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Costly number seven

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ABSTRACT

Lotto players often choose numbers non-randomly, a behavior known as *conscious selection*. In many Western countries, the number 7 is considered lucky, causing it to be disproportionately selected in lotto games. This study quantifies the financial cost of this tendency using data from lotto games in Belgium (2011–2025) and France (2002–2008, 2019–2025), as well as Euromillions data (2016–2025). Due to the parimutuel payout system, tickets containing the number 7 earn significantly lower prizes than those without it. We find that this cost persists across different game formats and time periods.

1. Introduction

Lotto players often deviate from rational choice by using heuristics to select numbers (a behavior called *conscious selection*, Cook and Clotfelter, 1993); they do not choose numbers at random (Baker and McHale, 2009, 2011; Farrell et al., 2000; Polin et al., 2021; Simon, 1998; Turner, 2010; Wang et al., 2016), either because of superstitious beliefs, or preferences for some specific numbers (e.g., birth dates). In particular, 7 is perceived as a lucky number in Western countries and is thus overrepresented in lottery tickets (Turner, 2010; Roger, 2011; Wang et al., 2016; Polin et al., 2021; Roger et al., 2023).

While gambling is already difficult to rationalize given the take-out rates of about 50% in lotto games (Stetzka and Winter, 2023), it is even more puzzling that players tend to cluster around specific number choices. Indeed, in parimutuel games, the prize pool depends on sales, not on the number of winners, so the payout per winner declines as more players choose the same numbers. Using common heuristics is therefore suboptimal, as it increases the likelihood of sharing prizes and reduces expected payoffs.

In this paper, we show that lotto players experience a statistically and economically significant loss when selecting the number 7 on their ticket. Our analysis covers four sets of publicly available data: (1) the Belgian lotto (2011–2025), (2) the French lotto (2002–2008), (3) the Euromillions lottery (2016–2024), and (4) the French lotto (2018–2025).[2] These four datasets relate to two different lottery designs. In the first two lotteries, the bonus numbers are drawn from the main set of numbers (players do not select a bonus number). In the latter two, the bonus number(s) is (are) drawn from an independent set and players also bet on bonus numbers. We show that, on average, players who bet on 7 earn significantly lower gains than those who do not. The difference is economically meaningful in most cases (between 10% and 20% in most cases). To illustrate the magnitude, the average payout for a third-rank prize in the Belgian lotto (five correct numbers out of six) is 1183 € when betting on 7, compared to 1610 € when not betting on 7, a reduction of 26.5%. Our results remain robust after controlling for the birth date effect, that is, the tendency of players to favor numbers below 30.

Superstitious beliefs and culturally grounded heuristics can distort economic decision-making, with measurable effects across a range of markets. In China and Hong Kong, for example, symbolic associations with numbers, such as 8 being considered lucky and 4 unlucky, have been shown to affect prices in license plate auctions (Woo et al., 2008; Ng et al., 2010), real estate transactions (Fortin et al., 2014), and financial markets (Hirshleifer et al., 2018; Bhattacharya et al., 2018).

Our study shows that the widespread belief in 7 as a "lucky" number leads to systematically lower returns in parimutuel lotteries. This highlights how irrational preferences can cause persistent and economically meaningful inefficiencies despite clear probabilities and payoffs.

2. General presentation of lotto games

In a typical lotto game, players select n numbers from a pool of $N \gg n$ numbers. In some games, players also notch one or two bonus numbers, selected in an independent set of numbers. After the official

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[2] The datasets are available for download at https://www.loterie-nationale.be and https://www.fdj.fr.

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Table 1
Gain ranks and winning probabilities.

