"May the Odds Be Ever in Your Favor"

An Empirical Analysis of British Premium Bonds

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"I pray that out of His glorious riches he may strengthen you with power through His Spirit in your inner being, so that Christ may dwell in your hearts through faith. And I pray that you, being rooted and established in love, may have power, together with all the saints, to grasp how wide and long and high and deep is the love of Christ, and to know this love that surpasses knowledge—that you may be filled to the measure of all the fullness of God."

Ephesians 3:16–19

Soli Deo gloria,
David Li

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1

Introduction

There exists a general consensus that the present state of individual savings in the United States is approaching crisis levels. According to the Employee Benefit Research Institute's 2014 Retirement Confidence Survey, 36 percent of Americans have saved less than $1,000 for retirement (EBRI 2014). A recent study by the Brookings Institution indicates that more than half of those surveyed cannot procure $2,000 given an emergency in the next month (Lusardi et al. 2011). Astoundingly, the FDIC estimates that more than 30 percent of U.S. households do not have a savings account (Burhouse et al. 2013). At the same time, Americans have developed an addictive appetite for gambling through state lotteries that is both serious and regressive. While various theories exist that try to explain why an individual would invest in a product that offers one of the worst odds in legal gambling (returning about 55 percent of what people paid for tickets), it nevertheless remains baffling to consider that Americans spent a total of $78 billion on lotteries in 2012, the equivalent of $675 per household (NASPL 2014). To put that into context, that is $200 more than what the average American household spent in the same year on milk or beer (BLS 2012). Average spending on lotteries is level across the low, middle, and high segments of the

income distribution, meaning that lower-income households spend a much larger share of their income on lotteries (Kearney 2002). Although lotteries are typically cited as a major contributor to the U.S. savings crisis, they may in fact prove to be a formidable part of the solution to the problem.

What if savings could be like a lottery? Far from a hypothetical question, so-called "prize-linked savings" (PLS) programs have existed for more than three centuries and offer a savings product with an added element of thrill.[1] Whereas traditional savings accounts return a recurring risk-free interest rate, PLS accounts offer holders a stochastic, heavily skewed payout. More specifically, PLS holders are given a periodic (e.g., monthly) chance of winning a prize, where an individual's probability of winning depends both on the amount, the total amount deposited in the entire PLS program, and an interest rate used to calculate total prize payouts in the period. Whereas traditional lotteries offer negative expected returns, PLS accounts offer holders a positive (although nominal) return because all principal from savings deposited are secure and can be withdrawn on demand. In effect, PLS holders gamble using only the potential interest payments.

In this paper, we explore four fundamental questions about PLS programs within the context of the British Premium Bond (PB) system. First, what characteristics of an individual predict whether she will take advantage of PBs over (or perhaps, in addition to) more traditional safe savings products? Second, what characteristics of an individual determine the level of PBs that an individual will hold? Third, looking specifically at the income/wealth distribution, to what extent do PBs cater towards lower-wealth groups and are PB savings

[1] The first ever recorded PLS program was the U.K. "Millions Adventure" launched in 1696.

"regressive" in a similar fashion as is spending on traditional lotteries? And fourth, given similar demographic and behavioral characteristics, do those who hold PBs have more total safe savings than those who only save using traditional savings products? Answering the first two questions can offer important insights into what sorts of individuals PLS programs can best target given the implementation of such a savings program elsewhere. Answering the third question provides more specific insights into an issue of wealth inequality—namely, whether such a product has the potential to reduce the large gap in savings between the most financially fragile and the wealthiest individuals in an economy. Answering the fourth question offers insight into the question of whether PBs simply help individuals reallocate savings across savings products or if PBs actually encourage higher levels of savings.

It has been hypothesized in the literature that the lottery-like payment structure of PLS programs can act as a substitute for lottery spending, with the added benefit of individuals never losing their initial deposits. Moreover, it has been theorized that PLS programs appeal in particular to lower-income and lower-wealth individuals—the group that typically has the lowest level of savings. Kearney et al. (2010) refer to these individuals as "emergency savers" because instead of saving with the long-term horizon in mind (in which case the power of compound interest should provide a strong incentive to save and save early on), these individuals save up for emergency use over an uncertain, much shorter horizon of a few months to a few years. For this group, both because of the small amount of money that they have available to save and their short-term mindset, the rewards of compound interest are not a very compelling reason to save. In

contrast, a PLS product—which offers the same liquidity and principal security as a savings account, but comes with the added benefit of an uncertain return that might offer a chance at winning a large amount of money—can in theory provide much larger incentives for so-called "emergency savers" to save more of their money. Not only would these increased savings somewhat reduce the gap in financial wealth across the population, it would also mean more opportunities for consumption smoothing for those who would otherwise save very little.

PLS programs have only been established in the United States in recent years (roughly 2006 onwards), with small-scale credit-union-based programs providing all of the infrastructure.[2] Various legal barriers prevent PLS programs from existing in any larger capacity in the U.S., because federal laws restrict federally chartered banks from participating in lotteries and state regulations prohibit private-run lotteries in order to maintain the states' monopolies over lotteries and their revenue streams (Kearney et al. 2010). In Britain, however, National Savings & Investments (the state-owned savings bank in the U.K.) has offered one of the most well-established and longest-running PLS programs in existence. Prime Minister Harold Macmillan first introduced this savings product—called Premium Bonds (PBs)—in 1956 as a means of encouraging savings after World War II. Presented with "Savings with a thrill!" as the official tag-line, Macmillan reasoned that PBs would appeal to those who are not attracted by the "rewards of interest, but do respond to the incentives of fortune" (Tufano 2008). By the end of November 1, 1956 (the first day PBs were offered

[2] Two PLS programs—one run through Centra Credit Union in Indiana in 2006 and another called "Save to Win" in Michigan with eight participating credit unions that began in 2009—are almost exclusively the ones cited in the literature. See Section 2.1 for more details.

to the market), more than £5 million worth of PBs were sold. Their popularity has only grown over time, with more than £48 billion deposited by the end of fiscal year 2014 and over 21 million U.K. citizens holding some amount of deposits as PBs (NS&I 2014a). Today, any U.K. resident 16 years of age and older is eligible to purchase PBs. Moreover, both monthly winnings and withdrawals are free from all taxes.

If a large-scale PLS program has the ability to become as well-established in the U.S. as PBs are in the U.K.—and if PBs can in fact divert negative-return lottery gambling into nominally positive-return savings, particularly for lower-income individuals and households who are at highest risk of having little to no savings at all—then there are policy implications at both the U.S. federal and state levels, since neither privately run PLS programs nor one large publicly run PLS program can exist, legally, under current regulations.[3] Thus, the focus of this paper will be on the British PB system. We will not attempt to answer the question of whether PBs increase savings by shifting consumer spending from lottery gambling to PB savings, because of difficulties with testing such a question, and will rely instead on existing literature to better understand the nuances of this topic. Instead, we will focus on the four aforementioned, more fundamental questions.

As will be discussed in the Literature Review section of this paper, research on the topic of PLS programs has been rather sparse. Thus, this paper

[3] As cited by Kearney et al. (2010), state lottery laws prohibit privately run lotteries in order to protect the state's monopoly over lottery games and the large funds associated with them. Federal banking regulations (such as the National Bank Act) prohibit federally chartered banks (regulated by the Office of the Comptroller of the Currency) from participating in lotteries in order to protect the safety and soundness of the banking system. See 12 U.S.C. § 25a.

contributes to the existing literature in two main ways. First, no prior micro-level study has ever been done on British PBs—the most prominent PLS program in existence today. Prior literature has only focused on macro-level data (Tufano 2008) or data from online lab experiments (Atalay et al. 2012). The only comparable micro-level study is one focused on a PLS program in South Africa—a product that was shut down after three years because of a violation of the government's monopoly on lotteries (Iverson et al. 2013). Second, this paper makes use of behavioral economics-type data on attitudes towards risk, discounting, saving, and debt to gauge the compatibility of empirical findings regarding PB savings with existing lottery-demand theories.

The remainder of the paper is organized as follows. Section 2 provides background information including a more detailed overview of the existing literature on PLS programs, a historic and present-day summary of how PBs operate in the U.K., and a theoretical framework that models savings behavior. Section 3 describes the 2006–2008 Wealth and Assets Survey used in our micro-level study and offers some initial summary statistics. Section 4 discusses the Probit and Tobit methodology used in answering the four main questions examined in this paper and the accompanying results. Section 5 discusses the implications of the results through a comparison with existing theories and hypotheses. Section 6 concludes and suggests areas for further research.

2

Background

2.1 Literature Review

Although PLS products have existed since as early as 1694 (the "Million Adventure" in the U.K.) and exist in many variations across the world today, they have received relatively little academic attention (Murphy 2005). Tufano (2008) investigates whether PBs are used more as a tool for saving or for gambling through a time-series analysis of the net sales of the PB program as a function of various macro-level factors (e.g., total gambling activity, the largest prize offered in the PB prize pool, the spread between interest rates used to calculate PB prizes and rates on secure short-term government bonds, the marginal income tax rate, U.K. stock indexes, real gross savings per capita, income levels, unemployment). He finds using first differences that the time series of net sales is positively correlated with both total gambling activity and the largest PB prize (similar to lottery sales being dependent upon the jackpot prize), indicating that PBs have a gambling component. He also finds, however, that net sales of PBs respond to the attractiveness of other savings and investment products as would a substitute, indicating that PBs also have a savings component. Moreover, PB sales are

higher in periods of low savings, suggesting that PBs may indeed appeal more to non-savers, as hypothesized in the literature. While this macro-level study is important in understanding some of these more rudimentary, aggregate trends and correlations, it makes use of macro-level averages, which does not allow for any detailed analysis into person-specific variations such as differences across wealth categories or behavioral tendencies.[4]

Research on PLS programs outside the U.K. spans from hypothetical lab-created environments to programs piloted across South Africa, Latin America, and the United States. Atalay et al. (2012) observe changes in individuals' savings behavior through an online experiment that allows for the introduction of a PLS product. While behavioral results obtained from lab experiments should always be treated with caution, their lab results seem to suggest that PLS products do increase total savings and reduce lottery expenditures, especially for lower-income individuals. Iverson et al. (2013) use micro-level data from First National Bank in South Africa for the "Million-a-Month" PLS program that lasted 2005–2008 to show that the introduction of the PLS product increased both the number of savers and individual savings, decreased lottery spending, and was most attractive for financially constrained individuals facing heavy debt burdens and low levels of discretionary income.[5] Furthermore, their results also

[4] Moreover, one might question the statistical power of Tufano's results since he only makes use of 38 time-series observations. To Tufano's credit, he does not claim to establish any causation between gambling activity or savings activity and PB sales from this macro-level study.

[5] In measuring both the impact of financial constraint and later, the impact of risk tolerance, Iverson et al. (2013) creates indexes based on individual's responses to questions such as, "Do you struggle to keep up with your debts?" or, "To what extent do you agree with the statement that, to get ahead in life, you must take some risks?" These indexes are then employed as explanatory variables in OLS regressions that estimate participants' level of deposits in the PLS product.

demonstrate that higher risk tolerance is positively related to PLS demand, and the introduction of the PLS program did not cannibalize existing savings of PLS holders. Guillen and Tschoegl (2002) discuss anecdotally how PLS accounts at two example banks in Latin America have successfully catered towards lower-income customers and a market with many individuals outside the banking system altogether.

Kearney et al. (2010) provide an overview of the two main PLS programs tested out in the U.S. in recent years. Centra Credit Union in Indiana launched the first-ever PLS pilot program in the U.S. with support from the non-profit Doorways to Dreams (D2D) in 2006 as a "no purchase required" sweepstakes in order to avoid legal barriers banning private lotteries.[6] Over the course of the first three months of launching the program, 1,300 individuals (1.3 percent of the credit union's member base) enrolled in the program and $500,000 in deposits was amassed. Because of the small scale of the pilot program, however, monthly prize drawings were quite small in value, which limited the program's long-term success. A larger program involving eight credit unions was piloted in Michigan in 2009. Officially named "Save to Win," the project was intended to be temporary experiment and ran for eleven months. Unlike the Centra pilot, this larger program in Michigan was able to limit participants strictly to depositors (and thereby stay true to the lottery element of PLS programs) because of a

[6] Because Indiana state regulations forbid the hosting of lotteries by financial institutions, Centra Credit Union launched its PLS pilot program as a "no purchase necessary sweepstakes" in which individuals could register for an account, make no deposits into the account, and still be eligible for both a quarterly prize that doubles an account holder's deposits up to $1,000 and an annual prize of $5,000. Only depositors who have positive levels of deposits were eligible for the monthly prize drawings, which offered numerous smaller prizes and one $1,000 top prize (Maynard 2007).

unique stipulation in Michigan state law that allows "savings promotion raffles" to be run by credit unions.[7] With its scale, "Save to Win" was able to offer a $100,000 grand prize and brought in 11,600 depositors over the course of the eleven months, amassing over $8.6 million in deposits.[8] Participants were surveyed at the conclusion of the program, and the results indicated that more than half of participants did not save regularly prior to "Save to Win," almost 40 percent had total financial assets of less than $5,000, and almost 60 percent had spent money on the state lottery in the past six months. Thus, corroborating both evidence from South Africa's "Million-a-Month" program and PLS programs in Latin America, Michigan's "Save to Win" program provides some empirical evidence that suggests PLS programs in the U.S. would appeal to the lower-income, low-savings, lottery-playing demographic.

2.2 Premium Bonds in the U.K.

As previously mentioned, PBs were first introduced in 1956 as a means of encouraging savings after World War II. In line with the "Savings with a thrill!" tag-line, Prime Minister Macmillan reasoned that PBs would appeal to those who are not attracted by the "rewards of interest, but do respond to the incentives of

[7] As cited by Kearney et al. (2010), Section 411 of the Michigan Credit Union Act allows state-charted credit unions to run "raffle(s) conducted by a domestic credit union where the sole consideration required for a chance of winning designated prizes is the deposit of at least a specified amount of money in a savings account or other savings program offered by the domestic credit union." See Michigan Compiled Laws § 490.411.

[8] Since the publishing of the work by Kearney et al. (2010), the "Save to Win" program has expanded, both in Michigan (where the program was continued past the eleven month pilot) and in credit unions across three more states (Nebraska in 2012, North Carolina in 2013, and Washington in 2013) that passed laws allowing for savings promotion lotteries. As of the end of 2013, over 50,000 credit-union members had over $94 million deposited across 62 credit unions in the four states (Save To Win 2015).

fortune" (Tufano 2008). By the end of November 1, 1956 (the first day PBs were offered to the market), more than £5 million worth of PBs had been sold. Their popularity has grown steadily since then, with more than £48 billion deposited by the end of fiscal year 2014 and an estimated 21 million U.K. citizens holding some amount of deposits as PBs (NS&I 2014a). All deposits are held by the U.K.'s government-run savings organization, National Savings & Investments (NS&I).

Many changes took place between 1956 and the present in terms of requirements for minimum investment, rules limiting the maximum amount of PBs held by any individual, and top-prize offerings given away monthly. A detailed historical timeline of these changes can be found in Section A.1 of the Appendix. Today, the rules regarding PB ownership are as follows:[9]

- Any U.K. resident 16 years of age and older is eligible to purchase PBs. Parents or grandparents can also purchase PBs in the name of their children or grandchildren.
- Purchases can be made online or via telephone using a debit or credit card. Alternatively, a form can be filled out by hand and mailed in along with a check.

[9] All of these current rules regarding PB ownership are taken from NS&I's brochure, "Premium Bonds: A Winning Way to Save" (NS&I 2014b).

- Each new or additional investment in PBs must be at least £100 in value, or £50 if purchased through a recurring monthly standing order.[10]
- Individuals can hold up to £40,000 in PBs (as of June 1, 2014; up from £30,000).
- Money held as PBs is 100 percent secure because NS&I is backed by Her Majesty's Treasury.
- Bonds must be held for one full calendar month following the month in which you made the original purchase in order to be eligible for the prize draw (i.e., PBs purchased in June will first become eligible for the August draw).
- The same winning bond can win again in a different month in the future.
- PBs can be cashed-in (i.e., withdrawn) in multiples of £1 at any time, free of charge, via telephone or online without need for prior notice. Funds will be electronically transferred to a user-nominated bank account.
- Monthly winnings and withdrawals are free from both all U.K. taxes, such as the Income Tax and Capital Gains Tax.

In terms of the logistics of the prize draw that takes place each month, winning PB numbers are selected at random using ERNIE (Electronic Random

[10] As we will see in our dataset, many individuals hold PBs in values smaller than £100. This is both because rules regarding minimum initial investment were changed gradually from £1 to £100 from 1972 to 1993. See Section A.1 of the Appendix for more historical information.

Number Indicator Equipment), which was invented in 1956 by one of the original Bletchley Park code breakers from World War II. ERNIE has undergone multiple series of upgrades to improve speed of random-number generation, but continues the same basic function of generating random numbers, ensuring that all PB numbers (whether eight, nine, ten, or eleven digits long) have an equal chance of selection.[11] In order to ensure the randomness of ERNIE's output each month, the Government Actuary's Department (GAD) does an independent verification prior to the release of the winning numbers each month.

Alongside the many changes that have taken place historically in the requirements and rules regarding PB ownership, both the total amount of funds invested into PBs and the corresponding monthly prize payouts have seen significant growth (and more recently, fluctuations) over time. Figure A.1 and Table A.1 in Appendix Section A.1 show five-year snapshots of the growth in both the total amount invested as PBs and the corresponding monthly prize payouts. As seen in Figure A.1, the total amount invested as PBs has grown almost exponentially since 1992, having risen from just over £2.4 billion to over £44 billion in 2012 (NS&I 2009; NS&I 2014a). Over the same period, monthly prizes have grown from £12.8 million per month to £55.2 million.[12] While prize payouts generally follow the same growth trend as total investments, fluctuations

[11] NS&I current uses ERNIE 4, which generates the almost two million winning PB numbers in under two-and-a-half hours. The original ERNIE used in 1957 for the first prize draw took 52 days to complete the random-number generation (NS&I 2014b).

[12] The monthly prize value was as high as £118 million in June of 2007. As explained in the following paragraph, total monthly prize values are determined both by the total amount invested as PBs and the prize-fund interest rate, which peaked at 3.25–3.40 percent between August 2005 and November 2008 (NS&I 2009).

do arise as a result of variations in both the prize-fund interest rate and odds ratio, which we define next.

NS&I follows three separate steps to determine prize payouts each month. First, the total value of the prize fund is calculated for the given month. Second, the total number of prizes to be given out is calculated for the given month. And then, third, the total prize fund is allocated to the determined number of prizes following a particular formula. In order to determine the total value of the prize fund in a given month, a forecasted value for the total value of PB investments in the month of the drawing is multiplied by one month's value of the prize fund interest rate (i.e., one-twelfth of the annual prize-fund rate, which is set by the Treasury). Over the past decade, the prize-fund interest rate has varied from as high as 3.4 percent to as low as 1.0 percent in the heart of the recent recession. In order to determine the total number of prizes distributed in a given month, the total number of PB units (i.e., the value of total PB investments in British pounds) is divided by a specified number called the "odds ratio," which is also set by the Treasury. In the past ten years, the odds ratio has varied from as low as 24,000 to 1 to as high as 36,000 to 1 during the recent recession. Table A.2 in Section A.1 of the Appendix lists the changes to both the prize-fund interest rate and the odds ratio over the past decade. The prize-fund interest rate tumbled 2.4 percentage points from May 2008 to April 2009 (and has been on a slow upward climb since) and the odds ratio was raised to 36,000 to 1 from December 2008 to October 2009—both reactions to the recent economic downturn.

After determining both the total value of the prize fund in a given month and the total number of prizes to be distributed, NS&I follows a particular

formula in allocating the prize fund to different prize values ranging from £25 prizes to the two £1 million prizes. A forecasted prize payout schedule for the January 2015 draw is shown in Table A.3 in Section A.1 of the Appendix. As seen in the table, there are three prize bands (high, medium, and low value), into which 7 percent, 5 percent, and 88 percent of the total monthly prize fund are paid, respectively (NS&I 2015).[13] Moreover, it is evident that the number of prizes increases exponentially as the prize values get smaller. Section A.1 of the Appendix describes the prize-fund allocation process in more detail.

Each month, NS&I matches the random-number output of ERNIE with eligible PB numbers in descending order of prize value. PB holders can check whether or not they have won each month by using the online "Prize Checker" tool or using the "Official Prize Checker" app developed by NS&I for smartphones. Depending on the value of the prize, winners have several ways of claiming their winnings. For prizes smaller than £5,000, PB holders can choose to have winnings directly deposited into the PB holder's bank account, automatically reinvested in more PBs, or sent as a check in the mail. For prizes with values of £5,000 and up, a claim form will be mailed to the PB holder before the money is transferred. In the event that a PB holder wins one of the two £1 million jackpots, an NS&I "Agent Million" will visit the lucky winner in person.

[13] The Treasury determines the fraction of the total monthly prize fund paid into each of the three prize bands; changes (very minor) occur in these fractions over time.

2.3 Theoretical Model of Savings Behavior

In order to provide a theoretical framework upon which we will build our predictions and our later analysis, we will outline a basic model of utility maximization to show some comparative statics of characteristics that in theory should lead one person to choose to save using a more risky PLS product, such as PBs over a safer savings product, such as a riskless Income Bond (also offered by NS&I) or a regular savings/deposit account.

As proposed by some of the earliest decision theorists in the eighteenth century, utility can be modeled as a concave function of money (Bernoulli 1738). This concavity is a direct result of both the assumption of risk aversion and the decreasing marginal utility of money or wealth.[14] We assume in our formulation of our basic model of savings behavior that individuals' utility functions take on the functional form of the Arrow-Pratt constant relative risk aversion (CRRA) utility function (Arrow 1965; Pratt 1964):

$$u(x) = \begin{cases} \dfrac{x^{(1-\alpha)} - 1}{1 - \alpha} & \text{if } \alpha \neq 1, \text{where } \alpha(t_i, c_i) \\ \ln(x) & \text{if } \alpha = 1 \end{cases} \tag{1}$$

Here, x is the amount of money held by an individual and α is a measure of an individual's risk aversion, which we define as a function of both an individual's inherent risk tolerance (t_i) and her level of financial constraint (c_i).[15] As seen in

[14] To clarify, an individual is defined as being risk averse if she prefers the certain prospect of receiving some amount n to a risky prospect with expected value n.

[15] In the CRRA utility function, a higher α indicates a higher degree of risk aversion. When $\alpha = 0$, we say that the individual is risk neutral. When $\alpha < 0$, we say that the individual is risk loving.

