

Lottery Loans in the Eighteenth Century

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Abstract

In the 18th century Britain repeatedly issued lottery loans, in which investors bought bonds whose size was determined by a draw. The probability distribution of these draws was perfectly known and highly skewed. After the draw the bonds were indistinguishable from other bonds. I collect market prices for the lottery tickets and show that investors were paying a substantial premium to be exposed to this artificial risk. Information about winners indicates that investors were well-to-do and included many merchants and bankers. I turn to cumulative prospect theory to make sense of these observations.

Preliminary and incomplete.

A Lottery is a taxation
Upon all the fools in creation;
And Heav'n be prais'd
It is easily rais'd. . .

The Lottery (1731)

HENRY FIELDING

I Introduction

The use of randomizing devices for convexification purposes is very ancient (see *Numbers* 26:55 or *Iliad* 7:175 for some Bronze Age examples). Selling lotteries for more than their expected value is an old method of raising revenues; in Europe the earliest attested examples appear in the Low Countries in the mid-15th century, when cities organized lotteries to finance capital improvements and charitable works (Bernard et al. 1994). The use of lotteries spread to Italy in the 16th century where private and public lotteries were organized in Rome and Venice (Welch 2008). Venice may indeed have been the first government to issue public debt through lotteries.

In England, aside from an early example under Elizabeth I, lottery loans began in 1694 and became a regular component of wartime financing until 1768. Other countries, most notably the Netherlands (Hoekstra 2010) but also France and various German states, followed suit. In this paper I focus on the English and British lottery loans because they provide a remarkable case study in investor attitudes toward risk. From 1694 to 1768 thirty-six lottery loans were issued, with broadly similar characteristics. The lottery tickets were traded on an active secondary market from the moment that the subscription closed to the end of the lottery draw, a period of several months. Moreover, each draw took several weeks, and it is possible to reconstruct the remaining distribution of prizes at the end of each day. As a result we have a large number of observations on market pricing of these lotteries.

Lotteries are, of course, quite common and successful. What makes this case interesting is that the price of a ticket was substantial by the standards of the time and (for the most part) access was restricted to serious investors. Moreover this case presents market prices for a wide variety of perfectly-known pay-off distributions, something

we rarely observe. It thus provides an ideal testing ground for theories about investor attitudes toward risk.

2 Lottery Loans in English and British public finance

2.1 Overview

Early history: lotteries used by cities in the Netherlands to raise funds since the 15th c. Italians proficient: story of how lotteries developed from betting on the selection of Senators in Genoa (Welch 2008, Bellhouse 1991). (Coste 1933) Big cash lottery in Venice in 1693.

The first major lottery loan took place in England in 1694, in the midst of war.¹ The initiator was Thomas Neale (1641–99), a member of Parliament, master worker of the mint, and groom-porter of the king from 1678 to his death. In this last position he was responsible for organizing and supervising gambling at the royal court. In 1693 he organized a private lottery, selling 50,000 tickets at 10s each with prizes between £2 and £3000, keeping a 10% management fee for himself. The following year, he successfully proposed to Parliament the floatation of a lottery loan.

This first lottery loan had many features of its successors. Tickets were sold for £10 each and all entitled the bearer to an annuity of £1 per year for 16 years, payable twice a year. Furthermore 2,500 tickets would receive an additional 16-year annuity, ranging from £10 to £1000 pounds. Of these additional prizes, one £100 annuity went to the first-drawn ticket, and one £150 annuity to the last-drawn ticket.

The subscription opened immediately on March 26, and it filled steadily: £400,000 by mid-April, £832,000 by mid-May and by late June it was closed. The drawing started on October 8 and took two months. Two boxes were displayed, one containing all the ticket numbers and the other containing slips for all the prizes, and blank slips for the rest.

A second lottery loan was issued soon after, in 1697. It was different in many respects: the prizes were payable in principle immediately, while the blanks received a 3.8% interest until reimbursement whose date was not set. This loan was in effect a redeemable annuity sold at a rebate of 4% (the value of the cash prizes divided by the total size of the loan). The terms were not generous, and it is no surprise that it failed: only 1% of the tickets were sold, the rest was used by the Exchequer as a form of cash.

¹See Ewen (1932) for the general history of British lotteries (earlier and less exhaustive treatments include Walford 1885 and Ashton 1893), United Kingdom (1898) and Dickson (1967) for their place in British public finance. Murphy (2005) studied the 1694 lottery and its context.

Period	Increases in funded debt (£)		
	Total	Lottery loans	(%)
1694–1700	8,380,230	1,000,000	11.9
1703–15	37,448,102	10,500,000	28.0
1719–26	19,429,220	4,911,990	25.3
1742–51	31,489,272	4,672,727	14.8
1755–68	64,095,553	6,042,256	9.4

Table 1: Increases in the funded debt, total and through lottery loans. Source: United Kingdom (1898, 5–6, 14–29).

This loan (called the “Malt lottery” because it was funded with duties on malt) will not be studied further.

Perhaps spurred by the example her Dutch ally, Britain resumed lottery loans began in 1710 and they became a regular feature of British public finance.² They continued until 1768, by which time a total of 37 lottery loans had been issued.³ After the first lotteries of 1694 and 1697, we find them issued during periods of debt refinancing (1719–26) or during wars and in their immediate aftermath (1710–14, 1743–51, 1755–68). Table 1 shows that they represented a substantial although declining share of gross debt issues. In February 1769, as the government was working on the budget, rumors of a new lottery loan circulated, but ultimately it was decided to launch a pure cash lottery instead, that is, one which paid cash prizes rather than bonds. The Prime Minister, Lord North, was reported (Cobbett 1806–20, 16:608) as declaring in his budget speech that:

“... a lottery being a tax on the willing only, though many might object to it, as an encouragement of gaming, yet he thought the public would be right to avail themselves of the folly of mankind, especially as it laid no burthen on the poor; that lotteries were of various natures, and the more they were varied, the more desirous the public were of running into

²The Estates General issued lottery loans from 1709 and Holland from 1711. The first Dutch loans of 1709 offered prizes in the form of life annuities, and those of 1710–13 offered 20-year annuities, perhaps imitating the British 1710 lottery. Conversely the Holland loans of 1711–13, which offered interest-bearing bonds repaid over the course of 30 years, may have influenced the British loans of 1711–14. See Fokker (1862), Hoekstra (2010) and the the loan descriptions in the *Gazette d'Amsterdam*.

³I exclude the guinea lottery of 1757, a cash lottery that fared poorly, as well as a few other special-purpose lotteries such as the Westminster Bridge lotteries of 1737–42 (with £5 tickets) and the British Museum lottery of 1753 (with £3 tickets).

them: he thought it good policy not to over-stretch them, as that would be destroying the hen for her eggs.”

The State Lottery continued until 1826, once a year or more at times. In the end, concerns about the morality of the lottery and its incidence on the poor led to its abolition.

2.2 *Characteristics*

With the exception of the “class lotteries” of 1711 and 1712 (described below), the lotteries all shared the same characteristics. Tables 2 and 3 presents the general characteristics of the loans and Tables 4 and 5 shows the probabilities of the prizes and blanks. The characteristics of the loans, including the distribution of pay-offs, all come from the acts passed by Parliament.

Issue

The ticket price was usually £10 (except for the “classes” lotteries of 1711 and 1712, at £100, and the lotteries of 1719 and 1760, at £3). The tickets were sold for cash, except in 1748 and from 1759 to 1768 when the tickets bundled with new issues of perpetual annuities; but even in those cases, the tickets were issued as a separate, tradeable security to the bearer with a face value of £10 (the number of tickets given for each £100 in annuities varied by loan). The tickets could often be bought in installments, sometimes with a discount for early payment.⁴ The draw took place within a few months of the subscription, always in the great medieval hall of Guildhall in London and always following the same format (Figure 1). Two six-foot wooden wheels were filled, one with the ticket numbers, the other with the prizes and blanks (see Figure 1). One paper was drawn from each by a “blue coat” (a student at a charity school in London) and the match recorded by the clerks under the watchful eye of the commissioners. The draws took place six days a week, from 9 in the morning to 3 in the afternoon, except holidays.

