature. It began to take off after an OECD (2005) report and gained further interest following then Federal Reserve Chairman Ben Bernanke's (2006) Senate testimony on the topic.

[8] More than 60 percent of our participants exhibit some degree of money illusion, while nearly 81 percent of Lusardi and Mitchell's (2007) participants correctly answer the RAND money illusion question (implying no money illusion). Both results are consistent with Shafir, Diamond, and Tversky (1997). In Problem 1, they find that 71 percent of participants can calculate correctly when economic terms are made salient, but 65 percent show bias in evaluations of well-being. Mees and Franses (2014) replicate these numbers for Chinese samples.

Following Shafir, Diamond, and Tversky (1997), we define money illusion as a *bias* towards nominal representations, and not as thinking in purely nominal terms. We define proneness to money illusion as an individual-level parameter $\psi_i \in [0, 1]$. ψ_i is the weight that individual i places on the *nominal* representation of a given gain or loss, leaving $1 - \psi_i$ as the weight placed on the *real* representation, in both cases assuming a standard prospect theory value function. A value of zero thus indicates the absence of money illusion, while a value of one indicates purely nominal thinking. In line with Shafir et al. (1997), we expect the majority of people to fall between the two extremes (see Online Appendix C for details).

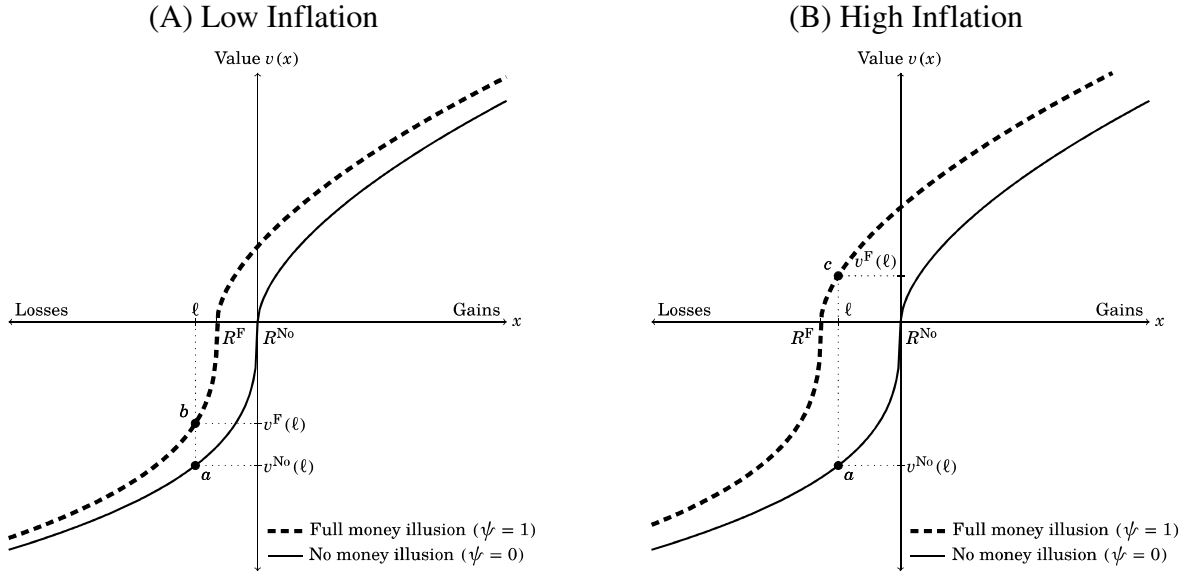
2.1 Inflation shapes Evaluations and Asset Choices

Figure 1 illustrates the evaluation of a real reduction in wealth by loss averse individuals who differ in terms of money illusion, in different inflationary environments. The horizontal axis shows gains and losses, while the vertical axis shows values. The solid curve is a value function for an individual who is free of money illusion, with a reference point R^{No}. The dashed curve is the same for an otherwise identical individual who is fully illuded, with the reference point R^{F}. From the perspective of the illuded individual, nominal losses are to the left of $R^{\text{F}}$and nominal gains to the right. A fully illuded individual focuses entirely on nominal gains and losses, so a real loss that is hidden by inflation is coded as a gain rather than a loss.[9] The reference point for a fully illuded agent thus shifts to the left as inflation increases (note the distance between R^{No} and R^{F} in A and B).

The figure compares how a given real loss ℓ is evaluated by an illusion-free agent (solid curve) and an illuded agent (dotted) at low and high inflation. To illustrate, consider a real loss ℓ of 3 percent of some initial value. A non-illuded agent evaluates the loss at point a, independent of whether inflation is high or low. But the valuation of the illuded agent varies with inflation. When inflation is low (2 percent, say), the illuded agent perceives the real loss as nominal loss of about 1 percent (ℓ is to the left of R^{F} in panel A). Now consider the same real loss ℓ at high inflation (4 percent, say). The illuded agent perceives such a real loss as a nominal gain of approximately 1 percent and evaluates it positively (see point c in panel B).

[9] More precisely, a real rate of return equal to $-\frac{\pi}{1+\pi}$ is the nominal break-even point, where π is the rate of inflation and $\pi \approx \frac{\pi}{1+\pi}$ for low rates of inflation.

Figure 1: Effect of Inflation on Evaluations of Real Losses



Notes: The figure shows evaluations of a real loss ℓ linked to an asset, in the extreme cases of no money illusion ($\psi = 0$, with a reference point R^{No}) and full money illusion, in the sense of thinking purely in nominal terms ($\psi = 1$, with a reference point R^{F}). The evaluation of a real loss ℓ by an individual free of money illusion is represented by point a, with the real loss ℓ valued as $v^{\mathrm{No}}(\ell)$, irrespective of inflation. An investor who is fully prone to money illusion codes the same real loss as a loss if inflation is low (see point b), but as a gain if inflation is high (see point c).

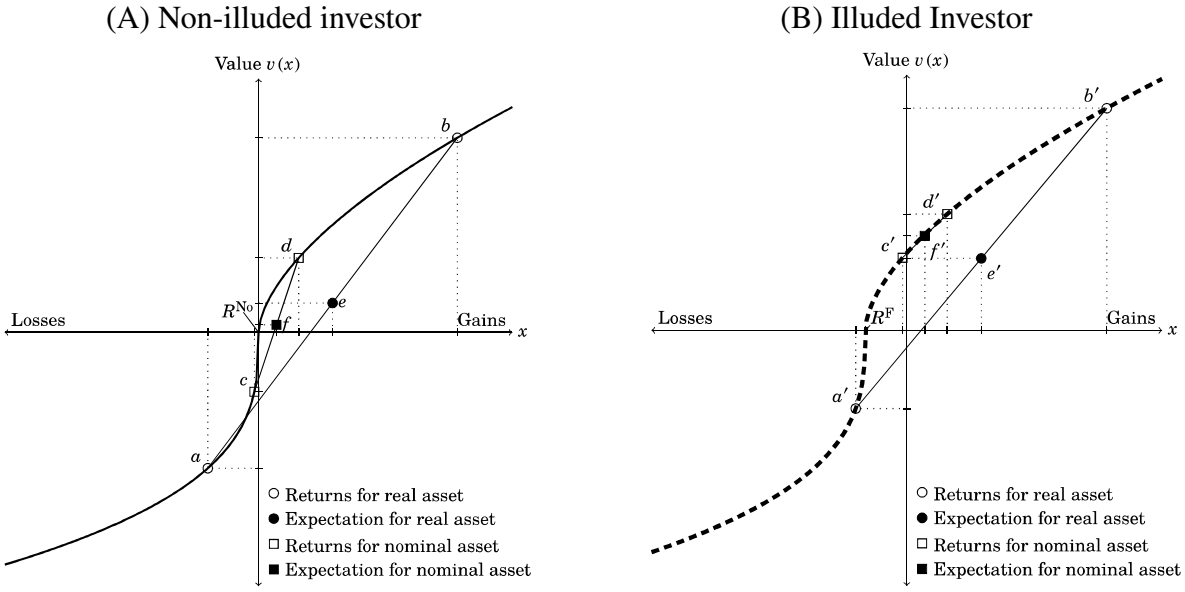
To summarize, inflation hides sufficiently small real losses from illuded investors, creating the illusion of gains. Illuded investors therefore tend to view small losses more favorably than non-illuded investors do. Our money illusion index (to be explained in more detail in Section 3.2) measures the variation in evaluations of given real losses as inflation varies. More specifically, the index measures how individuals change their evaluations of a given loss as inflation changes, which allows us to measure susceptibility to money illusion. An individual whose evaluations differ at high versus low inflation (points c vs. b) exhibits money illusion.[10]

Figure 2 illustrates that, in the presence of inflation, an illuded investor (Panel B) may prefer a nominal asset in a situation where a non-illuded investor (Panel A) prefers a real asset. For illustrative purposes, we consider two stylized assets, one real and the other nominal. The real asset is represented by circles and the nominal asset by squares. We consider a simple situation in which each asset offers two possible returns that are equally likely. For the non-illuded investor, points a and b are return-value pairs for the real asset, and points c and d are the same

[10] Irving Fisher (1928, p. 7) illustrated this idea with reference to a shopkeeper who sold him a shirt for 150 marks in 1922 that she had bought for 100 marks a year earlier, while inflation in that year had been 67 percent. He said about the shopkeeper: "She had made no profit; she had made a loss. She *thought* she had made a profit only because she was deceived by the "Money Illusion." In fact, as Fisher explains in Figure 1 (p. 9), the shopkeeper made a real loss of 10 marks which was masked by inflation as a nominal gain of 50 marks.

for the nominal asset. The expected return-value pairs for the real and nominal assets are indicated by points e and f, respectively. Both assets may lead to losses, but the real asset offers a higher expected gain (e is to the right of f) and a higher expected value (e is above f). The non-illuded investor therefore prefers the real asset.

Figure 2: Money Illusion determines the Asset Allocation



Notes: The figure shows evaluations of two stylized assets by two investors who differ only in the extent to which they are prone to money illusion. The assets include one that is a *real asset* (real and nominal losses may be realized) and one that is *nominal asset* (real losses may be realized, but will be hidden by inflation and appear as nominal gains). Panel A represents an investor who is free of money illusion (with a reference point R^{No}), while panel B represents an investor who is fully illuded (with a reference point R^{F}). For the non-illuded investor, points a and b are the potential returns and their associated values for the real asset, while points c and d are the same for the nominal asset. Assuming equal probability of either outcome, the expected return/value pair for the real asset is point e, and for the nominal asset it is point f. Since point e is higher than point f, the non-illuded investor would choose the real asset. Absent inflation, the choice of the fully illuded investor would be the same. Under low inflation, however, the return/value pairs for the fully illuded investor shift up to a' and b' for the real asset, and c' and d' for the nominal asset, with respective expectations e' and f'. Since point f' is higher than point e', the fully illuded investor chooses the nominal asset.