Winning ranks	# of correct numbers	# of correct bonus numbers	# of possible combinations	Probability
Panel A: Belgian lotto (2011–2025)				
1	6	0	1	1.22×10^{-7}
2	5	1	6	7.37×10^{-7}
3	5	0	228	2.80×10^{-5}
4	4	1	570	7.00×10^{-5}
5	4	0	10,545	1.29×10^{-3}
6	3	1	14,060	1.73×10^{-3}
7	3	0	168,720	2.07×10^{-2}
8	2	1	126,540	1.55×10^{-2}
9	1	1	442,890	5.44×10^{-2}
Panel B: French lotto (2002–2008)				
1	6	0	1	7.15×10^{-8}
2	5	1	6	4.29×10^{-7}
3	5	0	228	1.80×10^{-5}
4	4	1	570	4.50×10^{-5}
5	4	0	10,545	9.23×10^{-4}
6	3	1	14,060	1.23×10^{-3}
7	3	0	168,720	1.64×10^{-2}
Panel C: Euromillions lottery (2016–2024)				
1	5	2	1	7.15×10^{-9}
2	5	1	20	1.43×10^{-7}
3	5	0	45	3.22×10^{-7}
4	4	2	225	1.61×10^{-6}
5	4	1	4500	3.22×10^{-5}
6	3	2	9900	7.08×10^{-5}
7	4	0	10,125	7.24×10^{-5}
8	2	2	141,900	1.01×10^{-3}
9	3	1	198,000	1.42×10^{-3}
10	3	0	445,500	3.00×10^{-3}
11	1	2	744,750	5.33×10^{-3}
12	2	1	2,838,000	2.03×10^{-2}
13	2	0	6,385,500	4.57×10^{-2}
Panel D: French lotto (2019–2025)				
1	5	1	1	5.24×10^{-8}
2	5	0	9	4.72×10^{-7}
3	4	1	220	1.15×10^{-5}
4	4	0	1980	1.04×10^{-5}
5	3	1	9460	4.96×10^{-4}
6	3	0	85,140	4.46×10^{-3}
7	2	1	132,440	6.95×10^{-3}
8	2	0	1,191,960	6.25×10^{-2}
9	0 or 1	1	1,764,763	9.25×10^{-2}

This table reports the requirements of winning ranks and their associated probabilities for the four games. Columns two and three indicate the number of correct numbers/bonus numbers of the rank numbered in the first column. Columns four and five give the number of winning combinations and the corresponding winning probabilities.

draw that consists in n numbers for the main draw and $b = 1$ or 2 bonus numbers, prizes are awarded based on the number of matches. Table 1 summarizes the structure of winning ranks and associated probabilities for the different games analyzed in this paper: the Belgian and French lotto games, and the Euromillions lottery.

The Belgian lotto is a (45,6) game: players choose six numbers from a set of 45. The earlier version of the French lotto (2002–2008) follows a (49,6) format. In both cases, the draw consists of n main numbers and one bonus number selected from the remaining $N-n$ numbers (referred to hereafter as Design 1).

In contrast, the Euromillions lottery and the recent French lotto (2019–2025) adopt another design (Design 2 hereafter), where bonus numbers are drawn from an independent pool of size K. These games are characterized by the quadruple (N, n, K, b). The Euromillions follows a $(50, 5, 12, 2)$ structure, while the recent French lotto is a $(49, 5, 10, 1)$ game. In Design 1, the jackpot requires matching all n main numbers, that is, the bonus number does not affect the top prize. In Design 2, players select n main numbers and b bonus numbers, and the jackpot is won only if all $n + b$ numbers match.

Lotto games follow the parimutuel principle: a fixed proportion of the total amount wagered (typically around 50%) is withheld as a takeout. The remaining pool, denoted M, is allocated to winners according to predefined rules across a set of prize ranks (see Table 1). For example, in the Belgian lotto, matching four numbers from the main draw without the bonus number corresponds to rank 5. Since the total amount M is redistributed proportionally to sales, a higher number of winners at a given rank reduces individual prizes. Thus, maximizing returns requires selecting unpopular numbers. Under rational play, the number selection method should not affect expected returns. We show, however, that this is not the case: players incur a significant cost by choosing numbers based on superstitions and/or preferences.

Some game-specific rules affect how prizes are distributed. In the case of the French lotto, two such rules are important for interpreting the results presented in the next section.

