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Seeking Leviathan? A test of the revenue maximisation objective in the South African National Lottery

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A Leviathan is an inefficient government that maximises the public revenue it raises. This article seeks evidence of a Leviathan in the South African government in respect of the National Lottery. This search is motivated by the Lotteries Act of 1997 which legislates that the goal of the National Lottery is to maximise the public revenue raised from the sale of National Lottery tickets. The effective price model is used to estimate the demand curve for National Lottery tickets. Although the National Lottery is not yet maximising revenue, the actions of the National Lottery suggest seemingly Leviathan tendencies.

Op soek na Leviatan: 'n toets van die inkomste-maksimeringsdoelstelling in die Suid-Afrikaanse Nasionale Lotery

'n Leviatan is 'n ondoeltreffende regering wat die openbare fondse wat dit bring maksimaliseer. Hierdie artikel ondersoek bewyse van 'n Leviatan in die Suid-Afrikaanse regering met betrekking tot die Nasionale Lotery. Die soektog word gemotiveer deur die Wet op Loterye van 1997 wat bepaal dat die doel van die Nasionale Lotery is om die openbare inkomste wat uit die verkoop van die Nasionale Lotery-kaartjies ingevorder word te verhoog. Die effektiewe prysmodel word gebruik om sodoende die vraagkurwe vir Nasionale Lotery-kaartjies te bepaal. Alhoewel die Nasionale Lotery nog nie die inkomste optimaal verhoog nie, toon die optrede van die Nasionale Lotery waarskynlik Leviatan-neigings.

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The first South African National Lottery draw took place on 11 March 2000.¹ Besides other lotteries in South Africa, the National Lottery is governed by the Lotteries Act of 1997, which provides for the establishment of a National Lotteries Board to allocate licences for lotteries and to regulate these lotteries in South Africa (Lotteries Act 1997).² Consequently, the National Lotteries Board is the statutory body that is responsible for the regulation of all lotteries conducted in South Africa.

The National Lotteries Board operates independently, although it reports to the South African parliament annually. The National Lotteries Board is thus a unit of the South African government. In addition, the stated goal of the National Lotteries Board is to ensure that, "... the net proceeds of the National Lottery are as large as possible" (Lotteries Act 1997: 14).³ The National Lotteries Board is unique in that it is a public fundraising unit of government with the explicit goal to ensure that its net proceeds are maximised. In other words, the National Lotteries Board is mandated to maximise the portion of public revenue that is raised from the sale of National Lottery tickets.⁴

1 I am grateful to Giampaolo Garzarelli, Aldo A Siteo, Eugene Stolk, Erna van Aswegen and, in particular, the two anonymous referees, for their valuable comments and feedback. I also thank Natasha Suhecki for research assistance. Earlier work on this topic was presented at the Biennial Conference of the Economic Society of South Africa in 2007. Any remaining errors are my responsibility.

2 In addition, the Lotteries Act provides for the disbursement of revenue obtained from the lotteries. The revenue raised from the National Lottery is legislated to be channelled into causes that received direct government funding before the National Lottery was legislated. These causes include "charities", "sports and recreation" and "arts, culture and national heritage". Additional provision is made for the revenue to go to the Reconstruction and Development Plan (RDP), which has since been abandoned. There is also a miscellaneous or discretionary category (Lotteries Act 1997: 26-31).

3 In the Lotteries Act (1997: 5), "net proceeds of the National Lottery" is defined as "... the sums that are payable to the [National Lottery Distribution Trust Fund] or the [National Lotteries Board ...] but not the sums which are paid out for prizes of the National Lottery".

4 The goal of revenue maximisation is common to government-run lotteries worldwide (*cf* Clotfelter & Cook 1990, Walker 1998, Garrett 2001).

In public choice theory, a government that maximises revenue is termed a Leviathan.⁵ While the traditional view of public finance considers the government to be a benevolent public good provider, the theory of Leviathan shows that the government is a revenue maximiser for its own sake (Brennan & Buchanan 1977, 1978 & 1980).

The term “Leviathan” has taken on several meanings. The earliest use of Leviathan is in the Bible where a Leviathan is a monstrous sea creature that symbolises evil (Bible (NKJV) 1982: Job 41). Later Thomas Hobbes (2009, originally published 1651) uses Leviathan to describe an autonomous state. However, as the term “Leviathan” is currently used in the public choice literature (*cf* Brennan & Buchanan 1977, 1978 & 1980, Mueller 2003), the term has negative connotations in that a Leviathan is a government that has grown so large that it has become inefficient.

A Leviathan government is inefficient because it raises public funds to maximise revenue instead of raising funds merely to cover the costs of providing public goods and services (Buchanan 2000). According to Brennan & Buchanan (1977: 258), a Leviathan occurs when the

... citizenry has no effective or operational control over government, once established, beyond the constraints that are imposed at the constitutional level; in-period or post-constitutional fiscal decisions are made entirely by the budget-maximizing or revenue-maximizing politician-bureaucrat.

