Economically irrational pricing of 19th century British government bonds

Andrew Odlyzko

School of Mathematics
University of Minnesota
Minneapolis, MN 55455, USA
odlyzko@umn.edu
http://www.dtc.umn.edu/∼odlyzko
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Abstract. British government bonds formed the deepest, most liquid, and most transparent financial market of the 19th century. This paper shows that those bonds had long periods, extending over decades, of anomalous behavior, in which Consols, the largest and best known of these instruments, were noticeably overpriced relative to equivalent gilts which offered the same interest rate and the same guarantee of payment. The British government did take advantage of this market inefficiency, but apparently to a lesser extent than it could have.

This finding and similar ones for other comparable pairs of British gilts appear to provide the most extreme counterexamples documented so far to the Efficient Markets Hypothesis and to the Law of One Price. They also offer a promising test case for exploring the effects of mass psychology on economic behavior. It appears that several communities held divergent views on the values of securities that standard theory provides unambiguous answers for.

1 Introduction

19th century Britain led the world in the development of modern economic and financial institutions as well as of economic theory. This paper shows that these developments were accompanied by a striking example of large scale economic irrationality that adds a new dimension to the modern literature on market efficiency and pricing anomalies. This irrationality was not quite as extreme as if pound notes with odd serial numbers were worth an extra penny compared to those with even serial numbers when buying groceries and clothing, say, even though all were of equal value for payment of taxes or meeting legal debts. But it came close, in that the most notable instance involved two British government bonds, which carried exactly the same interest rate and were backed by the full faith and credit of the government. They differed essentially only in name, volume, and dates interest was paid. The price difference, adjusted for accrued interest, reached as high as 2% for short periods, and averaged over 1% for several years, and over 0.5% for decades, as is shown in Fig. 1. (The notation is explained lightly in the figure caption, and in full detail later.) One could argue that this was even more extreme than some banknotes being worth more than others based just on their serial numbers, since the sums affected by the

mispricing were an order of magnitude larger than the volume of paper and gold currency in circulation. The potential arbitrage profits from eliminating the discrepancy reached 1% of UK GDP at the peak in the mid-1860s. Thus this phenomenon appears to represent a more striking counterexample to the Efficient Market Hypothesis and the Law of One Price than any available in modern literature, as is argued in Section 5.

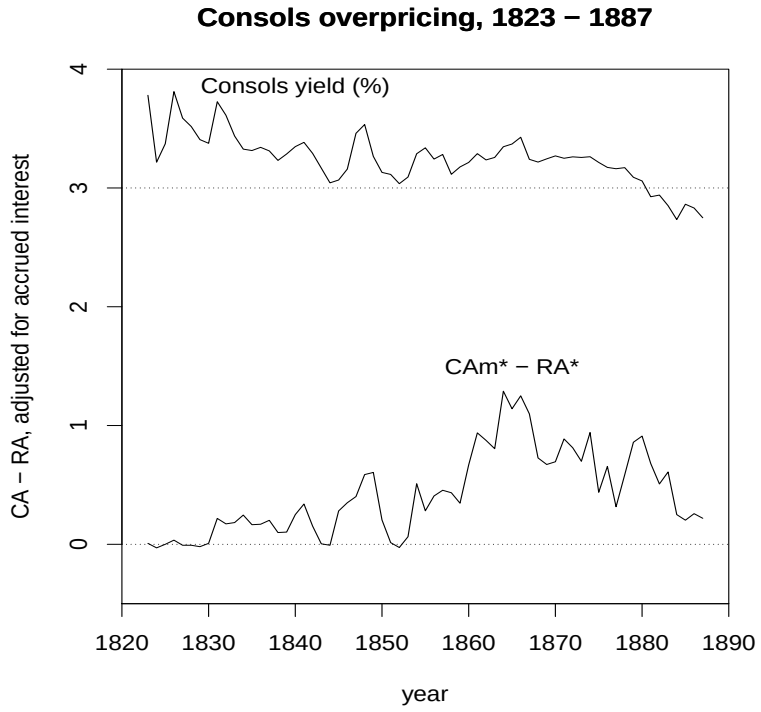

Fig. 1. Average annual overpricing of Consols (CA) relative to Reduced Annuities (RA), 1823 to 1887. Stars denote market prices after subtraction of accrued interest, in pounds sterling for a unit of nominal value 100 pounds. Theory predicts that CAm* - RA* should have been zero in an efficient market. Also shown is the average annual market yield on Consols.