Most of the issues were successful, subscriptions being filled within a month, sometimes within a few days (*Daily Journal*, issue 636). From the 1740s the subscription were opened at the Bank of England on the basis of a resolution of the House of Commons, before the loan act had received the royal assent. In 1722, it was reported that brokers charged a 5s premium to deliver the tickets (*Daily Journal*, 2 Mar 1722,

⁴In 1712 and 1743, the last payment was due after the draw.



Figure 1: Drawing the State Lottery at Guildhall, 1739 (engraving) by Guildhall Library, City of London/ The Bridgeman Art Library.

n346). A few issues, made shortly after the South Sea Bubble, were not successful: when the draw of the 1721 lottery began it was reported that 39% of the tickets were held by the government (*Evening Post*, issue 1901). Likewise, the 1726 lottery was quoted at a discount on the secondary market throughout the subscription, and when the draw began it was reported in the papers that 11% of the tickets remained in the Exchequer (*Daily Journal*, 20 Sep 1726, issue 1773).

Prizes

What the draw determined was the size of the bond to which the bearer was entitled. The 1719 lottery was peculiar in offering a cheaper ticket (£3) and in giving no prizes to the blanks, no doubt because of the costs of paying annuities as small as £0.12. In all other lotteries, each ticket received a long-term government bond of some size. The nature of the bond changed over time. The first lotteries, in 1694 and 1710, offered 16-year annuities with no repayment of principal; the prizes were expressed in terms of the annuity, and are capitalized at 10 to make them comparable in Tables 4 and 5.

From 1711 to 1719 the lotteries offered bonds with a fixed coupon and repayment of principal over a period of 32 years. The order in which the bonds were repaid was determined by a second draw. The acts appropriated the revenues from certain taxes to the payment of interest and principal, but if funds were insufficient the repayment was merely delayed, with interest accruing at the statutory rate. The lotteries of 1721–24 formally promised repayment within a year of the draw, with interest to accrue at a set rate on all unredeemed tickets until repayment was effected. This was a perpetual redeemable annuity in all but name, and all subsequent lotteries from 1726 explicitly offered fixed-rate annuities with no set repayment date but redeemable upon six months' notice. After the consolidation of the public debt in 1750, a number of lotteries paid out in 3% consolidated annuities. From 1722 the annuities were paid at the Bank of England like most of the public debt.⁵

The so-called “class lotteries” of 1711 and 1712 were a little different: not only was their price higher (£100 instead of £10), but the prizes were grouped in five classes; the order of reimbursement was determined by the class, and the capital of the blanks in each class was larger for the later classes, ranging from £110 to 130 for the 1711 class

⁵For some of the lottery loans of the 1750s and 1760s, which were bundled with other issues of annuities, the lottery's annuities began accruing six or twelve months later than the regular annuities with which they were bundled.

Year	Size (£m)	cost (%)	Authority	Royal assent	ticket price (£)	draw	benefits
1694	1.00	11.57	5 W & M, c. 7	2 Apr 1694	10	8 Oct - 5 Dec	16-year annuities
1697	1.40	4.06	8 & 9 Will. 3, c. 22	16 Apr 1697	10	10 Aug - 17 Aug	4% annuities, no term
1710	1.50	8.30	8 Anne, c. 4	18 Jan 1710	10	26 Jul - 26 Sep	32-year annuities
1711	1.50	8.39	9 Anne, c. 6	6 March 1711	10	2 Oct - 8 Jan	6%, repaid in 32 yrs
1711 (*)	2.00	8.68	9 Anne, c. 23	12 June 1711	100	1 Aug - 15 Aug	6%, repaid in 32 yrs
1712	1.80	8.62	10 Anne, c. 19	22 May 1712	10	20 Nov - 22 Jan	6%, repaid in 32 yrs
1712 (*)	1.80	8.62	10 Anne, c. 26	21 June 1712	100	30 Sep - 16 Oct	6%, repaid in 32 yrs
1713	0.50	5.95	12 Anne, st. 1, c. 11	13 Oct 1713	10	11 Jan - 13 Feb	4%, repaid in 32 yrs
1714	1.40	6.52	12 Anne, st. 2 c. 9	9 Jul 1714	10	3 Jan - 4 Apr	4 or 5%, repaid in 32 yrs
1719	0.51	3.95	5 Geo 1, c. 3	18 Feb 1719	3	21 Sep - 31 Dec	4% redeemable annuities
1719	0.51	4.71	5 Geo. 1, c. 9	10 Mar 1719	3	21 Sep - 31 Dec	4% redeemable annuities
1721	0.70	4.00	7 Geo. 1, st. 1 c. 20	24 Jun 1721	10	2 Oct - 10 Nov	4% redeemable annuities
1722	0.70	4.00	8 Geo. 1, c. 2	12 Feb 1722	10	2 Jul - 9 Aug	4% redeemable annuities
1723	0.75	3.00	9 Geo. 1, c. 3	31 Jan 1723	10	17 Jun - 29 Jul	3% redeemable annuities
1724	0.75	3.00	10 Geo. 1, c. 2	19 Mar 1724	10	17 Aug - 1 Oct	3% redeemable annuities
1726	1.00	3.00	12 Geo. 1, c. 2	24 Feb 1726	10	19 Sep - 16 Nov	3% redeemable annuities
1731	0.80	3.00	4 Geo. 2, c. 9	7 May 1731	10	11 Oct - 25 Nov	3% redeemable annuities
1743	0.80	3.00	16 Geo. 2, c. 13	22 Mar 1743	10	21 Nov - 5 Jan	3% redeemable annuities

Table 2: Characteristics of lottery loans, 1694–1748. (*): class lotteries. Note: the terms of the 1713 lottery were set forth in letters patent of 13 Oct 1713. The terms of the 1714 lottery were altered by 1 Geo 1 st. 1 c. 2, s. 2 (interest on blanks increased from 4 to 5%). Sources: the statutes listed, newspaper reports (for beginning and ending dates of the draws).

Year	Size (£m)	cost (%)	Authority	Royal assent	ticket price (£)	draw	benefits
1744	0.60	3.00	17 Geo. 2, c. 18	22 Mar 1744	10	26 Nov - 3 Jan	3% redeemable annuities
1745	0.50	3.00	18 Geo. 2, c. 9	19 Mar 1745	10	25 Nov - 28 Dec	3% redeemable annuities
1746	0.50	4.00	19 Geo 2 c. 12	19 Mar 1746	10	24 Nov - 26 Dec	4% redeemable annuities
1747	1.00	4.00	20 Geo 2 c. 10	24 Mar 1747	10	23 Nov - 24 Dec	4% redeemable annuities
1748	0.57**	4.00	21 Geo. 2, c. 2	18 Feb 1748	10	12 Sep - 22 Oct	4% redeemable annuities
1751	0.70	3.00	24 Geo 2 c. 2	12 Mar 1751	10	11 Nov - 24 Dec	3% redeemable annuities
1755	1.00	3.00	28 Geo 2 c. 15	25 Apr 1755	10	6 Oct - 1 Nov	3% 1752 consols
1756	0.50	3.00	29 Geo 2 c. 7	9 Mar 1756	10	22 Nov - 23 Dec	3% 1752 consols
1758	0.50	3.00	31 Geo 2 c. 22	9 Jun 1758	10	13 Nov - 14 Dec	3% 1752 consols
1759	0.57**	3.00	32 Geo 2 c. 10	5 Apr 1759	10	13 Nov - 22 Dec	3% 1759 annuities
1760	0.23**	***	33 Geo 2 c. 7	4 Feb 1760	3	17 Nov - 13 Dec	4%–3% 1760 annuities
1761	0.60**	3.00	1 Geo 3 c. 7	20 Jan 1761	10	16 Nov - 24 Dec	3% 1752 consols
1763	0.29**	4.00	3 Geo 3 c. 12	31 Mar 1763	10	30 May - 21 Jun	4% 1763 annuities
1763	0.29**	4.00	3 Geo 3 c. 12	31 Mar 1763	10	28 Nov - 20 Dec	4% 1763 annuities
1765	0.25**	3.00	5 Geo 3 c. 23	10 May 1765	10	18 Nov - 24 Dec	3% 1752 consols
1766	0.60**	3.00	6 Geo 3 c. 39	6 Jun 1766	10	17 Nov - 24 Dec	3% 1752 consols
1767	0.60**	3.00	7 Geo 3 c. 24	20 May 1767	10	16 Nov - 15 Jan	3% 1752 consols
1768	0.60**	3.00	8 Geo 3 c. 31	8 Mar 1768	10	14 Nov - 3 Jan	3% 1752 consols

Table 3: Characteristics of lottery loans, 1644–1768. (**): lotteries bundled with issues of annuities, a in lottery offered for each b in annuities subscribed : the amount raised is computed as the total sum raised multiplied by $a/(a + b)$. (** *): 4% for 20 years, 3% thereafter. Sources: the statutes listed, newspaper reports (for beginning and ending dates of the draws).