In the presence of Leviathan, the only constraint on the government in the long term lies in the constitutional rules which limit the government’s power to raise revenue, whether it is through tax, by issuing debt, or through printing money (also known as seigniorage) or a combination thereof (Brennan & Buchanan 1977, 1978 & 1980, Mueller 2003).⁶

- 5 The public choice definition of “Leviathan” presumes that a government maximises public revenue from any sources made available to it by the constitution. If no constraints are put in place, then the revenue becomes similar to private income to government decision-makers. Essentially, maximising revenue is equivalent to maximising the portion of public revenue over and above what is needed to provide public goods and services (Brennan & Buchanan 1980: 26-7).
- 6 Taxation, public debt and seigniorage are the three traditional methods of public fundraising. Taxes (or rent extraction) are compulsory transfers from citizens to

Many studies have been conducted to test for evidence of Leviathan.⁷ The Leviathan hypothesis has been explored in the context of taxation (Brennan & Buchanan 1977 & 1978, Nelson 1986, Marlow & Orzechowski 1988), public debt (Vanberg & Buchanan 1986) and seigniorage (Brennan & Buchanan 1981).⁸ More recently, a link has been made between the lottery and Leviathan.⁹ Garrett (2001) uses data from state lotteries in the USA to find evidence of Leviathan. He finds that 95% of these lotteries are structured to maximise revenue and are thus evidence of a “Leviathan Lottery”. The present article seeks evidence of Leviathan in the South African National Lottery. The primary reason to test for Leviathan is the stated goal of revenue maximisation. However, there are three additional reasons to test for Leviathan: the definition of a lottery in the Lotteries Act; a court case brought against a South African bank, namely First National Bank (FNB), and the lack of constraints on the revenue-raising capacity of the National Lottery.

The definition of a lottery in the Lotteries Act gives some indication of the monopoly power of the National Lotteries Board. A lottery is generally defined as a pari-mutuel game in which the prizes come directly from ticket sales (*cf* Walker 1998: 361). In the Lotteries Act, however, a “lottery” is defined more broadly as

... any game, scheme, arrangement, system, plan, promotional competition or device for distributing prizes by lot or chance and any game, scheme, arrangement, system, plan, competition or

the government. Public debt (or bonds) are those bonds which the government sells to individuals and corporations. Seigniorage (or printing money) is rarely used as it creates inflation. A government may deliberately set the tax rate to maximise tax revenue (Laffer 2004). A difference between maximising tax revenue and maximising lottery revenue is that the government does not explicitly state the goal of revenue maximisation as far as taxation is concerned.

- 7 *Cf* Shadbegian (1999) for a review of the empirical studies on the Leviathan.
- 8 *Cf* Oates (1985), Forbes & Zampelli (1989) and Zax (1989) for other studies that seek evidence of Leviathan.
- 9 The different methods of raising public revenue have different characteristics. As mentioned earlier, taxation is a coerced transfer of revenue from entities to the government. Public debt, on the other hand, is not coerced. Instead, individuals or corporations can choose whether or not to purchase bonds. Hence, public debt is characterised by self-selection. The lottery shares this characteristic: individuals can choose whether or not to purchase lottery tickets.

device, which the Minister may by notice in the Gazette declare to be a lottery (Lotteries Act 1997: 4).

Accordingly, the Lotteries Act uses a broader definition of “lottery” in that a lottery can include any other “game, scheme, arrangement, system, plan, competition or device” that would typically not be considered a lottery under the usual definition. Thus, the Lotteries Act can allow for monopoly power by portraying any “game, scheme, arrangement, system, plan, competition or device” as a lottery, thus rendering this “game, scheme, arrangement, system, plan, competition or device” illegal in terms of the Lotteries Act.

An example of the National Lottery exerting this monopoly power is a South African court case from 28 March 2008 when the South African Supreme Court of Appeal compelled a local bank (FNB) to cease conducting the “Million-a-Month Account” competition. In this competition, for every R100 that an FNB customer placed in a 32-day-notice fixed savings account, that customer would have a corresponding entry in a monthly draw to be eligible to win R1 000 000. The Supreme Court’s decision upheld a December 2006 ruling by the High Court that declared the competition an unlawful competition. By the Lotteries Act definition of a lottery, the “Million-a-Month Account” competition could be legally classified as a lottery, and thus deemed unlawful (First National Bank Competition 2008, National Lotteries Board 2010).¹⁰

Robert Keip, FNB’s Chief Executive Officer for Savings and Investment Products, commented after the court ruling:

The point that we [FNB] argued that there was no subscription in terms of the Lotteries Act, because nobody paid anything to take part in the lottery. The full capital that you (the account holder) put into the account came back to you, and therefore it was always your money. The route that the court took, they interpreted the word ‘payment’ which was in the Act, and they said the mere fact of putting money into the account constituted payment, and as a consequence, we fell into the Lotteries Act, and therefore it was an illegal lottery. The reason for that is that the National Lotteries Act really creates a statutory monopoly – that only the National Lotteries

10 First National Bank Competition illegal under Lotteries Act (31 March 2008) *Gambling SA*. <<http://www.gamblingsa.com/stories/gsa-first-national-bank-competition-illegal-under-lotteries-act.html>>

Board can run a lottery in this country (*First Rand Bank v National Lotteries Board* 2008, First National Bank Competition 2008).¹¹

In addition, there are no limits on the total revenue raised from National Lottery ticket sales. The Lotteries Act allows for much of the conditions of the National Lottery, including any constraints, to be determined by the licence terms given by the National Lotteries Board to the lottery management company.¹² The constraints legislated include the proportion of funds from each ticket sold that should be allocated to the National Lottery prizes, to administrative and operating costs, and to the National Lotteries Board for public spending (Lotteries Act 1997: 18).¹³ However, there is no limit on how many tickets can be sold. Thus, there is no limit on how much revenue the National Lottery can generate from ticket sales. In addition, in order to increase its revenue, the lottery management company needs to either increase the number of National Lottery tickets sold or change the structure of the National Lottery to maximize revenue.