For the fully illuded investor, the same real gains or losses are associated with points a' to d' in panel B, and the same expected gains with points e' and f'. Inflation shifts all of the points upwards, but the sizes of the shifts differ. The low outcome for the real asset remains to the left of R^{F}, so is coded as a nominal loss. The low outcome for the nominal asset, however, is to the right of R^{F}, so is coded as a nominal gain. The upward shift from c to c' is much larger than the shift from a to a'. To the illuded investor, the expected value associated with the nominal asset is thus greater than the expected value associated with the real asset (point f' is above point e'), because of the illusion of a certain gain. The illuded investor therefore prefers the nominal asset.

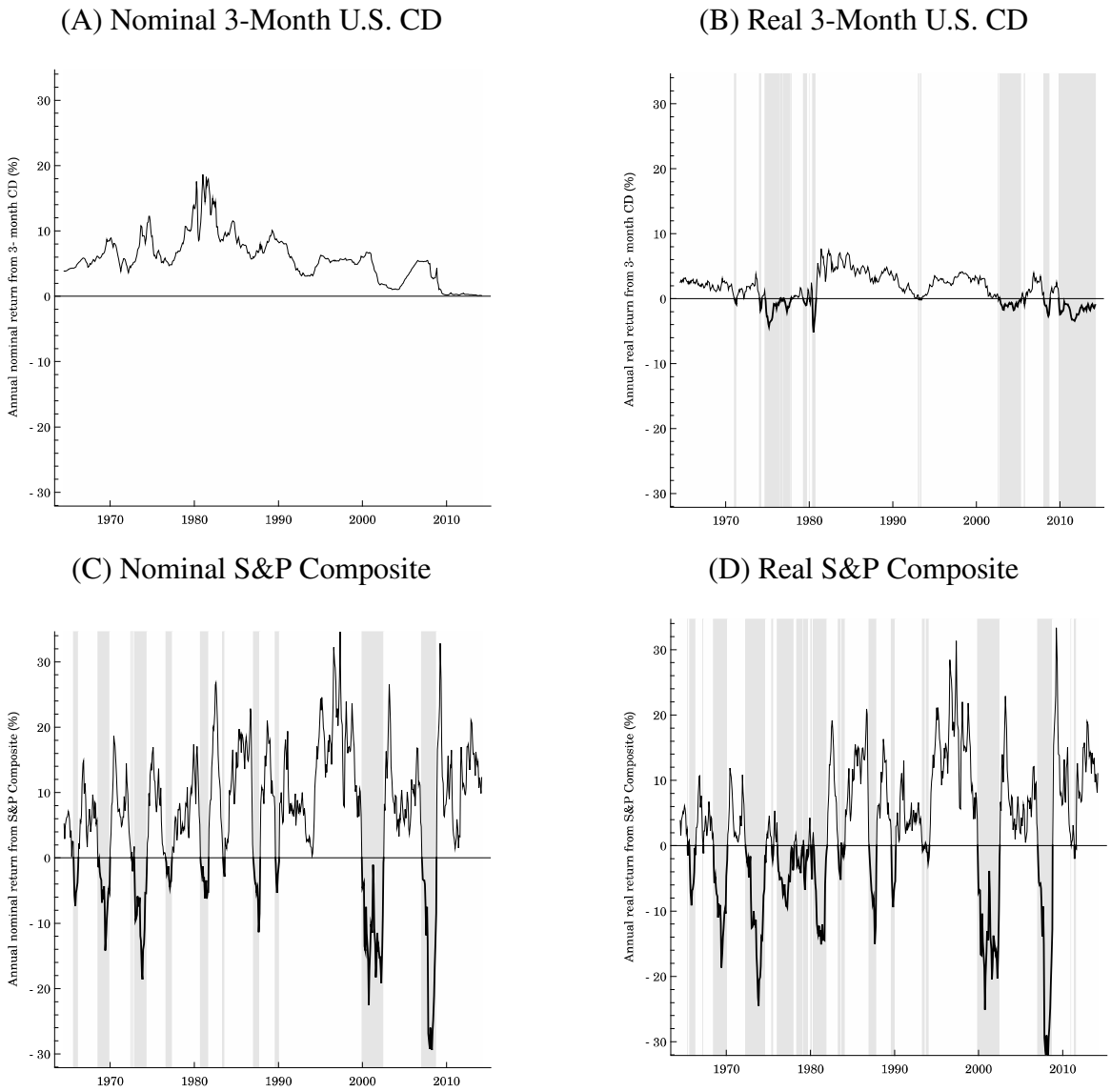
In the example above, the fully illuded investor finds the nominal asset more attractive than the real asset because the real loss is obfuscated by (moderate) inflation (c' versus c). However, if inflation were sufficiently high to shift point a into the nominal gain domain, this reversal of rankings would once again be reversed. This simple example illustrates that, for prospect theory investors, the effect of money illusion on evaluations depends on the distributions of returns and on the rate of inflation.

2.2 Nominal versus Real Assets

We now consider nominal and real assets from an empirical perspective. Nominal assets, as the name suggests, are defined in money terms. A nominal asset has a nominal face value that is payable either on demand or at maturity, together with a nominal income stream that is also defined in money terms. Examples of nominal assets include cash, bank deposits and debt instruments (bills, notes, and bonds). Real assets, in contrast, are linked to real economic variables. They lack nominal face values, and the income streams are determined by the real value of goods and services produced. The most important real assets from the household perspective are real estate (primarily housing) and equities (stocks). Abstracting from speculation, the market price for real estate is determined primarily by the expected real value of the housing and business services it produces. Similarly for equities, the market price is determined primarily by the expected real value of the income stream a firm generates by producing and selling goods and services.

The crucial difference between nominal and real assets as we define them is the way they interact with inflation. Barring exceptional circumstances such as uninsured bank failures and defaults, *nominal assets allow investors to avoid nominal losses*. In the absence of perfect price stability, they can nevertheless expose investors to real losses. In modern economies where positive inflation is the norm, real losses may indeed be relatively common for certain nominal assets. While inflation perfectly hides real losses on nominal assets, it does not do the same for real assets. In an inflationary environment, real assets with sufficiently low volatility may appear to be relatively safe in nominal terms, but an increase in volatility or a reduction in inflation can rapidly change this perception. All else equal, the higher the rate of inflation, the more likely it is that real losses will be hidden.

Figure 3: Annual Returns on Nominal versus Real Assets 1964–2015



Notes: The figure shows year-on-year returns for two selected assets, with monthly observations for the period from 1964 to 2015. The upper panels, A and B, show returns for 3-Month certificates of deposit (CDs) in the United States using data from the OECD (2015), while the lower panels show the same for the S&P Composite, including dividends and capital gains or losses, using updated data from Shiller (2015). The left panels, A and C, show nominal returns, while the right panels, B and D, show real returns. Periods in which losses were realized are shaded. Since CDs are *nominal* assets, real losses are hidden by inflation, and hence nominal returns are positive. Equities, on the other hand, are *real* assets, so real losses are typically not hidden by inflation, especially when inflation is low.

Figure 3 shows that bank deposits, more specifically U.S. certificates of deposit or CDs (OECD 2015), clearly exhibit the properties of a nominal asset, while equities, represented by the U.S. S&P Composite (Shiller 2015), clearly exhibit the properties of a real asset. The figure shows nominal (left panels) and real (right) year-on-year returns, using monthly observations from 1964 to 2015. Periods with negative returns are shaded in grey. Panel A shows that CDs always offer positive nominal returns, so are *nominally safe*. Real returns in Panel B, however,

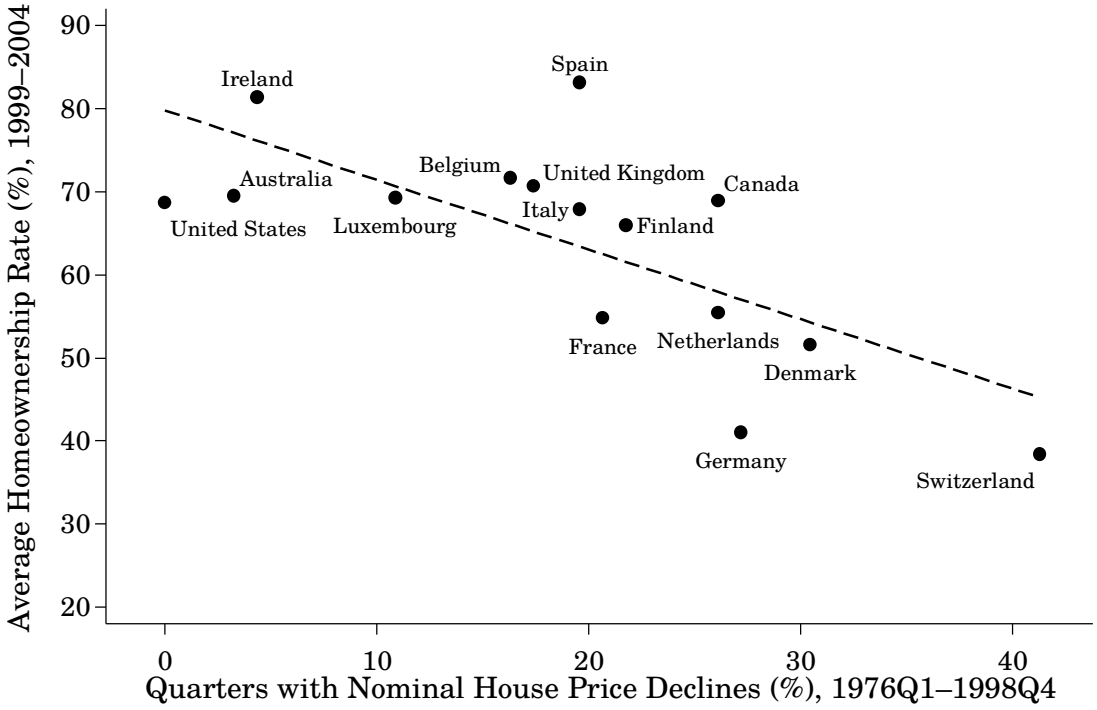
are often negative for extended periods of time, so this protection from losses is an illusion. In contrast, equities are *nominally risky* (see Panel C), with real losses typically not hidden by inflation (Panel D). During the 1970s and early 1980s, when inflation was particularly high in the U.S., there was some divergence in the sign of the nominal and real returns. In most other periods, however, real losses were not hidden.