Figure A.2 in Appendix Section A.2, this set of utility functions becomes more concave for higher values of α. This indicates that, given a choice between some guaranteed level of return and a risky option, the expected return of the risky option necessary for an individual to choose the risky option over the guaranteed return is higher for more risk-averse individuals. In the finance literature, this is equivalent to saying that, when faced with the same risky prospect, the certainty equivalent of the risky payoff is lower for a more risk-averse individual than for a more risk-tolerant individual (Bodie et al. 2011).

As explained in more detail in Appendix Section A.2, classical expected-utility theory cannot explain fully why individuals put their savings into a risky product that has an expected return not very different from the guaranteed return of other savings products. One alternative explanation, which we will discuss next, may be that individuals are less risk averse than we predict. Another explanation, which we will discuss later in this section, has to do with behavioral misperceptions of the probability of winning a prize in a PLS product.

As cited by Hartley & Walker (2013), most of the literature that employ expected-utility theory estimate individuals' degrees of risk aversion (α) to be between 0.3 and 3.0, but as shown through work by both Chetty (2006) and Hartley & Walker (2013), more recent estimates of the average individual's degree of risk aversion place the value at around 1.0. While a certain portion of an individual's degree of risk aversion likely stems from some innate behavioral preferences and risk tolerance (t_i), the literature suggests that a separate portion of an individual's degree of risk aversion can be explained by her level of financial constraint (c_i), which we define as a combination of low levels of discretionary

income and high incidence of debt. As cited by Iverson et al. (2013), the potential winnings from a PLS product offer individuals an opportunity to dramatically alter their financial circumstances at the very low cost of depositing some relatively small sum of savings—an opportunity that those who are the most financially constrained, such as the most indebted or least wealthy, find the most valuable and the most worthwhile upon which to gamble (Ng 1965).[16] Thus, financial constraint, which is typically viewed as a function of an individual's budget constraint, manifests itself here as part of the individual's degree of risk aversion. As discussed by Ng (1965), those who are the most financially constrained will in turn tolerate more risk in order to given themselves this financially life-changing opportunity. All of this points to the notion that less risk-averse individuals will be more likely to save using a risky PLS product. Having given a functional form to the utility functions we will use in our basic theoretical model of savings behavior, we continue by defining this model in more detail.

We specify the model as a two-period model in which an individual faces two concurrent decisions. She must decide both *how much* of her income to allocate in period one as savings for use in period two and *where* to invest that

[16] Ng (1965) explains in his paper, "Why Do People Buy Lottery Tickets? Choices Involving Risk and the Indivisibility of Expenditure," that because the "indivisibility of expenditure"—a concept referring to the idea that various expensive goods (e.g., a car, a house, a college education, etc.) can only be purchased in whole, discrete quantities—manifests itself most strongly amongst the lowest income and most financially constrained individuals, these individuals are willing to tolerate more risk and become more eager to buy into gambles that would allow them to change their expenditure possibilities. While some economists have argued against the idea of an "indivisibility of expenditure" by citing the ability for individuals to borrow money or buy less expensive substitutes to some of these goods requiring indivisible expenditures (e.g., buying a used car instead of that brand new sports car), there still seems to be an argument made for the validity of "indivisibility" for lower and lower-middle class individuals because their financial constraints also often limit their ability to borrow money or pay back existing loans (McCaffery 1994).

savings amount in order to maximize total utility. For the purposes of this simplified model, the individual only has two savings products from which to choose: a safe-return savings product with a guaranteed rate of return and a risky-return PLS product. The savings choice model is given by:

$$\max \begin{cases} \max_{s} U = u\big[(m_i - s) + (1 - \beta_i) \cdot \big(1 + q_i(l_i) \cdot \bar{r}_{safe}\big) \cdot s\big] & (2) \\ \max_{s} \mathbb{E}[U] = s \cdot \tilde{p}_i \cdot u[(m_i - s) + (1 - \beta_i) \cdot (s + W)] + & (3) \\ \qquad (1 - s \cdot \tilde{p}_i) \cdot u[(m_i - s) + (1 - \beta_i) \cdot (s)] \end{cases}$$

where m_i is the earnings in period one, s is the amount of savings put aside in period one for use in period two, β_i is the individual's discount rate, q_i is a behavioral misperceptions function, l_i is a measure of the financial literacy of a given individual, $\bar{r}_{safe}$ is the after-tax return on the safe-return product, $\tilde{p}_i$ is the individual's *perceived* probability of winning a prize from holding one unit of the PLS product, and W is the value of the winning prize.[17] We assume in the model that the individual does not receive additional earnings in period two. We also assume that there is only one prize of some winning prize value (W), which a PLS holder who owns a single unit of the PLS product has some actuarial probability (p) of winning.[18]

[17] The weights attached to the two utility scenarios in (3) are specified as $s \cdot \tilde{p}_i$ and (1 – $s \cdot \tilde{p}_i$) because the probability of winning a prize is proportional to s, the amount of PLS deposits.

[18] As described in the Background Section 2.2 and Table A.3 in the Appendix, PB payouts are of a multi-prize structure and thus, the expected utility function in a more representative model would need to account for the probabilities of winning different prize values. Given that one bond can only win one prize per monthly draw, the expected utility can still be described as a simple probability-weighted summation of individual prize winnings. For simplicity's sake, we ignore the *perceived* probability and instead use the actuarial probability (p) of winning one prize from holding one PB. Thus, a more representative model can be specified as:
$\mathbb{E}[U] = s \cdot p \cdot \sum_{j=1}^{n} U\big[(m_i - s) + (1 - \beta_i) \cdot \big(s + W_j\big)\big] + (1 - n \cdot s \cdot p) \cdot U[(m_i - s) + (1 - \beta_i) \cdot (s)]$
where we assume that there are n prizes of possibly different values.

The first savings choice (2) is a safe-return savings product that guarantees a rate of return (r_{safe}) in period two. Since these returns are taxable—a key difference from tax-free PLS products such as PBs—and tax rates faced by an individual are dependent upon an individual's income (m_i), the after-tax (τ) return ($\bar{r}_{safe}$) on the safe-return product is given by:[19]

$$\bar{r}_{safe} = (1 - \tau(m_i))r_{safe} \tag{4}$$

The after-tax return on the safe-return product is weighted by a behavioral misperceptions function (q_i) that reflects various theories in the literature, which suggest that those with lower levels of financial literacy (l_i) may be unable to understand the returns to compound interest offered by other savings products, and thus find the idea of winning a large prize by chance more appealing (Iverson et al. 2013). The literature on savings behavior makes use of financial-literacy measurements primarily by measuring how indicators such as knowledge of interest compounding, ability to perform basic mathematical calculations, and awareness of tax and macroeconomic policies positively impact an individual's planning for retirement, which manifests as more savings held (Lusardi & Mitchell 2007). As discussed by both Iverson et al. (2013) and Lusardi & Mitchell (2007), however, financial literacy may also impact an individual's

[19] In the fiscal year 2006–2007 (the year from which our data comes from), individuals in the U.K. had a personal allowance of £5,035, which meant that any gross income beyond that allowance counted towards taxable income. The first £2,150 of taxable income is taxed at the "starting rate" of 10 percent, taxable income £2,151–33,000 is taxed at the "basic rate" of 22 percent, and taxable income £33,001 and over is taxed at the "higher rate" of 40 percent (Institute for Fiscal Studies 2015).

choice of savings product, since one might expect those with lower financial literacy to prefer saving using a PLS product over a safe guaranteed interest-bearing product, because the financial return from a chance at winning a large prize is easier to comprehend than the intricate return calculations necessary for understanding compound interest. The behavioral misperceptions function (q_i) is decreasing in lower levels of financial literacy, which captures this preference toward PLS products that arises from an under-valuing, or misperception of the value, of returns offered by savings products that bear compound interest.

In both (2) and (3), utility in period one is a function of the individual's income (m_i) minus her savings (s). Moreover, in both (2) and (3), utility in period two is multiplied by a factor ($1 - \beta_i$), which is one minus the individual's discount rate (β_i), which measures an individual's rate of time preference, or how an individual weighs intertemporal tradeoffs in utility.[20] We expect those with higher individual discount rates to place higher value on utility and consumption in the present, which means we expect them to save less relative to those with lower individual discount rates.

While we model the safe-return savings choice (2) as a standard utility function, we model the risky-return PLS choice (3) as an expected-utility function. The second (3) savings option is a risky-return PLS product representative of PBs in such that the initial savings amount (s) is secure as the principal while the return on the PLS product is stochastic. Thus, in the risky-return choice (3), we weight each of the two possible outcomes by the total

[20] The idea of time preference being represented by a discounted utility model is the standard model in intertemporal choice theory and follows from the work of Paul Samuelson in his 1937 paper, "A Note on Measurement of Utility" (Frederick 2002).

perceived probability of each one occurring, which is the perceived probability ($\tilde{p}_i$) multiplied by the amount of the PLS product held (s). We use a *perceived* probability rather than the true actuarial probability to account for behavioral misperceptions. As we outline in Section A.2 of the Appendix, together with the possibility that some individuals may inherently have significantly higher levels of risk tolerance than others, behavioral misperceptions may best explain why individuals buy into risky-return PLS products—a behavior that classical expected-utility theory cannot ordinarily explain.

We specify this *perceived* probability of winning a prize from holding one unit of the PLS product as:

$$\tilde{p}_i = w_i(p) \cdot p \tag{5}$$

The perceived probability is the actuarial probability scaled by a second behavioral misperceptions function (w_i), which is itself a function of the actuarial probability of winning a prize (p). This function (w_i) is greater than one for very low probabilities (p). We specify our model to include this second behavioral misperceptions function to capture existing behavioral economic theories, which suggest that individuals tend to over-weigh low probability events (Kahneman & Tversky 1992). As shown by Kahneman & Tversky (1979) in their landmark paper explaining Prospect Theory, individuals under-weigh moderate and high probabilities of an event occurring, but over-weigh low probabilities.[21] They

[21] For a graphical representation of the hypothetical weighting function used by individuals in determining their decision weights under risk, please see Appendix Section A.4 for the original

observe that the under-weighing of moderate and high probabilities contributes to an individual's risk aversion in gains and explains why, when given the choice between receiving $240 for sure and taking on a gamble of winning $1,000 with 25 percent chance, the vast majority of individuals choose the former despite the latter option's higher expected return. When faced with very low probabilities, however, individuals' over-weighing of those stated probabilities leads to risk-seeking behavior in the face of improbable gains, which—as cited by Kahneman & Tversky—contributes to the attractiveness of lottery tickets. The behavioral misperceptions function (w_i) captures this over-weighing effect.

Thus, once an individual chooses the level of savings (s) that maximizes utility under each savings product option, she will then compare the total utility offered to her by each savings product and choose the one that provides higher total utility. Thus, an individual will invest in the risky PLS product with her savings only if:

$$\max_s U = U\left[(m_i - s) + (1 - \beta_i) \cdot \left(1 + q_i(l_i) \cdot \bar{r}_{safe}\right) \cdot s\right] \tag{2}$$

$$\leq$$

$$\max_s \mathbb{E}[U] = s \cdot \tilde{p}_i \cdot U[(m_i - s) + (1 - \beta_i) \cdot (s + W)] + (1 - s \cdot \tilde{p}_i) \cdot U[(m_i - s) + (1 - \beta_i) \cdot (s)] \tag{3}$$

Conversely, she will invest in the safe-return savings product if (2) gives higher total utility than (3).

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figure used by Kahneman and Tversky in their 1979 paper, "Prospect Theory: An Analysis of Decision under Risk."

Although our model of utility maximization under a choice between two savings products is very simplified, it provides some comparative statics from which we can develop a basic framework of predictions and expectations regarding consumer-savings choice when given an option to save using a PLS product such as PBs. Our model predicts the following:

- Those who fall into a higher tax bracket are more likely to save using PBs because of the tax-free nature of returns on PBs. The safe-return savings product will be significantly less attractive for an individual who falls into a higher tax-rate bracket because the after-tax return ($\bar{r}_{safe}$) will be much lower for her.
- Those who are unable to fully comprehend the value proposition of compound interest paid out by other savings products and in turn under-weigh the returns from compound interest because of insufficient financial literacy (l_i) are more likely to save using PBs because of the relatively ease with which winning a large prize in a lottery-style setting can be understood.
- Those who misperceive and inflate the actuarial probability (p) of winning a prize under the PB prize payout structure are also more likely to save using PBs. This likely results from general behavioral tendencies to over-weigh low probability events through a *perceived* probability ($\tilde{p}_i$)—in which case the expected return on the risky-return savings product is overstated.
- Those who are less risk averse are more likely to save using PBs. This occurs either because an individual has an inherently higher level of risk

tolerance (t_i) or because her financial constraint (c_i) puts her in a risk-seeking state of desperation.

Through the analysis in this paper, we will attempt to offer empirical evidence from the data to demonstrate how these numerous theories behind the simple model perform in practice.

3

Data Description and Summary Statistics

3.1 Wealth and Assets Survey (WAS) 2006–2008

The dataset that we use in this study comes from the U.K. Data Archive's Wealth and Assets Survey (WAS), which is a longitudinal survey that currently provides three waves of data spanning 2006–08, 2008–10, and 2010–12. We will only use the first wave in this study (using it as a cross-sectional dataset), which surveyed 30,595 households comprised of 71,182 total individuals in the period July 2006 through June 2008. The survey aims to gauge household wealth across all private households in Great Britain and thus excludes individuals who reside in communal establishments such as retirement homes, prisons, hotels and residence halls, as well as homeless people. The survey questionnaire consists of two parts—a household schedule and an individual schedule. The household schedule is mainly about the number and demographics of individuals in the household, as well as residence and household assets. Our analysis makes use of the individual schedule, which is given to each adult 16 years and over not currently in school and asks about economic status, education, employment, assets, attitudes towards saving and debt, retirement, and financial assets. Because the dataset was

collected in part to conduct a detailed analysis of the wealthiest segments of the population, those in the top overall wealth decile were oversampled. In order to adjust for this upwards bias in wealth measurements, a probability weight is used in all calculations throughout this study.[22]

The WAS provides an ideal dataset for our analysis because it asks a detailed set of questions regarding types and amounts of savings held, amounts of other financial assets held, demographics of the responder, and behavioral attitudes toward risk, debt, and financial literacy. In order to determine an individual's total financial assets, the WAS runs through a comprehensive list of assets, asking individuals questions regarding their current accounts, savings or deposit accounts, Individual Savings Accounts (ISAs), fixed-term investment bonds, personal equity plans (PEPs), unit and investment trusts, employee shares or options, Premium Bonds (PBs), government or corporate bonds and gilts, life insurance policies, and endowments. The dataset also includes rich demographic data on the age, sex, income, and education of respondents. In order to measure an individual's net income in our analysis, we sum up incomes from employment in her first and second jobs, as well as from self-employment. To allow for non-linearity in the effects of education, we parse the sample into three educational attainment categories including (1) completed compulsory schooling, (2) completed senior high school, and (3) has higher education.[23] We also match

[22] The survey was designed so that household addresses in wealthier regions had a higher chance of selection than others. To compensate for this upwards bias in wealth, the probability weight used in the dataset was calculated to equal the reciprocal of the address selection probabilities (UKDA WAS User Guide Vol. 1).

[23] In order to place individuals into the three educational attainment categories, we derive a years of education measure from the survey question that asks individuals the age at which they completed their education by subtracting five from this response. Those with nine to eleven years

individuals' gross-income levels with U.K. tax code from the 2006–2007 fiscal year in order to categorize individuals as falling into one of three tax brackets—the "starting rate" of 10 percent, the "basic rate" of 22 percent, or the "higher rate" of 40 percent (Institute for Fiscal Studies 2015).

The distinguishing factor that really sets the WAS apart from other financial wealth surveys is its inclusion of a wide array of behavioral questions pertaining to attitudes toward risk, debt, and financial literacy. As discussed in Section 2.3, individuals who have a higher individual discount rate tend to save less because of their relatively higher valuation of utility and consumption in the present. Although it is a somewhat crude measurement, the WAS offers insight into each surveyed individual's discount rate by asking the question, "Given choice of receiving £1,000 today or £1,100 in a year's time, which would you choose?" Those who chose £1,000 today discount at a rate greater than ten percent, while those who chose £1,100 in a year's time discount at a rate lower than ten percent. Thus, we can include a binary variable of high versus low discounting in our analysis.

As we will later discuss in the Methodology and Results section, we model the work done by Iverson et al. (2013) and create three indexes that measure and individual's risk tolerance, financial literacy, and financial constraint. To measure

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of schooling constitute the "completed compulsory schooling" category. Compulsory schooling laws in the U.K. currently require schooling until age sixteen—changed from fifteen since 1972 and fourteen since 1918. ("Education Leaving Age" 2012). Twelve to thirteen years constitutes the "completed senior high school" category. Finally, those with fourteen or more years of education fall into the "has higher education" category.

risk tolerance, we generate a Risk Tolerance Index, which is derived from one survey question:[24]

- "Given choice between guaranteed payment of £1,000 and a 1 in 5 chance of winning £10,000, which would you choose?"

To measure financial literacy, we create a Financial Literacy Index, which is derived from three questions:[25]

- First, "If you were to rate your mathematical skills for daily life, would you say they are (1) excellent, (2) good, (3) moderate, or (4) poor?"
- Second, "On a scale of 1 to 5, 1 meaning you strongly agree and 5 meaning you strongly disagree, how would you rate the statement, 'I tend to shop around for the best deal on interest rates?'"
- And third, "Have you heard of any changes, in the last 12 months, in government policy relating to savings or investments?"

To measure financial constraint, we create a Financial Constraint Index, which is also derived from three questions:[26]

- First, "In the past 12 months, how often have you had money left over at the end of the week or month? Would you say it was (1) always, (2) most of the time, (3) sometimes, (4) hardly ever, or (5) never?"
- Second, "What is the total amount outstanding on your credit cards?"

[24] The Risk Tolerance Index ranges 0.0–1.0. Please see Appendix Section A.3 for more details about the composition of the index.
[25] The Financial Knowledge Index ranges 0.0–3.0. Please see Appendix Section A.3 for more details about the composition of the index.
[26] The Financial Constraint Index ranges 0.0–3.0. Please see Appendix Section A.3 for more details about the composition of the index.

- And third, "What is the total amount overdrawn on your current accounts?"

For a more detailed explanation of the construction of these indexes, please consult Section A.2 in the Appendix. Along with the rich demographic variables and information regarding how much and which of the many financial assets each individual holds, these behavioral questions and their corresponding indexes offer a uniquely multifaceted representation of each individual in the WAS.

3.2 General Summary Statistics

Table 1 presents some summary statistics for the overall sample by grouping individuals into one of three mutually exclusive groups based on holdings of various types of "safe-savings" products. We define "safe-savings" products as those that expose the principal to minimal/zero risk, can be withdrawn with ease and speed, and are accessible to medium and lower-income individuals. Of the various financial assets included in the questionnaire, we classify three main savings products as "safe savings"—namely, savings/deposit accounts, Cash Individual Savings Accounts (ISAs), and PB holdings.[27] To avoid confusion, we contrasted PBs with a "safe-returns savings product" in the "Theoretical Model of Savings Behavior" in order to distinguish between the safe and risky natures of the *returns* on the products. We categorize PBs as "safe savings" because the

[27] Assets included under "safe savings" were selected from the eleven financial asset categories covered by the WAS (i.e., current accounts, savings or deposit accounts, Individual Savings Accounts (ISAs), fixed-term investment bonds, personal equity plans (PEPs), unit and investment trusts, employee shares or options, Premium Bonds (PBs), government or corporate bonds and gilts, life insurance policies, and endowments).

Table 1

Summary Statistics and Difference of Means

	Mean	*Mean*			*Test of difference (p-values)*	
	Whole Sample	*Holds PBs*	*Other Savings Only*	*No Safe Savings*	*Holds PBs vs. Other Savings*	*Holds PBs vs. No Safe Savings*
% of sample in group	*1.00*	*0.14*	*0.48*	*0.38*		
Age	42.2	46.8	41.6	37.5	0.00***	0.00***
Years of Education	12.7	13.2	13.1	12.1	0.00***	0.00***
Percent Female	0.52	0.51	0.52	0.48	0.05**	0.00***
Total Safe Savings	10,189	21,328	10,070	0	0.00***	0.00***
Total Financial Assets	26,154	49,110	22,971	3,265	0.00***	0.00***
% of sample in group	*1.00*	*0.16*	*0.50*	*0.34*		
Percent chose Risky Option[1]	0.23	0.27	0.23	0.20	0.00***	0.00***
Percent chose High Discount Rate[2]	0.79	0.73	0.76	0.85	0.00***	0.00***
% of sample in group	*1.00*	*0.15*	*0.54*	*0.31*		
Net Income[3]	12,379	19,313	17,332	13,642	0.00***	0.00***

Notes: Sample is composed of Wave 1 of UKDA's Wealth and Assets Survey spanning 2006–2008 with n = 42,220. "Holds PBs" group includes both individuals who hold *both* PBs and other safe savings, and those who only hold PBs. These two subgroups were combined because those who only hold PBs represent 2 percent of the sample. Other safe savings includes both savings/deposit accounts and Cash ISA accounts. "Risky Option" denotes choosing one-in-five chance of receiving £10,000 over receiving £1,000 for certain. "High Discount Rate" denotes choosing £1,000 today over £1,100 in one year. * significant at 10%, ** significant at 5%, *** significant at 1%.

[1]"Risky Option" means calculated using n = 33,499 because of non-response.

[2]"Discount Rate" means calculated using n = 33,639 because of non-response.

[3]"Net Income" and "Total Safe Savings" means calculated using n = 25,844 because only includes individuals currently in workforce (i.e., employed, unemployed, self-employed).

