The Effect of Wealth on Individual and Household Labor Supply: Evidence from Swedish Lotteries

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We study the effect of wealth on labor supply using the randomized assignment of monetary prizes in a large sample of Swedish lottery players. Winning a lottery prize modestly reduces earnings, with the reduction being immediate, persistent, and quite similar by age, education, and sex. A calibrated dynamic model implies lifetime marginal propensities to earn out of unearned income from −0.17 at age 20 to −0.04 at age 60, and labor supply elasticities in the lower range of previously reported estimates. The earnings response is stronger for winners than their spouses, which is inconsistent with unitary household labor supply models.

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Understanding how labor supply responds to changes in wealth is critical when evaluating many economic policies, such as changes to retirement systems, property taxes, and lump-sum components of welfare payments. Because the income effect provides the link between uncompensated and compensated wage elasticities via the Slutsky equation, accurate estimates of how labor supply responds to wealth shocks are also valuable for obtaining credible estimates of compensated wage elasticities, which, in turn, are critical inputs in the theory of optimal taxation (Mirrlees 1971; Saez 2001) and studies of business cycle fluctuations (Prescott 1986; Rebelo 2005).

Despite a large empirical literature, consensus on the magnitude of the effect of wealth on labor supply is limited (Pencavel 1986; Blundell and MaCurdy 2000; Keane 2011; Saez, Slemrod, and Giertz 2012). Although some agreement exists among labor economists that large, permanent changes in real wages induce relatively modest differences in labor supply, Kimball and Shapiro (2008) write that "there is much less agreement about whether the income and substitution effects are both large or both small." The lack of consensus stems in part from the substantial practical challenges associated with isolating plausibly exogenous variation in unearned income or wealth, which is necessary to produce credible wealth-effect estimates. In this paper, we confront these challenges by exploiting the randomized assignment of lottery prizes to estimate the causal impact of wealth on individual- and household-level labor supply. Our work is most closely related to Imbens, Rubin, and Sacerdote's (2001) survey of Massachusetts Lottery players. Comparing winners of large and small prizes who gave consent to release their post-lottery earnings data from tax records, they estimate that around 11 percent of an exogenous increase in unearned income is spent on reducing pre-tax annual labor earnings.

Our study has three key methodological features that enable us to make stronger inferences about the causal impact of wealth than previous lottery studies evaluating the effect of wealth on labor supply (Kaplan 1985; Imbens, Rubin, and Sacerdote 2001; Furåker and Hedenus 2009; Larsson 2011; Picchio, Suetens, and van Ours 2017).[1] First, we observe the factors conditional on which the lottery wealth is randomly assigned, allowing us to leverage only the portion of lottery-induced variation in wealth that is exogenous. Second, the size of the prize pool is very large (approximately $650 million), allowing us to obtain precise estimates of treatment effects

[1] Our work is also related to previous research that uses natural experiments such as policy changes or bequests to estimate the causal effect of wealth on labor supply (Bodkin 1959; Krueger and Pischke 1992; Holtz-Eakin, Joulfaian, and Rosen 1993; Joulfaian and Wilhelm 1994).

in many subsamples. Prizes also vary in magnitude, which allows us to test for nonlinear effects.[2] Third, Sweden's high-quality administrative data allow us to observe a rich set of labor market outcomes many years after the event, in a virtually attrition-free sample. Finally, our data allow us to address many of the concerns that are often voiced about the external validity of studies of lottery players.

In our reduced-form analyses of individual-level labor supply, we find winning a lottery prize immediately reduces earnings, with effects roughly constant over time and lasting more than 10 years. Pre-tax earnings fall by approximately 1.1 percent of the prize amount per year. A windfall gain of 1M Swedish krona (about $140,000) thus reduces annual earnings by about 11,000 SEK, corresponding to 5.5 percent of the sample average.[3] Adjustments of the number of hours worked account for the majority of the overall earnings response. Evidence of heterogeneous or nonlinear effects is scant, and winners are not more likely to change employers, industries, or occupations. We also find winning a lottery prize reduces self-employment income, which contrasts with several studies that find positive wealth shocks increase transition into self-employment (Holtz-Eakin, Joulfaian, and Rosen 1994; Lindh and Ohlsson 1996; Taylor 2001; Andersen and Nielsen 2012).

We next estimate a simple dynamic labor supply model with a binding retirement age in order to extend the results beyond the first 10 years following the prize event to estimate lifetime marginal propensities to earn (MPE) out of lottery wealth. The estimated model quantitatively accounts for our main reduced-form results. We account for the role of taxes by matching the model to the after-tax earnings response. The best-fit parameters imply the lifetime MPE varies with age and is strongest in the youngest winners, where our estimates suggest a lifetime MPE in the range −0.15 to −0.17. Relying on the structural assumptions of the model, we also estimate key labor supply elasticities. The average uncompensated labor supply elasticity is close to zero, the individual-level compensated (Hicksian) elasticity is 0.1, and the intertemporal (Frisch) elasticity is 0.15. These estimates are in the lower range of previously reported estimates (Keane 2011; Reichling and Whalen 2012).

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[2] The estimated effects in Imbens, Rubin, and Sacerdote (2001) are highly non-linear and also somewhat sensitive to the small number of individuals in the sample who won prizes exceeding USD$2 million, as well as specifications that account for non-random survey non-response (Hirano and Imbens 2004).

[3] All dollar amounts are converted using the January 2010 exchange rate ($7.153 per SEK).

In our household-level analyses, we find that taking into account the labor supply of non-winning spouses increases the estimated labor supply response by 23 percent. Our estimates are precise enough to reject both a zero effect on the non-winning spouse's earnings and the null hypothesis that the earnings responses of winning and non-winning spouses are identical; we systematically find the winning spouse reacts more strongly. The latter result is inconsistent with unitary household labor supply models, which have the strong prediction that the observed labor supply responses to household wealth shocks should not depend on the identity of the lottery winner (Lundberg, Pollak, and Wales 1997).

Our finding that winners adjust labor supply more strongly than spouses complements a large empirical literature that uses labor supply data to test the exogenous income-pooling restriction of unitary models of the household (see the review by Donni and Chiappori 2011). As described in Lundberg and Pollak (1996, 145), an "ideal test of the pooling hypothesis would be based on an experiment in which some husbands and some wives were randomly selected to receive an income transfer." Our test comes close to these ideal conditions, and to our knowledge, we are the first to use random shocks to wealth from lottery prizes to directly test whether income is pooled when households make labor supply decisions.

The remainder of this paper is structured as follows. Section I describes the lottery data and reports the results from a randomization test. We discuss our empirical framework in section II, and describe our measures of labor supply and report the individual-level empirical results in section III. Section IV describes a dynamic lifecycle model and uses this model to estimate key labor supply elasticities. Section V reports household-level results and discusses how they inform household labor supply models. Section VI concludes the paper. We refer to our Online Appendix (henceforth, OA) for robustness tests and details regarding the data.

I. Lottery Samples

We construct our estimation sample by matching three samples of lottery players and their spouses to population-wide registers on labor market outcomes and demographic characteristics. The main threat to the internal validity of lottery studies is that the amount won is correlated with the number of lottery tickets bought. We address this challenge by using available data and knowledge about the institutional details about each of the three lotteries to define "cells" within which the amount won is random. We subsequently control for cell fixed effects in all analyses, thus ensuring all identifying variation comes from players in the same cell. Because the exact construction of the cells varies across lotteries, we describe each lottery separately.[4] Table 1 summarizes the cell construction for each lottery.

TABLE 1 HERE

A. Prize-Linked Savings Accounts

The first sample we use is a panel of Swedish individuals who held "prize-linked savings" (PLS) accounts between 1986 and 2003. PLS accounts incorporate a lottery element by randomly awarding prizes to some accounts rather than paying interest (Kearney et al. 2011). PLS accounts have existed in Sweden since 1949 and were originally subsidized by the government. When the subsidies ceased in 1985, the government authorized banks to continue to offer prize-linked-savings products. Two systems were put into place, one operated by the savings banks and one by the major commercial banks and the state bank. Each system had over 2 million accounts in the late 1980s, implying that half of the Swedish population held a PLS account at the time. We combine two sources of information from the PLS program run by the commercial banks, *Vinnarkontot* ("The Winner Account"). Our first source is a set of prize lists with information about all prizes won in the draws between 1986 and 2003. The prize lists were entered manually and contain information about prize amount, prize type (described below), and the winning account number, but not the identity of the winner. The second source is a large number of microfiche images with information about the account number, the account owner's personal identification number (PIN), and the account balance of all eligible accounts participating in the draws between December 1986 and December 1994 (the "fiche period"). By matching the prize-list data with the microfiche data, we are able to identify PLS winners between 1986 and 2003 who held an account during the fiche period.

In each draw – held every month throughout most of the studied time period – account holders were assigned one lottery ticket per 100 SEK in the account balance. Each lottery ticket had the same chance of winning a prize, so a higher account balance increased the chance of winning. PLS account holders could win two types of prizes: fixed prizes and odds prizes. Fixed

[4] The cell construction is identical to Cesarini et al. (2016) with the only exception being that we use exact matching on age and sex for the Kombi lottery. A more detailed account of the institutional features of our three lottery samples, the processing of our primary sources of lottery data, data quality, and how cells were constructed is provided in the Online Appendix to Cesarini et al. (2016).

prizes were regular lottery prizes that vary between 1,000 and 2 million SEK. The size of the prize did not depend on the account balance. Odds prizes, on the other hand, paid a multiple of 1, 10, or 100 times the account balance to the winner (with the prize capped at 1 million SEK during most of the sample period).

To construct the cells, we use different approaches depending on the type of prize won. For fixed-prize winners, our identification strategy exploits the fact that the total prize amount is independent of the account balance among players who won the same number of fixed prizes in a particular draw. For each draw, we therefore assign winners to the same cell if they won an identical number of fixed prizes in that draw. For example, one cell consists of 1,509 winners who won exactly one fixed prize in the draw of December 1990. We hence exclude account holders that never won from the sample. Several previous papers have used this identification strategy (Imbens, Rubin, and Sacerdote 2001; Hankins and Hoestra 2011; Hankins, Hoestra, and Skiba 2011). Because it does not require information about the number of tickets owned, we can use it for fixed prizes won both during (1986-1994) and after (1995-2003) the fiche period.