It appears that there is sufficient motivation to test for evidence of Leviathan in the South African National Lottery. The explicit objective of the National Lottery is to maximise revenue, which means that the objective of the National Lottery is to be a Leviathan. In addition, the Lotteries Act definition of the lottery and the court case against FNB provide an indication of the presence of statutory monopoly. Finally, the Lotteries Act fails to provide limits on the revenue-raising ability of the National Lottery. The purpose of this article is to test for evidence of Leviathan in the South African National Lottery.

The next section gives an overview of the related literature prior to discussing the particulars of the South African National Lottery. This is followed by the methodology, the results of the empirical investigation, the conclusion and suggestions for future research.

11 *First Rand Bank v. National Lotteries Board* 2008. Case No 385/07 <<http://www.saflii.org/za/cases/ZASCA/2008/29.pdf>>

12 Lotteries Act of 1997 <<http://www.nlb.org.za/pdf/Lotteries%20Act%2057.pdf>>

13 By way of a comparison, in 2010 the South African public revenue raised from taxes totalled R625.5 billion while the public revenue raised from the South African National Lottery totalled R1.2 billion (National Lotteries Board 2010, South African Reserve Bank 2010).

1. Related literature

National Lottery tickets are sold to those citizens willing to purchase them in order to stand a chance of winning a prize. There is an old adage: “The lottery is a tax on people who are bad at math”. As mentioned earlier, the National Lottery is pari-mutuel which means that prizes come directly from ticket sales. There is thus never a risk of the prizes exceeding sales revenue. For the government, the National Lottery is a risk-free method of raising public funds. As such, the risk of playing the National Lottery is held entirely by the lottery players. The National Lottery players face risk as the level of prizes is dependent on the overall sales and the number of players who have chosen the same combinations of numbers (Walker 1998: 361).

A lottery is not a new method of public fundraising. Most modern lotteries, such as the South African National Lottery, have their origins in the Genoese lottery of the seventeenth century.¹⁴ From a historical point of view, the revenue generated from lotteries has been used for different purposes, whether for general public revenue purposes or earmarked for specific purposes. Examples of specific purposes include cultural activities, education, health, debt repayment (as was the case for Montreal’s Expo and the Montreal Olympics), worker compensation (Illinois), transport infrastructure (Arizona) and terrorist victim compensation (Spain) (Walker 1998: 362-3). Lottery funds even financed the American Revolutionary War (Rodgers & Stuart 1995).

The economics literature on lotteries provides several reasons as to why a government (whether at the national or state level) will adopt a lottery.¹⁵ Essentially, these reasons fall into three categories. First, there is rent-seeking on the part of lottery providers. Secondly, a government requires either greater public revenue or lower taxes or both.¹⁶ Thirdly, a lottery is a popular form of recreation.

14 Cf Bellhouse (1991) and Stigler (2003) for a history of lotteries.

15 Cf Hersch & McDougall (1988), Davis *et al* (1992), Alm *et al* (1993), Walker (1998), Glickman & Painter (2004).

16 In considering the decision of whether or not to implement a lottery, Glickman & Painter (2004) are unable to establish whether the decision is made by a median voter or by a Leviathan government.

A lottery has been nicknamed a “painless tax” because participation is voluntary and the game is a form of recreation (*cf* Clotfelter & Cook 1987, Alm *et al* 1993). Whether lottery participation is truly as non-coercive as it appears has been the subject of many studies.¹⁷ Buying a lottery ticket may be voluntary, but state and national lotteries are designed and advertised in such a way as to encourage participation. Conceivably, encouraging participation in this manner can be a consequence of both the revenue maximization goal of lotteries and the lack of constraints on the revenue-raising power of lotteries. Walker (1998) finds that lottery marketing campaigns target the poor and do not always reflect the true odds of winning the jackpot. Walker (1998: 364) and Clotfelter & Cook (1990: 101) also argue that the marketing of the lottery leads to misperception of the odds, which means that players are not aware of the true chances of winning the jackpot prize. Clotfelter & Cook (1990: 102) add that the effect of lottery advertising is to create an impression that winning is easy.

In addition, lottery games are designed to suit the local market (and thereby maximise revenue) by taking into consideration both the market size and initial participation in the lottery. One example of a consideration for lottery design is the potential market size. A game which is suitable for the British population is likely to be too difficult for the Israeli market because the Israeli population is one tenth of the British population. As such, the Israeli lottery was redesigned to lower the odds of winning. Similarly, Ireland’s lottery has been redesigned twice to make it harder to win in order to induce more rollovers, and thus induce more interest in the lottery. Likewise, the state of California changed its lottery three times, each time reducing the odds of winning the game, partly because of its population of 34 million. The state of Florida also changed the lottery game once, to reduce the odds of winning the lottery (Walker & Young 2001: F702).

One method for determining whether a lottery is maximising revenue is by finding the elasticity of demand: a price elasticity of demand equal to -1 shows that the lottery is structured so that revenue is maximised. To find the elasticity of demand, the first step is to determine the effective price of a lottery ticket. This can be done

17 *Cf* Thaler & Ziemba (1988), Clotfelter & Cook (1990), Walker (1998), Nyman (2004), Kearney (2005).

by using the effective price model.¹⁸ Several studies have used this method, although the majority of these studies were done on either the British lottery or the USA state lotteries.¹⁹ One exception is Yu (2008) who finds that the price elasticity of demand for the Canadian Lottery is not equal to -1 ; in other words, the lottery is not structured to maximise revenue.

In considering the British lottery, Walker (1998), Forrest *et al* (2000) and Forrest *et al* (2002) find that the revenue from the lottery is maximised. However, Farrell *et al* (1999) use a slightly modified method to estimate price elasticity through changes in the expected value of holding a ticket, and find that the British lottery is not maximising revenue in the long term specifically.