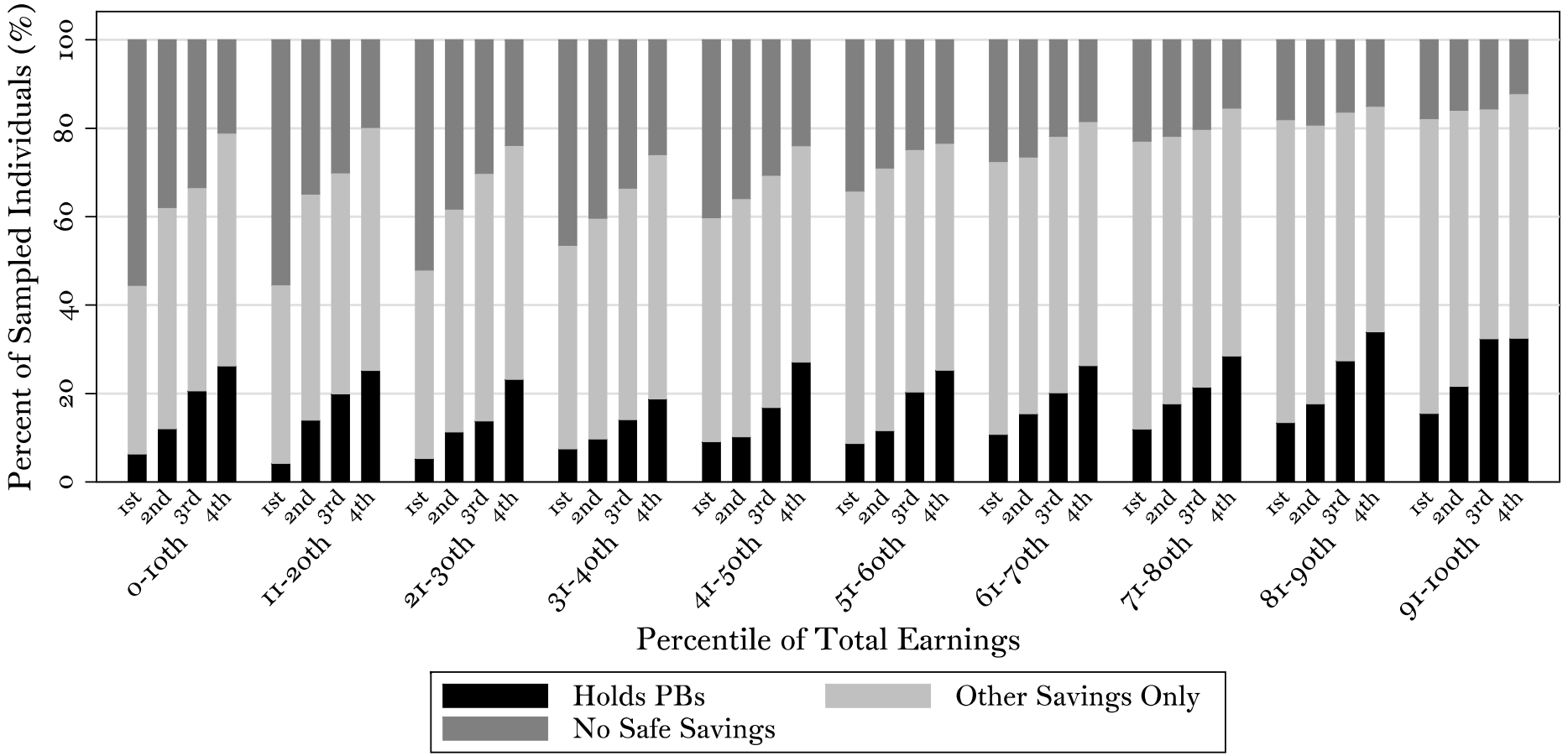
principal faces minimal/zero risk, PB holdings can be withdrawn easily, and PBs are accessible to medium- and lower-income individuals.

The first group in the Table 1 consists of both individuals who hold PBs and some other safe savings and those who only hold PBs.[28] The second group consists of individuals who only hold some other safe savings, but not PBs. The third group consists of individuals who hold no safe savings at all. Table 1 reports group means of age, years of education, percent female, total safe savings, total financial assets, and net income. Moreover, it also reports the percent of individuals in each group who preferred a one-in-five chance of receiving £10,000 over receiving £1,000 for certain (denoted as "risky option") and the percentage of individuals in each group who preferred £1,000 today over £1,100 in one year (denoted as "high discount rate").

The summary statistics table describes some general trends in the data. On average, PB holders are older, have more years of education, have more total safe savings, hold more total financial wealth, and earn more money than both those who only have other safe-savings products and those who have no savings at all. Moreover, in terms of individuals' responses to the behavioral/attitude questions, PB holders are also more risky and discount at a lower rate than the other two groups, on average. Given the uncertain nature of the returns from PBs, it makes sense that PB holders are more risk tolerant than those who only have safe savings. A difference of means or proportions test is included in Table 1 testing

[28] This first group is not split up into individuals who (1) hold PBs *and* some other safe savings and (2) only hold PBs because individuals who only hold PBs without holding any other safe savings make up less than two percent of the sample (i.e., if you hold PBs, you almost certainly also hold other safe-savings products).

Figure 1
Fraction of Individuals within Safe-Savings Categories
by Age Quartile and Total Earnings Decile

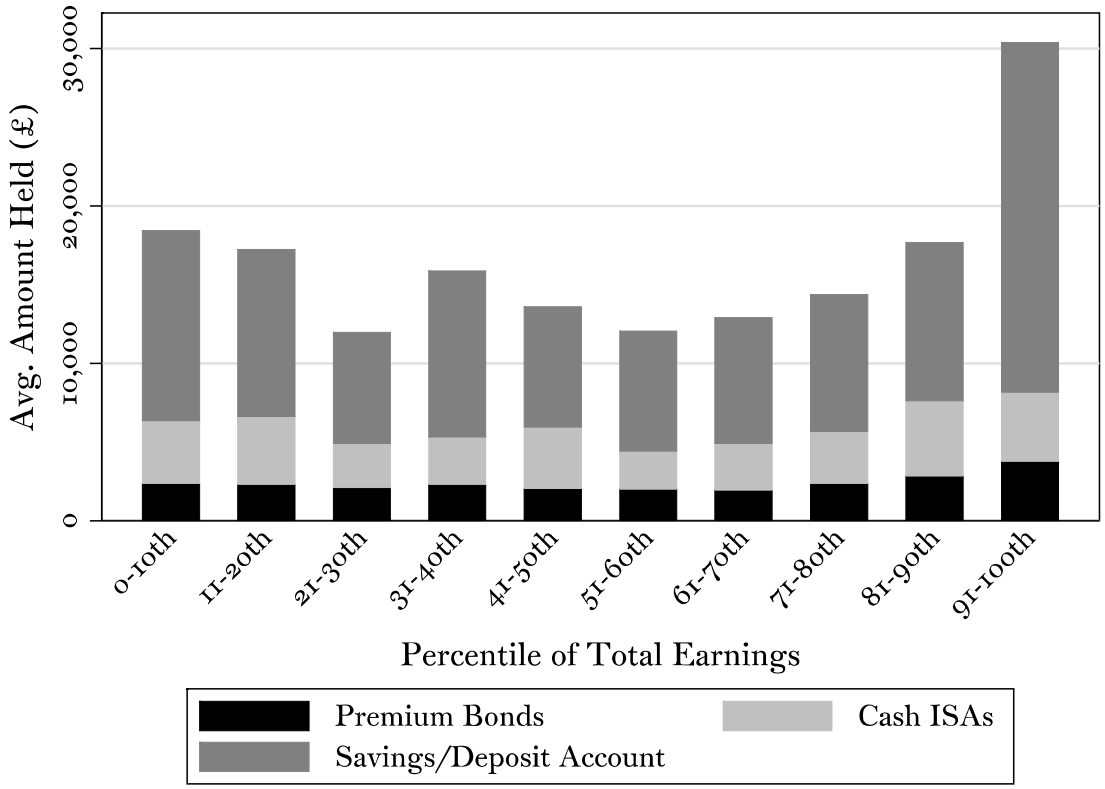


Notes: Sample is composed of Wave 1 of UKDA's Wealth and Assets Survey spanning 2006–2008 with n = 42,220. Age quartiles denoted by 1st through 4th with 1st being the youngest quartile. "Other Savings" includes both savings/deposit accounts and Cash ISA accounts.

both the difference between the first and second group (holds PB vs. other safe savings only) and between the first and third group (holds PB vs. no savings). All differences were significant at the 1 percent level, with the exception of the difference in proportion being female between the first and second group, which was significant at the 5 percent level.

In order to better understand safe-savings behavior in the sample, we illustrate the fraction of individuals that belong to each of the three groups from Table 1 broken down by total earnings decile in Figure 1. Within each earnings

Figure 2
Average Amount of Safe Savings Held by PB Holders
by Total Earnings Decile



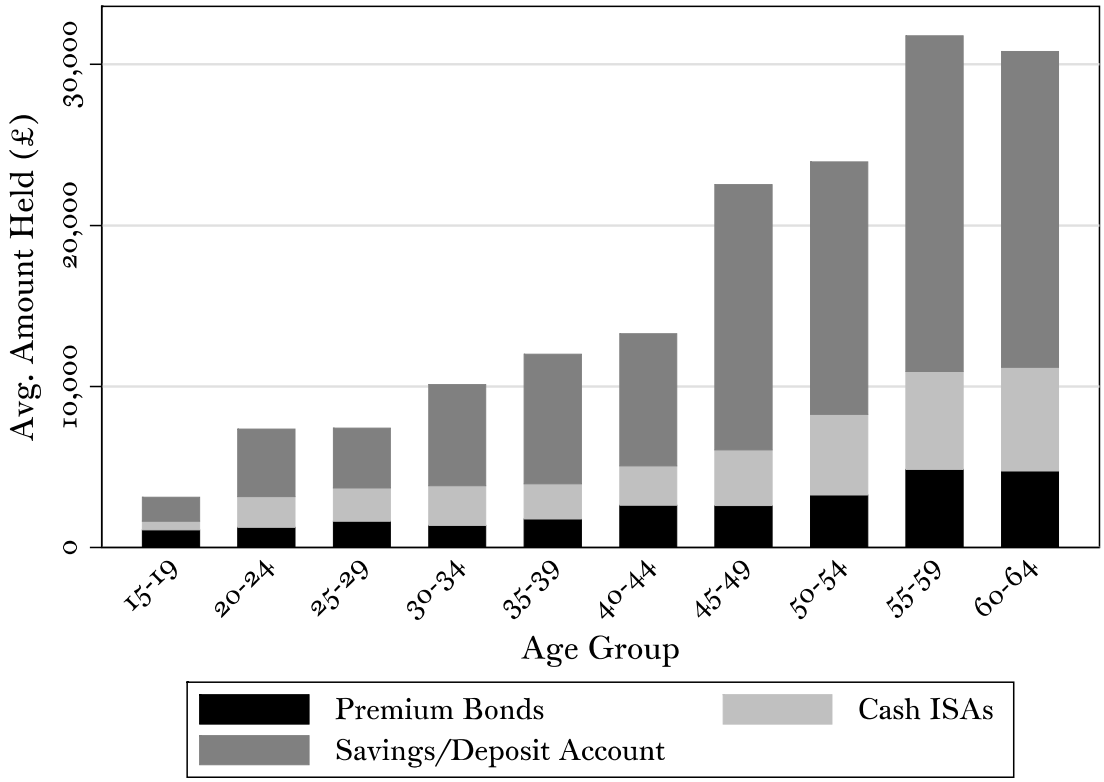
Notes: Sample is composed of Wave 1 of UKDA's Wealth and Assets Survey spanning 2006–2008 with n = 6,659. Only includes those who hold PBs.

decile, we further break down the observations by age quartile. The figure shows that PB ownership is fairly independent of earnings, as the fraction of individuals holding PBs (controlling for age quartile) only increases slightly in the top two or three deciles. There does appear to be a positive relationship between earnings deciles and fraction of individuals holding safe-savings products other than PBs, which also implies that the fraction of individuals holding no safe savings decreases concurrently at higher earnings deciles.

On the other hand, PB ownership is highly correlated with age. We see that across all earnings deciles, the fraction of individuals holding PBs is higher for older cohorts in an almost linear fashion. Looking instead at the *level* of PBs held, Figures 2 and 3 illustrate the average amount of PBs held, broken down by total earnings deciles and age groups, respectively. Figure 2 shows that the average amount held as PBs is relatively even across the earnings distribution, with an uptick only at the highest three deciles.[29] Figure 3 shows that not only does PB ownership increase linearly with age, but the average level of PBs held also grows almost linearly across the age groups.

[29] While examining Figure 2, it may at first appear counterintuitive for those at the lowest earnings deciles to have average total safe savings higher or roughly equal to others in the first eight earnings deciles. However, it is important to note that whereas total savings tend to grow continuously throughout the typical individual's working age life cycle (as shown in Figure 3), an individual's annual earnings tend to be more parabolic (convex) in shape, typically peaking sometime in the middle of his/her working age life cycle. According to a study by the n the U.K. Department of Social Development, the highest average income by age group is achieved in the 30–34 age band for women, 35–39 for men. As seen in Figure A.4 in Section A.5 of the Appendix, our data reflects the same story. Thus, it is likely that average savings in some of the lower earnings deciles are biased upwards by older individuals.

Figure 3
Average Amount of Safe Savings Held by PB Holders
by Age Group



Notes: Sample is composed of Wave 1 of UKDA's Wealth and Assets Survey spanning 2006–2008 with n = 6,659. Only includes those who hold PBs.

Tables A.6 and A.7 in Appendix Section A.7 provide more general summary statistics of the key variables from the WAS. Both tables break down the sample by financial wealth halves. Table A.6 provides means, standard deviations, minima, and maxima for the key variables, and Table A.7 provides the correlations between each of the variables.

4

Methodology and Results

This paper aims to answer four main empirical questions. First, what characteristics of an individual predict whether someone will take advantage of PBs over (or perhaps, in addition to) more traditional safe-savings products? Second—as a follow up to the first question—what determines the level of PB holdings of an individual? Third, looking specifically at the income and wealth distribution, to what extent do PBs cater towards lower-wealth groups and are PB savings "regressive" in a similar fashion to spending on traditional lotteries? And fourth, given similar demographic and behavioral characteristics, do those who hold PBs have more total safe savings than those who only save using traditional savings products?

4.1 Predicting Characteristics of PB Holder: the Probit Model

4.1.1 Basic Probit Model

In order to begin answering the first question of what characteristics of an individual best predict whether someone will invest in PBs over more traditional

safe-savings products, we employ a Probit model.[30] The basic model is specified with a dummy for holding PBs as the dependent variable and multiple demographic-type explanatory variables including age, age-squared, dummies for the two higher (out of three) educational attainment levels, dummy for female, other safe savings, and net income. We include the age-squared variable and the educational attainment categories to allow for more flexibility in the estimates, since we do not want to restrict either the age effects or education effects to being linear.[31] Since our aim is to accurately estimate the characteristics that best predict whether someone will invest in PBs *over more traditional safe-savings products*, we restrict the sample to only include PB holders and holders of other safe savings (i.e., we exclude those in the sample that have no safe savings).[32] The results of this basic Probit model are reported in the first column of Table 2, which shows the marginal effects at the means for the explanatory variables. We find that an increase of one year in age corresponds to a 0.7 percent increase in the likelihood of holding PBs.[33] Moreover, being female corresponds to a 1.6

[30] Because our aim is to calculate the likelihood of holding PBs given a certain set of explanatory variables and because our dependent variable is binary, we employ a Probit model rather than a simple OLS.

[31] In fact, it is common practice in life cycle economic models of savings and consumption behavior to assume a convex relationship between savings and age, mirroring the relationship between life cycle earnings and age.

[32] For the full output of the Probit model employed in Table 2, please see Table A.6 in Appendix Section A.8, which includes all observations instead of leaving out the non-saver group.

[33] Throughout this paper, the marginal effect at the means for the age variable is calculated as $\beta_1 + 2\beta_2 \cdot \mu_{age}$, where β_1 and β_2 are the marginal effect at the means for the age and age-squared variables, respectively, and μ_{age} is the mean age for the sample (which equals 43.6 for the models with 23,745 observations and 44.1 for the models with 11,726 observations). The different observation sizes result from missing behavioral variables for some observations (because the WAS allowed for spouses to answer demographic questions on their significant other's behalf, but not behavioral questions, since those pertain to personal preferences).

Table 2

Probit Model of Probability an Individual will Hold PBs
Conditional on Having Safe Savings

Dependent Variable: *Dummy for Holding PBs*	(1)	(2)	(3)
	Marginal Effects at Means		
Age	0.0075***	0.0071***	0.0089**
	(0.0024)	(0.0024)	(0.0036)
Age^2	-0.0000	-0.0000	-0.0000
	(0.0000)	(0.0000)	(0.0000)
Education Categories:			
Senior High	0.0801***	0.0796***	0.0764***
	(0.0099)	(0.0099)	(0.0143)
Higher Education	0.0785***	0.0764***	0.0616***
	(0.0091)	(0.0093)	(0.0135)
Female	-0.0161**	-0.0137*	0.0104
	(0.0071)	(0.0074)	(0.0109)
Other Safe Savings	0.0043***	0.0043***	0.0036**
	(0.0013)	(0.0012)	(0.0017)
Net Income	0.0008	-0.0001	-0.0008
	(0.0009)	(0.0008)	(0.0011)
Tax Bracket Categories:			
Middle Tax Bracket		0.0062	-0.0083
		(0.0083)	(0.0119)
High Tax Bracket		0.0331*	-0.0128
		(0.0200)	(0.0265)
High Discount Rate			-0.0080
			(0.0119)
Risk Tolerance Index			0.0385***
			(0.0118)
Financial Literacy Index			0.1134***
			(0.0127)
Financial Constraint Index			-0.0199*
			(0.0108)
Observations	15,957	15,957	8,016
Pseudo R-squared	0.04	0.04	0.05

Notes: Sample is composed of Wave 1 of UKDA's Wealth and Assets Survey spanning 2006–2008. Only includes individuals with some safe savings (i.e., excludes non-savers). "Other Safe Savings" includes savings/deposit accounts and Cash ISA accounts. "Middle Tax Bracket" indicates falling into the "basic rate" bracket of 22% tax; "High Tax Bracket" indicates falling into the "higher rate" bracket of 40% tax. "High discount rate" denotes choosing £1,000 today over £1,100 in one year. "Risk Tolerance," "Financial Literacy," and "Financial Constraint Indexes" all generated by author (see text of paper for description). * significant at 10%, ** significant at 5%, *** significant at 1%.

percent decrease and an increase of £10,000 in holdings of other safe savings corresponds to a 0.4 percent increase in the likelihood of holding PBs. The correlation between net income and the likelihood of holding PBs is insignificant, as Figure 1 already suggested. In terms of the likelihood of holding PBs across education categories, compared to those who only completed compulsory education, those who completed senior high are 8.0 percent more likely, and those who have some form of higher education are 7.9 percent more likely. Further t-tests indicate that the difference between the senior high and higher education groups is insignificant.

4.1.2 Expanded Basic Probit Model (with Tax Bracket Dummies)

We find in the basic Probit model that the effect of net income on the propensity to invest in PBs is insignificant. However, because our Theoretical Model of Savings Behavior predicts that higher tax bracket individuals are more incentivized to purchase PBs because of their tax-free status, we expand upon the basic model and include dummies for the two higher (out of three) tax brackets. The second column of Table 2 reports marginal effects at the means from this expanded basic Probit model. The effects of an increase of one year in age, an increase of £10,000 in holdings of other safe savings, and being female do not change much from the results in column one. The effect of net income remains insignificant. The likelihood of holding PBs across education categories does not change much either and differences between the senior high and higher education groups remain insignificant. Compared to those in the lowest tax bracket, those in the middle tax bracket are not significantly more likely to hold PBs. However,

those in the high tax bracket are 3.3 percent more likely to hold PBs than those in the lowest tax bracket. Further t-tests show that the effect is also significantly higher for high tax bracket individuals when compared to those in the medium tax bracket. Thus, we see some evidence that higher tax bracket individuals—at least, those in the highest tax bracket—have a higher propensity to hold PBs.

4.1.3 Full Probit Model (with Behavioral Variables)

To elaborate on this model and make use of the behavioral questions asked by the WAS, we then run the same expanded basic Probit model, but also include a dummy for preferring a high discount rate as well as the three indexes—modeled after work done by Iverson et al. (2013)—that measure risk tolerance, financial literacy, and financial constraint. The third column of Table 2 reports the marginal effects at the means from this full Probit model. The effects on the likelihood of holding PBs from an increase of one year in age and from an increase of £10,000 in holdings of other safe savings do not change much from the results in the first two columns. The likelihood of holding PBs across education categories also remains largely the same and differences between the senior high and higher education groups remain insignificant. Having controlled for the behavioral variables, we see that all differences across tax brackets become insignificant.[34] We also observe that the negative effect of the female dummy observed in the first two columns becomes insignificant. In terms of the

[34] Although, as seen in the third column of Table A.6 in Section A.8 of the Appendix, when we include non-savers into the sample, both middle and high tax bracket individuals are significantly more likely to hold PBs than those in the lowest tax bracket. This likely occurs because the majority of non-savers fall into the lowest tax bracket, which creates wider differences across tax brackets, in terms of the likelihood of holding PBs.

behavioral variables themselves, we see that the coefficient on the discount rate dummy is insignificant, those who are more risk tolerant are significantly more likely to hold PBs, those who are more financially literate are significantly more likely to hold PBs, and those who are more financially constrained are significantly less likely to hold PBs.[35]

4.2 Estimating Level of PB Holdings: the Tobit Model

4.2.1 Background on the Tobit Model

As a follow-up to the Probit model, which identifies the characteristics that help predict whether an individual will save using PBs, we also explore the question regarding determinants of the level of PB holdings. As shown in the summary statistics of Table 1, only roughly 15 percent of the surveyed population holds PBs, which means that a vast majority of those surveyed report zero PB holdings. Such a data scenario constitutes a censored regression application, but, as clarified by Wooldridge (2009), a distinction must be made between typical censored regressions and corner solution models, both of which create problems for using an OLS model.[36] The observations of zero PB holdings are only

[35] Because the three indexes were created to fit arbitrarily-set scales, the actual values of the coefficients on the three indexes only provide information in terms of the positive or negative direction of the effect, not the size of the effect. In other words, they serve an ordinal rather than a cardinal purpose in our analysis.

[36] A standard censored regression involves true censoring in that a variable with a quantitative meaning is only observed as some limited number because of censoring from above or below, which means that the true value is not observed in the data for part of the population. For example, in some datasets, an individual's annual income—if very high (say, over $1 million)—will be censored and recorded as $1 million. In our dataset, however, using the term "censoring" is a bit misleading because an individual's PB holdings is an observable choice outcome and those who choose the corner solution of holding zero PBs actually did make that choice because it leads to an optimal solution to their individual maximization problem. It is not a problem of data observability, but rather a problem of a significant pooling of observations at one limit of values

"censored" observations in the sense that one cannot typically observe negative spending on such a product, which is why we only observe the corner solution of zero spending. However, it is not inconceivable that there is a latent demand hidden beneath the observation of zero spending that is actually negative (Cameron & Trivedi 2009). Our PB holdings data calls for Tobit analysis (a model first devised by Tobin in 1958) because it is assumed in Tobit models that the dependent variable has a number of its values clustered at a limiting value, usually zero. The Tobit technique allows for the use of all observations in the sample—both those at the limit and those above it—to estimate a regression result and not only addresses the econometric issues faced by an OLS model when dealing with a corner solution model, but is also generally preferred to alternative techniques that provide estimates using only observations strictly above the limit, such as an OLS conditional on an individual holding some positive amount of PBs (McDonald & Moffitt 1980).[37] Thus, we employ a Tobit model in analyzing the determinants of an individual's level of PB holdings.