For odds-prize winners, matching on number of prizes won and draw is insufficient because winners of larger odds prizes have larger account balances (which may be correlated with unobservable determinants of labor supply). To construct the odds-prize cells, we therefore match individuals who won exactly one odds prize in a draw to individuals who also won exactly one prize (odds or fixed) in the same draw and whose account balances are similar to the winner's. For example, one cell consists of an odds prize winner that won one odds prize in December 1990 and 19 winners of exactly one fixed prize in the same draw, all with account balances between 3,000 and 3,200 SEK. This matching procedure ensures that within a cell, the prize amount is independent of potential outcomes. A fixed-prize winner who is successfully matched to an odds-prize winner is assigned to the new odds-prize cell instead of the original fixed-prize cell. Thus, in the previous example from December 1990, none of the 19 fixed-prize winners in the odds-prize cell are included in the fixed-prize cell with 1,509 fixed-prize winners. An individual is hence assigned to at most one cell in a given draw, but because players can win in several draws, they will also be included in cells corresponding to other draws in which they won. We do not observe account balances after 1994; therefore, we restrict attention to odds prizes won during the fiche period (1986-1994). To keep the number of cells manageable, we exclude all odds-prize cells in which the total amount won is below 100,000 SEK.

B. The Kombi Lottery

Our second sample consists of about half a million individuals who participated in a monthly ticket-subscription lottery called *Kombilotteriet* ("Kombi"). The proceeds from Kombi go to the Swedish Social Democratic Party, Sweden's main political party during the post-war era. Subscribers choose their desired number of subscription tickets and are billed monthly. Our data set contains information about all draws conducted between 1998 and 2010. For each subscriber, the data contain information about the number of tickets held in each draw and information about prizes exceeding 1M SEK. The Kombi rules are simple: two individuals who purchased the same number of tickets in a given draw face the same probability of winning a large prize. To construct the cells, we match each winning player to (up to) 100 randomly chosen non-winning players with an identical number of tickets in the month of the draw. To improve the precision of our estimates, we choose controls of the same sex and age. Complete random assignment of prizes within cells requires that controls are drawn with replacement from the set of potential controls. Players who win in one draw may therefore be used as controls in a different draw, and some individuals are used as controls in multiple draws. We exclude four winners who could not be exactly matched to any controls.

C. Triss Lotteries

Triss is a scratch-ticket lottery run since 1986 by Svenska Spel, the Swedish government-owned gaming operator. Triss lottery tickets can be bought in virtually any Swedish store. The sample we have access to consists of two categories of winners: Triss-Lumpsum and Triss-Monthly. Winners of either type of prize are invited to participate in a morning TV show. At the show, Triss-Lumpsum winners draw a new scratch-off ticket from a stack of tickets with a known prize plan that is subject to occasional revision. Triss-Lumpsum prizes vary in size from 50,000 to 5 million SEK. Triss-Monthly winners participate in the same TV show, but draw one ticket that determines the size of a monthly installment and a second that determines its duration. The tickets are drawn independently. The durations range from 10 to 50 years, and the monthly installments range from 10,000 to 50,000 SEK. To make the installments in Triss-Monthly comparable to the lump-sum prizes in the other lotteries, we convert them to present value using a 2 percent annual discount rate.[5] Svenska Spel supplied us with data on all participants in Triss-Lumpsum and Triss-Monthly prize draws in the period between 1994 and 2010 (the Triss-Monthly prize was not introduced until 1997).[6] We exclude about 10 percent of the lottery prizes for which the data indicate the player shared ownership of the ticket.

Conditional on making it to the TV show, the amount won in Triss-Lumpsum or Triss-Monthly is random for a given prize plan. We therefore assign players to the same cell if they won exactly one prize (of the same type) in the same year and under the same prize plan. No suitable controls exist for players that won more than one prize within a year and under the same prize plan, and a few such cases have been excluded.

D. Estimation Sample

Merging the three lotteries gives us a sample of 435,966 lottery players. Primarily because many PLS lottery players win small prizes several times, these observations correspond to 334,532 unique individuals. To arrive at our estimation sample, we first exclude individuals who (i) died the same year they won, (ii) lack information on basic socio-economic characteristics in public records, or (iii) have no recorded income in any year up to 10 years after winning, leaving us with a sample of 426,598 observations. We further restrict attention to players who were between age 21 and 64 at the time of the win, which reduces the sample to 249,402 observations. Finally, we drop cells without variation in the amount won and end up with an estimation sample of 247,425 observations (200,937 individuals).

E. Prize Distribution

Table 2 shows the distribution of prizes in the pooled sample and for each lottery separately. All lottery prizes are net of taxes and expressed in units of year-2010 SEK. Among the 247,725 lottery players in our sample, less than nine percent won more than 10,000 SEK ($1,400). Yet in total more than 5,500 prizes are in excess of 100,000 SEK ($14,000) and almost 1,500 prizes are in excess of 1 million SEK ($140,000) or more. To put these numbers into perspective, the median

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[5] We set the discount rate to match the real interest rate in Sweden, which, according to Lagerwall (2008), was 1.9 percent during 1958-2008.

[6] The data file supplied to us by Svenska Spel does not include information on personal identification numbers (PINs), but using information on name, age, and address, we reliably identify 98.7 percent of the lottery show participants.

disposable income among a representative sample of Swedes in 2000 was 170,000 SEK. The total prize amount in our pooled sample is 4,662 million SEK (about $650 million). PLS and Triss-Monthly each account for 36 percent of the total prize amount, Triss-Lumpsum account for 21 percent, and Kombi 7 percent.[7] The fact that most prizes are small does not imply our estimates are mostly informative about the marginal effects of wealth at low levels of wealth. The reason is that most of the identifying variation in our data comes from within-cell comparisons of winners of small or moderate amounts to large-prize winners.

TABLE 2 HERE

F. Internal and External Validity

Internal Validity. Key to our identification strategy is that the variation in amount won within cells is random. If the identifying assumptions underlying the lottery cell construction are correct, then characteristics determined before the lottery should not predict the amount won once we condition on cell fixed effects, because, intuitively, all identifying variation comes from within-cell comparisons. To test for violation of conditional random assignment, we therefore run the regression

$$L_{i,o} = \boldsymbol{X_i \eta} + \boldsymbol{Z_{i,-1} \theta} + \varepsilon_{i,0}, \tag{1}$$

where $L_{i,o}$ is the total amount won, $\boldsymbol{X_i}$ is a vector of cell fixed effects, and $\boldsymbol{Z_{i,-1}}$ is a vector of baseline controls. In our tests for random assignment, the controls are indicator variables for sex, born in the Nordic countries, college completion, pre-tax annual labor earnings, and a third-order polynomial in age. All time-varying baseline covariates are measured in the year prior to the lottery. We estimate this equation for the pooled sample and for each lottery separately. For the pooled sample, we also estimate the equation without cell fixed effects. The results are consistent with the null hypothesis that wealth is randomly assigned conditional on the fixed effects (see Table A1).

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7 Figure A2 shows the total prize amount is quite stable over time for all lotteries except PLS, where the prize sum falls from the late 1980s onward. Figure A2 also shows that, for each lottery, the proportion of the prize sum awarded within a certain prize range is quite stable over time.

External Validity. An important concern about lottery studies is that lottery players may not be representative of the general population. We therefore compare the demographic characteristics of players in each of our lottery samples to random population samples drawn in 1990 and 2000. Men are over-represented in the Kombi sample (60.9 percent) and the average age in the lottery sample (48.6 percent) is about seven years older than in the population (see Figure A1 for the full age and sex distribution). Consequently, characteristics that vary substantially between the sexes or over the life cycle (such as income) will differ between players and the population. To adjust for such compositional differences, we reweight the representative samples to match the age and sex distribution of the lottery winners. Compared to the reweighted representative samples, lottery players are more likely to be born in the Nordic countries and (except for the PLS lottery) have lower levels of education, but are quite similar with respect to income and marital status (see Table A2 for detailed results). A related concern is that, even though *lottery players* may be similar to the population at large, *lottery prizes* constitute a specific type of wealth shock that cannot be generalized to other types of wealth. Although we cannot rule out this concern completely, the evidence presented below shows lottery winners do not squander their wealth, and their labor supply response fits the predictions of standard life-cycle models fairly well irrespective of the type of lottery (PLS, Kombi or Triss) or mode of payment (Triss-Lumpsum or Triss-Monthly).

II. Estimation Strategy

Normalizing the time of the lottery to $t = 0$, our basic estimating equation is

$$y_{i,t} = \beta_t L_{i,0} + \boldsymbol{X}_{i,0}\boldsymbol{\delta_t} + \boldsymbol{Z_{i,s}}\boldsymbol{\gamma}_t + \varepsilon_{i,t}, \tag{2}$$

where $y_{i,t}$ is individual i's year-end outcome of interest measured at time $t = 0,1,\ldots,10$, $L_{i,0}$ is the lottery prize won and $\boldsymbol{X}_{i,0}$ is a vector of cell fixed effects. $\boldsymbol{Z_{i,s}}$ includes the lagged outcome of the dependent variable plus the same vector of pre-lottery characteristics as in equation (1) measured *s* years prior to winning the lottery. The key identifying assumption is that $L_{i,0}$ is independent of potential outcomes conditional on $\boldsymbol{X}_{i,0}$. We control for the pre-lottery characteristics in $\boldsymbol{Z_{i,s}}$ to improve the precision of our estimates. We estimate equation (2) by OLS and cluster standard errors at the level of the individual.

We report our main results in two formats. First, we often summarize our results by plotting the coefficient estimates $\hat{\beta}_0$, $\hat{\beta}_1$,.., $\hat{\beta}_{10}$ in a figure with time (in years) on the horizontal axis. These figures show the dynamic effects of a $t = 0$ wealth shock on the labor supply outcome of interest at $t = 0,1, \dots ,10$. To verify the absence of differences in pre-treatment characteristics of players who won large or small prizes, the figures also include estimates for two or four pre-lottery years, which should not be significantly different from zero under our identifying assumption. In these regressions, the time-varying controls in $\boldsymbol{Z}_{i,s}$ are measured one year prior to the first estimate shown in the figure (i.e., s is −3 or −5 depending on the first estimate shown).

Second, we report estimates from a modified version of equation (2) in which we include all person-year observations available for $t = 1, \dots ,5$ and use baseline controls measured in the year prior to the lottery event (i.e., $s = -1$). We also impose the restriction that $\beta_t = \beta$, which, as we show below, is motivated in part by our empirical evidence that the response to wealth shocks is near-immediate and quite stable over time for most outcomes we consider. We refer to these estimates as five-year estimates. The five-year estimates allow us to improve precision and present our findings in a parsimonious way.