(a) Between 2002 and 2008, ranks 4 and 5 (and similarly, ranks 6 and 7) shared a common prize pool, with a winner at the higher rank receiving twice the payout of a winner at the lower rank.[3] We refer to this as the *doubling rule*.
(b) From 2019 to 2025, if no winner is recorded at rank j ($j = 2, \ldots, 7$), the corresponding prize amount is transferred to rank $j + 1$.[4] We refer to this as the *transfer rule*.

3. Data and descriptive statistics

Our data selection focuses on draws conducted under stable rules during the analyzed periods. For instance, the French lotto datasets (2002–2008 and 2019–2025) span periods without rule (or currency) changes. The Belgian lotto dataset includes 1409 draws from October 1, 2011, to March 31, 2025.[5] Finally, the Euromillions sample starts on September 29, 2016, reflecting the change in the bonus number pool size from 11 to 12.

Table 2 summarizes the characteristics of our datasets (Panel A) which cover 4532 draws (1409 for the Belgian lotto, 853 + 1408 draws for the French lotto and 862 for the Euromillions lottery). For each draw, we collected: (1) the date of the draw; (2) the drawn numbers, including the bonus number(s); (3) the number of winners at each rank; (4) the individual prizes at each rank. Panel B of Table 2 provides information about the average number of winners per rank. Because ranks one and two (and rank three for Euromillions) have very few winners, resulting in limited observations, our statistical analysis focuses primarily on the remaining ranks.

4. Results

4.1. Univariate analysis

For each relevant rank of gain, we test whether the difference in gains is zero between draws with/without the number 7.

The results are reported in Table 3. Games from Design 1 (Design 2) are presented in Panels A and B (C and D). Columns 2 and 3 (6 and 7) report average gains conditional on whether the number 7 appears in the main draw (as a bonus number). Columns 4 and 5 (8 and 9) show the corresponding differences, both in absolute and relative terms, in average gains. For instance, in Panel A (Belgian lotto), the average gain at rank 4 is 280.7 € when 7 does not appear in the main draw, compared to 238.7 € otherwise, a statistically significant difference

[3] See Article 11 of the official rules: https://www.legifrance.gouv.fr/jorf/id/JORFTEXT000000735598.
[4] See Article 8.1.1.5: https://media.fdj.fr/generated/media/JEUX/reglement_loto.pdf.
[5] An eighth prize rank was introduced in October 2011, and a ninth rank was added on May 26, 2018, coinciding with a ticket price increase from one euro to 1.25 euros.

Table 2
Lottery design and descriptive statistics.

	Design 1		Design 2	
	Belgian lotto (2011–2025)	French lotto (2002–2008)	Euromillions lottery (2016–2024)	French lotto (2019–2025)
	Panel A: Characteristics of the four lotteries			
Number of draws	1409	1408	862	853
Period start	01/10/2011	01/09/2002	09/27/2016	06/11/2019
Period end	03/29/2025	12/04/2008	12/31/2024	04/06/2025
N (main draw)	45	49	50	49
K (bonus)	–	–	12	10
# numbers to select	6+0	6+0	5+2	5+1
# numbers drawn (n+b)	6+1	6+1	5+2	5+1
Tickets sold	3633,660.8	–	48,956,329.7	–
	Panel B: Average number of winners			
Rank 1	0.5	1.6	0.2	0.2
Rank 2	2.6	9.5	3.5	2.0
Rank 3	102.5	396.8	8.3	49.8
Rank 4	252.3	1002.9	41.4	444.9
Rank 5	4683.1	20,554.6	827.0	2100.7
Rank 6	6254.3	27,405.4	1823.1	18,996.2
Rank 7	75,070.1	365,454.2	1864.2	29,361.5
Rank 8	56,426.3	–	26,190.0	264,932.4
Rank 9	176,509.3	–	36,256.1	390,424.9
Rank 10	–	–	81,577.5	–
Rank 11	–	–	137,418.6	–
Rank 12	–	–	518,195.4	–
Rank 13	–	–	1164,816.0	–

The average number of winners at rank 9 for the Belgian lotto is calculated over 715 draws because the 9th rank of gain appeared on May 26th 2018, associated with a price ticket increase from 1 € to 1.25 €. The aggregate number of Euromillions winners comes from www.fdj.fr and Euromillions sales come from https://lottery.merseyworld.com/Euro/Sales_index.html.