As indicated by Cameron and Trivedi (2009), Tobit models are better suited to model dependent variables that are more symmetrically distributed and have more normal kurtosis. Because roughly 85 percent of individuals in our sample

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(namely, at zero). As Wooldridge (2002) shows, this characteristic of a large number of corner solution observations is problematic for incorporating OLS models because the expected value of the dependent variable is no longer a linear function of the explanatory variables and OLS assumes linearity. Please see Wooldridge (2002) for more detailed econometric theory.

[37] Alternative techniques such as restricting an OLS to only include individuals holding positive amounts of PBs systematically ignores the zeroes and will result in bias when estimating means and regression coefficients. Including all observations and taking the zeroes at face value will result in an over-estimate in the mean of the dependent variable and a bias in estimation because there are almost for certain individuals with a latent demand hidden beneath the observation of zero spending that is actually negative.

are corner solution observations and—as seen in Figure A.5 in Section A.6 of the Appendix—of the 15 percent of individuals who do hold PBs, half hold less than £200 worth and 80 percent hold less than £5,000 worth, our data on PB holdings is highly skewed to the right with very abnormal kurtosis.[38] In order to correct for this skewness and abnormal kurtosis, we transform the level of PB holdings variable by taking its natural logarithm and use this log-level of PB holdings as the dependent variable in our Tobit analysis.[39] However, since our corner cases occur at a level of zero PB holdings and the natural logarithm of zero is negative infinity, we need to manually adjust the value of the log-level of PB holdings for these observations. Following the procedure of Cameron and Trivedi (2009), we set the log-level of PB holdings for these non-PB holders equal to a value just below the lowest non-censored log-level of PB holdings, which is zero (the natural log of £1).[40]

Tobit models require the specification of lower or upper limits at which censoring (or, in our analysis, corner cases) takes place. After our manual manipulation of the log-level of PB holdings variable, we can set the lower limit to $1x10^{-7}$, indicating that those with zero PB holdings are part of the corner solution set. Our analysis requires a second limit, however—an upper limit—because the rules governing PB ownership limit any individual's PB holdings to

[38] The skewness of the level of PB holdings variable conditional on being positive is 2.42, where a skewness of 0 indicates no skewness (i.e., symmetrically distributed like a normal distribution). The kurtosis of the level of PB holdings variable conditional on being positive is 7.71, where STATA uses a kurtosis of 3 to indicate normal (no excess) kurtosis.

[39] Once transformed by taking the natural logarithm, the log-level of PB holdings variable has a skewness of -0.06 and a kurtosis of 2.18, which is a significant improvement on the original variable.

[40] Specifically, we set the log-level of PB holdings for non-PB holders equal to $-1x10^{-7}$, following the procedure outlined by Cameron and Trivedi (2009).

£30,000 or less. As seen in Figure A.5 of the Appendix, there is also a significant (albeit much smaller) concentration of corner solution observations at this £30,000 limit as many individuals who would otherwise purchase more than £30,000 in PBs are constrained to this amount solely by the rules. Thus, when employing the Tobit model in our analysis, we will specify both a lower and an upper censoring limit.

Like the three Probit models we estimated previously, we estimate three Tobit models beginning first with demographic-type explanatory variables, then adding tax brackets, and finally adding the set of behavioral variables. In all three models, the dependent variable is the log-level of PB holdings and the upper and lower censoring limits are in place. Rather than reporting the direct results of the Tobit output—which show the marginal effects at the mean of the latent dependent variable, which Wooldridge (2009) shows has little meaningful interpretation in the context of corner solution models—we report the marginal effects at the mean of the log-level of PB holdings for the uncensored (positive PB holdings) observations. The results of these three Tobit models are reported in the three respective columns of Table 3.

Table 3

Tobit Model of Determinants of Level of PB Holdings (in Natural Logs)

Dependent Variable: Log-Level of PB Holdings	(1)	(2)	(3)
	Marginal Effects at Means of Uncensored Log-Level PB Holdings		
Age	0.0736***	0.0507***	0.0331
	(0.0179)	(0.0181)	(0.0253)
Age^2	-0.0002	0.0001	0.0002
	(0.0002)	(0.0002)	(0.0002)
Education Categories:			
Senior High	1.0088***	0.9677***	0.8708***
	(0.0729)	(0.0729)	(0.0989)
Higher Education	1.1778***	1.0900***	0.7948***
	(0.0693)	(0.0701)	(0.0974)
Female	-0.1546***	-0.0277	0.1801**
	(0.0564)	(0.0582)	(0.0802)
Other Safe Savings (£10,000)	0.0668***	0.0671***	0.0600***
	(0.0063)	(0.0063)	(0.009)
Net Income (£10,000)	0.0369***	0.0052	-0.0096
	(0.0094)	(0.0117)	(0.0161)
Tax Bracket Categories:			
Middle Tax Bracket		0.5643***	0.3708***
		(0.0672)	(0.0905)
High Tax Bracket		0.8962***	0.4969**
		(0.1630)	(0.2239)
High Discount Rate			-0.2309***
			(0.0893)
Risk Tolerance Index			0.3380***
			(0.0878)
Financial Literacy Index			1.2714***
			(0.0951)
Financial Constraint Index			-0.5881***
			(0.08)
Observations	23,745	23,745	11,726
Pseudo R-squared	0.02	0.03	0.04

Notes: Sample is composed of Wave 1 of UKDA's Wealth and Assets Survey spanning 2006–2008. Please see "Notes" of Table 2 for description of explanatory variables. Tobit models use lower censoring limits of $-1x10^{-7}$ and upper limits of 10.3089 (the natural log of £30,000). Marginal effects calculated at mean of log-level of uncensored PB holdings observations.
* significant at 10%, ** significant at 5%, *** significant at 1%.

4.2.2 Basic Tobit Model

As seen in the first column—in terms of their effect on the level of PB holdings—an increase in age by one year corresponds to a 7.2 percent increase, being female corresponds to a 15.5 percent decrease, an increase of £10,000 in holdings of other safe savings corresponds to an 6.7 percent increase, and an increase of £10,000 in net income corresponds to a 3.7 percent increase. Thus, while net income is a poor predictor of an individual's propensity to save using PBs over other safe-savings products, it is a significant predictor of the level of PB holdings. In terms of the level of PB holdings across education categories, compared to those who only completed compulsory education, those who completed senior high hold 101 percent more, and those who have some form of higher education hold 118 percent more.[41] Further t-tests indicate that the higher education group is also significantly more likely to hold PBs than the senior high group.

4.2.3 Expanded Tobit Model (with Tax Bracket Dummies)

After including the tax bracket dummies into the model, we see in column two of Table 3 that the effects of an additional year of age and an increase of £10,000 in

[41] While it is common practice when running log-linear models to use the coefficients to approximate (by multiplying the coefficient by 100) the percent change in the dependent variable from a one unit increase in the explanatory variable, this relies upon the assumption that this percent change is small. This follows from the mathematical derivation that shows that $\ln(x + \Delta x) - \ln x \cong \Delta x x$ when $\Delta x x$ is small (Stock & Watson 2007). Given the large coefficients on the education categories, simply multiplying the coefficients by 100 will overstate the actual percent change in the dependent variable. For the purposes of this paper, however, and in the interest of brevity, we will report the coefficients as given. Moreover, although these estimates will still seem very large even after adjusting for the overstatement, their size is likely due to the very skewed distribution of PB holdings. Given that half of PB holders hold less than £200 as PBs and 80 percent hold less than £5,000 (as seen in Figure A.5 in the Appendix), doubling the current holdings of an individual only requires a relatively low amount of additional PBs.

holdings of other safe savings do not change much from the results in column one. The level of PB holdings does not change much across education categories either. Compared to those who completed compulsory education, those who completed senior high hold 96.8 percent more PBs, and those who have some form of higher education hold 109 percent more PBs.[42] Differences between the senior high and higher education groups become insignificant, as shown through a t-test. By controlling for tax brackets, we see that the previously significantly negative effect of being female becomes insignificant and the effect of net income also becomes insignificant. Compared to those in the lowest tax bracket, those in the middle tax bracket hold 56.4 percent more PBs and those in the high tax bracket hold 89.6 percent more PBs. Further t-tests show that the effect is significantly higher for high tax bracket individuals when compared to those in the medium tax bracket.

4.2.4 Full Tobit Model (with Behavioral Variables)

The third column of Table 3 shows the marginal effects of the Tobit model after including the behavioral variables. The positive effect of age on the level of PB holdings observed in the first two columns becomes insignificant once we control for behavioral differences. The effect of an increase of £10,000 in holdings of other safe savings does not change much from the results in the prior two columns.[43] Across education categories, we see that those who completed senior

[42] See previous footnote for comments on the large size of these coefficients.

[43] The inclusion of "other safe savings" as an explanatory variable raises possible concerns of endogeneity, since it is conceivable for there to be omitted variables (for example, personal preferences such as level of conservativeness in consumption/savings behavior or outside factors such as the existence of wealthy relatives from whom individual may expect to receive

high or have some higher education hold 87.1 percent and 79.5 percent more PBs than those who completed compulsory education. A t-test shows that the difference between the senior high and higher education groups remains insignificant. Interestingly, having controlled for the behavioral variables, the female coefficient turns significantly positive, indicating that females hold 18.0 percent more in PBs than their male counterparts. The effect of net income remains insignificant, just as in column two, and compared to those in the lowest tax bracket, those in the middle tax bracket hold 37.1 percent more PBs and those in the high tax bracket hold 49.7 percent more PBs. Differences between the middle and higher tax bracket groups become insignificant, as shown through a t-test. In terms of the behavioral variables themselves, we see that those who discount at a higher rate hold 23.1 percent fewer PBs, those who are more risk tolerant hold significantly more PBs, those who are more financially literate hold significantly more PBs, and those who are more financially constrained hold significantly fewer PBs.[44]

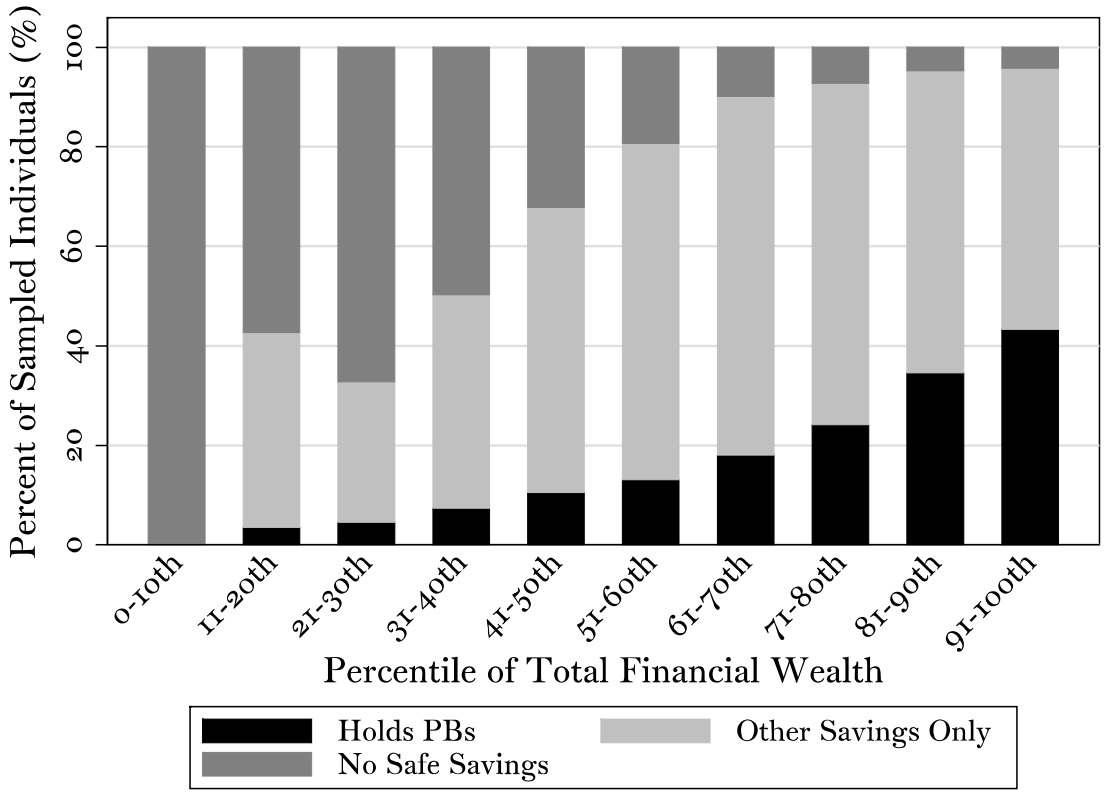
endowments) in the error term that are correlated with both levels of "other safe savings" and levels of PB holdings. The fact that we observe minimal change in the coefficient on "other safe savings" even after controlling for various behavioral preference factors provides some reassurance that this possible endogeneity problem is not too severe.

[44] As explained in a footnote in the Probit results Section 4.1.3, because the three indexes were created to fit arbitrarily-set scales, the actual values of the coefficients on the three indexes only provide information in terms of the positive or negative direction of the effect, not the size of the effect. In other words, they serve an ordinal rather than a cardinal purpose in our analysis.

4.3 PBs and Wealth Inequality: Probit and Tobit by Wealth Groups

4.3.1 Graphical Illustration of PBs and Financial Wealth

Figure 4
Fraction of Individuals within Safe Savings Categories
by Total Financial Wealth Decile



Notes: Sample is composed of Wave 1 of UKDA's Wealth and Assets Survey spanning 2006–2008 with n = 42,220. "Other Savings" includes both savings/deposit accounts and Cash ISA accounts.

In order to answer the third main question of the extent to which PBs cater towards lower-wealth groups and the potential "regressive" nature of PBs (regressive in a fashion similar to spending on traditional lotteries), we first use some figures to describe PB holdings in terms of total financial wealth.[45] Figure 4

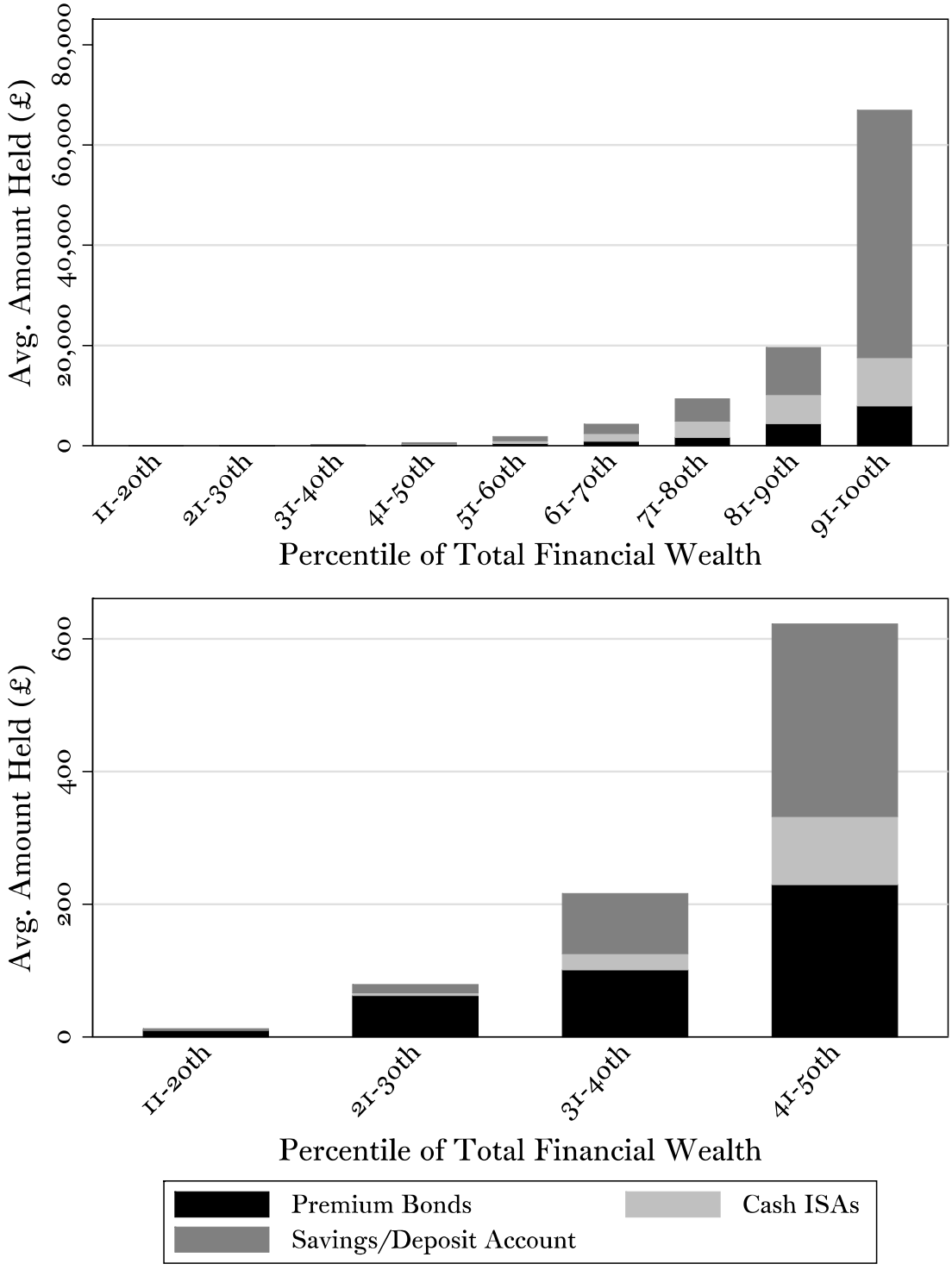
[45] "Total financial wealth" is defined as the sum of the eleven financial asset categories covered by the WAS (i.e., current accounts, savings or deposit accounts, Individual Savings Accounts

shows the fraction of individuals that belongs to each of the three groups from Table 1, broken down by total financial wealth decile. By comparing Figure 4 with Figure 1, we see that by breaking down the sample by financial wealth rather than by earnings, there is a clear positive relationship between level of financial wealth and percent of individuals who hold PBs. The relationship is almost linear, ranging from 4 percent of those in the second lowest decile to 43 percent of those in the highest decile.[46] Thus, it appears that it is the wealthiest individuals who take the most advantage of PBs as a savings product. Figure 5 shows the average amount of the three safe-savings products held by individuals, also broken down by financial wealth decile. While the top panel shows that wealthier individuals have more of all types of savings, on average, the bottom panel takes a closer look at the bottom half of the financial wealth distribution. It appears that as one moves down the distribution toward lower wealth deciles, PBs more and more dominate the composition of savings in each decile. In fact, a simple tabulation shows that in the fifth decile, PB holdings make up 36 percent of total safe savings, on average, compared with 79 percent in the second decile and 11 percent in the tenth decile. Thus, while a higher fraction of the wealthiest individuals makes use of PBs, of those who do save using PBs, the least wealthy are most dependent upon PBs as their means of saving.

(ISAs), fixed-term investment bonds, personal equity plans (PEPs), unit and investment trusts, employee shares or options, Premium Bonds (PBs), government or corporate bonds and gilts, life insurance policies, and endowments).

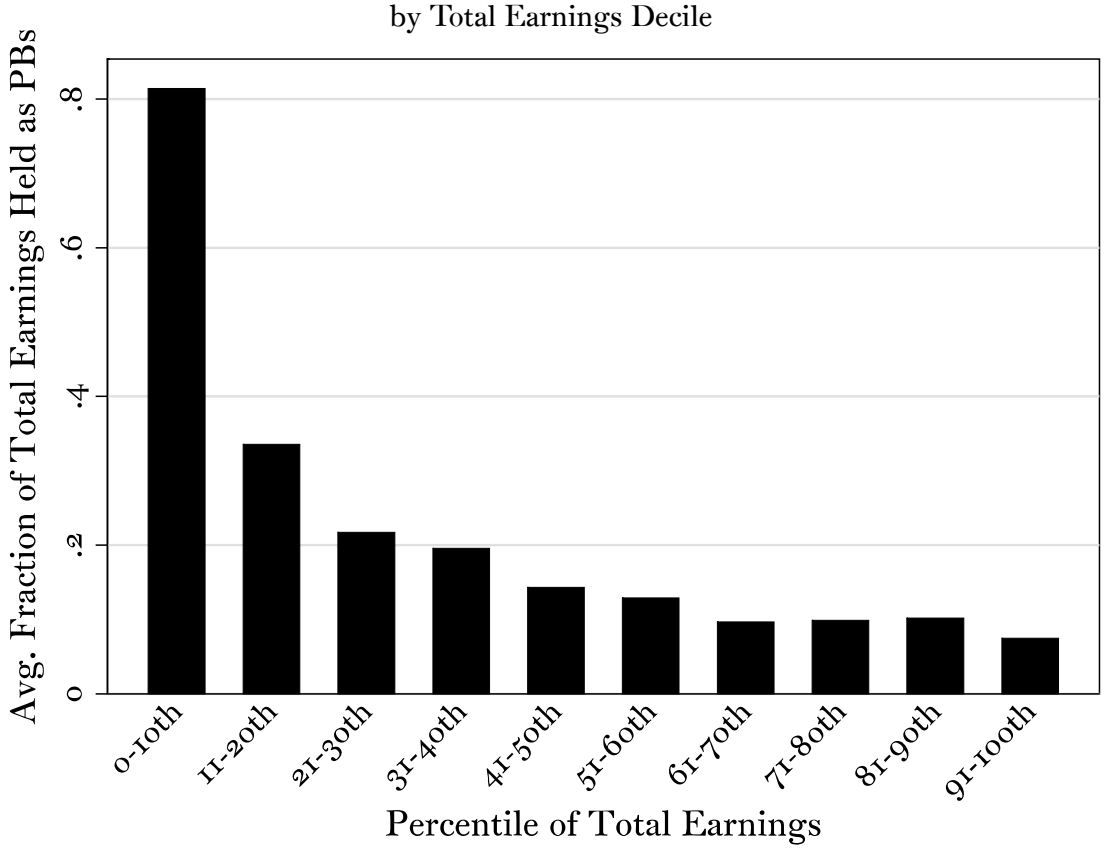
[46] We report the second lowest total financial wealth decile because over one-tenth of the sample hold no form of safe savings at all and thus, no observations in the lowest financial wealth decile hold PBs.

Figure 5
Average Amount of Safe Savings Held by PB Holders
by Total Financial Wealth Decile



Notes: Sample is composed of Wave 1 of UKDA's Wealth and Assets Survey spanning 2006–2008 with n = 6,659. Only includes those who hold PBs. Second panel only shows first five "Total Financial Wealth" deciles. The 0-10th percentile bar is missing in both panels because more than one-tenth of the sample holds zero safe savings.

