ISSN 1791-3144

DEPARTMENT OF ECONOMICS
DISCUSSION PAPER SERIES

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Discussion Paper No. 16/2021

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Split Personalities? Behavioral Effects of Temperature on Financial Decision-making

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November 9, 2021

Abstract

Do environmental factors affect financial decision-making and how might personality traits mediate these effects? Using plausibly exogenous variation in individuals' exposure to within-country fluctuations in temperature between 2004 and 2018 across 28 European countries and Israel, we estimate the causal effect of a marginal change in temperature on financial investments and its interaction with individual personality characteristics. We find that a 10% increase in temperature is associated with a 0.1 percentage point (pp) rise in the probability that an optimist invests in bonds and a 0.12 pp decline in the probability for stocks. However, among pessimists, we find null effects. We find similar results when we focus on the intensive margin of investment as well. We explain the mechanism behind these results with a stylized model where optimists are involved in more cognitively-demanding activities and sensitive to external stimuli. Our results are consistent with behavioral finance models where expectations moderate the transmission of shocks onto financial decision-making.

Keywords: Behavioral Finance; Expectations; Optimism; Stocks; Temperature

JEL Codes: D87, D91, G11, G41, G51

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1 Introduction

There is a large body of empirical evidence pointing towards the role of behavioral factors in financial decision-making (Beshears et al., 2018).¹ Saliency behaves as a mediating force (Bordalo et al., 2013). Expectations have emerged as a leading explanation for why and how individuals undertake different financial investments (Bordalo et al., 2018), such as whether to participate in the stock market (Barber and Odean, 2001) or whether to allocate more of their portfolio to stocks over bonds (Grinblatt and Keloharju, 2000). However, much less emphasis has been placed on the interplay between personality characteristics and environmental factors—that is, exploring how shocks interact with behavioral factors that may influence financial decision-making.

Empirically, understanding the role of environmental factors and their interaction with personality characteristics is challenging. For example, since individuals sort into different labor market arrangements based on their underlying preferences and abilities, fluctuations in income are endogenously related with their underlying characteristics and financial decision-making. Similarly, macroeconomic conditions might influence risk taking and financial decision-making, but these conditions are potentially related with other unobserved factors that affect financial behavior.

To address this challenge, our paper exploits plausibly exogenous variation among individual financial investment decision in response to fluctuations in temperature across 28 European countries and Israel between 2004 and 2018. By controlling for country and year fixed effects, we purge time-invariant differences, such as the quality of institutions or culture, that could be related with both climate and financial investments. Furthermore, since we observe the same individual over

¹Leading theories of behavioral finance have emphasized the role of attention for asset prices (DellaVigna and Pollet, 2009; Bordalo et al., 2012) and financial decision-making (Stango and Zinman, 2009, 2014).

time, we exploit within-person variation, controlling for country $\times$ year fixed effects, allowing us to trace out an individual’s investment behavior in response to regional fluctuations in temperature after controlling for all shocks that are common to individuals in the same country and year.

A plausible question that arises is why environmental conditions affect optimists versus non-optimists? While there is no obvious biological evidence that would support this differential effect, and we cannot fully isolate the mechanism behind these results, we reason that optimism is a personality trait that affects decision-making in multiple dimensions. Contributions from psychology suggest that optimistic individuals process and respond to information differently than their more pessimistic counterparts. For example, optimists manifest different working habits (Coval et al., 2005; Gervais and Goldstein, 2007) and saving habits (Puri and Robinson, 2007). Moreover, growing evidence suggests that climate has also an effect on individual action and decision making (Park, 2020). We build a model where optimism reflects hope about the future and behaves as a moderating force for environmental stimuli, leading them to adjust their financial investments. Here, increases in temperature have a differential effect on optimists due to the greater toll imposed on them through the effort required to execute more demanding activities. Our focus on optimism stems from the growing recognition that expectations are a major determinant of behavior and economic activity (Adam et al., 2017; Adelino et al., 2018; Kaplan et al., 2020).

To empirically test our hypothesis, we exploit within-person heterogeneity in a sample of NUTS 1 regions in Europe. Using the Survey of Health, Aging and Retirement in Europe (SHARE) between 2004 and 2018, together with climatic regional data, we find that a 10% rise in temperature is associated with a 0.1 pp rise in the probability an optimist invests in bonds, and a 0.12 pp decline in the probability an optimist invests in stocks. We find null effects for pessimists. Put together, these results suggest that higher temperatures lead to a reallocation towards (away

from) safer (risky) assets for optimists, but no effect for pessimists. In this sense, we provide new microeconomic evidence on how idiosyncratic factors not only affect financial behavior, but also interact with personality characteristics to generate movements in asset prices. While we recognize that temperature fluctuations are not a first-order determinant of asset prices, we view them as a useful window and source of variation to learn more about how people respond to external stimuli.

Furthermore, we investigate these phenomena on the intensive margin and find similar results. We show that a 10% rise in temperature is associated with a 0.097% rise in investment in bonds and a 0.12% decline in investment in stocks for optimism. However, there are no such effects for pessimists. Given that optimism is a function of beliefs about people and risk, among other factors, we subsequently decompose the determinants to understand more about the mechanism underlying these results. In particular, we find that variation in optimism is driven more heavily by attitudes about taking risk (as in [Coval and Shumway \(2005\)](#)), rather than attitudes about trust. This result is important since it helps us disentangle between different types behavioral biases that moderate the effects of shocks on financial decision-making ([Hirshleifer, 2020](#)).

Our paper is related to a large behavioral finance literature on the relationship between personality characteristics and financial decision-making, including stock market participation. For example, [Grinblatt et al. \(2011\)](#) show that stock market participation is monotonically related with IQ even after controlling for a wide array of demographic and income characteristics. [Barber and Odean \(2001\)](#) shows similar results for males, as well as [Addoum et al. \(2017\)](#) by height and weight. Building on these characteristics, we focus primarily on the role of optimism as a mediator for attention for personality traits.² In the presence of a lot of noise, optimists might be more likely to pay attention to their surroundings since they have greater expectations and hope for

²See [Caplan \(2016\)](#) for a review of the literature on attention in behavioral finance.

the future, whereas pessimists might “accept their fate” and tune out external stimuli. Other personality traits, particularly across different cultures, also matter. For example, [Hirshleifer et al. \(2016\)](#) show how superstitious attitudes about “lucky numbers” plays a role in explaining abnormally high returns about firms that undergo an initial public offering with a “lucky” listing code. Besides time-invariant personality characteristics, investor moods also shape the fluctuations and growth in stock returns ([Hirshleifer et al., 2020](#)), which can also be influenced by environmental factors, like weather ([Makridis, 2020](#)), in addition to seasonal patterns.

Our paper also contributes to a literature on climate and financial decision-making. Motivated by a large literature in macroeconomics on the determinants of cross-country growth rate, geography, and the corresponding climate, has emerged as one potential factor ([Bloom and Sachs, 1998](#)). Although there is generally a recognition that climate does not affect economic growth directly, it can impact the evolution of institutions and culture ([Rodrik et al., 2004](#); [Robinson and Acemoglu, 2012](#)). We provide such a mechanism: hotter climates can discourage risk taking (e.g., participation in the stock market), particularly among those most likely to become entrepreneurs (e.g., optimists). These results also build on research within psychology, including [Sanders and Brizzolara \(1982\)](#) who show that weather has a direct effect on human behavior, health, emotion and mood. Others have explored the effect of sunshine on returns ([Hirshleifer and Shumway, 2003](#); [Goetzmann and Zhu, 2005](#); [Goetzmann et al., 2014](#)) and the effect of temperature on mood and economic sentiment ([Baylis, 2020](#); [Makridis, 2020](#)). Moreover, our paper complements research that finds a close connection between personality and stock market investment ([Puri and Robinson, 2007](#)). Some research showed that investors’ personality is correlated to stock market investment ([Durand et al., 2008](#); [Donnelly et al., 2012](#)). Others have found a similar relationship between economic behavior and personality traits ([Becker et al., 2011](#); [Maggiori et al., 2021](#)).

The structure of the paper is organized as follows. Section 2 introduces the data and measurement strategy. Section 3 lays out the empirical specification and identification strategy. Section 4 presents the main results. Section 5 examines heterogeneity and robustness. Section 6 concludes.

2 Stylized Model of Temperature and Cognitive Demands

We begin with a simple model to clarify the intuition behind our empirical specification and results. Our model modifies the model in [Guiso et al. \(2008\)](#) to allow for two additional refinements: (a) investment in the stock market is mediated by the degree of individual optimism about the future ([Puri and Robinson, 2007](#); [Angelini and Cavapozzi, 2017](#)), and (b) temperature, among other environmental factors, imposes greater cognitive demands on individuals ([Park, 2020](#)).