	1694	1710	1711	1711 (classes)	1712	1712 (classes)	1713	1714	1719
20,000				5.0		5.6		0.7	0.6
12,000			0.7		1.7				
10,000	1.0	0.7					4.0	1.4	1.2
5,000	9.0	2.0	2.0	10.0	1.7	11.1	2.0	2.1	3.0
4,000		2.7	2.7	15.0	1.7	16.7	2.0	2.9	
3,000		2.7	2.7	20.0	3.3	22.2	2.0	3.6	
2,000		2.7	2.7	20.0	3.3	22.2	2.0	7.1	
1,500	1.0								
1,000	21.0	13.3	13.3	25.0	16.7	27.8	10.0	15.0	17.8
500	80.0	21.3	21.3	70.0	33.3	22.2	20.0	29.3	42.1
400				80.0		88.9			
300				100.0		111.1			
250	90.0								
200	300.0	66.7	66.7	3750.0	50.0	9405.6	40.0	71.4	
105									
to 130				99655.0		90266.7			
100	2000.0	400.7	166.7		166.7		100.0	357.1	239.5
50		1988.7	954.0		940.0		800.0	714.3	474.3
25									834.8
20			15434.0		15448.3		12982.0	16126.4	
10	97500.0		83333.3		83333.3		86036.0	82668.6	15053.5
8									
7		97500.0							
0									83333.2

Table 4: Probabilities of the prizes (1694–1722). The total number of tickets is normalized to 100,000. Note: For the 1694 and 1710 lotteries, the annuities are capitalized at 10 years to make them comparable to the other lotteries. Sources: the statutes listed in Tables 2 and 3.

lottery, and from £105 to £125 for the 1712 class lottery. The repayment was scheduled to be completed within 32 years as with the other lotteries of the 1711–19 period.

The repayment history of the early lottery loans is not stellar. The 1694 lottery ran into arrears almost immediately; funds were appropriated in 1698 and the original payment schedule was restored. The Malt Lottery was likewise paid off by 1711. Payments on the annuities of the 1710 lottery fell immediately one year behind and remained for several years, as did the interest payments and reimbursements on the 1711 and 1712 lotteries, which were five quarters behind by 1717. Most of the 1710 annuities and the capital owed on the lotteries of 1711–14 were converted into South Sea Stock in two operations, in 1717 and 1720, eventually becoming 5% perpetual annuities (United Kingdom 1898). What was not converted was paid off progressively during the 1720s.

	1721-2	1723-4	1726	1731	1743	1744	1745-7	1748
20,000			1.0					
10,000	1.4	1.3	2.0	2.5	2.5	3.3	4.0	4.8
5,000	2.9	2.7	2.0	5.0	5.0	6.7	6.0	6.3
3,000	2.9	2.7	3.0	2.5	2.5			
2,000	4.3	4.0	5.0	6.3	6.3	8.3	10.0	11.1
1,000	30.0	28.0	29.0	18.8	20.0	21.7	32.0	31.7
500	44.3	54.7	50.0	27.5	32.5	43.3	64.0	63.5
100	214.3	333.3	360.0	296.3	311.3	331.7	302.0	271.4
50	571.4	666.7			586.3	673.3	796.0	701.6
20	9128.6	8906.7	7550.0	9643.8	10773.8	15215.0	13090.0	12801.6
8	90000.0							
7.5		90000.0	91998.0	89997.5				
7					88260.0			
6						83696.7	85696.0	86107.9

Table 5: Probabilities of the prizes (1721-48). The total number of tickets is normalized to 100,000. Sources: the statutes listed in Tables 2 and 3.

The lotteries of 1721-24 were each paid off within two years. From 1726 to 1768 the lottery loans were almost all of the same type: £10 tickets, prizes up to £10,000 (£20,000 in a few instances) in the form of standard perpetual redeemable annuities (now known as “consols” after the consolidation of 1751).

2.3 *Who invested in the lotteries?*

Winners

From newspaper reports we can glean information about some of the winners. The reports become more detailed over time, and are particularly abundant in the 1719 lottery. Tables 7 and 8 present the information.

Some of the winners have left a trace in history.

The winners of the big prize in 1694 were two French Huguenots who left France after the repeal of the edict of tolerance in 1685: Samuel Ravenel, seigneur du Boistilleul (c1676-1731) a nobleman from Brittany living with the duke of Leeds, and François Le Cocq (1640-1719), a magistrate in the Parlement of Paris (Douen 1894, 2:373-78, Lart 1924, 1:90). The winner of the top prize in the 1712 classes lottery, Thomas Weddell, was a merchant from York; cousin of the chancellor of the Exchequer John Aislable, he was paymaster of the Navy and enriched himself during the South Sea bubble; he

	1751	1755	1756, 58	1759	1760	1761, 65, 66	1763	1767	1768
20,000				3.0				1.7	3.3
10,000	2.9	2.0	4.0		2.5	3.3	5.7	5.0	6.7
5,000	5.7	4.0	6.0	3.0	2.5	3.3	5.7	6.7	8.3
3,000	7.1			3.0					
2,000	11.4	6.0	12.0	3.0	5.0	6.7	11.4	16.7	16.7
1,000	30.0	32.0	36.0	39.4	17.5	18.3	31.4	31.7	35.0
500	60.0	42.0	60.0	47.0	27.5	35.0	80.0	71.7	68.3
100	285.7	198.0	284.0	227.3	125.0	166.7	357.1	333.3	333.3
50	600.0	4020.0	1252.0	1060.6	500.0	335.0	1514.3	1016.7	1000.0
20	13285.7		11350.0	12768.2	2500.0	19343.3	14571.4	34916.7	31958.3
6	85711.4	95696.0	86996.0	85845.5		80088.3			
5							83422.9		
0					83445.0			63600.0	66570.0

Table 6: Probabilities of the prizes (1751–68). The total number of tickets is normalized to 100,000. Sources: the statutes listed in Tables 2 and 3.

won several other prizes in the same lottery and left £70,000 at his death. Samuel Strode, a barber-surgeon, who shared £5,000 in the same lottery, bought Ponsbourne mansion in Hertfordshire in 1718 for £6,800; his son William was MP for Reading. Matthew Wymondesold, the other claimant of the prize, was John Aislable's broker. Joseph Hodges, who won in 1711, was the son of Sir William Hodges (c1645–1714), a merchant, director of the Bank of England, and MP.

