The Credit Card Debt Puzzle
and Non-cognitive Ability[*]

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Abstract

Many households concurrently hold low-yield liquid assets while incurring costly credit card debt. In our sample, more than 80% of households with credit card debt also have low-yield liquid assets. Using the Health and Retirement Study ($N = 9,574$), we examine the role of non-cognitive skills as well as the economic, financial and demographic factors that affect the likelihood of co-holding. We find that the "Big Five" personality traits have a statistically significant and economically important effect: households with a more agreeable, introvert, and less conscientious head of household are more likely to co-hold. We also examine the role of intra-household dynamics.

JEL: D1, D03, D12, D14.

Keywords: personality, household finance, liquidity, self-control, intra-household dynamics, financial literacy.

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1 Introduction

In the U.S., almost 40% of all households carry a credit card balance with an average interest rate of 13% (Bricker et al. (2012)). Most households with credit card debt also hold considerable amounts of low-yield liquid assets such as checking and savings account balances that have a negligible return. Gross and Souleles (2002) report that among households with credit card debt, 95% have positive net wealth and almost 70% have positive home equity that can be used to get lower-cost home equity loans to pay down their credit card loans. Among the households in our sample that have a credit card balance not paid in full (22% of households), more than 80% simultaneously have a positive checking and/or savings account balance. This financial phenomenon is seemingly at odds with a no-arbitrage condition and has been referred to as a "puzzle" in the literature (e.g. Gross and Souleles (2002), Bertaut et al. (2009), and Telyukova (2013)).

In this paper, we study the role of non-cognitive skills in explaining the credit card debt puzzle using data for 9,574 households from the Health and Retirement Study (HRS). Our focus on non-cognitive skills is motivated in part by a growing literature in economics that examines the role of cognitive limitations (Simon (1955)) and other psychological factors in explaining empirical anomalies in consumption and savings (Rabin (1998)), accumulation of wealth (Ameriks et al. (2003)), portfolio choice (Barberis and Thaler (2003)), and labor market outcomes (Heckman et al. (2006)). The HRS data contain detailed longitudinal information on financial, economic, health, and psycho-social measures, which allows us to investigate the role of non-cognitive factors while controlling for a host of financial and demographic variables. We define the "puzzle group" as households with a positive credit card balance carried over to the next billing cycle (commonly referred to as "revolvers") and $500 or more in low-yield liquid assets (checking, savings, and money market account balances).[1] As in Telyukova (2013), our preferred specifications use $500 as

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[1]We define revolvers as those that reported a positive value to the following HRS question: "How much credit card debt did you (and your [husband/wife/partner]) carry over from last month to this one? We want the total amount owed (not paid off), not the minimum payment [Code zero if all accounts were paid in full]".

the threshold for low-yield liquid assets, as such assets may be more convenient or necessary for certain types of expenses.[2]

There are two main components at the heart of our empirical identification strategy for estimating the effect of the non-cognitive factors. First, we exploit the longitudinal nature of our data to overcome the inherent simultaneity between spending and saving decisions, as well as other financial decisions. This also allows us to address other non-financial factors such as a change in family composition or health shocks. Second, we exploit the constancy of the non-cognitive measures we use during adulthood. Though this assumption is used by many, our data allow us to examine the validity of this assumption.

The finding of a credit card debt puzzle by Gross and Souleles (2002) has led to several proposed explanations. Lehnert and Maki (2002) examine whether people strategically increase credit card debt prior to filing bankruptcy. Zinman (2007) puts forward a model where liquid assets generate a higher premium than that suggested by a straightforward neo-classical model. Becker and Shabani (2010) analyze the role of various types of household debt (e.g., mortgage and credit card debt) in the choice of portfolio, and calculate that some households would be better off redeeming their debt (akin to purchasing a risk-free asset with the return equal to the debt's interest rate) using their equity holdings. Fulford (2015) focuses on the role of uncertainty in future credit availability that may lead households to not pay down their debt and maintain low-yield liquid assets. Telyukova (2013) also examines the demand for low-yield liquid assets by developing a structural model in which credit card borrowers need low-yield liquid assets for certain types of transactions that credit cards cannot be used for, such as rent or mortgage payments. However, she acknowledges her results do not fully explain all low-yield liquid assets holding levels. Therefore, it is possible other mechanisms are also at play.

Others have focused on the role of non-financial factors. Bertaut et al. (2009) construct an accountant-shopper model where high credit card debt is used as a way to exert self- (or spousal-) control; a reduction of available funds (due to high credit

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[2]We show in Section 5.1 that our results are robust to using both a lower and higher than $500 threshold.

card debt) reduces the temptation to spend. The study by Gathergood and Weber (2014) is the only one, to the best of our knowledge, to empirically examine the role of a non-cognitive skill (self-control) in explaining the puzzle. It studies the role of self-control and financial literacy, and concludes the former, rather than the latter, affects the likelihood of co-holding assets and debt, using a cross-section of British households. Their results support the aforementioned accountant-shopper model of Bertaut et al. (2009).

This paper makes several important contributions to the existing literature. First, we identify the factors that play a role in explaining the credit card debt puzzle by investigating a much wider range of non-cognitive skills than self-control. Second, using the rich data set at our disposal our results complement the other types of explanations suggested in the literature. For example, we control for the need for liquidity (e.g. Telyukova (2013)), and self-control and financial literacy (e.g. Gathergood and Weber (2014)). Finally, our paper is the first to examine the effect of non-cognitive abilities among (intra) household members on households' saving and borrowing behavior.

To capture a broad and comprehensive range of non-cognitive skills, we employ the "Big Five" personality traits (McCrae and Costa (1987, 1999)). Personality traits are also referred to by some as character skills, soft skills, or non-cognitive abilities. Throughout our paper, we follow the prevalent naming convention and also refer to the traits as non-cognitive skills.[3] The five traits are Openness (O), Conscientiousness (C), Extraversion (E), Agreeableness (A), and Neuroticism (N), and are commonly abbreviated as OCEAN. For example, John et al. (2008), p. 120 describe Conscientiousness as "socially prescribed impulse control . . . such as thinking before acting, delaying gratification, following rules, planning, organizing, and prioritizing tasks;" Agreeableness is conceptually defined as "prosocial communal orientation toward others . . . such as altruism, tender-mindedness, trust and modesty."[4] We further

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[3]See Heckman and Kautz (2012), p. 452 for a brief discussion of the various naming interpretations and conventions.

[4]Openness "describes the breadth, depth, originality, and complexity of an individual's mental and experiential life [with a behavioral example] of tak[ing] time to learn something simply for the joy of learning." Extraversion "implies an energetic approach toward the social and material world

discuss the measurement of the Big Five in Section 3.2.

The Big Five personality traits are by far the most commonly used in the field of social psychology and have been widely studied over the last couple of decades. The Big Five personality traits provide several major advantages for our setting. First, they cover a very broad domain of non-cognitive abilities. Second, they have been extensively studied in other settings, and have been shown to be a tractable set of measures for describing variation across people in types of personality. Third, the measures have been shown to be relatively rank-stable among adults, reducing the threat of endogeneity in our study.[5]

Although psychologists have been studying correlations between various personality traits and financial outcomes (e.g. income, debt, consumption, and saving) for several decades,[6] in recent years there has been a growing interest among economists in incorporating personality traits such as self-control, perseverance, and grit. Borghans et al. (2008) and Almlund et al. (2011) provide an introduction to the recent developments in the intersection of psychology and economics. Personality traits, including the Big Five, have been shown to be an important complement to more traditionally-economic measures of human capital in explaining education attainment, labor market outcomes, wealth, etc.[7]

We build on several previous papers in the economics literature that have either: 1) considered only a narrow facet of non-cognitive skills and its effect on savings, borrowing, or the propensity to co-hold assets and debt (e.g. Ameriks et al. (2003),

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... such as sociability, activity, assertiveness, and positive emotionality." Neuroticism "contrasts emotional stability and even-temperedness with negative emotionality, such as feeling anxious, nervous, sad, and tense." Ibid. John and Srivastava (1999) provide an overview of the traits as well as a historical account of the last several decades.

[5]In Appendix A, we use the longitudinal nature of our sample to examine the assumption that personality is exogenous.

[6]See Livingstone and Lunt (1992), Nyhus and Webley (2001), Norvilitis et al. (2006), Rabinovich and Webley (2007), and Conti and Heckman (2014) for some examples.

[7]For example, Bowles et al. (2001), Nyhus and Pons (2005), and Mueller and Plug (2006) study how personality traits are related to earnings. Brown and Taylor (2014) study the effect of the Big Five personality traits on household finances. Their study considers assets and debts separately. Lundberg (2013) examines the role of the Big Five personality traits in educational attainment. Heckman et al. (2006) and Heckman and Kautz (2012) study the role of personality traits in academic achievements and labor market outcomes.

Laibson et al. (2003), Gathergood and Weber (2014), respectively); or 2) used a neo-classical framework and do not consider non-cognitive skills to explain the co-holding of assets and debt (e.g. Bertaut et al. (2009), Telyukova (2013), Fulford (2015)). We combine these previous studies and their proposed mechanisms, and hypothesize the channels through which personality traits operate.

The propensity to be in the puzzle group, by definition, depends on two necessary dimensions: the incurrence of debt and not using available low-yield liquid assets to pay down debt. We hypothesize that four of the Big Five personality traits might play a role in the likelihood that a household is in the puzzle group: Conscientiousness, Extraversion, Agreeableness, and Neuroticism might play a role for the dimension of spending and/or borrowing; and Conscientiousness, Extraversion, and Neuroticism might play a role in the dimension of (not) using low-yield liquid assets to pay down debt.

We first implement in Section 4.1 a reduced-form approach that does not require us to assume a certain set of channels or mechanisms. In our preferred specification (column 5 in Table 2), we find that Conscientiousness, Extraversion, and Agreeableness have statistically significant effects at the 10% level or better. Households with a more agreeable and introvert, and those with a less conscientious household head are more likely to be in the puzzle group. Specifically, a one standard-deviation increase in Conscientiousness, Extraversion, and Agreeableness changes the likelihood of being in the puzzle group by -0.74, -0.83, and 1.76 percentage points, respectively. For example, all else equal, a one standard-deviation increase in Conscientiousness is equivalent to the effect that an increase of \$18,387 in financial assets would have on the likelihood of being in the puzzle group.[8] We find that this result holds after we additionally control for measures suggested in previous studies, such as liquidity demand, self-control, and financial sophistication.

In Section 2, we describe the underlying potential mechanism through which each of the traits may affect debt incurrence and/or not paying down the debt using low-yield liquid assets. For example, for the incurrence of debt, Agreeableness may lead to higher levels of spending and debt. Nyhus and Webley (2001) explain that:

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[8]See Section 4.1 for the calculation used.

"Agreeableness involves thinking of, and being concerned about, other people. This might be reflected in a person's generosity in terms of gift-giving, inter vivos transfers, charity, etc." Those with higher levels of Agreeableness prefer less conflict (with employer in case of wages, with self, spouse, or friends in the case of debt) over financial gains such as higher wages or less debt.[9] Similarly, we hypothesize that Conscientiousness is an important factor for explaining spending and/or borrowing.[10]

However, an increased propensity to borrow (or save) would just lead to a disparity in net wealth (such as that examined by Ameriks et al. (2003)). But personality may also play an important role in explaining the propensity to co-hold low-yield liquid assets and debt. We consider three main channels through which co-holding may occur. The first channel we consider relies on the fact that certain personality traits may help/hinder a decision maker when dealing with their finances. For example, those with higher levels of Conscientiousness might be more likely to notice they have sufficient low-yield liquid assets to pay down their debt. The second channel we consider is precautionary saving for expected or unexpected liquidity demand as proposed in Telyukova (2013). For example, conscientious individuals might hold more liquidity as they are more likely to plan. The third channel focuses on the role of personality traits in intra-household (or dual-self) dynamics. For example, in the "accountant-shopper" model suggested by Bertaut et al. (2009), high levels of debt incurred by a "shopper" might lead an "accountant" to maintain high levels of credit utilization rather than paying down the debt as a way to limit the shopper's spending. Similarly, the personality of both household members may play a role, and personality differences among household members may attenuate or increase the likelihood of being in the puzzle group.