While definitions of optimism vary, we focus on the concept of “dispositional optimism” that reflects an individual’s expectations about their life. Building on the seminal contributions by [Scheier and Carver \(1985\)](#) and [Scheier et al. \(1994\)](#), optimism reflects “generalized positive expectations about future events”—more of a psychological trait than a mood or feeling. Health researchers have demonstrated how optimism is associated with lower mortality risk ([Schulz et al., 1996](#)), faster recoveries ([Scheier et al., 1989](#)), and smoother life transitions ([Aspinwall and Taylor, 1992](#)). [Puri and Robinson \(2007\)](#) and [Angelini and Cavapozzi \(2017\)](#) have shown, for the United States and Europe, that optimism is also related with greater stock market participation. Last, it is worth mentioning that while in our model we focus on optimism and not on trust as in the standard [Guiso et al. \(2008\)](#) model, yet trust is a significant determinant of optimism as well.

Following the rationale of [Guiso et al. \(2008\)](#) when individuals decide whether to invest in a stock or a bond, they forecast the distribution of returns and the probability of tail events (e.g.,

stock market crashes). One assumption in these models is that investors are aware of the “true” distribution of returns. We adhere to the assumption, although deviating from it amplifies our results, and introduce an additional parameter that determines the returns to stocks, i.e., their own effort spent on deciding whether to invest, allowing us to capture the effect of temperature on cognitively demanding activities. Investing in stocks or bonds requires some effort in order to get familiar with how the market works and in which specific asset to invest, i.e., in devising the portfolio. We model effort as a function of time allocated to deciding whether to invest in stocks or bonds, denoted $e \in [0, 1]$, and ambient temperature, denoted $A \in [0, 1]$, where zero denotes the ideal temperature and one denotes the “physically uninhabitable ambient temperature.” While both extremely hot and extremely cold weather can adversely affect effort, empirical evidence suggests that the disutility of effort is more sensitive to heat (e.g., [Park \(2020\)](#)).

We define a general effort function as $y(e; A, h)$ where $\frac{\partial y}{\partial e} > 0$ and $\frac{\partial y}{\partial A} < 0$. Therefore,

$$\lim_{e \rightarrow 1, A \rightarrow 0} y(e, A) = h$$

where h is the peak performance obtained for the maximum time and ideal ambient temperature. We also denote p as the probability that the market crashes due to an extremely bad event and $1 - p$ as the probability it will not crashed, which we interpret as optimism.

We now introduce a simple model that clarifies the relationship between of optimism and temperature in the determination of investment. Investors have the option to invest either in a safe asset (e.g., bonds) with a return, denoted r_b . While the return is certain, individuals still must exert effort $y_b(e_b; A, h_b)$, i.e., their effort is a function of the time allocated in investing in bonds as well as a function of ambient temperature affecting this cognitively demanding task. For

the sake of simplicity, we assume that the total return on investment in bonds, conditional on the time allocated and ambient temperature, is given by $y_b(e_b; A, h_b)r_b$.

The second asset is the risky asset (e.g., stocks) with an uncertain “true” return r_s . This return is distributed with mean $r_s > r_b$ and variance σ^2 . Moreover, this return is realized by allocating time towards investing in stocks, which is also a function of effort and ambient temperature, $y_s(e_s; A, h_s)$. For simplicity, we do not allow e_s and e_b to vary, so we treat them as parameters and assume that $e_s > e_b$, i.e., investing in stocks requires more time compared to investing in bonds, as stocks is a more risky decision. We also assume that ambient temperature affects both tasks in the same way. However, there is another source of risk for stocks that stems from a market crash that wipes away the investment. Since the probability that the market crashes always exists, the investor’s optimism is a driving force behind whether he invests in the risky or safe asset. In line with [Guiso et al. \(2008\)](#), we abstract from participation costs to restrain our scope.

For an initial level of wealth W , an individual will choose the share α to invest in stocks to maximize his expected utility:

$$\text{Max}_{\alpha} (1 - p)EU(\alpha y_s(e_s; A, h_s)r_s W + (1 - \alpha)y_b(e_b; A, h_b)r_b W) + pU((1 - \alpha)y_b(e_b; A, h_b)r_b W) \quad (1)$$

The first term indicates the utility of the investor if the market does not crash, while the second term indicates the utility that the market crashes. The first order condition is given by:

$$(1 - p)EU'(\alpha y_s(e_s; A, h_s)r_s W + (1 - \alpha)y_b(e_b; A, h_b)r_b W)(y_s(e_s; A, h_s)r_s - y_b(e_b; A, h_b)r_b) \leq \quad (2)$$

$$pU'((1 - \alpha)y_b(e_b; A, h_b)r_b W)(r_b y_b(e_b; A, h_b))$$

The left-hand side (LHS) is the expected marginal utility of investing one more unit in stocks. This yields an excess return $(y_s(e_s; A, h_s)r_s - y_b(e_b; A, h_b)r_b)$ with probability $1 - p$, i.e., when the market does not crash. This return must be less than or equal to the cost of losing the total amount of the investment if the market crashes. To study the conditions under which this may occur and given that our paper focuses primarily on the extensive margin (i.e., whether individuals decide to invest or not), we will study the case where $\alpha = 0$, i.e., in the case where there is no investment in stocks. If at $\alpha = 0$ the cost exceeds the benefit, then individuals find it optimal to stay out of the stock market. Setting $\alpha = 0$ we obtain:

$$(1 - p)(y_s(e_s; A, h_s)r_s - (y_s(e_s; A, h_s)r_s) - p(r_b y_b(e_b; A, h_b)) \leq 0 \quad (3)$$

For the cost exceeding the benefit it must be the case that $p < \tilde{p}$ where $\tilde{p} = (y_s(e_s; A, h_s)r_s - y_b(e_b; A, h_b)r_b)/y_s(e_s; A, h_s)r_s$ is the threshold value of p above which an individual decides to invest in stocks. We now infer the following about the extensive margin of investment in stocks:

Proposition I: The investors that will invest in stocks have high levels of optimism, i.e., the ones where $1 - p > 1 - \tilde{p}$. Correspondingly, investors with low level of optimism will invest in bonds.

Proposition I provides the first testable hypothesis for our empirical application. The intuition behind this lies in the fact that investors will choose the risky asset if its expected return is higher than the risk-free rate. The expected return on stocks is $(1 - p)y_b(e_b; A, h_b)r_s + p * 0 =$

$(1 - p)y_b(e_b; A, h_b)r_s$, so the investor will invest only if $(1 - p)y_s(e_s; A, h_s)r_s > y_b(e_b; A, h_b)r_b$.

Setting the two equations equal to each other yields the threshold level of optimism. Given that investors allocate more time to stock investment and that $y_s(e_s; A, h_s) > y_b(e_b; A, h_b)$ for a given A , the LHS is higher than the RHS for a sufficiently high level of optimism $1 - p$.

Our second hypothesis concerns the interaction between temperature and the level of optimism.

Proposition II: The positive effect of optimism on stock investment is mitigated by increases in temperature.

Taking the partial derivative of $\Omega =$ with respect to $(1 - p)$ we obtain:

$$\frac{\partial \Omega}{\partial (1 - p)} = y_s(e_s; A, h_s)r_s > 0, \quad (4)$$

i.e., there is a positive effect of optimism on the decision to invest. Taking the second derivative with respect to A we obtain

$$\frac{\partial \Omega}{\partial (1 - p) \partial A} = y'_s(e_s; A, h_s)r_s < 0. \quad (5)$$

Reversely, the higher the level of optimism the less investors will invest in bonds. However, this negative effect of optimism is mitigated by higher temperature. We restrict our discussion to the extensive margin only. However, as we show empirically, we anticipate similar effects on the intensive margin of investment, i.e., the amount invested in stocks and bonds. The empirical part of our analysis empirically tests Propositions I and II.

3 Data and Measurement

3.1 Individual Investment Data

Our primary data comes from six waves (i.e., wave combination 1-2-4-5-6-7) of the Survey of Health, Aging and Retirement in Europe (2004-2018), an individual panel across 28 European countries and Israel. SHARE gathers detailed information on important areas of respondents' lives, ranging from partners and children over housing and employment history to more detailed questions on economic decisions, social attitudes, expectations, demographic and health status. The SHARE sample comprises individual-level micro data, including 140,000 individuals aged 50 or older who currently reside in 28 European countries, including: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Germany, Finland, France, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Sweden, Slovenia, Slovakia, Spain, Switzerland, and Israel. SHARE data collection is based on computer-assisted personal interviewing (CAPI) and provides a common generic questionnaire that is translated into the national language of each country.

We use two alternative dependent variables, i.e., investments in i) bonds and ii) stocks. Respondents are given the question “Do you currently have invested in bonds or stocks? Yes or No”. The value 1 predicts that individual has invested and 0 means he or she has no investments, i.e., it captures the extensive margin of investment. Moreover, SHARE provides us with information about additional financial derivatives such as investments in mutual funds and retirement accounts, together with their gender, age, health status across multiple dimensions, country of residence, and month that the interview took place.