The winners of the first 1719 lottery were two German Jews, whose generosity after their good fortune was prominently featured in London newspapers: they were Moses Hart (1675–1756), a merchant who was employed in financial dealings for the government of Queen Anne, and Isaac Franks, a stockbroker who soon after married one of Hart's daughters and received the half of the ticket he did not own as part of the marriage contract. Remarkably, Isaac Franks had previously won 30,000 florins (the equivalent of £2750) in a Dutch lottery in 1715 (*Weekly Journal*, 1 Jan 1715). John Rudge, who won £10,000 in the same lottery, was a prominent merchant and director of the Bank of England, having served as its governor in 1713–14. Another winner was Robert Heysham, a merchant, banker, shipowner and broker, and MP for London. George Wanley, a goldsmith and banker (whose partnership eventually became Goslings and Sharpe), retired in 1720 to his house in Tottenham where he died in 1729; his daughter and heiress married in 1728 the son of a former director of the South Sea Company, and was said to be worth £30,000 (*Daily Post*, 26 Feb 1728; *British Journal*, 23 Nov 1728;

Daily Post, 19 Jul 1729). John Goodwyn, winner of the top prize in the 1726 lottery, was a surgeon and later mayor of King's Lynn; he had his portrait painted, holding the winning ticket in hand (Goodwyn 1876). Thomas Walker, winner of the top prize in 1731, was said to be worth £300,000 at his death in 1748 (*Penny London Post*, issue 1017).

Not all winners prospered. Susanna Mountfort, winner of £5,000 in 1714, was the daughter of two famous actors and an actress herself at Drury-Lane; not long after, she became insane, and is famous for having once walked onstage in the middle of a performance of Hamlet (in which she was not cast) and recited Ophelia's monologue (Doran 1880, 1:268,272). The winner of the 1714 prize was a clergyman, brother to the headmaster of Westminster school. According to his entry in the *ODNB*, he died in debtor's prison.⁶ John Garway, who won £5,000 in the 1731, was a prominent hop, flax and hemp merchant and sail-cloth maker in Worcester; he also won two £1,000 prizes in the 1737 Bridge lottery but nevertheless went bankrupt in 1749. John Julian, a merchant of Swiss origin who won £5,000 in the 1743 lottery, died in 1754 and his son and surviving partner was declared bankrupt immediately after (*London Evening Post* issue 4102, *London Gazette* issue 9356). The winner of one of the two top prizes in the 1751 lottery, Sir Charles Armand Pawlett, died the day his ticket was drawn, although it is not known if there is any causal link (*London Daily Advertiser*, issue 221, *General Evening Post*, issue 2806).

What comes out of these lists is that (if we take the winners to be a random sample of the population of participants in the lotteries), most participants were well-to-do individuals: prominent citizens of London, bankers, merchants, clergymen, military officers, magistrates, tradesmen, clerks, and the occasional nobleman. We also find a butler, a coachman and a few apprentices, but the poor clothier with ten children (*Daily Post*, 21 Nov 1719, issue 43) seems to be more the exception than the rule. One must however note an interesting report: "The journeymen weavers in Spittle-Fields, having a box in which they contributed weekly money for the relief of such as would be sick, and having 90L in stock, unanimously agreed to buy tickets, and 4 of them are drawn prizes of 10L each, and another 25L, the other 25 as yet undrawn" (*Weekly Journal*, 17 Oct 1719, issue 46).

The social table of England and Wales in 1688 (Table 10) gives an idea of the income distribution at the time: the mean is £39, while the median is around £20 (the statistics for the income distribution in 1759 are very similar, at £46 and £25 respectively). At £10, the price of a lottery ticket was half of median income, or a quarter of average income.

⁶His other brother John, a physician, won a small prize in the 1719 lottery.

But a prize of £10,000 would yield a perpetual income of around £300–400, enough to move a winner's dynasty to the top 1–2% of the income distribution. We also see that almost all the winners belonged to groups with family incomes above the median.

1694 Lottery

- £1,000 Samuel de Ravenel (c1667-1731) and François Le Coq (d. 1719), French émigrés
£500 Sir William Gore (Irish magistrate, d. 1700)
Gibbs, stone-cutter and 3 others
Proctor, stationer and Skinner, hosier

1710 Lottery

- £1,000 Thomas Barnaby, attorney
£500 the lord Harvey (former MP, later earl of Bristol, 1655-1751)
£400 Dunning, cheesemonger

1711 Lottery

- £12,000 Joseph Hodges (d. 1722), son of a merchant and politician

1711 Classes Lottery

- £20,000 Thomas Weddell (d. 1747), merchant of York and London
£5,000 Samuel Strode (d. 1728), surgeon and Matthew Wymondesold (1677-1757), goldsmith
£5,000 John Hunt, gentleman of Northants.

1712 Classes Lottery

- £20,000 Margaret Williams, widow
£5,000 Theophilus Dillingham, woollen draper
£5,000 John Mendes de Costa, merchant

1713 Lottery

- £10,000 Colonel Mathew

1714 Lottery

- 20,000 Rev. William Freind (c1669-1745)
10,000 Renerana, a French merchant in St Bartholomew Lane
Tovey, a Norwich factor, and Wm Trumsher, a hosier's apprentice
5,000 attorney in Essex
brewer in the Seven Dials
Susanna Mountfort, actress (1690-1720)
4,000 Mitford Crowe (former governor of the Barbados, 1669-1719)
3,000 butler of the dean of Salisbury
— Bridges, Esq
Thomas Caverley, dancing-master (d. 1745)
2,000 mercer of Colchester
1,000 orange-merchant near Billingsgate
Madam Mead's coachman
Rev. Gibbs, of Bristol
-

Table 7: Some winners of the largest prizes, 1694-1714. Sources: *Gazette d'Amsterdam* 1 Nov 1694 issue 87, 15 Nov 1694 issue 91, (Luttrell 1857, 3:380-394, 6:611-618), *Protestant Post-Boy* 5 Jan 1712, (Ewen 1932, 137, 140), *Post Boy* issue 2925, *Weekly Journal*, Jan 29 Jan, 12, 19 Feb, 12, 26 Mar 1715, *Weekly Packet* issue 137.

1719 Lottery

20,000	Moses Hart (1675–1756) and Isaac Franks (d. 1736) Mr Cox, a merchant in Berry-St
10,000	a poor clothier in Newberry with ten children John Rudge (1669-1740), merchant, MP, director of the Bank
5,000	Mr Warren in Theobald's Row, by Red-Lion Square Mr Owen, a clerk in the East India House John Lloyd (d. 1737), Blackwell-Hall factor (cloth merchant) Mr Narsh George Wanley (d. 1729), goldsmith Job Matthews, apothecary a merchant in this city a cow-keeper in Islington Revd Mr Morris, of Abergavenny in Monmouthshire
1,000	an in-keeper in St Martin in the Fields one of the Lord Mayor's officers [Thomas] Nash, upholsterer Robert Heysham (1663–1723), MP for London [Thomas] Snow (d. 1748), partner with [John] Warner (d. 1722), goldsmiths Arthur Cutting and Thomas Hyeth, cheesemongers [William] Jenkins, deputy [of Billingsgate ward] Jenkinson, cheesemonger in Thames Street [James] Colebrooke and Ruck [Rooke], bankers [Robert] Spark[e] (d. 1728), ironmonger (to HM), Catherine-St in the Strand Philip Gibbs (d. 1752), Backwell-Hall Factor (cloth merchant) Henry O'Brien, earl of Thomond (d. 1741) a gentlewoman unknown
500	the share of Mr Martin and Company, goldsmiths in Lombard St. George Wanley, goldsmith (d. 1729) Dr. John Freind, physician (1675-1728) a vintner at the Crown, by Guildhall Glisson Maydwell (d. 1748), glass-seller David Milne, a great insurer of ships Mr Jenkins, cheesemonger in Thames St and an orange-merchant's apprentice

Table 8: Some winners of the largest prizes, 1719. Sources: *Original Weekly Journal*, 10 Oct, 24 Oct, 26 Dec 1719, 2 Jan 1720; *Weekly Journal*, issues 42, 45–53, 55–56 ; *Weekly Packet*, issues 380–382, 391; *Daily Post*, issues 14, 25, 43, 52, 68, 75.