The three channels have testable implications regarding the effect of personality. Overall, as we explain in Section 2, we would expect Conscientiousness, Extraversion,

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[9]Several studies have found that Agreeableness is negatively correlated with income (Judge et al. (1999), Mueller and Plug (2006), and Babcock and Laschever (2003)).

[10]Previous studies found that self-control (e.g. Laibson et al. (2003), Bertaut et al. (2009)) and impulse spending (e.g. Gathergood and Weber (2014)) are important in explaining the incurrence of debt. Self-control, impulsiveness, and planning ability are all examples that are captured by the broader measure of Conscientiousness. See John et al. (2008) for a discussion of the close relationship between self-control, planning, and Conscientiousness.

Agreeableness, and Neuroticism to have a negative, negative, positive, and undetermined effect, respectively, on the likelihood of being in the puzzle group. We find that the Big Five personality traits are important predictors of the propensity to be in the puzzle group, and that the effects have the predicted sign. We find that the effects of Conscientiousness, Extraversion, and Agreeableness tend to be the most persistent of the Big Five personality traits across our various specifications. In Section 5.1, we show our results are robust to various alternative definitions of the puzzle group. In Section 4.2 we take into account the simultaneity between spending and saving, and examine the role of personality on borrowing, and holding low-yield assets conditional on borrowing separately.[11]

Finally, the unique nature of our data allows us to examine the role of personality in intra-household dynamics among couples in explaining the puzzle. In Section 4.3, we find that even after controlling for age and education levels differences among couples, the personality of both partners explains some of the observed co-holding patterns in the data. We also find that income differences among couples (a proxy for intra-household power) interact with personality in explaining the likelihood of being in the puzzle group. To the best of our knowledge, our paper is the first to explain assets and debt co-holding among couples by examining personality and power differences among household members.

Taken together, our findings suggest that regulatory policies, personal debt default options, debt counseling, and educational programs are all domains that can be made more cost effective by taking into account the role of non-cognitive abilities. We discuss some policy implications in Section 6. To illustrate the economic significance of our results, extrapolating our findings to the entire U.S. population, even a reduction of 1% in the number of the households co-holding low-yield liquid assets and credit card debt would translate into an annual decrease of $565-$795 million in interest payments while maintaining the same level of consumption.[12]

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[11]The decision to save and the decision to borrow could be made simultaneously, and our decomposition here is only for the purpose of exposition.

[12]Though our calculation is, of course, for illustrative purposes, our findings are stronger among the younger households in our sample, thereby suggesting that our examination of a relatively older segment of the population is potentially a lower bound. Appendix C contains the assumptions and

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The rest of the paper is organized as follows. We first describe our empirical framework and source of identification in Section 2. The HRS data and our construction of the personality measures are described in Section 3. The results are in Section 4. Section 5 provides additional robustness checks and examines alternative specifications. Section 6 concludes and discusses some potential areas for future research.

2   Empirical framework

The decision of how much to consume and save (or borrow) has long been studied, and often modeled using the neo-classical expected life-cycle utility maximization framework. There is also a large literature in economics and finance examining asset allocation across types of assets and across time. Given that the focus of our paper is on the role of personality traits, and not on the calculation of inter-temporal substitution rates or elasticity measures, we implement our empirical strategy using a reduced-form examination of the decision of how much low-yield liquid assets and debt to concurrently hold. Our approach has two main advantages. First, we require far fewer assumptions by not estimating a structural model. Second, our examination of the credit card puzzle avoids the need to address the inherent simultaneity in the decision of consumption and saving that consequently determine asset and debt accumulation. In Section 4.2, however, we do examine the underlying mechanisms of our findings by studying the relationship between asset holding and debt utilization.

We first define a household to be in the puzzle group if it co-holds credit card debt and more than \$500 in low-yield liquid assets, i.e., checking, savings, and money market accounts. We assume that household i's likelihood of being in the puzzle group at time t depends on a latent utility. The observed behavior Y_{it} is equal to one if a household i is in the puzzle group at time t, and 0 otherwise. We further assume an additive random utility model and that the excess utility of being in the puzzle group $\Delta U_{it}^* = U_{it}^*(\text{in the puzzle group}) - U_{it}^*(\text{not in the puzzle group})$ depends on a

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calculations used.

vector $\mathbf{w}_{it}$ of household characteristics and a random component ε_{it}^*, i.e.

$$\Delta U_{it}^* = \mathbf{w}_{it}'\boldsymbol{\beta}^* + \varepsilon_{it}^*,$$

$$Y_{it} = \begin{cases} 1 & \text{if } \Delta U_{it}^* \geq 0 \ \text{(in the puzzle group)} \\ 0 & \text{if } \Delta U_{it}^* < 0 \ \text{(not in the puzzle group)}, \end{cases}$$

where $\mathbf{w}_{it}'$ consists of both time-invariant and time-variant factors of household i and ε_{it}^* are serially independent but hetroskedastic and potentially correlated within clusters. We first focus on a definition of the puzzle group in which holding more than \$500 in low-yield liquid assets with positive revolving credit card debt is considered a puzzle. But in Section 5.1, we show that our results hold when we examine alternative definitions that allow households to have different levels of low-yield liquid assets for liquidity purposes.

We estimate the probability of being in the puzzle group using the linear-probability model (OLS) for ease of interpretation of the coefficients.[13] We have also used the logit model, and obtained very similar qualitative and quantitative results.[14] Our base reduced-form specification can be written as:

$$Y_{it} = \beta_0 + \mathbf{x}_{i(t-2)}'\boldsymbol{\beta} + \varepsilon_{it}, \tag{2.1}$$

where $\mathbf{E}(\varepsilon_{it}|\mathbf{x}_{i(t-2)}) = 0$ and $\mathbf{x}_{i(t-2)}'$ is a vector of the time invariant and (2-year lagged) control variables. Our empirical strategy exploits the panel nature of our data, thereby allowing us to address the potential simultaneity inherent in the financial and demographic measures we examine. For example, a health shock could affect the need for credit (due to large medical bills), uncertainty in future earnings, and one's employment (requiring someone to retire earlier than planned). Our preferred specifications therefore use 2-year lags of financial measures.

Financial measures such as income and wealth are, of course, crucial for one's saving and borrowing decisions as they affect both the need for saving or borrowing

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[13]See Angrist (2001) and Angrist and Pischke (2008) for further discussion.

[14]The results from the logit specification are available upon request from the authors.

and its return or costs (as different borrowers would face different interest rates). Personality measures may cause two households with the same demographic and financial measures to have a different need for liquid-assets and debt. For example, those with higher levels of Conscientiousness may be able to better interpret and more accurately perceive their financial situation. More extravert people may be able to better negotiate and leverage their financial situation when restructuring their debt with a lender, etc.

To examine the role of personality, we augment the model in (2.1) by adding the (5×1) vector $\mathbf{p}_i$ of the Big Five personality traits. We include these measures additively, and allow them in some of the specifications to have an interactive effect with another characteristic z_{it}:

$$Y_{it} = \beta_0 + \mathbf{x}'_{i(t-2)}\boldsymbol{\beta} + \mathbf{p}'_i\boldsymbol{\gamma} + z_{it}\mathbf{p}'_i\boldsymbol{\delta} + \varepsilon_{it}. \tag{2.2}$$

Equation (2.2) is useful in demonstrating how non-cognitive ability, such as personality, might affect a household's financial decision to co-hold low-yield liquid assets and credit card debt.

Researchers have previously proposed various explanations (see Section 1) for the credit card puzzle. An advantage of our reduced-form model is that it allows us to succinctly control for those proposed explanatory factors. We use financial controls (such as income, various assets and debts), education levels, and demographic controls (such as age, and marital status) that have been suggested in the literature as important in determining the decision to save and borrow. In addition to the very detailed financial data at our disposal, we are also able to control for other demographic variables that are likely to affect household financials such as health status (both self-reported, and by controlling for medical expenditures) or changes in family composition (due to death, marriage, or divorce).

The reduced-form specification examines the overall effect of a household's characteristics. Therefore, the specification in (2.2) does not separate out the decision to be a revolver, and the factors that affect the likelihood of being in the puzzle group (i.e. become a revolver and hold a low-yield liquid assets balance simultaneously).

As such, our findings potentially encompass several channels or mechanisms at work. We further examine the decomposition of the effect of personality to understand the relative importance of the potential mechanisms at play. For example, the overall reduced-form effect of Conscientiousness might be zero. However, this might be because the underlying effects nullify each other. Conscientious individuals might be more likely to qualify for or have access to debt, but at the same time might be less likely to borrow and hold large amounts of cash at the same time, since they carefully examine their monthly statements, or consider the cost of debt.

To examine the decomposition, we consider two necessary conditions for being in the puzzle group through which personality traits may operate. First, a necessary condition to be included in the puzzle group is to be a revolver. Second, conditional on being a revolver, one may or may not be in the puzzle group depending on whether one holds low-yield liquid assets that are not used to pay down debt. We therefore separately examine the propensity to be a revolver, and the propensity of revolvers to hold low-yield liquid assets and not pay one's debt down.[15] One could think of the two conditions as being related to two dimensions: consumption and financial management of the household's accounts for a given level of consumption.

For the dimension of incurrence of debt, several personality traits are likely to affect levels of spending and/or borrowing, and financial terms (such as interest rates and credit limits) that affect debt levels. Self-control (Laibson et al. (2003), Bertaut et al. (2009)), impulse spending (Gathergood and Weber (2014)), and the propensity to plan (Ameriks et al. (2003)) have been shown to be related to incurence of debt and wealth accumulation. These traits are all captured by Conscientiousness, and the effect on debt is likely to be negative. Agreeableness may lead to higher levels of spending and debt because agreeable people tend to spend more on others,[16] and might be more susceptible to marketing campaigns.[17] A large literature has docu-

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[15]This sequential framework is, of course, for exposition purposes only. An alternative would involve the decision to hold low-yield liquid assets, and conditional on holding those assets, the decision to incur debt instead of using one's available assets.

[16]See the explanation suggested by Nyhus and Webley (2001) we aforementioned in Section 1.

[17]Bernerth et al. (2012) note that "the trusting, submissive, and accommodating tendencies of agreeable individuals can put them in precarious positions as they sacrifice personal resources for others."

mented lower incomes among those with higher levels of Agreeableness (e.g. Judge et al. (1999), Mueller and Plug (2006), and Babcock and Laschever (2003)). A similar tradeoff (less financial gains in return for less conflict or an increased preference for others' utility) is likely to play a role in this instance as well. Extravert people may acquire financial advice from their peers, or may be able to better negotiate and leverage their financial situation when restructuring their debt with a lender. The direction of the effect of Neuroticism is ambiguous. Higher levels of Neuroticism would lower the likelihood of borrowing due to the increased psychological cost of worrying about the future ability to repay. On the other hand, lower levels of Neuroticism have been found to be associated with more discretionary savings (e.g. Brandstätter (2005) p.70). For example, Wang et al. (2011) find a negative relationship between revolving credit use and self-esteem, self-efficacy, and locus of control, all of which are related to low levels of Neuroticism. Donnelly et al. (2012) show that Neuroticism is positively related to compulsive buying.