While only one contemporary economist, Robert Giffen, appears to have written about this pricing anomaly (which by itself gives rise to interesting questions considered later), it was widely known among those involved in finance, even if not among the general public. Some Chancellors of the Exchequer (the equivalent of a finance minister in many countries, or the Secretary of the Treasury in the U.S.) spoke about it in Parliament, and it was cited in a popular textbook on arithmetic. Several newspapers waged extended campaigns, attempting to persuade their readers to take advantage of this mispricing. One of the more colorful expressions came from the *Newcastle Journal* of 14 July 1860, which wrote that "the public mind has been sorely puzzled to understand why the value of [RA and NR, another, almost identical gilt] should be so much lower than [CA]." Such efforts had little

noticeable effect. This mispricing was eliminated only in 1888, when almost all gilts (the modern term for British government bonds) were converted to a single new class. The memory of this pricing anomaly faded away quickly afterwards[1]. There does not seem to be any mention of it in modern literature.

The City (the commercial and financial heart of London), the London Stock Exchange, and British financial markets of the 19th century in general have been investigated extensively, since London was the world's dominant financial center during that century. Some of the basic references are [2,13,30,38,44,47,48]. Thus the development of the key institutions and laws are well documented. The last few decades have also produced an extensive and noteworthy literature on the role of gender in Victorian investments. (See, for example, the collection [21] and the references there.)

Table 1. British economy and national debt, 1840–1880.

All figures in millions of pounds sterling.

year	GDP	debt	CA	RA	NR	N35	R35
1840	566	798	362.2	126.1	-	157.6	67.2
1850	593	798	374.2	121.3	247.8	-	-
1860	828	802	400.6	115.0	246.2	-	-
1870	1153	748	393.6	102.7	220.1	-	-
1880	1379	738	390.9	92.3	204.2	-	-

But there are more topics that deserve deeper study than they have received so far. One is corruption. It is widely regarded as a major impediment to the advance of the less developed world. Yet the Industrial Revolution originated in a deeply corrupt Britain, and flowered while that country was transitioning to what we now often refer to as Victorian morality. Hence we might learn useful lessons from the British experience. Another topic of modern relevance is the management of large national debts. Given the still primitive state of the economy and of the financial system, and the relatively low tax intake in the early 19th century as fraction of GDP, the debt visible in Table 1 (with NR, N35, and R35 denoting some additional gilts) was far more onerous than any faced by modern countries[2]. Fiscal repression, which is discussed increasingly as a tool for managing large national debts, appears to have been an important instrument of British policy as well, as is briefly mentioned in Section 12.

The main topic of this paper concerns yet another issue that has been not just neglected, but appears totally unknown to modern scholarly literature, namely the pricing anomalies of British gilts in the 19th century. Trading in those bonds was the reason the London Stock Exchange was created. (The word "Stock" referred primarily to government perpetual annuities, Consols the most prominent of them.) They provided almost all the

trading volume on that exchange for the first two decades of the 19th century, with shares of companies such as the Bank of England, and then increasingly also canals, insurance companies, etc., being essentially negligible. Around 1820, foreign government bond trading began to grow, and then, in the 1830s and 1840s, shares of joint stock companies, railways most prominently, grew in importance. A contemporary compilation showed that in the 1816–1820 period, UK national debt was about 67% of all tradeable national debts in the world, with the Dutch debt in second place at 11%[3]. (This simple statistic provides a quick illustration of the well-known transition, with London taking over from Amsterdam as the world financial center around 1800.) Even in the early 1860s, as other nations grew their debts, the UK accounted for about 40% of world total [32], at a time when such securities were still far larger in volume than equity investments. (See [38] for more comprehensive data on the evolution of the London Stock Exchange and the changing importance of various securities.)

The UK was the greatest exporter of capital in the 19th century, and gilts were initially most of its financial market, and remained its sizable and stable foundation until the end of that century. Hence those gilts played a major role in world finance. Since Consols were the largest security in this class, with about half the total capitalization, they naturally attracted the most attention. "For many decades before World War I the price of Consols was the single most important asset price in the world economy" ([29], p. 165).

