The association between saving disposition and financial distress: A genetically informed approach

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Abstract

Saving disposition, the tendency to save rather than consume, has been found to be associated with economic outcomes. People lacking the disposition to save are more likely to experience financial distress. This association could be driven by other economic factors, behavioral traits, or even genetic effects. Using a sample of 3,920 American twins, we develop scales to measure saving disposition and financial distress. We find genetic influences on both traits, but also a large effect of the rearing family environment on saving disposition. We estimate that 44% of the covariance between the two traits is due to genetic effects. Saving disposition remains strongly associated with lower financial distress, even after controlling for family income, cognitive ability, and personality traits. The association persists within families and monozygotic twin pairs; the twin who saves more tends to be the twin who experiences less financial distress. This result suggest that there is a direct association between saving disposition and financial distress, although the direction of causation remains unclear.

Keywords:

saving

income

genetics

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1 Introduction

1.1 Saving disposition and the origins of wealth inequality

The persistence of wealth disparities in contemporary Western societies is well-documented (Donovan, Labonte, & Dalaker, 2016), but its causes are much less clear. Lifetime income and inherited wealth predict only a small part of the variance in wealth accumulation over the life course (Venti & Wise, 1998; Xu, Beller, Roberts, & Brown, 2015).

A substantial portion of the variance in wealth at retirement seems to be accounted for by saving disposition, i.e. the choice by an individual to save or consume while young (Börsch-Supan, Bucher-Koenen, Hurd, & Rohwedder, 2023; Cronqvist & Siegel, 2015; Lusardi, 1998; Venti & Wise, 1998). The effect of saving on economic disparity is greater than that of income, investment choices, or chance events (Venti & Wise, 1998). It has been suggested that saving disposition is related to low delay discounting, the tendency to prefer greater rewards in the future over immediate pleasure (Lusardi, 1998).

However, saving rates cannot be explained solely by delay discounting, and may be themselves driven by income, as richer households save more throughout their life cycle (Dynan, Skinner, & Zeldes, 2004), while scarcity is associated with reduced delay discounting (Hilbert, Noordewier, & van Dijk, 2022). Those with higher income may be more likely to save because they can afford to do so. Hence, the association between saving disposition and wealth seems to be bidirectional.

1.2 Saving disposition and financial distress

Can the sources of variance in wealth accumulation also explain the variability in experiencing financial distress, or extreme economic hardship?

Financial distress is usually measured by a composite score of items asking about financial hardship experienced in the past 12 months (Xu, Beller, Roberts, & Brown, 2015). The British Household Panel Survey used items related to current financial situation, financial situation worsened since last year, whether the household has housing payment problems, or problems requiring borrowing (Taylor, 2011). The National Survey of America's Family (NSAF) includes survey questions about difficulty paying bills, skipping meals due to lack of money, going without phone service for at least one month, and postponing medical care (Melzer, 2011).

Financial distress can be the result of inadequate income, but also of poor financial management or unsustainable borrowing (Anderloni, Bacchiocchi, & Vandone, 2012; De Bruijn & Antonides, 2020; Donnellan, Conger, McAdams, & Neppl, 2009). Saving disposition refers to the tendency to save rather than consume. Measured with items such as *making ends meet*, *planning ahead*, and *keeping track*, it has been found to have the strongest association with reduced financial distress, even after controlling for income and education (Von Stumm, O'Creevy, & Furnham, 2013).

1.3 Psychological traits and financial distress

Psychology can help us shed more light into the origin of economic disparities. Certain psychological traits that are related both to financial distress and saving disposition may be responsible for confounding their association.

Personality and cognitive ability are associated with delay discounting, which partly drives saving rates, as well as with abilities that are valued in the labor market, and thus shape income (Becker, Deckers, Dohmen, Falk, & Kosse, 2012; Heckman, Stixrud, & Urzua, 2006). A recent study of twins found that cognitive ability and personality are predictive of offspring socioeconomic outcomes, independently of their parents' socioeconomic status (McGue et al., 2020).

In particular, higher conscientiousness has been found to correlate substantially with increased saving and reduced borrowing (Furnham & Cheng, 2019; Nyhus & Webley, 2001), higher income (Nyhus & Pons, 2005), and reduced financial distress (Xu, Beller, Roberts, & Brown, 2015). Cognitive ability is strongly associated with income and long-term financial planning (Belsky et al., 2016; Strenze, 2007). One study reported that cognitive ability is associated with financial distress in a quadratic fashion, with increased levels of economic hardship at both extremes of the IQ distribution (Zagorsky, 2007).

A recent analysis reported that cognitive ability is the best predictor of income and wealth, even after controlling for parental socioeconomic status (Marks, 2022). The analysis replicated the results reported in *The Bell Curve*, and also made the same argument: that American society is now a meritocracy stratified along cognitive lines (Herrnstein & Murray, 1994). However, these studies do not consider the contribution of non-cognitive skills, such as conscientiousness, restraint, or saving disposition.

1.4 The nature and nurture of economic outcomes

Many of the correlates of economic behavior have been shown to be influenced by genetics. Cognitive ability and, to a lesser extent, personality are known to be substantially heritable (Bouchard & McGue, 2003). Part of the variance in delay discounting can be accounted for by genetic factors, with estimates ranging from 20% to 60% (Anokhin, Golosheykin, Grant, & Heath, 2011; Anokhin, Grant, Mulligan, & Heath, 2015; Cesarini, Johannesson, Magnusson, & Wallace, 2012).

Multiple twin and adoption studies, conducted in different Western countries, have converged on heritability estimates of ∼40% for income (Hyytinen, Ilmakunnas, Johansson, & Toivanen, 2019). The effect of the family environment is significant but small, with most of the environmental influence being due to factors that operate outside the household (Sacerdote, 2002, 2007).