For the dimension of co-holding low-yield liquid assets and credit card debt, we consider three main channels through which personality may operate: the management of household finances; liquidity demand; and intra-household dynamics. For the first channel, Conscientiousness individuals are more likely to notice they have sufficient low-yield liquid assets to pay down their debt. Extraverts may be more likely to discuss their finances and solicit possible solutions from others on how to pay down their credit card debt.[18] The effect of Neuroticism is a priori ambiguous. Those with higher levels of Neuroticism might be constantly worried about their finances or missing a payment, thereby having a heightened awareness of their ability to pay down credit card debt. On the other hand, people with low levels of Neuroticism may make financial decisions in a calm and deliberate manner.[19]

For the second channel of precautionary saving, conscientious individuals might

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[18]For example, in the context of coping and coping effectiveness under stress or constraints, McCrae and Costa (1986) find that "Extraversion is correlated with rational action, positive thinking, substitution, and restraint." Related, Carver and Connor-Smith (2010) find that "Extraversion predicted more problem solving, use of social support, and cognitive restructuring." See also Connor-Smith and Flachsbart (2007).

[19]For example, Donnelly et al. (2012) find that Neuroticism is negatively related to the management of personal finances.

be more likely to hold low-yield liquid assets even when they have debt, as they are more likely to plan ahead. The effect of Neuroticism is a priori ambiguous. More neurotic individuals might have higher demand for liquidity because they worry about their uncertain future. On the other hand, they may worry about being burdened with debt and prefer to pay down as much of it as they can.

The third channel we consider is intra-household (or dual-self) dynamics. For example, as suggested by Bertaut et al. (2009), an "accountant" may choose to maintain high levels of credit utilization to control the spending temptation of their "shopper" spouse. The personality traits we consider readily translate into those two types. For example, an "accountant" is likely to have a high level of Conscientiousness, whereas a "shopper" may have a low level of Conscientiousness and a high level of Agreeableness for the aforementioned reasons.

Because a household might be a revolver for reasons correlated with the likelihood of being in the puzzle group, we must find an exclusion restriction that would predict being a revolver, but would not affect a household's likelihood of being in the puzzle group. In Section 4.2, we employ an exclusion restriction strategy and examine whether personality has a differential effect on checking/savings balance among debt holders and those with no debt. Our identification strategy is akin to using the 2-year lag of revolving behavior to predict current revolving behavior.

Finally, our specification also allows us to test whether personality might also interact with a spouse's personality, or a proxy for the household's power structure. The unique nature of our data, being able to observe the personality and individual sources of income for both couple members, allows us to examine intra-household dynamics in co-holding decisions. Here our identification strategy uses single households' co-holding decisions to examine decisions among couple households, and separate the contribution of each family member to the overall household decision. The intra-household dynamics is studied in Section 4.3.

3   Data and the Big Five personality traits

3.1   Data

Our data is based on the HRS (2012).[20] The HRS is a biennial longitudinal survey that collects detailed demographic, health, economic, and financial information from a nationally representative sample of the population over age 50. The HRS has three main advantages for our setting. First, the longitudinal nature of the data is crucial for our identification strategy as explained in the previous section. Second, the data have high-quality personality measures,[21] as well as detailed financial information. Third, as explained in Section 1, personality measures are more likely to be stable among older adults thereby reducing the threat of validity to our results.[22]

The HRS contains both respondent- and household-level data. Because most of the financial measures are collected at the household level, and financial decisions depend on and impact the entire household, our primary unit of analysis is at the household level. The households in the data consist of singles and couples (we also control for the presence of additional household members). For the households with couples, because our dependent variables of interest are financial, we focus on the demographics and personality of the person who has answered the survey questions related to household finances. In the HRS data, this person is identified as the "financial respondent" of the household.[23] Although we model household behavior, we also use respondent-level information from financial respondents with the assump-

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[20]Additional information can be found at http://hrsonline.isr.umich.edu/

[21]Other commonly used datasets may have a wider range of age groups but either lack any personality measures (e.g. the Survey of Consumer Finances) or have less complete personality measures (e.g. The National Longitudinal Survey (NLSY79) only has an abridged Ten-Item Personality Inventory).

[22]While our preferred specification (column 5 in Table 2) uses all households, the magnitudes of the personality effects are larger for households with a head 60 or younger (column 6 in Table 2). However, we acknowledge that our sample cannot be used to estimate the effect on those under 50 years old. Our predictions for the entire population therefore require us to assume the effects are similar among younger households.

[23]Smith et al. (2010) find that males and those with more years of education are more likely to be the financial respondent of the household in the HRS survey. Our analysis controls for both of these factors.

tion that the coordination within a household is not a significant factor. However, as an extension, we relax this assumption in Section 4.3 and investigate the effect of spouse characteristics using the data on couple-households.

Our main sample contains 9,574 households who are observed at least during 2008 and 2010. Table 1 shows the summary statistics for the full sample for the 2010 HRS data, and for the subgroup of households that are revolvers. The households consist of 5,254 singles and 4,320 couples. Among the couples, females are the financial respondent in 1,709 (39.6%) households. The average credit card balance among revolvers is $8,686 in 2010.

3.2 The Big Five personality traits

The Big Five personality traits have been measured in the HRS since 2006. About half of the full sample is surveyed every wave. As a consequence, we have personality traits for almost all individuals in either 2006/2010 or 2008/2012. The HRS uses 26 personality survey items developed originally for the Midlife in the United States Survey.[24] The 26 variables are self-administered adjectival measures. Participants are asked to "Please indicate how well each of the following DESCRIBES YOU" for 26 adjectives. Each adjective is coded from 1 ("not at all") to 4 ("a lot"). The adjectives are then grouped and averaged to create a score for each of the five traits. For example, Conscientiousness is constructed from these five items (with "−" indicating an inverse coding): organized, responsible, hardworking, careless (−), and thorough.[25] This variant of the Big Five personality trait scales has been shown by Mroczek and Kolarz (1998) and Prenda and Lachman (2001) to have strong construct validity evidence and closely related to the Neuroticism-Extraversion-Openness (NEO) personality trait scales which contain 240 questions.[26]

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[24]http://www.midus.wisc.edu/

[25]The other measures are Openness (7 items): creative, imaginative, intelligent, curious, broadminded, sophisticated, adventurous; Extraversion (5 items): outgoing, friendly, lively, active, talkative; Agreeableness (5 items): helpful, warm, caring, softhearted, sympathetic; and Neuroticism (4 items): moody, worrying, nervous, calm (−).

[26]The strong construct validity of the HRS's personality questionnaire is the main reason that we chose the HRS rather than the other data sets with personality measures. For example, the

The stability of personality measures over time has been widely studied in the field of developmental psychology. For example, some studies have emphasized the hereditary and biological factors that shape traits (e.g. Bouchard Jr and Loehlin (2001), Canli (2006), and DeYoung et al. (2010)). In financial and economic settings, many scholars assume that personality traits are fixed among adults (e.g. Nyhus and Pons (2005), Mueller and Plug (2006), and Heineck and Anger (2010)). In recent years, an emerging view is that personality traits are influenced by hereditary and biological factors, but can change over time and may be mutable by intervention especially during early childhood. However, after early adulthood, the mean level changes relatively less and the rank ordering of personality traits in a population become increasingly more consistent (stable) as one ages (Roberts and DelVecchio (2000)).[27]

For the purpose of our study, the crucial issue is whether the measurement of personality is endogenous with respect to financial decisions. For example, Roberts et al. (2006) find some mean-changes of personality traits over the life-cycle. However, we control for age and only examine adults later in life, so life-cycle patterns are not a concern for our setting. Cobb-Clark and Schurer (2012) show that the mean level of the Big Five personality traits is stable over a four-year period among working-age adults. Further, they show that intra-individual changes over time are not correlated with life events in an economically significant way. Cobb-Clark and Schurer (2013) also show that the changes of the mean level of locus of control, which is the personality trait of their focus, are mild, consistent rather than idiosyncratic. They argue that for working-age adults the changes are economically insignificant.[28]

Taken together, the results suggest that our identification assumption regarding the exogeneity of personality measures is likely to hold. However, given the longitudinal data at our disposal, we are further able to test the stability and inverse-causality

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NLSY97 data set contains only the Ten-Item Personality Inventory since 2006. Ten items would only be sufficient for exploratory investigation into the role of personality.

[27]Roberts et al. (2008) and Borghans et al. (2008) provide a review of this matter.

[28]The average age in our sample is higher, but our results remain qualitatively and quantitatively the same if we just focus on the younger working-age segment of our sample. See column 6 of Table 2.

of the Big Five personality traits. We find that the personality traits are stable in our sample, and we do not find any evidence of an inverse-causal relationship with our dependent variables of interest after controlling for the relevant variables.

In our study, we use the personality measures calculated by the average of the personality traits over all available years for each of the Big Five personality traits. We then standardize the personality traits measures (*Z*-score) by subtracting the average and dividing by the sample standard deviation calculated using the 2010 data.

4   Results

4.1   Main results

We first examine the reduced-form estimates in Table 2 corresponding to equation (2.2) without the interaction term. In all columns, the dependent variable is the binary indicator of whether a household in 2010 is in the puzzle group (i.e. not paying their credit card balance in full, and having low-yield liquid assets of $500 or more). Throughout, we report the linear-probability model results using the OLS method with cluster-robust standard errors. For all regressions in this paper, we use clusters defined by the cross product of nine U.S. geographical regions and three rural-urban groups based on county population sizes (more than million, 250,000-1,000,000, and 250,000 or less).

We control for household size with a dummy indicator for non-single (couple) households, a dummy for having any other household members (such as dependents), as well as marital status. For reasons explained in the previous section, in the case of households with couples, we use the personal measures of the financial respondent (i.e. age, race, education, and personality traits). However, for couples, our analysis shows that the personal characteristics of the financial respondent are a sufficient control, as our results remain very similar if we additionally include some key spousal measures. In Section 4.3, we further examine the effect of within-couple income and personality differences.

The first column in Table 2 includes basic demographic controls and employment status. The Big Five personality traits Z-scores (standardized to have a mean of zero and standard deviation equal to one) are added in column 2. Conscientiousness, Extraversion, and Neuroticism are shown to have a negative effect (statistically significant at the 1%, 10%, and 10% level, respectively) whereas Agreeableness increases the likelihood of being in the puzzle group (statistically significant at the 1% level). Openness is almost never statistically significant across the various specifications with the one exception being the specification that only examines those under 60 years old.

We then include financial measures in column 3, such as financial assets (excluding checking/savings), housing debt, income, and medical spending. To alleviate concerns of simultaneity, we lag the financial measures by two years in column 4. We add controls for changes to a household's size and food-stamp usage, in column 5.[29] The coefficients of the personality traits remain qualitatively the same. The coefficients for Conscientiousness, Extraversion, Agreeableness, and Neuroticism are similar in columns 2-5, and are statistically significant at the 10% level or better throughout.

In summary, the effects of the personality measures remain similar across our different specifications, even after controlling for a wide range of financial measures. For example, in column 5 which is our preferred specification, a one standard-deviation increase in Conscientiousness, Extraversion, and Neuroticism, all else equal, decreases the propensity to be in the puzzle group by 0.74, 0.83, and 0.62 percentage points, respectively.[30] For Agreeableness, the probability increases by 1.76 percentage points.

