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ABSTRACT

Recent research has documented that delaying the commencement of Social Security benefits increases the expected present value of retirement income for most people. Despite this research, the vast majority of individuals claim Social Security at or before full retirement age. Claiming Social Security early is not necessarily a mistake, as delaying Social Security commencement requires forgoing current income in exchange for future income. The decision to claim early could therefore rationally be driven by liquidity constraints, mortality concerns, bequest motives, a high time discount rate, or a variety of other preference related factors. However, for some individuals, delaying Social Security offers a significant arbitrage opportunity because they can defer Social Security and have higher income in all future years. Arbitrage exists for most primary earners who either purchase a retail-priced annuity or opt for a defined benefit annuity when a lump sum payout is offered, while forgoing the opportunity to defer Social Security. These individuals are essentially buying an expensive annuity when a cheaper one is available, and their decision to claim Social Security early is almost certainly a mistake. The magnitude of the mistake can reach up to approximately $250,000.

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1. Introduction

Social Security retired worker benefits can be claimed at any age between 62 and 70. Individuals who claim later receive higher monthly benefits, an actuarial adjustment that is supposed to account for the fact that they will collect benefits for fewer total months. Delaying Social Security is equivalent to purchasing an inflation-indexed life annuity, as individuals who delay forgo current benefits in exchange for higher future benefits plus cost-of-living adjustments. A growing literature suggests that delaying Social Security increases the expected present value of retirement income for most primary earners and singles (e.g., Meyer and Reicherstein 2010; Munnell and Soto 2005; Shoven and Slavov 2014a,b). However, it is very difficult to say whether any given individual should defer Social Security. Individual preferences could be such that delaying Social Security actually lowers utility (e.g. due to poor health, liquidity constraints, high time discounts, or bequest motives).

In contrast to this literature, we are able to make much stronger positive statements. In this paper, we find that many people have the opportunity to make an arbitrage profit by selling (implicitly) an expensive annuity, and using the proceeds to purchase a cheaper supplemental Social Security annuity by delaying commencement of Social Security benefits. This arbitrage opportunity is available to individuals who are considering either purchasing a retail-priced annuity or taking a defined benefit annuity when a lump sum settlement is offered by their employer. Taking advantage of the arbitrage opportunity involves forgoing the defined benefit annuity and taking the lump sum payout instead, or forgoing the purchase of a retail-priced annuity. The funds from either the lump sum payout or the forgoing of the retail annuity would be used to delay the commencement of Social Security benefits.

Classic arbitrage occurs when one can simultaneously buy and sell the same asset and earn a riskless profit from differences in the market price of the asset. A more general definition of an arbitrage opportunity is a strategy whose payout in every state of the world and every period is non-negative, and whose payout in at least one state of the world is strictly positive. Arbitrage opportunities are usually

small and fleeting in competitive financial markets, but this is not necessarily so when prices are set by the government. Such is the case for Social Security inflation-indexed life annuities, which are priced by federal government legislation and which co-exist with more expensive private annuities. If an individual can strategically plan Social Security claiming so as to achieve an arbitrage profit but ignores this opportunity, we can confidently say that the individual is making a mistake.

The rest of the paper is organized as follows. Section 2 reviews the prior research and explains our contribution to the literature. Section 3 provides institutional background on Social Security and pension payout choices. Section 4 presents some illustrative examples. Section 5 generalizes the arbitrage argument. Section 6 discusses tax considerations. Section 7 presents empirical evidence on the extent to which individuals forgo arbitrage opportunities. Section 8 provides a discussion and concludes.

2. Related Literature

A number of papers have demonstrated that the *expected* value of deferring Social Security is positive for a large subset of individuals (e.g., Meyer and Reichenstein 2010; Munnell and Soto 2005; Sass, Sun, and Webb 2007, 2013; Coile et al. 2002; Mahaney and Carlson 2007; Shoven and Slavov 2014a,b). Studies that focus on more recent cohorts have generally found larger expected gains from delay (Meyer and Reicherstein 2010; Munnell and Soto 2005; Shoven and Slavov 2014a,b). In particular, Shoven and Slavov (2014a,b) show that when today's historically low interest rates are taken into account, the majority of individuals can gain from delay. Measured in terms of expected utility, the gains from delay are even larger due to the length-of-life insurance that Social Security provides (Sun and Webb 2009). Delaying Social Security is of greatest benefit to primary earners in married couples, since the secondary earner can continue to receive these benefits if she or he is widowed. Thus, delay has the added benefit of reducing widow poverty (Sass, Sun, and Webb, 2013).

In all of these expected monetary value and expected utility calculations, Social Security deferral reduces income initially. This means that deferral does not increase expected utility for individuals with sufficiently high time discount rates or mortality risks, or for individuals who face liquidity constraints or have strong bequest motives.[1] Similarly, regardless of ex ante preferences, delay does not increase realized utility in states of the world where the individual dies much earlier than expected. Thus, in order to argue that people are making a mistake by not delaying, one needs to be certain that one is using the correct utility function. We contribute to this literature by showing that some individuals are *absolutely* better-off by changing how they use their private pension assets and also choosing to delay the commencement of Social Security, receiving the same or higher income in all periods and states of the world. For these individuals, delaying Social Security is a good choice regardless of mortality risk, time preference, bequest motives, or liquidity.

A related strand of literature examines individuals' decisions to annuitize income. One key theme in this literature is that many individuals fail to annuitize income even though annuitization would appear to increase expected utility (e.g., Yaari 1965; Mitchell et al. 1999; Brown, Casey, and Mitchell 2007). Some studies have specifically examined determinants of the choice to annuitize income from employer-based defined benefit plans (e.g., Hurd, Lillard, and Panis 1998; Bütler and Teppa 2007; and Mottola and Utkus 2007) or defined contribution plans (e.g., Brown 2001). Our work also contributes to this literature by jointly examining the lump sum versus annuity choice *and* the Social Security claiming decision. We provide the insight that annuitizing pension wealth can be suboptimal for an individual who also claims Social Security early.

Several other studies have documented situations in which individuals appear to be forgoing arbitrage profit. For example, Choi, Laibson, and Madrian (2011) examine data from a set of companies

[1] Indeed, some empirical studies have demonstrated a correlation between actual or perceived mortality risk and early claiming (Hurd,Smith, and Zissimopoulos 2004; Glickman and Hermes 2015; Beauchamp and Wagner 2012; Waldron 2002; Goda et al. 2015).

and document that more than one third of employees aged 59½ or older contribute less to their 401(K) plans than the amount that would maximize their employer-provided matching contribution, despite the fact that they are immediately vested in the matching contribution and can make penalty-free withdrawals. The magnitude of the forgone income is around $500 per year for the years between age 59½ and retirement, and the total arbitrage profit amounts to $3,250 for those retiring at age 66. Amromin, Huang, and Sialm (2007) show that more than a third of households could realize tax arbitrage gains from contributing to a tax-deferred retirement account and paying off their mortgage more slowly. These arbitrage gains amount to roughly $400 per year, over the years remaining in the mortgage. At the upper end of the range, if 30 years remain for repayment, the arbitrage gains can reach $15,000. Finally, Li and Smith (2010) show that around half of the individuals in their sample could realize arbitrage gains on the order of $200-$275 per year by using 401(k) loans to pay off credit card debt. An upper bound estimate of the total arbitrage profit is $13,750 over a 50-year horizon. Compared to these studies, the potential arbitrage gains we find are much larger. For low-income individuals aged 69, arbitrage gains can amount to about $9,000. For individuals with average earnings in their early 60s, the gains are greater than $100,000. For those with high earnings, arbitrage gains can reach $250,000.