A recent study reported that 43% of the variance in financial distress is accounted for by genetics, with some of that heritability being mediated by cognitive and personality traits (Xu, Briley, Brown, & Roberts, 2017).

Another large twin study has found that saving rates are 32% heritable. The genetic component of saving was found to be shared with income, smoking, and obesity, suggesting that it reflects individual differences in delay discounting (Cronqvist & Siegel, 2015).

In general, most human behavioral traits show substantial heritability, with the effect of parental nurture being negligible (Polderman et al., 2015). According to recent adoption studies, this pattern seems to hold true for income and cognitive skills, but not for saving disposition or wealth, which are strongly affected by the rearing family environment (Black, Devereux, Lundborg, & Majlesi, 2020; Fagereng, Mogstad, & Rønning, 2021).

The availability of molecular-genetic data has opened new possibilities for exploring such questions. A genome-wide association study has shown that 12% of the variance in delay discounting is due to common genetic variants (Sanchez-Roige et al., 2018). A polygenic score (the sum of the effects of all known genetic variants affecting a trait; a measure of genetic predisposition) for educational attainment (Lee et al., 2018) is able to predict wealth at retirement, even after controlling for education, income, or parental bequests (Barth, Papageorge, & Thom, 2020). A substantial part of the association seems to be mediated by risk-taking and investment. A recent genome-wide association study of income has produced a polygenic score which predicts a multitude of socioeconomic and health outcomes (Kweon et al., 2020).

1.5 Aim of this study

Ours is the first study to explore the association between saving disposition and financial distress, using a genetically informative twin design and controlling for cognitive ability and personality. The first goal is to estimate the relative importance of cognitive and non-cognitive skills in predicting financial distress. The second goal is to estimate the contribution of genetic and environmental sources in the variance of saving disposition and financial distress, and in the covariance between them. Finally, we examined whether the association between saving disposition and financial distress is consistent with a causal effect. The natural theory we test is that a higher disposition to saving causes higher savings available to the households, and as a consequence lower probability of financial distress.

In this simple model, a higher saving disposition plays a role similar to the one assigned, in the standard economic model of lifetime consumption, to a higher subjective discount factor (lower discount rate, or higher patience), which induces higher savings, everything else being equal. In a model with random shocks to income and expenditures, higher savings reduce the probability of financial distress.

We constructed measures of saving disposition and financial distress from self-reported data in a study of 3,920 American twins. Using the classical twin study design, we estimated the heritability of saving disposition and financial distress. We also estimated how much of the association between the two scales is accounted for by genetic versus environmental factors. Additionally, we examined the association after adjusting for family income, cognitive ability, and aspects of personality that are most relevant to our research question (impulsivity and irresponsibility).

To establish whether a causal effect is plausible, we compared twins who differ in their levels of saving disposition, and checked whether they also differ in financial distress. By comparing twins, we are controlling for a number of factors that might confound the association: age, rearing socioeconomic status (SES), household conditions, parental age, school and neighbourhood effects. In the case of monozygotic (MZ) twins, we additionally control for genetic effects, since these twins share 100% of their DNA. Therefore, any within-MZ pair association between financial distress and saving disposition cannot be attributed to genetic predisposition or rearing environment.

2 Methods

2.1 Sample

We used the Colorado and Minnesota Twin Study (COMN), a joint effort by the Minnesota Center of Twin and Family Research (MCTFR) and the Institute for Behavioral Genetics (IBG) in Colorado. Minnesota participants were recruited and assessed through the Minnesota Twin Family Study (Wilson et al., 2019), while Colorado participants were recruited through the Colorado Twin Registry as part of IBG's Community Twin Sample (Corley, Reynolds, Wadsworth, Rhea, & Hewitt, 2019).

We included participants who had completed a questionnaire on their financial behavior and also had measurements of cognitive ability and personality. Our total sample consisted of 3,920 individuals from both states (48% from Colorado and 52% from Minnesota). 91% of the participants were White, 4% were Hispanic, and 5% were of other backgrounds. There was a slight over-representation of females (58%), which is common in twin studies (Lykken, McGue, & Tellegen, 1987). The mean age of the participants was 35.2 (S.D. 5.0) years. A more detailed account of the data is given in Supplementary Table 1.

Participants belonged to 1,284 pairs of monozygotic (MZ) twins and 1,072 pairs of dizygotic (DZ) twins. We included participants whose co-twin did not participate in the assessment, so 792 pairs were incomplete, with data available only on one of the twins. The 151 opposite-sex DZ pairs were all from Colorado, as Minnesota did not recruit opposite-sex pairs.

2.2 Measures

The COMN study questionnaire includes 24 items pertaining to economic behavior and income (Supplementary Figure 1).

Participants were asked to report their annual gross family income, which includes their own and their spouse's work income, as well as any income from investment. This measure was lumped into 15 categories, the highest being more than $200,000 per year, and the lowest less than $10,000 per year. Due to the large number of categories, we have treated this measure of income as continuous.

The other 22 items were subjected to exploratory factor analysis (EFA) in an attempt to partition them into those measuring saving disposition and those measuring financial distress. Although an exploratory approach is not ideal research practice (McDonald, 1985, 1999), it can be justified in cases when the trait domain is in need of clarification. Given that this is the first time that these items are used, EFA can provide a sense of whether the two sets of items do indeed measure the intended latent factors. We also report the reliability of the two newly-derived scales, indicating how much of their observed variance is due to variance in true latent factor scores.