Table 3
Lottery gains with and without the number 7.

	Main draw				Bonus number			
	Without 7 (Gain in €)	With 7 (Gain in €)	Difference (in €)	Difference (in %)	Without 7 (Gain in €)	With 7 (Gain in €)	Difference (in €)	Difference (in %)
	Panel A: Belgian lotto (2011–2025)							
Number of draws	1231	178			1371	38		
Rank 3 (5+0)	1610.1	1183.0	−427.1***	−26.5%				
Rank 4 (4+1)	280.7	238.7	−42.0***	−15.0%	277.3	205.4	−72.0***	−26.0%
Rank 5 (4+0)	27.0	22.1	−4.8***	−19.0%				
Rank 6 (3+1)	10.6	9.4	−1.2***	−11.1%	10.5	7.8	−2.7***	−25.5%
	Panel B: French lotto (2002–2008)							
Number of draws	1246	162			1372	36		
Rank 3 (5+0)	1021.9	753.7	−268.2***	−26.3%				
Rank 4 (4+1)	44.5	34.4	−10.1***	−22.8%	43.4	42.3	−1.1	−2.6%
Rank 5 (4+0)	22.2	17.2	−5.1***	−22.8%				
Rank 6 (3+1)	5.2	4	−1.2***	−23.1%	5.1	4.8	−0.3	−5.1%
Rank 7 (3+0)	2.6	2	−0.6***	−23.1%				
	Panel C: Euromillions (2016–2025)							
Number of draws	771	91			723	139		
Rank 4 (4+2)	2389.7	2028.0	361.7*	−15.1%	2442.7	1877.1	−565.7***	−23.2%
Rank 5 (4+1)	146.6	125.9	−20.7***	−14.1%	146.4	133.8	−12.7***	−8.6%
Rank 6 (3+2)	81.9	71.8	−10.0***	−12.3%	83.4	67.0	−16.5***	−19.7%
Rank 7 (4+0)	49.5	43.1	−6.5***	−13.0%				
Rank 8 (2+2)	16.9	15.4	−1.5***	−8.9%	17.2	14.0	−3.3***	−18.9%
Rank 9 (3+1)	12.9	11.5	−1.4***	−11.1%	12.9	11.8	−1.1***	−8.8%
Rank 10 (3+0)	10.7	9.6	−1.1***	−9.9%				
Rank 11 (1+2)	8.5	8.0	−0.5	−5.4%	8.7	7.0	−1.7***	−19.7%
Rank 12 (2+1)	6.7	6.1	−0.5***	−7.8%	6.7	6.0	−0.7***	−10.0%
Rank 13 (2+0)	4.2	3.9	−0.3***	−6.0%				

(*continued on next page*)

Table 3 (*continued*).

	Panel D: French lotto (2019–2025)							
Number of draws	755	98			762	91		
Rank 3 (4+1)	2523.9	2072.3	−451.6	−17.9%	2567.0	1676.9	−890.2***	−34.7%
Rank 4 (4+0)	457.3	363.5	−93.8***	−20.5%				
Rank 5 (3+1)	55.3	48.2	−7.1***	−12.9%	56.9	34.2	−22.7***	−39.8%
Rank 6 (3+0)	21.3	17.5	−3.8***	−17.9%				
Rank 7 (2+1)	10.6	9.9	−0.7***	−6.8%	11	6.4	−4.6***	−41.8%
Rank 8 (2+0)	4.5	4.0	−0.5***	−11.6%				

This table compares average lottery gains when the number 7 is included versus not included on a ticket, separately for the main draw and the bonus number. Each panel corresponds to a dataset covering a specific country and time period. For each prize rank (e.g., 4+1 means four correct main numbers plus one correct bonus), we report the average gain in euros when 7 is absent and when it is present, along with the difference between the two, both in absolute terms and in relative terms. Significance levels refer to two-sample *t*-tests of equality in means. The number of draws in which 7 was present or absent is also reported for reference. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

Table 4
Multivariate analysis.