3. Institutional Background

An individual can begin Social Security retirement benefits at any age between 62 and 70, with 100% of the retirement benefit (referred to as the primary insurance amount, or PIA) payable at the full retirement age (which is 66 for individuals born between 1943 and 1954). Claiming benefits before the full retirement age results in a reduced monthly benefit.[2] An early claim by the higher earner in a married couple also reduces the survivor benefit paid to the lower earner of the couple in the event that

[2] Individuals who claim before full retirement age but continue to earn above a threshold income level are subject to the earnings test, which effectively forces them to delay part of their benefit, receiving the actuarial adjustment described in this paragraph.

the higher earner dies first.[3] Similarly, claiming benefits after age 66 and up to age 70 (the maximum deferral age) results in a higher monthly benefit for both the individual and the surviving spouse. For claims prior to full retirement age, the monthly benefit is reduced by 5/9ths of one percent of PIA for each month between 1 and 36 months and 5/12ths of one percent of PIA for each additional month. For claims after full retirement age, the monthly benefit increases by 2/3rds of one percent of PIA per month up to 48 months. Although many individuals appear to link retirement timing to the commencement of Social Security benefits, the two decisions can be made independently.

Retirees with an employer-based defined benefit plan are usually offered an option to receive their benefit in the form of a life annuity (single-life or joint and survivor annuities are typically offered). Many plans also offer the option to take all or part of the benefit as a lump sum.[4] The IRS provides the interest rates and mortality rates that employers must use to calculate the lump sum cash-out value (see appendix A for the most current interest and mortality rates).[5] Retirees with defined contribution plans or other forms of retirement savings can purchase annuities, either from an insurance company in the retail market or by choosing to annuitize a portion of their retirement savings (e.g., through a TIAA-CREF plan). Alternatively, retirees can choose not to annuitize, a decision that can be thought of as taking the defined contribution funds or other savings as a lump sum. Yakoboski (2013) shows that around 40 percent of TIAA-CREF retirees choose to annuitize their defined contribution balances.

[3] The widow receives the larger of the deceased spouse's actual benefit and 82.5% of the deceased spouse's PIA (see Weaver 2002 for additional details). In the arbitrage calculations that follow we do not take into account the 82.5% floor on widow benefits. We simply assume the widow receives the deceased spouse's actual benefit. In situations where the 82.5% floor applies (when the primary earner claims before 63 and 5 months), delaying Social Security is not equivalent to a 100% joint and survivor annuity. Therefore, strictly speaking, the arbitrage argument cannot be made. However, we believe this difference is likely to be small – i.e., something very close to an arbitrage opportunity exists.

[4] According to Bureau of Labor Statistics data from 2010 (the latest available), 24% of private sector workers in traditional defined benefit plans and 98% of workers in non-traditional defined benefit plans had a full or partial lump-sum option at normal retirement age. (See Bureau of Labor Statistics, National Compensation Survey: Health and Retirement Plan Provisions in Private Industry in the United States, 2010, Table 33.)

[5] Employers may use different discount rates but the lump sum value cannot be below the value calculated when using the IRS rates. A more generous lump sum only strengthens our arbitrage argument.

In the analysis below we show that choosing to collect defined benefit or retail annuities while also choosing to claim Social Security early is dominated by the option of taking the retirement savings as a lump sum and using it to defer Social Security. That is to say, the first choice is a "can't win strategy" relative to the alternative option. Switching from the annuity to the lump sum and deferring the commencement of Social Security produces either the same or higher income in all years and states of the world. Other combinations of decisions regarding pension accumulations and Social Security claiming (such as choosing to defer Social Security *and* annuitizing retirement savings, or taking retirement savings as a lump sum *and* claiming Social Security early) are not dominated by other options and the value of these strategies depends on the health, time discount rate, liquidity, and other preferences of the individual (and his or her spouse).

4. Illustrative Examples

A few simplified examples will illustrate the various arbitrage opportunities we examine. Consider John, who is single and at age 66 claims an annual Social Security benefit of $12,500. John also uses his retirement savings to purchase an inflation-indexed, single-life retail annuity that pays him $1,000 annually, starting immediately. The cost of this annuity is $22,290, or $22.29 per $1 of annual lifetime income.[6] All told, John pays $22,290 out of pocket, and enjoys $13,500 in inflation protected lifetime annual income.

We would argue that John has made a costly mistake. Given John's age, he has the opportunity to delay claiming Social Security. If he delays by one year, his Social Security benefit increases by 8 percent. In this case, delaying a year increases John's annual benefit from $12,500 to $13,500. Thus, after the delay period, John's income is exactly the same as it was under his original strategy. During the first year, John's income is even higher as he has access to the $22,290 that he would have used to

[6] In these examples, all annuity prices refer to Principal Life quotes retrieved on August 23, 2016. Principal Life was used because their annual CPI adjustment process most closely follows the Social Security process.

purchase the annuity. By deferring Social Security, John can increase his annual real lifetime income by $1,000 for a one-time cost of $13,500. In effect, Social Security is offering to sell John an inflation-indexed annuity for $13.50 per $1 of annual lifetime income, much lower than the retail annuity cost of $22.29 per $1 of annual lifetime income

This example highlights two key points. First, deferring Social Security is equivalent to purchasing an annuity. In this case, the deferral based annuity costs $13.50 per $1 of income. Second, since the deferral annuity is cheaper, there is a clear arbitrage opportunity. Compared to John's original strategy, the new strategy that eschews the retail annuity purchase (an implicit annuity sell), and purchases the Social Security annuity (an annuity buy) earns a risk free arbitrage profit of $8,790. Note that, by itself, purchasing the retail annuity is not necessarily a mistake. Moreover, claiming Social Security at age 66 could also be justified under certain conditions. However, the combination of purchasing of a retail annuity *and* claiming Social Security at age 66 is clearly a mistake in that there is an alternative strategy that replicates the payouts at a lower cost.

This same basic argument can be applied to other situations. For example, if John is a married primary earner, then an increase to his Social Security benefit last for as long as either John or his spouse is alive. John could also buy this type of income boost in the retail market by purchasing an inflation-indexed annuity with a 100% joint and survivor provision. Assuming his spouse is also 66, the cost of a retail annuity that provides $1,000 in annual income is $28,547, or $28.55 per $1 of annual lifetime income. But the cost of the Social Security annuity is still $13,500 – a better than half off sale! In this case, avoiding the retail annuity and purchasing the Social Security annuity earns a risk free gain of $15,047.