The items are characterized by the extreme endorsement rates and factor loadings indicative of a linear approximation's inadequacy (McDonald, 1999). For this reason we turned to multidimensional item response theory (IRT), as implemented in the `mirt` package for the `R` computing platform (Chalmers, 2012). IRT is a mild nonlinear generalization of factor analysis (Lee, Lee, Wells, & Sireci, 2016; McDonald, 1999). At this stage

Table 1: Questionnaire measuring saving disposition

Item	π	λ
Do you have a retirement plan from a current or previous employer or an individual retirement account?	0.762	0.709
Is saving for the future important to you?	0.954	0.779
Do you regularly save some of the money you earn by placing it in a special account?	0.754	0.818
Do you think it is important to live within your budget?	0.979	0.578

π is the percentage of the subsample with no missing data responding *yes* to the item. λ is the item's factor loading in the factor-analytic parameterization of a 2PL IRT model.

we eliminated one item about loss of possessions in a fire that was negatively correlated with several others. We also eliminated an item about home ownership, because of its low loading and uncertain connection to saving disposition (Supplementary Figure 1). Using only participants with complete data on all financial behavior items, we obtained a sample of 3,124 individuals for the psychometric analysis.

For all subsequent analyses, we measure saving disposition as the sum of the items in Table 1, and financial distress as the sum of the items in Table 2. More details about factor analysis and IRT can be found in the Supplementary Information.

As a measure of cognitive ability, we made use of the 16-item International Cognitive Ability Resource (Condon & Revelle, 2014), a reliable and easy-to-administer test of cognitive performance. We also included the two personality scales that are most relevant to our study, impulsivity and irresponsibility. Both scales are part of the general disinhibition factor in the short version of the Personality Inventory for DSM-5 (Maples et al., 2015).

Table 2: Questionnaire measuring financial distress

Item	π	λ_1	λ_2
Do you find yourself living paycheck to paycheck?	0.372	0	0.858
Do you have enough savings to cover living expenses for 3 months? (reverse)	0.597	0	0.823
At any time in the past 12 months, have you ...			
Been turned down for a credit card?	0.106	0.818	0
Defaulted on a credit card payment?	0.061	0.856	0
Sold one or more of your belongings to a pawnbroker?	0.025	0.854	0
Declared bankruptcy?	0.011	0.716	0
Had your belongings repossessed for non-payment?	0.011	0.822	0
Had your home foreclosed on or sold at auction?	0.004	0.730	0
Been homeless?	0.014	0.855	0
Received any form of government assistance?	0.111	0.656	0
In the past 12 months, did you ever find it difficult to meet the cost of ...			
Food or other necessities?	0.112	0	0.950
Rent or mortgage?	0.130	0	0.931
Bills for things like insurance, phone or heating?	0.139	0	0.963
Things like having a night out or presents?	0.221	0	0.952
Holidays or travel?	0.308	0	0.904
Major repairs to your home or car?	0.226	0	0.891

π is the percentage of the subsample with no missing data responding *yes* to the item. λ_1 and λ_2 are the item's factor loadings in the factor-analytic parameterization of a 2PL IRT model. We estimated the latent correlation between the two factors to be 0.761. The complete wording of each item is given in Supplementary Figure 1.

2.3 Biometric analysis

The family structure of the data allows us to explore how much of the variance in our measures is due to genetic or environmental effects. Members of a twin pair are expected to be similar in behavioral (including economic) traits, since they are of the exact same age and are raised in the same household. Any additional similarity that is observed in MZ pairs, but not in DZ pairs, is hypothesized to be due to the effect of genes. Under the equal environments assumption, the degree of environmental similarity is equal in MZ and DZ pairs; therefore any differences between them must be due to the fact that MZ twins also happen to be genetically identical.

More formally, the standard quantitative genetics model (Falconer & Mackay, 1996) defines the additive genetic effect (or true polygenic score) a_{ij} on a given trait y_{ij}, for twin i in pair j:

$$a_{ij} = \sum_{k=1}^{m} (x_{ijk}\alpha_k), \tag{1}$$

where α_k is the causal effect of genetic site k on trait y (Fisher, 1941; Lee & Chow, 2013), x_{ijk} is the number of alleles of the counted type carried by the individual at site k (0, 1, or 2), and m is the total number of sites in the genome affecting the trait.

The trait value of individual i can be modeled as a function of three unobserved effects:

$$y_{ij} = \beta_0 + a_{ij} + c_j + e_{ij}, \tag{2}$$

where β_0 is the intercept and c_j represents the effect of the common environment, i.e. conditions that are shared between family members, such rearing family SES, parental nurture, childhood diet and place of residence. e_{ij} is the residual effect, which includes environmental influences that are unique to each individual, as well as measurement error. a_{ij} being the only genetic term above means that by assumption the genes combine additively; they do not statistically interact. This assumption seems to be justified by theoretical and empirical work, which indicates that a very substantial contribution of non-additive genetic effects to complex traits is implausible (Hill, Goddard, & Visscher, 2008; Hivert et al., 2021; Lee, Vattikuti, & Chow, 2016; Maki-Tanila & Hill, 2014; Okbay et al., 2022).

Assuming that a_{ij}, c_j and e_{ij} are uncorrelated with one another and distributed with zero means and variances σ_a^2, σ_c^2, and σ_e^2 respectively, we have that the total variance of the trait is the sum of the genetic, shared environmental, and non-shared environmental variance components:

$$\sigma^2 = \sigma_a^2 + \sigma_c^2 + \sigma_e^2. \tag{3}$$

We are able to estimate these parameters by maximizing the likelihood of the data under the restriction that the covariance matrix for two sets of twins is of the form:

$$\Sigma = \begin{bmatrix} \sigma_a^2 + \sigma_c^2 + \sigma_e^2 & R\sigma_a^2 + \sigma_c^2 \\ R\sigma_a^2 + \sigma_c^2 & \sigma_a^2 + \sigma_c^2 + \sigma_e^2 \end{bmatrix}, \tag{4}$$

where R is the coefficient of relatedness, which equals 1 for MZ twins (who share 100% of their DNA), and 0.5 for DZ twins (who, on average, share 50% of their DNA identical by descent). The coefficient of σ_c^2 in the covariance formula equals 1 for both MZ and DZ twins, due to the equal environment assumption. By definition, the coefficient of the unique environment σ_e^2 equals 0.