While equity returns are typically volatile enough to produce real losses, even in periods of relatively high inflation, the same is not always true of house prices. The lower volatility of house prices means that in countries with moderately high inflation, real losses on housing are often hidden. Assuming that the distribution of money illusion within the population is similar across countries, we should therefore expect to see higher homeownership rates in countries where inflation has tended to be higher, house prices have tended to be less volatile, or both. In looking at a selection of OECD countries, this is exactly what we find.

Figure 4 plots average homeownership rates in a selection of OECD countries at the end of the 20th century, and the percentage of quarters during the preceding quarter century in which nominal house prices fell year-on-year. In terms of money illusion, the figure shows two important things. First, countries that experienced more frequent *nominal* house price declines in the last quarter of the 20th century tended to have lower homeownership rates at the end of the century. Second, it shows that nominal house price declines were relatively common in Denmark, relative to other OECD countries, occurring in 31 percent of observations, and that the homeownership rate in Denmark at the end of the period, about 50 percent, was one of the lowest in the OECD. The reason for this high incidence of nominal losses in Denmark is a combination of low inflation (about 5 percent) and high variability of nominal house prices.[11]

[11] Denmark experienced high inflation in the 1970s, but a fixed exchange rate policy was adopted in 1982. The Danish crown was pegged to the German mark, with stabilization of the exchange rate by 1987. The peg was accompanied by convergence of Danish inflation to the lower German levels by the end of the 1980s, and was converted to a euro peg in 1999 (Danmarks Nationalbank 2009).

Figure 4: Nominal Losses and Homeownership in Selected OECD Countries



Notes: Homeownership rates are from Andrews and Caldera Sánchez (2011), and are for 2004, with the exception of Belgium, France, and Ireland, where they are for 2000, and the Netherlands, where they are for 1999. Quarters with year-on-year nominal price increases are computed from the house price data set described in Mack and Martínez-García (2011). The line is an OLS estimate, using robust standard errors, with $\hat{\alpha} = 79.80$ ($p = 0.000$), $\hat{\beta} = -0.84$ ($p = 0.002$), and $R^2 = 0.49$. The figure includes the 15 OECD countries that are available in both data sets.

The cross-country correlation shown in Figure 4 is *consistent* with our account of how money illusion biases investment decisions. Investors seem to find housing less attractive in countries where it is subject to frequent nominal losses.[12] Needless to say, this correlation says nothing about causality. There are a variety of reasons why higher inflation might drive higher homeownership rates. Malmendier and Nagel (2016), for example, show that more extended experience with inflation increases inflation expectations. For investors who are not fully illuded, the expectation of higher inflation makes nominal assets less attractive, and borrowing more attractive (higher expected inflation reduces the real interest rate associated with any given nominal interest rate). By extension, real assets become relatively more attractive. In our empirical analysis, we shed light on this issue by comparing asset allocation across individuals within one country (Denmark), and include controls for experienced inflation, along with many other relevant factors.

[12] Remarkably, the relation between homeownership and real losses is much weaker. See Online Appendix D.

3 Empirical Analysis

To investigate the role of money illusion in household finance, we match a measure of money illusion (the MI index) elicited from a quasi-representative sample of the Danish population with a rich set of anonymized financial and socioeconomic register data.[13] We estimate the relation between our MI index and the share of total gross wealth invested in real assets (which we call the *real asset share*, or RA share). We find that people who are prone to money illusion (high MI index) tend to hold more nominal assets (low RA share). We further find that the MI index has greater predictive power than any of the other relevant measures and socioeconomics from our rich data set, with the exceptions of income and wealth.[14] The MI index outperforms general cognitive measures that might be expected to predict asset allocation ability. Strikingly, it also has better predictive power than official register data on the level and type of education.

The analysis is structured as follows. Section 3.1 describes the sampling and register data. We describe the population from which participants were recruited and the relevant financial, sociodemographic, and psychometric measures in our data set. Section 3.2 describes our survey and the resulting money illusion (MI) index. Section 3.3 investigates how the share invested in nominal vs. real assets relates to the MI index, and Section 3.3 estimates the cost to investors of being prone to money illusion.

3.1 Data

Our data set combines register data provided by the Danish statistical bureau (Statistics Denmark) with survey and incentivized behavioral data elicited through the internet Laboratory for Experimental Economics (iLEE). See http://www.econ.ku.dk/cee/ilee/ or Thöni, Tyran, and Wengström (2012) for a description of iLEE. We use data from 733 participants recruited from a random sample of 40,000 Danes aged 19–82, for whom we have detailed matched financial and sociodemographic data from official registers.[15]

---

[13] The matching was carried out under strict confidentiality by Statistics Denmark, the national statistical bureau in Denmark. Participant identities were validated, but all participants in our study remain completely anonymous to us.

[14] Income refers to non-capital income, so can be viewed as exogenous to asset allocation. Wealth, however, is influenced by asset allocation, so the direction of any effect is ambiguous.

[15] The population our sample was drawn from includes the entire population of Denmark aged 18 to 80 in 2007, excluding about 12 percent who had opted out of scientific research (for details see Statistics Denmark 2008).

The key variables from official registers include assets and liabilities, both total values and subtotals for major classes, the length and type of education (see OECD et al. 2015), experienced inflation, income, age, occupational skill level, and public or private sector employment. In addition, we include standard socioeconomic controls for gender, marital status, and the number of children. The measures we elicit through iLEE include cognitive measures, incentivized measures of risk and loss aversion and a standard personality test. The cognitive measures are the Matrices subtest (IST-M) of the IST-R 2000 test described in Liepmann et al. (2001), and Frederick's (2005) cognitive reflection test. The behavioral measures of risk and loss aversion we elicit are lottery tasks based on Tanaka, Camerer, and Nguyen (2010). The personality test is the Big Five Inventory described in Costa and McCrae (1992).

Our primary independent variable is an individual-level money illusion (MI) index, which we elicit using a survey instrument based on Shafir, Diamond, and Tversky (1997) and Weber et al. (2009). Our other key variable is the real asset (RA) share, which is the share of an individual's total gross wealth that is invested in real assets. The RA share is computed from high-quality register data on asset holdings, which includes total assets, as well as assets in each major class, namely bank deposits, bonds, real estate and equities.

Participants were recruited by Statistics Denmark, which sent letters to addresses of individuals who had participated in iLEE during previous waves of experiments (the participants for the first wave were recruited from the random sample). Each letter contained a login code for the iLEE website. No information linking login codes to the names and addresses of recipients of invitation letters was shared with us at any time. After the experiment was completed, the data set was delivered to Statistics Denmark, where it was merged with the participants' anonymized register data. Any potentially identifying information was removed from the experimental data set prior to delivery, and in the merged data set, Statistics Denmark replaced login codes with randomly generated identifiers.

We elicited money illusion from a total of 751 participants. Of these, 733 (97.6 percent) passed validation checks, which entailed comparing self-reported age and gender with the anonymized register data. Participants were told that their invitations were personal and not to be passed on to others, such as a spouse, child, or friend. At the same time, they were not told that we had access to their register data and could thereby validate their details. We are therefore confident that the 733 validated participants were indeed the intended recipients, and hence that the register data are correctly matched.

Table 1 gives an overview of the participants and the randomly drawn pool of 40,000 from which they were recruited. Our sample is well-balanced by gender (51 percent female), and the average participant is middle-aged (49.3 years). Participants are also moderately well educated (13.6 years of education), with an average gross non-capital income of kr. 321.3 thousand (about $62 thousand at the time), gross assets of kr. 1,219 thousand (about $234 thousand), excluding pensions, and net worth of kr. 571.2 thousand (about $110 thousand).

The major components of the average portfolio are real estate (56 percent) and bank deposits (35 percent), while stocks and bonds represent less than 6 percent and 4 percent, respectively. In fact, the median person in our sample owns a house, but does not hold any stocks or bonds. The distribution of assets across wealth quartiles can be characterized as follows. The people in the bottom quartile of the income distribution hold their wealth almost exclusively (about 89 percent) in bank deposits. In the next quartile, people allocate a small proportion of wealth to stocks (about 9 percent) and bonds (about 4 percent), but the majority (about 58 percent) goes into real estate, with the rest (28 percent) in bank deposits. People in the quartile just above the median put the bulk of their wealth (about 86 percent) into real estate, with most of the rest (about 10 percent) in bank deposits. The percentages in real estate (about 78 percent) and bank deposits (about 13 percent) are similar for the top quartile. There is only a small shift from real estate to stocks and bonds towards the top. This pattern is by no means unique to Denmark. The dominant role of real estate in particular corresponds to findings reported by Campbell (2006) for the U.S, where homeownership is more widespread than in Denmark.[16]

[16] Campbell (2006) uses data from the Survey of Consumer Finances in the U.S. which includes vehicles and private business. The overall pattern is similar, but vehicles are important at the low end of the distribution, real estate overtakes bank deposits sooner, and real estate is overtaken by stocks for roughly the top 5%.

Table 1: Descriptive Statistics for Participants and Population

	Our sample (N = 733)		Danish population	
	Average	SD	Average	SD
Age (years)	49.3	14.0	49.8	16.3
Female (%)	51.0		50.5	
Public sector (%)	33.3		22.8	
Self-employed (%)	4.9		4.5	
Student (%)	9.5		6.9	
Retired (%)	18.8		27.5	
Education				
Length (years)	13.6	2.4	12.2	2.9
Long tertiary (%)	42.1		25.7	
STEM (%)	21.3		19.8	
Occupational skill				
High- (%)	22.7		12.8	
Medium- (%)	25.2		14.1	
Low-/Other (%)	52.1		73.0	
Income (thousand kr.)	321.3	177.4	263.6	186.5
Assets (thousand kr.)	1,219.0	1,798.9	1,044.6	4,152.1
Liabilities (thousand kr.)	647.8	1,167.4	582.3	1,840.3
Asset Shares				
Bank deposits (%)	34.5	39.5	46.5	44.4
Bonds (%)	3.6	12.1	2.7	10.9
Real estate (%)	55.9	42.9	47.1	45.1
Stocks (%)	5.8	15.3	3.6	12.6
Real asset (RA) share (%)	61.9	40.3	50.8	44.4

Notes: Data in column "Danish population" is calculated from a sample of 40,000 individuals randomly drawn from the adult Danish population aged 19-82. Education length is the standard number of years required for an individual's completed education. Long tertiary includes ISCED levels 6 and above, which covers bachelor, master, and doctoral studies. STEM refers to science, technology, engineering, and mathematics education, using ISCED field classifications. Occupational skill is based on ISCO-88/DISCO-88 classifications. Income is gross non-capital income, comprising income from salaries, pensions, and benefits. Assets is total gross financial and real estate assets, including bank deposits, bonds, real estate, and equities. Liabilities is total gross liabilities, including bank loans and mortgages. Real asset share is total assets less bank deposits and bonds. For financial figures, kr. indicates Danish crowns.