Very few people purchase inflation protected annuities, so what happens if someone purchases a nominal annuity instead? Suppose John is single and purchases a nominal annuity paying out $1,000 per year. The cost of this annuity is $15,268. Does unwinding this purchase and delaying Social Security

for a year offer an arbitrage profit? The answer is yes. John is paying $15.27 per $1 of nominal income, and he could purchase $1 of real annual income from Social Security for $13.50. With a retail annuity, John can spend $15,268 and receive an extra $1,000 in nominal annual income for life. By deferring Social Security, John can spend $13,500 and receive an extra $1,000 in inflation indexed annual income for life.[7] The Social Security annuity income costs less, and its cash flows are higher if there is positive inflation and the same if there is zero inflation or deflation.[8] The difference in prices, $15,268 - $13,500 = $1,768, represents the arbitrage profit in this case. If John were married, a 100% joint and survivor nominal annuity would cost $18,797. Since John can buy a Social Security joint and survivor *real* annuity for the same price as the single-life annuity ($13,500), he would again be absolutely better off deferring Social Security and forgoing the retail annuity.

In the unmarried example, the arbitrage profit when John purchased a retail real annuity was $8,790. When John purchased the retail nominal annuity, the arbitrage profit dropped to $1,768. The arbitrage profit in the case of real retail annuity is higher because the cash flows from the real retail annuity exactly match the cash flows from the Social Security deferral annuity. Thus, the value difference between the strategies was concentrated in the immediate arbitrage profit. However, when John buys a nominal annuity, the future payouts do not match exactly due to inflation, where the Social Security payouts are equal or larger than the retail nominal annuity payouts. In this case, the total value of deferral is split between an immediate arbitrage profit of $1,768 and later value from increased payouts when there is positive inflation. Since we want to identify situations in which deferral yields higher payouts in all possible states of the world - including states with zero inflation or deflation - we focus on the immediate arbitrage profit. However, it should still be noted that significant additional value is often available from Social Security deferral above and beyond the arbitrage profit.

[7] Note that because the indexing occurs annually, real and nominal payouts are equivalent in the first year.
[8] Nominal Social Security benefits do not decrease in the event of deflation.

The same logic applies to a cash-out opportunity from a corporate defined benefit plan. Suppose John is a married primary earner, and he is eligible for a defined benefit pension that offers an annual $1,000 nominal joint and survivor annuity. John also has the option of taking a lump sum cash-out of $16,275.[9] While we cannot say for sure what John's optimal strategy is, we can say that taking the $1,000 defined benefit annuity and claiming Social Security at age 66 is a mistake. As in the examples above, John could take the $16,275 lump sum, receive an extra $1,000 per year (in real terms) by deferring Social Security for one year, and come out ahead by $16,275 - $13,500 = $2,275. The real $1,000 per year Social Security annuity also is more valuable than the nominal $1,000 defined benefit annuity.

If John were single, the lump sum for the $1,000 annual pension payment would only be $13,771 and yet it is still higher than the cost of the incremental $1,000 from Social Security, costing $13,500. However, we note that the arbitrage profit is small, and a slight increase in the IRS minimum present value segment rates could shift this number below the cost of the Social Security annuity. If that were to occur, we could no longer be certain that John's current strategy is inferior, since John would need to pay out-of-pocket the difference between the defined benefits lump-sum value and $13,500. John may still be much better off using the deferral strategy, since inflation protection is very valuable. However, this situation would not qualify as an arbitrage opportunity.

To provide intuition for the arbitrage opportunity, we have focused on the benefit from a single year deferral of a conveniently sized Social Security payout ($12,500). However, in many cases the arbitrage benefit can be quite large. To get a rough idea of the maximum arbitrage benefit, assume John is a 62-year-old primary earner and earned the maximum taxable amount in each year of his career. He is entitled to an annual Social Security benefit of $24,000 at age 62.[10] John can maximize his annual

[9] This amount is calculated using the IRS mortality tables and discount rates described above.
[10] This is slightly more than 75% of the maximum full retirement benefit in 2016 which is $23,751. We use the higher number to ease the exposition and to reflect a possibly higher PIA since John is only 62 in 2016.

payment from Social Security by deferring until age 70. At age 70, John would receive $42,240 from Social Security, an $18,240 increase. John could also receive $42,240 each year during the delay period if he used $337,920 of his retirement savings.[11] If instead of the Social Security deferral, John purchased an inflation protected joint and survivor annuity that paid out $18,240 annually, it would cost him $586,325. In this example, if John switches from purchasing the annuity to deferring Social Security, he can earn an immediate arbitrage profit of $248,405, quite a large risk-free opportunity indeed![12]

But only six percent of workers covered by Social Security earn more than the maximum taxable amount.[13] To explore further the arbitrage gains for more typical workers, we begin with a set of stylized workers whose career average earnings are equal to 45%, 100% and 160% of the national average wage index (AWI).[14] We consider the opportunity to defer benefits to age 70 from ages 62-69. The arbitrage

Table 1: Potential Arbitrage Gains by Delaying Social Security to Age 70

age	Low earnings (45% of AWI)	Medium earnings (100% of AWI)	High earnings (160% of AWI)
62	91,633	151,078	200,257
63	82,480	135,982	180,244
64	68,105	112,280	148,825
65	55,501	91,497	121,276
66	45,516	75,034	99,454
67	31,222	51,468	68,217
68	18,965	31,262	41,435
69	8,681	14,308	18,964

Notes: Gains for married couples. Spouse assumed to be at the same age as primary earner. Calculations based on CPI-adjusted 100% Joint and Survivor annuity quotes from Immediate Annuities retrieved on August 23rd, 2016.

[11] This assumes John has access to a riskless investment that earns a 0% real return. The arbitrage argument is strengthened if John can earn a positive real return.

[12] We choose to use a retail annuity quote by an A+ rated insurance company. We could have taken a cheaper annuity by an A rated company, which would take down gains to just below $215,000.

[13] Social Security Administration, Annual Statistical Supplement 2015, Table 4.B1

[14] Benefit amounts for these stylized earners are given in Table V.C7 of the 2016 Social Security Trustees Reports. The workers in the table are in the 1951 birth cohort and turn age 65 in 2016. For our analysis, however, we assume that each deferral under consideration (e.g., from age 62 to age 70) takes place this year.

gains for these cases are listed in table 1 above. These calculations assume a spouse of the same age as the primary earner. If the spouse is considerably younger, then the gains would be even higher because the retail annuity cost would increase while the cost of delaying Social Security remains the same. These arbitrage gains can be used to buy additional real annual income equivalent to 18% of the total annual income (for those at age 62).

The above examples give the intuition for the arbitrage argument, but they abstract away from several important factors. As we saw, the number of deferral years can dramatically impact the arbitrage profit. Moreover, there can be significant tax implications associated with shifting income from an annuity payout to a Social Security payout. Finally, the Social Security annuity price varies in a somewhat haphazard way across the relevant ages. At age 66, we showed that the Social Security annuity price was $13.50 per $1 of annual lifetime income. However, the annuity price depends on the Social Security formula for increasing benefits. For example, the price is $16 per $1 of annuity payout at age 62 and $13 per $1 of annuity payout at age 63. In the rest of this paper, we generalize the arbitrage argument to consider the universe of deferral options. In addition, we review the tax implications of the arbitrage strategy and argue that the arbitrage profits are present even after taking taxes into account.