Because small average effects could mask large effects in certain subpopulations, we also test for heterogeneous effects. In these analyses, we interact the lottery prize, $L_{i,o}$, the vector of cell fixed effects, $\boldsymbol{X}_i$, and the controls, $\boldsymbol{Z}_{i,-s}$, with the subpopulation indicator variable of interest, thereby leveraging only within-cell variation to estimate treatment-effect heterogeneity.

III. Individual-Level Analyses

In this section, we analyze individual-level responses to the wealth shocks. We begin by describing and analyzing a number of annual earnings measures. Next, we decompose the total wealth effect on earnings into extensive- and intensive-margin adjustments, and into hours and wage changes. The section concludes with analyses in which we test for treatment-effect heterogeneity and non-linear effects.

All analyses below are restricted to labor supply outcomes observed from 1991 until 2010 (the last year for which we have data).[8] The annual income measures we use are based on population-

[8] Sweden underwent a major tax reform in 1990-1991. Before 1991, capital and labor incomes were taxed jointly and taxes were strongly progressive, which complicates the analysis of wealth effects. Because some of our analyses are based on after-tax labor income, all analyses are based on labor supply measures from the period 1991-2010, during which labor income and capital income were taxed separately.

wide registers that contain information originally collected by the tax authorities. All income variables are winsorized at the0.5th and 99.5th percentile and are expressed in units of year-2010 SEK.

A. Effect of Wealth on Annual Earnings

Our primary earnings measure is pre-tax labor earnings, a composite variable derived almost entirely from three sources of income: annual wage earnings, income from self-employment, and income support due to parental leave or sickness absence. Figure 1 depicts the estimated effect of wealth on our primary outcome for $t = -4, -3, \ldots, 10$ along with 95 percent confidence intervals. The effect of wealth is near-immediate, modest in size, and quite stable over time. The tendency for the effect to decline over time vanishes if we restrict the sample to individuals who were below age 55 at the time of winning and who therefore had at least 10 years left to age 65, the modal retirement age in Sweden (see Figure 3B below).[9] As discussed in section IV, a stable response over time is consistent with a canonical life-cycle model where the discount factor equals the interest rate. The lottery variable is measured in units of 100 SEK, so the coefficient estimates of approximately −1 means winners reduce their annual earnings by ∼1 percent of the prize amount per year. To help interpret the magnitude of these point estimates, a 1M SEK prize ($140,000) reduces earnings by about 10,000 SEK, which corresponds to 5.5 percent of the annual average earnings in our sample.

FIGURE 1 HERE

A more detailed picture of the labor supply response is provided in Table 3, which shows the five-year estimates for pre-tax labor earnings along with a range of additional income measures. We begin in the upper panel, which reports results for the pre-tax labor earnings variable and the three variables from which it is derived: wage earnings, self-employment income, and income support. The results are shown in columns 1 to 4. Unsurprisingly, nearly all of the overall effect on the aggregate variable (−1.066) is accounted for by reductions in wage earnings (−0.964),

[9] Because we limit the sample to labor earnings measured in 1991-2010 and the sample consists of individuals who won the lottery in 1986-2010, the composition of the pooled sample in Figure 1 changes somewhat with *t*. For example, an individual who won the lottery in 1986 will not enter the data until t = 5. Conversely, an individual who won in, say, 2010, will exit the data at t = 1. In OA section 4, we show the time pattern of labor supply responses looks quite similar up until t = 10 when we hold the sample fixed. The data indicate larger responses after t = 10, but due to the smaller sample size, we rely on the model instead of these estimates to make inferences about long-term effects of lottery wealth on labor supply.

with self-employment income also contributing modestly (−0.051) to the overall decline.[10] Yet the effect on self-employment relative to baseline is actually larger than for wage earnings: a 1M SEK windfall gain reduces self-employment income by 7.7 percent of the annual average compared to 5.5 percent for wage earnings. The reduction in self-employment income is at odds with previous findings that windfall gains increase self-employment (Holtz-Eakin, Joulfaian, and Rosen 1994; Lindh and Ohlsson 1996; Taylor 2001; Andersen and Nielsen 2012). The effect on income support (primarily parental leave and sick-leave benefits) is very small (−0.016) and not statistically significant.

TABLE 3 HERE

The pre-tax labor earnings measure includes income taxes, but not so-called social security contributions (SSC) paid by the employer. These contributions are partly taxes and partly benefits that accrue to the employee, for example, in the form of higher pension income in the future. Pre-tax labor earnings plus SSC represent the employers' total labor cost and can hence be interpreted as a measure of total production value. Column 5 of Table 1 shows the estimated impact of wealth on earnings plus SSC. According to our estimate, a 100 SEK windfall is estimated to reduce the total production value by 1.412 SEK per year in the first five post-lottery years.

We also examine how lottery wealth affects after-tax income. In Sweden, labor market earnings are taxed jointly with unemployment benefits and pension income, so we use a measure of taxable labor income that includes all three sources of income. Column 6 shows the estimated impact on this measure (−0.890) is smaller than the impact on our primary earnings measure in column 1 (−1.066). The difference arises because lottery wealth causes a small increase in pension income (column 7) and unemployment benefits (column 8), and these benefits partly offset the reduction in labor earnings.[11] We use detailed information about the Swedish tax system to calculate implied after-tax labor income for each winner. As shown in column 10, the estimated effect on after-tax income (−0.576) is substantially smaller than the effect on total

[10] The three coefficient estimates in columns 2 to 4 do not add up exactly to the coefficient estimate in column 1, because labor earnings include some other minor forms of income support not included in column 4. However, the correlation between labor earnings and the sum of wage earnings, self-employment income, and parental leave and sickness payments is 0.99.

[11] The estimate in column 6 is not exactly equal to the sum of the estimates in columns 1, 7, and 8 because other minor differences exist between pre-tax labor earnings and taxable labor income we have not taken into account here.

production value in column 5 (−1.412).[12] The difference reflects the wedge induced by Sweden's extensive tax and transfer system.

How large is the after-tax labor supply response from a life-cycle perspective? The average winner in our sample is 48.6 years old and thus has roughly 16.4 years of work left before the typical retirement age of 65. Ignoring discounting and assuming a constant effect of wealth on labor supply, discounted lifetime after-tax income decreases by $0.576 \times 16.4 = 9.44$ SEK per 100 SEK won. This approximation is a simple estimate of the "lifetime marginal propensity to earn out of unearned income," or MPE for short. Relating the labor supply response to average total lifetime wealth before the win (wealth and future earnings and pensions) of approximately 4.7M SEK allows us to get a rough estimate for the labor supply elasticity with respect to lifetime income.[13] For the average winner, a 1M prize increases lifetime wealth by $1/4.7 = 21$ percent and increases after-tax labor income by 3.6 percent, implying an elasticity of about −0.17. This wealth elasticity is within the range of income elasticities reviewed by the Congressional Budget Office (CBO), which found estimates between −0.2 and 0 (Congressional Budget Office 1996; McClelland and Mok 2012).[14]

B. Margins of Adjustment

In this section, we decompose the overall effect on annual earnings into various margins of adjustment. We begin by estimating extensive-margin responses, and then turn to estimating the effect on wages and hours worked. To understand potential mechanisms, we also analyze whether lottery winners adjust their labor supply by changing occupations, employers, workplaces, industries, or location of work. The key results from our analyses are reported in Table 4 and Figure 2.

TABLE 4 HERE

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[12] Including the value of future benefits (notably pensions) implicit in social security contributions (SSC) in our after-tax income measure increases the estimated effect to −0.624.

[13] In addition to the assumptions made above, we assume wage and pension growth of 2 percent per annum, a post-tax income of 147,000 per year until retirement at age 65, a retirement replacement rate of 70 percent, a remaining life span of 30 years, and average pre-win wealth of 0.9M SEK.

[14] Note the wealth elasticity we calculate is not the exact same concept as the income elasticity estimates reviewed in the CBO reports. In those reports, the income-elasticity estimates represent the elasticity of hours worked with respect to total after-tax income, holding constant the marginal after-tax wage rate. By contrast, our reduced-form estimate of the effect of lottery wealth includes both the effects on hours and wages, and so it does not hold the wage constant.

We first estimate the effect of wealth on several extensive-margin indicator variables generated from labor earnings, wage earnings, self-employment income, and pension income. For each category, we define an indicator equal to 1 if annual income exceeded 25,000 SEK ($3,500) in a given year, and 0 otherwise. We restrict the sample to winners above age 50 when estimating the effect on retirement. The five-year estimates from these analyses are shown in Panel A of Table 4. We scale the treatment variable so that a coefficient of 1.00 means 1M increases participation probability by one percentage point. We also report coefficient estimates normalized by the baseline participation probability.

FIGURE 2 HERE

Figure 2A shows winning the lottery reduces labor force participation by about 2 percentage points per 1M SEK won up until five years after the win, after which the effect declines. The five-year estimates in Table 4 show the reduction in participation (−2.0 percentage points per 1M SEK won) is almost entirely due to a fall in the probability of wage labor (−2.2 percentage points) rather than self-employment income (−0.1 percentage point). Yet because the baseline incidence of self-employment is lower, the responses are similar in relative terms (3.1 percent and 2.6 percent). We also estimate a small positive, but statistically insignificant, effect of winning the lottery on retirement. The absence of a strong impact on retirement is likely to reflect institutional features of the pension system steering most people to retire at age 65 (see OA section 6 for details about the Swedish pension system).