Consols, denoted CA in Table 1 and in the rest of this paper, are a natural subject for scholarly study. Not only was their volume larte, but in addition they approximated the ideal financial instrument. They were book-entry entities, were long-lived (dating back to early 1750s, and replaced by a new type of bond, also called Consols, in 1888–89), were almost infinitely divisible (some accounts had just one penny, the old British penny, 1/240-th of a pound sterling, in them), and were traded all the time on the London Stock Exchange with low (for that time) transaction costs. In the words of a modern scholar, "[a]s a measure of the long-term rate of interest [CA] perhaps comes as close as we can get to that theoretical abstraction, which requires a loan of infinite duration without any risk of default" ([42], p. 649). In fact, most 19th century reports on money markets discussed primarily CA, and various investment guides noted that all other gilts followed the lead of CA in pricing[4].

Modern authors who have looked at long term interest rates in Britain have studied CA to the almost complete exclusion of other gilts, cf. [7,9,15,26,27,29,42,61]. Practically the only other 19th century gilt that has been considered seriously is a 2.5% annuity that was used to obtain adjusted yields in the 1880s, when the prospects of conversion kept CA yields higher than they would have been otherwise. (The definitive study in this area, which corrects for some of the pitfalls of earlier works, is [29].)

The efficiency of the London financial markets in the 18th century is still a subject of controversy. Some scholars continue to argue that there were rational foundations to the South Sea Bubble. For the rest of that century, the inefficiency conclusions obtained in papers such as [40,41] have recently been disputed in [49]. For the 19th century gilts markets, though, all the published studies found that those markets passed standard efficiency

tests [6,7,43]. However, those studies applied just a limited set of tests. More important, they used data just for CA.

While CA did constitute about half of the British national debt, there was another half. It consisted of other gilts and still other financial instruments. Even if we exclude short-term debt, for most of the 19th century there were between half a dozen and a dozen government securities on the market. They offer a rich subject for study. This paper concentrates just on what are called the "major gilts" of the 1831–87 period, namely the ones listed in Table 1. They are explained in Section 2, and had the property that their capital was large, they were widely held, and were traded almost every day that the London Stock Exchange was open. It turns out that even these major gilts displayed some striking and persistent pricing anomalies. It is not just that CA was mispriced relative to RA, as is shown in Fig. 1. For a couple of years in the late 1840s, NR was mispriced relative to both RA and CA, and in the early 1840s, N35 was mispriced relative to R35. The most important of these mispricings are documented in this paper.

Why weren't these market inefficiencies eliminated by arbitrage by clever investors? The London Stock Exchange was a sophisticated operation, with membership rising from about 700 in 1840 to over 900 in 1850, and far higher later. In the words of the most famous book on the history of interest rates ([27], p. 184), "[a]lmost all the principal services provided by today's City and today's Wall Street were then available in London." The members of the London Stock Exchange had a high reputation for sagacity. In a House of Commons debate over Gladstone's 1853 proposal for a conversion of the national debt, Disraeli claimed that "[t]here is not a more crafty creature in existence than the public creditor," and this sentiment was echoed by another participant in the debate[5]. Those "crafty creature[s]" had to have known of the pricing anomalies, and from press reports we know they knew about them. However, this appears to be a perfect example of the claim that is usually ascribed to Keynes, namely that "markets can remain irrational longer than you can remain solvent." that gap. Some of the gilts mispricing episodes lasted for decades, and might have bankrupted many an investor.

The full story may be even more interesting. Some of the gilts mispricings (especially for the minor gilts, which are not discussed in this paper, but are treated briefly in the supplementary manuscript [52]) were short-lived, and there are many press reports of arbitrage moves. So it is possible that some investors made money from these pricing anomalies, and it is also possible that some did become insolvent as a result of trying to fight an irrational mispricing which persisted and grew for many years. But as yet we do not have hard data to substantiate such speculations. What we can be sure of, based on market price data, is that traders on the Stock Exchange had to be acutely aware of precisely how irrational the market was. Mispricings were rather stable over extended periods of time, and even in crisis situations, when gilts prices gyrated wildly, pricing differentials were preserved fairly closely.

While classical arbitrage, selling short the overpriced CA and buying the underpriced RA, say, was the road to ruin most of the time, there was another type of arbitrage that should have eliminated the anomaly. Owners of CA could sell them and replace them with RA, and people who were were investing in gilts could buy just RA. We don't know the

precise breakdown of gilts ownership, but we do have evidence that there were many long-term investors, such as the universities of Cambridge and Oxford, interested primarily in the stream of interest payments, who owned large amounts of CA. The big puzzle, which is not resolved fully by this paper, as only some tentative guesses can be made, is why such investors did not follow this strategy, or at least did not do so in sufficient volume. (According to press reports, some maneuvers of this type did take place.)