In order to capture the personality of each individual and examine how it moderates the effects of environmental shocks on financial decision-making, we focus on the role of optimism. As we

discussed earlier, [Puri and Robinson \(2007\)](#) and [Angelini and Cavapozzi \(2017\)](#) both discuss dispositional optimism as generalized positive expectations about future events. In order to capture the optimistic feeling, we use hopes for the future in the SHARE data. Individuals respond to the question “What are your hopes for the future? Please note only whether hopes are mentioned or not.” We classify an individual as an optimist if he/she replies with hopes about the future, zero otherwise. We also focus on optimism due to its role in fluctuations in asset prices ([Coval and Shumway, 2005](#); [Frazzini, 2006](#); [Goetzmann et al., 2014](#)).

SHARE also provides us with additional personality variables, including: happiness and general interest. Happiness is measured in response to: “Have you feel enjoyment recently?” General interest is measured based on whether the respondent mentions any interest. We use these additional traits in the robustness section to show our heterogeneous effects are especially concentrated over the distinction between optimists versus pessimists and not a general phenomenon.

3.2 Country Data

We extract the data for weather from the ERA5 climatic reanalysis data. ERA5 contains time-series that have hourly, daily, and monthly frequency that are aggregated following all the Nuts levels of classification. This dataset belongs to the European Centre for Medium-Range Weather Forecasts (ECMWF) which is an independent intergovernmental organization supported by 34 states. ECMWF produces global numerical weather predictions and offers one of the largest meteorological data archives in the world. ERA5 climatic reanalysis data covers the majority of European countries from 1950 to present. Reanalysis combines model data with observations from across the world into a globally complete and consistent dataset, using the laws of physics

and produces data that goes several decades back in time, providing an accurate description of climate of the past. Additionally, ERA5 combines vast amounts of historical observations into global estimates using advanced modelling and data assimilation systems.

We restrict the geographical sample from 2004 to 2018, covering the same European countries according to SHARE dataset. Weather data come from reanalysis, which offers some improvements in regions with sparse data. Our approach follows that frequently used by economists in constructing and using weather data (Dell et al., 2014). We use the mean annual temperature measured in Celsius, constructed as the average of mean monthly temperature. We do so at the NUTS1 regional level, providing variation within the same country. We also measure mean annual precipitation, calculated as the sum of the mean monthly precipitation, measured in millimeters, from the ERA5 dataset too. Finally, we control for additional time-varying country characteristics from the World Bank, including: logged GDP per capita, annual population growth, value of services and agriculture as percentages of GDP.

One of the main reasons for using SHARE is precisely that it allows us to do our analysis at NUTS1 level of disaggregation and adopt such a strict specification compared to the rest of the associated literature. Another advantage is the fact that SHARE is considered the largest pan-European social science panel study providing internationally comparable longitudinal micro data which allow insights in the fields of public health and socio-economic living conditions of European individuals. Furthermore, for a panel study like SHARE, its value is strongly determined by the long-term participation of panel members over waves.

We merge our data and use the whole sample from 2004 to 2018, ending up now with 23 European countries including Austria, Germany, Sweden, the Netherlands, Spain, Italy, France, Denmark, Belgium, Czech Republic, Poland, Luxembourg, Hungary, Portugal, Slovenia, Estonia,

Croatia, Lithuania, Bulgaria, Cyprus, Finland, Latvia and Romania. The panel consists of 55,556 individuals, following them on a wave/year basis. We find each individual in more than 2 and less than 6 rounds of answers. All the interviews are conducted in several dates, without giving to individuals the opportunity to choose when they would like to answer. The cross section part contains 85,215 individuals who participate in only 1 or in more rounds of interviews.

3.3 Descriptive Statistics

Table 1 documents the descriptive statistics. We see that only 2.8% of individuals invest in bonds and 6.8% invest in stocks. We also see substantial differences in investment behavior among optimists versus pessimists. For example, whereas the share who invest in stocks is 8% among optimists, it is 2.2% among pessimists.

Turning towards the remaining variables, we see that the average temperature is 10 degrees Celsius. Roughly 44% of the sample is male and the average age is 67, showing that our sample skews towards those in retirement. Optimists tend to be slightly younger at age 66 on average, whereas pessimists are nearly 70. Finally, we see notable differences in country-level characteristics among pessimists and optimists, reflecting the correlation between happiness and income per capita (Deaton, 2008). For example, per capita GDP is \$37,462 among optimists and \$28,058—a difference of nearly \$10,000. We also see that optimists reside in countries with higher population growth, a higher services employment share, and a lower agricultural employment share.

[INSERT TABLE 1 HERE]

4 Empirical Strategy

To understand how environmental factors influence financial decision-making and interact with behavioral characteristics, we begin by relating measures of financial behavior with regional annual temperature and measures of personality through regressions of the form:

$$y_{ijt} = \gamma TEMP_{jt} + \phi c_{ijt} + \xi(TEMP_{jt} \times c_{ijt}) + \eta_c + \lambda_t + \epsilon_{ijt} \quad (6)$$

where y_{ijt} denotes two different measures of investments are employed: i) investment in bonds and stocks for each individual i residing in region j at year t , $TEMP$ denotes the logged average annual temperature, c denotes the personality characteristic indicator (e.g., optimist versus pessimist), and η and λ denote fixed effects on country and year, respectively. We estimate robust standard errors, clustered at the individual level to allow for autocorrelation in the error across individuals over time. We use annual, rather than monthly, temperature to focus on larger fluctuations in temperature that are more likely to affect the extensive margin of investment.

To identify a causal effect of temperature on investment activity in Equation 6, we exploit plausibly exogenous variation in the exposure of observationally equivalent individuals in the same country to different temperatures over time. The inclusion of country fixed effects purges variation in country-specific factors, such as geographic and institutions, that are correlated with both financial decision-making and environmental factors. The inclusion of year fixed effects purges aggregate fluctuations in financial decision-making, such as general trends towards greater financial literacy and and business cycle patterns.

One concern, however, is that there are omitted variables that are correlated with both per-

sonality and financial decision-making. Although we are controlling for age, and other standard demographic characteristics, we may have an upwards biased estimate on our indicator for optimism (and consequently the interaction). In particular, more optimistic individuals also take more risks, thereby leading to a higher probability of investing in the stock market and lower probability of investing in bonds. To address this concern, we further restrict our identifying variation by also introducing person fixed effects, which exploits the exposure of the same person to fluctuations in temperature in the same country over time.

Another concern is that the temperature alters an individual's mood. For example, using variation in individuals' exposure to different daily temperatures, [Makridis \(2020\)](#) shows that individuals become more pessimistic about the state of the national economy and their expectations over the future state at very cold and hot temperatures. To the extent that an individual's pessimism or optimism is a function of temperature, then we will have additional variation in our right-hand-side variable that is more reflective of the environmental conditions than their underlying personality characteristics, producing attenuation bias.

A final concern is that there are other time-varying unobserved country-specific characteristics, like macroeconomic shocks, that are correlated with both temperature and financial behavior. For example, [Dell et al. \(2012\)](#) show how economic growth is correlated with temperature. While [Makridis and Ransom \(2020\)](#) show that temperature is uncorrelated with real wages, income, and GDP over the short and medium run, we nonetheless introduce country $\times$ year fixed effects to focus on changes in financial behavior for a given individual after controlling for all shocks that are common within the same country and year. This exploits variation at the regional level within each country for each individual, thereby purging macroeconomic conditions or other country-specific policy factors that also influence financial decision-making.

5 Main Results

Table 2 documents the results associated with Equation 6 when the outcome variable is the indicator for whether an individual invests in bonds. Starting with the conditional correlation in column 1, we see that a 10% rise in temperature is associated with a 0.182 percentage point (pp) decline in the probability that a pessimistic individual invests in bonds, but a nearly null response among optimists. The interaction effect fully offsets the direct effect of temperature on investment, suggesting that optimism is an important dimension of heterogeneity. We also see that optimists are 4.4pp less likely to invest in bonds (and more likely to invest in stocks).

However, these conditional correlations could simply reflect differences in unobserved heterogeneity across individuals who live in countries that also have better macroeconomic conditions and institutions. While we have already controlled for time-varying country-specific factors, such as real GDP per capita, column 2 now introduces country and year fixed effects. The coefficients remain qualitatively similar, but lower in economic significance: a 10% rise in temperature is now associated with a 0.091pp decline in the probability of investing in bonds among pessimists, but a 0.023pp decline for optimists, although it is not statistically different from zero for optimists.

Yet another concern is that there are time-varying shocks to a country’s macroeconomic or policy conditions that correlate with financial decision-making. Column 3 controls for country $\times$ year fixed effects. While the direct effect of temperature becomes statistically insignificant, the coefficient on the interaction remains positive and significant. Now, a 10% rise in temperature is associated with a 0.133pp *rise* in the probability that an optimist invests in bonds, but a null effect for pessimists, showing that omitted variables is an unlikely culprit for our results.