Overall, our sample is very heterogeneous and is highly representative of the Danish population in some dimensions (e.g. age, gender), but with notable differences in others. In particular, our participants tend to have higher education and skill levels, are more likely to work in the public sector, and are less likely to be retired. In addition, participants tend to have higher

incomes, more assets, more liabilities, and to hold more of their gross assets in real estate, bonds and stocks than the average Dane. These differences arise because of selective participation and attrition across waves in iLEE.

The differences between our sample and the adult Danish population are relatively small and are not problematic, because our aim is not to draw inferences about the average level of money illusion in the Danish population. Our interest is rather in difference between individuals with high and low money illusion. For this analysis, what is required is heterogeneity, and it is clear from the descriptive statistics in Table 1 that our sample is very heterogeneous. If anything, our results may understate the extent and of money illusion in the population. The reason is that better educated and higher-income individuals tend to be less prone to money illusion (see Online Appendix A for details). Our estimates for the effects of money illusion on household finance may therefore be thought of as a lower bound for the effects in the general population.

3.2 Money Illusion Index

The money illusion index is generated using a series of hypothetical questions. We present each participant with eight housing questions, each of which asks the participant to evaluate the advantageousness of a hypothetical purchase and sale of a house. The eight questions come in four pairs. In each pair, the transaction results in a real loss, but because inflation is different across the two scenarios, the transaction comes with a nominal gain in one case and with a nominal loss in the other. The MI index is the average difference between the evaluations in the high- and low-inflation variants. This measure captures the effect of inflation in perceptions of how attractive an asset is.[17]

Table 2 shows the parameters for the housing scenarios. All four real scenarios involve real losses, but each loss is presented in a *low inflation* (Low) and a *high inflation* (High) variant. In the Low variant, the real loss is also a nominal loss. In the High variant, the accumulated inflation is sufficient to obfuscate the real loss and transform it into a nominal gain. A person prone to money illusion will provide different evaluations under different inflationary conditions (better when inflation is high), whereas a person free of money illusion will provide the same answer under both conditions (see Figure 1).

[17] Participants were allowed to spend as much time answering the questions as they liked, and since they took part over the internet, they were not constrained in terms of aids.

Table 2: Parameters for Housing Scenarios

Real Scenario	Inflation	Sale price	Nominal gain or loss	Nominal gain or loss (%)	Inflation	Real loss
1	Low	1,979,600	−20,400	−1.0%	1.0%	−2.0%
1	High	2,175,600	175,600	8.8%	11.0%	−2.0%
2	Low	1,958,400	−41,600	−2.1%	2.0%	−4.0%
2	High	2,515,200	515,200	25.8%	31.0%	−4.0%
3	Low	1,858,400	−141,600	−7.1%	1.0%	−8.0%
3	High	2,355,200	355,200	17.8%	28.0%	−8.0%
4	Low	1,754,400	−245,600	−12.3%	2.0%	−14.0%
4	High	2,373,600	373,600	18.7%	38.0%	−14.0%

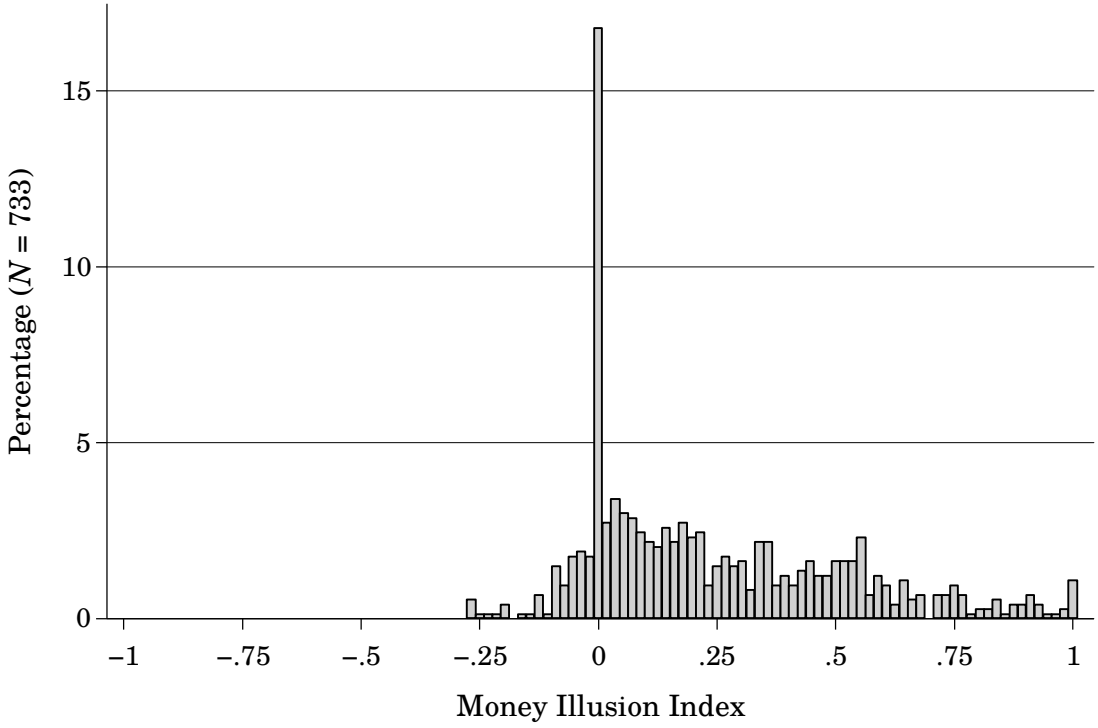
Note: The purchase price in all cases is 2,000,000 Danish crowns.

Each question includes a purchase price, sale price, nominal gain or loss in money and percentage terms, and a given amount of accumulated inflation over the holding period. Evaluations range from 1 to 15, where 1 is labelled "Not at all advantageous" and 15 is labelled "Very advantageous." Given that our interest is perceptions of inflation, participants received a flat participation fee rather than a piece rate for "correct" answers. An important aspect of the design of the index is that it isolates the *differences*, if any, in evaluations that are caused by exogenous variation of the inflation framing. For that reason, it does not conflate individual tastes for housing with the effect of inflation.

Figure 5 shows a histogram of the money illusion (MI) index, computed for the $N = 733$ validated participants. The index is clearly skewed to the right, consistent with the hypothesis of bias towards nominal representations. At the same time, there is considerable heterogeneity. About 17 percent of participants show behavior consistent with no money illusion, with an index of precisely zero. Another 10 percent have index values below zero, with most of them clustered relatively close to it, perhaps reflecting some noise around the rational choice. Assuming symmetrical noise around zero, about 38 percent of participants behave in a way that is consistent with no money illusion. The other 62 percent, however, show bias that is consistent with money illusion. The average index of 0.24 is highly significantly above zero, as predicted by the presence of money illusion.[18]

[18] A t-test rejects the null of a zero mean for the index with $t = 23.7$ ($p = 0.000$) and a 95 percent confidence interval of $[0.220, 0.261]$. A Schlag (2008) exact test confirms the parametric results, with highly significant evidence of a positive mean ($p = 0.000$) and a 95 percent confidence interval of $[0.211, 0.270]$, with $\theta = 0.2$.

Figure 5: Money Illusion Index



Notes: The figure shows the distribution of the money illusion (MI) index, the average difference between evaluations of identical real losses when inflation is low, so they are also nominal losses, and when it is high enough to transform them into nominal gains. For an individual who is not prone to money illusion, the expected value is zero. The positive skewness indicates systematically higher evaluations in the nominal gain treatment, which is consistent with money illusion.

We now briefly discuss some correlates of the MI index (for a detailed discussion, see Stephens and Tyran 2012 and Online Appendix A). Regression analysis shows that the MI index is negatively related to being a student, to the score on the cognitive reflection test, and to years of education. Students are clearly less prone to money illusion than other participants. The average index for the 70 students in our sample is only about half (0.12 vs. 0.25) of what it is for the 663 non-students.[19] The MI index is not, however, robustly related to a more general measure of intelligence or to STEM (science, technology, engineering, and mathematics) education.[20] Nor is it significantly related to age or experienced inflation. We find evidence that money illusion is negatively correlated with income and with skill level.

[19] This difference is highly significant according to both a t-test ($p = 0.000$) assuming unequal variance and a Wilcoxon Mann-Whitney U-test ($p = 0.000$). It remains highly significant in OLS regressions, and indeed the effect becomes even stronger when sociodemographic controls are included.

[20] See Online Appendix A for OLS and Tobit regressions of the MI index on relevant covariates.

3.3 Correlates of the Real Asset (RA) Share

We now discuss correlates of the real asset (RA) share (see Online Appendix B for details), defined as

$$\text{Real Asset Share} = 1 - \frac{\text{Bank Deposits} + \text{Bonds}}{\text{Total Assets}},$$

where all assets refer to gross values (e.g. a negative bank balance implies an asset value of zero, with the debt classified as a liability, and debts are not subtracted from total assets).

We focus below on the relation between the MI index and RA share because our hypothesis is that money illusion makes nominal assets more attractive to loss averse investors and, conversely, makes real assets less attractive (see Section 2 for explanations). We define nominal assets as those that preclude nominal losses, while real assets are those that do not, because returns are (at least in theory) based on real rather than nominal variables. Note that this definition differs from standard definitions of nominal assets.[21] Increasing the real asset share requires some deliberate action. The reason is that income from wages, pensions, and benefits is paid into bank accounts. Therefore bank deposits, a nominal asset, are effectively the default asset.