The best guess right now is that mass psychology led the mass of British investors to think of CA as being more prestigious than RA, and be willing to pay a bit more for it. The overpricing was never very large, only about 2% at the peak periods in the mid-1860s, and usually less, most of the time under 1%. So it seems that greed did operate, but that it had to overcome a substantial prejudice in favor of CA, a prejudice whose strength varied with time (and of course between individual investors) in ways that are hard to characterize. (It appears that economic crises often led to a strengthening of this prejudice. On the other hand, the prospects of government intervening by redeeming CA or changing it to make it equivalent to RA led to declines in this prejudice.)

The conjectured cause of the gilts mispricing is related to some ideas from behavioral finance, especially that of "investor sentiment" and "noice traders." However, as is discussed in Section 5, it does not fit the currently popular models of those phenomena perfectly. Therefore instead of using those modern technical terms, this paper sticks to the language of irrational crowd action, harking back to the pioneering 19th century work of Charles Mackay (*Extraordinary Popular Delusions and the Madness of Crowds*) and Gustave Le Bon (*The Crowd: A Study of the Popular Mind*).

Could the British government have been responsible for the observed CA overpricing? It was not only the issuer of gilts, but an active participant in the market (as will be described later, in Section 13), and it got to make the laws that ruled that market. Still, that does not appear to have been a serious contributor to gilts mispricing, at least if we assume rational market action. This issue is discussed in more details later in this paper, and in [52]. While the government did set and enforce the rules, it was very careful to do it in ways that were seen as fair, and sometimes bent over backwards to be nice to investors. Furthermore, the main form of intervention that investors could expect from the government was reduction of interest rate on gilts. For CA and RA, that was worthwhile for the government only when long term rates were below 3%. Yet Fig. 1 shows that periods when such a conversion appeared likely (for example, 1844, or 1851–52) were also periods of rational relative pricing of CA and RA.

Yet another argument that the government was not responsible for CA overpricing comes from looking at Table 1, which shows the volume of RA and NR shrinking, while that of CA grew initially and then was about stable. During the period 1840–80 that is covered there, government occasionally issued new debt, but most of the time it redeemed it through market purchases. We find (and more detail is available in Section 13) that it issued primarily CA, and repurchased primarily RA and NR. Thus it was increasing the supply of the overpriced CA and decreasing that of the underpriced RA and NR. Whatever the reasons for gilts mispricing might have been, rational economic thinking suggests that this should have worked to lessen CA overpricing.

On the other hand, one can make a persuasive case that the British government did contribute to gilts mispricing. The arguments above assume economically rational investors. But this paper's tentative conclusion is that investors had an irrational preference to CA, regarding it as the "gold standard," with other gilts inferior in some way. If that is correct, then the government actions which increased the fraction of the national debt that was in CA probably helped reinforce the special status that CA enjoyed in those investors' minds. That likely increased CA overpricing and the associated market inefficiency.

In this paper, rationality is equated with economic rationality, which values a security according to the discounted value of its payouts. Clearly what happened is that large blocks of British investors did not share this view. They were normal, respectable, and productive members of their society, but with a different type of rationality driving their financial decisions. One of the fascinating findings of this research is that there seemed to be several classes of investors, each with somewhat divergent views on the values of the major gilts. The market was not able to fulfill its purpose, and drive the consensus price towards the correct value.

This paper is based on two collections of data that had not been assembled before. One is an extensive dataset of gilts prices in the 1823–88 period, primarily of the major gilts, but also of some minor ones. It is publicly available on the author's home page,

⟨http://www.dtc.umn.edu/∼odlyzko/19finance/⟩

The other collection is of notes and discussions about gilts mispricings in the contemporary literature, primarily the press, but also books, pamphlets, and official documents. They are cited frequently with full references in this paper, as well as in the supplementary manuscript [52]. That paper considers in more detail the behavior of CA overpricing during various interesting periods, the coverage of the overpricing in the press, and the gilts investments of various groups, such as the universities of Cambridge and Oxford. It also has more details about data sources, gilts ownerships, the functioning of 19th century gilts markets, the variety of opinions expressed about the gilts pricing anomalies, and discusses potential extensions of this work.