<i>1721 lottery</i>	
10,000	John Bennet (1683-1739), master in chancery
5,000	a French merchant in Mincing-Lane
5,000	a mercer
<i>1722 Lottery</i>	
10,000	the countess of Darlington (1675-1725)
5,000	Soulier, French merchant near the royal exchange
5,000	the house-keeper, butler and footman of Mr Windham, a linen draper in Cornhill
<i>1723 Lottery</i>	
10,000	Mr. Bernard, a shopkeeper in Southampton
5,000	Sir John Lambert (1666-1723), late director of the South Sea Co
5,000	
<i>1724 Lottery</i>	
10,000	Henry Pelham (1694-1754), gave it to Dr Bradshaw, a Sussex clergyman, his former tutor
5,000	Major Mason, of Downing Street
5,000	
<i>1726 Lottery</i>	
20,000	John Goodwyn (1672-1763), surgeon, alderman of King's Lynn
10,000	Anthony Duncombe (1695-1763), MP, nephew of Charles Duncombe, banker
10,000	Thomas Brian (+1749), custom-house officer, son of the Harrow headmaster
5,000	Mr Gladwin and Mr. Williams, brokers
5,000	
<i>1731 Lottery</i>	
10,000	Thomas Walker (c1664-1748), HM Commissioner of Customs
10,000	John Bance (c1694-1755), merchant, director of East-India Co (later Bank director, MP)
5,000	Mr Van Eck, Dutch merchant in Threadneedle St
5,000	a goldsmith in Lombard St
5,000	Mr Heathcote, nephew to Sir Gilbert Heathcote (1652-1733, the richest commoner in England)
5,000	John Garway, hop-merchant in Worcester
<i>1743 Lottery</i>	
10,000	Eldridge, draughtsman in the shipyards at Deptford
10,000	the master of a pub in Greenwich
5,000	Mrs. [Mary] Shuckburgh, widow [of a stationer] in Stoke Newington
5,000	John Julian (d. 1754), merchant [from Berne]
5,000	a French clergyman in the City
5,000	

Table 9: Winners of the largest prizes, 1721-43.

	Families	
	number	income (£)
Temporal lords	200	6060
Baronets	800	1500
Spiritual lords	26	1300
Knights	600	800
Esquires	3,000	562.5
Greater merchants	5,264	400
Gentlemen	15,000	280
Persons in offices, greater	5,000	240
Lesser merchants, artisans and handicrafts	27,802	200
Persons in the Law	8,062	154
Persons in offices, lesser	5,000	120
Freeholders, greater	27,568	91
Naval officers	5,000	80
Clergymen, greater	2,000	72
Persons in sciences and liberal arts, military officers	16,898	60
Freeholders, lesser	96,490	55
Clergymen, lesser	10,000	50
Shopkeepers and tradesmen	101,704	45
Farmers	103,382	42.5
Manufacturing trades	162,863	38
Building trades	73,018	25
Common seamen	50,000	20
Laboring people and outservants, miners	299,237	15
Common soldiers	35,000	14
Cottagers and paupers	313,183	6.5
vagrants	23,489	2
All Families	1,390,586	39.1

Table 10: Social Table of England and Wales, 1688. Source: Lindert and Williamson (1982, Table 2).

2.4 *Information and Markets*

Information

Detailed information about the nature of the lotteries was available at the time. The Acts of Parliament authorizing the loans contain the exact number of tickets and prizes, and specify the method and latest possible date for the drawing. The opening of the draw was announced in newspapers. Over the course of the draw, various offices (which advertised their services in the newspapers) kept investors informed of the prizes drawn, sometimes as frequently as every quarter hour; it was also possible to register one's ticket to be informed immediately when it was drawn, for a fee. From the late 1710s, the newspapers also reported when the major prizes were drawn. Once the draw was over, the commissioners of the lottery published an official list of the prizes, and the early lists even include the date at which each prize was drawn. I have used the surviving lists for the early draws, and newspapers accounts for later draws, to collect information on the number of prizes remaining in the wheel day by day.

Intermediation

The lists of winners also reveal an interesting element: poorer individuals tended to share lottery tickets. This was an obvious way to overcome the relatively high hurdle imposed by the ticket price. As one might expect, an industry soon appeared to intermediate the tickets into smaller tickets.

Soon after the 1711 lottery was approved, Thomas Smyth and Jonathan Collyer published a broadside offering a subscription of $\frac{1}{20}$ shares in tickets of the lottery at the price of 10s 6d (5.25% of the face value), to purchase up to 2000 tickets in the lottery; the tickets would then be sold on the secondary market within three months after the draw. The proposal noted that if the market price of lottery tickets were to rise, the price of the $\frac{1}{20}$ shares would be adjusted upward. Another proposal was published in Abel Boyer's *Supplement* (March 9, 1711, issue 492) by Charles Weston and Griffith Lloyd, with a similar price for shares but also allowing a 5% share in the profits to the undertakers.

Matthew West, a goldsmith in Clare-Street, also advertised a similar scheme in the *British Mercury* starting in July, with shares selling at 11s, raised to 11s 6d on August 12 because of the rising market price of lottery tickets. This last venture is known to have reached completion, because the shares were paid off in February 1712 (*Daily Courant*, 21 Feb 1712, issue 3231), although its scale was not very large, since West bought only

100 lottery tickets (*British Mercury*, 15 Oct 1712, issue 380; *Flying Post*, 6 Nov 1712, issue 3293). He offered similar schemes in all subsequent lotteries, diversifying into foreign lotteries (Dutch and German) from 1714.⁷ In the 1719 lottery, which was priced at £3, he offered $\frac{1}{8}$ shares at a 20% premium.

Rental market

Another way to make the lotteries accessible to smaller incomes was to rent lottery tickets for period of time during the draw. This method appeared in the mid-1720s, and a rented ticket came to be known as a “horse.” The contract is described in *Mist’s Weekly Journal* (15 Oct 1726, issue 78): “the term Horse is technical for the chance of a number for a certain time, upon condition (if it draws a prize) or replacing it to the vendor with an undrawn ticket.” The price of a “chance for a day” was quoted in newspapers for the 1726 and 1731 lotteries.

The risk involved in renting a horse is illustrated in Henry Fielding’s farce “the Lottery” by the following exchange, taking place in Guildhall during the draw between a stock-jobber named Stocks and a coachman:

Coachman. Oh Sir! your worship has let me a very lucky horse: it is come up twenty pound already. So if your worship would let me have the money— *Stocks.* Let me see, tickets are this day nineteen pound; and your prize is worth eighteen pound eighteen shillings; so if you give me two shillings, which are the difference, we shall be quit. *Coachman.* How, Sir! how! *Stocks.* Upon my word, friend, I state the account right. *Coachman.* Oh,—the devil! and have I given three pound for the chance of losing two shillings more? *Stocks.* Alas, Sir! I cannot help ill fortune.—You have had ill luck; it might have come up a hundred, or a thousand, or ten thousand.

These practices were made illegal in 1737, and the prohibitions routinely included in all subsequent lottery acts.

Options

One enigmatic report in Houghton’s *Collection for the improvement of husbandry and trade* (13 Jul 1694) presents prices for what must be derivatives contracts based on the

⁷He may have run into temporary legal trouble: in November 1712 subpoenas were issued by the Court of Exchequer against him, as well as other “undertakers, printers and publishers of, and contributors to the several new schemes of lotteries” (*Post Boy*, 29 Nov 1712, issue 2735). Obviously nothing came of it.

Million lottery, before the draw: they are called “all or any”, “all or none”, “put”, and “refuse”: the last two names refer to options (now called put and call). I have not found anything similar in the later lotteries.

Insurance

The 1719 lottery was somewhat different from the previous ones in two respects. First, the ticket price was £3, a third smaller than the normal lotteries at £10 and significantly smaller than the classes lotteries at £100. Second, the blanks received nothing: less was ventured, but it could be completely lost. In the earlier lotteries (as well as in all subsequent ones), blanks received something.