In regards to demographic variables, compared to households with a financial respondent who did not complete high school, households with more educated financial

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[29]Our results remain the same when we additionally examine shocks to health and employment status.

[30]To illustrate the effect of the personality traits, one can translate the personality effects into the equivalent effect of the financial variables. For example, using the coefficient on financial assets in column 5 in Table 2, we calculate that the effect from an increase of \$18,386 in financial assets (stocks, bonds, and CDs) for a household in the 75-percentile of financial assets in our sample, would match the effect (-0.74) of a one standard-deviation increase in Conscientiousness on the likelihood of being in the puzzle group.

respondent (including those with a college degree) have a higher likelihood to be in the puzzle group. The effect is largest among those who have some college education without having completed college. This inverse U-shape effect of education is robust across our specifications, and also holds for the specifications that examine the amount of debt holding, discussed in Section 4.2. This could be due to the fact that those with the lowest levels of education have less access to credit.

The effects of the financial measures have the expected signs. For example, households with higher financial assets such as stock, bonds, certificate of deposits, real estate, or IRA accounts are less likely to be in the puzzle group. We also include dummy indicator variables for zero assets and IRA balances to account for the non-linearity of these factors.

Generally, we find that household income tends to have a positive effect on the likelihood of being in the puzzle group (significant at the 5% level in Table 2). Similarly, we find that households with an income below the poverty line are less likely to be in the puzzle group. These findings are consistent with low-income households having more difficulty in qualifying for credit cards. Our controls for employment status, health status, etc. in the reduced-form estimates capture the differential access to credit cards among households. We also find that households with high mortgage debt and negative home equity are more likely to be in the puzzle group. This is consistent with those having less access to cheaper forms of credit (such as home equity loans and mortgages) are more likely to have to resort to more expensive forms of credit, such as credit cards.

The last column in Table 2 examines only households where the financial respondent is less than 60 years old. Though the sample size is less than a sixth, the personality measures remain statistically significant at the 5% level, and of the same magnitude or larger. This suggests that our results are not driven by the older age of the sample. Therefore our estimates for the overall effects of personality are likely conservative.

Using the panel data at our disposal, we further examine several robustness specifications. First, to examine whether our results are due to a household's temporary financial mistake or a survey response error, we use a stricter definition for the puz-

zle group where a household is in the puzzle group only if it is in the puzzle group both in 2010 and 2012.[31] The results (available upon request from the authors) are qualitatively and quantitatively similar, suggesting our findings cannot be explained as a temporary mistake or a one-off transition.

Our measures of personality are multiple-period averages thereby preventing us from using individual household fixed effects. As a further robustness test, we examine individual fixed effects specifications where we allow personality to vary yearly.[32] Any permanent personality component would be subsumed by the fixed effects. As such, these examine the effect of the time-variant shocks to personality. We find that none of the yearly components of the personality measures are statistically significant, nor are they jointly significant (p-value of 0.49). This finding is consistent with the yearly within-individual variation in the personality measures being idiosyncratic.

We have also examined Table 2's specifications using lagged personality traits measured in 2006/2008 instead of our preferred multiple-period averages. This further reduces the concern of endogeneity of the personality traits, as discussed in Section 3.2. However, the coefficients have larger standard error estimates possibly due to the reduced sample size.[33] In addition, personality measures from a single year may be noisier than using average measurements from a longer period of time. We find that our results are robust to the use of the lagged Big Five personality measures from 2006 or 2008. The only exception is that in some specifications, Conscientiousness and Extraversion are no longer significant at the 10% level. However, the magnitudes of the personality effects are similar to those from the main specification in Table 2. Consistent with the results from our main specification, the effects of Agreeableness and Neuroticism remain statistically significant at the 1% and 5% levels, respectively. In Appendix A we further investigate whether personality is affected by our financial measures of interest. We find no statistically significant effects of financial measures on changes of personality traits over time. In summary,

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[31]We have also used the number of times (0-2) that a household has been in the puzzle group in 2010 and 2012.

[32]The results are available upon request from the authors.

[33]The reduced sample size is because the personality measures are not available for some individuals in certain years. The results are available upon request from the authors.

controlling for a wide range of demographic, financial, health, and location measures, we find a persistent effect of personality traits on the likelihood of being in the puzzle group.

4.2 Decomposing the effects on credit card debt and checking/savings balance

The reduced-form results in the previous section examine measures that are functions of both checking/savings balance and credit card debt, and as such circumvent the need to address the inherent simultaneity in the decision of allocating assets. However, as explained in Section 2, an aggregate effect of personality on co-holding may mask two opposing effects, i.e., one on checking/savings and the other, with an opposite sign, on credit card debt. Those effects may in turn, cancel each other out. Therefore, in this section, we first examine whether the personality traits are affecting credit card debt, and then study checking/savings balances conditional on credit card debt.

We first examine the likelihood that a household is a revolver, using the entire sample of households. As such, our results include both the extensive and intensive margin of whether to have a credit card, and if so, whether to use it as a source of unsecured loan. However, by using the entire sample, we avoid the need to model and address the endogeneity of the decision to obtain a credit card.[34]

There is a large body of literature on personal debt both focusing on economic and financial factors, and on psychological factors. For example, in the psychology literature, Livingstone and Lunt (1992), Lea et al. (1995), Roberts and Jones (2001), Wood (1998), Wang et al. (2011), Donnelly et al. (2012), and Wilcox et al. (2011) find effects that by and large are consistent with our findings.

We estimate the determinants of credit card debt revolving using a dichotomous variable for the existence of credit card debt, and the results are shown in Table

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[34]An alternative approach would be to find an exclusion restriction that predicts having a credit card, and then examining revolving behavior among those with a credit card. However, our data do not contain any information on credit "supply side" factors that may act as more plausible exclusions.

3.[35] In the first column of Table 3, we include demographic variables such as age, education, gender, race, marital and employment status. Households with a female financial respondent have more credit card debt. Those with some college education are more likely to have credit card debt than those with a high-school degree or those who completed college. The personality traits are added in column 2. Throughout the table, Neuroticism is never statistically significant at conventional levels, whereas Conscientiousness, Extraversion, and Agreeableness are almost always statistically significant at the 5% level or lower. The effect of Conscientiousness and Extraversion on the level of credit card debt is negative, and the effect of Agreeableness is positive.

In column 3, we add income and other financial variables. We use in column 4 lagged measures from 2008 instead of the measures from 2010 to reduce the concern of potential endogeneity between the credit card debt and the financial variables. In column 5, we add the changes (between 2008 and 2010) in household size and welfare payments to incorporate some financial and marital shocks that might have not been picked up in column 4.

Overall, the results in columns 1-5 show that personality traits predict the propensity to have credit card debt, which is a necessary condition for being in the puzzle group. We find that the magnitudes of the effects of personality traits are similar across our specifications. The results remain qualitatively similar even when we control for 2-year lag of being a revolver (column 6).

Those with a high level of Conscientiousness are perhaps more likely to avoid credit card borrowing because they are more likely to be self-controlled, plan ahead, and execute their plan. This is consistent with the overall findings on the importance of Conscientiousness in determining health, positive aging, and human capital (see Roberts et al. (2014) for a recent survey). On the other hand, Agreeableness has a strong positive effect on credit card debt levels. As discussed in Section 1, Agreeableness may lead to higher levels of spending. In addition, as discussed in Section 2, several studies have found that Agreeableness is negatively correlated with income. Similar preferences and mechanisms may be at work in this case. Those with higher

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[35]We obtain similar results, available upon request, when we examine the natural log of credit card debt.

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levels of Agreeableness prefer less conflict (with employer in case of wages, with self and friends in the case of debt) over financial gains such wages or less debt.

Next, we examine the effect of personality on checking/savings balance, while controlling for credit card debt revolving status. Because revolving is endogenous to the decision of how much to save, it is crucial to address this potential bias. One common empirical strategy is to use an instrumental variables approach, or more generally, an exclusion restriction. We use 2-year lagged revolving status as our exclusion restriction.

In our setting, we are interested in estimating the differential effect of the Big Five personality traits among those who are revolvers and those who are not. Given that there are ten such effects (5×2), we do not directly estimate the model using two-stage least squares. Instead, we consider a reduced-form regression and include the instruments directly into the "second-stage" equation (Angrist and Pischke (2008), p. 213). In other words, we estimate the effect of our instruments, instead of their endogenous counterparts, on the amount of checking/savings. For our exclusion to be valid, it must hold that 2-year lagged revolving behavior, conditional on our other measures, is not correlated with the unobservable propensity to have a checking/savings balance two years later.

The results in Table 4 demonstrate that the Big Five personality traits have a statistically significant effect on having a checking and savings balances of \$500 or more both for those who are revolvers and those who are not.[36] Both for revolvers and non-revolvers, Extraversion and Neuroticism have a statistically significant effect on checking and savings balance. Our results suggest that the effect of personality on having low-yield liquid assets is similar between revolvers and non-revolvers.[37] Moreover, Agreeableness has a very small and non-significant effect throughout the table, whereas it has the largest and strongest effect on the likelihood of being a revolver (see Table 3).[38]

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[36]To be consistent with our puzzle definition we use a binary variable, and the same \$500 threshold, but our results are robust to using the log of the balance.

[37]Using an F-test, we fail to reject the effects are jointly the same for revolvers and non-revolvers with a p-value of 0.40.

[38]We get similar results when we examine only those that are revolvers. However, due to sample

Taken together, the results in Tables 3-4 suggest that personality measures are important predictors both for credit card debt and for holding low-yield liquid assets. We find that Conscientiousness is important for both being a revolver and having a checking/savings balance (but with opposite signs), whereas the effect of Agreeableness operates mainly on the likelihood of being a revolver.

4.3   Intra-household dynamics

The effect of household dynamics on economic and financial outcomes has been widely studied.[39] These studies indicate that the financial behavior of a household could depend on the inner dynamics within the household. In the context of credit card debt, Bertaut et al. (2009) derive a model where high credit card debt is used as a mean to curb the spending of a spouse (or one's self) by committing to have less available funds through a high level of existing debt. This is conceptually similar to the model considered in Fudenberg and Levine (2006) who propose a dual-self model for impulse control.

In this section, we broaden our focus beyond that of the financial respondent's personality. In our setting, the intra-household dynamics between the financial respondent and their spouse may play an important role as each side may not be able to fully monitor or control the spending and saving behavior of their partner. For example, each partner may have their own credit card that can be used for spending without the others' pre-approval.[40] Personality differences (similarities) may exacerbate (alleviate) this dynamic. We examine both a reduced-form specification, where household members are treated symmetrically (columns 3 and 4), and specifications with some additional structure (columns 5 and 6) where we proxy for power imbalance within a household using the income difference (financial respondent's income − spouse's income).

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selection concerns, our preferred approach is to examine the entire sample.

[39]For example, see Lundberg and Pollak (2007) for a recent review of some of the issues in the U.S. context.

[40]Schaner (2015) argues that large differences in discount factors among couples can lead to holding individual bank accounts that have lower interest earnings than joint accounts.

First, we examine whether our main results in Table 2 hold only for couple households (column 1 of Table 5). The effects of the financial respondent personality traits remain largely the same as our main specification in Table 2. Next, to allow for a more parsimonious examination, we define a "puzzle personality index" by estimating the propensity to be in the puzzle group among single households. By examining single households, we circumvent the added complication of intra-households dynamics.