The estimated effects for the extensive margin imply much of the labor supply response occurs on the intensive margin, in the form of lower wages or fewer hours. Under the assumption that average wage earnings of workers who leave the labor force due to winning the lottery equal the sample average, the extensive margin accounts for about 40 percent of the five-year labor supply response.[15] Because the estimated effect on the extensive margin declines faster than the overall

[15] Because we do not observe the counterfactual earnings level of workers whose choice regarding whether to leave or enter the labor market was influenced by the lottery win, the decomposition into extensive- and intensive-margin responses is only suggestive. A more elaborate analysis where we estimate the effect of winning on entry and exit probabilities separately, and calculate counterfactual earnings based on pre-win entrants and exiters, shows the extensive margin accounts for about a third of the overall response in the first five years after the lottery win.

labor supply response, the importance of intensive-margin adjustments increases with time from the lottery event.[16]

Our second set of analyses focuses on wages and hours worked. We supplement the register-based variables with information from Statistics Sweden's annual wage survey. The survey asks employers to supply information about each employee's full-time equivalent monthly wage and the number of hours the individual is contracted to work. The survey has incomplete coverage of the private sector and covers 57 percent of the working population (those with wage earnings above 25K SEK) the year before the lottery win. The survey sample is not fully representative of the population of lottery winners.[17] In our main analyses, we impute information from adjacent years, increasing coverage to 67 percent of the working population.[18] Even after imputation, the survey measure on contracted hours has two potential problems. First, modest adjustment of hours worked on a number of margins, such as sick leave, unpaid vacation, and over-time, may not induce changes in contracted hours. Second, because the survey only covers the employed, individuals who are induced by the lottery wealth shock to leave their job are absent from the survey, creating a potential selection problem. To mitigate these problems, we use the register-based data on wage earnings to calculate an earnings-based measure for weekly hours worked:

$$Weekly\ hours = 40 \times \frac{Annual\ wage\ earnings}{12 * Contracted\ monthly\ wage}.$$

Because wage earnings are observed for the full sample in each year, the earnings-based measure will capture hours worked quite accurately also for workers who work few hours, as long as we are able to impute the wage from adjacent years.[19]

The five-year estimates of the impact of wealth on earnings-based hours and monthly wages are shown in Panel B of Table 4. Column 5 shows a 1M SEK prize reduces (earnings-based)

16 Applying the same back-of-the-envelope calculation as above, the share attributed to the extensive margin goes from around 40 percent in the first five years after the lottery to 24 percent 10 years after the lottery.

17 Lottery players in the wage-hours sample are about two years younger and have 19 percent higher earnings compared to the baseline sample. The effect of winning on labor earnings is similar in the first five years after the lottery. The five-year estimate is −1.064 for the wage-hours sample compared to −1.066 in the full sample, but the response in later years is somewhat larger in the wage-hours sample (see Figure A12).

18 In our baseline specification, we impute observations for year *t* from up to *t-3* and *t+3* when data closer to *t* are unavailable. However, we never impute observations for post-win years from pre-win years, or vice versa. Further details about the imputation procedure are presented in OA section 5.

19 Imputing contracted hours from adjacent years does not mitigate the selection problem. To see this point, consider a worker who is covered by the survey in year *t* but quits the labor force in year *t+1*. Imputing contracted hours in year *t+1* from year *t* implies we overstate the number of hours worked in *t+1*.

weekly hours by 1.3 hours, corresponding to 4 percent of an average workweek. The estimate in column 6 show the estimated impact of the pre-tax monthly wage (rescaled to its full-time equivalent for part-time workers) is −147 SEK, approximately 0.6 percent of an average monthly salary. The estimated reduction in weekly hours is precisely estimated, with a 95 percent CI from −0.80 to −1.77, whereas the monthly wage reduction is only marginally statistically distinguishable from zero (95 percent CI −312.6 to 17.9). Figure 2B and 2C show the effect is quite stable over time for both wages and hours.

The modest wage response suggests a limited role for the wage margin in accounting for the overall labor supply response. To investigate the relative importance of the wage and hours margins more formally, we decompose the change in wage earnings into an hours and a wage component. Let $w_{i,t}$ denote the hourly wage and let $h_{i,t}$ denote annual hours worked by individual *i* at time *t*. The difference in wage earnings between time *t* and the year before the lottery can be written as

$$(3)\quad w_{i,t}h_{i,t} - w_{i,-1}h_{i,-1} = w_{i,t}h_{i,-1} + w_{i,-1}h_{i,t} + (w_{i,t} - w_{i,-1})(h_{i,t} - h_{i,-1}).$$

We estimate the contribution of changes on the wage and hours margin by using each of the three components on the right-hand side in (3) as dependent variables in regression (2) while controlling for $w_{i,-1}h_{i,-1}$. The five-year estimate indicates the reduction in hours worked accounts for 81 percent of the fall in wage earnings, whereas 18 percent is due to the negative effect of lottery wealth on wages, and only 1 percent to the interaction between hours and wages. Figure 2D shows the hours component dominates the wage component at all time horizons.

In OA section 5, we report on a number of robustness checks using contracted hours and alternative ways to impute earnings-based hours and wages. While these analyses indicate the hours component plays a relatively smaller role for the long-term earnings response, the hours component still dominates the wage effect at all time horizons.

Finally, we examine whether wealth affects employer, workplace, occupation, industry, or location of work. These variables are available for all employees, except occupation which is only available for a subset of employees from 1996 and onwards. We find no evidence that wealth affects any of these variables in our analysis of five-year outcomes, nor in flexible analyses of the response at $t = 0,1, \ldots ,10$ (see Figure A3). Because a plausible mechanism behind wage adjustments is that workers switch occupations, industries, or regions of work, the fact that we find no evidence of such switches is consistent with the hypothesis that changes in hours worked are likely to account for the bulk of the intensive margin response.

In summary, we conclude that both extensive- and intensive-margin adjustments account for the responses we observe, and that wages contribute modestly to the adjustment on the intensive margin.

C. Heterogeneous and Non-linear Effects

We conduct a number of analyses to examine whether the effects of wealth on our primary earnings measure are heterogeneous by lottery, sex, age at the time of win, education, pre-lottery earnings, and self-employment status. Figure 3 reports the labor supply trajectories for the different subsamples (except self-employment).[20]

FIGURE 3 HERE

Figure 3A shows the effect is similar across lotteries, and we cannot reject the null hypothesis that the five-year estimates for the four lotteries are equal. Of particular interest is the comparison between Triss-Lumpsum and Triss-Monthly, because the underlying populations are the same, but the mode of payment differs. If winners have a significant bias to the present (O'Donoghue and Rabin 1999) and Triss-Monthly winners are unable to borrow against their future income stream, we would expect bigger immediate responses from lump-sum prizes. Yet the response patterns for the two Triss lotteries are quite similar, suggesting winners' behavior is consistent with a forward-looking dynamic labor supply model (which we estimate in the following section).

Standard life-cycle models predict stronger wealth effects for older workers because they have fewer years to spend the lottery prize. We test for heterogeneous effects by dividing the sample into three age ranges: 21-34, 35-54, and 55-64. As Figure 3B shows, the effects are similar by age in the years following the win. We fail to reject the null hypothesis that the five-year coefficients from the three subsamples are equal. Yet because the oldest age group has lower pre-win earnings, their response is larger relative to baseline (−8.9 percent of average pre-tax

[20] The corresponding five-year estimates are reported in Table A3.

earnings for each 1M SEK) compared to winners aged 21-34 (−5.9 percent) and 35-54 (−4.4 percent). Over longer time horizons, the effect tends to be weaker in the subsample of individuals in the 55-64 bracket, but this result is due to many of these individuals reaching retirement age, which mechanically attenuates the effect.

A common finding in the literature is that labor supply elasticities are larger for women than men (Keane 2011), though some recent work finds evidence of a decrease in labor supply elasticities for married women between the 1980s and 1990s (Blau and Kahn 2007). Our event-study estimates suggest that, if anything, women's labor supply responses to wealth shocks are weaker than those of men. The difference between the five-year estimates is not statistically significant (p = 0.11), and even if the coefficients are scaled relative to mean annual earnings (which are 31 percent lower for women), the coefficient estimates are in the opposite direction of what prior work typically have found. Yet the flexible coefficient estimate for $t = 0,1, \dots ,10$, plotted in Figure 3C, suggests the difference becomes smaller with time from the lottery. We do not infer from these results that women's labor supply is less responsive to wealth shocks than men's, but the 95 percent confidence intervals for the five-year estimates allow us to rule out that the female labor supply response exceeds the male response by more than 9 percent.

Figures 3E and 3F show both the initial pre-tax and after-tax response is stronger for winners in the highest tertile of pre-lottery earnings, though we can only marginally reject that the five-year estimates differ across income groups for pre-tax earnings (p = 0.079).

Earlier research has suggested the self-employed have greater flexibility in choosing their hours (Gurley-Calvez, Biehl, and Harper 2009; Hurst and Pugsley 2011). Yet the five-year estimates for self-employed (−1.130) and wage earners (−1.059) are very similar. We also find no evidence of heterogeneous effects depending on college completion.

Some theories predict wealth should have nonlinear effects on labor supply if workers who wish to reduce their labor supply face fixed adjustment costs (as in Chetty et al. 2011). In this case, the marginal effects of modest wealth shocks will be smaller than those of more substantial wealth shocks. We therefore estimate both a quadratic model and a spline model with a knot at 1M SEK. The point estimates suggest the marginal effect of lottery wealth is smaller for larger prizes, but the difference is not statistically significant. Moreover, the estimated effect is about 10 percent to 30 percent larger when we exclude very large (≥5M SEK), large (≥2M), or moderate (≥1M SEK) prizes.[21]

IV. Dynamic Labor Supply Model

In this section, we estimate a simple dynamic life-cycle labor supply model using a simulated minimum-distance procedure.

A. Model Setup

The model is a discrete-time, dynamic labor supply model with perfect foresight, no uncertainty, and no liquidity constraints. The agent lives for T periods ($t = 0,1, \dots, T-1$) and receives unearned income α_t in period t. Each period, the agent chooses consumption c_t, annual work hours h_t, and next period's assets (A_{t+1}). Annual earnings (γ_t) are the product of the after-tax wage w_t and annual hours. Assets earn interest rate r between periods. Individuals in the model will choose to save for retirement, which must occur at $t = R^*$ or earlier; at this time, individuals can no longer choose $h_t > 0$.

Individuals make consumption, labor supply, and savings/borrowing decisions to maximize lifetime present discounted utility (using a discount rate δ), according to

$$(4) \qquad U = \sum_{t=0}^{T-1} \frac{1}{(1+\delta)^t} (\beta \log(c_t - \gamma_c) + (1-\beta)\log(\gamma_h - h_t))$$

$$A_{t+1} = (1+r)(A_t - c_t + w_t h_t + \alpha_t),$$

$$A_T \geq 0,$$

$$h_t = 0 \text{ for all } t \geq R^*.$$

Following Bover (1989) and Imbens, Rubin, and Sacerdote (2001), we use a Stone-Geary utility function. The parameter β is the relative weight on consumption in utility, γ_c is the subsistence term for consumption, and γ_h is the maximum annual hours of work available. A lump-sum lottery prize is represented as a one-time shock to A_t. The empirical results provide individual-level estimates of $\partial y_{t+s}/\partial A_t$ for each time period following the lottery win.

[21] Detailed results for the analysis of non-linear effects are reported in Table A4.

We use the model to recover estimates of the lifetime marginal propensity to earn out of unearned income as well as uncompensated (Marshallian), compensated (Hicksian), and intertemporal (Frisch) labor supply elasticities. Before describing the simulation strategy, we discuss the role of three important model assumptions.