This potential loss appears to have spurred the growth of a market for insurance. Insuring lottery tickets was not new, either in England or elsewhere. An early example of insurance on a private lottery in 1664 is given by (Pepys 1894, 4:92). In the Netherlands, John Law made a business insuring tickets in the Dutch lotteries of 1713. But the terms of the 1719 lottery prompted the advertisement of several rival schemes in London papers. In the *Daily Courant* of August 1719 (issues 5565 to 5571), Richard Turner and John Marke, two goldsmiths in Exchange Alley, offered to insure lottery tickets against drawing blank, in which event they would pay the insured £3. The premium was 22.5s per ticket for 50 tickets or more, and 25s for 25 to 49 tickets. At the same time, the Company of Mines Royal and Mineral and Battery Works (a moribund mining company that had been turned into a vehicle for insurance business by Richard Onslow) considered but declined to offer lottery insurance. Instead, a subscription was opened to raise £120,000 for that purpose in a separate vehicle. The subscription was completed in two days and terms were offered on August 26. The fund offered to insure sets of $n = 12, 24, 48$ or 96 tickets. The owner handed over the set to the fund, which issued a receipt with the ticket numbers. After the draw, the value of the tickets in v the set would be computed and the fund would pay out $\max\{0, 3n - v\}$. The insurance premium depended on the size of the set. The insured could choose to pay a lower premium in exchange for ceding 5% of the set’s realized value.

Table II shows the premia charged, the insurer’s expected pay-out, and profits.

2.5 *Secondary markets*

Once the subscription closed (and sometimes before), market prices for the tickets appear in contemporary newspapers, alongside prices for stocks and government bonds.

size of set	96	48	24	12
premium (£/ticket)				
with 5%: p_1	0.8	0.95	1.1	1.25
without: p_2	0.9	1.05	1.2	1.375
insurer's expected profit per ticket				
with 5%: $p_1 - E(\max\{0, 3n - v\}/n) + E(.05v v > 3n)/n$	0.60	0.40	0.31	0.30
without: $p_2 - E(\max\{0, 3n - v\}/n)$	0.57	0.34	0.16	0.10

Table 11: Profitability of the insurance scheme, 1719 lottery. Notation: v is the realized value of a set, p_i the premium charged, n the number of tickets in a set.

Table 12 lists the sources. Prices were quoted for the lottery tickets during the course of the draw, which took anywhere from one to three months, and also for blanks and prizes. Of course, after the draw, the blanks and prizes represented straight government bonds.

2.6 Prices

There are also anecdotal reports relating to purchases on the secondary market for the 1719 lottery. The *Weekly Journal* (5 Dec 1719, issue 53) reported that “a gentlewoman unknown came in a coach to Exchange-Alley, and bought the ticket numbered 102114 which the next day came up a prize of £1,000.” It was also reported (*ibid.*, 17 Oct 1719, issue 46) that Mr. Cox, who won one of the top prizes, “had but two tickets in the lottery which he bought a month ago for £2 18s each.”

The papers reported also on the movement in prices during the draw.

There is no official source for the market prices: the quotes reported in the contemporary newspapers are presumably gathered in and around Exchange Alley where financial transactions took place. Some newspapers (the morning papers) report the previous evening's quotations; the evening papers report the prices as they stood at noon or 1 o'clock.

Lottery	Sources	
	Prices	Draw
1694	Houghton's <i>Collection for the Improvement of Husbandry and Trade</i>	
1710	<i>Post Master, Evening Post, British Mercury</i> (from 4 Oct 1710)	<i>Daily Courant</i> , 29 Sep 1710
1711	<i>British Mercury</i>	Rhodes (1711a)
1711 (class)	<i>British Mercury</i>	Rhodes (1711b)
1712	<i>Daily Courant, Evening Post</i> issues 512–539, <i>British Mercury</i>	
1712 (class)	<i>Daily Courant</i>	
1713	<i>Post Boy, British Mercury, Course of the Exchange</i>	
1714	<i>British Mercury, Course of the Exchange, Freke's Courant</i>	Account (1715)
1719	<i>Weekly Packet, Whitehall Evening Post, Post Man, Course of the Exchange</i>	Account (1719)
1721	<i>Daily Journal</i>	<i>Evening Post,</i>
1722	<i>Daily Journal</i>	<i>Daily Journal, Evening Post, London Journal</i>
1723	<i>Daily Journal, Daily Post</i> issues	<i>Evening Post, Weekly Journal or British Gazetteer</i>
1724	<i>Daily Journal, Daily Post</i> issues	<i>Parker's London News, Original London Post</i>
1726	<i>Daily Journal, Daily Post</i> issues	<i>Parker's Penny Post</i>
1731	<i>Daily Advertiser, London Evening Post, Daily Post</i>	<i>Parker's Penny Post</i>
1743	<i>Daily Advertiser, Daily Post</i>	<i>Westminster Journal</i>
1744	<i>Course of the Exchange</i>	<i>Westminster Journal</i>
1745–47	<i>General Advertiser, Course of the Exchange</i>	<i>General Advertiser</i>
1748	<i>Course of the Exchange</i>	<i>General Advertiser, Remembrancer</i>
1751	<i>Course of the Exchange</i>	<i>London Evening Post</i>
1755	<i>Course of the Exchange</i>	<i>London Evening Post, Read's Weekly Journal</i>
1756	<i>Course of the Exchange</i>	<i>Read's Weekly Journal</i>
1758	<i>Public Advertiser</i>	<i>Lloyd's Evening Post</i>
1759	<i>Public Advertiser</i>	<i>Read's Weekly Journal</i>
1760	<i>Public Advertiser</i>	<i>Lloyd's Evening Post</i>
1761	<i>Public Advertiser</i>	<i>Lloyd's Evening Post</i>
1763	<i>Public Advertiser, Course of the Exchange</i>	<i>Lloyd's Evening Post</i>
1765	<i>Public Ledger</i>	<i>Lloyd's Evening Post</i>
1766	<i>Gazetteer and New Daily Advertiser</i>	<i>London Evening Post</i>
1767	<i>Gazetteer and New Daily Advertiser</i>	<i>London Evening Post, Lloyd's Evening Post</i>
1768	<i>Lloyd's Evening Post, St James's Chronicle</i>	<i>Lloyd's Evening Post</i>

Table 12: Sources for market prices and draws.

3 Analysis of the prices

3.1 *The Data*

The data I analyze concern 25 lotteries: the 1711 £10 lottery and all lotteries from 1719 except the 1755 lottery for which price data is insufficient.

First, newspaper reports give me daily price observations for each lottery; the length of the series depends on the duration of the draw and ranges from 25 to 89. In addition, newspaper reports provide information on the prizes remaining in the wheel at the end of each drawing day. This allows me to reconstruct the distribution of remaining prizes. Oftentimes the count of lowest (hence most common) prizes (£10 or £20) are not reported, and I assume that the law of large numbers applies.

As noted above, the lotteries I am studying are not cash lotteries. The ticket prices quoted in the sources are cash prices, but a prize of £N is in fact a bond with a face value of £N. I therefore need a market value for that bond.

For the later lotteries (1743 to 1768), the lottery's prizes were composed of bonds that were being issued simultaneously in a non-random form, of that were already in existence. In the former case we can readily find market prices for exact underlying bond; in the latter case, the bonds being perpetual redeemable annuities at the same rate, there is no difference between the two issues. For the earlier lotteries, the underlying bonds may not have an exact counterpart in the secondary market; also, the farther back in time one goes the less price information there is.

For earlier lotteries, blank tickets appear on the secondary market, usually within a week or two of the beginning of the draw. This gives me an exact price of the underlying bond. Prior to the appearance of the blanks on the market, I have to use another bond.