5. Generalizing the Argument

We now generalize the arbitrage argument that we sketched in the previous section. We consider first the case of defined benefit pensions. Since defined benefit annuities are cheaper than retail annuities, the arbitrage argument will hold for retail annuities whenever it holds for defined benefit annuities.

The examples in the previous section were constructed in such a way that the increase in Social Security benefits from deferral was exactly equal to the defined benefit annuity. This ensured that the cash flows after the deferral period were identical (under the assumption of zero or negative inflation),

allowing us to establish dominance by comparing income during the deferral period. If the defined benefit annuity is greater than the annuity available from deferring Social Security, then deferring Social Security will not be able to fully cover the defined benefit annuity payment and the individual may be worse off in some states of the world.

We can get around this problem by assuming that the individual can choose a partial defined benefit lump sum, which allows him or her to give up exactly the amount of defined benefit annuity income that will be offset by the increase in Social Security benefits.[15] This creates the same situation we saw in the examples, where the cash flows of the two strategies are identical (again, assuming zero or negative inflation) from the moment Social Security benefits are claimed, allowing us to simply compare the cash flows from the two strategies during the delay period. As we discussed in the previous section, the presence of positive inflation only increases the attractiveness of deferral. While not all employers offer partial lump sums, there is no additional accounting cost in doing so. Thus, in cases where employers do not offer a partial lump sum, our analysis suggests that the employer and employee are jointly forgoing an attractive arbitrage opportunity.

We consider both primary earners and single individuals. For primary earners, we assume the spouse is the same age as the primary earner. Single individuals are assumed to take a single life defined benefit annuity, while primary earners are assumed to take a 100% joint and survivor defined benefit annuity. With these assumptions and applying the IRS rules (see appendix A), we calculate the defined benefit lump sum value for all ages (in months) from age 62 through 69.

When comparing cash flows for deferral periods longer than one year, we use interest rates to discount the forgone cash flows from the Social Security and defined benefit annuity payments. We discount the Social Security payments using the real interest rates on Treasury Inflation Protected

[15] In these calculations we are implicitly assuming that the defined benefit annuity is at least as large to allow for the delay in Social Security. Delaying for several years will require large defined benefit annuities, but delays of a few months can be financed with small defined benefit annuities.

Securities (TIPS) as of August 2016. A real interest rate is appropriate here since Social Security benefits increase with inflation (adjusted once a year). Since defined benefit annuity payments are generally not inflation adjusted, we discount these by the nominal risk free CD rates over appropriate horizon. The CD and TIPS rates used in this analysis are given in Appendix C. Both cash flows are discounted annually. Discounting the payments allows us to determine whether we can take the defined benefit lump sum, invest it in an appropriate portfolio of CDs and TIPS, and replicate the forgone Social Security and defined benefit annuity payments during the delay period. If this is possible, then there are arbitrage gains from deferring Social Security and taking a partial lump sum. After the delay period, the cash flows are, by construction, the same with zero or negative inflation, and higher for the deferral strategy if there is positive inflation.

Consider an individual aged a who claims Social Security immediately and takes a defined benefit annuity. We compare this strategy to the alternative of deferring Social Security from age a to age $a + d$ and taking a partial lump sum. Both *a* and *d* are measured in months, since Social Security benefits are actuarially adjusted on a monthly basis. We analyze the net cash flows from the deferral strategy for every possible value of a and d. The results are presented in the top row of Figure 1 for primary earners and singles. Note that for defined benefit pensions, the gender of the individual does not matter as the IRS rules for calculating lump sum payments are gender neutral.

In each graph in this figure the x-axis depicts the number of deferral months and the y-axis depicts the primary earner's age (in years). Each black cell indicates the presence of arbitrage gains from the deferral strategy. Dark grey indicates that arbitrage gains do not exist, but the difference between the forgone Social Security income and the defined benefit lump sum is below 5% of the lump-sum value. That is to say that an individual choosing to take the lump sum and use the funds to delay Social Security will need to supplement the lump sum by up to 5%. Despite the absence of arbitrage gains, paying this cost may be worth it as the individual is exchanging a nominal annuity for a real annuity. The

next lighter shade of grey indicates that the difference between the forgone Social Security income and the defined benefit lump sum is between 5% and 10% of the lump-sum value.

For married primary earners (the top-left graph) there are arbitrage gains from deferring at most ages. For singles (the right graph) opportunities for arbitrage gains are limited but still exist for some ages. In particular, for those aged 63, there are arbitrage gains from deferring at least to age 64. And for those aged 66, there are arbitrage gains from deferring by a couple of months.

We emphasize, however, that the absence of arbitrage gains does not necessarily mean that deferral is the wrong strategy; it simply means that the choice to defer depends on the individual's health and preferences. As we see in the graph, for couples, choosing the deferral strategy may be a good deal at any age since even when arbitrage is not possible, the cost of exchanging the nominal defined benefit annuity for the real Social Security annuity is less than 10% of the present value of the defined benefit lump sum.

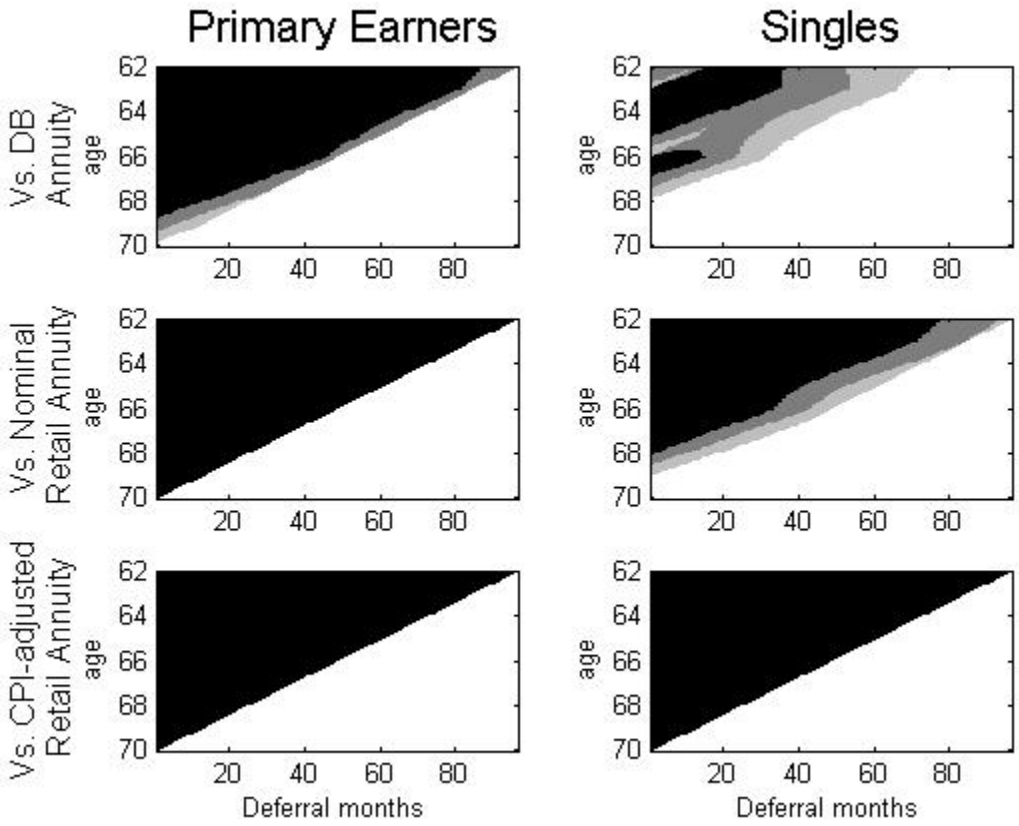
Next we consider two types of retail annuities, nominal annuities and CPI-adjusted annuities, and we calculate the arbitrage gains for primary earners and single men. We obtain annuity quotes from the Immediate Annuities website (www.immediateannuities.com; additional details are provided in Appendix B). Male and female primary earners face the same retail annuity prices for joint and survivor annuities, since the same amount is paid out until the second person in the couple dies. However, retail annuity prices are lower for single males relative to single females due to higher life expectancy for females. Since Social Security annuities cost the same for females and males, when the arbitrage argument holds for a single male, it will hold for a single female. For this reason, we obtain quotes for single males.