To address concerns about unobserved individual-specific heterogeneity, column 4 subsequently introduces person and year fixed effects, reducing the statistical significance. Column 5 introduces both person and country $\times$ year fixed effects. Now, we find that a 10% rise in temperature is associated with a 0.1pp rise in the probability of investing in bonds for optimists, but a null effect for pessimists. Given that the share of individuals who invest in bonds is only 0.03pp, this marginal effect is economically meaningful.

Columns 6-10 replicate the same analysis as in columns 1-5, using stocks instead of bonds. Focusing on our preferred specification that contains both person and country $\times$ year fixed effects (column 10), we also identify other noteworthy patterns. For example, we find that a 10% rise in temperature is associated with a 0.119pp decline in the probability that an optimist invests in stocks, but a null effect for pessimists.

[INSERT TABLE 2 HERE]

Next, we examine the intensive margin effects of temperature on financial investments, moderated by optimism. We replace our outcome variable with the logged amount of investment in each category, treating individuals who do not invest as having zero expenditures. Table 3 documents these results. We find similar results. Under our strictest specification with person fixed effects, a 10% rise in temperature is now associated with a 0.097% rise in investment in bonds and a 0.12% decline in investment in stocks for optimism. However, we find null effects again for pessimists.

[INSERT TABLE 3 HERE]

6 Discussion and Further Heterogeneity

6.1 Sources of Optimism

The benchmark results in Table 2 point to an important moderating effect of personality, in particular the degree of optimism, on financial market participation. However, are these differences in optimism driven more by underlying levels of trust, risk aversion, or some other determinant, such as health or gender? We now consider regressions of an indicator for whether the individual is an optimist on an indicator for whether they have trust in others, whether they are risk averse, health quality, age and gender. We proxy risk aversion by the response to the question “What amount of financial risk are you willing to take when you save or make investments”. The possible answers are “the individual is not willing to take any financial risks” or “takes above average financial risks expecting to earn above average returns.”

Table 4 documents these results. Age is negatively correlated with optimism, showing that people tend to become more pessimistic as they grow older. More importantly, we find that there is a strong association between optimism and trust, risk aversion, and health. For example, those who tend to have trust in others have a 0.82 pp higher probability of also being an optimist under our preferred specification in column 4, which controls for country $\times$ year fixed effects.

We also see that those in good health have a 5.61pp higher probability of being an optimist, consistent with empirical evidence that health shapes the way that people process their environment (Finkelstein et al., 2013). Not surprisingly, risk aversion is also negatively correlated with optimism: risk averse individuals are 1.46pp less likely to be optimists. Importantly, the coefficient on risk aversion is twice as large as the coefficient on trust, suggesting that attitudes related to risk more heavily driven expectations and hope for the future, relative to overall trust in others.

[INSERT TABLE 4 HERE]

6.2 Eastern vs Western Countries

The cultural economics literature quite often documents distinct cultural differences between Eastern and Western countries ([Alesina and Fuchs-Schündeln, 2007](#)). The results in Table 5 further explore this cultural division by splitting the sample into these two groups and replicating the results for each group separately. Qualitatively our results are similar across the two specifications. Quantitatively though, the results are stronger for the Eastern countries as opposed to Western countries. This effect is even further stronger for the case of stocks, which is the more risky asset. The intuition behind these findings lies in the higher levels of depressions reported in Eastern countries ([Jenkins et al., 2005](#)), where optimism becomes an even more important driver of investment attitudes as well as its interplay with temperature.

[INSERT TABLE 5 HERE]

6.3 High vs Low Trust Countries

There is also a growing recognition that trust matters for financial development ([Guiso et al., 2004](#)), as well as the large cross-sectional differences across countries in preferences about time ([Wang et al., 2016](#); [Rieger et al., 2021](#)). Using data from [Rieger et al. \(2021\)](#) that distinguishes between time preferences and time across 117 countries, we partition the sample into countries that rank above and below the median.

Table 6 document the results for high and low trust countries. In our preferred specifications containing person and country $\times$ year fixed effects (columns 5 and 10), we find that the treatment

effects for temperature and its interaction with personality are concentrated among the high trust countries. In particular, we find no statistically or economically significant effects in the low trust countries. Since we expect that trust amplifies salience, and it is a complement to investments, this is consistent with our hypothesis. Moreover, in low trust countries, we would expect that personality and temperature matter less in general since trust is such a crucial ingredient. Indeed, columns 5 and 10 do not even show a statistically significant association between optimism and financial decision-making and the weaker specifications in columns 1-4 and 6-9 show less statistically significant associations as well. This is comforting since we would expect that low trust dwarfs every other factor, especially ones like temperature.

[INSERT TABLE 6 HERE]

We also explore heterogeneity in the rate of time preference, but find no statistically distinguishable results. This suggests to use that the primary mechanism at work is through a channel related to trust: optimism about life is connected with social capital and personal relationships.

6.4 Alternative Outcome Variables

In the benchmark analysis , we explore the relation between temperature, optimism and their moderating effect on financial investments. More specifically, we find that hotter temperatures reduce optimists' appetite for risk by declining their demand for stocks and increasing their demand for safer assets, such as bonds. In section B of the Online Appendix, we try to explore the relation between temperature, optimism and economic behavior, according to [Puri and Robinson \(2007\)](#). For that reason, in Table 7 we investigate the relation between temperature, optimism and different economic choices like retirement timing and work ethic (self-employment status and

job satisfaction). Both optimism and risk tolerance affect the willingness of individuals to become entrepreneurs. This is consistent with the theoretical predictions of (Gervais and Goldstein, 2007), who argue that optimists overestimate the marginal product of their labor, working harder and taking more risks. Similarly, more optimistic people feel more satisfied with their work (Dawson, 2017) and are more likely to report that they will work forever. Thus, not only do they work more currently, but they intend to continue doing so indefinitely. This fact works against the possibility that increased optimism leads to false beliefs about early retirement. Furthermore, risk-tolerant and higher net worth individuals are more likely to continue working indefinitely (Puri and Robinson, 2007). Our findings are in accordance with the existing literature.

[INSERT TABLE 7 HERE]

7 Robustness Exercises

In the online appendix we investigate several robustness exercises. One concern is that we are capturing other unobserved shocks to an individual’s financial portfolio, i.e. an income effect. For example, an individual might experience a decline in their overall net worth, thereby affecting their willingness to invest in different financial assets. Although we do not have comprehensive measures of wealth, we have their self-reported property value, which we use as a proxy for household wealth since property is one of the most significant contributors to household wealth (Flavin and Yamashita, 2011). Table A.1 documents these results. While there is a strong positive correlation between temperature and property values in the cross-section (column 1), these effects disappear when we control for country and year fixed effects (column 2). We subsequently layer additional fixed effects on NUTS and person (columns 3-5). The fact that we find no statistically

significant association suggests that income effects are not at play.

Another potential concern is that we are simply detecting another omitted person-specific characteristic that also varies with temperature. Table A.2 presents similar results when we use happiness as a dimension of heterogeneity. However, the interaction effects with temperature are all statistically insignificant. We also show similar results for general interest. Table A.3 examines these results using general interest as another personality characteristic.

Tables A.4 and A.5 also conduct robustness checks using the minimum values and the median value of the temperature index correspondingly. Instead of using the mean value for each Nuts at the yearly level, we use instead the minimum value throughout the year and the medial value. These produce qualitatively similar results, although they are slightly less significant. This is what we would expect if averaging across days and months tends to mitigate measurement error, or if people respond more to the average temperature than other parts of the distribution.

Last, we include in our analysis some additional robustness checks to investigate whether our results remain robust adding extra fixed effects. In order to control more carefully for age, it is important to explore the relation between age and investments, thus we use in our benchmark analysis (Table 2) the individuals' age as a control variable, presuming the existence of a linear relation. In Tables A.6 and A.7 we now introduce age fixed effects, examining the effect of temperature and optimism on extensive and intensive margins of investments, in order to capture the response of different age cohorts on investing behavior. The related tables are exported in the Section B of the Online Appendix Supplementary Tables.

8 Conclusion

Despite the large and growing empirical evidence that points towards the role of behavioral biases that affect asset prices and the real economy, there is little understanding about the interaction between personality characteristics for an individual investor and external stimuli. That is, how do personality characteristics moderate or mediate the effects of shocks on financial decision-making? Exploiting year-to-year variation in the exposure to different temperatures across countries for over a decade, we identify the causal effect of temperature on both the intensive and extensive margin of financial investments, ranging from bonds to stocks, and the moderating role of optimism. Our identification comes from within-person variation, controlling for country $\times$ year fixed effects.

Our primary result is that hotter temperatures reduce optimists' appetite for risk by depressing their demand for stocks and boosting their demand for safe assets, such as bonds. However, we find no such effects for pessimists. Given a large body of empirical literature from psychology that has documented differences between optimists and pessimists, especially with regards to their responsiveness to external stimuli, these results show how different types of investors may respond to external stimuli. In this sense, the fluctuations that are observed in stock returns reflects a change in not only underlying fundamentals, but also the composition of investors. We show that these results are driven by optimism as the personality characteristic, rather than general interests or mental well-being. Furthermore, we find that attitudes about risk are a major determinant of the differences in optimism that we observe in the cross-section.