No Barriers to Saving and Borrowing. We assume agents can save and borrow at interest rate *r*. An implication of this assumption is that two prizes with identical present discounted values should have the same dynamic effects on labor earnings. This model prediction is consistent with our reduced-form analysis, which finds similar results for Triss-Lumpsum and Triss-Monthly prizes.

Stone-Geary Functional Form. Stone-Geary preferences simplify the simulation because the per-period problem can be solved in closed form. Additionally, in a static model, this functional form delivers an income effect that does not vary with the wage, which is consistent with our reduced-form finding that the after-tax earnings response is quite similar in different income groups.

Binding Retirement Age. The Swedish retirement system admits flexibility in the timing of retirement, but as we discuss further in section 6 in the OA, a binding retirement age at 65 is a reasonable simplifying assumption. Clear "bunching" of retirement ages occurs at around age 65, with some retirement before age 65, but very little retirement after age 65. The model also contains no incentive to retire early, because individuals prefer to smooth leisure and consumption over the life cycle. In line with this feature of the model, we find no statistically significant effect for pension income on the extensive margin for individuals who win prizes in their 50s and 60s (see Table 4).

B. Model Simulation

We simulate the model to match the main individual-level after-tax results. The years of life remaining depend on the age of the winner when the prize is awarded. When simulating the model, we match the empirical distribution of the age of winners in the data. Individuals retire at age 65 and die at age 80, so a 25-year-old winner would face $T = 55$ and $R^{*} = 40$. We choose $r = 0.02$ to match the average real risk-free rate in Sweden during the time period the data span.

We assume the subsistence consumption term is $\gamma_c = 20{,}000$ SEK, about 12 percent of a median annual disposable income, and we assume the maximum annual hours of work available are $\gamma_h = 1{,}880$, which is the annual hours for a full-time worker in Sweden (working 40 hours per week with 5 weeks of mandated vacation). We set the wage in each period to be equal to the average after-tax labor income divided by average hours worked in our data. Unearned income a_t is set to 0 for all $t < R^*$ and to 70 percent of average annual after-tax labor income for $t \geq R^*$.[22]

We estimate via simulation the two remaining parameters, the discount rate (δ) and the relative weight on consumption in utility (β). For a given value of r, the time path of the labor earnings response following the lottery helps pin down δ. The lifetime earnings reduction to winning the lottery is primarily determined by the value of β, because this parameter governs the strength of the income effect.[23]

We estimate the two parameters using a standard simulated minimum-distance procedure. For each set of parameters, we simulate the model and compute the effect of winning the lottery (i.e., $(\partial(y_t)/\partial(A_t), \ldots, \partial(y_{t+10})/\partial(A_t))$.[24] We calculate these statistics for each simulated individual and then average across individuals, weighting individuals so that the age distribution in the simulated sample matches the lottery sample. See OA section 7 for further details about the model simulation, including the minimum-distance criterion we use and how we estimate standard errors for the parameter estimates.

C. Simulation Results and Implied Labor Supply Elasticities

Table 5 summarizes the simulation results. The χ^2 goodness-of-fit test statistic is not large ($\chi^2(8) = 3.285$, p = 0.092), suggesting the model provides a reasonably good fit to the

[22] We make the simplifying assumption that pension income does not respond to labor earnings prior to retirement.

[23] This discussion of identification is meant to convey intuition, but the actual identification of δ and β is more subtle. First, the lifetime earnings reduction is affected both by δ and β. Holding constant r and β, higher values of δ will increase the lifetime earnings reduction. Second, the binding retirement age will cause earnings reductions to decline over time mechanically as winners reach the binding retirement age. Thus, both a binding retirement age and $\delta > r$ will work toward producing reductions in annual earnings in the short run that are larger than the long-run reductions. Therefore, the full structure of the model is needed to separate the mechanical effect of retirement from the effect of the magnitude of δ relative to r.

[24] To compute this effect, we first solve a full life-cycle model assuming no lottery win and perfect foresight. Then, this solved model (solved over a large grid of possible asset choices) also contains the implied solution of how households would re-optimize at whatever age the person wins the lottery. In other words, the lottery is treated as an unexpected shock to assets at some time t, and so up until the time of the lottery prize, the individual follows the "no lottery" optimal path of asset accumulation, and then assets jump from A_t to the $A_t + L$ and then the dynamic programming solution gives a new (re-optimized) path of labor earnings, consumption, and savings following the lottery win for the remaining time periods.

reduced-form results. Additionally, the implied average annual hours are close to the average annual hours in the lottery sample (1654 hours vs. 1633 hours). The estimate of β is 0.866 (SE = 0.048), suggesting (holding the marginal utility of wealth constant) roughly 13 percent of unearned income is spent reducing after-tax labor income, with the rest spent increasing consumption. The estimate of δ is 0.014 (SE = 0.039), which is close to the assumed interest rate of $r = 0.020$. This finding is consistent with fairly similar earnings responses over time, with the attenuation primarily driven by the mechanical effect of workers gradually reaching the binding retirement age.

Figure 4 compares the simulated model to the reduced-form effects of lottery wealth on after-tax income. Consistent with the relatively low χ^2 test statistic, the model-based estimates track the empirical estimates fairly closely. Panel B of Table 5 compares simulated results with empirical results that were not directly "targeted" in estimation, focusing on differences in the after-tax response by age, size of prize amount, and pre-win earnings of the winner. Our simulation results are broadly in line with the empirical results, which show fairly limited variation across pre-win earnings and the size of the prize. For age, the results are mixed. The empirical results indicate smaller estimates for older winners, although the differences by age are not statistically significant. By contrast, the results by age in the simulated model indicate the opposite pattern. This finding suggests other important factors may be present, such as human-capital accumulation, that are outside the model, but are important for understanding differences in wealth effects by age.[25]

FIGURE 4 HERE

Estimating the Lifetime Marginal Propensity to Earn. Using the estimates of the model, we can compute the lifetime marginal propensity to earn (after-tax) income out of unearned income, where the calculation extrapolates beyond the first 10 years following the lottery win to the entire remaining years of life. The model estimates imply lifetime MPEs that vary with age at the time of win, from −0.17 for 20-year-old winners to −0.04 for winners aged 60 (see Panel C of Table 4). For younger winners, the model estimates imply most of the lifetime-earnings

[25] Despite the many simplifying assumptions, we note the model can also provide a reasonable fit for asset accumulation over the life cycle in a Swedish representative sample. Figure A4 shows the simulated asset path for a 25-year-old non-winner together with the median and mean net wealth by age in a Swedish representative sample in year 2000. The simulated model assumes lifespan ends at 80 and no bequest motive exists; either a bequest motive or uncertain lifespan would likely allow the model to better fit the wealth data after age 65.

reduction occurs after the first 10 years, implying the cumulative 10-year effects significantly understate lifetime wealth effects. Estimates of the MPE previously reported in the literature vary substantially, but the average lifetime MPE in our data (−0.083) is lower than the median (−0.15) among the 30 different estimates reported by Pencavel (1986).[26] Incidentally, our average MPE is closer to the MPE of −0.11 reported by Imbens, Rubin, and Sacerdote (2001) when they exclude non-winners and winners of extremely large prizes from their data.[27]

TABLE 5 HERE

Recovering Key Labor Supply Elasticities. Using the full structure of the model, we can also recover key labor supply elasticities that feature prominently in previous research. In Panel D of Table 5, we report the uncompensated (Marshallian) elasticity, the compensated (Hicksian) elasticity, and the intertemporal (Frisch) elasticity. The simulated elasticities are computed for someone who wins at age 50. The uncompensated elasticity is very small in magnitude, which is a direct consequence of the Stone-Geary functional-form assumption. The Hicksian elasticity is estimated to be around 0.1, which is smaller than the average Hicksian elasticity estimate of 0.31 reported in the meta-analysis in Keane (2011).

The Frisch elasticity is estimated to be close to 0.15, which is smaller than the range of estimates (0.27-0.53) used by the CBO (Reichling and Whalen 2012). Although these specific elasticities are recovered from the reduced-form income-effect estimates and the functional-form assumptions of the dynamic model, the specific Stone-Geary functional form does not entirely drive the estimated elasticities. In a wide range of time-separable utility models, the Frisch elasticity and the Hicksian elasticity are related by the intertemporal elasticity of substitution (IES), the estimated income effect, and the ratio of wealth to income (Ziliak and Kniesner 1999; Browning 2005). Therefore, modest estimates of the income effect necessarily constrain the Frisch elasticity to be similar in magnitude to the Hicksian elasticity, as long as the IES and the

[26] Two recent studies that consider settings similar to ours find substantially larger MPEs than we do. Kimball and Shapiro (2008) estimate an MPE of −0.37 using survey responses about hypothetical lottery winnings, whereas Bengtsson (2012) estimates an MPE of about −0.30 among recipients of unconditional cash grants in South Africa.

[27] The similarity in terms of average MPEs masks non-trivial differences in estimation and modeling. Plugging our five-year estimate for the after-tax response (column 10 of Table 3) into the model in Imbens, Rubin, and Sacerdote (2001) gives an MPE of −0.05. The reason for the lower MPE is that they assume $\delta = r = 0.10$, whereas we assume $r = 0.02$ and estimate δ to be 0.014. A high interest rate implies lump-sum prizes are "large" relative to yearly installments (the setting studied by Imbens, Rubin, and Sacerdote 2001), attenuating the MPE based on our estimates. The same exercise with $\delta = r = 0.02$ gives an MPE based on our estimates of −0.13 compared to −0.14 based on the estimates in Imbens, Rubin, and Sacerdote (2001). The reason for the higher MPE compared to our calibration is the high implicit retirement age in Imbens, Rubin, and Sacerdote (2001). Because they assume winners continue working for 30 years, the implicit average retirement age would be 78 in our sample and 80 in theirs.

Marshallian elasticity are not very large in magnitude.[28] We illustrate this point through a series of sensitivity analyses (reported in OA section 7) that report broadly similar elasticities under different assumptions on the interest rate, consumption floor, the IES, and the Marshallian elasticity.

V. Household-level Analyses

Two questions guide our household-level analyses. First, if winners' spouses also adjust their labor supply following a wealth shock, individual-level estimates will understate the overall labor supply response, implying elasticities inferred under the assumption that the winner's response fully captures the labor supply effects of the wealth shock are potentially misleading. Because the register data contain the spouses of winners, we can test for and quantify the size of the difference between the household- and individual-level responses.