We first estimate the specification in column 5 of Table 2 with only single households. Using the estimated coefficients for the personality traits, we create a score defined by $0.005 \times$Openness$- 0.04 \times$Conscientiousness$- 0.012 \times$Extraversion$+ 0.013 \times$ Agreeableness $- 0.002 \times$Neuroticism. We then apply this formula to each member of the household. The puzzle personality index (PPI) for each person in the couple household is obtained by standardizing this score.

Column 2 of Table 5 includes the PPI only for the financial respondent. The coefficient is significant at the 1% level, suggesting the index performs well in capturing the likelihood of being in the puzzle group for the couple households. Next, we allow the personality of both members of the household to have an effect. In column 3, we add the PPI for the non-financial-respondent spouse. The coefficient for the financial respondent remains statistically significant and of the same magnitude. The spouse's PPI is also statistically significant suggesting that both household members' personality traits contribute to the likelihood of being in the puzzle group. The point estimates suggest that the effect of the financial respondent's PPI is 14% higher (though our measures are not precise enough to reject that they are of the same magnitude). This result is consistent with that of Schaner (2015), where the difference in the preferences of household members leads to costly separate individual financial accounts rather than joint accounts. In column 4, we add an interaction effect between the couple's PPIs. The interaction coefficient (significant the 10% level) is negative, implying an attenuating effect of a spouse's PPI on the marginal effect of the PPI of the financial respondent.

The second type of specification includes a possible proxy for the power difference within a household. For a couple household, total income in our data is reported as the sum of all personal income sources and any household-level income. Personal

income includes earned income, government transfers, pension and annuity income, social security, unemployment and worker's compensation income. Personal income is related to personal borrowing capacity since credit card companies use an individual's credit history rather than a household's for underwriting, credit limit determination, and pricing.[41] On the other hand, household-level income includes capital income and other lump-sum household-level income. We consider the difference within a couple of their personal incomes[42] as a proxy for the power imbalance within the household.[43] A positive value of this measure (the financial respondent earns more than their spouse) could proxy for more power for the financial respondent within the relationship.

The last specification in Table 5 (columns 5 and 6) examines the interaction effect of the power imbalance measure and the personality traits as well as intra-household differences (in absolute values) of age and schooling levels among the couple. In column 5 we use the PPI, and in column 6 we use instead the Big Five personality traits for the financial respondent and obtain similar results. In both cases, the interaction term between the financial respondent's Agreeableness and the income difference is negative and statistically significant at the 5% level. This indicates that when the proxy for power is negative, i.e., the spouse earns more, the effect of Agreeableness on the financial respondent is larger than the effect of Agreeableness in households in which the financial respondent has more power. When the spouse earns relatively less, the financial respondent's Agreeableness is a less influential factor for the household's decision to be in the puzzle group. The finding is consistent with the following scenario: a financial respondent is aware of the financial situation and

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[41]Credit cards are considered at the individual level whereas mortgage loans are typically considered based on both household members' credit history.

[42]Since the income difference can be negative, we cannot use the log transformation. Instead, we use the inverse hyperbolic sine function $f(z) = \log(z + \sqrt{1 + z^2})$, where z is the income difference (financial respondent's - spouse's) in 1000's of dollars. The shape of this transformation is very close to that of the log transformation for large $|z|$. The same type of imputation of financial variables is used in the HRS.

[43]Our measure encompasses both unearned income (see Lundberg and Pollak (1996) for a discussion) and earned income. For example, Basu (2006) shows how intra-couple power relationships measured by income disparity affect household decision making and Ashraf (2009) uses an experimental design in the Philippines.

is interested in reducing the likelihood of co-holding assets and debt, but their more powerful spouse is not. The more disagreeable the financial respondent is, the more likely is that the financial respondent would be able to impose his or her preference when facing a powerful spouse. High levels of disagreeableness (i.e., less willing to accommodate or compromise) can therefore be thought of as a substitute for power.

In contrast to the effects of personality, age and schooling differences among couple members do not have a statistically significant effect on a household's likelihood of being in the puzzle group, and the coefficients are small in magnitude. Overall, our analysis suggests that co-holding behavior is influenced by the dynamics within a household. This highlights that potential policy interventions and future research should consider both members of a household.

5 Robustness of the results

5.1 Alternative definitions of the puzzle group

The measure of co-holding used in Section 4 might mis-attribute some decisions as a puzzle, where in fact, they are a result of "rational" calculations. For example, a certain amount of low-yield liquid assets might be required even among borrowers, as not all expenses can be paid with a credit card and perhaps the threshold of $500 we used is too low. Or, if one were anticipating a large financial shock, it may be rational to not pay down one's debt, but rather preemptively keep a debt balance, because when the financial hardship hits (for example due to job loss), it might be harder to obtain a secured or unsecured loan. We therefore examine alternative definition of the puzzle group in Table 6.

The first definition (Y_0) relaxes the threshold for the low-yield liquid assets to zero. 84% of the revolvers are in the puzzle group under this definition.[44] We find in column 1 of Table 6 that the magnitude of the effects of Conscientiousness, Extraversion, and Agreeableness becomes even larger than that in the main specification (column

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[44]Applying our preferred definition of the puzzle group used in Table 2, 68% of the revolvers are in the puzzle group.

5) in Table 2.

The second definition, denoted as Y_T, allows households to hold \$500 in checking and savings for liquidity demand, and a low level (\$500) of credit card debt. This definition is used in Telyukova (2013). Only households with more than \$500 in checking and savings and more than \$500 in credit card debt (60% of the revolvers) are considered to be in the credit card debt puzzle according to this definition. In column 2 of Table 6, we find that the effect of Agreeableness is significant at the 1% level and the magnitude of the effect is around 80% of the estimate from the main specification (column 5) in Table 2.

The third definition (Y_B) uses the threshold used in Bertaut et al. (2009). Under this definition, the threshold for the low-yield liquid assets is increased to \$1200 or one-half of average monthly income, whichever is larger. Therefore, a household would have to be a revolver and have at least \$1200 and at least one-half of their average monthly income in checking, savings, and money market accounts to be in the puzzle group (49% of the revolvers). In column 3 of Table 6, we find that Extraversion and Agreeableness are significant at the 10% and 5% level, respectively. Though this much stricter definition reduces the magnitude of the effects, we still find that personality traits are important factors for being in the puzzle group.

For the last alternative definition (Y_I), we allow a household to hold the average monthly household income as liquidity demand. Therefore, only a household that has positive credit card debt and more than one-month income in checking, savings, and money market accounts is considered to be in the puzzle group. This criterion is similar to that considered in Gathergood and Weber (2014). Even under this stricter definition, 38% of the revolvers would be considered to be in the puzzle group. We find in column 4 of Table 6 that the effects of the personality traits are quite similar to those in column 3.

Overall, we find that as the definition becomes stricter (from column 1 to 4), some of the personality measures become smaller or lose statistical significance, but the overall importance of personality traits remains across the different specifications. Given the very strict definitions we used, these can be construed as a lower bound of the true effect of personality.

In addition to stricter thresholds for the dichotomous puzzle group definition, we also consider some continuous measures that can be interpreted as the cost of being in the puzzle group or the severity of the puzzle under certain assumptions. For example, our base specification only controls for gross income. However, as debt increases, net income due to interest rate costs decreases. Given the concavity of a household's utility function, higher interest costs (due to higher debt levels) would not have an identical effect along a household's utility curve. We cannot directly control for debt on the right hand side, but these specifications account for the potential non-linear effect of debt. We develop several continuous measures that are positive only if a household is in the puzzle group, and monotonically increase (or non-decrease) as either checking and savings or credit card debt increase. See Appendix B for the detailed definitions of these continuous measures and the regression results. We find qualitatively similar results as those from our base specification in Section 4.1. Conscientiousness and Extraversion have statistically significant negative effects at the 10% and 5% levels, respectively, while Agreeableness has a positive effect that is statistically significant at the 1% level.

Overall, we find that among the five personality measures, Agreeableness tends to be the most robust across the various specifications in terms of its statistical significance.

5.2 Alternative explanations

To examine whether our findings of the effect of personality measures using the Big Five traits are just proxies for other measures, we use the rich dataset at our disposal to include the effects of other alternative measures, such as financial sophistication or self-control.[45]

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[45]Although self-control is often studied independently in the literature without referencing the Big Five personality traits, among personality psychologists self-control is thought to be one of the primary facets of Conscientiousness (see Roberts et al. (2014)). Ahadi and Rothbart (1994), Graziano (1994), and Jensen-Campbell et al. (2002) argue that effortful control influences the developmental process of Conscientiousness and Agreeableness. Jensen-Campbell et al. (2007) find that Conscientiousness is related to self-control in the context of anger regulation. Tobin et al. (2000) relate Agreeableness to self-regulation in interpersonal relationships.

The first column in Table 7 adds an impulsiveness measure to our main specification in Table 2 as a proxy for self-control which is suggested by Bertaut et al. (2009) and Gathergood (2012) as an important factor for the puzzle. The impulsiveness measure is one of five additional questions introduced in 2010 HRS to capture subdimensions of Conscientiousness.[46] We find that impulsiveness has a positive but not a statistically significant effect. On the other hand, four of the personality measures remain statistically significant at the 10% level or lower. The result also suggests that the impulsiveness aspect of Conscientiousness is not sufficient to explain the likelihood of being in the puzzle group. This illustrates that the decision to co-hold low-yield liquid assets and credit card debt is influenced by a much wider domain of non-cognitive ability than self-control or economic factors.[47] Column 2 in Table 7 examines the effect of internal locus of control. Locus of control is the degree to which people believe in their own ability to control events that influence them.[48] People with a high internal locus of control believe that events are outcomes of their own behavior, and people high in external locus of control believe that events occur for reasons out of their control, or external factors.[49] The coefficient for internal locus of control is small in magnitude, and not statistically significant. On the other hand, four of the personality traits remain statistically significant at the 10% level.

In column 3, we use the self-perception of how much a household has control

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[46]Impulsiveness is measured using the same scale (1 ("not at all") to 4 ("a lot")) as the other personality measures. We use the 2010/2012 measures. Because we do not have the measure in 2006 and 2008, we do not include it in the Conscientiousness measure in our main specifications, and cannot test its stability, or robustness to using lagged measures.

[47]We also examined "ever smoked" following Bertaut et al. (2009) who used it as a proxy for self-control. We find that this self-control proxy has a statistically significant effect in our regression, but that the effects of personality traits remain qualitatively and quantitatively the same.

[48]Locus of control has been shown to be an important factor in economic decision making. For example, Coleman and DeLeire (2003) argue that locus of control affects high school completion and college attendance. Caliendo et al. (2015) find that those with a higher level of internal locus of control search for a job longer when unemployed. Self-efficacy, which is a closely related concept, is shown be related to the likelihood of loan delinquency (Kuhnen and Melzer (2015)).

[49]We use the average scores of the following five questions as the measure of internal locus of control (1 = strongly disagree, to 6 = strongly agree). "1. I can do just about anything I really set my mind to; 2. When I really want to do something, I usually find a way to succeed at it; 3. Whether or not I am able to get what I want is in my own hands; 4. What happens to me in the future mostly depends on me; 5. I can do the things that I want to do."

over their financial situation.[50] We find that households who assess themselves as having more control over their finances are less likely to be in the puzzle group. To reduce the likelihood of reverse causality, we use the lagged self-perception of financial control (though financial problems may be persistent over longer horizons). We find that the effects of the Big Five traits are quite similar to those in our base specifications.