One limitation of our research is that our sample consists of primarily older individuals. While we still believe these results are important and applicable to behavioral finance, especially since

younger individuals are less likely to participate in the stock market anyways, it would be interesting to see whether these results hold on a more representative sample and at a higher frequency. For example, is it climate (i.e., longer-run changes) or weather (i.e., shorter-run changes) that affects financial decision-making? However, we believe that what we capture is the lower bound of our results given that older people tend to become more pessimistic. Similarly, how do personality characteristics moderate other external stimuli? We have focused on temperature because of its ability to cleanly identify causal effects, but there are many other external shocks that are even more interesting for understanding fluctuations in asset prices as a result of investor behavior.

Main Tables and Figures

Table 1: Descriptive Statistics, 2004-2018

	Pooled Sample		Optimists		Pessimists	
	mean	sd	mean	sd	mean	sd
<i>financial investments</i>						
investments in bonds	0.03	0.17	0.03	0.18	0.01	0.11
investments in stocks	0.1	0.3	0.1	0.3	0.0	0.1
<i>amounts in financial investments</i>						
amount invested in bonds	45596.94	72485.29	46535.57	73585.56	35230.61	58153.96
amount invested in stocks	41103.5	86946.0	41642.2	87850.4	33327.8	71812.6
<i>personality</i>						
optimism	0.86	0.35	1.00	0.00	0.00	0.00
happiness	0.8	0.4	0.9	0.3	0.7	0.5
interest	0.88	0.33	0.91	0.28	0.78	0.41
trust others	6.8	2.4	7.0	2.3	6.2	2.5
risk aversion	0.82	0.39	0.80	0.40	0.90	0.30
health quality	0.6	0.5	0.6	0.5	0.3	0.5
<i>demographics</i>						
male	0.44	0.50	0.45	0.50	0.42	0.49
age at interview	67.5	10.0	66.5	9.6	69.9	10.6
property value	200786.97	188239.27	211036.02	190386.94	138327.99	158932.25
<i>country sentiment</i>						
gdp per capita	34526.27	17471.82	37462.86	16959.48	28058.82	13448.59
population growth	0.26	0.62	0.34	0.57	0.23	0.56
services value	62.77	5.15	63.14	5.01	61.89	5.02
total agriculture value	1.95	0.93	1.78	0.86	2.21	0.89
<i>weather</i>						
temperature	10.00	3.99	10.36	3.89	10.38	3.75
precipitation	11.91	3.09	12.01	2.81	11.98	2.86
Observations	206743		127375		21376	

Notes.—Sources: Survey of Health, Ageing and Retirement (SHARE) in Europe (2004-2018). The table reports financial investments, amounts invested in financial derivatives, personality traits, region weather information, individual basic demographic and country sentiment descriptive statistics. Financial investments are binary variables taking 0 or 1 and show if the respondents have invested or not in financial derivatives. Real amounts invested in bonds and stocks are continuous variables, presenting the amounts that the respondent has invested in bonds and stocks. The personality traits are binary variables taking 0 or 1 and indicate if the respondents have felt optimism, happiness and interest in things, recently. Other personality traits such as the levels of trust, risk aversion and health quality as determinants of optimism. Risk aversion and health quality are binary variables whereas trust takes values from 0 to 10 related to a higher level of trust. Temperature is measure in degrees of Celsius and precipitation in millimeters. Male indicates the gender of each respondent, taking the value 1 for males and 0 for females. Age is measured as continuous variable. Property value is a continuous variable, expressed in real terms and it is used as an indicator of wealth. GDP per capita is measured also as a continuous variable in current U.S dollars, population growth, services value and total agriculture are all measured as percentages of GDP. Sample weights are not used.

Table 2: Benchmark Results: Temperature, Optimism and the Extensive Margin of Investment

	Investment in Bonds				Investment in Stocks					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Optimist	-.0436*** [.0083]	-.0095 [.0084]	-.0274*** [.0082]	-.0031 [.0128]	-.0253** [.0087]	-.0545*** [.0144]	.0174 [.0145]	-.0098 [.0147]	.0617*** [.0173]	.0341** [.0095]
log(Temperature)	-.0182*** [.0027]	-.0091** [.0036]	-.0004 [.0044]	-.0071 [.0052]	-.0071 [.0074]	.0001 [.0047]	-.0126** [.0057]	-.0033 [.0070]	.0028 [.0066]	.0098 [.0059]
x Optimist	.0189*** [.0031]	.0068** [.0031]	.0133*** [.0031]	.0018 [.0048]	.0099** [.0034]	.0274*** [.0055]	.0009 [.0055]	.0107* [.0056]	-.0219*** [.0066]	-.0119** [.0041]
R-squared	.02	.03	.04	.55	.55	.06	.12	.12	.71	.71
Sample	89701	89701	89701	61798	61798	89732	89732	89732	61817	61817
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	No	Yes	No	No	No	No	Yes	No	No	No
Year FE	No	Yes	No	Yes	No	No	Yes	No	Yes	No
Person FE	No	No	No	Yes	Yes	No	No	No	Yes	Yes
Country*Year FE	No	No	Yes	No	Yes	No	No	Yes	No	Yes

Notes.—Sources: Survey of Health, Ageing and Retirement (SHARE) in Europe (2004-2018). The table reports the coefficients associated with regressions of an indicator for investment in bonds and stocks on an indicator for whether the individual is optimistic, logged annual temperature for the NUTSI region (within a country), their interaction, and a vector of precipitation and individual demographic characteristics, which include age and gender. Additional country level controls are used such as GDP per capita, population growth, services and agriculture value as a percentage of GDP. Standard errors are robust and clustered at the individual-level. Observations are unweighted.

Table 3: Benchmark Analysis: Temperature, Optimism and the Intensive Margin of Investment

	Amounts in Bonds				Amounts in Stocks					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Optimist	-.1955*** [.0478]	-.0096 [.0103]	-.0263*** [.0098]	-.0055 [.0166]	-.0239*** [.0022]	-.0545*** [.0144]	.0174 [.0145]	-.0098 [.0147]	.0617*** [.0173]	.0341** [.0095]
log(Temperature)	-.0395** [.0165]	-.0242*** [.0047]	-.0073 [.0055]	-.0245*** [.0072]	-.0108 [.0077]	.0001 [.0047]	-.0126** [.0057]	-.0033 [.0070]	.0028 [.0066]	.0098 [.0059]
x Optimist	.0865*** [.0179]	.0074* [.0040]	.0136*** [.0038]	.0024 [.0063]	.0097*** [.0012]	.0274*** [.0055]	.0009 [.0055]	.0107* [.0056]	-.0219*** [.0066]	-.0119** [.0041]
R-squared	.01	.91	.91	.95	.95	.06	.12	.12	.71	.71
Sample	90412	90412	90412	62464	62464	89732	89732	89732	61817	61817
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	No	Yes	No	No	No	No	Yes	No	No	No
Year FE	No	Yes	No	Yes	No	No	Yes	No	Yes	No
Person FE	No	No	No	Yes	Yes	No	No	No	Yes	Yes
Country*Year FE	No	No	Yes	No	Yes	No	No	Yes	No	Yes

Notes.—Sources: Survey of Health, Ageing and Retirement (SHARE) in Europe (2004-2018). The table reports the coefficients associated with regressions of an indicator for logged real amounts invested in bonds, stocks on an indicator for whether individual is optimistic, logged annual temperature for the NUTS1 region (within a country), their interaction, and a vector of precipitation and individual demographic characteristics, which include age, and gender. Additional country level controls are used such as GDP per capita, population growth, services and agriculture value as a percentage of GDP. Standard errors are robust and clustered at the individual-level. Observations are unweighted.

Table 4: Discussion: Determinants of Optimism

	Optimist			
	(1)	(2)	(3)	(4)
Trust others	.0089*** [.0006]	.0086*** [.0005]	.0084*** [.0005]	.0082*** [.0009]
Risk Aversion	-.0255*** [.0025]	-.0160*** [.0025]	-.0161*** [.0025]	-.0146** [.0056]
Health quality	.0729*** [.0026]	.0568*** [.0025]	.0565*** [.0025]	.0561*** [.0085]
Age at interview	-.0012*** [.0001]	-.0022*** [.0001]	-.0022*** [.0001]	-.0021*** [.0004]
Male	-.0009 [.0024]	.0009 [.0022]	.0006 [.0022]	.0008 [.0021]
Constant	-.9601*** [.0581]	3.6918*** [.6177]	3.8251*** [.6197]	-1.5223 [.8194]
R-squared	.09	.20	.21	.22
Sample	66417	66417	66417	66417
Controls	Yes	Yes	Yes	Yes
Country FE	No	Yes	No	No
Year FE	No	Yes	No	Yes
Nuts FE	No	No	Yes	Yes
Country*Year FE	No	No	No	Yes

Notes.—Sources: Survey of Health, Ageing and Retirement (SHARE) in Europe (2004-2018). The table reports the coefficients of determinants of optimism such as the levels of trust, risk aversion and health quality, logged annual temperature for the NUTS1 region (within a country), their interaction, and a vector of precipitation and individual demographic characteristics, which include age and gender. Additional country level controls are used such as GDP per capita, population growth, services and agriculture value as a percentage of GDP. Standard errors are robust and clustered at the individual-level. Observations are unweighted.