Second, we use our data to test the unitary model of the household, in which two spouses are modeled as a single decision-making unit (Becker 1973; Becker 1976). These models make the strong prediction that the identity of a spouse who experiences a random wealth shock should not influence the labor supply responses of each of the two spouses (see Lundberg, Pollak, and Wales, 1997, and Attanasio and Lechene, 2002, for similar empirical tests).

We conduct our household-level analyses by augmenting the sample of married individuals with their spouses. The key results are summarized in Table 6. Beginning with our first question, column 1-3 of Panel A shows the five-year estimates for pre-tax labor earnings of married winners, spouses, and married households (defined as the sum of the winner's and spouse's labor supply response). Figure 5 shows the corresponding dynamic effects.

We find that married winners reduce their pre-tax annual labor earnings by 0.98 SEK per 100 SEK won, compared to 0.52 SEK for their spouses. The total household-level response of −1.50 is thus substantially stronger than the individual-level response of married individuals. Column 4 of Table 6 shows earnings of unmarried winners fall 1.29 SEK per 100 SEK won, more than for married winners, but less than the household-level response for married couples. Finally, column

[28] If lifetime utility is additively separable, and there is perfect foresight, no uncertainty, and perfect capital markets, the relation between the Frisch (e_F) and the Hicksian (e_H) elasticity is $e_F = e_H + \rho(\partial(wh)/\partial A)^2(A/w_h)$, where ρ is the IES, $\partial(wh)/\partial A$ is the income effect, and $A/w_h$is the ratio of wealth to income (see Ziliak and Kniesner, 1999, and Browning, 2005). In the calculations in Panel D of Table 5, e_H is roughly 0.1, ρ is roughly 1 given Stone-Geary utility, the income effect is roughly 0.09, and the ratio of A/w_h is approximately 6.7. This implies an estimate of e_F of 0.15, which is the same as the value calculated directly from model simulation. Assuming a small Marshallian elasticity, e_H and the income effect will be similar in magnitude from the Slutsky equation. A large Frisch elasticity consequently requires a large value of IES. A doubling of IES to 2.0 and an increase in magnitude of Marshallian elasticity to 0.2 would still give a value of Frisch elasticity below 0.4.

5 shows the effect on household labor supply for the full sample. Including the response of non-winning spouses increases the labor supply response from −1.066 (column 1 of Table 3) to −1.306. Focusing only on winners thus leads us to an underestimation of the labor supply response by 23 percent.

TABLE 6 HERE

Turning to the second question, Panel B of Table 6 shows the difference between the labor supply responses of winners and spouses. Negative estimates imply the winner reacts more strongly than the spouse. Column 6 shows the difference in the full sample (i.e., between the labor supply response of winners and spouses in columns 1 and 2). Married winners reduce their labor supply by 0.56 SEK more than their spouses for every 100 SEK won (p = 0.045), a finding seemingly at odds with income pooling.

FIGURE 5 HERE

To more carefully assess the unitary model, we exclude the Triss lottery from columns 7-10, for two reasons. First, married couples may sometimes buy Triss lottery tickets together, implying ownership of the winning ticket within the couple is unclear.[29] By contrast, both the winning account in PLS and lottery ticket subscription in Kombi pertain to a specific individual. Using data from the Wealth Registry, we find married winners in Kombi and PLS retain a larger share of households' observable lottery wealth (78 percent and 85 percent) than married Triss winners (72 percent), suggesting within-couple ownership is indeed more clearly defined in the former two lotteries.[30] Second, non-winning spouses may differ systematically from winning spouses in ways that correlate with how they respond to wealth shocks. In Triss, this concern is difficult to put to a stringent test, because we do not have information about the population of lottery players who selected into the lottery, only players who appear on the TV show. In PLS and Kombi, we have information about the universe of players and the number of tickets owned.

[29] The Triss data contain information about shared ownership of lottery tickets, but the data rarely indicate shared ownership between married spouses, probably because "contracts" regarding ownership are less explicit between spouses, and because wealth is split equally in the event of a divorce. Consequently, in some cases, married couples are likely to have bought a winning ticket together, but only one of the spouses appears on the show.

[30] Figure A5 and Table A5 shows the complete results for how lottery wealth is allocated between spouses. Because the Swedish Wealth Registry only existed in 1999-2007, we observe wealth for very few winners in PLS and therefore use capital income as a proxy for wealth in this case. We exclude Triss-Monthly winners because inferring how the prize money is allocated within couples when it is paid out over a long time is difficult.

This information allows us to test if the differential response observed between winners and their spouses persists in households where both spouses participated in the lottery.

Column 7 of Table 6 shows restricting attention to the PLS and Kombi samples increases the spousal difference to −0.964 ($p = 0.015$), in line with the relatively larger share of the wealth shock that pertains to the winner in PLS and Kombi. Column 8 shows the difference decreases somewhat when we further restrict the sample to couples in which both spouses (and not just the winner) were below the age of 64 at the time of win (−0.812). We impose this restriction because retired spouses may be constrained in their labor supply choices.

Next, we attempt to reduce any biases due to possible non-randomness in which the spouse experiences a windfall gain. In column 9, we restrict the sample to couples in which the non-winning spouse participated in the winning draw or pre-win draws in the same lottery. In column 10, we go further and restrict the sample to couples in which both spouses participated in the winning draw. Imposing these sample restrictions reduces the difference between winners and spouses both in terms of number of lottery tickets held (see Table 6) and demographic characteristics (Table A6). It is therefore reassuring that imposing these restrictions strengthens the differential response between winners and spouses.[31] It is also reassuring that the winner's share of the households' total labor supply response in columns 7 to 10 (between 79 and 89 percent) corresponds well with the share of lottery wealth allocated to the winner in PLS and Kombi.

In additional analyses, we find no clear evidence that the effect of lottery wealth on winner and spousal earnings depends on the winner's sex or whether the primary or secondary earner wins the lottery.[32] Because of the smaller sample sizes, however, these estimates are considerably less precise. Another concern with our household-level results is that lottery wealth might affect household composition. In OA section 9, we find a small positive, but statistically insignificant, effect of lottery wealth on divorce risk. Our results do not change appreciably when the sample is restricted to couples that remain married.

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[31] Consistent with the weaker bargaining position of cohabitants, we find the estimated difference between winners' and spouses' responses becomes stronger if we define cohabiting couples with children as "married" (identifying cohabiting couples without children isn't possible in the Swedish data).

[32] We report these analyses in Table A7. When including the Triss sample, we obtain suggestive evidence that the differential response is stronger when the husband or the primary earner wins the lottery.

We conclude from our household analyses that estimates of wealth effects on married individuals' labor supply underestimate the overall household labor supply response. Across a suite of analyses, we also consistently find the winning spouse responds more strongly than the other spouse, with the strongest evidence in the specifications that most closely approximate the ideal experiment.

The household-level results suggest the identity of the winner determines who in a married couple reduces labor supply the most, which is inconsistent with the unitary model. A prominent alternative class of non-unitary household models emphasizes the role of bargaining under the threat of divorce (Manser and Brown 1980; McElroy and Horney 1981). Reconciling our results with this class of models, however, is difficult. According to Swedish marriage law, the default rule in the event of divorce is that all assets are divided equally between spouses, unless the couple has a prenuptial agreement. Prenuptial agreements are uncommon and lottery winnings will therefore, in most cases, affect the outside option of the winner and spouse symmetrically.[33]

Instead, our results appear to be more consistent with the "separate spheres" household model of Lundberg and Pollak (1993) that relies on bargaining with threat points internal to the marriage. As long as a couple remains married, the winner owns and controls the prize money unless he or she decides to transfer part of the prize to the non-winning spouse, or deposit the money in a joint account. Lottery wealth can therefore improve the bargaining power of the winner by making the winner better off in the within-marriage non-cooperative equilibrium that defines the threat points in the separate-spheres model. Our results are consistent with related work that finds empirical support of the separate-spheres model over divorce-threat models (Lundberg, Pollak, and Wales 1997; Lundberg, Startz, and Stillman 2003).[34]

VI. Conclusion

We have shown that an exogenous wealth shock results in an immediate and permanent reduction in earnings. The magnitude of the response is modest; pre-tax earnings decrease by about 1 percent of the wealth shock in each of the first 10 years following the win. The response

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[33] OA section 8 provides additional details about Swedish marital law and documents that prenuptial agreements are uncommon.

[34] Both the "divorce threat" and "separate spheres" models are cooperative household models. Our results may also be consistent with specific non-cooperative models (Lundberg and Pollak 1994; Doepke and Tertilt 2014), as well as limited commitment models that combine elements of cooperative and non-cooperative models (Ligon, Thomas, and Worrall 2002; Voena 2015). Distinguishing between these models is difficult and subtle, which is why we focus on testing the income-pooling property of the unitary model and comparing two specific non-unitary cooperative models.

is about 40 percent smaller when we instead consider after-tax income, and about 40 percent larger when we measure labor supply in terms of production value (earnings including employer-paid social security contributions). The earnings response is mainly due to a reduction wage earnings due to fewer hours worked. Although adjustment takes place on both the extensive and intensive margin, our estimates suggest the latter is more important.

A surprising finding is the limited heterogeneity across many interesting demographic subgroups. Imbens, Rubin, and Sacerdote (2001) similarly find no significant differences in the responses of men and women, and note this finding is at odds with a large literature that finds women are systematically more responsive to price and wealth changes. We extrapolate our main results using a dynamic life-cycle model in order to calculate lifetime wealth effects, which we find vary with age and are larger for younger workers. Because the estimated wealth effects are modest, our calibrated model implies labor supply elasticities that are in the lower range of previously reported estimates. In our household-level analyses, we find both winners and spouses reduce their labor supply, but the reduction is stronger for winners. This finding provides unusually strong evidence against the testable prediction of unitary models of household labor supply that exogenous unearned income is pooled within the household.