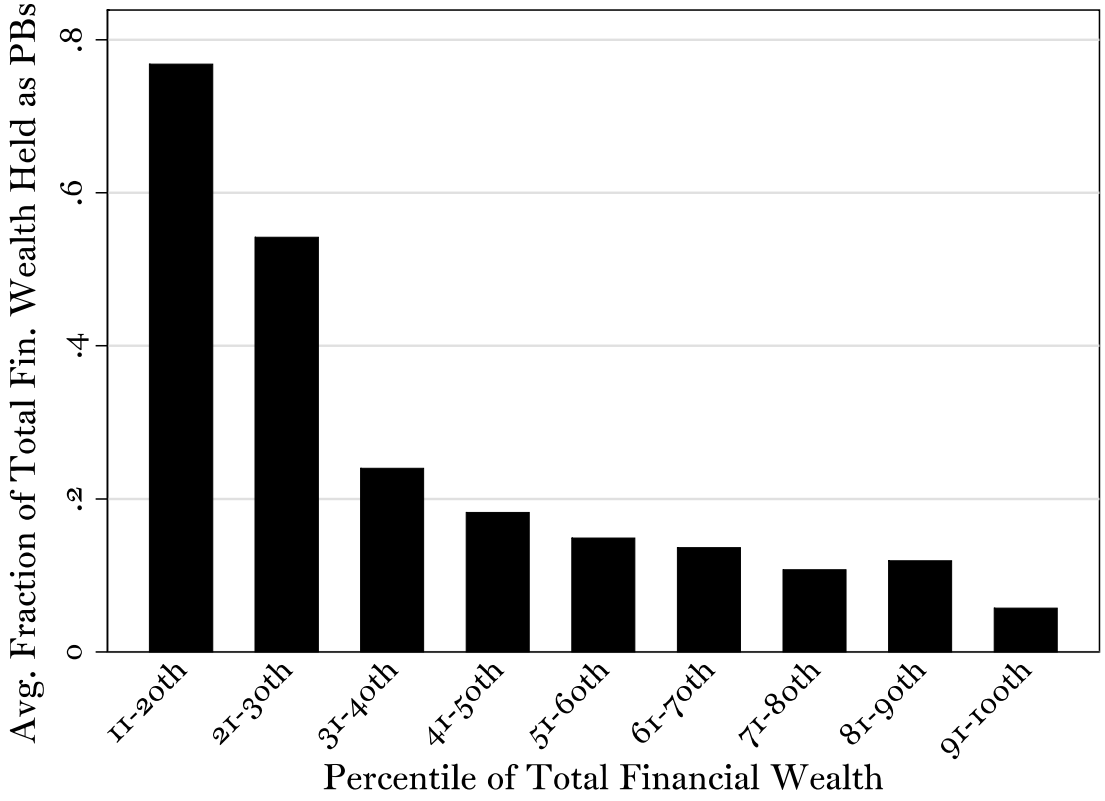
Figure 6
Average PB Holdings as Fraction of Total Earnings
by Total Earnings Decile



Notes: Sample is composed of Wave 1 of UKDA's Wealth and Assets Survey spanning 2006–2008 with n = 6,659. Only includes those who hold PBs.

Figures 6 and 7 explore the "regressive" nature of PBs by illustrating the average fraction of earnings held as PBs by earnings decile and the average fraction of total financial wealth held as PBs by financial wealth decile, respectively. As can be seen in Figure 6, those with the lowest income save a higher fraction of their income as PBs than those at higher incomes. As seen in Figure 7, those with the lowest financial wealth hold a higher fraction of their financial wealth as PBs than those at higher levels of financial wealth. Thus, similar to how the poorest individuals in society spend a much larger proportion

Figure 7
Average PB Holdings as Fraction of Total Financial Wealth
by Total Financial Wealth Decile



Notes: Sample is composed of Wave 1 of UKDA's Wealth and Assets Survey spanning 2006–2008 with n = 6,659. Only includes those who hold PBs.

of their income on lottery tickets, individuals with the lowest income and financial wealth save a much larger proportion of their income and financial wealth as PBs.

4.3.2 Probit Model by Financial Wealth Halves

Taking a more econometric route in answering the question of whether PBs cater towards lower-wealth groups, we repeat the Probit and Tobit models from our previous analysis, but this time break down the sample into two groups based on which half of the total financial wealth distribution individuals fit into. Table 4

reports the results of the Probit model.[47] In the interest of brevity, we only report two panels of results for each half of the financial wealth distribution—one including the demographic and tax bracket dummies as explanatory variables and another also including the behavioral variables.[48] We add a variable measuring the value of each individual's other financial assets (financial assets other than the three already categorized as safe savings) in order to gauge how variations in individuals' total financial wealth affect their likelihood of holding PBs for individuals within the same financial wealth half.

We observe in the first column of Table 4 that for those in the bottom half of the financial wealth distribution—in terms of their effects on the likelihood of holding PBs—an increase in age of one year corresponds to a 0.4 percent increase, an increase in education of one year corresponds to a 0.4 percent increase, an increase of £10,000 in holdings of other safe savings corresponds to a 94.6 percent decrease, and an increase of £10,000 in other financial assets corresponds to a 23.4 percent increase.[49] The effects of being female and net income are both insignificant. Both the effect of net income and differences

[47] Like in Section 4.1, we again restrict the sample to only include PB holders and holders of other safe savings (i.e., we exclude those in the sample that have no safe savings) because we wish to examine the specific question of what characteristics best predict whether someone will invest in PBs *over more traditional safe-savings products*. For the full output of the Probit model employed in Table 4, please see Table A.7 in Appendix Section A.8, which includes all observations instead of leaving out the non-saver group.

[48] We leave out the age-squared variable because a linear measure of age better fits this particular Probit model. We use a linear measure of years of education instead of the three categorical education dummies for the same reason.

[49] The large coefficients on both the Other Safe Savings and Other Financial Assets variables result from the fact that both are measured in £10,000 increments. For lower-wealth individuals, an increase of £10,000 in either variable is a huge increase when compared to their actual level of holdings for both.

Table 4
Probit Model of Probability an Individual will Hold PBs
Conditional on Having Safe Savings by Total Financial Wealth Halves

	(1)	(2)	(3)	(4)
	Total Financial Wealth Deciles 1–5		Total Financial Wealth Deciles 6–10	
Dependent Variable: Dummy for Holding PBs	Marginal Effects at Means			
Age	0.0036***	0.0036***	0.0062***	0.0063***
	(0.0005)	(0.0007)	(0.0004)	(0.0007)
Years of Education	0.0044**	0.0040	0.0069***	0.0041*
	(0.0022)	(0.0032)	(0.0016)	(0.0023)
Female	-0.0003	-0.0020	-0.0109	0.0231*
	(0.0112)	(0.0162)	(0.0094)	(0.0137)
Other Safe Savings (£10,000)	-0.9457***	-0.9717***	0.0022**	0.0027*
	(0.1535)	(0.2262)	(0.0011)	(0.0016)
Other Financial Assets (£10,000)	0.2339*	0.3272*	0.0023***	0.0013*
	(0.1313)	(0.1902)	(0.0006)	(0.0008)
Net Income (£10,000)	0.0042	0.0108	-0.0007	-0.0013
	(0.0090)	(0.0147)	(0.0009)	(0.0013)
Tax Bracket categories:				
Middle Tax Bracket	0.0129	-0.0147	-0.0091	-0.0182
	(0.0161)	(0.0255)	(0.0108)	(0.0153)
High Tax Bracket	0.0335	-0.0555	-0.0024	-0.0328
	(0.0826)	(0.0706)	(0.0216)	(0.0302)
High Discount Rate		0.0140		-0.0118
		(0.0194)		(0.0146)
Risk Tolerance Index		-0.0023		0.0434***
		(0.0189)		(0.0147)
Financial Literacy Index		0.0563***		0.1288***
		(0.0190)		(0.0160)
Financial Constraint Index		0.0278*		-0.0133
		(0.0152)		(0.0151)
Observations	4,488	2,243	11,469	5,773
Pseudo R-squared	0.03	0.05	0.03	0.04

Notes: Sample is composed of Wave 1 of UKDA's Wealth and Assets Survey spanning 2006–2008. Only includes individuals with safe savings (i.e., excludes non-savers). Please see "Notes" of Table 2 for description of explanatory variables. "Other Financial Assets" includes all financial assets other than safe savings (see text for details). * significant at 10%, ** significant at 5%, *** significant at 1%.

between tax brackets are insignificant. We include the behavioral variables in the second column and see that the effects of age, other safe savings, and other financial assets all remain largely the same as in the first column. Having controlled for behavioral characteristics, the previously positive correlation with additional years of education becomes insignificant. In terms of the behavioral variables themselves, only the coefficients for the Financial Literacy and Financial Constraint Indexes are significant—both being positive.

The third and fourth columns report the results for those in the top half of the financial wealth distribution. We see in the third column that, in terms of their effects on the likelihood of holding PBs, an increase in age of one year corresponds to a 0.6 percent increase, an increase in education of one year corresponds to a 0.7 percent increase, an increase of £10,000 in holdings of other safe savings corresponds to a 0.2 percent increase, and an increase of £10,000 in other financial assets corresponds to a 0.2 percent increase. The effects of being female and net income are insignificant and there are no differences between tax brackets. After including the behavioral variables in the fourth column, we see that the effects of age, years of education, other safe savings, and tax bracket dummies all remain largely unchanged. Having controlled for behavioral characteristics, we observe that females are 2.3 percent more likely to hold PBs and the effect of other financial asset holdings becomes insignificant. As for the behavioral variables, we observe that those who are more risk tolerant are more likely to hold PBs, those who are more financially literate are more likely to hold PBs, and those who are more financially constrained are less likely to hold PBs.

4.3.3 Tobit Model by Financial Wealth Halves

Focusing instead on the determinants of the level of an individual's PB holdings in each of the two financial wealth halves, we employ the Tobit model once more and illustrate the effect that various explanatory variables have on the log-level of PB holdings in Table 5.[50] As with Table 4, we also only report two panels of results for each half of the financial wealth distribution—one including the demographic and tax bracket dummies as explanatory variables and another also including the behavioral variables. Moreover, we again add a variable measuring the value of each individual's other financial assets in order to gauge how variations in individuals' total financial wealth affect their level of PB holdings for individuals within the same financial wealth half.

As seen in the first column of Table 5, for those in the bottom half of the financial wealth distribution, an increase in age of one year corresponds to a 2.0 percent increase in PB holdings, an increase of £10,000 in holdings of other safe savings corresponds to a 957 percent increase in PB holdings, and an increase of £10,000 in other financial assets corresponds to a 352 percent increase in PB holdings.[51] Compared to those who only completed compulsory education, those

[50] We leave out the age-squared variable because a linear measure of age better fits this particular Tobit model.

[51] These estimates may seem questionably large, but it is a direct result of the fact that one unit increases in both represent £10,000 increases, which is a huge increment for both "Other Safe Savings" and "Other Financial Assets" given that this sample is limited to lower-wealth individuals. Also, as previously mentioned, while it is common practice when running log-linear models to use the coefficients to approximate (by multiplying the coefficient by 100) the percent change in the dependent variable from a one unit increase in the explanatory variable, this relies upon the assumption that this percent change is small. The marginal effects for £10,000 increases in "Other Safe Savings" and "Other Financial Assets," if equated with percent changes in the dependent variable, are very large and thus somewhat overstated. Again, for brevity, we nonetheless report the coefficients as given. The same applies to the education categories in the same column.

who completed senior high and those who have some higher education hold 69.7 and 49.3 percent more PBs, respectively. Differences between the senior high and higher education groups are insignificant. Those in the middle tax bracket are 56.5 percent more likely to hold PBs than those in the lowest tax bracket. Differences between both the highest tax bracket and lowest tax bracket and highest tax bracket and middle tax bracket are insignificant. After controlling for behavioral variables in the second column, we see that the effects of age, other safe savings, and other financial assets all remain largely the same as in the first column. The differences across education groups and tax brackets also remain largely unchanged. Having controlled for behavioral characteristics, we see that levels of PB holdings are positively correlated with higher financial literacy and higher financial constraint.

As seen in the third column of Table 5, for those in the upper half of the financial wealth distribution, an increase in age of one year corresponds to a 4.0 percent increase in PB holdings, females hold 14.2 percent fewer PBs, and an increase of £10,000 in holdings of other safe savings corresponds to a 3.0 percent increase in PB holdings. Compared to those who only completed compulsory education, those who completed senior high and those who have some higher education hold 63.7 and 61.4 percent more PBs, respectively. Differences between the senior high and higher education groups are insignificant. Differences between the tax brackets are likewise insignificant. Moreover, the coefficient on the level of an individual's other financial assets is also insignificant.

Table 5

Tobit Model of Determinants of Level of PB Holdings (in Natural Logs)
by Total Financial Wealth Halves

	(1)	(2)	(3)	(4)
	Total Financial Wealth Deciles 1–5		Total Financial Wealth Deciles 6–10	
Dependent Variable: *Log-Level of PB Holdings*	Marginal Effects at Means of Uncensored Log-Level PB Holdings			
Age	0.0200***	0.0143**	0.0404***	0.0388***
	(0.0046)	(0.0064)	(0.0031)	(0.0044)
Education Categories:				
Senior High	0.6974***	0.6465***	0.6368***	0.6175***
	(0.1307)	-0.1810	(0.0848)	-0.1160
Higher Education	0.4929***	0.5414***	0.6138***	0.4614***
	(0.1404)	(0.1935)	(0.0786)	(0.1105)
Female	0.0640	0.0503	-0.1420**	0.1367
	(0.1086)	-0.1500	(0.0669)	(0.0932)
Other Safe Savings (£10,000)	9.5676***	8.5304***	0.0297***	0.0335***
	(1.4859)	(2.0697)	(0.0064)	(0.0089)
Other Financial Assets (£10,000)	3.5165***	5.2495***	0.0050	-0.0006
	(1.3452)	(1.9085)	(0.0035)	(0.0045)
Net Income (£10,000)	0.0678	0.0306	-0.0110	-0.0176
	(0.0582)	(0.0768)	(0.0136)	(0.0183)
Tax Bracket Categories:				
Middle Tax Bracket	0.5647***	0.3732**	-0.0256	-0.1037
	(0.1403)	(0.1891)	(0.0798)	(0.1079)
High Tax Bracket	0.4717	0.2276	0.1057	-0.0161
	(0.6102)	(0.8239)	(0.1684)	(0.2331)
High Discount Rate		0.0770		-0.1295
		(0.2007)		(0.0976)
Risk Tolerance Index		-0.1059		0.2978***
		(0.1826)		(0.0988)
Financial Literacy Index		0.8511***		0.9490***
		(0.1845)		(0.1082)
Financial Constraint Index		0.5589***		-0.3152***
		(0.1467)		(0.1007)
Observations	11,229	5,450	12,516	6,276
Pseudo R-squared	0.02	0.03	0.01	0.02

Notes: Sample is composed of Wave 1 of UKDA's Wealth and Assets Survey spanning 2006–2008. Please see "Notes" of Table 2 for description of explanatory variables. Tobit models use lower censoring limits of $-1x10^{-7}$ and upper limits of 10.3089 (the natural log of £30,000).
* significant at 10%, ** significant at 5%, *** significant at 1%.

Once we control for behavioral variables in the fourth column, we see that the effects of age and other safe savings remain largely the same as in the third column and differences across education groups remain largely unchanged. In terms of the behavioral variables themselves, we observe that levels of PB holdings of those belong to the top half of the financial wealth distribution are positively correlated with risk tolerance and financial literacy, but negatively correlated with an individual's level of financial constraint.

4.4 PB Ownership's Impact on Total Safe Savings: Tobit Model

In order to preliminarily address the question of whether PBs simply shift savings across savings products or if PBs actually encourage higher levels of savings, we again employ a Tobit model, but instead explore how total safe-savings levels vary between PB holders and non-PB holders when controlling for demographic and behavioral characteristics. In other words, does a PB holder who is demographically and behaviorally similar to a non-PB holder hold more total safe savings, or does the PB holder simply reallocate a certain amount of savings as PBs that would have otherwise become traditional safe savings? The use of a Tobit is again appropriate because a significant portion of the sample holds zero safe savings, which results in a clustering of observations at a lower limit.[52]

[52] In fact, 36.4 percent of sample holds zero safe savings.

As a follow-up to this question, we also investigate whether PB holdings cannibalize other safe-savings amounts. Iverson et al. (2013) find in their study of the "Million-a-Month" PLS program in South Africa that the introduction of the PLS program not only encouraged new PLS holdings amongst the less financially wealthy and more financially constrained, but that individuals who opened up PLS accounts also increased their balances in their standard savings accounts. This implies that in South Africa, individuals viewed the PLS product as a complement rather than a substitute for traditional savings accounts. Although we cannot prove causality without observing PB and other safe-savings amounts before and after the introduction of the PLS program—as is the case in the work by Iverson et al. (2013)—we can explore how non-PB safe-savings levels vary between PB holders and non-PB holders when controlling for demographic and behavioral characteristics.

4.4.1 Total Safe Savings across Safe-Savings Groups

To see how total safe-savings levels vary between PB holders and non-PB holder, we estimate six Tobit models, as shown in Table 6, with columns one and two including the whole sample, columns three and four including just the bottom half of the total financial wealth distribution, and columns five and six including just the upper half of the total financial wealth distribution. Similar to the Tobit models previously employed in determining the log-level of PB holdings, all six models use a natural log-level of total safe savings as the dependent variable in order to correct for the skewness and abnormal kurtosis of the original total safe

Table 6

Tobit Model of Level of Total Safe Savings (in Natural Logs) across Savings Categories by Total Financial Wealth Halves

	(1)	(2)	(3)	(4)	(5)	(6)
	Whole Sample		Total Financial Wealth Deciles 1–5		Total Financial Wealth Deciles 6–10	
Dependent Variable: *Log-Level of Total Safe Savings*	Marginal Effects at Means of Uncensored Log-Level Total Safe Savings					
Safe-Savings Categories:						
Only Other Safe Savings	-0.2962***	-0.2565***	-0.1455***	-0.1884***	-0.1596***	-0.1483***
	(0.0188)	(0.0240)	(0.0376)	(0.0507)	(0.0154)	(0.0201)
No Safe Savings	-13.70***	-12.40***	-11.56***	-12.23***	-10.71***	-10.27***
	(0.0092)	(0.0111)	(0.0165)	(0.0265)	(0.0067)	(0.0087)
Demographic Variables:	Yes	Yes	Yes	Yes	Yes	Yes
Behavioral Variables:	No	Yes	No	Yes	No	Yes
Observations	23,745	11,726	11,229	5,450	12,516	6,276
Pseudo R-squared	0.36	0.38	0.46	0.46	0.28	0.30

Notes: Sample is composed of Wave 1 of UKDA's Wealth and Assets Survey spanning 2006–2008. Omitted "Safe-Savings Category" is the "Holds PBs" category and thus, coefficients on other two categories are relative to the "Holds PBs" group. "Demographic Variables" controlled for include age, age-squared, three categories for education, female dummy, net income, three tax bracket categories, and level of other financial assets (i.e., non-safe savings financial assets). "Behavioral Variables" controlled for include measure of discount rate, risk index, financial literacy index, and financial constraint index. Tobit models use lower censoring limits of -0.69314728 (the natural log of the lowest positive total safe-savings observation minus -1x10^{-7}). Marginal effects calculated at mean of log-level of uncensored total safe-savings observations.
* significant at 10%, ** significant at 5%, *** significant at 1%.

savings variable.[53] However, since our corner cases occur at a level of zero total safe savings and the natural logarithm of zero is negative infinity, we need to manually adjust the value of the log-level of total safe savings for these observations. We again follow the procedure of Cameron and Trivedi (2009) and set the log-level of total safe savings for these non-savers equal to a value just below the lowest non-censored log-level of total safe savings.[54] In each pair of columns, the first only includes demographic variables (age, age-squared, three categories for education, female dummy, net income, three tax bracket categories, and level of other non-safe savings financial assets) and dummies for the latter two of the three safe-savings categories (holds PBs, holds only safe savings, and no safe savings) as explanatory variables. In the second column of each pair, we also control for behavioral variables (individual's discount preference, Risk Tolerance Index, Financial Literacy Index, and Financial Constraint Index).

We gather the following results from Table 6. Compared to PB holders (the omitted safe-savings category), those who only hold other safe savings have less total safe savings across all six Tobit models. More specifically, compared to PB holders, those who only hold non-PB safe savings have on average 25.6 percent less in total safe savings in the whole sample, 18.8 percent less in the bottom half

[53] The skewness of the level of total safe savings variable conditional on being positive is 26.3, where a skewness of 0 indicates no skewness (i.e., symmetrically distributed like a normal distribution). The kurtosis of the level of total safe savings variable conditional on being positive is 1214.2, where STATA uses a kurtosis of 3 to indicate normal (no excess) kurtosis. Once transformed by taking the natural logarithm, the log-level of total safe savings variable has a skewness of -0.92 and a kurtosis of 3.55, which are significant improvements from the original variable.

[54] The lowest non-censored log-level of total safe savings occurs at -0.69314728 (the natural log of 0.5) and thus, we manually adjust the value of censored log-level total safe savings observations to $1x10^{-7}$ less that value, or -0.69314828. This value is used for defining the lower limit in the Tobit models in Table 6.

of the financial wealth distribution, and 14.8 percent less in the top half of the financial wealth distribution.[55] Thus, independent of whether we examine the sample as a whole or in halves by total financial wealth and also independent of whether we account for behavioral variables, PB holders tend to hold more total safe savings than those who only hold non-PB safe savings.

4.4.2 Cannibalization of Other Safe Savings by PBs

Having seen that PB holders tend to hold more total safe savings when we control for both demographic and behavioral characteristics, we investigate a follow up question regarding whether PB holders hold more total safe savings because they hold higher levels of both PBs and other safe savings, or if PB holdings cannibalize other safe-savings amounts. Using a model almost identical to the Tobit model displayed in Table 6, we again employ six separate Tobit models to show how those who only hold non-PB safe savings differ from PB holders in terms of their level of non-PB safe savings. We again break down the six columns into three pairs based on the portion of the sample each includes (the whole sample, just the bottom half of the financial wealth distribution, or just the top half). We also transform the dependent variable from levels to log-levels in

[55] We rely upon the assumption that the coefficient on the "only other safe savings" variable is exogenous and not correlated with the error term. It is possible for there to be some omitted variable that is correlated with both higher total safe savings and the likelihood of being a PB holder. Without an instrumental variable, we cannot control for such potential endogeneity. A possible solution may be to use Propensity Score Matching or some other form of statistical matching (Rosenbaum & Rubin 1983). With all that said, the minimal change in coefficients between the pre- and post-inclusion of behavioral variable models provides some assurance that this endogeneity problem is not too severe.