In terms of the USA state lotteries, Cook & Clotfelter (1993) consider the “jackpot elasticity of demand” for Massachusetts. Gulley & Scott (1993) examine four USA state lotteries, namely Kentucky, Ohio and two Massachusetts state lotteries. In the state lotteries of Kentucky and Ohio, the games are structured to maximise revenue. But in the case of the two Massachusetts lotteries, net revenue is not maximised. Scoggins (1995) applies the model to the Florida Lotto and finds that revenue is not maximised either.

2. The South African National Lottery

The National Lottery Board has licensed two operators to date. The first licensed operator of the South African National Lottery was Uthingo Management Pty (Ltd) which operated the National Lottery draws from 11 March 2000 to 31 March 2007. In 2007, a second operator, Gidani Pty (Ltd), was licensed to replace Uthingo Management Pty (Ltd). There was a six-month break between the two operators. The first draw under Gidani Pty (Ltd) took place on 13 October 2007.

18 Garrett (2001)’s method is designed to find evidence of Leviathan in the many state lotteries in the USA. The author of this article seeks a single lottery, namely that of the South African National Lottery, hence the need for a different methodology.

19 Cf Walker (1998), Farrell *et al* (1999), Forrest *et al* (2000) and Forrest *et al* (2002) for studies on British lotteries. Cf Cook & Clotfelter (1993), Scoggins (1995), Alm *et al* (1993) and Garrett (2001) for studies on USA state lotteries.

National Lottery draws are held twice a week. Initially the draws only took place on a Saturday, but a second draw, on a Wednesday, was introduced on 3 October 2001. When the National Lottery first started, the nominal price of a ticket was R2.50. The nominal price increased to R3.50 on 26 March 2009.²⁰ The National Lottery is designed in such a way that for each ticket purchased, the player must choose six numbers from one to forty-nine. The player can either choose the numbers him-/herself or s/he can take a computer-generated random “quick-pick”.

The odds of one ticket matching the winning numbers drawn are 1 in 13,989,816.²¹ The jackpot is the principal prize pay-out which is much greater than any of the lower prize divisions. The jackpot is won if all six ticket numbers are matched to the six numbers drawn. In lower prize divisions, smaller prizes are allocated to tickets in which fewer than 6 but more than 2 numbers are matched to the numbers drawn. The odds of winning in the lower prize divisions are given in Appendix 1. When the jackpot is not won, in other words, when no ticket matches all six numbers drawn, a rollover occurs. In this case, the prize money allocated to the jackpot is added to the next National Lottery draw’s jackpot (National Lottery 2006).

The National Lottery prizes (and public revenue) are determined by the take-out rate. The take-out rate is that proportion of sales which is not returned to the players in the prizes. The take-out rate of the South African National Lottery is 50%. Thus, 50% of National Lottery ticket sales is allocated to the prizes and the remaining 50% is “taken out” to be allocated elsewhere. Of the 50% of proceeds “taken out”, 30% is allocated to public revenue, 15% to the lottery management company, and 5% to the ticket retailers (National Lottery 2006).

In South Africa, National Lottery tickets are subject to 14% Value Added Tax (VAT). Thus, the funds allocated to prizes, to public revenue, to the lottery management company and to the ticket retailers are determined by the total ticket sales less VAT. One possible reason

20 Similarly, Canada raised the lottery ticket price which increased revenue, but fewer tickets were sold (Turner & Ferentzy 2010: 28).

21
$$\text{Odds of winning lottery} = \left(\frac{(\text{possible number choices})!}{(\text{possible number choices} - \text{numbers chosen})!(\text{numbers chosen})!} \right)^{-1}$$

$$= \left(\frac{49!}{43!6!} \right)^{-1} = \frac{1}{13,989,816}$$

for VAT levied on National Lottery ticket sales is to offset the loss in revenue from other consumption tax sources due to purchases of National Lottery tickets (Fink *et al* 2004).

Subsequent to the National Lottery, lottery management companies have instituted additional lottery games in keeping with their mandate, as legislated in the Lotteries Act. LottoPlus is one such addition. When purchasing a National Lottery ticket, the lottery player can pay R1 extra above the nominal price to include his/her ticket in a second draw. The first LottoPlus draw took place on 26 November 2003. Another addition is Powerball. The first Powerball draw took place on 23 October 2009. Like the National Lottery, Powerball has two draws a week, on a Tuesday and on a Friday. A Powerball ticket has the same nominal price (R3.50) as the National Lottery ticket, but the odds of winning the Powerball jackpot are lower compared to the odds of winning the National Lottery jackpot: 1 in 24 435 180 compared to 1 in 13 989 816.