Table 5: Discussion: Eastern vs Western Countries

	Investment in Bonds					Investment in Stocks				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel A. East										
Optimist	-.0323***	-.0367***	-.0315***	-.0406***	-.0277*	.0112	.0121	.0114	.0416**	.0437**
	[.0096]	[.0089]	[.0087]	[.0131]	[.0103]	[.0143]	[.0142]	[.0142]	[.0169]	[.0140]
log(Temperature)	-.0092***	-.0008	.0050	-.0002	-.0040	-.0091**	.0080	.0242**	.0193**	.0277**
	[.0031]	[.0064]	[.0099]	[.0086]	[.0100]	[.0044]	[.0079]	[.0116]	[.0092]	[.0071]
x Optimist	.0145***	.0172***	.0148***	.0164***	.0111**	.0005	.0000	-.0001	-.0147**	-.0157*
	[.0038]	[.0036]	[.0035]	[.0054]	[.0037]	[.0056]	[.0056]	[.0056]	[.0068]	[.0064]
R-squared	.04	.04	.04	.55	.55	.04	.04	.04	.69	.69
Sample	31946	31946	31946	21905	21905	31976	31976	31976	21928	21928
	Investment in Bonds					Investment in Stocks				
Panel B. West										
Optimist	-.0254	-.0264	-.0288	-.0203	-.0229*	.1255***	.0253	.0049	.0150	.0103
	[.0206]	[.0211]	[.0215]	[.0322]	[.0085]	[.0353]	[.0353]	[.]	[.0437]	[.0322]
log(Temperature)	-.0099	-.0231***	-.0035	-.0209*	-.0082	.0836***	-.0215*	-.0017	-.0269*	-.0013
	[.0070]	[.0077]	[.0081]	[.0118]	[.0081]	[.0125]	[.0129]	[.]	[.0160]	[.0111]
x Optimist	.0121*	.0133*	.0138*	.0086	.0089*	-.0365***	-.0002	.0068	-.0043	-.0032
	[.0073]	[.0075]	[.0077]	[.0115]	[.0033]	[.0129]	[.0129]	[.]	[.0159]	[.0119]
R-squared	.01	.03	.03	.55	.55	.07	.13	.13	.71	.71
Sample	57755	57755	57755	39893	39893	57756	57756	57756	39889	39889
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	No	Yes	No	No	No	No	Yes	No	No	No
Year FE	No	Yes	No	Yes	No	No	Yes	No	Yes	No
Person FE	No	No	No	Yes	Yes	No	No	No	Yes	Yes
Country*Year FE	No	No	Yes	No	Yes	No	No	Yes	No	Yes

Notes.—Sources: Survey of Health, Ageing and Retirement (SHARE) in Europe (2004-2018). The table reports the coefficients associated with regressions of an indicator for investment in bonds and stocks on an indicator for whether the individual is optimistic, logged annual temperature for the NUTS1 region (within a country), their interaction, and a vector of precipitation and individual demographic characteristics, which include age and gender splitting the sample in eastern and western European countries. Additional country level controls are used such as GDP per capita, population growth, services and agriculture value as a percentage of GDP. Standard errors are robust and clustered at the individual-level. Observations are unweighted.

Table 6: Discussion: High vs Low Trust Level Countries

		Investment in Bonds					Investment in Stocks				
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel A. High Optimist											
		-.0425***	-.0086	-.0236***	-.0095	-.0282*	-.0541***	.0272*	-.0010	.0678***	.0371*
		[.0091]	[.0092]	[.0090]	[.0140]	[.0110]	[.0162]	[.0162]	[.0164]	[.0193]	[.0138]
log(Temperature)		-.0193***	-.0108***	.0004	-.0106*	-.0065	.0020	-.0116*	-.0024	.0040	.0114
		[.0030]	[.0039]	[.0048]	[.0058]	[.0078]	[.0053]	[.0064]	[.0079]	[.0074]	[.0104]
x Optimist		.0187***	.0065*	.0120***	.0047	.0115*	.0273***	-.0028	.0076	-.0239***	-.0128*
		[.0034]	[.0034]	[.0034]	[.0054]	[.0042]	[.0062]	[.0062]	[.0063]	[.0074]	[.0059]
R-squared		.02	.03	.04	.55	.55	.07	.12	.12	.71	.72
Sample		77318	77318	77318	51375	51375	77344	77344	77344	51383	51383
		Investment in Bonds					Investment in Stocks				
Panel B. Low Optimist											
		-.0357*	-.0269	-.0472**	-.0511	-.0058	-.0218	-.0500*	-.0553**	.0959	.0053
		[.0198]	[.0196]	[.0204]	[.0763]	[.0674]	[.0250]	[.0267]	[.0274]	[.1200]	[.0533]
log(Temperature)		-.0101	.0009	-.0061	-.0316	-.0021	-.0103	-.0104	-.0081	.0263	-.0054
		[.0065]	[.0088]	[.0108]	[.0398]	[.0440]	[.0070]	[.0107]	[.0132]	[.0506]	[.0437]
x Optimist		.0149*	.0120	.0192**	.0153	-.0055	.0132	.0239**	.0256**	-.0319	.0042
		[.0077]	[.0076]	[.0078]	[.0342]	[.0273]	[.0097]	[.0103]	[.0107]	[.0479]	[.0265]
R-squared		.01	.02	.03	.57	.59	.03	.06	.06	.61	.62
Sample		12383	12383	12381	1542	1538	12388	12388	12386	1544	1540
Controls		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE		No	Yes	No	No	No	No	Yes	No	No	No
Year FE		No	Yes	No	Yes	No	No	Yes	No	Yes	No
Person FE		No	No	No	Yes	Yes	No	No	No	Yes	Yes
Country*Year FE		No	No	Yes	No	Yes	No	No	Yes	No	Yes

Notes.—Sources: Survey of Health, Ageing and Retirement (SHARE) in Europe (2004-2018). The table reports the coefficients associated with regressions of an indicator for investment in bonds and stocks on an indicator for whether the individual is optimistic, logged annual temperature for the NUTSI region (within a country), their interaction, and a vector of precipitation and individual demographic characteristics, which include age and gender splitting the sample taking into consideration the levels of trust (high and low trust levels). Additional country level controls are used such as GDP per capita, population growth, services and agriculture value as a percentage of GDP. Standard errors are robust and clustered at the individual-level. Observations are unweighted.

Table 7: Alternative Outcome Variables: Temperature, Optimism and Economic Behaviour

	Self Employed					Satisfied with job					Look for early retirement				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Optimist	.4708*** [.1125]	-.1046 [.1141]	-.1963* [.1159]	-.2938** [.1411]	-.3876*** [.0809]	-.1045 [.1148]	-.2006* [.1163]	-.1337 [.1183]	-.3823** [.1860]	-.2512* [.1081]	-.2791 [.3255]	1.3393*** [.3250]	1.1636*** [.3316]	.7962* [.4775]	.5244 [.2912]
log(Temperature)	.3121*** [.0419]	.1154** [.0459]	-.0227 [.0521]	.0059 [.0532]	-.1623*** [.0341]	-.0011 [.0425]	-.0483 [.0472]	.0204 [.0523]	-.1936*** [.0737]	-.1125 [.0720]	-.5856*** [.1198]	.4030*** [.1263]	.4280*** [.1385]	.3462* [.1819]	.3181* [.1330]
x Optimist	-.1675*** [.0434]	.0468 [.0439]	.0839* [.0446]	.1012* [.0532]	.1392** [.0358]	-.0008 [.0445]	.0375 [.0452]	.0128 [.0459]	.1468** [.0713]	.0979* [.0450]	.1949 [.1243]	-.4551*** [.1239]	-.3871*** [.1263]	-.3044* [.1805]	-.1978 [.1134]
R-squared	.03	.05	.05	.80	.81	.04	.04	.05	.59	.59	.02	.08	.09	.64	.65
Sample	36303	36303	36303	22885	22885	25911	25911	25911	12903	12903	34531	34531	34531	21430	21430
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	No	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No
Year FE	No	Yes	No	Yes	No	No	Yes	No	Yes	No	No	Yes	No	Yes	No
Person FE	No	No	No	Yes	Yes	No	No	No	Yes	Yes	No	No	No	Yes	Yes
Country*Year FE	No	No	Yes	No	Yes	No	No	Yes	No	Yes	No	No	Yes	No	Yes

Notes.—Sources: Survey of Health, Ageing and Retirement (SHARE) in Europe (2004-2018). The table reports the coefficients associated with regressions of an indicator for working attitudes such as self-employment, satisfaction with job, plans for early retirement and an indicator for whether the individual is optimistic, logged annual temperature for the NUTS1 region (within a country), their interaction, and a vector of precipitation and individual demographic characteristics, which include age and gender. Additional country level controls are used such as GDP per capita, population growth, services and agriculture value as a percentage of GDP. Standard errors are robust and clustered at the individual-level. Observations are unweighted.