We can thus estimate the proportion of total variance which is due to additive genetic effects (also known as the heritability of the trait): $a^2 = \sigma_a^2/\sigma^2$, where σ^2 is the total variance. The proportions of variance due to the common ($c^2 = \sigma_c^2/\sigma^2$) and unique environment ($e^2 = \sigma_e^2/\sigma^2$) are calculated similarly.

In the case of multivariate data, we can make use of cross-twin, cross-trait correlations to estimate the genetic and environmental components of the covariance between traits (Martin & Eaves, 1977). We assume that the cross-trait covariance matrix for two sets of twins for is of the form:

$$\Sigma = \begin{bmatrix} R\sigma_{a1}^2 + \sigma_{c1}^2 & R\sigma_{a12} + \sigma_{c12} \\ R\sigma_{a12} + \sigma_{c12} & R\sigma_{a2}^2 + \sigma_{c2}^2 \end{bmatrix}, \tag{5}$$

where σ_{a12} is genetic covariance between trait 1 and trait 2 (i.e., the covariance between the genetic values defined by Equation 1), and σ_{c12} is the common environmental part of the covariance. On the diagonal are within-trait, cross-twin correlations, while cross-trait, cross-twin correlations are on the off-diagonal. σ_{e12} can be estimated by subtracting σ_{a12} and σ_{c12} from the total covariance.

We can thus estimate the genetic correlation between traits 1 and 2:

$$r_{g12} = \frac{\sigma_{a12}}{\sqrt{\sigma_{a1}^2 \sigma_{a2}^2}}; \tag{6}$$

r_g measures the association between the genetic components of the two traits. Analogously, we can estimate the environmental correlations r_c and r_e.

We can also estimate the proportion of observed covariance that is due to genetics as σ_{a12}/σ_{12}. Similarly for the covariance due to the common environment and unique environment.

For each zygosity group, we can estimate multiple within-trait and cross-trait correlations. This leaves us with more pieces of information than unknown parameters. Therefore, we estimate parameters by minimizing the sum of squared deviations of model-implied values from observed values. Each observation is weighted by the reciprocal of its sampling variance (Eaves, Last, Young, & Martin, 1978). In the case of non-normally distributed traits, such the ones we examine, parameter estimates may not coincide with maximum likelihood estimates.

Power analyses indicated that we had more than 80% power to detect a heritability of at least 0.5 and a common environmental component of at least 0.2, as well as genetic correlations of at least 0.3 (Verhulst, 2017; Visscher, 2004).

We adjusted for the effects of age and sex, since not doing so could result in biased parameter estimates (McGue & Bouchard, 1984).

All biometric analyses were performed in `R`, using `OpenMx 2.0` (Neale et al., 2016).

2.4 Association analysis

We first used Pearson correlations to examine the criterion validity of our derived scales, by looking at the correlations between them, as well as their associations with family income, which we consider an approximation of family wealth.

We also assessed the association between financial distress and saving disposition, while controlling for personality, cognitive ability, and family income. By including income as a covariate, we wanted to test whether the association is driven by access to financial resources or by financial management.

We standardized all variables, in order to facilitate the interpretation of regression coefficients. Since the family clustering and positively skewed distributions might bias our estimates, we estimated standard errors by bootstrapping 1,000 times over families.

Finally, we tested to see if the association between saving disposition and financial distress also holds within families, using the co-twin control design. We fit the model:

$$y_{ij} = \beta_0 + \beta_W(x_{ij} - \bar{x_j}) + \beta_B\bar{x_j} + \epsilon_{ij}, \quad (7)$$

where y_{ij} is the financial distress of twin i in pair j, x_{ij} is the twin's saving disposition, $\bar{x_j}$ is the mean saving disposition of the pair, β_0 is the intercept term and ϵ_{ij} is the residual. β_B is the between-pair effect of saving disposition on financial distress, while β_W is a direct estimate of the effect within pairs. If the association is due to environmental confounding, i.e. conditions that are shared by twins in the same family, we would expect that $\beta_W < \beta_B$. In the presence of genetic confounding – genetic variants affecting both saving disposition and financial distress – we would expect β_W to be further attenuated within MZ pairs. If the coefficient retains its size and statistical significance within DZ and MZ pairs, this is consistent with a true causal effect that is not due to any confounders (Lee, 2012; McGue, Osler, & Christensen, 2010).

All regression models controlled for the effect of sex, state of residence, the linear and quadratic effects of age, and family fixed effects. We used the Hausman specification test to determine whether to model the effects of family clusters as fixed or random. The test led us to reject the null hypothesis that the random-effects estimator is consistent, and we therefore opted for fixed effects.

3 Results

3.1 Factor analysis and construct validity

Our first satisfactory IRT/EFA solution was obtained with the Metropolis-Hastings Robbins-Monro (MHRM) algorithm (Cai, 2010). We specified two factors, but the pattern of loadings could not easily be interpreted. At this point it occurred to us that the common stems shared by many items might induce method variance, warranting the representation of financial distress with two factors (Tables 1 and 2). We accordingly ran an EFA with three factors. The fit was outstanding (RMSEA = 0.026; SRMR = 0.029; where values < 0.08 are considered acceptable), and as expected one factor corresponded recognizably to saving disposition and the other two to financial distress. We estimated the parameters of our final IRT model with confirmatory factor analysis (CFA), producing an outstanding fit (RMSEA = 0.038; SRMR = 0.046).