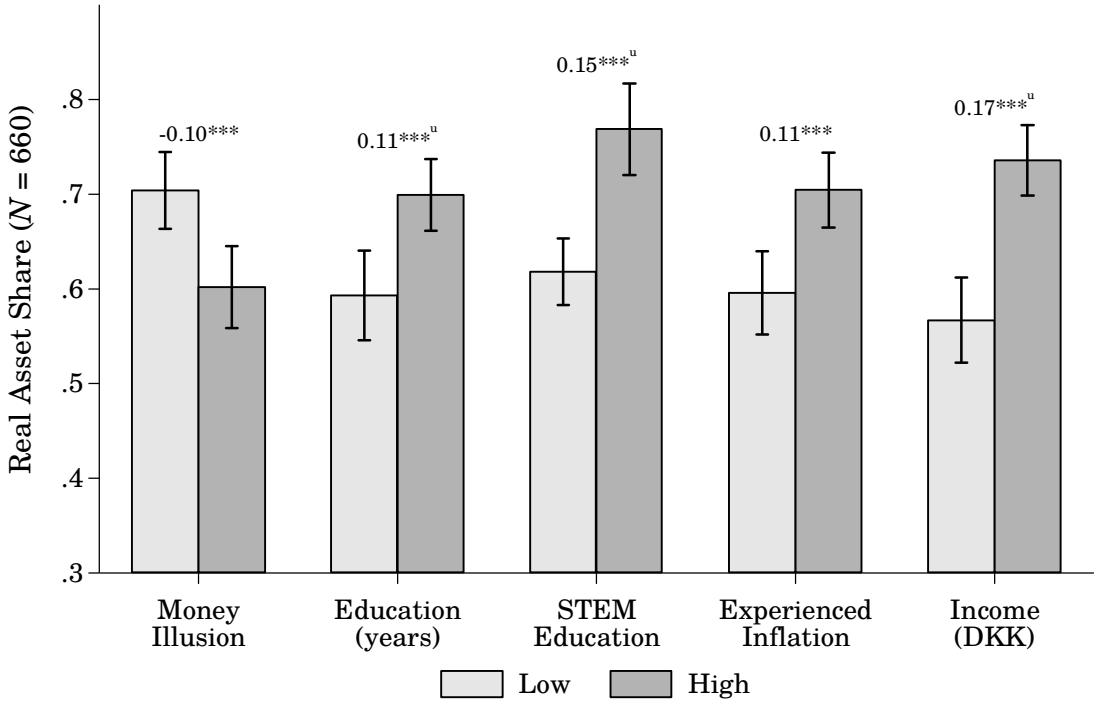
As shown in Table 1, Danish household portfolios are dominated by real estate and bank deposits, with stocks and bonds together representing less than 10 percent of total gross assets for the average individual. As a result, an analysis including only real estate and bank deposits yields similar results to one that includes all of the major asset classes. Given that our focus is household finance in general, we nevertheless include stocks and bonds in our analysis, hence the RA share is the obvious variable to focus on. Table 1 shows that the RA share is about 62 percent in our sample (51 percent for the population).

We begin our analysis of the relationship between money illusion and the RA share by looking at the average RA share for participants with high and low levels of money illusion, using a median split of the MI index. We compare the difference between groups with similar differences for high and low levels of education, experienced inflation, income, and other relevant variables.

---

[21] The standard corporate finance literature (see Hurwicz 1946 for an early example) equates "real" assets with physical assets such as real estate and commodities (also "real" under our definition), contrasted with "financial" assets such as stocks (which we call "real"), bonds, and bank deposits (which we both call "nominal").

Figure 6: Real Asset Share (RA) by Key Characteristics



Notes: The bars show the Real Asset Share (RA) by key characteristics. "STEM Education" is a dummy set to 1 if a participant completed an education in a STEM (science, technology, engineering, and mathematics) field and zero otherwise. Other variables are split at the medians, with Low vs. High referring to the lower vs. upper halves of the distributions. Whiskers show 95% confidence intervals for the means. The numbers above the bars are the differences between the High and Low groups. Significance at 10% is denoted by *, at 5% by **, and at 1% by ***, based on a two-sided t-tests. A superscript "u" indicates that the test was run without the assumption of equal variance, because a test for equality of variance was rejected.

Figure 6 shows that the MI index has a similar effect on the RA share to education and experienced inflation. The two leftmost bars show that people who are strongly prone to money illusion are less likely to hold real assets. In particular, we find that participants with a high MI index (those above the median) have an RA share that is 10 percentage points lower than those with a low MI index, and this difference is highly significant ($p < 0.001$).[22] The rightmost bars show, perhaps unsurprisingly, that the RA share reacts strongly to differences in income (17 percentage points). We also obtain highly significant results for years of education and for whether a participant has completed a STEM education. In addition, we find that those who experienced higher inflation throughout their lifetimes invest a higher share of their portfolios

[22] The p-value is below 0.001 using either a two-sided t-test assuming unequal variance or a Wilcoxon Mann–Whitney U-test.

in real assets, perhaps because the experience of higher inflation in the past leads to the expectation of higher inflation in the future, as argued by Malmendier and Nagel (2016).[23]

We do not find effects for differences in cognitive ability and cognitive reflection on the RA share (see Online Appendix B for insignificant correlates). This result is surprising in the light of studies showing a positive relation between cognitive ability and financial choices (e.g. Choi et al. 2014, Grinblatt, Keloharju, and Linnainmaa 2011). However, the result also suggests that the MI index is *not* simply a proxy for cognitive ability. We also find no significant correlation between the risk and loss aversion measures and the RA share. This lack of a relation is consistent with the view that money illusion plays a distinct role in household financial decisions, and suggests that the MI index is not simply a proxy for general risk or loss aversion.

3.4 Zero-One Inflated Beta Model

To investigate the relation between the real asset (RA) share and the money illusion (MI) index, controlling for many relevant characteristics, we use the zero-one inflated beta (ZOIB) model developed by Cook, Kieschnick, and McCullough (2008).[24] The reasons for using ZOIB are twofold. First, the RA share is a proportion, defined on the interval $[0, 1]$. The conditional expectation therefore cannot be a linear function of the explanatory variables, and the conditional variance is a function of the conditional mean. Second, the decision to hold real assets at all is qualitatively different from the choice of the proportion of total gross assets to allocate to them. The RA share is therefore best described as a mixed discrete-continuous variable, with the discrete and continuous outcomes reflecting different decisions. These decisions may be generated by different processes, and related to the explanatory variables in different ways. The ZOIB approach takes these characteristics into account.

The following descriptives on the RA share make clear that using ZOIB is appropriate. The distribution of the RA share is bimodal with peaks at zero and close to one.[25] About 18.6

---

[23] We use the geometric average rate of inflation over a subject's life, which assigns equal weight to all years, because the current portfolio also reflects decisions made over many years.

[24] We use the Stata implementation of ZOIB developed by Buis (2012). Supplementary results from the ZOIB regressions, as well as OLS regression, are in Online Appendix B.

[25] For both participants and the pool from which they were recruited, we focus on non-students. Students tend to be highly able, but typically have little wealth and low incomes.

percent of participants have RA shares of zero and the corresponding share for the population is about 33.6 percent. There is also positive mass at exactly one, but it is small among both participants and the population (1.8 and 5.0 percent, respectively).[26] However, the mass very close to one is considerable. For example, about 10.2 percent of participants have RA shares above 0.99 and nearly a third, 31.2 percent, have RA shares above 0.95. The corresponding figures for the population are similar, at 10.1 percent and 28.0 percent, respectively. Individuals with RA shares close to one invest almost all of their wealth in real assets, but maintain small bank balances to cover expenses. In general, they hold nearly all of their wealth in real estate.

The mass at an RA share of zero is not surprising. As noted previously, bank deposits are effectively the default asset. Investing in any other asset requires a deliberate decision to move wealth out of the default asset, followed by a choice of how much to allocate to each asset. The fact that the mass at zero is larger in the population than in our sample is explained by the fact that our participants are better educated and richer than the average Dane. As a result, they are more likely to have made the decision to move some of their wealth out of the default asset.

For participant i, the dependent variable in the ZOIB model is the RA share $y_i \in [0, 1]$, with a vector of independent variables $\mathbf{x}_i$. The model combines logit estimates for probabilities of zero and one with a two-parameter beta function for the region in between. The probability of acquiring any real assets (real estate or stocks) is $C(\boldsymbol{\alpha}'\mathbf{x}_i)$, where C is the cumulative logistic function. Conditional on acquisition, the individual chooses a real asset share $y_i \in (0, 1]$, leaving the remaining share $1 - y_i$ in nominal assets. With conditional probability $C(\boldsymbol{\gamma}'\mathbf{x}_i)$, an individual who holds real assets exhausts all nominal assets. The ZOIB model is therefore

$$
\begin{aligned}
&f(y_i = 0 \mid \mathbf{x}_i) = 1 - C(\boldsymbol{\alpha}'\mathbf{x}_i), && y_i = 0 \\
&f(y_i \mid \mathbf{x}_i) = C(\boldsymbol{\alpha}'\mathbf{x}_i)\big(1 - C(\boldsymbol{\gamma}'\mathbf{x}_i)\big) \left[\frac{\Gamma\big(p + q(\mathbf{x}_i)\big)}{\Gamma(p)\Gamma\big(q(\mathbf{x}_i)\big)} y_i^{p-1}(1 - y_i)^{q(\mathbf{x}_i)-1}\right], && y_i \in (0, 1), \\
&f(y_i = 1 \mid \mathbf{x}_i) = C(\boldsymbol{\alpha}'\mathbf{x}_i)C(\boldsymbol{\gamma}'\mathbf{x}_i), && y_i = 1
\end{aligned}
$$

where $q(\mathbf{x}_i) = p \exp(-\boldsymbol{\beta}'\mathbf{x}_i)$ and p is parameter of the beta function. We simultaneously estimate $\hat{\boldsymbol{\alpha}}$, $\hat{\boldsymbol{\beta}}$, and $\hat{\boldsymbol{\gamma}}$ using maximum likelihood. The first two relate to the probability of acquiring any real assets and the proportion of total wealth allocated to real assets, respectively. The third is

[26] Danish law requires residents to have a bank account, so a real asset share of one implies a zero or negative balance in in individual's bank accounts. This situation can be viewed as something of a special case, indicating that day to day expenditure is being financed by debt, to avoid reducing real asset holdings.

included for completeness, because a small number of participants have RA shares of one, but there is no prediction of a relationship between exhaustion of nominal assets and money illusion. Since the model is non-linear and our interest is in the overall effects on both acquisition and the proportion given acquisition, we report combined average marginal effects.[27]

Table 3 shows that the estimated effects of money illusion are strong and very robust to inclusion of a host of variables (note the significant estimates in the first row across all specifications).[28] In particular, we find that going from an index value of 0 to 1 reduces the RA share by between 8.3 and 14.4 percentage points (16.4 to 28.4 percent of the population average). The robustness result is important because it suggests that the effect of money illusion is unlikely to be a confound. Most other determinants tend to lose significance as additional controls with which they are correlated are added. For example, a significant effect of income on the RA share is clearly to be expected, because real estate is a superior good. However, even income ceases to be significant in specification (5), where wealth is included.[29]

Column (2) shows that the inclusion of cognitive and educational controls improves (reduces AIC) the basic model in (1), but has little effect on the estimated effect of the MI index. A standard deviation increase in the MI index is associated with a reduction in the RA share of about 3.9 percentage points (7.7 percent of the population average RA share). The effect size of the MI index is comparable to a reduction in education of one standard deviation (2.9 years), which is associated with a reduction in the RA share of about 3.7 percentage points. It is about a third the size of the effect of a STEM education, which is associated with an increase in the RA share of about 11.3 percentage points (22.2 percent). However, a shift in the MI index from 0 to 1 has an even larger effect than STEM education, with a reduction in the RA share of about 14.2 percentage points (28 percent).