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A Online Appendix: Variable Definitions

This section provides an analytical overview of all the variables employed in the analysis.

A.1 SHARE NUTS 1 Regional Data

Investment in Bonds: The variable takes the value 1 if the respondent has currently invested in bonds and 0 otherwise. Bonds are a debt instrument issued by the government or a corporation in order to generate capital by borrowing.

Investment in Stocks: The variable takes the value 1 if the respondent has currently invested in stocks and 0 otherwise. Stocks are a form of investment that allows a person to own a part of a corporation and gives him/her the right to receive dividends from it.

Amounts invested in Bonds: The respondents answer the question “How much do you currently have in government or corporate bonds?”. It is a continuous variable, expressed in Euros.

Amounts invested in Stocks: The respondents answer the question “How much do you currently have in stocks or shares?”. It is a continuous variable, expressed in Euros.

Optimism: Individuals respond to the question “What are your hopes for the future ? Please note only whether hopes are mentioned or not”. Takes the value 1 if the respondent is optimist about the future and 0 if the individual is pessimist.

Happiness: Individuals respond to the question “Have you feel enjoyment recently?”. Takes the value 1 if the respondent has mentioned any enjoyment and 0 if not.

Interest: Individuals respond to the question “In the last month what is your interest in

things?”. Takes the value 1 whether the respondent mentions no loss of interest and 0 whether mentions less interest than usual.

Trust others: Individuals respond to the question “Generally speaking, would you say that most people can be trusted or that you can’t be too careful in dealing with people?” Takes values from 0 to 10, where 0 means you can’t be too careful and 10 means that most people can be trusted.

Risk aversion: Individuals respond to the question “What the amount of financial risk you are willing to take when you save or make investments?”. Takes the value 1 where 1 means that individual is not willing to take any financial risks, or takes above average financial risks expecting to earn above average returns and 0 depicts that individual takes average financial risks expecting to earn average returns or substantial financial risks expecting to earn substantial returns.

Health quality: The individual completes the sentence “Would you say your health is...” taking the value 1 if the respondent has mentioned excellent or good health and 0 if not.

Male: The gender of each respondent. Takes the value 1 for males and 0 for females.

Property value: The individual answers the question “In your opinion, how much would you receive if you sold your property today?”. It is a continuous variable, expressed in Euros.

Age: The age of the respondent, calculated by the year of birth and year of interview.

Self employed: The individual answers the question “In this job are you an employee, a civil servant, or a self-employed?” Takes the value 1 whether the respondent is working as a self-employed and 0 whether the respondent is working in the public or private sector.

Job satisfaction: The individual answers the question “All things considered I am satisfied with my job. Would you say you strongly agree, agree, disagree or strongly disagree?”. It takes the value 1 whether the respondent agree or strongly agree and 0 otherwise.

Retirement timing: The individual answers the question “Thinking about your present job, would you like to retire as early as you can from this job?”. Takes the value 1 if the respondent is looking forward for early retirement and 0 if not.

A.2 World Bank Indicators and Aggregate Data

GDP per capita: GDP per capita is gross domestic product divided by midyear population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in current U.S. dollars.

Population growth: Annual population growth rate for year t is the exponential rate of growth of midyear population from year $t-1$ to t , expressed as a percentage. Population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship.

Services value: Services correspond to ISIC divisions 50-99 and they include value added in wholesale and retail trade (including hotels and restaurants), transport, and government, financial, professional, and personal services such as education, health care, and real estate services. Also included are imputed bank service charges, import duties, and any statistical discrepancies noted by national compilers as well as discrepancies arising from rescaling. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources.

Total agriculture value: Agriculture corresponds to ISIC divisions 1-5 and includes forestry, hunting, and fishing, as well as cultivation of crops and livestock production. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources.

A.3 ECMWF ERA 5 Reanalysis Data

Temperature: The log yearly temperature is calculated as the sum of the mean monthly temperature at 2 meters, measured in Celsius degrees.

Precipitation: The yearly precipitation is calculated as the sum of the mean monthly precipitation in 1000's of millimeters.

B Supplementary Tables

This section exports some additional robustness tables.

Table A.1: Robustness: Income and Wealth Effects

	Value of Property				
	(1)	(2)	(3)	(4)	(5)
Optimist	.8484*** [.1588]	.3539** [.1559]	.3727** [.1594]	.1772 [.2256]	.2119 [.1561]
log(Temperature)	.3392*** [.0579]	-.0595 [.0587]	-.0045 [.0639]	-.0387 [.0860]	.0409 [.0693]
x Optimist	-.2497*** [.0594]	-.0578 [.0583]	-.0658 [.0596]	-.0631 [.0852]	-.0776 [.0579]
R-squared	.32	.35	.35	.76	.77
Sample	51315	51315	51315	30286	30286
Controls	Yes	Yes	Yes	Yes	Yes
Country FE	No	Yes	No	No	No
Year FE	No	Yes	No	Yes	No
Person FE	No	No	No	Yes	Yes
Country*Year FE	No	No	Yes	No	Yes

Notes.—Sources: Survey of Health, Ageing and Retirement (SHARE) in Europe (2004-2018). The table reports the coefficients associated with regressions of the respondent's logged self-reported real property value on logged annual temperature for the NUTS1 region (within a country), an indicator for being optimistic, their interaction, and a vector of precipitation and individual demographic characteristics, which include age and gender. Additional country level controls are used such as GDP per capita, population growth, services and agriculture value as a percentage of GDP. Standard errors are robust and clustered at the individual-level. Observations are unweighted.

Table A.2: Robustness: Happiness

	Investment in Bonds					Investment in Stocks				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
happy	.0521*** [.0105]	.0546*** [.0110]	.0229* [.0127]	.0703*** [.0170]	.0381 [.0196]	-.0272 [.0180]	.0442** [.0176]	.0034 [.0187]	.0928*** [.0206]	.0415 [.0228]
log(Temperature)	.0064* [.0035]	-.0034 [.0042]	.0089 [.0061]	-.0016 [.0059]	.0082 [.0083]	.0146** [.0059]	-.0136** [.0063]	-.0016 [.0079]	-.0159** [.0068]	-.0134 [.0074]
x happy	-.0163*** [.0040]	-.0171*** [.0042]	-.0052 [.0049]	-.0253*** [.0065]	-.0130 [.0070]	.0203*** [.0069]	-.0117* [.0068]	.0037 [.0072]	-.0349*** [.0079]	-.0148 [.0090]
R-squared	.02	.03	.04	.53	.54	.07	.12	.12	.71	.71
Sample	69603	69603	69603	39512	39512	69632	69632	69632	39518	39518
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	No	Yes	No	No	No	No	Yes	No	No	No
Year FE	No	Yes	No	Yes	No	No	Yes	No	Yes	No
Person FE	No	No	No	Yes	Yes	No	No	No	Yes	Yes
Country*Year FE	No	No	Yes	No	Yes	No	No	Yes	No	Yes

Notes.—Sources: Survey of Health, Ageing and Retirement (SHARE) in Europe (2004-2018). The table reports the coefficients associated with regressions of an indicator for investment in bonds and stocks on an indicator for whether the individual has felt any enjoyment recently, logged annual temperature for the NUTS1 region (within a country), their interaction, and a vector of precipitation and individual demographic characteristics, which include age and gender. Additional country level controls are used such as GDP per capita, population growth, services and agriculture value as a percentage of GDP. Standard errors are robust and clustered at the individual-level. Observations are unweighted.

Table A.3: Robustness: General Interest

	Investment in Bonds					Investment in Stocks				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
interested	.0277** [.0119]	.0491*** [.0123]	.0196 [.0130]	.0419* [.0230]	.0056 [.0414]	-.0502** [.0226]	.0461** [.0219]	.0078 [.0226]	.0975*** [.0308]	.0637* [.0277]
log(Temperature)	-.0007 [.0041]	-.0049 [.0050]	.0070 [.0066]	-.0083 [.0085]	.0034 [.0076]	.0112 [.0078]	-.0137 [.0083]	.0016 [.0102]	-.0184* [.0112]	-.0059 [.0067]
x interested	-.0074 [.0045]	-.0149*** [.0046]	-.0039 [.0049]	-.0152* [.0087]	-.0014 [.0165]	.0260*** [.0086]	-.0132 [.0083]	.0009 [.0086]	-.0354*** [.0118]	-.0225 [.0110]
R-squared	.02	.03	.04	.53	.54	.07	.12	.12	.70	.71
Sample	66426	66426	66426	36625	36625	66446	66446	66446	36634	36634
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	No	Yes	No	No	No	No	Yes	No	No	No
Year FE	No	Yes	No	Yes	No	No	Yes	No	Yes	No
Person FE	No	No	No	Yes	Yes	No	No	No	Yes	Yes
Country*Year FE	No	No	Yes	No	Yes	No	No	Yes	No	Yes

Notes.—Sources: Survey of Health, Ageing and Retirement (SHARE) in Europe (2004-2018). The table reports the coefficients associated with regressions of an indicator for investment in bonds and stocks on an indicator for whether the individual has mentioned any interest in general things, logged annual temperature for the NUTSI region (within a country), their interaction, and a vector of precipitation and individual demographic characteristics, which include age and gender. Additional country level controls are used such as GDP per capita, population growth, services and agriculture value as a percentage of GDP. Standard errors are robust and clustered at the individual-level. Observations are unweighted.