Although the dependence between twins precluded a straightforward statistical test, there was an appreciable improvement of our three-factor model over a one-factor model (RMSEA = 0.044; SRMR = 0.046). Inspection of the residual correlation matrix showed

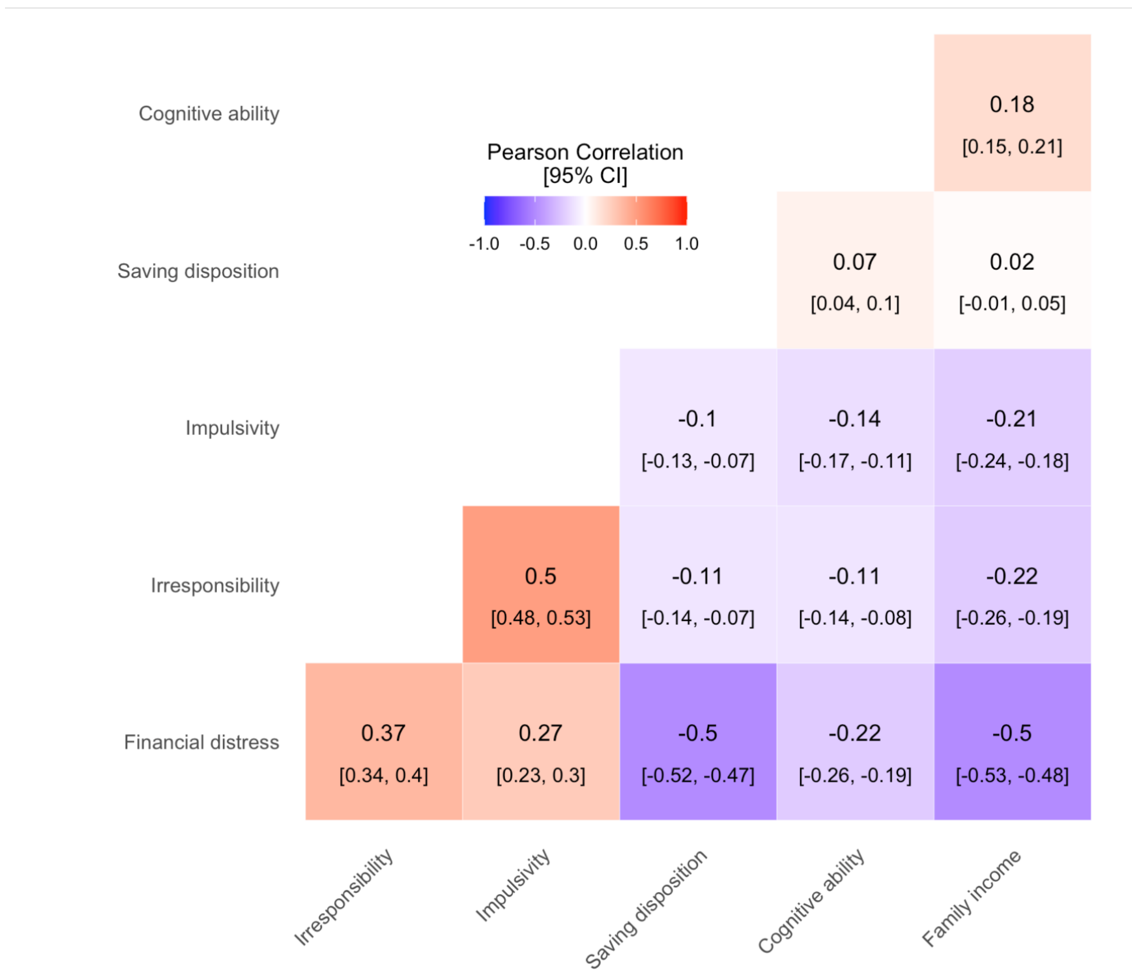

Figure 1: Correlation matrix. 95% confidence intervals in brackets; all correlations are statistically significant ($p < 0.001$).

a large positive residual between the items *declared bankruptcy* and *had your home foreclosed on or sold at auction* (Supplementary Figure 2), one of which might be reasonably discarded in any future research employing these scales. Tables 1 and 2 show the factor loadings of the items. There are two factors of financial distress, and we estimated the correlation between them to be 0.761. The factors of financial distress showed correlations of -0.735 and -0.712 with the factor of saving disposition.

We chose to use unit-weighted scores in subsequent analyses, in order to facilitate reproducibility. We included all participants with at most one missing response to the five-item scale measuring saving disposition and at most two missing responses to the sixteen-item scale measuring financial distress. (Some of these participants were not included in the factor analysis.) For purposes of scoring financial distress, we took the sum of all items and did not distinguish between the two factors; given that these factors are highly correlated and their items are conceptually similar. Missing items were imputed to the sample mean of the item.

The extreme endorsement rates and factor loadings of many items might initially suggest that the notion of a single reliability for a given scale is inapplicable. The test information functions for saving disposition and financial distress confirm that the metric of the underlying common factors implies very weak power to discriminate among individuals over much of the range (Supplementary Figure 3). For example, while there is substantial information about individuals experiencing various shades of high financial distress, there is almost none about individuals experiencing low to moderate levels. This uneven reliability corresponds to the massive numbers of individuals reporting at most one indicator of financial distress and the long tail of others reporting more (Supplementary Figure 4). But we might reasonably regard the metric of the sum score as more appropriate than that of the underlying common factors. That is, we might have a very positively skewed distribution of financial distress, not because of a defective measuring instrument failing to record differences among the lower half of the population, but rather because it really is the case that most people are not in financial distress at the moment. If we adopt this interpretation and corresponding metric, then we can also adopt the definition of reliability as the proportion of the observed variance attributable to variance in true scores and calculate it with the method described in the Supplementary Information. In this way we calculated the reliability of saving disposition to be 0.60 and that of financial distress to be 0.86.