Gilts mispricings were never very large, at most 2 to 2.5% for the major gilts (but more for the minor ones), and they never became a serious public issue. There was substantial press coverage of them, which included several long, multi-year campaigns by some papers to persuade their readers to take advantage of the CA overpricing. Most of the commentary on it that has been found came from financial journalists, who almost uniformly shared modern views on the appropriate relation in prices of the major gilts, even though many of them accepted as valid the rationalizations that were being offered for mispricings. However, there are a few opinions from others, such as Chancellors of the Exchequer, more general journalists, and some readers writing letters to newspapers.

Gilts mispricings offer an unusually promising topic for investigating the diffusion of information in society, which is key to understanding how the economy functions, and in particular how bubbles and crashes arise. What the 19th century phenomenon documented here suggests is that we should consider seriously what might be called "information viscosity," in which important information that is potentially market-moving does not spread and is not utilized properly. This was an issue in the 2008 crash. Many people were aware

that the financial system was in a precarious state, as expressed in a message from an analyst at a credit ratings agency, who wrote to a colleague, "Let's hope we are all wealthy and retired by the time this house of cards falters"[22]. However, various fragments of such knowledge were often concealed, and were never integrated into a comprehensive picture of the entire system at the policy levels. A journalism scholar has recently taken his profession to task for not carrying out the task of warning society of the looming danger [63], and similar complaints have been lodged against other professional groups. The mispricing of 19th century gilts suggests that to understand how this happens we have to go deeper than just complaints of incompetence, dereliction of duty, or corruption. In the case of gilts, there were no influential agents obfuscating the issue. The mispricing was completely in the open, and there does not appear to have been anyone who benefited from it. That it was a market inefficiency was apparently clear to all observers who thought about it, even if they accepted the rationalizations that were offered for its existence. Many of them did speak out publicly on the topic. Yet the message did not penetrate large strata of society, which went off on their own tracks, with their own valuations for the various gilts.

Section 2 describes the major gilts that are the main subject of this study. Then Section 3 presents a detailed study of the underpricing of NR relative to both RA and CA in the late 1840s. Section 4 discusses the CA overpricing relative to RA, which is pictured in Fig. 1, but over shorter periods, to demonstrate some of the features of this phenomenon in more detail. Section 5 compares the gilts mispricing discovered in this research to pricing anomalies that have been published earlier. It also discusses the implications of this work for behavioral finance and the study of bubbles. Then come several sections with technical details of this study. Section 6 delves into gilts valuations, and the theoretically expected behavior of the relative pricing of CA to RA, and of other pairs of gilts. Section 7 discusses a complicating factor, the system of "shuttings" which, until 1861, stopped trading in each gilt for about two months each year. Section 8 presents sources of the price data used in this study. Section 9 describes transactions costs in gilts. Section 10 investigates differences among the major gilts, and the extent to which they could have led to the observed mispricings. Our limited knowledge of who the owners of gilts were is the subject of Section 11, and this is followed by presentation on fiscal repression and gilts holdings of some public agencies in Section 12. Section 13 studies the sales and purchases of gilts by the British government. This is followed in Section 14 by an investigation of gilts investments by some extremely small investors, which shows one of those divergent views on gilts valuations that were mentioned before. Section 15 has a summary of the coverage of gilts mispricings in the contemporary press. Section 16 considers possible causes of CA overpricing. This is followed by Section 17 which considers the (non-)reactions to the gilts mispricing by contemporary economists, and by Section 18 which demonstrates that there were several divergent views on gilts valuations. Finally, Section 19 presents the conclusions of this work, and outlines a program of desirable further investigations.

2 British gilts

The main subjects of this study are the three major gilts that formed the bulk of the British national debt in the 1844–88 period:

- CA = Consols, the Consolidated 3% Annuities of 1751, paying 3% annually, in early January and early July
- RA = Reduced 3% Annuities, also dating to the 1750s, paying 3% annually, in early April and early October
- NR = gilts created in the 1844 debt conversion, paying 3.25% from late 1844 to late 1854, and then 3%, with a guarantee of no redemption until late 1874, with interest payable on the same days as RA

After 1854 these three securities all paid 3% per year, were collectively often referred to as "the Three per Cents.," and a famous phrase cited "the sweet simplicity of the Three per Cents." They were often regarded as interchangeable in the popular press or works of fiction, and were often all referred to as Consols. NR itself was called the 3.25% annuity between 1844 and 1854, and after October 1854 was usually designated in price tables and writings as the "New Three per Cents." They were all perpetual, in that investors could not cash them in, but the government could call them by paying face value (following some rules discussed in Section 10). Such redemptions happened a number of times in the 19th century. In a recent book some of them are listed as examples of "domestic default or restructuring" ([57], p. 112). This is misleading, since the British government was punctilious in observing all its legal obligations. These conversions took place in times of prosperity, when interest rates were low.