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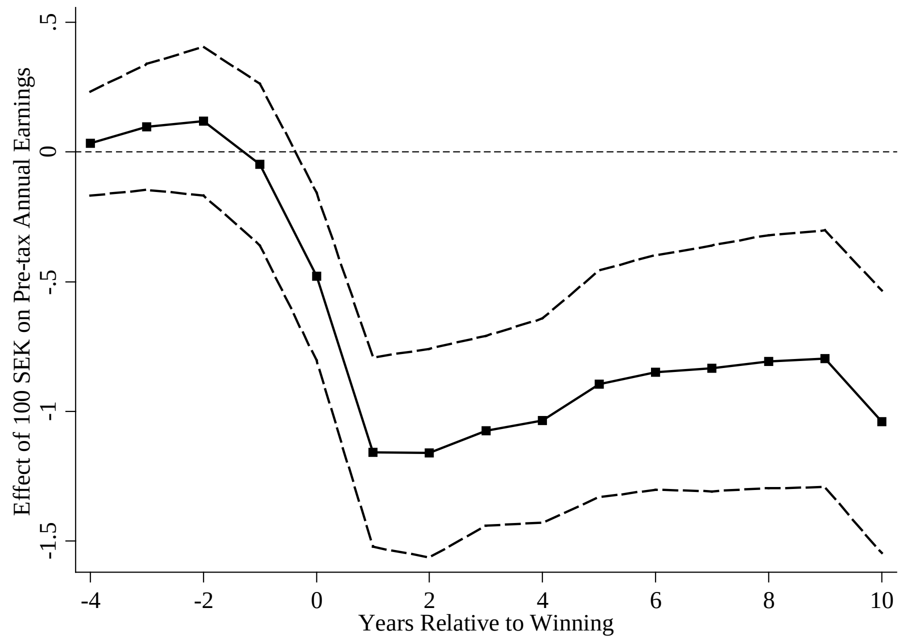
Figure 1. Effect of Wealth on Individual Earnings

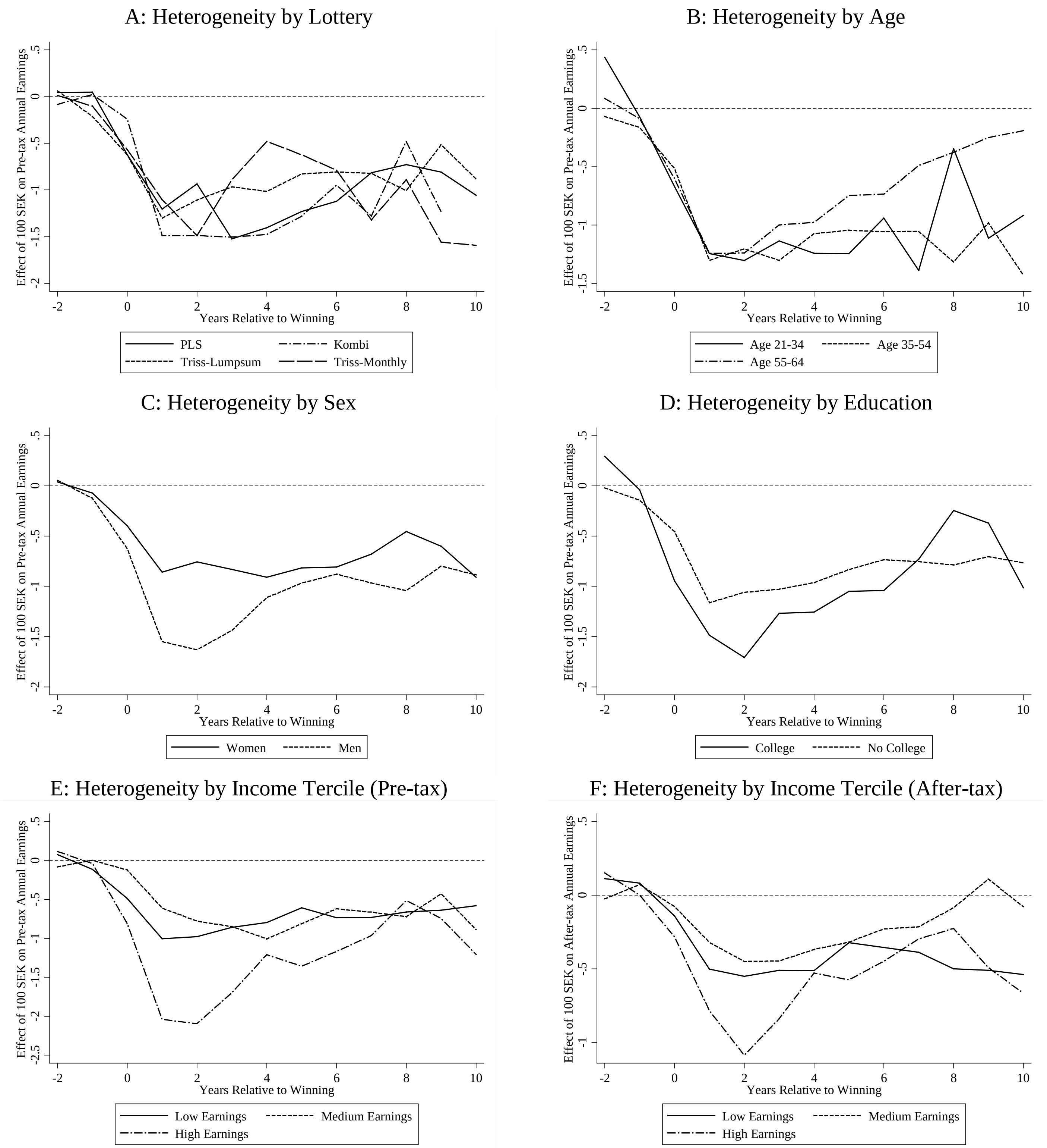


Notes: This figure reports estimates obtained from equation (2) estimated in the pooled lottery sample with pre-tax labor earnings as the dependent variable. A coefficient of 1.00 corresponds to an increase in annual earnings of 1 SEK for each 100 SEK won. Each year corresponds to a separate regression and the dashed lines show 95 percent confidence intervals.

Figure 2. Margins of Adjustment

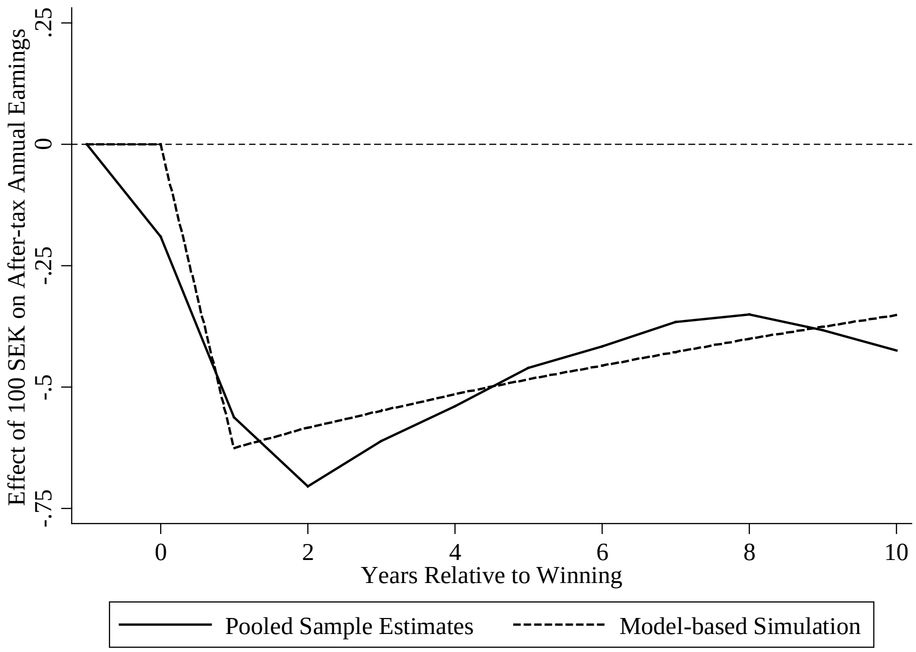
Notes: Panels A-C report estimates obtained from equation (2) estimated for some of the different margins of adjustment discussed in section III.B. Each year corresponds to a separate regression. The dashed lines in Panels A-C display 95 percent confidence intervals. Panel D reports the wage-hours decomposition described by equation (3) for each year separately, but using lagged values from $t = -3$ rather than $t = -1$.

Figure 3. Heterogeneous Effects of Wealth on Earnings



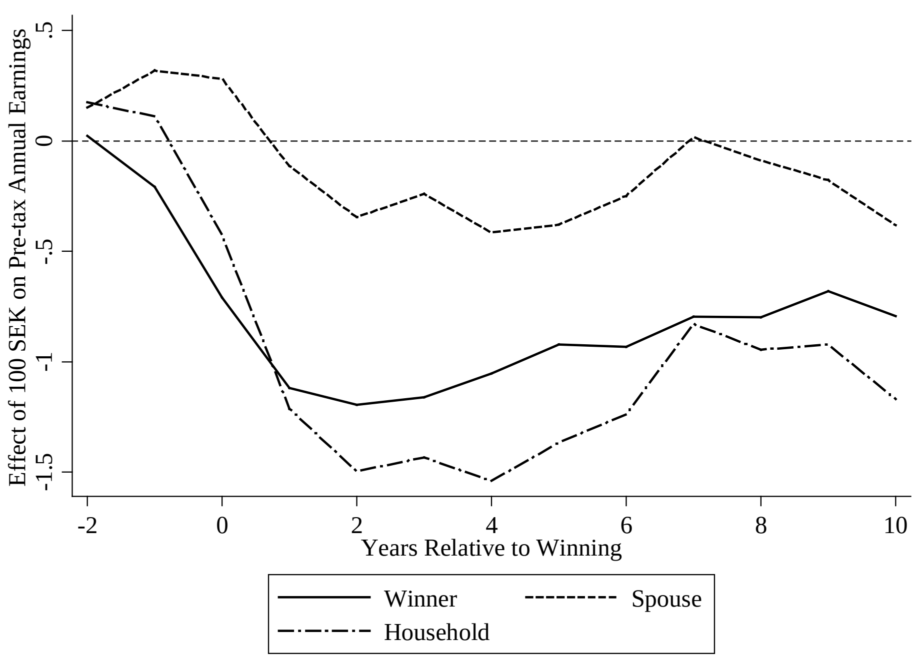
Notes: This figure reports estimates obtained from equation (2) estimated in different subsamples. The dependent variable is pre-tax labor earnings in Panels A- E and after-tax labor income in Panel F. A coefficient of 1.00 corresponds to an increase in annual earnings of 1 SEK for each 100 SEK won. Each year corresponds to a separate regression. The estimate for year 10 in Panel A is excluded for Kombi winners because very few observations are available.

Figure 4. Comparing Model-based Estimates to Empirical Results



Notes: This figure compares the model-based estimates using the best-fit parameters reported in Table 5 to the estimates obtained from equation (2) estimated in the pooled lottery sample with after-tax labor income as the dependent variable. Each year corresponds to a separate regression. The graph shows results for $t = -1$ for illustrative purpose only. We control for earnings at $t = -1$, so the empirical estimate is exactly zero. In the simulation, the prize is assumed to be awarded at end of year 0, so dy/dL for both $t = -1$ and $t = 0$ are zero by assumption.