Retail annuity quotes vary by state of residence since some states tax annuities. To abstract from this complication, we request annuity quotes applicable in Texas, the biggest (in terms of population) state with no income tax. We again use nominal CD interest rates to discount the cash flows

of the nominal retail annuities during the deferral period and we use TIPS rates to discount the cash flows of the CPI adjusted annuities and Social Security.

Results for nominal retail annuities are presented in the second row of Figure 1, and results for retail CPI adjusted annuities are presented in the third row. As before, black cells indicate pure arbitrage gains that can be made choosing the deferral strategy. Dark grey cells indicate that the cost of the deferral strategy is up to 5% of the annuity cost, and light grey cells indicate that the cost is 5%-10% of the private annuity cost.

Figure 1: Presence of Arbitrage Gains from Deferring Social Security



Notes: Each cell in the top triangle of each graph represents a combination of age and number of deferral months. Black cells indicate the presence of arbitrage gains from the deferral strategy relative to the option of taking the defined benefit annuity or buying the private annuity and commencing Social Security immediately. Dark grey indicates that arbitrage gains do not exist, but the difference between the forgone Social Security income and the alternative private sector annuity cost is below 5% of the private sector annuity cost. Light grey indicates that the difference between the forgone Social Security income and the private sector annuity cost is between 5 and 10% of the private sector annuity cost. Defined benefit lump sums are calculated based on IRS rules. Private sector annuity costs are based on quotes retrieved from Immediate Annuities.

There are several interesting results observed in these graphs. First, couples have larger arbitrage gains opportunities relative to singles, and there are larger arbitrage gains from choosing the deferral strategy over retail annuities compared to defined benefit annuities. Second, the primary earner in a couple should *never* choose to claim Social Security before age 70 and buy a retail annuity (nominal or CPI adjusted), since for all ages the area is black (see left graphs in the second and third row). Third, even for singles, choosing to buy a retail annuity and not defer Social Security is almost always a dominated strategy. Real retail annuities are dominated by the deferral strategy in all circumstances. For nominal annuities, even where there are no arbitrage profits, the additional cost of the deferral strategy is in most ages less than 5% of the retail nominal annuity cost.

6. Tax Implications

Up to this point, our analysis has focused on pre-tax dollars. In reality, however, the two strategies we analyze have different tax implications. Our baseline case concerns a couple that is receiving Social Security income as well as taxable income from an annuity source. Our alternative strategy assumes the annuity is either not purchased or, in the case of a corporate DB pension, cashed out. The proceeds are then used to cover costs during the Social Security deferral period. Compared to the baseline, the alternative strategy has less Social Security income during the deferral years, and more Social Security income in the later years. In addition, the alternative concentrates non-Social Security income in the deferral years. The net tax implications of this strategy change are indeterminate and depend primarily on how much other income a household enjoys.

Table 2 illustrates the after-tax benefit a married couple receives from deferring Social Security from age 62 to 66 instead of purchasing a real annuity. For this analysis, we quantify the benefit by matching after-tax income during the deferral stage, and then calculating the increase in income once the deferral stage is over. In this example, John and his spouse claim Social Security at age 62, and are

receiving $20,000 and $10,000, respectively, in benefit payments. To augment their income, John has used money from a traditional individual retirement account (IRA) to purchase a real annuity that pays out $5,000 per year. John's household also receives $30,000 in annual income from other sources. Given this situation, the household receives $30,000 in Social Security, but only $11,100 of the Social Security is taxable income.[16] The aggregate taxable income is $46,100, and the total Federal taxes owed amount to $5,993. Adding up income and subtracting taxes implies the after-tax income for the household is $59,008.

Table 2: Post-Tax Analysis
Real Annuity Purchase vs. Deferral to Age 66

	Age 62 - 65		Age 66+		Survivor	
	Baseline	**Deferral**	**Baseline**	**Deferral**	**Baseline**	**Deferral**
Primary Social Security	$20,000	$0	$20,000	$26,667	$20,000	$26,667
Secondary Social Security	$10,000	$10,000	$10,000	$10,000	$0	$0
Annuity Payout[1]	$5,000	$1,722	$5,000	$1,722	$5,000	$1,722
Other Income	$30,000	$56,349	$30,000	$30,000	$30,000	$30,000
"Combined Income"	$50,000	$63,071	$50,000	$50,055	$45,000	$45,055
Federal Taxable Social Security	$11,100	$8,500	$11,100	$11,147	$13,850	$13,897
Federal Taxable income	$46,100	$66,571	$46,100	$42,869	$48,850	$45,619
Federal Taxes Owed	$5,993	$9,063	$5,993	$5,508	$8,006	$7,198
After tax income	$59,008	$59,008	$59,008	$62,881	$46,994	$51,190
			Net Improvement:	$3,873	**Net Improvement:**	$4,196
			% of Primary Benefit:	19%	**% of Primary Benefit:**	21%

[1]The real annuity is assumed to cost $32.15 per $1 of annual income.

Suppose John considers an alternative strategy where he buys a smaller annuity, and uses the money he saves to augment his income while he defers Social Security from age 62 to age 66. If John wants to exactly maintain his after-tax income during the deferral stage, how much less of an annuity should he purchase? Table 2 answers that question. If John reduces his annuity purchase from $5,000 to

[16] To determine how much Social Security is taxable, a side calculation is required to determine the couple's "combined income." Combined income generally consists of non-Social Security income plus 50% of Social Security income. The amount of Social Security subject to taxation varies based on combined income, but never exceeds 85% of the total Social Security income.

$1,722, he will find that he exactly replicates his original after-tax income during the deferral period. He has less Social Security during this period, and substantially higher "other income" owing to the fact that he is spending $26,349 each year from his IRA. The net effect, however, is that John's after-tax income during the deferral period is $59,008 in either case. John begins taking his Social Security at age 66. At this point, his Social Security and after-tax income is higher. To find out if deferral was advantageous, we calculate the after-tax income after the deferral. In this case, the after-tax income per year is $3,873 higher using the deferral strategy compared to the original strategy. In after-tax dollars, John is equally well off between age 62 and 66. After age 66, John's household enjoys an after-tax income increase of $3,730.