Although in the 1860s it became possible to obtain certificates for gilts, they were originally and remained primarily book entries at the Bank of England (and to a much smaller extent at the Bank of Ireland). Since CA and RA (and NR from 1855 on) paid 1.5% interest twice a year, they were really approximately 3.02% annuities, but we'll follow the convention of the time and disregard this pedantic point. These gilts (the modern term, contemporaries referred to them by terms such as the "public funds," "English funds," or, often, just as "The Funds") were quoted in units of nominal value £100, although they could be, and were, traded in any amount down to a penny (the old English penny, 1/240-th of a pound sterling). Thus they were a good approximation to the ideal of liquid and infinitely divisible securities.

There was a large variety of British government securities on the market at various times. Most involved small capital, will occasionally be referred to as "minor gilts," and a few are described in [52]. They deserve further study, as their behavior, and in particular the disparities of their prices among themselves, and in comparison with the major gilts, might provide insights into CA overpricing. However, that is left for other studies, as far more data will need to be gathered, and it will require extensive space to document the research, as there were many special features to those gilts.

In addition to the three major gilts listed above, we also consider, although only briefly, two other gilts that also deserve to be called major, namely N35 and R35. Both are listed in Table 1, and both were converted (together with two minor gilts) into NR in 1844. (See [52] for some details on this process, and the two minor gilts that were involved.)

- N35 = New 3.5% Annuity, paying 3.5% annually, in early January and early July
- R35 = Reduced 3.5% Annuity, paying 3.5% annually, in early April and early October

The nominal capital of these annuities in 1840 is given in Table 1. It was substantial, and N35 and R35 were traded almost every day, unlike the minor gilts. What makes the relative prices of N35 and R35 worth investigating is that they were almost analogous in their relation to each other to the pair of CA and RA. N35 and R35 bore the same interest rate, and differed only in name, capital, and dates when interest was paid. So it is interesting to look for N35 vs. R35 mispricing, and we do that in Section 3. However, the situation is not completely analogous. CA and RA both went back to the 1750s, both were callable under the same conditions, and both were extinguished in the Goschen conversion of 1888–89. R35 originated in 1824 (through conversion of higher coupon securities). During the period we consider them, namely start of 1831 through their extinction in the Goulburn conversion of 1844, they were callable at short notice. N35 arose late in 1830, also through conversion of a higher coupon annuity, but was not redeemable until 5 January 1840. Thus from 1831 through 1839, rational pricing would call for N35 to carry some premium relative to R35, after adjusting for accrued interest. However, from the beginning of 1840 to mid-1844, there was no economically rational reason for the prices of N35 and R35 to differ (once we adjust for accrued interest).

Transaction prices and quotes for the major gilts were almost universally reported in increments of £0.125, printed as $\frac{1}{8}$. This was equal to standard brokerage commission, and also to the jobber (market maker) standard margin, see Section 9. As is detailed in [52], there was more flexibility than that in actual transactions even in the 1840s, and in the 1860s, one begins to see quotes given in units of £0.0625 (all for a unit of nominal value £100). The main point, though, is that differences in price of £0.125 during that period were in general not significant, and could often be due just to the drift of prices and the timing of transactions that were reported. (Averaged over longer periods, though, they could indicate a trend.)

As is described in more detail in sections 6–9, CA was unique in trading both for immediate settlement, like the other major gilts, in which case it is denoted CAm, and "for account," denoted CAa, which was a form of futures trading. Almost all studies have been carried out with CAm.

Gilts traded in London with accrued interest. The * symbol is used to denote the price after subtraction of accrued interest. Rational pricing therefore would call for CAm* - RA* to be close to zero. (See Section 6 for details.)