Figure 5. Effect of Wealth on Earnings of Married Winners and Spouses



Notes: This figure reports estimates obtained from estimating equation (2) separately for married winners, their spouses, and married households. The dependent variable is pre-tax labor earnings. Each year corresponds to a separate regression.

Table 1. Identification across Lottery Samples

	Time Period	Treatment Variable	Cells/Fixed Effects	# Cells
PLS Fixed-prize Lottery	1986-2003	Sum of Prizes	Prize Draw × # Prizes	206
PLS Odds-prize Lottery	1986-1994	Prize	Prize Draw × Balance	1620
Kombi Lottery	1998-2010	Prize	Prize Draw × # Tickets × Age × Sex	260
Triss-Lumpsum	1994-2010	Prize	Year × Prize Plan	18
Triss-Monthly	1997-2010	NPV of Prize	Year × Prize Plan	19

Notes: This table shows how we construct cells within which prizes are randomly assigned for the different lotteries. PLS odds prizes are only included for winners that win a single prize in a draw, and odds-prize cells with prizes totalling less than 100,000 SEK are excluded. NPV is net present value assuming an annual discount rate of 2 percent.

Table 2. Distribution of Prizes

	Pooled Sample		Individual Lottery Samples							
			PLS		Kombi		Triss-Lumpsum		Triss-Monthly	
	Count	Share	Count	Share	Count	Share	Count	Share	Count	Share
0 to 1K SEK	23,910	9.7%	0	0.0%	23,910	98.9%	0	0.0%	0	0.0%
1K to 10K SEK	201,600	81.5%	201,600	91.9%	0	0.0%	0	0.0%	0	0.0%
10K to 100K SEK	16,284	6.6%	15,376	7.0%	0	0.0%	908	27.9%	0	0.0%
100K to 500K SEK	3,656	1.5%	1,632	0.7%	0	0.0%	2,024	62.1%	0	0.0%
500K to 1M SEK	355	0.1%	195	0.1%	0	0.0%	160	4.9%	0	0.0%
≥1M SEK	1,470	0.6%	471	0.2%	262	1.1%	168	5.2%	569	100.0%
TOTAL	247,275		219,274		24,172		3,260		569	

Notes: This table reports the distribution of lottery prizes for the pooled sample and the four lottery subsamples. The development of the prize distribution over time for each lottery is shown in Figure A2.

Table 3. Effect of Wealth on Annual Income

	Pre-tax Labor Earnings ≈ (2)+(3)+(4)	Wage Earnings	Self-empl. Income	Income Support	Production Value = (1)+SSC
	(1)	(2)	(3)	(4)	(5)
Effect (100 SEK)	-1.066	-0.964	-0.051	-0.016	-1.412
SE	(0.148)	(0.151)	(0.030)	(0.030)	(0.199)
p	[<0.001]	[<0.001]	[0.088]	[0.594]	[<0.001]
Mean (SEK)	194,505	175,608	6,598	7,327	258,757
Effect (1M SEK)/mean	-5.48%	-5.49%	-7.72%	-2.15%	-5.46%
N	244,826	244,826	244,826	244,826	244,826

	Taxable Labor Income ≈ (1)+(7)+(8)	Unemployment Benefits	Pension Income	Taxes (excl. SSC)	After-tax Labor Income = (6)-(9)
	(6)	(7)	(8)	(9)	(10)
Effect (100 SEK)	-0.890	0.024	0.114	-0.313	-0.576
SE	(0.131)	(0.024)	(0.070)	(0.054)	(0.080)
p	[<0.001]	[0.317]	[0.104]	[<0.001]	[<0.001]
Mean (SEK)	244,837	4,615	29,973	83,134	161,703
Effect (1M SEK)/mean	-3.64%	5.20%	3.80%	-3.76%	-3.56%
N	244,826	244,826	244,826	244,826	244,826

Notes: This table reports five-year estimates (per 100 SEK won) obtained by estimating equation (2) for various annual income measures as dependent variables. Pre-tax labor earnings (1) is approximately the sum of income from wages (2), self-employment (3), and parental leave and sickness payments (4). Taxable labor income is approximately the sum of pre-tax labor earnings (1), unemployment benefits (7), and pensions (8). For details on the calculations of taxes owed , see OA section 4.2. SSC: social security contributions paid by employer. Effect (1M SEK)/mean: Effect of 1M SEK divided by mean of dependent variable. Standard errors are clustered at the level of the player.

Table 4. Margins of Adjustment

	Panel A. Extensive Margin (>25K)				Panel B. Hours and Wages	
	Labor Earnings	Wage Earnings	Self-empl. Income	Pension Income	Weekly Hours	Monthly Wage
	(1)	(2)	(3)	(4)	(5)	(6)
Effect (M SEK)	-2.015	-2.241	-0.139	0.246	-1.282	-147.3
SE	(0.435)	(0.473)	(0.202)	(0.472)	(0.247)	(84.2)
p	[<0.001]	[<0.001]	[0.491]	[0.603]	[<0.001]	[0.080]
Proportion/mean	77.7%	71.2%	5.3%	35.8%	32.8	22,999
Effect/mean	-2.6%	-3.1%	-2.6%	0.7%	-3.9%	-0.6%
N	244,826	244,826	244,826	129,254	108,919	108,919

Notes: This table reports five-year estimates (per 1M SEK won) obtained by estimating equation (2) in the pooled lottery sample. In Panel A, each dependent variable is equal to 1 if annual income exceeded 25,000 SEK, and 0 otherwise. The regresssion in column (4) is restricted to individuals aged 50 or above at the time of the lottery event. The variables in columns (1)-(4) are scaled so that a coefficient of 1.00 implies a one-percentage-point increase in participation or fraction of full-time worked per million SEK won. In Panel B, the dependent variables are the imputed number of hours worked per week (5) and the pre-tax monthly wage (6). Effect/mean: Effect of 1M SEK divided by mean of dependent variable. Standard errors are clustered at the level of the player.

Table 5. Simulation-based Estimates of Model Parameters

Panel A: Parameter Estimates

	Estimate	SE
Consumption Weight (β)	0.866	(0.048)
Discount Rate (δ)	0.014	(0.039)
	$\chi^2(8)$	*p* -value
Goodness of Fit	3.385	[0.092]
	Data	Model
Average Annual Hours	1633.0	1653.8

Panel B:Model Fit

	Reduced Form	Model Prediction
Baseline	-0.58	-0.55
High wage	-0.58	-0.55
Low wage	-0.54	-0.56
100k SEK prize	-0.54	-0.55
2M SEK prize	-0.55	-0.55
Age 21-34	-0.73	-0.38
Age 35-54	-0.68	-0.53
Age 55-64	-0.38	-0.58

Panel C: Implied Wealth Effect by Age

Assumed Age-at-Win	Lifetime MPE
20	-0.169
30	-0.145
40	-0.119
50	-0.087
60	-0.036

Panel D: Implied Labor Supply Elasticities

Marshallian Elasticity (e_M)	0.010
Hicksian Elasticity (e_H)	0.096
Frisch Elasticity (e_F)	0.150

Notes: Panel A reports results of estimating the dynamic model via simulated method of moments. The goodness-of-fit test uses the minimized value of weighted minimum distance procedure, based on 11 moments and 3 parameters. Panel B compares the model-generated predictions to our causal estimates; in each case, the comparison is to the five-year estimate for after-tax labor income. Panel C reports the lifetime wealth effect at different ages at the time of win. Panel D reports key labor supply elasticities implied by the model-generated parameters for individuals who play the lottery at age 50. In these analyses, we assume individuals retire at 65 and die at age 80. Panel C reports the effect of a lottery prize on total labor earnings (i.e., sum of dy/dL across all remaining working years, as implied by model), whereas Panel D reports the implied effect of a permanent increase of wages on total hours worked (summed up across all remaining working years), the implied Hicksian elasticity (calculated from the Slutsky equation), and the Frisch elasticity.

Table 6. Effect of Wealth on Household Earnings

Panel A. Individual and Household Labor Supply Responses

	Married Lottery Players			Unmarried Lottery Players	Total Household Effect
	Winner	Spouse	Household		
	(1)	(2)	(3)	(4)	(5)
Effect (100 SEK)	-0.965	-0.408	-1.373	-1.289	-1.306
SE	(0.201)	(0.208)	(0.299)	(0.228)	(0.194)
p	[<0.001]	[0.049]	[<0.001]	[<0.001]	[<0.001]
Mean (SEK)	195,848	186,017	381,865	195,034	301,330
Effect/mean	-4.93%	-2.19%	-3.60%	-6.61%	-4.33%
N	142,102	142,102	142,102	99,287	244,826

Panel B: Difference between Winner and Spousal Responses

	Married Lottery Players	PLS and Kombi			
			Both Spouses Age <= 64		
				Spouse Ever Played Lottery	Spouse Played in Draw
	(6)	(7)	(8)	(9)	(10)
Effect (100 SEK)	-0.557	-0.964	-0.812	-1.241	-1.338
SE	(0.278)	(0.397)	(0.422)	(0.588)	(0.624)
p	[0.045]	[0.015]	[0.054]	[0.035]	[0.032]
# PLS tickets winner/spouse		173.59/48.6	168.9/47.4	162.1/73.7	164.1/113.6
# Kombi tickets winner/spouse		1.34/0.15	1.34/0.14	1.33/0.97	1.34/1.20
N	142,102	140,398	127,344	75,893	49,352

Notes: This table reports five-year estimates obtained by estimating equation (2) on winners, winners' spouses, and at the household level for different subsamples with pre-tax labor earnings as the dependent variable. Panel A shows the effect on winners, spouses, and households, whereas Panel B shows the estimated differential response for winners relative to spouses. Except in columns (4) and (5), the estimation sample is restricted to married couples. Results in columns (7)-(10) are restricted to the PLS and Kombi lotteries. In column (8), we further restrict the sample to couples in which both the winner and the spouse were between 21 and 64 at the time of the win. The prize amount is scaled so that a coefficient of 1.00 implies a 1 SEK increase in earnings per 100 SEK won. The estimates includes baseline controls for the winner's spouse (when applicable). The number of lottery tickets refers to the average number of tickets held by winners in each lottery (and Kombi controls) and their respective spouses. Effect/mean: Effect of 1M SEK divided by the mean of the dependent variable. Standard errors are clustered at the level of the player.