	Dummy 7 in the main draw	Dummy Bonus 7	#numbers ≤30	Bonus ≤30	R^2
Panel A: Belgian lotto (2011–2025)					
Rank 3 (5+0)	−336.71***	33.95	−265.80***	29.68	0.17
Rank 4 (4+1)	−35.58***	−59.41***	−31.99***	−48.19***	0.32
Rank 5 (4+0)	−3.83***	0.71	−3.01***	0.07	0.41
Rank 6 (3+1)	−1.04***	−2.16***	−0.86***	−1.88***	0.44
Panel B: French lotto (2002–2008)					
Rank 3 (5+0)	−216.76***	19.20	−136.04***	−13.50	0.32
Rank 4 (4+1)	−8.17***	0.08	−5.22***	−0.90**	0.48
Rank 5 (4+0)	−4.08***	0.04	−2.61***	−0.45**	0.48
Rank 6 (3+1)	−1.02***	−0.19	−0.52***	−0.04	0.14
Rank 7 (3+0)	−0.51***	−0.10	−0.26***	−0.02	0.14
Panel C: Euromillions (2016–2025)					
Rank 4 (4+2)	−269.73*	−573.71***	−368.42***		0.06
Rank 5 (4+1)	−16.44***	−13.08***	−21.41***		0.35
Rank 6 (3+2)	−7.71**	−16.59***	−8.58***		0.12
Rank 7 (4+0)	−5.31***	0.09	−6.87***		0.28
Rank 8 (2+2)	−1.13**	−3.27***	−1.18***		0.14
Rank 9 (3+1)	−1.13***	−1.16***	−1.40***		0.36
Rank 10 (3+0)	−0.88***	0.21	−1.13***		0.34
Rank 11 (1+2)	−0.33	−1.72***	−0.25***		0.07
Rank 12 (2+1)	−0.40***	−0.68***	−0.45***		0.14
Rank 13 (2+0)	−0.21***	0.13***	−0.27***		0.49
Panel D: French lotto (2019–2025)					
Rank 3 (4+1)	−118.98	−1011.63***	−863.13***		0.11
Rank 4 (4+0)	−54.72***	−62.00***	−94.89***		0.56
Rank 5 (3+1)	−4.27***	−24.10***	−9.14***		0.55
Rank 6 (3+0)	−2.34***	−2.65***	−3.59***		0.73
Rank 7 (2+1)	−0.53**	−4.79***	−1.16***		0.50
Rank 8 (2+0)	−0.33***	−0.54***	−0.49***		0.79

This table reports the results from regressions estimating the impact of selecting the number 7 on lottery gains, across various game formats and time periods. Each row corresponds to a prize rank, with rank definitions given in parentheses (e.g., 5+0 denotes five correct main numbers and zero bonus numbers). The dependent variable is the individual prize at that rank. *Dummy* 7_t (respectively, *Bonus* 7_t) is a dummy variable equal to 1 when 7 appears in the main draw (respectively, as a bonus number). *#Numbers* $\leq 30_t$ counts how many main draw numbers are less than or equal to 30, and *Bonus* $\leq 30_t$ is a dummy equal to 1 if the bonus number is below 30. The R^2 of each regression is reported in the final column. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

of 42 € (−15%) at the 1% level. Similarly, when 7 is not the bonus number, the average gain at rank 4 is 277.3 €, versus 205.4 € when it is, a significant difference of 72 € (−26%) at the 1% level.