The criterion validity of the scales can be examined by looking at their correlations with other traits in Figure 1. Saving disposition correlates slightly but positively with cognitive ability; $r = 0.07$; 95% CI = (0.04, 0.1). There is a negative correlation with impulsivity; $r = -0.1$; 95% CI = $(-0.13, -0.07)$, irresponsibility; $r = -0.11$; 95% CI = $(-0.14, -0.07)$ and financial distress; $r = -0.5$; 95% CI = $(-0.52, -0.47)$. In turn, financial distress correlates positively with impulsivity; $r = 0.27$; 95% CI = (0.23, 0.30) and irresponsibility; $r = 0.37$; 95% CI = (0.34, 0.40), and negatively with income; $r = -0.50$; 95% CI = $(-0.53, -0.48)$ and cognitive ability; $r = -0.22$; 95% CI = $(-0.26, -0.19)$. Note that the observed correlation between saving disposition and financial distress of -0.5 is broadly consistent with the estimated latent correlation attenuated by imperfect reliability ($-0.75 \times \sqrt{0.60} \times \sqrt{0.86} \approx -0.54$).

Descriptive statistics broken down by sex and state of residence are presented in Supplementary Table 1. Using ANOVA, we find that there are statistically significant differences between states (with Colorado participants being higher on saving disposition), as well as between the sexes (with males reporting less financial distress). We therefore adjust for the effects of sex, state, and family cluster in subsequent analyses.

3.2 Biometric variance decomposition

Table 3 includes within-twinship Pearson correlation coefficients on the diagonal. All correlations between twins for the same trait are strong and statistically significant ($p < 0.01$), indicating that both traits are influenced by genetic inheritance and/or the family environment. Additionally, we observe that the correlations in MZ pairs are greater compared to those in DZ pairs. This is a first indication that the traits are genetically influenced. All cross-twin, cross-trait correlations are statistically significant ($p < 0.001$)

Table 3: Cross-twin, cross-trait correlation matrix

	Twin 1	
Twin 2	Financial distress	Saving disposition
MZ		
Financial distress	**0.41 (0.34, 0.47)**	−0.22 (−0.28, −0.14)
Saving disposition	−0.25 (−0.32, −0.18)	**0.75 (0.72, 0.78)**
DZ		
Financial distress	**0.23 (0.15, 0.31)**	−0.15 (−0.23, −0.07)
Saving disposition	−0.19 (−0.27, −0.11)	**0.62 (0.57, 0.67)**

Note: Cross-twin, within-trait correlations are bolded on the diagonal. Twin 1 refers to the first twin of the pair, while Twin 2 refers to the second twin. 95% confidence intervals in parentheses. All correlations are statistically significant ($p < .001$).

and are higher in MZ twins compared to DZ twins, indicating a genetic component in the covariance of the traits.

After having established the existence of a genetic component, we proceed with the estimation of variance components (Figure 2). More than half of the variance in financial distress is accounted for by the unique environment, while the remainder is due to genetic influence. The contribution of the family environment component is negligible. In contrast, 39% of the variance in saving disposition can be attributed to the common family environment, while only 13% is due to genetics.

The genetic correlation between saving disposition and financial distress is −0.21, implying that the genetic component of the two variables is, to an extent, shared (Figure 2). The unique environmental correlation is −0.22, suggesting that there is overlap in the environmental factors that affect the two traits. There was no common environmental correlation, given that the shared environment did not contribute to the variance of financial distress.

Additive genetic effects account for 0.44; 95% CI = (0.22, 0.63) of the observed phe-