3. Methodology

3.1 The effective price model

As indicated earlier, the portion of public revenue raised from the National Lottery is a percentage of the total revenue raised from the National Lottery. Thus, in order for this portion of public revenue to be maximised, the total revenue from the National Lottery needs to be maximised.²² To determine whether the total revenue (and thus the public revenue) is being maximised, the elasticity of demand for National Lottery tickets must be considered. In order to find the elasticity of demand for the National Lottery, the demand curve for National Lottery tickets based on the effective price of a lottery ticket

22 It is unlikely that the public revenue raised from the sale of lottery tickets is in competition with tax revenue. Typically, lottery tickets are purchased with net income (after income tax has been levied). In addition, as indicated earlier, the consumption tax, VAT, is levied on the sale of lottery tickets. This means that buying a lottery ticket instead of buying another consumption good will not reduce tax revenue collected from VAT.

must be established. Thereafter, a straightforward calculation can determine the elasticity of demand.²³

The effective price model is one way to estimate the effective price of the National Lottery.²⁴ The effective price is the nominal ticket price (initially R2.50 which has since been increased to R3.50) less the expected value of the ticket. Intuitively, the expected value of the ticket is the probability of winning multiplied by the jackpot multiplied by the expected share of jackpot if won: (*probability of winning*) \times (*value of the jackpot*) \times (*expected share of a jackpot if won*) (Cook & Clotfelter 1993). Thus, the effective price (P_E) of a National Lottery ticket is:²⁵

$$P_E = P_N - \left(\frac{1}{N}\right) (R + jQ) (1 - e^{-Np}) + \sum EVs \quad 1$$

where P_E is the effective price of the ticket which is calculated by taking the nominal price of a National Lottery ticket (P_N) and subtracting the expected value of the ticket. The expected value of the ticket is equal to the sum of the expected value of the jackpot,

$\left(\frac{1}{N}\right) (R + jQ) (1 - e^{-Np})$, where N is the number of tickets sold, Q is the value in Rands of tickets sold in the draw, R is any amount added to the prize fund from a rollover or an *ad hoc* payment by the lottery management company,²⁶ j is the proportion of the revenue from a draw that is allocated to the jackpot fund (taking into account both the take-out rate and VAT levied on ticket sales), p is the probability of any ticket winning the jackpot and the sum of the expected value of the smaller prizes, $\sum EVs$, which is calculated in the same way as the expected value of the jackpot (Forrest *et al* 2000).

It should be noted that the demand curve in the effective price model depends on the expected value of a draw which, in turn, depends on actual sales values for a draw. In practice, the lottery management

23 As this is a first glance at the National Lottery, my focus is limited to the National Lottery game only (controlling for the introduction of other games). The difference between the National Lottery and the other games run by the lottery management company makes it necessary to consider the data from each game separately (Garrett & Sobel 2004).

24 Cf Forrest *et al* (2000); Gulley & Scott (1993), Scoggins (1995).

25 Nominal prices are used, and sales figures do not take inflation into account. If inflation were to be included, it would feature in both the numerator and denominator, and thus cancel out.

26 If there is no rollover or *ad hoc* payment by the lottery company, then $R = 0$.

company makes a prediction of the size of the jackpot available to prospective lottery players.²⁷

Data from the National Lottery are used to establish whether the revenue collected from the South African National Lottery is being maximised and, thus, whether the National Lottery provides evidence for a Leviathan.²⁸ The data sample for the National Lottery contains data on lottery draws from the first lottery draw on 1 March 2000 to the draw on 29 December 2010. The data includes the draw number, the date of the draw, the numbers drawn, the prizes in each division, rollovers (if no prize is won), any guaranteed jackpots, and total sales of lottery tickets. The data sample for this period consists of 990 lottery draws. The sample includes the period during which there was a break due to the change in the lottery management companies. In addition, the sample period covers the addition of Wednesday draws and the introduction of new lottery games such as Powerball.

Table 1: Descriptive statistics of the lottery data

	Effective price (Rands)	Total sales (Rands)	Number of tickets sold	Rollover (Rands)
Minimum	0.30	11 604 673.00	3 315 621	0
Maximum	2.23	107 470 590.00	42 988 236	35 481 060.00
Mean	1.49	32 456 261.37	12 515 985	2 903 096.59
Standard deviation	0.31	14 019 803.65	5 967 345	5 036 947.49

Table 1 shows a few descriptive statistics. For this sample of lottery data, the effective price of the National Lottery ranges from a minimum effective price of R0.30 to a maximum effective price of R2.23. The mean effective price is R1.49 and its standard deviation is R0.31. The total sales of the National Lottery ranges from a minimum total sales of R11 604 673 (with 3 315 621 tickets sold) to a maximum total sales of R107 470 590 (with 42 988 236 tickets sold). The mean of total sales is R32 456 261 (12 515 985 tickets sold) and the standard

27 This analysis is consistent with rational expectations (*cf* Sargant 2008).

28 The National Lottery data is freely available from <<http://www.nationallottery.co.za>>

deviation is R14 019 804 (5 967 345 tickets sold). The largest rollover is R35 481 060, while the mean rollover is R2 903 096.

3.2 Specifications of equations

A two-stage least squares regression model is used since the effective price is not exogenous. The first stage estimates effective price based on the information that is publicly available, such as the presence of rollovers. The second stage then estimates the number of tickets sold as a function of the predicted effective price obtained in the first stage.

In both stages, dummy variables are used to capture features such as the weekday of the draw, new draw features (for example, the introduction of LottoPlus and the Powerball game) and to control for changes (for example, the nominal price increase and the new lottery management company). Dummy variables are included to avoid omitted variable bias in line with Garrett & Sobel (2004). Stage 2 in the log-linear form is estimated, in part, for ease of interpretation.²⁹

The two-stage estimation is as follows:

- Stage 1

Log of Effective Price = $f(\text{Constant, Trend, Trend}^2, \text{Log of Rollover, (Log of Rollover)}^2, \text{Saturday Draw Dummy, Rollover Dummy, Guaranteed Jackpot Dummy, New Operator Dummy, New Nominal Price Dummy, LottoPlus Dummy})$

29 Alternatively, linear demand (such as that used by Garrett (2001)) or semi-log linear demand functions could be estimated. In this case it does not make a difference from a statistical point of view as there is low variation in the effective price (from R0.30 to R2.23). Note the elasticity of demand with respect to price on a logged demand function compared to that of a linear demand function:

Given the demand function $q = \alpha - \beta P$, the elasticity of the demand function with respect to price is $\varepsilon_{q,p} = -\beta \frac{P}{q}$. Taking the log of this function yields $\ln(Q) = \ln(\alpha) - \beta \ln(P)$. Thus, the differential of this log-linear demand function is $\frac{dQ/Q}{dP/P} = -\beta$.