This $3,730 of additional income represents a 6.3% increase relative to the $59,008 of baseline after-tax income. However, the baseline income is highly dependent on the assumption that other income was $30,000. To better capture the opportunity afforded from Social Security deferral and to normalize across scenarios, we report the income increase as a percentage of the primary benefit that is being deferred. In this case, the increase in after-tax income is 19% of the $20,000 primary benefit that was deferred. A significant advantage of deferring Social Security is that a surviving spouse also receives an increased payout. In this example, the surviving spouse enjoys an after-tax income increase of $4,196, or 21% of the primary benefit.

The taxation implications of the alternative strategy depend on the amount of other income the household receives. To explore this aspect of the strategy, we repeat the analysis from Table 2 and vary the amount of other income from $0 to $100,000. The top panel in Figure 2 summarizes the results. For a married couple, the after-tax income boost ranges from 14% to 20% of the primary benefit. For a single individual, the boost range is 10% to 18%. At higher income levels, the married income increase is roughly 40% larger (14% vs. 10%) than the single income increase. This is due to the fact that a joint and survivor annuity is substantially more valuable than a single life annuity. The general pattern is an

upward trend across lower incomes followed by a sharp reduction towards a constant percentage increase at higher income levels. This pattern is primarily caused by the Social Security taxation rules. At low income levels, Social Security is not taxable income. At high income levels, 85% of Social Security is treated as taxable income. The transition creates anomalously high marginal tax rates that the alternative strategy helps avoid. For example, suppose the household is in a 30% tax bracket, and then receives a marginal $1 in extra income. The tax on this $1 would normally be $0.30. However, an extra $1 in income could cause up to $0.85 of Social Security to transition from non-taxed to taxable income. The $1 in additional income would then create a total tax increase of $0.555, $0.30 for the normal tax bracket, and an additional tax of $0.255 in tax due to higher Social Security taxable income. The marginal tax rate is 55.5%! In this income region, the alternative strategy converts highly taxed annuity income into more lightly taxed Social Security income[17], and that benefit is captured by the upward trend in the top graph in Figure 2. At sufficiently high income, Social Security is maximally taxed irrespective of the strategy, so the benefit peak dissipates into a plateau.

The second graph in Figure 2 repeats the analysis for a nominal annuity purchase. The same general pattern emerges although the income boosts are uniformly lower. For this situation, the alternative strategy still represents an arbitrage opportunity at all income levels for both couples and singles, but the benefit for a married couple ranges from 6% to 14%, and for singles it ranges from 1% to 12%. At high income levels, the benefit to a married couple is approximately 7% compared to 2% for the single individual. It should be again noted that the arbitrage analysis assumes the worst possible outcome for the alternative strategy, which in this case is either no inflation or deflation. If there is any inflation, the alternative strategy would generate even larger benefits.

The last graph in Figure 2 considers the after tax implications of a defined benefit cash-out. Here the arbitrage results are mixed. For a married couple, the arbitrage results hold, but for a single person

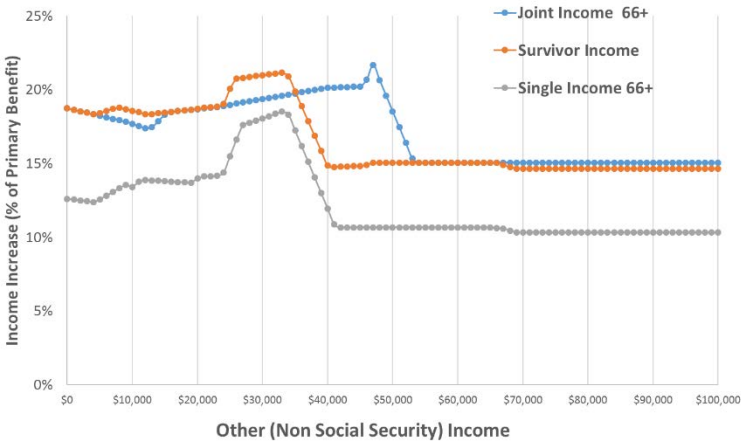
[17] Recall that only 50% of Social Security income enters the calculation for determining how much Social Security income is taxed.

there is no arbitrage opportunity since the post-deferral income change is negative at many income levels. The overall benefit to the alternative strategy is significantly reduced owing to the lower implicit annuity prices offered as a defined benefit cash-out. While after-tax arbitrage is not available to singles in this case, the alternative strategy can still represents a highly desirable opportunity. For a fairly modest cost, a nominal corporate annuity can be exchanged for a government inflation protected annuity. Indeed, if cumulative inflation ever exceeds a few percent, the alterative strategy will have higher payouts.

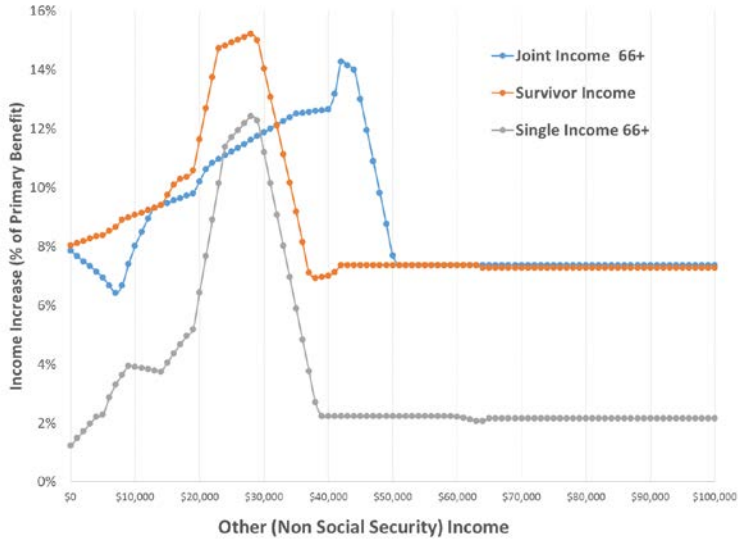
There are many dimensions of the U.S. tax code, and an exhaustive tax analysis is far beyond the scope of this paper. However, we have considered the main tax components for the important case when an individual is considering deferring Social Security from age 62 (the earliest eligibility age) to age 66 (the full retirement age). Our after-tax results corroborate the pre-tax analysis. Namely, there is a large and ubiquitous arbitrage opportunity when a real annuity is purchased and a smaller but still widely available arbitrage when a nominal annuity is purchased. When a defined benefit cash-out is considered, married couples generally have an arbitrage opportunity. For singles, there likely is not an arbitrage although they are still likely to be better off cashing out their defined benefits plan to defer Social Security. Given the consistency with which the after-tax results track the pre-tax results and the fact that the alternative strategy often conveys tax advantages, we believe that the arbitrage results are generally robust to after-tax considerations. The results in this section are also consistent with Mahaney and Carlson (2012), who document tax advantages from replacing IRA income with Social Security income through delaying Social Security.