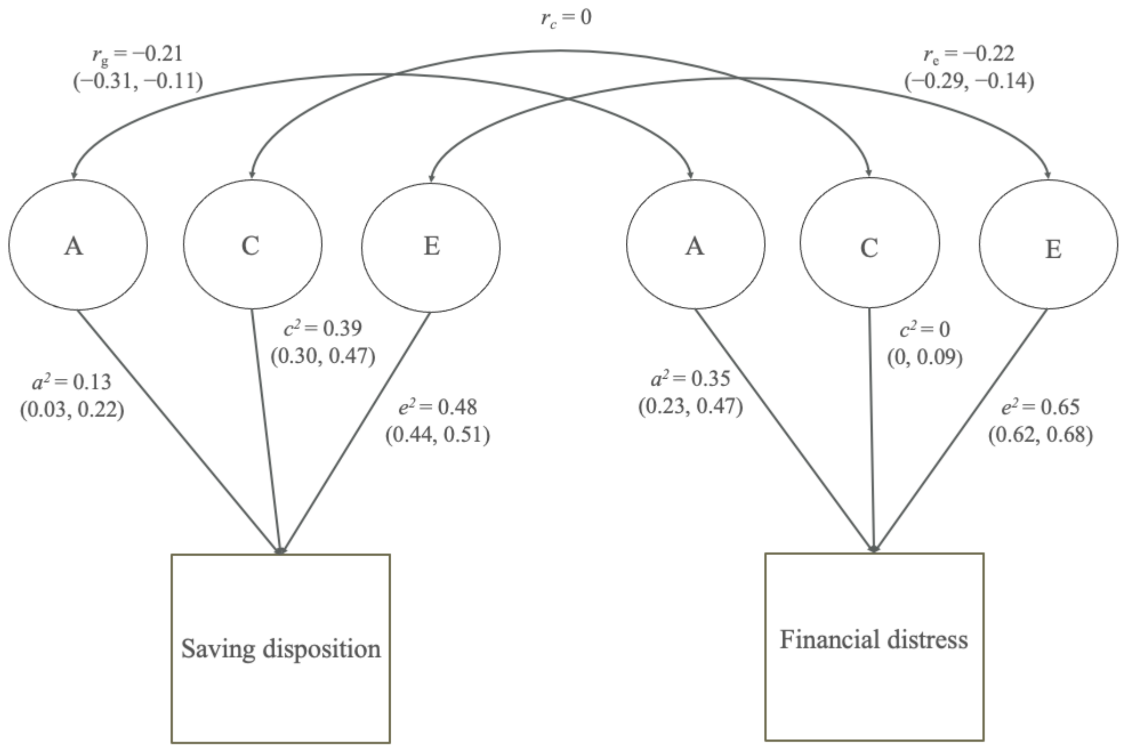

Figure 2: Biometric analysis. The 95% confidence interval is given below each estimate. a^2 = proportion of variance that is due to A (additive genetics effects); c^2 = proportion of variance that is due to C (common family environment); e^2 = proportion of variance that is due to E (unique environment); r_g = genetic correlation; r_c = common environmental correlation; r_e = unique environmental correlation.

notypic correlation between the two traits, with the the remaining 0.56; 95% CI = (0.36, 0.77) being due to the unique environment.

As a form of sensitivity analysis, we re-estimated the parameters after controlling for rearing SES, a composite score of mid-parent educational attainment, highest parental occupation status, and rearing family income (Supplementary Figure 5). Heritability estimates are greatly reduced for both traits, and the genetic component of financial distress is no longer statistically significant. The contribution of the common family environment increases, now accounting for 54% of the variance in saving disposition and 17% of the variance in financial distress.

Although we did have the power to conduct any formal interaction analyses (Hanscombe et al., 2012), we observed no substantial differences in parameter estimates across age groups, rearing family SES, or the sexes.

3.3 Association between saving disposition and financial distress

Table 4: Regression coefficients of financial distress on saving disposition

	Financial distress	
	Standard covariates	Additional covariates
Saving disposition	−0.61 (0.04)*	−0.38 (0.04)*
Family income	—	−0.29 (0.02)*
Cognitive ability	—	−0.01 (0.01)
Impulsivity	—	0.01 (0.02)
Irresponsibility	—	0.23 (0.02)*
Adj. R^2	0.41	0.48

Note: Coefficients are standardized. All models control for standard covariates (sex, state, linear and quadratic effect of age, family fixed effects). Second column additionally includes family income, cognitive ability and personality traits as covariates. N = 3,920; standard errors (shown in parentheses) are bootstrapped over 1,000 iterations. $^{*}p < 0.001$

We then move to examine how saving disposition is associated with financial distress within families, using family income, cognitive ability, and personality traits as covariates. When one sibling is one standard deviation higher in saving disposition compared to their co-twin, they will also, on average, be 0.61 standard deviations lower in financial distress (Table 4). When income, cognitive ability, impulsivity, and irresponsibility are included as covariates, the effect size of saving disposition attenuates only slightly, and the incremental amount of variance explained is small. Of the behavioral predictors, only irresponsibility was significantly associated with financial distress (a 1-SD increase in irresponsibility is associated with a 0.23-SD increase in financial distress, within twin pairs). The effect of family income seems to be lower compared to that of saving disposition; an 1-SD increase in family income is associated with a 0.29-SD decrease in financial distress.

3.4 Co-twin control analysis

Table 5 summarizes the results of the within-pair regressions of financial distress on saving disposition. The first column reports the association in the entire sample, without controlling for family clustering. A 1-SD increase in saving disposition is associated with a 0.85-SD decrease in financial distress. The association remains statistically significant ($p < 0.001$) within DZ, as well as within MZ pairs. Within a DZ twinship a 1-SD increase in saving disposition is associated with a 0.73-SD decrease in financial distress. The effect is slightly attenuated within MZ pairs to 0.51.

Table 5: Co-twin control regressions of financial distress on saving disposition

	Financial distress		
	Individual level	Within DZ pairs	Within MZ pairs
Saving disposition	−0.85 (0.02)	−0.73 (0.07)	−0.51 (0.07)
N pairs	2,356	1,072	1,284
Adj. R^2	0.26	0.28	0.27

Note: Coefficients are standardized. All models control for standard covariates (sex, state, the linear and quadratic effects of age). First column is the association at the individual level, without controlling for family clustering. Second column is the association within DZ twin pairs. Third column is the association within MZ twin pairs. Standard errors (shown in parentheses) are bootstrapped over 1,000 iterations. All coefficients are statistically significant ($p < 0.001$).

4 Discussion

The main findings of this study are the following: 1) Saving disposition and financial distress, as well as the association between them, are, to an extent, genetically influenced. The family environment seems to account for a large part of the variance in saving disposition. 2) There is a strong association between saving disposition and financial distress, even after adjusting for the effects of family income, cognitive ability, impulsivity, and irresponsibility. 3) The association is robust and persists within families. This implies that the association is not completely confounded by genetic or environmental factors, and the possibility of a causal effect cannot be rejected.

Controlling for rearing SES saw a major reduction in our heritability estimates, accompanied by an increase in the variance explained by the common family environment. This result might seem counterintuitive, given than rearing SES is equal across MZ and DZ twins. One interpretation is that parental SES is a mediator of the genetic effect on economic outcomes, while the common rearing environment must include factors that are not captured by family SES.

The large influence of the rearing family environment on saving disposition confirms findings from adoption studies, highlighting the role of parental transmission (Black, Devereux, Lundborg, & Majlesi, 2020; Gauly, 2017). In contrast to cognitive and personality traits that are known to be substantially heritable and not malleable by the rearing environment (Bouchard & McGue, 2003), saving disposition appears to be weakly heritable and substantially influenced by the family environment. In that sense, it is similar to other personal beliefs and attitudes, such as political opinion, for which there is an influence of the rearing family environment that persists through adulthood (Willoughby et al., 2021).