Hence the monotonic transformation of the demand function has constant elasticity $-\beta$.

- Stage 2

Log of Quantity of Tickets Sold = $f(\text{Constant, Predicted Log of Effective Price, Log of Quantity Tickets Sold (lagged by one time period), Log of Quantity Tickets Sold (lagged by two time periods), Trend, Trend}^2, \text{Saturday Draw Dummy, Rollover Dummy, Guaranteed Jackpot Dummy, New Operator Dummy, New Nominal Price Dummy, LottoPlus Dummy})$

A trend term is included in both stages to capture time effects such as an initial leap in the sales data. Meiers (1996) finds an initial leap in the sales data in the USA where state lotteries show an increase in sales soon after being launched, but this is followed by a drop in sales that can be attributed to satiation once the novelty value of the National Lottery has worn off. Forrest *et al* (2000) find similar evidence of consumer satiation after a few months of the British lottery. To capture these time effects, a linear trend variable (Trend) and a non-linear trend variable (Trend²) are included.

Log of Rollover is the log of the number of Rands carried over from the previous National Lottery draw(s). The presence of a rollover has a direct impact on the jackpot size. The square of the Log of Rollover to allow for non-linearity is included.

Several dummy variables are also included either to capture characteristics of National Lottery draws or to control for events that affected the National Lottery sample. These dummy variables include a Saturday Draw Dummy, a Rollover Dummy, a Guaranteed Jackpot dummy, a New Operator Dummy, a New Nominal Price Dummy and a LottoPlus Dummy. The Saturday Draw Dummy is included to capture the effect of a Saturday draw as opposed to the Wednesday Draw. Saturday draws are considered more popular with higher ticket sales than those on Wednesdays (Forrest *et al* 2000: 857). The Rollover Dummy and the Guaranteed Jackpot Dummy may capture any additional interest a jackpot rollover might generate in terms of ticket sales. A New Operator Dummy is to control the change of companies. A New Nominal Price Dummy can control the increase in nominal price of the National Lottery from R2.50 per ticket to R3.50 per ticket which may affect the number of tickets sold.³⁰ The

30 This article does not isolate the effect of the change in nominal price, but instead controls for effect to determine the elasticity of demand.

LottoPlus Dummy is included to capture the effect of the launch of the LottoPlus game extension. As mentioned earlier, LottoPlus is an add-on to the National Lottery game in which players pay an additional rand on over and above the nominal price of the ticket to participate in a second draw which has no rollovers and lower prizes. Lastly, a Powerball dummy is included to capture the effects of the launch of a new lottery game, Powerball, which has draws on the days preceding the National Lottery draws, namely Tuesday and Friday (National Lottery 2011).

4. Results

4.1 First stage

Table 2: First stage: dependent variable is Log of Effective Price

Variable	Coefficient (p value)
Constant	0.432*
	(0.010)
Trend	0.000**
	(0.000)
Trend Squared	0.000**
	(0.000)
Log of Rollover	0.236*
	(0.005)
Log of Rollover Squared	-0.016*
	(0.000)
Saturday Draw Dummy	-0.017*
	(0.005)
Rollover Dummy	-0.062*
	(0.009)
Guaranteed Jackpot Dummy	0.017
	(0.011)
New Operator Dummy	0.018

Variable	Coefficient (p value)
	(0.013)
New Nominal Price Dummy	0.366*
	(0.014)
Lottoplus Dummy	0.013
	(0.012)
Powerball Dummy	-0.146*
	(0.020)
Number of observations	990
R-squared	0.89
Note: standard errors in parentheses ** significant at 5% * significant at 1%	

The first stage of the effective price model (*cf* Table 2) shows that both Trend and Trend Squared coefficients are significant and close to zero.³¹ As the Trend variables are significant in this first stage, it appears that time effects have an effect on the Log of Effective Price but that these effects are small and negative.

The Log of Rollover and the Log of Rollover Squared coefficients are significant. The Log of Rollover variable is positive, indicating that a rollover increases the effective price, while the square of the Log of Rollover is negative, indicating that a rollover increases the Log of Effective Price at a decreasing rate. Taking the first order condition, the turning point at which a rollover has a maximum contribution on the effective price occurs when the rollover is R1 484.43. This turning point is only a fraction of an “average” rollover (the mean rollover for this data sample is R2 903 096.59, while the largest rollover in this sample is R35 481 060.00). Therefore, the value is in effect zero. Note that a large rollover may bring down the effective price of the National Lottery ticket (though not below zero).

In terms of the dummy variables, the Saturday Draw Dummy is significant and negative, which implies that a Saturday National

31 Both Trend and Trend Squared coefficients are shown as zero in Table 2 due to rounding off.

Lottery draw has a lower effective price than a Wednesday National Lottery draw. Saturday draws are likely to have a lower effective price than Wednesday draws because more tickets are sold for Saturday draws than for Wednesday draws. One reason for the greater Saturday ticket sales is that the National Lottery can be regarded as a form of weekend entertainment (Gulley & Simmons 2000: 857).