Columns 4-5 of Table 7 include various measures of financial literacy (see Lusardi and Mitchell (2014) for a summary of the important role financial literacy has on economic outcomes). Behrman et al. (2012) find that financial literacy is a key factor for household wealth accumulation. Gathergood (2012) provide some evidence that both financial literacy and self-control are correlated with loan delinquencies. Our financial literacy measures are based on questionnaires which are only administrated to a smaller sub-sample. Therefore, we have a small sample for these specifications. We construct the financial literacy measure based on the following two questions: "Q1. Suppose you had a bank loan of $1000 and the interest rate was 10% per year. Suppose you never made any payments on the loan. After 2 years, how much would you owe on the loan? Would it be more than $1,200, exactly $1,200, or less than $1,200? Q2. Suppose that the interest rate on a loan is 10% per year and inflation is 12%. Who will benefit from these conditions – the borrowers, the savers, or neither borrowers nor savers?" Column 4 in Table 7 uses the dummy indicator (0-1) for answering both questions correctly as the measure of financial literacy.

Column 5 uses a self-assessed measure of the degree of understanding of economics and finance.[51] For this measure, we used a dummy variable for each level 1 through 7. The results in columns 4-5 show that the effects of the Big Five personality traits have the same sign as those in our base specification in Table 2 and are of similar magnitude even after controlling for financial literacy. This is consistent with the result of Gathergood and Weber (2014).

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[50]We use the question: "Using a 0 to 10 scale where 0 means 'no control at all' and 10 means 'very much control,' how would you rate the amount of control you have over your financial situation these days?"

[51]"On a scale from 1 to 7, where 1 means very low and 7 means very high, how would you assess your own understanding of economics and finance?"

Our final specification controls for credit card interest rates on the card used most often. We group the rates into four interest rate categories: 0%, 1-6%, 7-14%, and 15% or higher. Column 6 in Table 7 shows that interest rates have a statistically significant effect. Yet, the magnitudes of the Big Five personality trait effects remain largely the same as those in column 4-6. Conscientiousness and Extraversion lose its significance at the 10% level, but Agreeableness remains statistically significant. While the sample size for this specification is rather small (only 1 in 20 of our households were asked the question), the results suggest that our findings capture "true" interest-paying revolvers and are not solely driven by households that are taking advantage of 0% balance transfer offers.

In summary, we find that the personality effects are robust to controlling for self-control, locus of control, financial literacy, and credit card interest rates.

6   Conclusion

Using a rich longitudinal data set, we find that controlling for a host of demographic, financial, and economic factors, personality traits play a role in explaining the credit card puzzle. We find that Conscientiousness, Extraversion, and Agreeableness have statistically significant effects, and that the signs of the effects are consistent with the findings in other domains. The results complement other types of explanations suggested in the literature for the credit card puzzle, as they hold after controlling for other factors suggested. Our findings that a broad set of non-cognitive measures is important, suggest that researchers should be cautious of focusing on a single aspect or dimension of non-cognitive ability when studying financial decision making.

Our results also suggest that intra-household dynamics might play an important role in financial decisions, and highlight the importance of both coordination and power dynamics among household members. The effect of intra-household interactions on the economic and financial well-being of families remains an important area for future research.

The findings in this paper contribute to an emerging and growing set of economic outcomes (e.g. earnings, education, etc.) in which non-cognitive skills play an im-

portant role. It is therefore plausible that non-cognitive skills would play a role in additional areas that economists have yet to examine.

There are two types of polices to consider that could yield substantial returns: investments in non-cognitive skills, and policies that target the non-cognitive aspects of financial decision-making. Investments in non-cognitive skills, such as planning, may have large benefits.[52] However, personality is mostly/solely malleable at early childhood, so such investments require an early intervention and a long-term horizon. The second type of policies is related to the design of interventions or marketing campaigns to address debt. Both the government and non-profit organizations have programs to assist people with managing their finances.[53] Participants in these programs could be asked to answer a short survey that would assess their personality type, and would then receive an intervention that would be tailored to their profile. Financial planners already ask their clients about their investment goals and risk tolerance. Similar assessments could be performed by debt counselors or by consumers visiting websites.[54] In addition, banks and credit unions routinely have access to credit reports. They are therefore potentially positioned to combine information on the availability of low-yield liquid assets and revolving credit card balances and alert their clients to costly levels of co-holding.

Co-holding credit card debt and low-yield liquid assets exerts a non-negligible toll on households. For example, we extrapolate that in the U.S. even a one percentage point decrease in the fraction of households in the puzzle group, would generate interest payment savings of over half-a-billion dollars per year, while maintaining the same level of consumption.

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[52]Some schools, such as NY City's KIPP charter school, teach skills, such as grit, as part of their curriculum. For example, see http://www.kipp.org/our-approach/character

[53]For example, the Consumer Financial Protection Bureau launched in May 2015 a financial coaching initiative with 60 certified coaches all across the US. See http://www.consumerfinance.gov/blog/the-launch-of-the-cfpb-financial-coaching-initiative/

[54]The National Foundation for Credit Counseling, the oldest and foremost nonprofit organization for financial counseling, now accepts credit counseling requests online. See https://www.nfcc.org/agency-locator/online-counseling/

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Table 1: Summary Statistics

Variables	Mean Main Sample	Mean Revolvers Only	S.D. Main Sample	S.D. Revolvers Only
N	9,574	2,079		
Couple household	45%	50%	50%	50%
Household Level Variables				
Revolver	22%	100%	41%	0%
Credit card debt	$1,886	$8,686	$7,428	$13,968
Puzzle groups				
Revolver and low-yield liquid assets > $500	15%	68%	35%	47%
Revolver and				
low-yield liquid assets > one-month income	8%	38%	28%	49%
Assets and Debts				
Checking and savings	$30,393	$11,739	$91,805	$48,106
No checking or savings	20%	16%	40%	36%
Financial assets	$132,563	$38,896	$484,103	$134,612
Debts including credit card debt	$4,362	$13,656	$32,354	$35,373
Value of business	$38,739	$25,990	$353,246	$306,121
IRA balance	$59,121	$29,660	$179,531	$95,587
Own home	67%	70%	47%	46%
Real estate	$218,946	$192,573	$491,500	$487,556
Mortgages and home equity loans	$32,592	$57,746	$87,065	$102,560
Income and Medical Expense				
Income	$52,529	$53,122	$75,077	$60,214
Received food stamp	7%	8%	25%	27%
Out-of-pocket medical expense	$2,794	$2,717	$7,627	$5,338
Below 2010 poverty line	11%	8%	32%	27%
Financial Respondent Level Variables				
Personality Traits (1-4)				
Openness	2.92	2.97	0.54	0.52
Conscientiousness	3.35	3.36	0.46	0.44
Extraversion	3.18	3.21	0.53	0.52
Agreeableness	3.51	3.57	0.45	0.43
Neuroticism	2.02	2.04	0.58	0.58
Demographic and other variables				
Age	71.69	67.51	10.12	8.66
White	82%	79%	38%	41%
Male	41%	37%	49%	48%
High school	34%	33%	47%	47%
Some post-secondary schooling	22%	28%	41%	45%
College (4 yrs) or more	23%	22%	42%	41%
Married	45%	48%	50%	50%
Separated/divorced	18%	22%	38%	41%
Widowed	32%	25%	47%	43%
Poor health (excellent (1)-poor (5))	2.89	2.89	1.08	1.05
Employed	24%	36%	43%	48%
Self-employed	7%	9%	26%	29%
Retired	56%	46%	50%	50%

Note: Variables reported for 2010.

Table 2: The Effect of Personality on Being in the Puzzle Group (Reduced-Form)

Explanatory Variables	(1)	(2)	(3)	(4)	(5)	(6)
	Linear probability model; Dependent variable: In the Puzzle Group in 2010.					
	All households in (1)-(5); Households with a head of household 60 or younger in (6).					
Openness (st. dev.)		0.0045	0.0034	0.0027	0.0027	-0.0272**
		(0.0034)	(0.0036)	(0.0037)	(0.0038)	(0.0116)
Conscientiousness (st. dev.)		-0.0120***	-0.0086*	-0.0075*	-0.0074*	-0.0211**
		(0.0042)	(0.0044)	(0.0041)	(0.0042)	(0.0102)
Extraversion (st. dev.)		-0.0089*	-0.0081*	-0.0085*	-0.0083*	0.0129
		(0.0045)	(0.0040)	(0.0042)	(0.0042)	(0.0136)
Agreeableness (st. dev.)		0.0230***	0.0171***	0.0175***	0.0176***	0.0214**
		(0.0046)	(0.0049)	(0.0046)	(0.0046)	(0.0096)
Neuroticism (st. dev.)		-0.0063*	-0.0061*	-0.0062*	-0.0057*	-0.0198**
		(0.0032)	(0.0031)	(0.0033)	(0.0032)	(0.0084)
Age	0.0071	0.0069	0.0064	0.0077	0.0073	0.0149
	(0.0047)	(0.0048)	(0.0046)	(0.0048)	(0.0050)	(0.0329)
Age-squared (divided by 100)	-0.0078**	-0.0077**	-0.0063**	-0.0072**	-0.0070**	-0.0153
	(0.0032)	(0.0032)	(0.0031)	(0.0032)	(0.0033)	(0.0315)
Is male	-0.0377***	-0.0309***	-0.0321***	-0.0328***	-0.0314***	-0.0541**
	(0.0107)	(0.0109)	(0.0110)	(0.0106)	(0.0106)	(0.0258)
In poor health	0.0015	0.0019	0.0036	0.003	0.0033	0.0017
	(0.0030)	(0.0029)	(0.0030)	(0.0027)	(0.0027)	(0.0078)
Ln(financial assets excluding low-yield liquid assets)†			-0.0261***	-0.0215***	-0.0216***	-0.0174***
			(0.0036)	(0.0028)	(0.0028)	(0.0061)
Ln(retirement assets)†			-0.0180***	-0.0218***	-0.0217***	-0.0302***
			(0.0030)	(0.0030)	(0.0031)	(0.0090)
Is home owner†			-0.0116	-0.0225**	-0.0225**	-0.002
			(0.0094)	(0.0103)	(0.0104)	(0.0458)
Ln(income)†			0.0067***	0.0053**	0.0061**	0.0087**
			(0.0022)	(0.0025)	(0.0025)	(0.0042)
Ln(medical spending)†			0.0040*	0.0045**	0.0050***	0.0092**
			(0.0023)	(0.0017)	(0.0017)	(0.0040)
Below poverty line†			-0.0406***	-0.0230**	-0.0217**	-0.0161
			(0.0087)	(0.0097)	(0.0094)	(0.0262)
Ln(mortgage+HELOC)†			0.0118***	0.0110***	0.0111***	0.0078***
			(0.0014)	(0.0009)	(0.0009)	(0.0025)
2-year change in welfare and food stamps assistance					-0.0257**	-0.0317
					(0.0103)	(0.0273)
2-year change in household size					0.0378***	0.0731**
					(0.0105)	(0.0347)
R^2	0.06	0.06	0.12	0.11	0.11	0.13
Sample size	9574	9574	9574	9574	9574	1565

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. Standard errors, in parentheses, are clustered at the region × metro type (highly-urban, medium-size, and rural). All specifications control for race, marital status, whether widowed, household size, presence of additional household members (dependents), education (high-school, some college, and college or more dummies), and region and metro type fixed effects. Columns 3-6 also include assets (transportation, housing), whether underwater, employment status, percent of household members employed, and whether retired.

† Measures lagged by two years (2008 values) in columns 4-6.