Almost all differences reported in Panels A, B, C, and D are highly significant, which indicates that 7 is a costly bet. Notable exceptions are (1) ranks 4 and 6 of Panel B (bonus number), (2) rank 11 of Panel C, and (3) rank 3 of Panel D.

For ranks 4 and 6 of Panel B, differences are significant for the main draw test but not for the bonus number test. This result is a direct consequence of the doubling rule described in Section 2. The role of the bonus number becomes negligible in this case because the expected number of winners is 10 to 20 times lower at rank 4 (respectively, 6), compared to the number of winners at rank 5 (7).[6]

For rank 11 of Panel C, the difference is significant for the bonus but not for the main draw. This can easily be explained by the fact that rank 11 corresponds to one correct number in the main draw and

[6] The last column of Table 1 indicates a 4.50×10^{-5} winning probability at rank 4 versus 9.23×10^{-4} at rank 5. Probabilities are 1.23×10^{-3} versus 1.64×10^{-2} for ranks 6 and 7.

two correct bonus numbers. As a result, gains at this rank are primarily driven by the bonus draw.

Rank 3 in Panel D is notable. Despite a difference of −17.9% in average gains, the difference is not statistically significant. This result is explained by the transfer rule described in Section 2. In 197 out of 853 draws, there were no rank 2 winners, and the corresponding prize pool was transferred to rank 3 winners, inflating the average gain for those draws (6977.26 €) compared to the remaining 656 draws (1119.10 €). This transfer mechanism introduces substantial noise, obscuring any underlying difference. Restricting the analysis to the 656 unaffected draws yields a significant difference (unreported results, t-stat = 4.57, p-value = 0.0000).

4.2. Multivariate analysis

The results obtained in the previous subsection could be influenced by the fact that a lot of players bet on birthday dates. The result of such a popular heuristic is an increased popularity (and a decreased return) of numbers below 30 (D'Hondt et al., 2024; Roger et al., 2023; Wang et al., 2016). We thus need to disentangle the effect of the number 7 as a small number from its role as a "lucky" number. We perform the following regression for each relevant rank already analyzed in Section 4.1.

$$Prize_t = \alpha_0 + \alpha_1 \text{Dummy } 7_t + \alpha_2 \text{Bonus } 7_t + \alpha_3 \#\text{Numbers} \leq 30_t + \alpha_4 \text{Bonus} \leq 30_t + \epsilon_t, \quad (1)$$

where $Prize_t$ is the individual gain at draw t for the rank under consideration. *Dummy* 7_t (respectively, *Bonus* 7_t) is a dummy variable equal to 1 when 7 appears in the main draw (respectively, a bonus number), *#Numbers* $\leq 30_t$ counts how many main draw numbers are less than or equal to 30, and *Bonus* $\leq 30_t$ is a dummy equal to 1 if the bonus number is below 30. These two variables account for the birth date effect. *Bonus* $\leq 30_t$ is included only in Design 1 games, as bonus numbers are inherently small in Design 2 games (no greater than 12 in Euromillions and 10 in the 2018–2025 French lotto).

The regression results are presented in Table 4. Overall, the findings closely align with those from the univariate analysis in the previous subsection. Both *Dummy* 7_t and *Bonus* 7_t are highly significant in most specifications. Cases of insignificance can be attributed to structural features of the game, such as the doubling rule and the transfer rule, as discussed earlier. Also the coefficient on *Bonus* 7_t is insignificant for ranks 3, 5, and 7 in Panel A, which is consistent with the fact that these ranks do not involve a matched bonus number.

5. Conclusion

We quantify the cost of betting on the "lucky" number 7 using data from four lotto games over 4000 draws and 20 years. Players who choose 7 earn significantly lower payouts, even after controlling for the birth date effect. The results suggest that individuals are willing, perhaps unintentionally, to forgo monetary gains to satisfy superstitious beliefs, in contrast to the assumptions of rational choice theory.

Declaration of competing interest

The authors have no relevant financial or non-financial interests to disclose. No funding was received for conducting this study.

Data availability

The data are publicly available.

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