For the period 1711–14, I use the blank tickets of the 1710 lottery, which remained quoted in the secondary market until their complete redemption in the 1740s. The 1711–14 underlying bonds are not exactly of the same type as the annuity of 1710, which promised a fixed annual payment for 32 years. Rather, they were 32-year bonds with a fixed coupon and random redemption date, but in expected value the stream of payments is also a 32-year constant payment. Of course, a 1710 blank in 1714 had less than 32 years to run, and I adjust for that. For 1719 and 1726, I use quotations for a 4% redeemable annuity

Lottery	ticket price	mean pay-off	lowest /mean	% blanks	std	σ/μ	skew	1st 2 weeks		last week	
								mkt price	premium	mkt price	premium
1694	10	13.75	0.73	0.98	63.0	4.58	86.0	10	0.12		
1710	10	9.00	0.78	0.98	47.0	5.22	114.7	10.84	0.22	10.78	0.21
1711	10	12.86	0.78	0.83	49.7	3.86	136.6	13.20	0.15	11.00	0.20
1711 (class)	100	130.11	0.85	0.96	165.4	1.27	92.6	105.35	0.08	100.75	0.04
1712	10	13.01	0.77	0.83	61.7	4.74	141.5	102.84	0.16	110.31	0.11
1712 (class)	100	130.10	0.81	0.90	175.0	1.35	86.8	98.55	0.11	95.48	0.04
1713	10	12.66	0.79	0.86	72.5	5.73	116.6	10.43	0.37	10.42	0.37
1714	10	13.40	0.75	0.83	78.5	5.86	160.2	10.38	0.13	11.01	0.15
1719	3	2.96	0.00	0.83	68.0	22.95	200.6	3.50	0.18	3.15	0.06
1721	10	10.50	0.76	0.90	54.8	5.22	117.0	10.82	0.03	10.49	0.00
1722	10	10.50	0.76	0.90	54.8	5.22	117.0	11.42	0.09	11.06	0.05
1723	10	10.18	0.74	0.90	53.4	5.24	118.2	10.68	0.05	10.91	0.07
1724	10	10.18	0.74	0.90	53.4	5.24	118.2	10.93	0.07	11.34	0.11
1726	10	10.00	0.75	0.92	86.0	8.60	163.0	13.90	0.39	12.68	0.27
1731	10	10.00	0.75	0.90	67.1	6.71	107.7	10.74	0.07	11.77	0.18
1743	10	10.00	0.70	0.88	67.4	6.74	106.4	11.13	0.11	11.02	0.10
1744	10	10.00	0.60	0.84	75.5	7.55	98.6	11.95	0.19	12.06	0.21
1745	10	10.00	0.60	0.86	80.1	8.01	94.5	12.57	0.26	11.93	0.19
1746	10	10.00	0.60	0.86	80.1	8.01	94.5	11.54	0.15	11.18	0.12
1747	10	10.00	0.60	0.86	80.1	8.01	94.5	10.93	0.09	11.11	0.11
1748	10	10.00	0.60	0.86	85.4	8.54	90.8	11.32	0.13	11.84	0.18
1751	10	10.00	0.60	0.86	76.6	7.66	86.3	11.51	0.15	11.76	0.18
1755	10	9.00	0.67	0.96	61.1	6.79	112.7	10.01	0.11	10.29	0.14
1756	10	10.00	0.60	0.87	80.8	8.08	92.4	13.14	0.31	13.45	0.34
1758	10	10.00	0.60	0.87	80.8	8.08	92.4	11.45	0.15	12.55	0.26
1759	10	10.00	0.60	0.86	117.5	11.75	152.3	13.51	0.35	14.65	0.46
1760	3	3.00	0.00	0.83	60.1	20.02	132.4	5.37	0.79	5.89	0.96
1761	10	10.00	0.60	0.80	68.8	6.88	117.0	14.85	0.48	15.77	0.58
1763	10	10.00	0.50	0.83	90.4	9.04	88.6	14.07	0.41	12.99	0.30
1765	10	10.00	0.60	0.80	68.8	6.88	117.0	13.85	0.38	13.18	0.32
1766	10	10.00	0.60	0.80	68.8	6.88	117.0	13.47	0.35	13.11	0.31
1767	10	10.00	0.00	0.64	120.8	12.08	109.5	14.31	0.43	14.70	0.47
1768	10	10.00	0.00	0.67	152.8	15.28	96.6	16.45	0.64	16.74	0.67

Table 13: Financial characteristics of the loans.

3.2 PDFs and prices

Table 13 reports the financial characteristics of the loans. The ticket price is the cash value of the ticket. The mean pay-off is the average face value of the bonds given out as prizes (for the 1694 and 1710 lotteries, it is 10 times the average value of the term annuities issued). The next five columns are statistics of the distribution of prizes: ratio of lowest pay-off to mean pay-off, proportion of blanks (tickets receiving the lowest pay-off), standard deviation, coefficient of variation, and skewness. What appears from this table is that the government never settled on a fixed format for its lotteries, but rather continuously varied the terms. There is a general trend for the share of blanks to decrease over time, but the second and third moments of the prize distribution vary

substantially. The 1719 and 1760 lotteries stand out by these measures because the blanks received no pay-off. This was also true of the last two lotteries but there were fewer blanks ($2/3$ instead of 83%).

The last columns provide information on the market prices of the lottery tickets, at two points in time: during the first two weeks for which prices are available (typically after the subscription had sold out), and in the week before the draw. The market price reported is normalized by the market value of the underlying bond: in other words, it says how much of the underlying bond could be bought on the same day with a cash amount equal to the market price of the ticket. Hence it is directly comparable to the prizes. The premium is computed relative to the mean pay-off in the second column: it shows how much investors were willing to pay in order to receive their bond in lottery form rather than its certainty equivalent. This premium is always positive, and in the last years it is considerable.

The goal of this paper is to make sense of these premia.

Moments

Figures 2 and 3 relate the final week premia with the moments of the prize distribution (plotting the seventh and eighth columns against the last column of Table 13).

3.3 Time Series

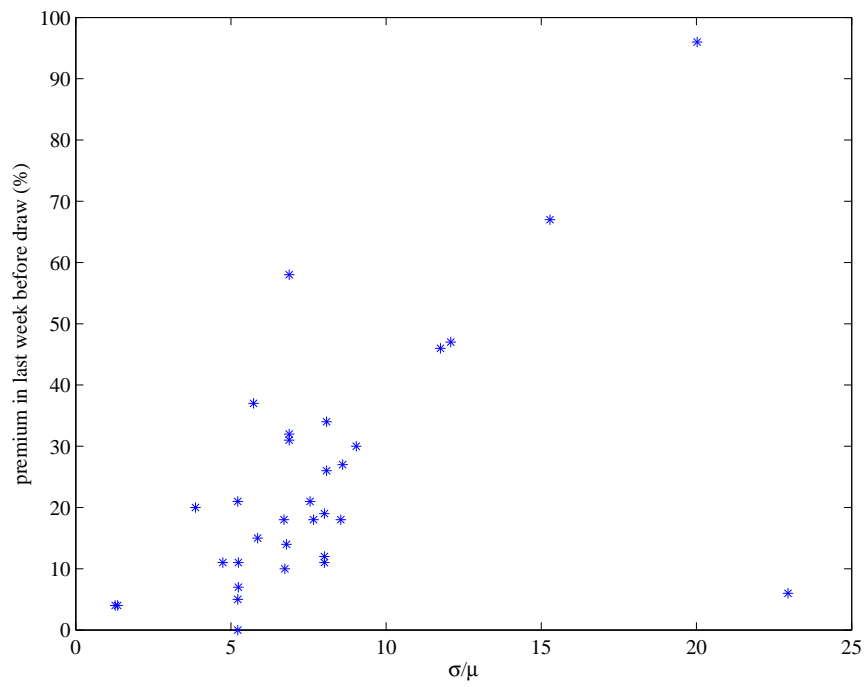


Figure 2: Coefficient of variation of prizes and market risk “premium.”