Table 3: The Effect of Personality on Having Revolving Credit Card Debt

	Linear probability model; Dependent variable: Revolving Credit Card Borrower in 2010.					
Explanatory Variables	(1)	(2)	(3)	(4)	(5)	(6)
Openness (st. dev.)		0.0090**	0.0081*	0.0067	0.0065	0.0008
		(0.0038)	(0.0040)	(0.0042)	(0.0042)	(0.0041)
Conscientiousness (st. dev.)		-0.0193***	-0.0128**	-0.0129**	-0.0130**	-0.0064
		(0.0048)	(0.0047)	(0.0048)	(0.0047)	(0.0038)
Extraversion (st. dev.)		-0.0117**	-0.0108**	-0.0118***	-0.0118***	-0.0039
		(0.0046)	(0.0041)	(0.0041)	(0.0041)	(0.0041)
Agreeableness (st. dev.)		0.0333***	0.0237***	0.0270***	0.0271***	0.0163***
		(0.0056)	(0.0060)	(0.0056)	(0.0055)	(0.0045)
Neuroticism (st. dev.)		0.0001	-0.0006	-0.001	-0.0007	-0.0038
		(0.0039)	(0.0032)	(0.0036)	(0.0035)	(0.0031)
Age	0.0087	0.0088	0.0112*	0.0122*	0.0121*	0.0088*
	(0.0062)	(0.0062)	(0.0057)	(0.0065)	(0.0064)	(0.0048)
Age-squared (divided by 100)	-0.0109**	-0.0109**	-0.0111***	-0.0119**	-0.0118**	-0.0079**
	(0.0041)	(0.0042)	(0.0038)	(0.0043)	(0.0043)	(0.0032)
Is male	-0.0465***	-0.0353***	-0.0355***	-0.0392***	-0.0377***	-0.0281***
	(0.0096)	(0.0093)	(0.0094)	(0.0091)	(0.0090)	(0.0076)
In poor health	0.0159***	0.0146***	0.0115**	0.0129**	0.0125**	0.0073*
	(0.0044)	(0.0049)	(0.0048)	(0.0049)	(0.0048)	(0.0036)
Ln(financial assets excluding liquid assets)†			-0.0299***	-0.0031**	-0.0033**	-0.0012
			(0.0033)	(0.0015)	(0.0015)	(0.0013)
Ln(income)†			0.0044	0.0013	0.0022	-0.0013
			(0.0031)	(0.0031)	(0.0032)	(0.0025)
Ln(medical spending)†			0.0066***	0.0069***	0.0076***	0.0032*
			(0.0021)	(0.0022)	(0.0023)	(0.0018)
Below poverty line†			-0.0453***	-0.0361**	-0.0389**	-0.0148
			(0.0133)	(0.0140)	(0.0142)	(0.0127)
Ln(mortgage+HELOC)†			0.0132***	0.0139***	0.0139***	0.0070***
			(0.0015)	(0.0011)	(0.0011)	(0.0010)
2-year change in welfare and food stamps assistance					0.0353*	0.0270*
					(0.0186)	(0.0151)
2-year change in household size					0.0370***	0.0153
					(0.0112)	(0.0146)
Previously a revolver						0.4332***
						(0.0141)
R^2	0.07	0.07	0.13	0.12	0.12	0.29
Sample size	9574	9574	9574	9574	9574	9574

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. Standard errors, in parentheses, are clustered at the region × metro type (highly-urban, medium-size, and rural). All specifications control for race, marital status, whether widowed, household size, presence of additional household members (dependents), education (high-school, some college, and college or more dummies), and region and metro type fixed effects. Columns 3-6 also include assets (transportation, housing), whether underwater, employment status, percent of household members employed, and whether retired.

† Measures lagged by two years (2008 values) in columns 4-6.

Table 4: The Effect of Personality on The Likelihood of a Checking/Savings Account Balance of over $500

| | Linear probability model; | | |
| Dependent variable: Have a Checking/Savings Account Balance over $500 in 2010. | | | |
Explanatory Variables	(1)	(2)	(3)
Openness (st. dev.)	-0.0077	-0.0076	
	(0.0064)	(0.0063)	
Conscientiousness (st. dev.)	0.0228***	0.0226***	
	(0.0075)	(0.0074)	
Extraversion (st. dev.)	-0.0239***	-0.0241***	
	(0.0044)	(0.0043)	
Agreeableness (st. dev.)	0.0052	0.0054	
	(0.0039)	(0.0040)	
Neuroticism (st. dev.)	-0.0174***	-0.0173***	
	(0.0040)	(0.0039)	
Previously a revolver (2008)		-0.0098	-0.0095
		(0.0120)	(0.0119)

Lagged Revolving Status (Having a Credit Card Balance Two Years Earlier)
  Interacted with Personality Traits

Was not revolver × Openness			-0.0056
			(0.0067)
Was not revolver × Conscientiousness			0.0226***
			(0.0067)
Was not revolver × Extraversion			-0.0245***
			(0.0048)
Was not revolver × Agreeableness			0.0055
			(0.0050)
Was not revolver × Neuroticism			-0.0140***
			(0.0045)
Was a revolver × Openness			-0.0146
			(0.0108)
Was a revolver × Conscientiousness			0.0222
			(0.0172)
Was a revolver × Extraversion			-0.0226*
			(0.0117)
Was a revolver × Agreeableness			0.0054
			(0.0076)
Was a revolver × Neuroticism			-0.0279**
			(0.0106)
R^2	0.35	0.35	0.35
Sample size	9574	9574	9574

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. Standard errors, in parentheses, are clustered at the region × metro type (highly-urban, medium-size, and rural). All specifications control for all variables in column 5 of Table 2, including region and metro type fixed effects.

Table 5: The Effect of Intra-Household Dynamics On the Probability of Being in the Puzzle Group

Linear probability model; Dependent variable: In the Puzzle Group in 2010.						
Explanatory Variables	(1)	(2)	(3)	(4)	(5)	(6)
Puzzle personality		0.0137***	0.0122**	0.0118**	0.0150***	
		(0.0049)	(0.0047)	(0.0046)	(0.0046)	
Spouse's puzzle personality			0.0107*	0.0093	0.0083	0.0074
			(0.0061)	(0.0060)	(0.0062)	(0.0061)
Interaction of couple's				-0.0071*	-0.0075*	-0.0072*
puzzle personalities				(0.0041)	(0.0040)	(0.0041)
Couple difference in age					-0.0017	-0.0017
					(0.0010)	(0.0010)
Couple difference in					-0.0001	-0.0001
yrs. of schooling					(0.0027)	(0.0027)
Couple power difference					-0.0013	-0.0013
					(0.0024)	(0.0024)
Openness ×					-0.0011	-0.0008
Couple power difference					(0.0018)	(0.0018)
Conscientiousness ×					-0.002	-0.0019
Couple power difference					(0.0028)	(0.0028)
Extraversion ×					0.001	0.0004
Couple power difference					(0.0018)	(0.0019)
Agreeableness ×					-0.0035**	-0.0041***
Couple power difference					(0.0016)	(0.0015)
Neuroticism ×					-0.0026	-0.0024
Couple power difference					(0.0017)	(0.0018)
Openness (st. dev.)	0.0000					0.0026
	(0.0059)					(0.0066)
Conscientiousness (st. dev.)	-0.0120*					-0.0069
	(0.0064)					(0.0059)
Extraversion (st. dev.)	-0.0034					-0.0032
	(0.0086)					(0.0092)
Agreeableness (st. dev.)	0.0209***					0.0239***
	(0.0058)					(0.0048)
Neuroticism (st. dev.)	-0.0115***					-0.0069
	(0.0038)					(0.0049)
R^2	0.12	0.12	0.12	0.12	0.12	0.12
Sample size	4320	4320	4067	4067	4052	4052

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. Standard errors, in parentheses, are clustered at the region × metro type (highly-urban, medium-size, and rural). All specifications control for all variables in column 5 of Table 2, including region and metro type fixed effects. Age and education differences measured as the absolute value of (financial respondent's - spouse's). Couple power difference based on income difference between couple members.

Table 6: Alternative Definitions of the Puzzle Group and Continuous Measures of the Cost (Severity) of the Puzzle

Panel A

Alternative Puzzle Group Definitions	Y_0 (1)	Y_T (2)	Y_B (3)	Y_I (4)
Openness (st. dev.)	0.0047	0.0014	0.0023	0.0008
	(0.0035)	(0.0034)	(0.0052)	(0.0039)
Conscientiousness (st. dev.)	-0.0097**	-0.005	-0.0046	-0.0017
	(0.0040)	(0.0038)	(0.0044)	(0.0038)
Extraversion (st. dev.)	-0.0144***	-0.0075*	-0.0071*	-0.0078**
	(0.0046)	(0.0043)	(0.0036)	(0.0031)
Agreeableness (st. dev.)	0.0241***	0.0144***	0.0099**	0.0082**
	(0.0051)	(0.0040)	(0.0039)	(0.0030)
Neuroticism (st. dev.)	-0.004	-0.0048	-0.0001	-0.0008
	(0.0030)	(0.0030)	(0.0032)	(0.0035)
R^2	0.12	0.11	0.07	0.04
Sample size	9574	9574	9574	9574

Panel B

Continuous Measure of Puzzle Severity	Y_m (5)	Y_{m2} (6)	Y_a (7)	Y_c (8)
Openness (st. dev.)	0.0281	0.0001	0.0357	0.0401
	(0.0258)	(0.0076)	(0.0307)	(0.0272)
Conscientiousness (st. dev.)	-0.0615*	-0.0046	-0.0647*	-0.0712**
	(0.0315)	(0.0088)	(0.0351)	(0.0343)
Extraversion (st. dev.)	-0.0830**	-0.0032	-0.0993***	-0.1056***
	(0.0324)	(0.0083)	(0.0345)	(0.0354)
Agreeableness (st. dev.)	0.1564***	0.0151**	0.1712***	0.1788***
	(0.0350)	(0.0072)	(0.0408)	(0.0397)
Neuroticism (st. dev.)	-0.0241	-0.0027	-0.0287	-0.0275
	(0.0207)	(0.0048)	(0.0231)	(0.0235)
R^2	0.13	0.10	0.12	0.12
Sample size	9574	9574	9574	9574

Notes: The measures are detailed in Section 5.1 and Appendix B. * significant at 10%; ** significant at 5%; *** significant at 1%. Standard errors, in parentheses, are clustered at the region × metro type (highly-urban, medium-size, and rural). All specifications control for all variables in column 5 of Table 2, including region and metro type fixed effects.

Table 7: Robustness Checks with Alternative Explanations for the Puzzle

	Linear probability model; Dependent variable: In the puzzle group in 2010.					
Explanatory Variables	(1)	(2)	(3)	(4)	(5)	(6)
Openness	0.0043	0.004	0.0032	0.0186	0.0146	0.0105
	(0.0050)	(0.0038)	(0.0046)	(0.0262)	(0.0210)	(0.0351)
Conscientiousness	-0.0086*	-0.0073*	-0.0053	-0.006	-0.018	-0.0171
	(0.0042)	(0.0041)	(0.0038)	(0.0184)	(0.0166)	(0.0248)
Extraversion	-0.0126**	-0.0086*	-0.0069	-0.0388	-0.0441	-0.0424
	(0.0050)	(0.0045)	(0.0048)	(0.0311)	(0.0263)	(0.0365)
Agreeableness	0.0193***	0.0175***	0.0170***	0.0476***	0.0487***	0.0661***
	(0.0060)	(0.0046)	(0.0046)	(0.0134)	(0.0131)	(0.0185)
Neuroticism	-0.0088**	-0.0078**	-0.0099**	0.0064	-0.0015	-0.0115
	(0.0040)	(0.0036)	(0.0036)	(0.0158)	(0.0137)	(0.0176)
Impulsive	0.0056					
	(0.0043)					
Internal locus of control		-0.0047				
		(0.0038)				
In financial control (lagged)			-0.0028**			
			(0.0013)			
Financial literacy				0.0308		
				(0.0292)		
Credit card rates						
0% interest rate						-0.2208***
						(0.0575)
1-6% interest rate						-0.1589
						(0.1011)
15%+ interest rate						-0.1045**
						(0.0382)
Levels of econ/financial understanding					7	
Are any of the of econ/financial understanding levels statistically significant?					No	
R^2	0.11	0.11	0.11	0.18	0.17	0.23
Sample size	7595	9305	8757	659	796	488

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. Standard errors, in parentheses, are clustered at the region × metro type (highly-urban, medium-size, and rural). All specifications control for all variables in column 5 of Table 2, including region and metro type fixed effects.