It is possible that the estimate of c^2 is inflated due to assumption violations. The classical twin model assumes the absence of gene-environment correlations and assortative mating. In the presence of passive gene-environment correlation, the estimate of the shared environmental variance component will be inflated (Rijsdijk & Sham, 2002). Parents who are genetically predisposed to save will also create a family environment that encourages saving. This will influence both members of the twin pair regardless of the zygosity, thereby inflating c^2. This issue can be addressed through adoption studies of saving disposition.

Another source of inflation for c^2 is assortative mating (Rijsdijk & Sham, 2002). If parents are genetically similar in their predisposition to save, then DZ twins will also share more of the genetic sites that are associated with saving, than would be expected by Mendelian segregation. This increase in the DZ correlation, relative to the MZ correlation, leads to an overestimation of the shared environmental variance component. Theoretical work has shown that modeling assortative mating can dramatically reduce estimates of c^2 (Beauchamp, Cesarini, Johannesson, Lindqvist, & Apicella, 2011). Preliminary results from MCTFR's Sibling Interaction and Behavior Study indicate spousal correlations of 0.24 for saving disposition, 0.70 for financial distress, and -0.22 for the cross-trait, cross-spouse correlation. Given the nature of these social outcomes, it is difficult to know how much of these correlations is driven by assortative mating on the genetic level, versus social homogamy or induced spousal similarity. We avoid modelling assortative mating due to this uncertainty. Nonetheless, our heritability estimates should be considered as lower bounds, and the interpretation of the shared environmental component should be cautious.

The large genetic component of the covariance between saving disposition and financial distress implies the possibility of genetically influenced individual differences in delay discounting, in accord with previous studies (Cesarini, Johannesson, Magnusson, & Wallace, 2012; Cronqvist & Siegel, 2015). The strong genetic correlation between the two traits can have multiple sources. In the case of vertical pleiotropy, genetically influenced differences in saving disposition would cause variance in financial distress. Another possibility is that genetic sites associated with saving disposition are also associated with other traits which cause financial distress (horizontal pleiotropy). Finally, estimates of genetic correlation may also reflect assortative mating (Beauchamp, Cesarini, Johannesson, Lindqvist, & Apicella, 2011).

The largest part of the variance in both traits is accounted for by the unique environment. The components of the unique environment are largely mysterious and may include serendipitous events as well as measurement error (Plomin & Daniels, 1987). This finding indicates that chance life events might play an important role on social outcomes. Depending on the opinions of policy makers, it can be viewed as an argument in favor of redistributive policies. Determining which specific life events explain the variance within sibling pairs is a goal for future studies.

The association between saving disposition and financial distress is not mediated by cognitive ability or personality. Decades of research have established the importance of cognitive ability for success in life outcomes (Strenze, 2007). Our finding suggests that, when it comes to economic outcomes, attitudes towards saving and planning for the future might be more relevant. Saving disposition may prove to be more responsive to education and policy manipulation, compared to cognitive ability or personality; the latter trait domains are very stable over the lifespan (Bouchard & McGue, 2003). A recent study has shown that attending college is associated with higher income and financial independence, regardless of one's level of cognitive ability (McGue et al., 2022), although a causal mechanism involving increased saving disposition was not demonstrated.

Controlling for family income did not alter the association between saving disposition and financial distress. Family income includes work income, spouse's income, and any income from investments and pensions, and is therefore a proxy for family wealth. This supports the hypothesis that financial distress is not only due to insufficient resources, but might also stem from poor financial management.

The results of the co-twin control analysis suggest that the association between saving disposition and financial distress is not completely confounded by other factors, environmental or genetic. If the association was due to the effects of the common family environment, we would expect the effect size to decline dramatically within DZ pairs. In fact, the within-DZ association decreases only slightly. The association is further attenuated within MZ pairs, as would be expected in the case of genetic confounding. The results are consistent with those of the biometric variance decomposition, indicating substantial genetic covariation between the traits and some contribution of the common environment to their association. The existence of such a strong association, even after controlling for genetics and shared environment, is suggestive of a causal effect. Nonetheless, we should note that our design cannot establish the direction of causation, or rule out confounding due to factors that vary within families (e.g. serendipitous life events).

A large heritability for a given trait does not mean that the trait is immutable. However, estimating heritabilities does provide an idea of which traits might be targeted for environmental intervention, if such is thought to be a worthy goal. The non-significant impact of the common environment on financial distress suggests that the kinds of factors that vary across households have no impact on adult offspring financial distress, aside perhaps from any effect mediated by saving disposition.

Certain weaknesses of our study must be noted. First, our sample can only be considered representative of two American states, and generalizations to other places may require caution. However, our findings do corroborate findings from larger and possibly more representative samples that do not require individuals to fit into a certain family structure (e.g., a twin pair) and that have used molecular data instead of a biometrical design (Barth, Papageorge, & Thom, 2020).

Finally, although our study shows that saving disposition is directly associated with financial distress, net of any environmental or genetic confounding, it does not rule out reverse causation or a confounder that varies even within families. In order to better establish a causal effect of saving disposition on financial distress, future studies should supplement family designs with longitudinal follow-up or apply genomic methods for causal inference.

Author contributions

AG designed the study and conducted the analyses with input from MG, JJL, and AR. Data collection was directed by MG, WGI, JA, RC, CH, JKH, and SV. AG wrote the manuscript, with revisions and additions made by JJL, MG, and EAW. Figures and tables were designed by EAW and AG. All authors read and approved the final manuscript.

Supplementary material

Supplementary information can be found in the online version, at [link].

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