Figure 2: Presence of Arbitrage Gains from Deferring Social Security, After-Tax Analysis

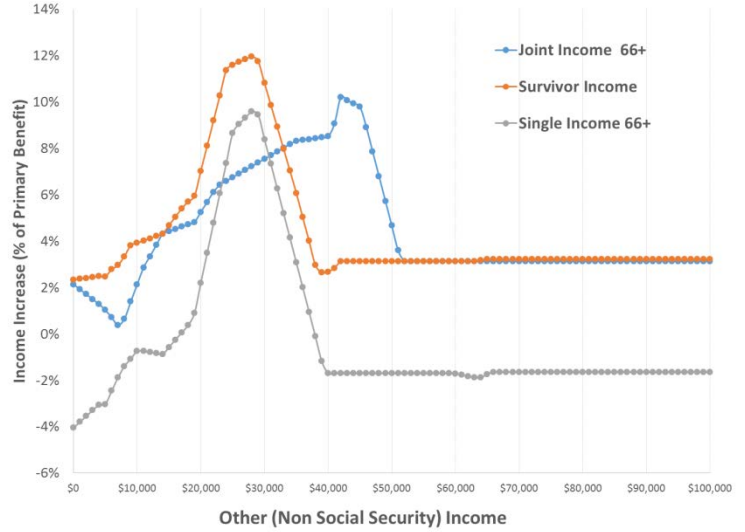
A: Real Retail Annuity



B: Nominal Retail Annuity



C: Defined Benefits Annuity



Notes: These calculations assume baseline Social Security income of $20,000 for the primary earner and single, and $10,000 of Social Security income for the secondary earners. Both couples and singles are assumed to receive a private sector annuity of $10,000.

7. Empirical Evidence from the Health and Retirement Study

We use data from the Health and Retirement Study (HRS) to get an idea of how many individuals may be using the dominated strategy of claiming Social Security early and at the same time taking a defined benefit pension annuity or buying a retail annuity. The HRS is a panel survey conducted every other year that is intended to be representative of the U.S. population age 50 and older. We utilize all 11 waves of the survey, from 1992-2012. Our analysis is conducted at the person-wave level.[18]

As we cannot observe how much individuals earned relative to their spouses, we restrict our sample to married men, who are more likely to be the primary earner in the couple. We also exclude singles, since our analysis suggests that arbitrage opportunities are limited for singles. Finally, we exclude anyone who has ever had a disability episode, as deferral opportunities are more limited for disability benefits.

We tabulate, at each age, the fraction receiving income from Social Security retirement, employer-sponsored pensions, and other annuities.[19] These results are shown in table 3. The full retirement age for the majority of individuals in our sample is 65. By age 66, 85% of the sample has claimed Social Security. Since HRS income figures refer to the previous calendar year, these are likely to be individuals who claimed at their full retirement age. At the same age, almost 40% receive income from employer-sponsored pensions and another 3% receive income from other annuities. The last two columns of the table suggest that more than a third of the population, by age 66, have claimed Social Security and are receiving pension or annuity income.

There are two caveats to this analysis. First, income from employer-sponsored pensions is derived from questions about "income from retirement pensions" that specifically instruct individuals to exclude lump sum payments. These variables include defined benefit and defined contribution

[18] We use the RAND version of the HRS, which is a cleaned dataset containing a subset of the variables from the original survey.

[19] Pension income is based on the RAND variables r1ipen-r11ipen. Annuity income is based on the RAND variables r1iann-r11iann.

annuities. However, they may also include withdrawals from defined contribution pensions, and the annuities may not be joint and survivor annuities. Thus, the fractions in the final column of the table represent upper bounds on the fraction of the population receiving both Social Security and joint-and-survivor annuity income. Second, it is not clear what fraction of these individuals had a lump sum (or partial lump sum) option in their pension. Again, this suggests that our fractions represent upper bounds on the fraction of people who are missing arbitrage gains. However, even if these individuals were not offered partial lump sums, we can say that these individuals and their employers have jointly missed a potential arbitrage opportunity.

Table 3: Receipt of Social Security and Pension Income by Age (All Birth Cohorts)

Age	Observations	Fraction Receiving Social Security	Fraction Receiving Pension	Fraction Receiving Annuity	Fraction Receiving Social Security and Pension	Fraction Receiving Social Security and Either Pension or Annuity
55	1985	0.01	0.06	0.00	0.00	0.00
56	2030	0.01	0.09	0.01	0.00	0.00
57	2096	0.01	0.11	0.01	0.00	0.00
58	2020	0.01	0.14	0.01	0.00	0.00
59	2022	0.01	0.14	0.01	0.00	0.00
60	2084	0.01	0.17	0.02	0.00	0.00
61	2015	0.02	0.21	0.02	0.00	0.00
62	1820	0.16	0.24	0.02	0.07	0.07
63	1777	0.43	0.29	0.02	0.20	0.20
64	1599	0.52	0.33	0.02	0.25	0.25
65	1606	0.64	0.33	0.03	0.28	0.30
66	1401	0.85	0.39	0.03	0.35	0.37
67	1439	0.93	0.38	0.02	0.36	0.37
68	1362	0.94	0.44	0.04	0.41	0.43
69	1471	0.95	0.42	0.04	0.40	0.43

Notes: Includes all person-year observations for married men who have never had a disability episode. Receipt of Social Security indicates positive Social Security retirement income. Receipt of pension indicates positive employer-sponsored pension income. Respondent level weights used.

Defined benefit pensions have declined in popularity over time; thus, it is possible that the fraction missing an arbitrage opportunity has also declined. Table 4 shows the same results as table 3,

but for individuals born in 1940 or later. This table suggests that the fraction missing an arbitrage opportunity may be as high as 25%.

Table 4: Receipt of Social Security and Pension Income by Age (Born in 1940 or Later)

Age	Observations	Fraction Receiving Social Security	Fraction Receiving Pension	Fraction Receiving Annuity	Fraction Receiving Social Security and Pension	Fraction Receiving Social Security and Either Pension or Annuity
55	1445	0.01	0.05	0.00	0.00	0.00
56	1426	0.01	0.08	0.01	0.00	0.00
57	1304	0.01	0.10	0.01	0.00	0.00
58	1164	0.02	0.13	0.01	0.00	0.00
59	1056	0.02	0.13	0.01	0.00	0.00
60	987	0.01	0.15	0.02	0.00	0.00
61	914	0.02	0.18	0.01	0.00	0.00
62	809	0.15	0.21	0.01	0.06	0.06
63	751	0.40	0.24	0.02	0.15	0.16
64	614	0.47	0.28	0.02	0.19	0.20
65	595	0.58	0.24	0.03	0.19	0.21
66	480	0.79	0.32	0.03	0.27	0.28
67	438	0.93	0.25	0.02	0.24	0.25
68	317	0.94	0.31	0.04	0.30	0.33
69	304	0.98	0.24	0.06	0.23	0.28

Notes: Includes all person-year observations for married men who have never had a disability episode. Receipt of Social Security indicates positive Social Security retirement income. Receipt of pension indicates positive employer-sponsored pension income. Respondent level weights used.