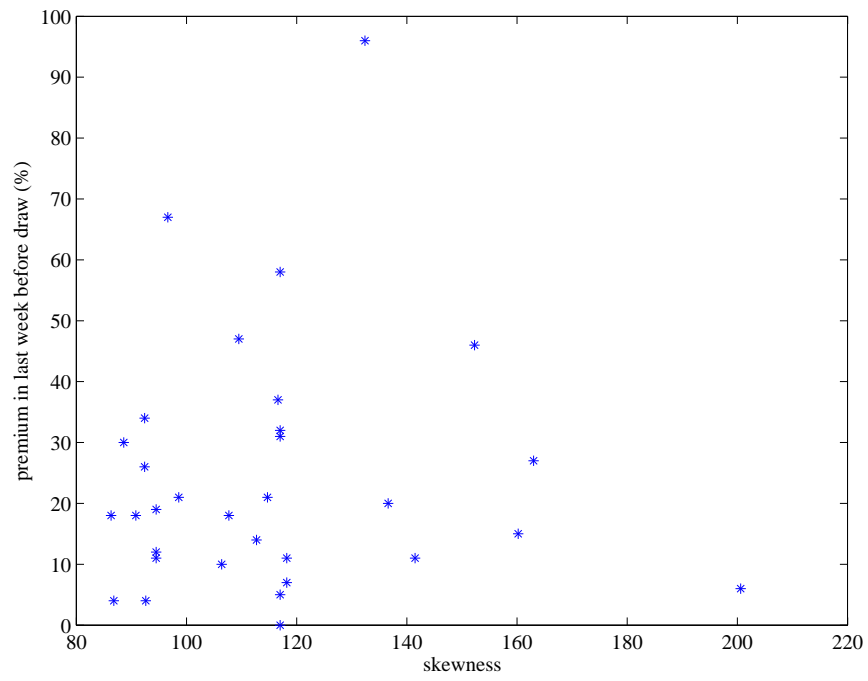


Figure 3: Skewness of prizes and market risk “premium.”

3.4 *Summary of facts*

The British government offered securities that were, in effect, a lottery whose pay-off was in the form of other, standard government bonds. The government did so repeatedly over the course of the 18th century. A sizeable portion (up to 25%) of the flow of new debt was issued in this form, so this type of instrument was not anecdotal. In terms of the stock of debt, however, these lotteries did not represent a large component of investor portfolios, except in the very first years: the 1710 lottery represented 7.5% of the public debt, 1726 lottery represented 2%, and the 1768 lottery 0.5%. Moreover the randomness was not a permanent component of the security: soon after issue, a draw determined the size of the bond delivered to each investor; after the draw, portfolios “returned to normal.”

The risk associated with the lotteries was perfectly exogenous and orthogonal to every other source of risk. It was perfectly known by all investors, who could easily find out (both before and during the draw) the exact probability distribution, and who had no reason to doubt it. It was a purely artificial risk that provided no hedge of any kind.

From an examination of the lottery winners, it appears that purchasers of these lotteries (from whom the winners were by construction randomly selected) were well-to-do and savvy individuals, and there is nothing to suggest that they were any different from other investors.

Market prices are available for these lotteries. The most striking observation is that the price of a lottery ticket was larger, sometimes substantially so, than the market value of its expected pay-off. Investors were willing to pay to randomize the size of a bond.

The randomization was substantial, with high variance and high skewness. The ticket price represented a half of median income, the top prize could reach a thousand times median income. The government appeared constantly to experiment with the design of the probability distribution. That investors had specific preferences over the probability distribution is also suggested by the private insurance market, which in effect rearranged the distribution for a fee.

The price observations have two dimensions: we have observations for a number of lotteries over the years, and for each lottery we have observations over the course of the draw. As prizes are drawn the distribution of the lottery changes in a known way, but (since drawing is without replacement) the market size shrinks steadily over the course of the draw. It appears that the premium paid for lottery tickets (over their expected value) trended upward systematically over the course of the draw. Nonetheless, casual observation shows that market prices responded to changes in the distribution (drawing

big prizes led to a fall in market prices of undrawn tickets).

It is important to note that short-selling these securities was difficult. The Act for Suppressing of Lotteries (10 Will 3 c. 23) passed in 1699 recited that “several evil disposed persons” have set up “many mischievous and unlawful games called Lotteries,” it declared lotteries “common and public nuisances” and prohibited anyone from setting them up. The Act was strengthened a few years later (9 Ann c. 6, s. 57) and remained in force until updated by the Betting and Lotteries Act (1934). Furthermore betting on the outcome of the official government lottery was made illegal in 1719 (5 Geo I c. 9 s. 43).

3.5 Searching for a framework

My goal is to make sense of these observations. Standard expected utility with concave preferences will not get me very far, which is why I turn to alternative specifications. I start with cumulative prospect theory (CPT).

Cumulative prospect theory (CPT) is a variant of prospect theory. The objective function assigned to individuals

$$\sum_{i=-m}^n \pi_i v(x_i) \quad (1)$$

has two features: (a) a value function $v(x_i)$ defined over gains and losses x_i , relative to a reference value (say, current wealth), and (b) a weighting function $\pi_i(p)$ that distorts the objective probabilities $p = \{p_i\}$ of gains and losses. It is assumed that v is concave over gains, convex over losses, and kinked at 0. It is also assumed that π_i is a function of the *cumulative* probability distribution.

For an ordered lottery $(x_{-m}, p_{-m}; \dots; x_{-1}, p_{-1}; x_0, p_0; x_1, p_1, \dots; x_n, p_n)$, weighting depends on *cumulative* probability distribution:

$$\pi_i = \begin{cases} w^+(p_i + \dots + p_n) - w^+(p_{i+1} + \dots + p_n) & 0 \leq i \leq n \\ w^-(p_{-m} + \dots + p_i) - w^-(p_{-m} + \dots + p_{i-1}) & -m \leq i \leq 0 \end{cases} \quad (2)$$

Tversky and Kahneman (1992) propose the following functional forms⁸:

$$v(x) = \begin{cases} x^\alpha, & x \geq 0 \\ -\lambda(-x)^\beta, & x < 0 \end{cases} \quad (3)$$

⁸See Stott (2006) for other functional forms.

and

$$\begin{cases} w^+(p) &= \frac{p^\gamma}{(p^\gamma + (1-p)^\gamma)^{1/\gamma}} \\ w^-(p) &= \frac{p^\delta}{(p^\delta + (1-p)^\delta)^{1/\delta}} \end{cases} \quad (4)$$

The five parameters $(\alpha, \beta, \lambda, \gamma, \delta)$ respectively govern the concavity over gains, the convexity over losses, the kink between small gains and losses, and the overweighting of left-tail and right-tail events. Tversky and Kahneman (1992) estimate $\alpha = \beta = 0.88$, $\lambda = 2.25$, $\gamma = 0.61$, $\delta = 0.69$.

Barberis and Huang (2008) present an equilibrium model with identical investors whose preferences conform to cumulative prospect theory (CPT). They consider a static model of investors with CPT-preferences, which are assumed to take the functional forms above with $\alpha = \beta$ and $\gamma = \delta$. The available assets are a risk-free asset, a set of J assets with multivariate normal pay-offs in fixed supply, and one skewed security (the lottery L), independent of the other assets, in infinitesimal supply.

They prove by example that an equilibrium can exist in which the skewed security earns a negative excess return. Let x be the share of the investor's portfolio invested in the lottery, the rest invested in a linear combination of the risk-free asset and the tangency portfolio formed from the J risky assets. The equilibrium is characterized by an indifference of investors between not holding the lottery ($x = 0$) or holding a certain amount x^* , at the market prices for the lottery p_L and the tangency portfolio p_J . Let $V(x, p_L, p_J)$ be the valuation of a portfolio valuation of the portfolio $(x, 1-x)$ by each CPT investor. The equilibrium conditions thus boil down to $V(0, p_L, p_J) = 0$, $V(x^*, p_L, p_J) = 0$, and $V'(x^*, p_L, p_J) = 0$. There are three variables to solve for: the price of the J normal portfolio p_J , the price of the lottery p_L , and the share x . given the assets' pay-offs (the standard deviation σ_J and the distribution of prizes L of the lottery), The equilibrium conditions can be represented as $F(x, p_J, p_L | \alpha, \gamma, \lambda, \sigma_J, L) = 0$.

In the data I observe L and p_L . I do not observe p_J or x , although I have a sense of what reasonable values could be. More precisely, I observe a collection $\{L_{it}, p_{L_{it}}\}$ of lotteries and their prices where t represents years, and i are successive observations over the course of each year's draw. I am willing to assume that preferences $(\alpha, \gamma, \lambda)$ and the "market portfolio" characteristics σ_J are constant for each t . Then the i observations in each year should be enough to estimate $\theta = (\alpha, \gamma, \lambda, \sigma_J)$ in each year. The idea for estimation is to find θ that minimizes $F'WF$ (where F is the 3-vector of equilibrium conditions).

Estimation (to be completed!)

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