Table A.4: Robustness: Minimum Temperature

	Investment in Bonds					Investment in Stocks				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Optimist	-.0158*** [.0058]	.0077 [.0055]	-.0092* [.0053]	.0074 [.0086]	-.0148*** [.0032]	-.0332*** [.0089]	.0259*** [.0085]	.0057 [.0084]	.0449*** [.0110]	.0215*** [.0043]
log(Temperature)	-.0098*** [.0019]	-.0001 [.0024]	-.0003 [.0029]	.0019 [.0037]	-.0043 [.0035]	.0108*** [.0029]	-.0003 [.0036]	.0028 [.0043]	.0085* [.0045]	.0078 [.0044]
x Optimist	.0089*** [.0023]	.0002 [.0021]	.0067*** [.0021]	-.0023 [.0034]	.0062*** [.0009]	.0197*** [.0036]	-.0025 [.0034]	.0051 [.0034]	-.0164*** [.0044]	-.0075*** [.0019]
R-squared	.02	.03	.04	.55	.55	.06	.12	.12	.71	.71
Sample	89701	89701	89701	61798	61798	89732	89732	89732	61817	61817
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	No	Yes	No	No	No	No	Yes	No	No	No
Year FE	No	Yes	No	Yes	No	No	Yes	No	Yes	No
Person FE	No	No	No	Yes	Yes	No	No	No	Yes	Yes
Country*Year FE	No	No	Yes	No	Yes	No	No	Yes	No	Yes

Notes.—Sources: Survey of Health, Ageing and Retirement (SHARE) in Europe (2004-2018). The table reports the coefficients associated with regressions of an indicator for investment in bonds and stocks on an indicator for whether the individual is optimistic, logged annual minimum temperature for the NUTS1 region (within a country), their interaction, and a vector of precipitation and individual demographic characteristics, which include age and gender. Additional country level controls are used such as GDP per capita, population growth, services and agriculture value as a percentage of GDP. Standard errors are robust and clustered at the individual-level. Observations are unweighted

Table A.5: Robustness: Median Temperature

	Investment in Bonds					Investment in Stocks				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Optimist	-.0456*** [.0092]	-.0133 [.0094]	-.0320*** [.0094]	-.0042 [.0143]	-.0285** [.0076]	-.0459*** [.0159]	.0152 [.0160]	-.0117 [.0163]	.0563*** [.0193]	.0285* [.0109]
log(Temperature)	-.0195*** [.0031]	-.0121*** [.0038]	-.0032 [.0047]	-.0089 [.0057]	-.0097 [.0071]	.0029 [.0053]	-.0140** [.0061]	-.0024 [.0074]	.0002 [.0072]	.0098 [.0062]
x Optimist	.0197*** [.0035]	.0082** [.0035]	.0150*** [.0035]	.0022 [.0054]	.0111** [.0029]	.0241*** [.0061]	.0017 [.0061]	.0114* [.0062]	-.0198*** [.0073]	-.0098* [.0045]
R-squared	.02	.03	.04	.55	.55	.06	.12	.12	.71	.71
Sample	89701	89701	89701	61798	61798	89732	89732	89732	61817	61817
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	No	Yes	No	No	No	No	Yes	No	No	No
Year FE	No	Yes	No	Yes	No	No	Yes	No	Yes	No
Person FE	No	No	No	Yes	Yes	No	No	No	Yes	Yes
Country*Year FE	No	No	Yes	No	Yes	No	No	Yes	No	Yes

Notes.—Sources: Survey of Health, Ageing and Retirement (SHARE) in Europe (2004-2018). The table reports the coefficients associated with regressions of an indicator for investment in bonds and stocks on an indicator for whether the individual is optimistic, logged annual median temperature for the NUTS1 region (within a country), their interaction, and a vector of precipitation and individual demographic characteristics, which include age and gender. Additional country level controls are used such as GDP per capita, population growth, services and agriculture value as a percentage of GDP. Standard errors are robust and clustered at the individual-level. Observations are unweighted

Table A.6: Robustness-Age Fixed Effects: Temperature, Optimism and the Extensive Margin of Investments

	Investment in Bonds					Investment in Stocks				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Optimist	-.0436*** [.0083]	-.0097 [.0085]	-.0275*** [.0084]	-.0000 [.0130]	-.0211* [.0091]	-.0536*** [.0144]	.0159 [.0147]	-.0114 [.0149]	.0582*** [.0178]	.0304** [.0104]
log(Temperature)	-.0182*** [.0027]	-.0090** [.0036]	-.0006 [.0045]	-.0053 [.0053]	-.0044 [.0075]	-.0009 [.0047]	-.0126** [.0058]	-.0036 [.0071]	.0018 [.0068]	.0086 [.0050]
x Optimist	.0190*** [.0031]	.0068** [.0032]	.0132*** [.0031]	.0007 [.0049]	.0083* [.0032]	.0282*** [.0055]	.0012 [.0056]	.0111* [.0057]	-.0206*** [.0068]	-.0106* [.0042]
R-squared	.02	.04	.04	.55	.56	.06	.12	.13	.71	.72
Sample	89705	89677	89677	61751	61751	89736	89706	89706	61766	61766
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Age FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	No	Yes	No	No	No	No	Yes	No	No	No
Year FE	No	Yes	No	Yes	No	No	Yes	No	Yes	No
Person FE	No	No	No	Yes	Yes	No	No	No	Yes	Yes
Country*Year FE	No	No	Yes	No	Yes	No	No	Yes	No	Yes

Notes.—Sources: Survey of Health, Ageing and Retirement (SHARE) in Europe (2004-2018). The table reports the coefficients associated with regressions of an indicator for investment in bonds and stocks on an indicator for whether the individual is optimistic, logged annual temperature for the NUTS1 region (within a country), their interaction, and a vector of precipitation, gender and as well as age fixed effects. Additional country level controls are used such as GDP per capita, population growth, services and agriculture value as a percentage of GDP. Standard errors are robust and clustered at the individual-level. Observations are unweighted.

Table A.7: Robustness-Age Fixed Effects: Temperature, Optimism and the Intensive Margin of Investments

	Amounts in Bonds					Amounts in Stocks				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Optimist	-.1923*** [.0477]	-.0129 [.0107]	-.0298*** [.0101]	-.0033 [.0176]	-.0204* [.0076]	-.0536*** [.0144]	.0159 [.0147]	-.0114 [.0149]	.0582*** [.0178]	.0308** [.0098]
log(Temperature)	-.0436*** [.0165]	-.0251*** [.0049]	-.0085 [.0057]	-.0227*** [.0075]	-.0074 [.0095]	-.0009 [.0047]	-.0126** [.0058]	-.0036 [.0071]	.0018 [.0068]	.0086 [.0047]
x Optimist	.0898*** [.0179]	.0087** [.0041]	.0149*** [.0039]	.0016 [.0068]	.0083** [.0022]	.0282*** [.0055]	.0012 [.0056]	.0111* [.0057]	-.0206*** [.0068]	-.0107* [.0040]
R-squared	.01	.91	.91	.95	.95	.06	.12	.13	.71	.72
Sample	90416	90388	90388	62415	62415	89736	89706	89706	61766	61766
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Age FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	No	Yes	No	No	No	No	Yes	No	No	No
Year FE	No	Yes	No	Yes	No	No	Yes	No	Yes	No
Person FE	No	No	No	Yes	Yes	No	No	No	Yes	Yes
Country*Year FE	No	No	Yes	No	Yes	No	No	Yes	No	Yes

Notes.—Sources: Survey of Health, Ageing and Retirement (SHARE) in Europe (2004-2018). The table reports the coefficients associated with regressions of an indicator for amounts invested in bonds and stocks on an indicator for whether the individual is optimistic, logged annual temperature for the NUTS1 region (within a country), their interaction, and a vector of precipitation, gender and as well as age fixed effects. Additional country level controls are used such as GDP per capita, population growth, services and agriculture value as a percentage of GDP. Standard errors are robust and clustered at the individual-level. Observations are unweighted.