3 The glaring NR pricing anomaly of the late 1840s

The main results of this paper, summarized in the Introduction, and discussed in more detail in the next section, concern the anomalies in the relative pricing of CA and RA. Their mispricing lasted, with just two interludes of more than a year, from 1831 to 1888. It involved securities that paid exactly the same interest rate, had essentially the same redeemability features, and differed primarily in name and dates of interest payments. As a preliminary step, though, we show the economically irrational pricing of another pair of major gilts, RA and NR, in the 1847–49 period. For background information on that period, see the section on "The economic environment of 1845 through 1854" in [52].

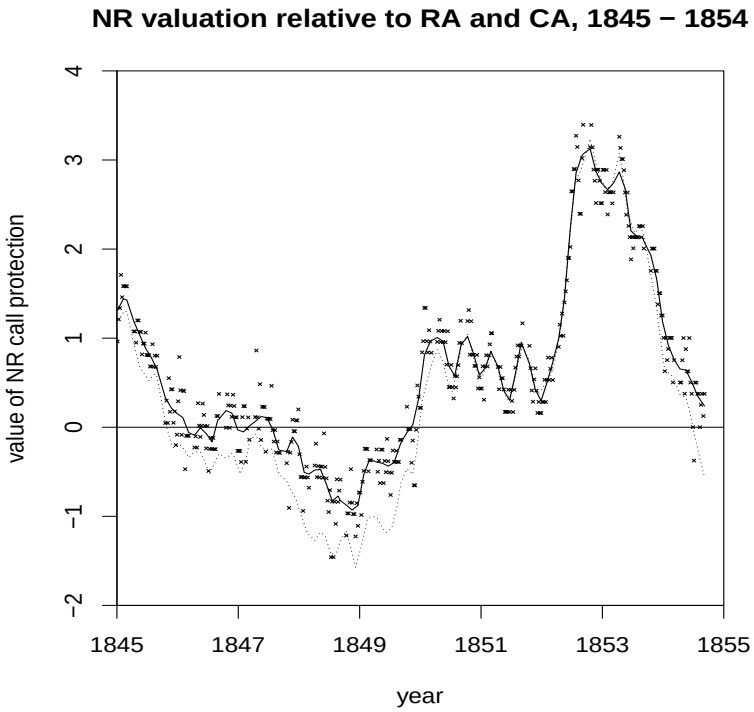

Fig. 2. Market value of NR non-callability, 1845 through 1854, in pounds sterling for units of nominal value £100.

NR before 1855 can be regarded as the combination of NR1 and NR2, where NR1 was a perpetual 3% annuity that could not be redeemed until after the October 1874 dividend was paid, and NR2 was a terminable annuity, paying £0.125 each April and October of 1845 through 1854. (It was regarded as such by contemporaries, too[6].) Except for the differences in redeemability that are discussed later in Section 10, and which did not appear to have much effect on pricing, NR1 was superior to RA by virtue of the call protection. Hence (using italic versions of symbols of securities to denote prices) we should have

$$NR1 = RA + C,$$

where C is the value of not being callable until the end of 1874. Hence rational pricing would force

$$C = NR - RA - NR2.$$

The values NR and RA are given in the price tables, while $NR2$, the value of the finite stream of payments NR2, can be computed explicitly if we are given a discount rate. This was done for each Friday from beginning of 1845 through early September 1854 (when RA and NR trading was shut, just prior to NR losing its extra interest). The prices for RA and NR were the closing prices from *CoE*, the *Course of the Exchange*. (See Section 8 for discussion of data sources.) $NR2$ was evaluated using the market yield of CA on each day (computed using the precautions of [29], as detailed in [52], with the resulting values in

the tables) to discount the interest payments. (The main results are not very sensitive to the discount rate, since NR2 was a rather short annuity.)

Fig. 2 shows the results. The scatter plot displays the values of C that were computed for the 420 Fridays when RA and NR were trading. The solid line is a smoothed version, obtained with the lowess function in the R statistical package. The dotted line is smoothed version (again, using lowess) but applied to a similar data set, in which the price of NR was compared not to RA, but to CA (after adjusting for accrued interest). From mid-1850 to mid-1853, CAm and RA were priced rationally in relation to each other, so the two lines overlap and cannot be distinguished.

The valuations of C shown for early 1845 are not unreasonable, as there were wide expectations interest rates would go lower, leading to redemption of CA and RA. Even the much higher values of C in late 1852 and early 1853 are plausible. Interest rates on gilts were declining to below 3%, the economy was booming, and there were wide expectations of further declines[7]. Had those come true, and had CA and RA been converted into 2.5% securities in the next couple of years, the value of 20 years of 0.5% extra return from NR would have been have been about £8, so a value of £3 for C was not completely unrealistic.