Table 7

Tobit Model of Level of Other (Non-PB) Safe Savings (in Natural Logs) across Savings Categories by Total Financial Wealth Halves

	(1)	(2)	(3)	(4)	(5)	(6)
	Whole Sample		Total Financial Wealth Deciles 1–5		Total Financial Wealth Deciles 6–10	
Dependent Variable: *Log-Level of Total Safe Savings*	Marginal Effects at Means of Uncensored Log-Level Total Safe Savings					
Safe-Savings Categories:						
Only Other Safe Savings	0.2070***	0.2594***	0.9205***	0.8891***	0.2158***	0.2363***
	(0.0217)	(0.0284)	(0.0435)	(0.0591)	(0.0191)	(0.0258)
No Safe Savings	-15.02***	-13.77***	-11.64***	-12.46***	-12.30***	-12.05***
	(0.0110)	(0.0136)	(0.0180)	(0.0293)	(0.0089)	(0.0122)
Demographic Variables:	Yes	Yes	Yes	Yes	Yes	Yes
Behavioral Variables:	No	Yes	No	Yes	No	Yes
Observations	23,745	11,726	11,229	5,450	12,516	6,276
Pseudo R-squared	0.36	0.38	0.46	0.46	0.28	0.30

Notes: Sample is composed of Wave 1 of UKDA's Wealth and Assets Survey spanning 2006–2008. Omitted "Safe-Savings Category" is the "Holds PBs" category and thus, coefficients on other two categories are relative to the "Holds PBs" group. "Demographic Variables" controlled for include age, age-squared, three categories for education, female dummy, net income, three tax bracket categories, and level of other financial assets (i.e., non-safe savings financial assets). "Behavioral Variables" controlled for include measure of discount rate, risk index, financial literacy index, and financial constraint index. Tobit models use lower censoring limits of -0.69314728 (the natural log of the lowest positive other safe-savings observation minus $-1x10^{-7}$). Marginal effects calculated at mean of log-level of uncensored other safe-savings observations. * significant at 10%, ** significant at 5%, *** significant at 1%.

order to account for the skewness and abnormal kurtosis of the original other safe-savings distribution.[56]

We report the results in Table 7. Compared to PB holders (the omitted safe savings-category), those who only hold other safe savings have more other safe savings across all six Tobit models. More specifically, compared to PB holders, those who only hold non-PB safe savings have on average 25.9 percent more in other safe savings in the whole sample, 88.9 percent more in the bottom half of the financial wealth distribution, and 23.6 percent more in the top half of the financial wealth distribution. Thus, independent of whether we examine the sample as a whole or in halves by total financial wealth and also independent of whether or not we account for behavioral variables, PB holders tend to hold less in non-PB safe savings than those who only hold non-PB safe savings. Although we cannot prove causality, the empirical results suggest that for individuals with similar demographic and behavioral characteristics, those who hold PBs likely have more total safe savings because of some reallocation of savings from non-PB safe-savings products to PB holdings.

[56] The skewness of the level of other safe savings variable conditional on being positive is 26.9, where a skewness of 0 indicates no skewness (i.e., symmetrically distributed like a normal distribution). The kurtosis of the level of total safe savings variable conditional on being positive is 1246.5, where STATA uses a kurtosis of 3 to indicate normal (no excess) kurtosis. Once transformed by taking the natural logarithm, the log-level of total safe savings variable has a skewness of -0.97 and a kurtosis of 3.70, which are significant improvements from the original variable.

5

Discussion of Results

5.1 Comments on the Econometric Analysis

Our results allow us to investigate four fundamental questions regarding U.K. Premium Bonds. First, what characteristics of an individual predict whether someone will take advantage of PBs over (or perhaps, in addition to) more traditional safe savings products? From the Probit model employed in Table 2, we find that we can characterize individuals who take advantage of PBs over (or, in addition to) more traditional savings products as individuals who are older, more educated, holders of larger amounts of other safe savings products, more risk tolerant, more financially literate, and less financially constrained.

Two possible reasons may account for the fact that older individuals are more likely to hold PBs (and hold higher levels of PBs). First, savings typically increase over the working life cycle of an individual, and thus, PB holdings accumulate just like traditional savings balances. Second, and more relevant, is the inertia associated with PB holdings. Namely, because keeping PBs with NS&I for an additional month affords individuals an extra opportunity at winning a large prize, we generally expect individuals to hold on to their PBs

once they purchase them and not cash them in unless they find it absolutely necessary.[57]

As discussed in Section 2.3, the Theoretical Model of Savings Behavior subsection of the Background section, we expect those with a higher Risk Tolerance Index to be more likely to hold PBs given the riskiness of their returns compared to the risk-free returns of other savings accounts. Our results are in accord with this expectation. However, as also discussed in the Theoretical Model, we also expect those with a lower Financial Literacy Index to prefer saving using PBs over a safe guaranteed interest-bearing product because the financial return from a chance at winning a large prize is easier to understand than the intricacies of compound interest. This does not appear to be the case in our results as those with higher levels of financial literacy are actually significantly *more* likely to hold PBs. We see in Appendix Table A.5 that financial literacy is highly positively correlated with education, levels of other safe savings, levels of non-safe savings financial assets, and financial constraint. Although we control for these variables in our Probit analysis, there may be omitted variables captured by the coefficient on the Financial Literacy Index—for example, measures of an individual's awareness of the existence of PBs or an individual's level of financial conservatism—that confound our estimate.[58] We also expect those with a higher

[57] Looking at NS&I's 2013–2014 Annual Report, we see the manifestation of this so-called "inertia" factor. Just over £8 billion new PBs were purchased over the course of the year. In the same time frame, only just over £6 billion was cashed out. To put these amounts in context, total PB investments at the end of fiscal year 2013–2014 stood at just over £48 billion (NS&I 2014a).

[58] As explained in Section 3.1 and Appendix Section A.3, we constructed the Financial Literacy Index as a composite of three questions measuring mathematical ability, awareness of government policies pertaining to savings/investments, and propensity of shopping around for the best interest rates. It is possible that one's awareness of government policies is also a proxy of an individual's awareness of the existence of non-traditional savings products such as PBs. It is also

Financial Constraint Index to prefer saving using PBs because of the opportunity afforded by PBs to drastically alter the financial circumstances of the PB holder. Our results are also inconsistent with this hypothesis from our Theoretical Model, as those with higher levels of financial constraint are significantly *less* likely to hold PBs.

Second—as a follow-up to the first question—what determines the level of PB holdings of an individual? From the Tobit model employed in Table 3, we find that higher levels of PB holdings are significantly correlated with having higher levels of education, being female, holding higher levels of other savings, belonging to higher tax brackets, discounting at a lower rate, tolerating more risk, being more financially literate, and facing less financial constraint. Other than age (which has an insignificant effect in the full Tobit model), the female dummy (which is originally insignificant in the Probit model), the tax bracket dummies (which are only significant in the Tobit model), and the discount rate dummy (which is also only significant in the Tobit model), the same set of variables explain both the level of PB holdings in the Tobit model and the likelihood of holding PBs in the Probit model.

Although more modern literature almost exclusively uses the discount rate to measure an individual's time preference, Frederick et al. (2002) show that an individual's time preference is actually an amalgamation of numerous intertemporal motives. Thus, one potential explanation for why those who

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possible that the propensity of shopping around for interest rates is a proxy for an individual's level of financial conservatism. After all, an individual with lots of wealth should reasonably be more conservative and care more about getting the best interest rate available. The positive correlation between financial literacy and financial wealth supports this hypothesis. Thus, omitted variables may lead to an upwards bias for the coefficient on the Financial Literacy Index.

discount at a lower rate tend to hold higher levels of PBs may be that the discount rate is a proxy for measuring an individual's inherent level of patience. If this is the case, then it is possible that a willingness to wait for a large return explains, in part, certain individuals' higher level of PB holdings. Some fairly intuitive determinants of an individual's patience in waiting for returns on an investment may include age and financial constraint. Younger individuals are most likely more patient since they will have use for the return even if it does not come for a few decades.[59] Those who are more financially constrained are most likely less patient since there is a certain immediacy with which they require the returns on their investments.[60]

As predicted by our Theoretical Model of Savings Behavior, the tax-free nature of PBs appears to incentivize those who face higher tax brackets to hold more of their savings as PBs. For reasons already mentioned, the directions of the correlations with financial literacy and financial constraint are inconsistent with our hypotheses. However, as we discuss next, breaking up the Probit and Tobit models by financial wealth halves offers some explanation for these surprising correlations.

Third, looking specifically at the income and wealth distribution, to what extent do PBs cater towards lower-wealth groups and are PB savings "regressive" in a similar fashion as is spending on traditional lotteries? From the graphical analysis in Figures 4 through 7, we find that the likelihood of

[59] The positive correlation between age and higher discount rates in Table A.5 supports this hypothesis.
[60] Table A.5 also supports this hypothesis, as we observe a negative correlation between financial constraint and higher discount rates.

individuals holding PBs grows almost proportionally with their level of financial wealth and thus, the wealthiest heavily dominate PB ownership. Interestingly, however, of the relatively small number of lower-wealth individuals who do hold PBs, PB holdings make up a much more substantial fraction of their total safe savings when compared to higher-wealth individuals and thus, we find that lower-wealth PB holders are much more dependent upon PBs as their main method of safe savings. We find that PBs are, indeed, "regressive" in the same way as is traditional lottery spending because those with the lowest income (or lowest financial wealth) save a higher fraction of their income (or hold a higher fraction of their financial wealth) as PBs than those at higher incomes (or levels of financial wealth).

From the Probit and Tobit models employed in Tables 4 and 5—both of which separate the observations in the sample by total financial wealth half—we observe numerous key differences between the lower-wealth and higher-wealth groups. Comparing the Probit results in Table 4 across the two financial wealth halves yields four such key differences. First, whereas education is positively correlated with the likelihood of holding PBs for the wealthy, it has no significant effect for the bottom half of the financial wealth distribution. Second, females are more likely to hold PBs, but only if they are relatively wealthy. Third, risk tolerance has no bearing on the likelihood of holding PBs for those in the bottom half of the wealth distribution, but riskier individuals in the top half are more likely to hold PBs. We hypothesized in our Theoretical Model of Savings Behavior that more risk tolerant individuals are more likely to hold PBs. This hypothesis is only supported by our data from the top half of the financial wealth

distribution.[61] Fourth, whereas the level of financial constraint is negatively correlated with the likelihood of holding PBs in Table 2 for the whole-sample Probit model, the relationship is exactly the opposite for those in the bottom half of the wealth distribution, as individuals who are *more* financially constrained have a higher propensity of holding PBs. At the same time, financial constraint has no significant effect for those in the upper half of the wealth distribution.[62] We hypothesized in our Theoretical Model of Savings Behavior that more financially constrained individuals prefer saving using PBs because of the opportunity afforded by PBs to drastically alter the financial circumstances of the PB holder. This hypothesis is supported by the bottom half of the wealth distribution—the group for which financial constraint has the most practical significance.[63]

By comparing the Tobit results in Table 5, we also see four key differences between the two financial wealth halves. First, whereas individuals' other financial assets are a significant estimator of the level of PB holdings for those in the bottom half of the wealth distribution, they have no bearing for the upper

[61] As we see in Table A.5 in the Appendix (and as we hint at in the Theoretical Model), higher risk tolerance is correlated with higher financial constraint. Given that financial constraint has a positive effect on the likelihood of holding PBs for those in the lower half of the wealth distribution, it is likely that the constraint variable co-varies and captures the effect of risk tolerance for the lower wealth group.

[62] This makes intuitive sense, given that financial constraint is negatively correlated with financial wealth. It is not surprising that those who are wealthier are more able to pay off debts and have more discretionary income to spend at the end of the month.

[63] As discussed in Section 3.1, the Financial Constraint Index is constructed from both measures of debt and a measure of money left over at the end of the month. While we assume that this is a measure of an individual's level of discretionary income, an argument can be made that this assumption really only applies to those with low wealth and low income. For someone with low wealth and low income, having little money left over at the end of the month likely means having to go without some essentials. For someone who is very wealthy, having very little money left over at the end of the month could very well be a result of excessive spending on luxury goods.

half. Second, those in the middle tax bracket hold relatively more PBs, but only for the bottom half of the wealth distribution. Third, risk tolerance has no bearing upon the level of PB holdings for those in the bottom half of the wealth distribution, but riskier individuals in the top half hold more PBs. And fourth, whereas those in the upper half of the wealth distribution hold lower levels of PBs at higher levels of financial constraint (similar to the results observed in Table 3 for the all-observation Tobit model), the relationship is exactly the opposite for those in the bottom half, as individuals who are more financially constrained tend to hold higher levels of PBs. Thus, not only are lower-wealth individual more likely to hold PBs due to financial constraint, those who are financial constrained also hold more in PBs—a result consistent with our financial constraint hypothesis in the Theoretical Model of Savings Behavior.

Fourth, given similar demographic and behavioral characteristics, do those who hold PBs have more total safe savings than those who only save using traditional savings products? We illustrate in Table 6 that PB holders tend to hold more total safe savings than those who only hold non-PB safe savings, independent of whether we examine the sample as a whole or in halves by total financial wealth and also independent of whether or not we account for behavioral variables. Thus, our results suggest that PBs actually encourage higher levels of savings rather than simply providing for a means of reallocating or diversifying the same level of safe savings. These results are consistent with results from Atalay et al. (2012), Iverson et al. (2013), and Kearney et al. (2010), which all suggest that PLS programs encourage individuals—particularly lower-wealth individuals—to increase their total amount of savings.

We also illustrate in Table 7 that although PB holders tend to hold more total safe savings than those who only hold non-PB safe savings, PB holders hold on average less in non-PB safe savings. Although we cannot prove causality and direct cannibalism within this result, the empirical evidence points to PBs as more of a substitute than a complement for other safe savings products. Although this result corroborates Tufano's (2008) macro-level findings, which show that aggregate levels of PB holdings are a substitute for traditional savings products, it also contrasts with the findings of Iverson et al. (2013) from their micro-level study of South Africa's "Million-a-Month" PLS program, which show using data from before and after the implementation of the PLS program that account holders in the PLS program actually increased their balances saved in their traditional savings accounts concurrently with their new PLS savings.

5.2 Limitations of our Analysis

Although our analysis focuses on some fairly fundamental empirical observations regarding the predictability of PB ownership, the determinants of different levels of PB holdings, the differences across wealth-distribution in PB holdings, and the potential for PBs to increase total safe savings, it faces numerous limitations or potential sources of error. First, the WAS may contain some measurement error resulting from individuals not reporting that they hold PBs when in actuality, they do. This might occurs simply because of the forgetfulness of individuals in being able to recall that they hold PBs. Our data shows that roughly 15 percent of the sampled individuals report holding PBs, which is a lower figure than that

reported by NS&I, which reports that over 21 million, or roughly 43 percent of U.K. citizens over the age of sixteen hold PBs (NS&I 2014b).[64] The forgetfulness of individuals manifests clearly itself in the large number and value of unclaimed prizes awarded by NS&I, which, as of the writing of this paper, stands at almost 1.1 million unclaimed prizes worth over £47 billion (NS&I 2015).[65] Thus, many of our estimates of the likelihood of holding PBs are probably understated.

In the creation of the three behavioral indexes (Risk, Financial Literacy and Financial Constraint) that are modeled after work done by Iverson et al. (2013), we implicitly rely upon the assumption that the various components of each index affect the dependent variables equally. The Risk Index suffers less from this problem because it is essentially binomial in nature.[66] However, for the Financial Literacy and Financial Constraint Indexes, each index is itself a composite of three separate author-generated sub-indexes based on three relevant survey questions. The two indexes are constructed such that each sub-index is scaled to fit within the 0.0 to 1.0 interval and thus, each index takes on values between 0.0 and 3.0 in aggregate. In order to avoid making the assumption of equal effect across sub-indexes, one could specify the models using the separate sub-indexes

[64] The current population of the U.K., as estimated by the Office for National Statistics for the middle of 2013, is 64.1 million (ONS 2015b). We assume that roughly 15 million of the 14.1 million are 16 years old or younger.

[65] NS&I defines "unclaimed prizes" as winning bonds that were selected over 18 months ago that have yet to be claimed (NS&I 2015).

[66] A small portion of observations reported being "unsure" about the choice between choice between guaranteed payment of £1,000 and a 1 in 5 chance of winning £10,000. We code these observations as having a Risk Index of 0.5 rather than the binomial choices of 0 and 1.

themselves and thereby not assume equal weighting across each sub-index.[67] Doing so may allow us to more fully exploit the rich behavioral data in the WAS.

A more significant limitation of this analysis arises from the fact that in employing the WAS, we make use of the individual schedule and treat individuals as distinct decision makers who base their decisions solely upon their own financial asset holdings. We base this methodology upon the assumption that individuals neither pool their resources within households nor make decisions based off of pooled resources. A literature exists, however, which suggests not only that individuals make decisions based on household levels of resources, but also that intra-household consumption behavior can be modeled as a collective of decision units in which each individual makes consumption choices given the interdependent preferences of others in the household (Bourgignon et al. 1993). With this in mind, and given that the WAS provides a household schedule that links individuals belonging to the same household in the individual schedule, one could expand upon the current Probit and Tobit models and include the safe savings, financial assets, demographic characteristics, and behavioral characteristics of individuals' significant others as explanatory variables in order to account for decision making based on pooled resources and the interdependent preferences of others in the household.

[67] One could even go one step further and deconstruct the sub-indexes themselves since a lot of these sub-indexes are based on questions in which respondents chose answers ranging from 1–5, for example. In these responses, assuming that those who answered a "5" are five times more financially constrained than those who answered a "1" implicitly assumes equal weighting across these numeric responses as well. Deconstructing the sub-indexes and having dummies for each numeric response would avoid all such equal-weighting assumptions.

6

Conclusion and Areas for Further Research

The motivation behind this paper stems from both the observation that the present state of individual savings in the U.S. is approaching crisis levels and the fact that various scholars have theorized that PLS programs appeal in particular to lower-income and lower-wealth individuals—the group that typically has the lowest level of savings. The literature suggests that, for these "emergency savers"—to borrow a term from Kearney et al. (2010)—the rewards of compound interest offered by traditional savings products are not a very compelling reason to save because of both the small amount of money they have available to save and their short-term savings mindset. In contrast, a PLS product—which offers the same liquidity and principal security as a savings account, but comes with the added benefit of an uncertain return that might offer a chance of winning a large amount of money—can, in theory, provide much larger incentives for so-called "emergency savers" to save more of their money. Such a prospect is attractive both for policymakers and individual consumers because the theory and literature suggest that these increased PLS savings can not only somewhat reduce the gap in financial wealth across the population (in the event that low-wealth individuals win a large sum from their PLS holdings), but also—more importantly—create

more opportunities for consumption smoothing for those who would otherwise save very little.

With this literature in mind, we set out to investigate the British PB program and determine the characteristics that best predict PB ownership and levels of holdings. We find that, across both halves of the financial wealth distribution, we can characterize individuals who take advantage of PBs over (or, in addition to) more traditional savings products as individuals who are older, holders of larger amounts of non-PB safe savings products, holders of more financial assets other than safe savings products, and more financially literate. The two financial wealth halves differ in such that the likelihood of holding PBs is positively correlated with education, being female, and higher risk tolerance for the upper half of the wealth distribution, whereas it is positively correlated with financial constraint for the bottom half of the wealth distribution. While most of these results are explainable both intuitively and through our Theoretical Model of Savings Behavior, other results prove to be surprising. Although our Theoretical Model hypothesizes that more risk tolerant individuals should be more likely to hold PBs and more likely to hold higher amounts of PBs, our results show that, for the bottom half of the financial wealth distribution, risk tolerance has no bearing on either the likelihood of holding PBs or the level of PBs held. Although our Theoretical Model hypothesizes that those with a lower financial literacy should prefer saving using PBs over safer guaranteed interest-bearing products, our results show that higher financial literacy is actually positively correlated with both the likelihood of holding PBs and the level of PBs held across the board, regardless of relative financial wealth.

As we demonstrate graphically, higher wealth individuals dominate both in terms of the propensity to hold PBs and the level of PBs held. Of the relatively small number of lower-wealth individuals who do hold PBs, however, most are much more dependent upon PBs as their main method of safe savings than their higher-wealth counterparts. We empirically observe that, controlling for a rich set of demographic and behavioral characteristics, PB holders hold on average more total safe savings than those who only hold non-PB safe savings. Moreover, PB holders also hold on average less non-PB safe savings than those who only hold non-PB safe savings. Although we cannot prove causality, it appears that PB holdings may cannibalize other safe savings by serving as a substitute for other safe savings, but still raise total safe savings, on average.

If, for those who advocate for the expansion of PLS programs into new markets, the ultimate intent lies solely in encouraging those who save very little to hold higher levels of overall safe savings and create opportunities for more consumption smoothing in later times of relative financial need, then our results suggest that PBs do accomplish this goal for low-wealth PB holders. With that said, however, there remains a program uptake problem in that only a relatively small fraction of low-wealth individuals actually hold PBs in our sample. If, on the other hand, the ultimate intent lies in actually reducing wealth inequality in the long run and giving low-wealth individuals a legitimate chance at significantly altering their financial circumstances through prize winnings, then our results suggest that PBs may not be the solution. Not only are the odds of winning a large prize extremely low, but on an individual PB holder basis, the already-wealthy group of PB holders holds significantly higher levels of PBs,

which means that their total probability of winning the large prizes is higher relative to those of lower-wealth.[68] Thus, in the long run, this positive feedback loop likely only leads the wealthy to becoming wealthier, which is at odds with any intentions of reducing financial wealth disparity.

As mentioned in the introduction to this paper, we do not attempt to answer the question of whether PBs increase savings by shifting consumer spending from lottery gambling to PB savings because of the lack of data on lottery spending and difficulties with testing such a question. At the same time, although we perform some preliminary analysis into the potential for PBs to increase total safe savings amongst low-wealth individuals, without data before and after the implementation of a PLS program such as the PB program, it is also difficult to definitively answer the question of whether those individuals at the bottom of the wealth distribution who save a large proportion of their save savings as PBs would have lower savings in the absence of such a PLS program.