Column (3) shows that both higher income and higher experienced inflation are associated with a higher RA share, which is in line with the partial correlations shown in Figure 6 (it is

---

[27] We decompose the overall marginal effects into the average marginal effects of the probability of staying out of real assets entirely and of how much to invest in real assets, given one invests at all, in Online Appendix B.

[28] OLS regressions provide similar but somewhat larger estimates (in line with Cook, Kieschnick, and McCullough 2008). For details, see Online Appendix B.

[29] Unsurprising exceptions are the number of children, total assets, and total liabilities. Having children tends to increase demand for housing, while housing purchases typically involve mortgage borrowing, thereby increasing assets and liabilities in tandem.

also in line with Calvet, Campbell and Sodini (2011), who find that wealth, income, and education are correlated with higher levels of stock market participation in Sweden). However, the effect of years of education ceases to be significant in column (3) and the effect of experienced inflation is not robust to the inclusion of sociodemographic and psychometric controls in column (4). Of the correlates in column (3), the MI index, STEM education and income remain significant in column (4). In addition, various non-financial demographics are robustly associated with the RA share, including the status of being self-employed, the number of children, and gender.

Column (4) shows that a standard deviation increase in the MI index is associated with a decrease of about 2.7 percentage points (5.3 percent) in the RA share. This difference is just over a quarter as large as the increase of about 9.6 percentage points (18.9 percent) associated with a standard deviation increase in income. In money terms, it is equivalent to a drop in income of about kr. 52,000 (roughly $10,000 at the time), representing almost 20 percent of the average income for the population. A full shift in the MI index, from 0 to 1, has an effect of similar magnitude to a drop in income of more than kr. 188,000 (about $36,000), which exceeds 70 percent of the average income. In terms of controls, self-employed participants have RA shares 21.3 percentage points (41.9 percent) higher than others (this contrasts with Calvet, Campbell, Sodini 2007 who find that Swedish entrepreneurs invest less in risky assets). Regarding children and gender, an additional child is associated with an increase in the RA share of about 6.6 percentage points (13.0 percent), and women tend to have RA shares about 6.4 percentage points (12.6 percent) lower than men.

Table 3: Real Asset Share and Money Illusion (RA Share ∈ [0, 1])

Dep. Var.: RA Share	(1)	(2)	(3)	(4)	(5)
Money Illusion Index	−0.144***	−0.142***	−0.123**	−0.097**	−0.083**
	(0.047)	(0.049)	(0.048)	(0.047)	(0.036)
IST-M Score		−0.003	0.000	0.002	0.003
		(0.005)	(0.005)	(0.005)	(0.003)
High CR Score		−0.015	−0.032	−0.040	−0.027
		(0.029)	(0.029)	(0.027)	(0.021)
Education (years)		0.013**	0.007	0.007	0.002
		(0.006)	(0.006)	(0.006)	(0.005)
STEM Education		0.113***	0.103***	0.074**	0.025
		(0.030)	(0.030)	(0.032)	(0.028)
Age			0.000	0.003	−0.001
			(0.001)	(0.002)	(0.001)
Experienced Inflation			0.106**	0.029	0.031
			(0.047)	(0.049)	(0.037)
Income (million kr.)			0.255***	0.513***	0.041
			(0.097)	(0.131)	(0.096)
Retired				0.053	0.043
				(0.048)	(0.039)
Self-employed				0.213***	−0.016
				(0.043)	(0.059)
Children (number)				0.066***	0.032***
				(0.016)	(0.012)
Female				−0.064**	−0.031
				(0.030)	(0.023)
Assets (million kr.)					0.278***
					(0.021)
Liabilities (million kr.)					0.106***
					(0.022)
Controls	No	No	No	Yes	Yes
Wald χ^2	2.91	9.89	19.76	41.34	111.33
AIC	67.83	52.52	39.83	16.48	−323.40
N	660	660	660	660	660

Notes: The table shows average marginal effects for ZOIB regressions of the share of gross wealth held in real assets (RA). Students and participants without any assets are excluded. *Money Illusion Index* is a measure of money illusion between −1 and 1. *IST-M Score* is a measure of fluid intelligence between 0 and 20 (Liepmann et al. 2001). *High CRT Score* is a dummy set to 1 for participants who correctly answered at least 2 of 3 cognitive reflection test questions (Frederick 2005). *Age* is in years at the time of the study, with linear and quadratic terms. *Education* is the standard number of years required to complete an individual's education. *STEM Education* is a dummy set to 1 if the participant completed an education in science, technology, engineering, or mathematics, based on ISCED-2011 classifications. *Experienced Inflation* is the average inflation rate over the participant's life. *Income* includes gross wages, pensions, and benefits. *Assets* is gross assets, excluding pension wealth. *Liabilities* is total liabilities. Financial variables are in millions of Danish crowns (kr.), with linear and quadratic terms. *Retired*, *Self-Employed*, and *Female* are dummies, while *Children* is the number of children. Controls include dummies for partnered, married, occupational skill level, and public sector employment, together with incentivized measures to control for risk and loss aversion (Tanaka, Camerer, and Nguyen 2010) and the Big 5 personality test (Costa and McCrae 1992). Significance at 10% is denoted by *, at 5% by **, and at 1% by ***.

The much higher average RA share for self-employed individuals is driven by substantially higher gross assets, and in particular gross real estate assets. Self-employed individuals in the population have, on average, total gross assets of about kr. 5.2 million (about $1 million at the time), of which about 4.5 million ($865 thousand) is real estate, with a participation rate of 78 percent. For the non-self-employed, total gross assets are kr. 907 thousand (about $175 thousand), with real estate assets of kr. 694 thousand (about $133 thousand) and a participation rate of 54 percent.[30] Interestingly, however, there is no evidence of lower money illusion among the self-employed.[31]

The gender difference also seems to be driven by higher overall wealth for men, and in particular higher real estate wealth, with higher real estate market participation. Average total gross assets are about kr. 1.4 million (about $269 thousand) for men, of which 1.2 million ($231 thousand) are in real estate, versus kr. 797 thousand ($153 thousand) and kr. 586 thousand ($112 thousand), respectively, for women. Real estate market participation rates also differ significantly, with about 63 percent of men participating, versus only 49 percent of women.[32] For couples with jointly owned assets, the value is divided equally between each partner in the register data. The low female participation rate is therefore likely to be driven by relatively low participation by single women, as compared with single men.

The positive relationship between the RA share and the number of children is also driven by real estate, and consistent with an intuitive explanation. Families with more children have more demand for housing services, and the number of children is positively correlated, based

---

[30] The self-employed differences in total gross assets, real estate assets, and real estate market participation are all highly significant. Results of two-sided t-tests with unequal variance for total gross assets and real estate assets are ($t = -12.5,\ p = 0.000$) and ($t = -12.0,\ p = 0.000$), respectively. For real estate market participation, the result of a z-test is ($z = -9.9,\ p = 0.000$).

[31] Average MI index values are 0.264 for the 35 self-employed participants and 0.253 for the 628 others (including 3 without assets who are excluded from the RA share regressions). The difference is not significant according to a two-sided t-test assuming equal variance ($t = -0.2,\ p = 0.822$). This finding supports Haigh and List (2005), who find that professional traders are not less prone to myopic loss aversion (in fact, they are significantly more prone to it than students).

[32] The gender differences in total gross assets, real estate assets, and real estate market participation are all highly significant. Results of two-sided t-tests with unequal variance for total gross assets and real estate assets are ($t = 12.1,\ p = 0.000$) and ($t = 17.5,\ p = 0.000$), respectively. For real estate market participation, the result of a z-test is ($z = 28.6,\ p = 0.000$).

on Spearman rank correlations, with total assets and real estate assets, and with real estate market participation, but negatively correlated with the value of gross assets in all asset classes other than real estate.

Column (5) includes gross assets and liabilities. We find that both of these are highly significant, but most of the explanatory variables in (4) cease to be significantly correlated with the RA share. The exceptions are the MI index and the number of children. Endogeneity issues make interpretation difficult, because the portfolio structure impacts the development of total assets and liabilities over time. It is nevertheless striking that the effect of the MI index remains significant, and that the effect size is not substantially smaller than in column (4).

3.5 The Cost of Money Illusion

We have shown above that money illusion biases household investment away from nominally risky (i.e. real) assets. We now show that this bias is costly. We find that those prone to money illusion have lower expected returns on their investment. The reason is essentially because real assets have higher (real) returns than nominal assets. Remarkably, we also find that median net worth, i.e. gross assets minus liabilities, is more than 50 percent higher in the low-MI group than in the high-MI group.

To approximate the cost of money illusion for investors, we consider the relationship between the MI index and estimated gross portfolio returns. We estimate portfolio returns by multiplying historical year-on-year arithmetic average returns for each asset class by the respective asset shares for each participant, giving an estimated average annual portfolio return r_i for participant i (see Online Appendix E for further details) We regress this return on the explanatory variables we used in the ZOIB regressions in Section 3.4. In this case, however, we can use OLS with the continuously compounding rate $\log(1 + r_i)$ as the dependent variable. Our estimated portfolio return is clearly a rough measure, resting on the assumptions that all asset returns equal averages for the respective classes, and that an individual's asset allocation choices remain fixed over time. Nevertheless, it does provide insight into the magnitude of the financial costs arising from proneness to money illusion.

We compute year-on-year returns for each asset class using quarterly data from the period 1992Q1 to 2016Q1, for which data on all asset classes are generally available. The nominal returns are deflated using the Danish CPI. For stocks and bonds, we use the total return indices

for the OMX Copenhagen All-Share Index and 10-year Danish government bonds, respectively. To approximate returns on bank deposits, we use the rate of return on Danish central bank certificates of deposits (total return indices for Danish CDs, stocks, and government bonds are taken from Global Financial Data 2016a; 2016b; 2016c). By and large, these rates should be similar to those offered by savings accounts, but higher than those offered by certain other accounts (such as checking accounts). For real estate, we use sale price indices from the Association of Danish Mortgage Banks (Realkreditrådet 2016). The data include sale prices for single family homes, condominiums, and vacation homes, measured in Danish crowns per square meter. We combine these prices into an average, weighted by the total value of real estate in each category at the time of the study, compute the rates of change and add the value of imputed rent.[33]

We have seen in figure 6 that the difference in RA shares between the low- and high-MI groups is about 10 percentage points, with those prone to money illusion investing more in bank deposits and less in real estate. This tendency leads to lower returns for people who are prone to money illusion because real estate has tended to offer considerably higher returns than bank deposits in Denmark. For the low-MI group, the average 10-year portfolio return is 83.5 percent, versus 73.3 percent for the high-MI group, suggesting a cost of about 10 percentage points from money illusion. We also find that the 10-year return on the low-MI portfolio is higher for every quarter in the data but three.