8. Conclusions

Economists are hesitant to call observed consumer behaviors "mistakes" as different preferences can justify lots of different behaviors. However, by focusing on cases that are more clear-cut, we have shown that it is possible for retirees to make big mistakes with their choices regarding annuitization of retirement resources and claiming of Social Security. Many American retirees have an arbitrage opportunity of effectively selling a more expensive life annuity and exchanging it for an equivalent or superior life annuity that is cheaper. Up to 25 percent of retirees may be receiving income from both Social Security and private annuities in their mid-60s. These individuals and their

employers (if they do not offer a lump sum option) are collectively forgoing an arbitrage opportunity. The arbitrage gains are around $100,000 for married primary earners with average earnings, and can reach about $250,000 for those with high earnings. Taking Social Security early and annuitizing income wastes this money. While taxes complicate the argument, our general findings are robust to the inclusion of taxes.

We have not taken up the question of why so many people are making these big monetary mistakes, but that is a topic worth further research. There are several possible explanations to be explored. First, many individuals may not have access to partial lump sum options in their defined benefit pensions. However, that explanation merely shifts the puzzle to the level of the employer. Employers may prefer not to offer a lump sum option for their defined benefit plans because they believe cashing out of the plan is inferior to taking an annuity. However, in many common situations, the opposite is true, and it suggests that employers are forgoing an opportunity to pass on arbitrage gains to their retirees. For example, employers could help employees integrate their pensions with Social Security deferral by offering annuities that provide higher payments through age 70 and lower payments thereafter. While some public sector employers do offer such "Social Security leveling," the lower payments often kick in at age 62 under the assumption that individuals will claim Social Security at that point (Clark, Hammond, and Morrill 2016). Second, Social Security rules are complicated and life annuities are probably not well understood by most Americans. Faced with this complexity, people may treat the Social Security claiming and annuity purchase decisions separately, rather than integrating them. Third, individuals may make claiming decisions according to simple rules of thumb. For example, even though retirement and claiming Social Security need not occur simultaneously, individuals may link the two decisions and believe they should claim when they retire (see, e.g., Nyce et al. 2015). There is also a strong tendency to claim at whatever age is designated the full retirement age (e.g., Behaghel and Blau 2012). Fourth, sophisticated hyperbolic discounters may prefer to receive income in the form

of an annuity rather than a lump sum, as the annuity is less liquid. Finally, if financial advisers are not aware of these arbitrage gains, they may not be integrating their advice regarding employer-sponsored pensions and Social Security claiming.

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Appendix: Rates and Annuity Quotes

A: Calculation of the Defined Benefits Cash-Out Value

To calculate the defined benefit lump sum value we use the interest rates and mortality rates as defined by the IRS. The values and sources are detailed as follows:

Table A1: IRS Minimum Present Value Segment Rates for Plans Beginning in July 2016

1st Segment: years 1-5	2nd Segment: years 6-20	3rd Segment: years 21-60
1.36%	3.26%	4.16%

Source: The IRS website https://www.irs.gov/Retirement-Plans/Minimum-Present-Value-Segment-Rates

Table A2: Unisex Mortality Rates

Age	62	63	64	65	66	67	68	69	70	71
Mortality rate	0.006	0.007	0.008	0.009	0.010	0.011	0.012	0.014	0.015	0.017
Age	72	73	74	75	76	77	78	79	80	81
Mortality rate	0.018	0.020	0.023	0.025	0.028	0.032	0.036	0.040	0.045	0.051
Age	82	83	84	85	86	87	88	89	90	91
Mortality rate	0.057	0.064	0.072	0.081	0.091	0.103	0.116	0.130	0.145	0.159
Age	92	93	94	95	96	97	98	99	100	101
Mortality rate	0.175	0.190	0.204	0.221	0.234	0.248	0.263	0.274	0.284	0.302
Age	102	103	104	105	106	107	108	109	110	111
Mortality rate	0.313	0.325	0.336	0.346	0.354	0.361	0.369	0.376	0.382	0.388
Age	112	113	114	115	116	117	118	119	120	
Mortality rate	0.393	0.397	0.399	0.4	0.4	0.4	0.4	0.4	1	

Notes: For presentation purposes we round the rates presented below to the third decimal, while in the calculations we use the original figures.
Source: Updated Static Mortality Tables for Defined Benefit Pension Plans for 2016 (IRS Notice 2015-53)

The IRS rules allow us to calculate the present value of defined benefits annuities for each age in months (the "lump sum cash-out value"). In table A3 we present the simulated defined benefits cash-out value for each $1 of annual defined benefits income calculated at the birthday month of the individual.

Table A3: Defined Benefits Lump Sum Cash-Out Value Per-$1 Annual Annuity

Age\ marital status	100% Joint and Survivor *	Single
62	17.63	15.27
63	17.30	14.90
64	16.97	14.53
65	16.63	14.16
66	16.28	13.77
67	15.91	13.38
68	15.54	12.99
69	15.15	12.59

Notes: Spouse age assumed to be the same as the primary pensioner.
Source: Authors calculations based on IRS rules.

B: Retail Annuity Quotes

We retrieved retail annuity quotes from Immediate Annuities website on August 23rd, 2016 for a $100 monthly annuity (the minimum annuity), for all ages between 62-69, for couples and singles, for annuities with and without cost of living adjustment (COLA). The COLA option chosen is the CPI adjustment factor. The quotes presented below are the cheapest quotes provided for each age and marital status, converted to value of a $1 annual annuity.

Table B1: Retail Annuity Value Per-$1 Annual Annuity

	Nominal		CPI adjusted	
Age\ marital status	100% Joint and Survivor*	Single Male	100% Joint and Survivor*	Single
62	20.67	17.11	32.15	25.42
63	20.32	16.69	31.21	24.65
64	19.98	16.26	30.20	23.89
65	19.18	15.62	29.23	23.17
66	18.80	15.27	28.55	22.29
67	18.40	14.91	27.52	21.36
68	17.98	14.53	26.54	20.93
69	17.52	14.04	25.69	20.21

Notes: Spouse age assumed to be the same as the primary pensioner.
Source: Immediate Annuities

C: Interest Rates

In our calculations we discount Social Security benefits and CPI-adjusted retail annuities based on the market rates for TIPS as of August 23rd 2016. We use the TIPS with coupons of 0.125 and interpolate the rates to correspond to maturities of 1 to 7 years. We discount defined benefit and nominal retail annuities' cash flows based on the highest CD rates for balances with at least $1,000 at nation banks as of August 23, 2016. The rates for TIPS and CD's are presented in table C1 below.

Table C1: TIPS and CD Market Rates

Horizon (years)	1	2	3	4	5	6	7
TIPS Rate	-0.038%	-0.35%	-0.34%	-0.28%	-0.21%	-0.16%	-0.15%
Top CD Rate	1.25%	1.50%	1.55%	1.70%	1.95%	1.975%	2.00%

Notes: The 6st year CD rate is interpolated from the data.
Source: TIPS: Wall Street Journal, rates for TIPS with 1.25 coupon rate.
http://www.wsj.com/mdc/public/page/2_3020-tips.html
CD's: http://www.nerdwallet.com/rates/cds/best-cd-rates/