The Rollover dummy is significant and negative, indicating a rollover, while increasing the jackpot prize, has a negative effect on the Log of Effective Price. Neither the Guaranteed Jackpot Dummy nor the New Operator Dummy is significant. The New Nominal Price Dummy is significant and is positive. The positive sign on the New Nominal Price Dummy is expected as the increase in nominal price will increase the Effective Price. The LottoPlus Dummy is not significant. However, the Powerball Dummy is significant and negative, which means that the introduction of the Powerball game decreases the Log of Effective Price. The constant term is significant and positive.

The Breusch-Pagan test finds no evidence of heteroskedasticity. The Portmanteau test finds no evidence of autocorrelation. The R^2 of 89% indicates both a good fit and that the predicted Effective Price is a good proxy for the original Effective Price.

4.2 Second stage

Table 3: Second stage: dependent variable is Log Number of Tickets Sold

Variable	Coefficient (p value)
Constant	11.098*
	(0.511)
Log of Predicted Effective Price	-0.443*
	(0.035)
Log of Quantity Tickets Sold[-1]	0.261*
	(0.027)
Log of Quantity of Tickets Sold[-2]	0.065**
	(0.028)

Keeton/Seeking Leviathan?

Variable	Coefficient (p value)
Trend	0.000
	(0.000)
Trend Squared	-0.000*
	(0.000)
Saturday Draw Dummy	0.469*
	(0.020)
Rollover Dummy	0.021
	(0.015)
Guaranteed Jackpot Dummy	0.025
	(0.022)
New Operator Dummy	-0.002
	(0.027)
New Nominal Price Dummy	-0.026
	(0.032)
Lottoplus Dummy	-0.107*
	(0.026)
Powerball Dummy	-0.103**
	(0.045)
Number of observations	988
R-squared	0.88
Note: Standard errors in parentheses ** significant at 5% * significant at 1%	

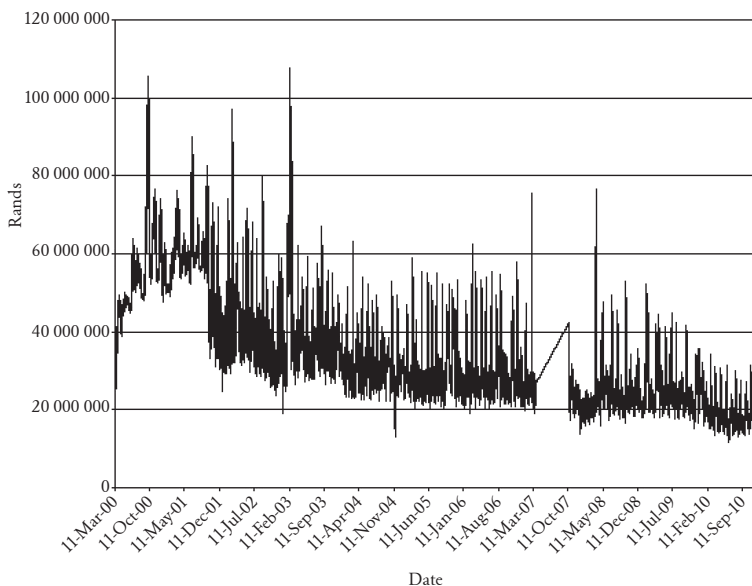
The dependent variable in the second stage (shown in Table 3) is the Log of the Number of Tickets Sold. The coefficient of the Log of the Predicted Effective Price (predicted from the first stage regression) is negative, indicating a downward slope of the demand curve. The coefficient indicates that an increase in the Effective Price will decrease National Lottery ticket sales.

Two lags on Log of the Number of Tickets Sold determine how previous National Lottery tickets sales affect current National Lottery

sales.³² Both show positive, significant coefficients. Additional lags failed to attract statistically significant coefficients, while the positive coefficient indicates that previous National Lottery ticket sales are a positive predictor for current National Lottery ticket sales.

The elasticity of demand with respect to the effective price can be determined from the coefficients of Log of Predicted Effective Price and the lagged Log of Quantity Tickets. Thus, the elasticity of demand with respect to the effective price is -0.656 for the first ten years of the National Lottery.³³ Hence, the elasticity of demand is significantly different from the revenue-optimising elasticity of -1 . Accordingly, the National Lottery does not appear to be structured to maximise revenue as per its legislated goal in this sample period.

Figure 1: National Lottery ticket sales (11 March 2000 – 31 December 2010)



Source: National Lottery data <<http://www.nationallottery.co.za>>

32 Additional lags were not statistically significant.

33 Calculated by setting the first derivative with respect to Rollover to zero (first order condition).

The linear Trend variable is not significant, but the non-linear Trend Squared variable is (although, once again, close to zero). As the Trend variable is not significant, it would appear that time effects that affect the first stage do not affect the second stage. The Trend Squared variable is significant and negative which indicates that there is a non-linear (but slightly decreasing) trend in the series. One explanation for this is that there may be an initial leap in sales when the National Lottery was first introduced in 2000 (*cf* Figure 1). The initial leap is then followed by consumer satiation as the National Lottery loses its novelty value. There can also be heightened interest in the National Lottery when there are large rollovers (accounting for the large spikes in Figure 1), which may reflect in the significance of the non-linear Trend variable.

The Saturday Draw Dummy is significant and positive, which implies that a Saturday National Lottery draw has higher ticket sales than a Wednesday National Lottery draw. This finding is in line with the expectations since the National Lottery can be a form of entertainment. None of Rollover Dummy, Guaranteed Jackpot Dummy, New Operator Dummy, or New Nominal Price Dummy is significant. It is unexpected that none of these dummy variables are significant at this stage of the regression as one might expect large rollovers, guaranteed jackpots, and a change in the nominal price to affect National Lottery ticket sales.