Table 4 shows the results of regressing the individual portfolio returns on the MI index and other potentially relevant correlates.[34] The correlation between the MI index and portfolio returns is statistically significant in all of the specifications in the table, though only marginally so in specification (4), and is economically large. In specification (1), a standard deviation increase in money illusion is associated with a decline in the continuous annual rate of about 0.3 percentage points.

---

[33] Weighting is based on aggregate household wealth data from Statistics Denmark (2016a). The value of imputed rent through 2014 is from Statistics Denmark (2016b) and we use the conservative 4 percent rule (see Quitzau 2014) as an approximation for 2015 and 2016. For details, see Online Appendix E.

[34] The dependent variable is $100\ \log(1 + r_i)$, where r_i is the simple annual rate of return. With a 5 percent year-on-year return, for example, $r_i = 0.05$ and $100 \log(1 + r_i) \approx 4.879$.

Table 4: Annual Average Real Portfolio Return

Dep. Var.: $100\log(1+r_i)$	(1)	(2)	(3)	(4)	(5)
Money Illusion Index	−1.109***	−1.089***	−0.933**	−0.776*	−0.781**
	(0.388)	(0.402)	(0.406)	(0.402)	(0.356)
Education (years)		0.113**	0.067	0.089*	0.068
		(0.049)	(0.052)	(0.054)	(0.051)
STEM Education		0.865***	0.800***	0.543**	0.375
		(0.213)	(0.214)	(0.234)	(0.228)
Experienced Inflation			1.138***	0.478	0.373
			(0.358)	(0.391)	(0.358)
Income (million kr.)			2.823*	5.912***	4.403*
			(1.499)	(2.163)	(2.423)
Income^2			−1.197	−4.095**	−4.067*
			(1.453)	(1.884)	(2.420)
Retired				0.284	0.354
				(0.457)	(0.423)
Self-employed				1.302**	0.209
				(0.563)	(0.641)
Children (number)				0.455***	0.427***
				(0.125)	(0.115)
Female				−0.448*	−0.263
				(0.239)	(0.213)
Assets (million kr.)					0.888***
					(0.149)
Assets^2					−0.054***
					(0.016)
Liabilities (million kr.)					0.561***
					(0.172)
Liabilities^2					−0.030***
					(0.011)
Constant	6.382***	4.964***	1.712	1.552	1.602
	(0.138)	(0.731)	(1.655)	(2.184)	(2.063)
Cognitive Controls	No	Yes	Yes	Yes	Yes
Age and Controls	No	No	No	Yes	Yes
R^2	0.013	0.045	0.092	0.201	0.328
AIC	3184.9	3171.2	3150.9	3098.9	2992.6
N	660	660	660	660	660

Notes: The table shows coefficients from OLS regressions. Students and people without assets are excluded. *Money Illusion Index* is a measure of money illusion between −1 and 1. *Education* is the standard number of years required to complete a participant's level of education. *STEM Education* is a dummy indicating completion of an education in science, technology, engineering, or mathematics, based on ISCED-2011 classifications. *Experienced Inflation* is the average inflation rate over the participant's life. *Income* is gross wages, pensions, and benefits. *Assets* is gross assets, excluding pension wealth. *Liabilities* is total liabilities. Financial variables are in millions of Danish crowns. *Retired*, *Self-Employed*, and *Female* are dummies. *Children* is the number of children. *Cognitive Controls* include the IST-M measure of fluid intelligence (Liepmann et al. 2001) and a dummy for high (two or more correct answers) cognitive reflection (Frederick 2005). *Age* is in years, with linear and quadratic terms, and *Controls* include dummies for partnered, married, occupational skill level, and public sector employment, plus incentivized measures to control for risk and loss aversion (Tanaka, Camerer, and Nguyen 2010) and the Big 5 personality test (Costa and McCrae 1992). Significance at 10% is denoted by *, at 5% by **, and at 1% by ***, using robust standard errors.

As can be seen in specifications (2) through (5), the effect of the MI index is larger and generally more significant than STEM education, and similar to about three or four additional years of education. The MI index is also one of the few correlates that is robust to the inclusion of total assets and liabilities in specification (5). Overall, the difference in continuously compounded rates of return between an individual with an index of zero (no money illusion) and an index of one ranges from 1.1 percentage points with no controls, to a 0.8 percentage points when controlling for an extensive set of financial and socioeconomic characteristics, a difference that is both statistically and economically significant.

Given the above differences in estimated portfolio returns, it seems plausible that individuals who are less prone to money illusion should be richer.[35] We find that this is indeed the case. Again using a median split based on the money illusion index, we find that the median net worth (gross assets minus liabilities) in the low-MI group is 61.8 percent higher than in the high-MI group, and this difference is statistically significant.[36] Data protection policies preclude the reporting of precise median values, but we can report that the median net worth in the low-MI group is in the low kr. 300 thousands (low $60 thousands at the time), while median net worth in the high-MI group is below kr. 200 thousand (about $38 thousand). Needless to say, this comparison of medians lacks controls, but it is consistent with the predictions of our money illusion hypothesis and, in conjunction with our other results, in particular the estimated portfolio returns, is suggestive of a possible causal relationship.

4 Concluding Remarks

We combine an individual-level measure of money illusion elicited in a survey with high-quality register data for a broad, heterogeneous sample, and show that people who are more prone to money illusion tend hold more of their gross wealth in nominal assets such as bank deposits, and less in real assets such as real estate. In addition, we show that this behavior is costly. As a result of a bias towards nominal assets, people who are more prone to money illusion earn substantially lower rates of return and have significantly lower median net worth. Taking advantage

[35] Precisely how much richer is unclear, because higher wealth and expected wealth may influence saving and consumption rates.

[36] A nonparametric Wilcoxon Mann-Whitney U-test reports a significant difference in net worth between the low- and high-MI groups, with $p = 0.034$.

of a rich data set including register data and psychometrics, we are able to show that our measure of money illusion is not simply a proxy for education, cognitive ability, income, inflation experience, or indeed wealth. Taken together, our result suggests that money illusion plays an important role in household investment decisions. Indeed, the large effects observed in our results may be something of a lower bound, given that our sample tends to be somewhat richer and more educated than the population as a whole.

Our findings are in line with Thaler et al. (1997). In a lab experiment with students, they find that when inflation hides real losses, it reduces the effect of loss aversion on portfolio allocation choices. While Thaler et al. are careful to avoid extrapolating from the behavior of students in experiments where stakes are low to that of investors in high stakes situations, we explicitly explore this issue by using a sample of people from all walks of life. We find that students are in fact significantly *less* prone to money illusion (i.e. more in line with the standard model) than non-students. This finding echoes Haigh and List (2005), who show that students in the lab tend to behave *more* like the rational agents of standard theory than do experienced individuals outside the lab. Our main finding is that real world portfolio choices are consistent with bias resulting from money illusion, based on our measure and controlling for relevant characteristics. Given the strong predictive power of our measure, this finding underscores the value to economists of unincentivized measures such as financial literacy tests.

The use of non-incentivized measures remains controversial in experimental economics (see Dhami 2016, chap. 1), yet the use of survey data is a mainstay of empirical economics. We counter objections to survey questions by arguing that the value of any measure, whether incentivized or not, is ultimately its ability to explain real world outcomes in the manner predicted by theory. Our data set provides a rare opportunity to test for this ability with a high degree of accuracy, because the financial data and demographic controls with which we match our measure of money illusion are *not* self-reported. They are rather taken from official registers and matched on an individual level with our measure of money illusion. We can therefore preclude confounds stemming from, for example, correlation between errors in our measure and errors in self-reported data. In addition, participation was completely anonymous to us (including payment) and participants were not told that we would have access to their register data, minimizing the risk of Hawthorne effects.

Our findings are also in line with the results of Andersen and Nielsen (2011), and Briggs et al. (2015), who find that the increase in stock market participation is strikingly low after

unexpected positive shocks to wealth, in the first case due to an unexpected inheritance in Denmark, in the second due to winning the lottery in Sweden. Briggs et al. conclude that "our results suggest that cognitive constraints or "nonstandard" beliefs and preferences are likely to play an important role in explaining the behavior of nonparticipating households," and Andersen and Nielsen conclude (2011, p. 1670) that the "vast majority of individuals do not respond to significant windfall wealth. For those individuals, other barriers, such as behavioral, cognitive, and psychological constraints, are likely to dominate."

While previous studies have pointed to the relevance of cognitive ability in the guise of general intelligence (Grinblatt, Keloharju, and Linnainmaa 2011), general financial literacy (e.g. van Rooij, Lusardi and Alessie 2011) and numeracy (e.g. Gerardi, Goette, and Meier 2013) as determinants of stock market participation and financial decisions more generally, our results suggest that money illusion is a specific and additional "cognitive constraint" to be taken into account in household finance.

References

Agell, Jonas, and Helge Bennmarker. 2003. "Endogenous Wage Rigidity." SSRN Scholarly Paper ID 466582.

Akerlof, George A., and Robert J. Shiller. 2009. *Animal Spirits*. Princeton, NJ: Princeton University Press.

Andersen, Steffen and Kasper M. Nielsen. 2011. "Participation Constraints in the Stock Market: Evidence from Unexpected Inheritance Due to Sudden Death." *Review of Financial Studies* 24 (5): 1667–97.

———, John Y. Campbell, Kasper Meisner Nielsen, and Tarun Ramadorai. 2015. "Inattention and Inertia in Household Finance: Evidence from the Danish Mortgage Market." SSRN Scholarly Paper ID 2463575.

Andrews, Dan, and Aida Caldera Sánchez. 2011. "Drivers of Homeownership Rates in Selected OECD Countries." OECD Economics Department Working Papers.

Barberis, Nicholas, and Ming Huang. 2001. "Mental Accounting, Loss Aversion, and Individual Stock Returns." *Journal of Finance* 56 (4): 1247–92.

———. 2008. "Chapter 6 - The Loss Aversion/Narrow Framing Approach to the Equity Premium Puzzle." In Handbook of the Equity Risk Premium, edited by Rajnish Mehra: 199–229. Handbooks in Finance. San Diego, CA: Elsevier.

Benartzi, Shlomo, and Richard H. Thaler. 1995. "Myopic Loss Aversion and the Equity Premium Puzzle." *Quarterly Journal of Economics* 110 (1): 73–92.

Bernanke, Ben S. 2006. "Financial Literacy." Testimony before the Committee on Banking, Housing, and Urban Affairs of the United States Senate, Washington, DC, May 23.

Briggs, Joseph S., David Cesarini, Erik Lindqvist, and Robert Östling. 2015. "Windfall Gains and Stock Market Participation." NBER Working Paper 21673.