Table 8: Summary Statistics for Intra-Individual Changes in Personality Measures Over Four Years

	Four-year change in personality traits					
Personality Trait	Sample Size	Mean	S.D.	25% quantile	Median	75% quantile
Openness	7,096	−0.07	0.46	−0.29	0.00	0.14
Conscientiousness	7,119	−0.03	0.42	−0.20	0.00	0.20
Extraversion	7,129	−0.06	0.45	−0.20	0.00	0.20
Agreeableness	7,068	−0.03	0.42	−0.20	0.00	0.20
Neuroticism	7,029	−0.05	0.52	−0.25	0.00	0.25

Table 9: Changes in Personality Trait Measures Conditional on 2-year Lagged Membership in the Puzzle Group

Change in:	Openness	Conscientiousness	Extraversion	Agreeableness	Neuroticism
	(1)	(2)	(3)	(4)	(5)
In the puzzle group (lagged (2008))	-0.0017	0.0002	0.0074	0.0069	-0.0105
	(0.0104)	(0.0124)	(0.0132)	(0.0128)	(0.0154)
Financial Measures (all lagged)†					
Ln(financial assets excluding	0.0015	0.0054	0.0013	0.0061	-0.0037
liquid assets)†	(0.0028)	(0.0036)	(0.0034)	(0.0039)	(0.0028)
Ln(transportation assets)†	0.0019	-0.0006	0.0008	-0.0007	0.0041*
	(0.0024)	(0.0023)	(0.0019)	(0.0018)	(0.0020)
Ln(business assets)†	0.0006	-0.0006	0.0006	-0.0014	-0.0002
	(0.0015)	(0.0014)	(0.0019)	(0.0016)	(0.0016)
Ln(retirement assets)†	-0.0015	0.0005	-0.002	-0.0064	-0.0084
	(0.0038)	(0.0050)	(0.0038)	(0.0049)	(0.0060)
Home owner†	0.0061	0.0111	0.0092	0.0075	-0.0145
	(0.0156)	(0.0157)	(0.0133)	(0.0122)	(0.0145)
Ln(real estate assets)†	-0.0004	0.0022	0.0011	0.0003	0.0009
	(0.0021)	(0.0017)	(0.0015)	(0.0018)	(0.0017)
Ln(income)†	-0.0149**	-0.0075	-0.0057	0.0012	-0.0046
	(0.0069)	(0.0057)	(0.0051)	(0.0050)	(0.0063)
Welfare and food stamps†	0.0268	0.0226	0.0072	0.009	-0.0056
	(0.0314)	(0.0291)	(0.0286)	(0.0412)	(0.0306)
Ln(medial spending)†	0.0016	-0.0012	0.0024	-0.0012	-0.0001
	(0.0023)	(0.0023)	(0.0025)	(0.0030)	(0.0038)
Below poverty line†	-0.0004	-0.0277	0.0064	0.0111	0.0005
	(0.0267)	(0.0295)	(0.0229)	(0.0242)	(0.0315)
Ln(mortgage+HELOC)†	0.0013	-0.0014	0.0003	0.0003	0.0007
	(0.0013)	(0.0010)	(0.0008)	(0.0012)	(0.0014)
No Retirement Assets†	-0.0349	0.0077	-0.036	-0.0871	-0.0851
	(0.0436)	(0.0582)	(0.0410)	(0.0551)	(0.0722)
No Financial Assets†	0.0021	0.0511	0.0091	0.0595	-0.0571*
	(0.0282)	(0.0354)	(0.0343)	(0.0420)	(0.0280)
Under water†	0.0144	0.0809*	-0.0108	0.0109	-0.0445
	(0.0444)	(0.0436)	(0.0486)	(0.0487)	(0.0414)
% household employed	0.0179	0.0006	-0.0201	-0.0320*	-0.0054
	(0.0213)	(0.0267)	(0.0244)	(0.0173)	(0.0251)
2-year change in welfare and	-0.0204	0.0005	-0.031	-0.0259	-0.0217
food stamps assistance	(0.0419)	(0.0347)	(0.0231)	(0.0273)	(0.0356)
2-year change in household size	-0.0144	0.0079	0.0107	-0.021	-0.0083
	(0.0254)	(0.0251)	(0.0146)	(0.0255)	(0.0263)
R^2	0.01	0.01	0.01	0.02	0.01
Sample size	7096	7119	7129	7068	7029

Notes: Estimated using OLS. * significant at 10%; ** significant at 5%; *** significant at 1%. Standard errors, in parentheses, are clustered at the region × metro type (highly-urban, medium-size, and rural).
† Measures lagged by two years (2008 values).

Appendices

A Time consistency and reverse causality of personality traits

To address the possible concern of reverse causality, that an individual's personality measures are influenced by their unobservable propensity to be in the puzzle group, we examine the stability of our personality traits, and the personality traits' response to changes in financial measures. Toward this end, we exploit two features of our data. First, we observe for the same individuals multiple measures of personality across time. Second, the panel data feature of our data allows us to examine whether personality is affected by the lag of our dependent variable and other key lagged financial measures.

As mentioned in Section 3.2, the Big Five measures are observed for most people first either in 2006 or 2008, and once again four years after the initial measurement, i.e. in either 2010 or 2012. Therefore, we define the change of the Big Five traits as the difference between the measurements from 2006/2008 (or the average if measured twice in this period) and 2010/2012 (or the average if measured twice in this period).

In Table 8, we provide summary statistics for the 4-year changes of the Big Five personality measures for the financial respondents in our sample. The overall change is quite small. The average change is between -0.07 and -0.03, and sample standard deviation is between 0.42 and 0.52. Furthermore, for all personality traits, the sample medians are zero.

Naturally, a crucial concern is how personality changes are related to the propensity to be in the puzzle group. We study potential reverse causality by examining whether the personality trait changes are affected by past membership in the puzzle group in 2008. The regression results in columns 1-5 of Table 9 show that being in the puzzle group in 2008 does not significantly influence the post-2008 changes in the Big Five personality traits.

1

B Alternative measures of the puzzle

We consider the following alternative measures that can be interpreted as the cost of being in the puzzle group or the severity of puzzle under certain assumptions. The regression results with these measures are in Table 6.

Let A = checking and savings balance, D = credit card debt. All the measures given below are zero if $A = 0$ or $D = 0$. If $A > 0$ and $D > 0$, they are defined as:

- $Y_m = \min\{ \log(A), \log(D) \}$,

- $Y_{m2} = \min\{ \log(A) - \log(500), \log(D) - \log(500) \}$ only if $A > 500$ and $D > 500$,

- $Y_a = \log(A)$,

- $Y_c = \log(A)^{0.5} \log(D)^{0.5}$.

The measure Y_m is the log amount of checking and savings balance that can be used to pay down credit card debt. Y_{m2} is a modified version of Y_m that allows households to have \$500 in checking and savings accounts for liquidity demand, and a low level (\$500) of credit card debt.

Y_a and Y_c are variants of Y_m. One feature of Y_m is that as long as the credit card debt is larger than the checking and savings balance, Y_m does not increase no matter how much credit card debt a household has. However, all else equal, a household with a larger amount of credit card debt will have less disposable income, i.e. income – total interest payment, because of the higher debt expenses. This household may face difficulties in paying essential expenses such as food and housing. Therefore, it is more crucial for those households to minimize the cost of being in the puzzle group by paying down their debt. In other words, under this definition, it is more puzzling for a household to have a very large credit card debt given the same level of checking and savings balance. Based on this idea, we develop an alternative measure that increases as credit card debt increases.

On the other hand, if checking and savings balance is higher than credit card debt, Y_m does not change no matter the size of a household's checking and savings balance. However, the more checking and savings balance a household has, the less

likely it is that previously proposed factors such as liquidity demand can explain this. Therefore, a very high checking and savings balance is more puzzling because it is difficult to explain as liquidity demand. Considering that we do not know exactly how much money a household needs for liquidity, it is reasonable to assume that the higher the checking and savings balance is, the higher the severity of the puzzle is.

Y_a and Y_c are two measures that incorporate these ideas. They increase as checking and savings balance or credit card debt increases. Noting that Y_m has the same form as the Leontief production function, Y_c can be thought as a generalization of Y_m to the Cobb-Douglas production function. These functions can be thought of as examples of the "credit card debt puzzle production" function.

C   Estimated total cost of the credit card puzzle

To calculate the economic magnitude of being in the puzzle group for the entire U.S. population, we first suppose that a household leaves one month's income in checking and savings accounts and uses the rest to pay down their credit card debt. In our sample, 8.32% of households had enough money to pay down at least some of their credit card debt and still have more than a month's income left in their checking and savings accounts.

For these households, we can calculate the total additional annual interest expense from not paying down credit card debt according to our scheme above. The cost would be

$$\text{Pay-down Amount} \ \times \ \text{Credit Card Annual Interest Rate}$$

for each household. We use the average credit card interest rate of 14% to calculate the cost of being the puzzle group. The estimated total annual cost is $488 per affected household. Since there are 115,610,216 households according to the U.S. Census (2009-2013) data,[55] the total imputed cost would be $4.69 billion per year

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[55]Source: U.S. Census Bureau, American Community Survey, 5-Year Estimates. Updated every year. http://factfinder2.census.gov

for the entire U.S. population. If an intervention program decreases the number of these households by 1-percentage point, this would translate to a $565 million decrease of the total cost for all U.S. households.

According to Table 13 in Bricker et al. (2012), households with heads younger than 65 years are much more likely to hold credit card debt. Therefore, it is likely that the cost of the puzzle is even larger for younger households. Since most of the people in our sample are 50 years old or older, the estimated total cost of the puzzle above likely represents a lower bound. In fact, only 21.7% of the households in our sample hold credit card debt while 39.4% of the households from the survey of consumer finances (SCF) in 2010 hold credit card debt. Moreover, among the households in our sample with 65 years old or older financial respondents (6,995 households, or 73% of our sample), only 17.8% have credit card debt. For the other households (2,579 households, or 27%), 32.4% hold credit card debt.

In 2013, 14.1% of the whole U.S. population were 65 years or older.[56] Using this estimate, we split the 115.6 million households into 16.3 million households (assumed to be 65+ years old) and 99.3 million households (assumed to be younger than 65 years). Then we apply the costs of the puzzle per households over 65 and under 65.. The total estimated cost of the puzzle calculated in this way is $6.60 billion, higher than the conservative estimate of $4.69 billion. The savings from a 1-percentage point decease in the number of households in the puzzle group under this potentially more realistic scenario would be $795 million.

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[56]Source: U.S. Bureau of the Census, Population Estimates Program (PEP). Updated annually. http://www.census.gov/popest/