In the second stage, the LottoPlus Dummy is significant and negative, indicating that the introduction of the LottoPlus game has decreased National Lottery ticket sales in both models. This may be due to the additional cost of entering the LottoPlus draw being lower than that of an additional ticket. Therefore, a player may choose to enter the LottoPlus draw with his/her existing ticket rather than to purchase additional tickets in the National Lottery draw.

The Powerball Dummy is negative and significant in both stages. Thus, the Powerball game decreases both the effective price of the National Lottery and the sale of National Lottery tickets. A possible reason for this decrease is that interest in the National Lottery may have diminished as people substituted a way to purchase Powerball tickets instead of National Lottery tickets. The lower odds of winning the Powerball means that there are more frequent Powerball rollovers

and, thus, higher jackpots. Players may choose to substitute National Lottery tickets for Powerball tickets which have higher prizes despite lower odds of winning. However, this is speculation and more investigation is required to fully understand the substitution effects of the two lottery games.

The Breusch-Pagan test finds no evidence of heteroskedasticity. The Portmanteau test finds no evidence of autocorrelation. Two observations are lost due to the two lags on the Log of Number of Tickets sold variables. Once again, the R^2 statistic shows a good fit at 88%.

Time series tests were also carried out on the data from the South African National Lottery (*cf* Appendix 2). Dickey-Fuller and augmented Dickey-Fuller Tests (two lags) are carried out to test for stationarity of Number of Tickets Sold, the Effective Price and on the Rollover. The null hypothesis of a unit root can be rejected in each instance and, therefore, the continuous variables are considered stationary.

5. Conclusion and suggestions for further research

This article investigated whether or not the South African National Lottery provides evidence of a Leviathan. The elasticity of demand estimated using the effective price model does not find evidence that the National Lottery is maximising revenue, given its current form. Thus, this article did not find evidence of Leviathan in the South African National Lottery. However, in not maximising revenue, the National Lottery is not meeting its legislated mandate of maximising the portion of public revenue raised from selling National Lottery tickets. These are the positive conclusions.

Normative implications should also be considered. As indicated in this article, the National Lottery is ostensibly displaying Leviathan tendencies. The broad definition of a lottery in the Lotteries Act provides a statutory monopoly for the South African government. The FNB court case shows that the National Lottery can use this definition to crowd out any private sector activities deemed as “lotteries” under the legislated definition. In addition, the National Lottery can sell as many tickets as individuals are willing to purchase.

As buying a lottery ticket is voluntary, the National Lottery can use both advertising and a deliberate game design to attract the South African public into buying National Lottery tickets. Any and all of these actions to increase ticket sales are in keeping with the mandate of the lottery management company to raise as much public revenue from the sale of National Lottery tickets as possible. Whether or not the revenue raised from these ticket sales goes to charities or to other so-deemed “good” causes, the South African National Lottery is a tool for public fundraising.

Like the need for constitutional constraints on other tools for public fundraising, namely taxation, debt and seigniorage, there ought to be similar constraints on the revenue-raising power of the National Lottery. Otherwise the poor and uneducated are likely to suffer the most. In South Africa, those who are unemployed and earn monthly incomes below R2 000 are active lottery players. Indeed, 23.3% of lottery players are unemployed and 50.3% of lottery players earn less than R2 000 per month. In addition, 88.9% of lottery players with no formal schooling play the lottery more than twice a week (Lighthelm 2011). Without constitutional constraints, it is likely that the poor and uneducated consumers are likely to increasingly shoulder the burden of this pool of public revenue.³⁴

To my knowledge, this is a first study on the South African National Lottery. This study offers a point of reference for research on the demand for lottery tickets. Further research could explore the bounded rationality of lottery players, possibly through experimentation, to elucidate which additional factors may contribute to the demand for lottery tickets. In addition, this article is the first investigation into whether the National Lottery provides evidence of Leviathan. In general, more research can be done on the National Lottery’s role as a tool for public fundraising in South Africa. Additional research into the spending of the funds raised may help to shed light on the Leviathan tendencies of the National Lottery.

34 Cf Clotfelter & Cook (1990) and Davis & Donald (1992) for a discussion on the lottery as a regressive tax.

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Appendix 1 Odds and probabilities of winning in different divisions of the National Lottery³⁵

Table 4: Differences between the divisions of the National Lottery

Division	Numbers ¹ matched	Odds ²	% of prizes allocated to division ⁴
1	6	1 in 13,983,816	18.25
2	5 + bonus	1 in 2,330,636	4
3	5	1 in 54,201	9
4	4 + bonus	1 in 22,197	5
5	4	1 in 1,032	16.75
6	3 + bonus	1 in 812	11
7	3	1 in 57	36

Sources:

1 National Lottery 2011

2 Calculated using the formula $n!/m!(n-m)!$ where n is the number of possible choices (e.g, $n=49$) and m is the number to be matched (e.g, $m=6$)

4 National Lottery 2011. Note that this percentage is after VAT

Appendix 2 Time series test results

Table 5: Dickey-Fuller and augmented Dickey-Fuller results

Variable	Lags	Test statistic	p value	Number of observations
Number of tickets sold	0	-16.483	0.0000	989
Number of tickets sold	2	-5.653	0.0000	987
Effective price	0	-13.345	0.0000	989
Effective price	2	-9.276	0.0000	987
Rollover	0	-19.290	0.0000	989
Rollover	2	-14.709	0.0000	987

35 Cf National Lottery website: <www.nationallottery.co.za>