Brunnermeier, Markus K., and Christian Julliard. 2008. "Money Illusion and Housing Frenzies." *Review of Financial Studies* 21 (1): 135–80.

Buis, Maarten L. 2012. "ZOIB: Stata Module to Fit a Zero-One Inflated Beta Distribution by Maximum Likelihood." Statistical Software Components. Boston College Department of Economics.

Calvet, Laurent E., John Y. Campbell, and Paolo Sodini. 2007. "Down or Out: Assessing the Welfare Costs of Household Investment Mistakes," *Journal of Political Economy* 115 (5): 707–47.

Campbell, John Y. 2006. "Household Finance." *Journal of Finance* 61 (4): 1553–1604.

——— and Tuomo Vuolteenaho. 2004. "Inflation Illusion and Stock Prices." American Economic Review 94: 19–23.

Choi, Syngjoo, Shachar Kariv, Wieland Müller, and Dan Silverman. 2014. "Who Is (More) Rational?" *American Economic Review* 104 (6): 1518–50.

Cohen, Randolph B., Christopher Polk, and Tuomo Vuolteenaho. 2005. "Money Illusion in the Stock Market: The Modigliani-Cohn Hypothesis." *Quarterly Journal of Economics* 120 (2): 639–68.

Cook, Douglas O., Robert Kieschnick, and B. D. McCullough. 2008. "Regression Analysis of Proportions in Finance with Self Selection." *Journal of Empirical Finance* 15 (5): 860–67.

Costa, Paul T, and Robert R McCrae. 1992. *Revised NEO Personality Inventory (NEO PI-R) and NEO Five-Factor Inventory (NEO-FFI).* Odessa, FL: Psychological Assessment Resources.

Danmarks Nationalbank. 2009. *Monetary Policy in Denmark. 3rd ed.* Copenhagen: Danmarks Nationalbank.

Dhami, Sanjit. 2016. *The Foundations of Behavioral Economic Analysis.* Oxford: Oxford University Press.

Einiö, Mikko, Markku Kaustia, and Vesa Puttonen. 2008. "Price Setting and the Reluctance to Realize Losses in Apartment Markets." *Journal of Economic Psychology* 29 (1), 19–34.

Fehr, Ernst, and Jean-Robert Tyran. 2001. "Does Money Illusion Matter?" *American Economic Review* 91 (5): 1239–62.

———. 2005. "Individual Irrationality and Aggregate Outcomes." *Journal of Economic Perspectives* 19 (4): 43–66.

———. 2007. "Money Illusion and Coordination Failure." *Games and Economic Behavior* 58 (2): 246–68.

———. 2008. "Limited Rationality and Strategic Interaction: The Impact of the Strategic Environment on Nominal Inertia." *Econometrica* 76 (2): 353–94.

Fisher, Irving. 1928. *The Money Illusion*. New York: Adelphi Company.

Frederick, Shane. 2005. "Cognitive Reflection and Decision Making." *Journal of Economic Perspectives* 19 (4): 25–42.

Genesove, David, and Christopher Mayer. 2001. "Loss Aversion and Seller Behavior: Evidence from the Housing Market." *Quarterly Journal of Economics* 116 (4): 1233–60.

Gerardi Kristopher, Goette Lorenz, and Meier Stephan 2013. "Numerical ability predicts mortgage default." *Proceedings of the National Academy of Sciences* 110: 11267–11271.

Global Financial Data. 2016a. "IDDNKCD: Denmark National Bank Rate on Certificates of Deposit." Global Financial Data. Accessed August 23.

———. 2016b. "_OMXCGID: OMX Copenhagen All-Share Gross Index." Global Financial Data. Accessed August 23.

———. 2016c. "TRDNKGVM: Denmark 10-Year Total Return Government Bond Index." Global Financial Data. Accessed August 23.

Gneezy, Uri, Arie Kapteyn, and Jan Potters. 2003. "Evaluation Periods and Asset Prices in a Market Experiment." *Journal of Finance* 58 (2): 821–37.

Gneezy, Uri, and Jan Potters. 1997. "An Experiment on Risk Taking and Evaluation Periods." *Quarterly Journal of Economics* 112 (2): 631–45.

Greenspan, Alan. 2005. "Globalization." Speech at the Council on Foreign Relations, New York, NY, March 10.

Grinblatt, Mark, Matti Keloharju, and Juhani Linnainmaa. 2011. "IQ and Stock Market Participation." *Journal of Finance* 66 (6): 2121-64.

Guiso, Luigi, and Paolo Sodini. 2013. "Chapter 21 – Household Finance: An Emerging Field." In Handbook of the Economics of Finance, edited by Milton Harris and Rene M. Stulz George M. Constantinides, 2, Part B:1397–1532. Elsevier.

Haigh, Michael S., and John A. List. 2005. "Do Professional Traders Exhibit Myopic Loss Aversion? An Experimental Analysis." *Journal of Finance* 60 (1): 523–34.

He, Xue Dong, and Xun Yu Zhou. 2014. "Myopic Loss Aversion, Reference Point, and Money Illusion." *Quantitative Finance* 14 (9): 1541–54.

Hurwicz, Leonid. 1946. "Theory of the Firm and of Investment." *Econometrica* 14(2): 109–36.

Kahneman, Daniel, Jack Knetsch, and Richard Thaler. 1986. "Fairness as a Constraint on Profit Seeking: Entitlements in the Market." *American Economic Review* 76 (4): 728–41.

Kahneman, Daniel, and Amos Tversky. 1979. "Prospect Theory: An Analysis of Decision under Risk." *Econometrica* 47 (2): 263–91.

Liepmann, Detlev, André Beauducel, Burkhard Brocke, and Rudolf Amthauer. 2001. *I-S-T 2000 R: Intelligenz-Struktur-Test 2000 R*. Göttingen: Hogrefe Verlag.

Lusardi, Annamaria, and Olivia S. Mitchell. 2007. "Financial Literacy and Retirement Planning: New Evidence from the Rand American Life Panel." SSRN Scholarly Paper ID 1095869.

———. 2009. "How Ordinary Consumers Make Complex Economic Decisions: Financial Literacy and Retirement Readiness." NBER Working Paper 15350.

———. 2014. "The Economic Importance of Financial Literacy: Theory and Evidence." *Journal of Economic Literature* 52 (1): 5–44.

Mack, Adrienne, and Enrique Martínez-García. 2011. "A Cross-Country Quarterly Database of Real House Prices: A Methodological Note." Federal Reserve Bank of Dallas Globalization and Monetary Policy Institute Working Paper, no. 99.

Malmendier, Ulrike, and Stefan Nagel. 2016. "Learning from Inflation Experiences." *Quarterly Journal of Economics* 131 (1): 53–87.

Mees, Helen and Philip H. Franses. 2014. Are Individuals in China prone to Money Illusion? *Journal of Behavioral and Experimental Economics* 51: 38–46.

Mehra, Rajnish, and Edward C. Prescott. 1985. "The Equity Premium: A Puzzle." *Journal of Monetary Economics* 15 (2): 145–61.

OECD. 2005. *Improving Financial Literacy.* Paris: Organisation for Economic Co-operation and Development. http://www.oecd-ilibrary.org/content/book/9789264012578-en.

———. 2015. "3-Month or 90-Day Rates and Yields: Certificates of Deposit for the United States." FRED, Federal Reserve Bank of St. Louis. https://fred.stlouisfed.org/series/IR3TCD01USM156N.

OECD, Eurostat, and UNESCO Institute for Statistics. 2015. *ISCED 2011 Operational Manual*. Paris: Organisation for Economic Co-operation and Development. http://www.oecd-ilibrary.org/content/book/9789264228368-en.

Quitzau, Jarl. 2014. "Revision af indkomststatistikken for 2013." Danmarks Statistik. http://www.dst.dk/ext/arbejde-loen-og-indkomst/rev13.

Realkreditrådet. 2016. “BM010: Ejendomspriser på boligmarkedet efter område, ejendomskategori og priser på realiserede handler.” Realkreditrådet. Accessed August 23. http://rkr.statistikbank.dk/BM010/.

Schlag, Karl H. 2008. “A New Method for Constructing Exact Tests.” University of Pompeu Fabra Working Paper No. 1109.

Schmeling, Maik and Andreas Schrimpf. 2011. “Expected Inflation, Expected Stock Returns, and Money Illusions: What can we Learn from Survey Expectations?" *European Economic Review* 55: 702–19.

Shafir, Eldar, Peter Diamond, and Amos Tversky. 1997. “Money Illusion.” *Quarterly Journal of Economics* 112 (2): 341–74.

Shiller, Robert J. 2015. Irrational Exuberance. 3rd ed. Princeton, NJ: Princeton University Press.

Statistics Denmark. 2008. “Notat om Forskerbeskyttelse i CPR 2008.” Danmarks Statistik. http://www.dst.dk/da/Statistik/dokumentation/metode/Forsker2008.

———. 2016a. “EJDFOE1: Market Value for Households Real Estate by Valuation, Municipality of Residence, Unit and Type of Real Estate.” Statistikbanken. Accessed August 23. http://www.statbank.dk/EJDFOE1.

———. 2016b. “TIMES Variabel – LEJEV_EGEN_BOLIG.” Danmarks Statistik. Accessed August 23. http://www.dst.dk/da/Statistik/dokumentation/Times/personindkomst/lejev-egen-bolig.

Stephens, Thomas A. and Jean-Robert Tyran. 2012. “‘At Least I Didn’t Lose Money’ – Nominal Loss Aversion Shapes Evaluations of Housing Transactions.” CEPR Discussion Paper 9198.

Tanaka, Tomomi, Colin F. Camerer, and Quang Nguyen. 2010. “Risk and Time Preferences: Linking Experimental and Household Survey Data from Vietnam.” *American Economic Review* 100 (1): 557–71.

Thaler, Richard H., Amos Tversky, Daniel Kahneman, and Alan Schwartz. 1997. “The Effect of Myopia and Loss Aversion on Risk Taking: An Experimental Test.” *Quarterly Journal of Economics* 112 (2): 647–61.

Thöni, Christian, Jean-Robert Tyran, and Erik Wengström. 2012. “Microfoundations of Social Capital.” *Journal of Public Economics* 96 (7–8): 635–43.

van Rooij, Maarten, Annamaria Lusardi, and Rob Alessie. 2011. “Financial Literacy and Stock Market Participation.” *Journal of Financial Economics* 101 (2): 449–72.

Weber, Bernd, Antonio Rangel, Matthias Wibral, and Armin Falk. 2009. “The Medial Prefrontal Cortex Exhibits Money Illusion.” *Proceedings of the National Academy of Sciences* 106 (13): 5025–28.