Further research is needed in order to begin to answer some of these more difficult empirical questions. Given the fact that the WAS is a longitudinal dataset with two more waves beyond the one used in this study, it is possible to examine how individuals' choices—both whether or not to hold PBs, and if so, how much to save—change over time given variations in national economic conditions, the attractiveness of PBs as a savings tool relative to other savings products (e.g., short term government bonds, Cash ISAs, etc.), and other changes. Such a longitudinal or panel data study can exploit changes in these more macro-level variables in order to both more definitely answer some of the

[68] In other words, it appears that "the odds [are] ever in [the wealthy individuals'] favor."

questions we already explored at a relatively surface level (e.g., the question of whether PBs act as a substitute and cannibalize other safe savings) and investigate new questions (e.g., how individuals change their PB holdings upon leaving the workforce and entering retirement, or how idiosyncratic shocks such as the increase of the maximum PB holdings limit from £30,000 to £40,000 impact the level of holdings for both the wealthy and the poor). The second and third waves of the WAS are particularly salient because they span the years 2008 through 2012—a period in which general economic conditions underwent significant change as the economy gradually moved out of a major recession. Through increased research, we can learn more both academically, about the savings behavior of individuals, and from a public policy standpoint, about whether changes in the legal statutes barring the expansion of PLS programs elsewhere are desirable.

References

Arrow, K. J. Stiglitz & J. E., & (1969). Aspects of the theory of risk bearing—Yrjo Jahnsson Lectures. *Econometrica*, 37(4), 742. doi:10.2307/1910455

Atalay, K., Bakhtiar, F., Cheung, S., & Slonim, R. (2012). *Savings and prize-linked savings accounts*. Discussion paper at the Institute for the Study of Labor in Bonn.

Bank of England. (n.d.). *Interest & exchange rates data*. Retrieved from http://www.bankofengland.co.uk/boeapps/iadb/index.asp?first=yes&SectionRequired=I&HideNums=-1&ExtraInfo=true&Travel=NIxIRx

Bernoulli, D. (1954). Exposition of a New Theory on the Measurement of Risk. *Econometrica* (L. Sommer, Trans.). 22(1), 23-36. Retrieved from http://www.econ.ucsb.edu/~tedb/Courses/GraduateTheoryUCSB/Bernoulli.pdf

Bodie, Z., Kane, A., & Marcus, A. (2011). *Investments* (9th ed.). New York: McGraw-Hill.

Bourguignon, F., Browning, M., Chiappori, P. A., & Lechene, V. (1993). Intra household allocation of consumption: A model and some evidence from French data. *Annales d'Economie et de Statistique*, *21*(2), 137–156. doi: 10.1111/j.1467-9914.2007.00376.x

Burhouse, S., Chu, K., Goodstein, R., Northwood, J., Osaki, Y., & Sharma, D. (2014). *FDIC national survey of unbanked and underbanked households*. Federal Deposit Insurance Corporation, (October 2014), 1–64.

Cameron, A., & Trivedi, P. (2009). *Microeconometrics using Stata*. College Station, TX: Stata Press.

Chetty, R. (2006). A new method of estimating risk aversion. *The American Economic Review,* 96(5), 1821–1834. Retrieved from http://www.jstor.org/stable/30034997

Education leaving age. (n.d.). *Politics.co.uk*. Retrieved from http://www.politics.co.uk/reference/education-leaving-age

Employment Benefit Research Institute, & Greenwald & Associates (2014). *Preparing for retirement in America*. Retirement Confidence Survey, 1–4.

Frederick, S., Loewenstein, G., & O'Donoghue, T. (2002). Time discounting and time preference: A critical review. *Journal of Economic Literature, 40*(2), 351–401. doi: 10.1257/002205102320161311

Guillen, M., & Tschoegl, A. (2002). Banking on gambling: Banks and lottery-linked deposit accounts. *Journal of Financial Services Research*, 21(3): 219–31.

Hartley R., Lanot G., and Walker I. (2014), Who really wants to be a millionaire? Estimates of risk aversion from gameshow data. *Journal of Applied Economics*, 29(6), 861–879. doi:10.1002/jae.2353

Institute for Fiscal Studies. (2015). *Recent headline tax rates*. Retrieved from http://www.ifs.org.uk/tools_and_resources/fiscal_facts

Iverson, B., Cole, S., & Tufano, P. (2013). *Can gambling increase savings? Empirical evidence on prize-linked savings accounts.* Retrieved from Social Science Research Network: http://papers.ssrn.com/sol3/Delivery.cfm/SSRN_ID2477839_code1174157.pdf?abstractid=2441286&mirid=1.

Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica: Journal of the Econometric Society*, *47*(2), 263–291. doi: 10.2307/1914185

Kahneman, D. & Tversky, A. (1992). Advances in prospect theory: Cumulative representation of uncertainty. *Journal of Risk and Uncertainty*, *5*(4), 297–323. doi: 10.1007/bf00122574

Kearney, Michelle S. (2002). State lotteries and consumer behavior (Working Paper No. 9330). Retrieved from National Bureau of Economic Research website: http://www.nber.org/papers/w9330.pdf

Kearney, M., Tufano, P., Guryan, J., & Hurst, E. (2010). Making savers winners: An overview of prize-linked savings products. Retrieved from National Bureau of Economic Research website: https://www.econ.umd.edu/research/papers/583/download/321.

Lusardi, A., & Mitchell, O. (2007). Baby boomer retirement security: The role of planning, financial literacy, and housing wealth. *Journal of Monetary Economics*, 54, 205–24.

Lusardi, A., Schneider, D., & Tufano, P. (2011). *Financially fragile households: Evidence and implications*. Brookings Papers on Economic Activity, (Spring 2011), 83–134.

Maynard, N. (2007). Prize-based savings: Product innovation to make saving fun. Retrieved from D2D Fund website: http://www.d2dfund.org/research_publications/prize_based_savings_product_innovation_make_saving_fun

McDonald, J. F., & Moffitt, R. A. (1980). The uses of Tobit analysis. *The Review of Economics and Statistics*, 62(2), 318–321. doi: 10.2307/1924766

Murphy, Anne L. (2005). Lotteries in the 1690s: Investment or gamble? *Financial History Review*, 12(2): 227–45.

National Savings and Investments. (2009). *The history of premium bonds and prize draw statistics 1957–2007*. Retrieved from http://web.archive.org/web/20100102114755/http://nsandi.com/press-room/premiumbonds50/history_pb.jsp

National Savings and Investments (2014a). *Annual report and accounts and product accounts 2013–2014*. Retrieved from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/320228/NSandI_AnnReport_13-14-Tagged-compressed.pdf

National Savings and Investments (2014b). *Premium bonds: A wining way to save* [Brochure]. Glasgow, UK.

National Savings and Investments. (2015). *Prize checker*. Retrieved from http://www.nsandi.com/prize-checker

National Savings and Investments. (n.d.). *Interest rate changes*. Retrieved from http://www.nsandi.com/files/published_files/asset/pdf/historical-interest-rates.pdf

Ng, Y.K. (1965). Why do people buy lottery tickets? Choices involving risk and the indivisibility of expenditure. *The Journal of Political Economy*, *73*(5), 530–535. doi:10.1086/259077

North American Association of State and Provincial Lotteries (2015). *Lottery sales and transfers*. Retrieved from http://www.naspl.org/index.cfm?fuseaction=content&menuid=14&pageid=1020#LotterySales.

Office for National Statistics. (2015a). *Consumer price indices*. Retrieved from http://www.ons.gov.uk/ons/taxonomy/index.html?nscl=Consumer Price Indices#tab-data-tables

Office for National Statistics. (2015b). *Population*. Retrieved from http://ons.gov.uk/ons/taxonomy/index.html?nscl=Population

Pratt, J. W. (1964). Risk aversion in the small and in the large. *Econometrica: Journal of the Econometric Society*, 32(1/2), 122–136. doi:10.2307/1913738

Rosenbaum, P. R., & Rubin, D. B. (1983). The central role of the propensity score in observational studies for causal effects. *Biometrika*, 70(1), 41–55. doi: 10.2307/2335942

Save to Win. (2015). *What is prize-linked savings?* Retrieved from http://www.savetowin.org/financial-education/prize-linked-savings-

Stock, J., & Watson, M. (2007). *Introduction to econometrics* (2nd ed.). Boston: Pearson Education.

Tufano, Peter (2008). Saving whilst gambling: An empirical analysis of U.K. premium bonds. Paper presented at the American Economics Association Session: Assets and Credit Among Low-Income Households.

U.K. Data Service. (2015). *Wealth and Assets Survey, Waves 1-3, 2006-2012* [Data file]. Retrieved from http://discover.ukdataservice.ac.uk/catalogue/?sn=6709&type=Data%20catalogue#documentation

U.S. Bureau of Labor Statistics (2012). *Consumer expenditure survey*. Retrieved from http://www.bls.gov/cex/2011/Standard/age.pdf.

Wooldridge, J. M. (2009). *Introductory econometrics: A modern approach* (4th ed.). Mason, OH: South Western Cengage Learning.McCaffrey, E. J. (1994). Why people play lotteries and why it matters. *Wisconsin Law Review*, 71–122.

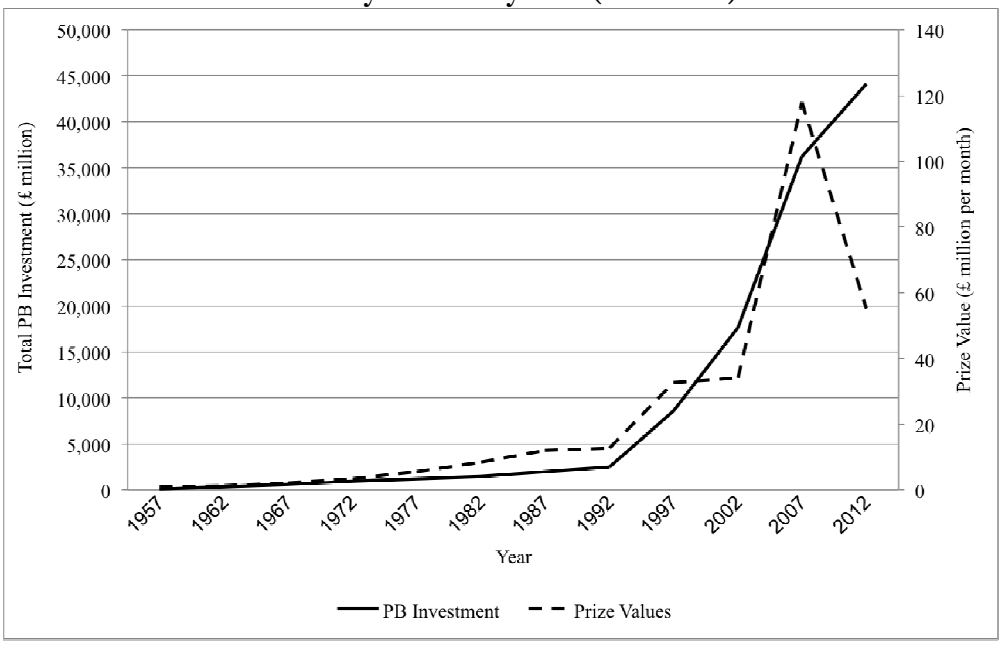
Appendix

A.1. Historical Timeline and Overview of Premium Bonds

Date	Change in PB Offerings, Rules, and Structure
November 1, 1956	Premium bonds are launched at Trafalgar Square, London. Bonds become eligible for prizes after held for six months. Top prize is £1,000.
June 1, 1957	First prize draw. ERNIE used to generate winning numbers.
August 1, 1971	New monthly top prize of £50,000 introduced.
February 5, 1972	Minimum purchase raised from £1 to £2.
November 1, 1976	New monthly top prize of £100,000 introduced. Minimum purchase raised from £2 to £5.
April 21, 1980	Maximum holdings rule of £10,000 instituted.
July 1, 1980	New monthly top prize of £250,000 introduced.
February 1, 1993	Minimum purchase raised from £5 to £100.
April 13, 1993	Maximum holdings rule of £20,000 instituted.
April 1, 1994	New monthly top prize of £1 million introduced.
September 9, 2002	Website www.nsandi.com introduced, allowing customers to check for prizes won in last six months.
May 12, 2003	New maximum holdings rule of £30,000 instituted.
October 1, 2004	Recurring standing order system introduced for existing customers. Minimum purchase now £50 if purchased through standing order after initial £100 purchase.
January 1, 2005	Online purchases introduced on www.nsandi.com and all (present and historic) monthly prize numbers listed on website.
August 1, 2005	New additional (second) top prize of £1 million introduced.
December 1, 2006	50th anniversary of PB launch. Special 5 by £1 million draw.
June 1, 2007	50th anniversary of first prize draw. Second special 5 by £1 million draw take place.
October 1, 2014	New maximum holdings rule of £40,000 instituted.

Notes: All information taken from NS&I website. Please see "Premium Bond History" in the References for direct link to source.

Figure A.1
Historical (1957–2012) Total Investments in PBs and Monthly Prize Payouts (Nominal)



Notes: Historical figures provided by NS&I. See Table A.1 for accompanying data and source.

Table A.1
Historical PB Investments and Prize Payouts (Nominal and 2012 £s Inflation Adjusted)

Year	*Total Investment (£ million)*		*Number of Customers*	*Prizes* (1,000 /	*Monthly Prize Value (£ million / month)*	
	Nominal	RPI Adj.	(million)	month)	Nominal	RPI Adj.
1957	70	1,429	6.0	23	1.0	19.8
1962	350	6,324	13.0	35	1.2	21.7
1967	590	9,069	16.0	59	2.1	32.3
1972	930	10,392	20.0	86	3.5	39.1
1977	1,220	6,419	22.0	109	5.5	28.9
1982	1,510	4,513	26.0	101	8.5	25.4
1987	1,950	4,645	24.3	171	12.1	28.8
1992	2,470	4,329	23.4	215	12.8	22.4
1997	8,600	13,255	23.1	434	32.7	50.4
2002	17,670	24,343	22.8	598	34.1	47.0
2007	36,210	42,546	23.7	1,494	118.0	138.6
2012	44,139	44,139	21.0	1,839	55.2	55.2

Notes: Historical figures provided by NS&I. Monthly figures through 2007 come from June of each year ("Prize draw statistics"). 2012 figures come from March data, as provided by NS&I's 2011–2012 Annual Report (NS&I 2014a). "RPI (Retail Price Index) Adjusted" values report inflation-adjusted values in 2012 pounds (ONS 2015a).

Table A.2

Changes in Annual PB Prize Fund Rate and Odds Ratio in Last 10 Years

Effective from:	*PB Annual Prize Fund Rate*	*PB Odds Ratio*	*U.K. Average Gilt Rate*
August 1, 2014	1.35%	26,000 to 1	1.31%
August 1, 2013	1.30%	26,000 to 1	1.29%
October 1, 2009	1.50%	24,000 to 1	1.62%
April 1, 2009	1.00%	36,000 to 1	1.54%
December 1, 2008	1.80%	36,000 to 1	2.83%
November 1, 2008	2.85%	24,000 to 1	4.46%
May 1, 2008	3.40%	24,000 to 1	5.35%
August 1, 2005	3.25%	24,000 to 1	4.35%
October 1, 2004	3.20%	24,000 to 1	4.49%

Notes: Figures provided by NS&I. Please see "Interest Rate Changes" in References for direct link to source. U.K. Average Gilt Rate from Bank of England. Gilt rate is calculated as weighted average of annualized interest rates on new gilts (bonds) with maturity dates less than one year from purchase that were issued by financial institutions other than the Bank of England. These gilt rates are pre-tax rates.

Table A.3

Allocation of Prize Fund to Individual Prize Values (January 2015)

Prize Band	*Prize Value*	*Number of Prizes*
Higher Value	£1 million	2
(7% of Prize Fund)	£100,000	4
	£50,000	8
	£25,000	17
	£10,000	41
	£5,000	82
Medium Value	£1,000	1,154
(5% of Prize Fund)	£500	3,462
Lower Value	£100	15,831
(88% of Prize Fund)	£50	15,831
	£25	1,938,600
Total Value (January 2015)	£57.7 million	1,975,032

Notes: Figures provided by NS&I. Please see "Prize Checker" in References for direct link to source. All figures are nominal.

Explanation of prize allocation from the NS&I "Prize Checker" website:

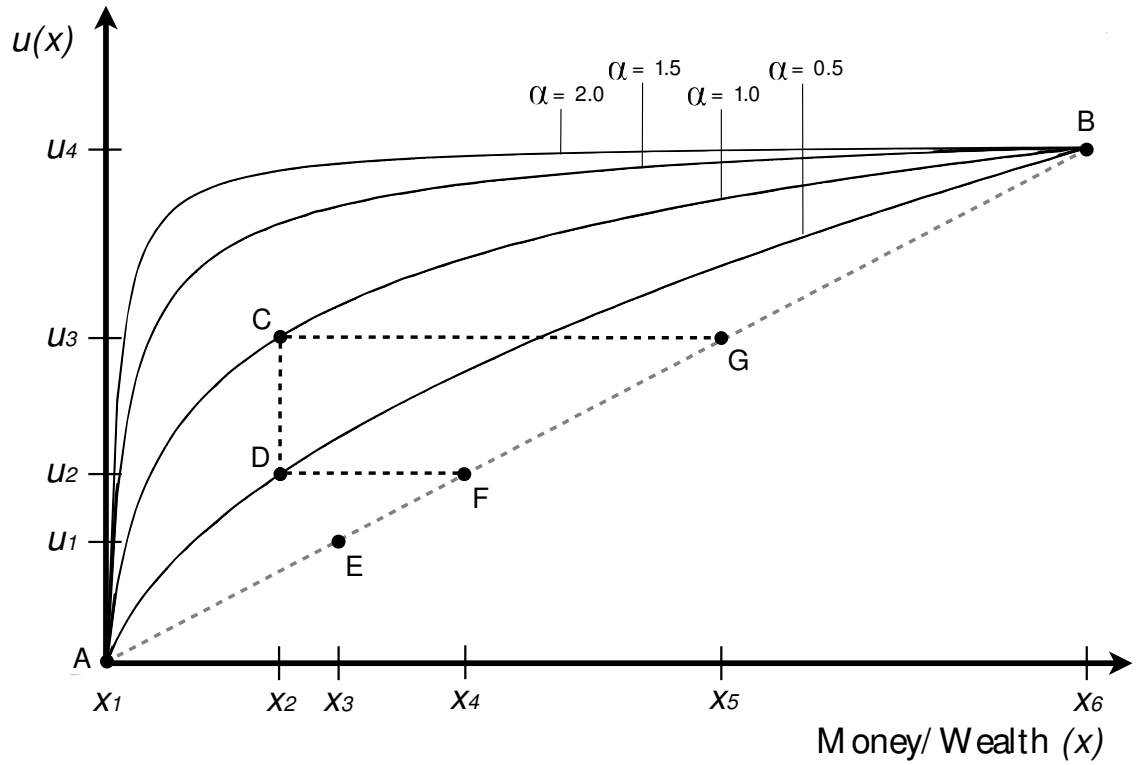
> "We split the prizes into three value bands—higher, medium and lower—and allocate a percentage share of the monthly prize fund to each band.
>
> *Higher value band:*
> We pay out two £1 million jackpots each month. We then divide the balance of the prize fund share allocated to the higher value band equally among the remaining prize values. First we work out the number of £100,000 prizes. When there is a balance that's less than half of that prize value, we carry it over to the share for the £50,000 prizes. Or when there's a balance that's at least half of the prize value, we award an additional prize of £100,000. We do this by taking the shortfall from the share for the £50,000 prizes.
>
> We then calculate the numbers of other prizes in this value band in the same way, from highest value to lowest value. When calculating the number of £5,000 prizes, any surplus or shortfall is added to or taken from the medium value band.
>
> *Medium value band:*
> From the share of the prize fund allocated to this band, we calculate the number of prizes so that there is one £1,000 prize for every three £500 prizes. Any surplus is added to the share allocated to the lower value band.
>
> *Lower value band:*
> We work out the number of lower value prizes so that there's an equal number of £100 and £50 prizes, and that the total number of prizes of all values (including £25 prizes) is equal to the number of eligible £1 Bond units divided by the odds" (NS&I 2015).[69]

[69] "In the unlikely event of a shortfall in the total number of prizes, we may increase the share allocated to the lower value band and reduce the shares allocated to the higher and medium value bands. Any surplus will be carried forward to the prize fund for the following month" (NS&I 2015).

A.2. Graphical Analysis of Constant Relative Risk Aversion (CRRA) Utility Functions

Figure A.2 shows four CRRA utility functions normalized such that they represent the same amount of utility received if given the one monthly prize in our hypothetical PLS product in Section 2.3.[70] For the purposes of illustration, we focus on two individuals—one with a higher degree of risk aversion (α = 1.0) and another with a lower degree of risk aversion (α =0.5). We assume that these two individuals start out with the same level of money/wealth and index this to zero (x_1) such that their initial state lies at point A. If either individual wins the monthly prize, her period two state will lie at point B, with increased wealth

Figure A.2
Normalized CRRA Utility Functions for Guaranteed vs. Risky Payoffs
for Varying Degrees of Risk Aversion



[70] We are able to normalize these utility functions by adjusting their heights through multiplication by some constant because utility functions are inherently cardinal rather than ordinal. In other words, an individual's preferences should not change, regardless of whether her utility function is defined as $u(x)$ or $z \cdot u(x)$, where z is some constant.

represented by x_6 and increased utility of u_4. We plot points C and D to show the increased level of utility for each individual under the assumption that they each take the safe-return savings product with a guaranteed return of x_2. The dashed line connecting points A and B represents the possible expected values of the return from the risky PLS product at varying probabilities of winning. Point E represents the expected value of the return from the risky PLS product at some actuarial probability (p).[71] By employing the concept of certainty equivalents, we see that in order for an individual with risk aversion $\alpha = 0.5$ to prefer choosing the risky option over choosing the guaranteed return of x_2, the risky option must provide an expected return of at least x_4, as shown by point F. Similarly, for the individual with risk aversion $\alpha = 1.0$ to prefer the risky option, the risky option must provide an expected return of at least x_5, as shown by point G. Given that the actual expected return from the risky option (x_3) is much lower than either x_4 or x_5, we see that expected utility theory cannot explain the real-world observation that individuals actually do save using risky PLS products when guaranteed-return savings products of minimally lower returns (or sometimes even higher returns) exist as an alternative savings choice.

One potential explanation for individual's purchase of PLS products such as PBs is behavioral misperceptions—namely, that individuals inflate the actuarial probability of winning and have a higher *perceived* probability that moves the *perceived* expected return of the risky product closer towards x_4 and x_5. As seen in the figure, individuals with lower degrees of risk aversion require much lower levels of probability inflation to make the risky PLS product appear attractive relative to guaranteed-return savings products. As we discussed in Section 2.3, and individual's degree of risk aversion depends both on an innate level of risk tolerance and a measure of her level of financial constraint.

[71] We plot point E such that expected value (x_3) is slightly higher than the guaranteed return (x_2) to reflect the fact that the PB prize-fund rate is currently higher than the guaranteed return from various safe-savings options, such as short-term government gilts, as seen in Table A.2. The same table also shows that the prize-fund rate has at times also dipped *below* the guaranteed return from other safe-savings options.

A.3. Construction of Risk, Financial Literacy, and Financial Constraint Indexes

The Risk Tolerance Index is constructed from the answers to the following survey question, which allowed for responses of (1) guaranteed payment of £1,000, (2) 1 in 5 chance of winning £10,000, or (3) I'm unsure:

- "Given choice between guaranteed payment of £1,000 and a 1 in 5 chance of winning £10,000, which would you choose?"

The Risk Tolerance Index ranges 0.0 to 1.0 and takes on one of three values based on the individual's response:

$$\text{Risk Tolerance Index} = \begin{cases} 0.0, & \text{if responded, "guaranteed payment of £1,000"} \\ 0.5, & \text{if responded, "I'm unsure"} \\ 1.0, & \text{if responded, "1 in 5 chance of winning £10,000"} \end{cases}$$

The Financial Literacy Index is constructed from the answers to the following survey questions:

- First, "If you were to rate your mathematical skills for daily life, would you say they are (1) excellent, (2) good, (3) moderate, or (4) poor?"
- Second, "On a scale of 1 to 5, 1 meaning you strongly agree and 5 meaning you strongly disagree, how would you rate the statement, 'I tend to shop around for the best deal on interest rates?'"
- And third, "Have you heard of any changes, in the last 12 months, in government policy relating to savings or investments?"

The Financial Literacy Index ranges 0.0 to 3.0 and is the sum of three sub-indexes measuring Mathematical Skills, Likelihood to Shop for Interest Rates, and Financial Policy Awareness:

$$\text{Mathematical Skills} = \begin{cases} 1.00, & \text{if responded, "excellent"} \\ 0.75, & \text{if responded, "good"} \\ 0.50, & \text{if responded, "moderate"} \\ 0.25, & \text{if responded, "poor"} \end{cases}$$

$$\begin{matrix}\text{Likelihood to} \\ \text{Shop for Interest Rates}\end{matrix} = \begin{cases} 1.00, & \text{if responded, "1 strongly agree"} \\ 0.80, & \text{if responded, "2 tend to agree"} \\ 0.60, & \text{if responded, "3 neither agree/disagree"} \\ 0.40, & \text{if responded, "4 tend to disagree"} \\ 0.20, & \text{if responded, "5 strongly disagree"} \end{cases}$$

$$\begin{matrix}\text{Financial Policy} \\ \text{Awareness}\end{matrix} = \begin{cases} 1.0, & \text{if responded, "yes"} \\ 0.5, & \text{if responded, "no"} \end{cases}$$

The Financial Constraint Index is constructed from the answers to the following three questions:

- First, "In the past 12 months, how often have you had money left over at the end of the week or month? Would you say it was (1) always, (2) most of the time, (3) sometimes, (4) hardly ever, or (5) never?"
- Second, "What is the total amount outstanding on your credit cards?"
- And third, "What is the total amount overdrawn on your current accounts?"

Similar to the Financial Literacy Index, the Financial Constraint Index also ranges 0.0 to 3.0 and is the sum of three sub-indexes, which measure Discretionary Income, Credit Card Debt, and Current Account Debt. In constructing both the Credit Card Debt and Current Account Debt indexes, we first take the natural log of the relevant amount to create a more normalized distribution and then divide it by the natural log of the maximum amount of the relevant debt observed in the sample to scale the index to a 0.0 to 1.0 scale:

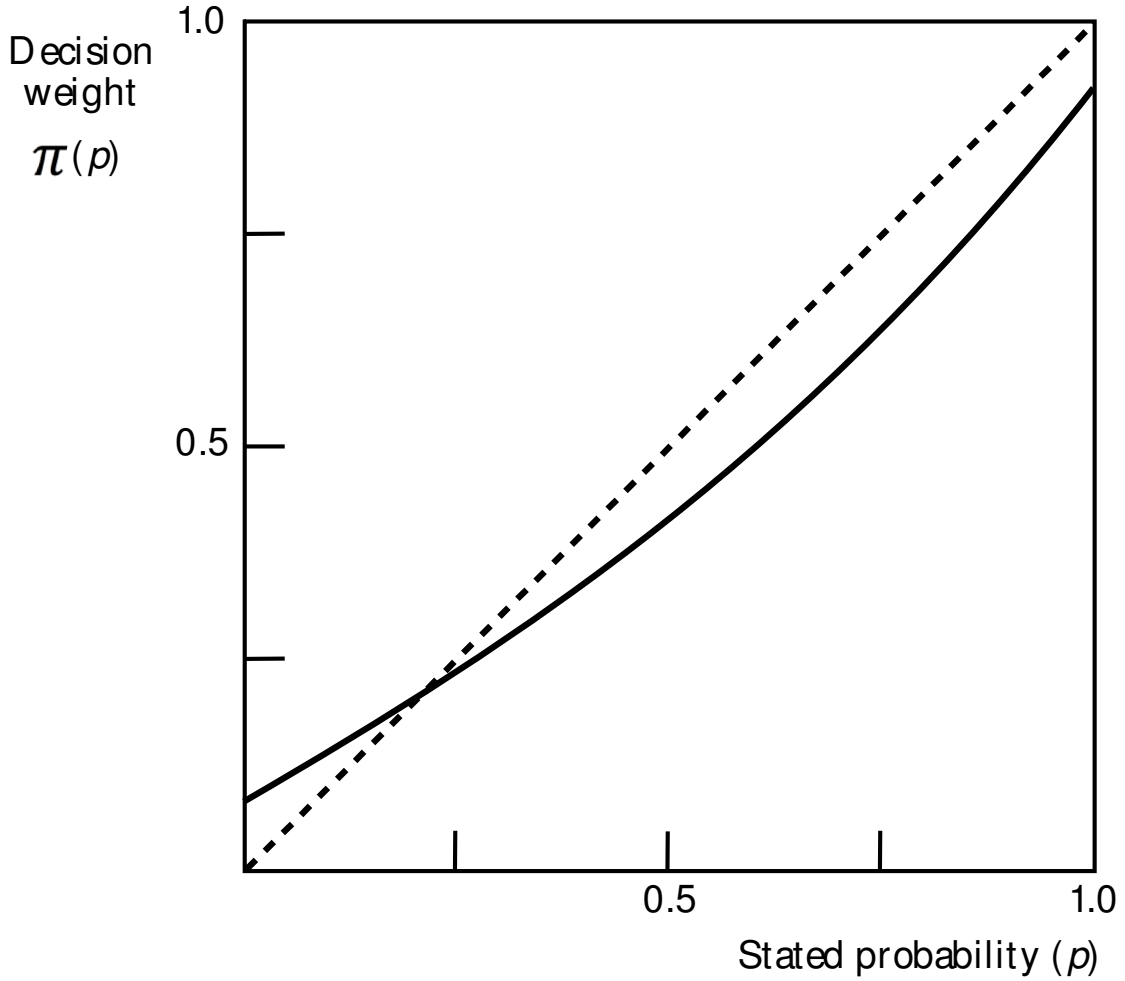
$$\text{Discretionary Income} = \begin{cases} 1.00, & \text{if responded, "1 always"} \\ 0.80, & \text{if responded, "2 most of the time"} \\ 0.60, & \text{if responded, "3 sometimes"} \\ 0.40, & \text{if responded, "4 hardly ever"} \\ 0.20, & \text{if responded, "5 never"} \end{cases}$$

$$\text{Credit Card Debt} = \frac{\ln(\text{£ total amount outstanding on credit cards})}{\ln(\text{£ maximum amount outstanding on credit cards in sample})}$$

$$\text{Current Account Debt} = \frac{\ln(\text{£ total amount overdrawn on current accounts})}{\ln(\text{£ maximum amount overdrawn on current accounts in sample})}$$

A.4. Decision Weighting Function from Prospect Theory

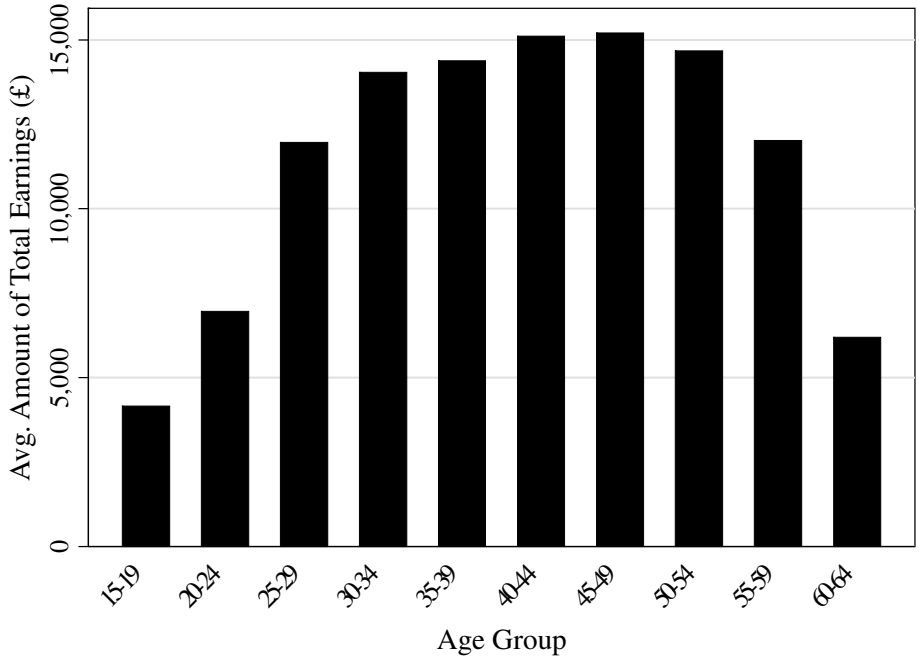
Figure A.3
Hypothetical Decision Weighting Function (Kahneman and Tversky, 1979)



Notes: Figure replicated directly from Kahneman and Tversky's 1979 paper, "Prospect Theory: An Analysis of Decision under Risk." Solid line indicates the hypothetical decision weighting function, showing the overweighing of low probabilities. Dashed line shows the 45-degree line, which is where the decision weight should be if perceived probabilities exactly matched stated probabilities.

A.5. Average Amount of Total Earnings Across Age Groups in WAS

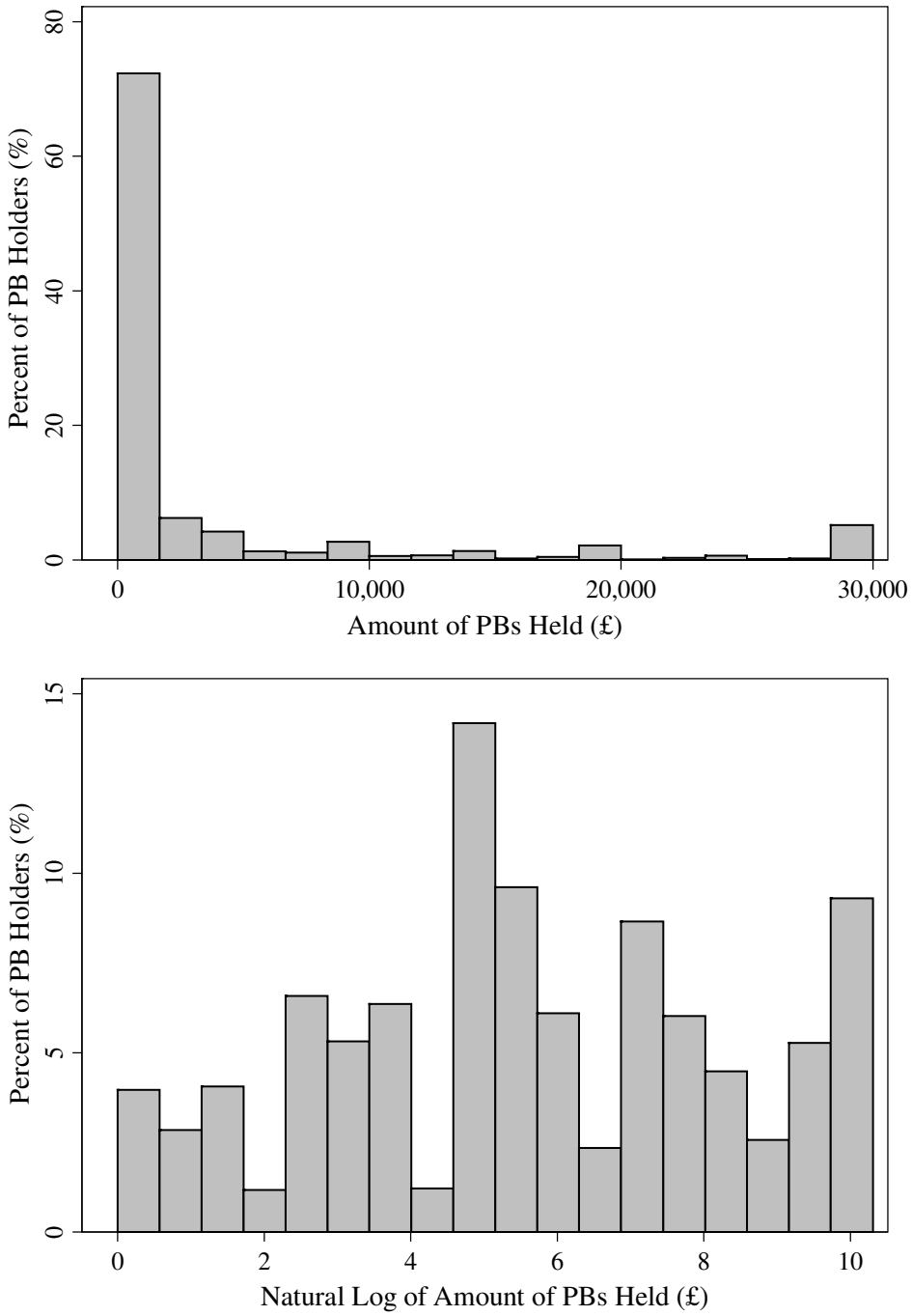
Figure A.4
Average Amount of Total Earnings
by Age Group



Notes: Sample is composed of Wave 1 of UKDA's Wealth and Assets Survey spanning 2006–2008 with n = 42,220.

A.6. Transformation of PB Holdings from Level to Log-Level

Figure A.5
Transformation of PB Holdings from Level to Log-Level



Notes: Sample is composed of Wave 1 of UKDA's Wealth and Assets Survey spanning 2006–2008 with n = 6,659. Only includes those who hold PBs.

A.7. Basic Summary Statistics and Correlations by Financial Wealth Halves

Table A.4
Basic Summary Statistics of Key Variables in WAS Dataset
by Financial Wealth Halves

Variable:	Mean	Std. Dev.	Min	Max
Lower half of wealth distribution:				
Age	39.63	12.03	17	62
Years of Education	12.22	2.44	9	21
Female	0.57	0.50	0	1
PB Holdings (£)	9.38	72.29	0.00	1500.00
Other Safe Savings (£10k)	0.01	0.03	0.00	0.19
Other Financial Assets (£10k)	0.02	0.04	0.00	0.19
Net Income (£10k)	0.89	1.23	0.00	42.10
High Discount Rate	0.86	0.35	0.00	1.00
Risk Tolerance Index	0.20	0.40	0.00	1.00
Fin. Literacy Index	1.99	0.40	0.95	3.00
Fin. Constraint Index	0.96	0.49	0.20	2.47
Upper half of wealth distribution:				
Age	45.76	11.41	17	62
Years of Education	13.31	2.97	9	21
Female	0.51	0.50	0	1
PB Holdings (£)	1100.76	4502.35	0.00	30000.00
Other Safe Savings (£10k)	1.53	4.38	0.00	302.40
Other Financial Assets (£10k)	2.62	9.76	0.00	410.00
Net Income (£10k)	1.64	3.50	0.00	240.00
High Discount Rate	0.71	0.45	0.00	1.00
Risk Tolerance Index	0.27	0.44	0.00	1.00
Fin. Literacy Index	2.23	0.43	0.95	3.00
Fin. Constraint Index	0.61	0.45	0.20	2.54

Notes: Sample is composed of Wave 1 of UKDA's Wealth and Assets Survey spanning 2006–2008.

Table A.5

Correlations Between Key Variables in WAS Dataset by Financial Wealth Halves

Lower half of wealth dist.:		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Age	(1)	1.000										
Years of Education	(2)	-0.275	1.000									
Female	(3)	-0.049	-0.030	1.000								
PB Holdings	(4)	0.007	0.045	0.003	1.000							
Other Safe Savings	(5)	-0.015	0.109	0.009	0.026	1.000						
Other Financial Assets	(6)	0.059	0.121	-0.049	0.021	0.020	1.000					
Net Income	(7)	-0.059	0.183	-0.209	0.025	0.093	0.167	1.000				
High Discount Rate	(8)	0.009	-0.050	-0.004	-0.003	-0.065	-0.052	-0.025	1.000			
Risk Tolerance Index	(9)	-0.034	0.012	-0.097	-0.011	0.008	0.011	0.049	-0.028	1.000		
Fin. Literacy Index	(10)	-0.006	0.208	-0.089	0.057	0.096	0.137	0.189	-0.055	0.005	1.000	
Fin. Constraint Index	(11)	-0.029	0.049	-0.003	0.008	-0.070	-0.244	0.051	0.048	0.011	0.071	1.000

Upper half of wealth dist.:		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Age	(1)	1.000										
Years of Education	(2)	-0.308	1.000									
Female	(3)	0.012	-0.023	1.000								
PB Holdings	(4)	0.135	0.030	-0.016	1.000							
Other Safe Savings	(5)	0.127	0.085	0.019	0.150	1.000						
Other Financial Assets	(6)	0.092	0.068	-0.048	0.079	0.159	1.000					
Net Income	(7)	-0.082	0.143	-0.141	-0.008	0.004	0.043	1.000				
High Discount Rate	(8)	0.023	-0.140	0.102	-0.060	-0.094	-0.060	-0.061	1.000			
Risk Tolerance Index	(9)	-0.065	0.045	-0.114	0.051	0.023	0.054	0.065	-0.070	1.000		
Fin. Literacy Index	(10)	-0.061	0.222	-0.180	0.047	0.058	0.066	0.105	-0.118	0.078	1.000	
Fin. Constraint Index	(11)	-0.131	-0.024	0.010	-0.101	-0.131	-0.049	-0.022	0.096	-0.019	0.002	1.000

Notes: Sample is composed of Wave 1 of UKDA's Wealth and Assets Survey spanning 2006–2008. Shaded values indicate difference in direction of correlation between the lower half and upper half of the wealth distribution.

A.8. Probit Outputs with Full Sample (Including Non-Savers)

Table A.6

Probit Model of Probability an Individual will Hold PBs

Dependent Variable: *Dummy for Holding PBs*	(1)	(2)	(3)
	Marginal Effects at Means		
Age	0.0075***	0.0058***	0.0053**
	(0.0015)	(0.0015)	(0.0023)
Age^2	-0.00002	0.000002	0.000002
	(0.00002)	(0.00002)	(0.00002)
Education Categories:			
Senior High	0.0894***	0.0852***	0.0805***
	(0.0074)	(0.0073)	(0.0106)
Higher Education	0.0985***	0.0901***	0.0696***
	(0.0069)	(0.0069)	(0.0102)
Female	-0.0012	0.0086*	0.0260***
	(0.0048)	(0.0049)	(0.0072)
Other Safe Savings (£10,000)	0.0075***	0.0075***	0.0053**
	(0.0007)	(0.0007)	(0.0022)
Net Income (£10,000)	0.0029**	0.0008	-0.0003
	(0.0013)	(0.0008)	(0.0007)
Tax Bracket Categories:			
Middle Tax Bracket		0.0421***	0.0285***
		(0.0052)	(0.0077)
High Tax Bracket		0.0787***	0.0379*
		(0.0176)	(0.0224)
High Discount Rate			-0.0185**
			(0.0086)
Risk Tolerance Index			0.0275***
			(0.0080)
Financial Literacy Index			0.1112***
			(0.0087)
Financial Constraint Index			-0.0402***
			(0.0076)
Observations	23,745	23,745	11,726
Pseudo R-squared	0.06	0.07	0.09

Notes: Sample is composed of Wave 1 of UKDA's Wealth and Assets Survey spanning 2006–2008. Please see "Notes" of Table 2 for description of explanatory variables. * significant at 10%, ** significant at 5%, *** significant at 1%.

Table A.7
Probit Model of Probability an Individual will Hold PBs: by Total Financial Wealth Halves

	(1)	(2)	(3)	(4)
	Total Financial Wealth Deciles 1–5		Total Financial Wealth Deciles 6–10	
Dependent Variable: Dummy for Holding PBs	Marginal Effects at Means			
Age	0.0013***	0.0011***	0.0061***	0.0061***
	(0.0002)	(0.0003)	(0.0004)	(0.0006)
Years of Education	0.0026***	0.0022*	0.0082***	0.0052**
	(0.0008)	(0.0012)	(0.0015)	(0.0022)
Female	0.0098**	0.0095	0.0017	0.0366***
	(0.0044)	(0.0064)	(0.0087)	(0.0127)
Other Safe Savings (£10,000)	0.3768***	0.3585***	0.0043***	0.0041**
	(0.0558)	(0.0824)	(0.0014)	(0.0020)
Other Financial Assets (£10,000)	0.1418***	0.2524***	0.0013***	0.0005
	(0.0521)	(0.0777)	(0.0005)	(0.0005)
Net Income (£10,000)	0.0029	0.0018	-0.0004	-0.0013
	(0.0021)	(0.0023)	(0.0009)	(0.0013)
Tax Bracket Categories:				
Middle Tax Bracket	0.0196***	0.0119	-0.0027	-0.0125
	(0.0054)	(0.0077)	(0.0099)	(0.0142)
High Tax Bracket	0.0159	-0.0017	0.0074	-0.0125
	(0.0311)	(0.0355)	(0.0204)	(0.0292)
High Discount Rate		0.0020		-0.0124
		(0.0084)		(0.0137)
Risk Tolerance Index		-0.0039		0.0362***
		(0.0078)		(0.0136)
Financial Literacy Index		0.0384***		0.1328***
		(0.0082)		(0.0148)
Financial Constraint Index		0.0263***		-0.0244*
		(0.0062)		(0.0139)
Observations	11,229	5,450	12,516	6,276
Pseudo R-squared	0.03	0.05	0.03	0.04

Notes: Sample is composed of Wave 1 of UKDA's Wealth and Assets Survey spanning 2006–2008. Please see "Notes" of Table 2 for description of explanatory variables. "Other Financial Assets" includes all financial assets other than safe savings (see text for details). * significant at 10%, ** significant at 5%, *** significant at 1%.

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He (David) Li