What is totally unrealistic are the negative values of C. In an economically rational world, the value of an option (in this case, protection from redemption) cannot be negative. Yet negative values is what we observe. Not only that, but in mid- to late-1848 those values were very large on the negative side, especially when we compare NR to CA. (CA was substantially overpriced relative to RA during this period.) As an example, tables show that on 28 July 1848, C was valued at a negative £1.46 relative to RA, and a negative £2.21 relative to CA. Since the price of CA (after removal of accrued interest) was £85.81, NR was underpriced relative to CA by over 2.5%, even if we value its call protection C at zero.

That C should be close to zero at that time is not surprising. With market yield on CA close to 3.5%, the prospects of redemption were far from investors' mind. But negative values should not have happened. Especially in this case, the markets could not stay irrational forever. The terminable annuity NR2 was going to terminate in 6 years, so one would expect that sophisticated investors should have been able place leveraged bets on NR rising in price relative to CA. (According to news reports, some may have done this, but apparently not enough.)

This extreme underpricing of NR is puzzling, especially when we look at actual prices. On four days in the summer of 1848, spread over two and a half weeks, the closing prices of RA and NR were identical. Thus not only was the NR call protection valued at zero, so was the £1.50 extra that was due in interest payments over the next 6 years! In this case, the actual pricing was apparently a little less absurd. The equal closing prices for RA and NR were likely an artifact of the market's ups and downs towards the close, and one of the securities not trading at the very end. These 4 incidents are investigated in more detail in [52]. The 3 (and sometimes 4) sources that were consulted for the closing quotes for those 4 days with identical closing prices for RA and NR have varying figures. Still, overall they suggest that at the closes, the quotes for NR were about £0.25 higher than for RA.

So the combination of call protection and £1.50 in interest was not worth quite zero in the market, but a still absurd £0.25. (As in all other cases investigated in this paper, we can discern some rationality, in that no case of NR being priced below RA has been found.)

The supplementary manuscript [52] (especially in the section on the *Daily News* and its coverage of the financial markets in 1848) has some background on this period. It was one of fast recovery from several shocks, and a large influx of "flight capital" from continental Europe. This inflow of money from overseas may have been "dumb capital" unacquainted with NR, and therefore insisting on purchases of CA. But even if that created a major demand for CA, it still leaves open the question as to why British owners of CA and RA did not switch into NR, which was so clearly underpriced. It would have been an exceedingly profitable move, especially if they then switched back to CA or RA in 1853, as is visible in Fig. 2.

Discussions of the overpricing of CA relative to RA during this period have been found in several newspapers, cited later in this paper and in [52]. But much less discussion of the far more dramatic overpricing of CA and RA relative to NR has yet been found in any serial publication in Britain before the end of 1849. Still, one press organ has been found that over an extended period of time kept pointing out the anomaly and urging readers to take advantage of it. This was the *Freeman's Journal,* a daily in Dublin, Ireland. Its gilts coverage is discussed in some detail in [52]. (The Irish gilts market at that time seemed to be somewhat less irrational than the English one.) Overall, though, the almost complete lack of attention to the very large CA vs. NR anomaly as compared to the still large but considerably smaller CA vs. RA anomaly suggests inefficiency in financial analysis available to the public.

NR underpricing provides a very striking example of economically irrational pricing. For the comparison of CA and RA, considerable effort is devoted later to showing that differences in redemption features cannot account for the observed mispricing, and that features such as the term structure of interest rates can not be responsible either. But for the relative pricing of NR and RA, those issues do not arise, as interest was paid on the same dates. Further, NR capital was larger than that of RA, there were more NR than RA accounts, and the liquidity of NR was higher. Perhaps more important, for anyone looking at possible government action as a reason for the mispricing, it was the undervalued NR that had by far the better call protection. (It would take a very improbable scenario of interest rate trends and government actions, spread over several decades, to make RA preferable to NR.)

4 Consols mispricings

Fig. 1 summarizes the evolution of CA overpricing during the period 1823 to 1887. The underlying data, as well as the annual averages that are displayed there, are all in the auxiliary tables. Here we consider in more detail some interesting subperiods of that era, and how the overpricing behaved.

Systematic overpricing of CA relative to RA makes its first appearance (in the post-1822 period that was investigated) in early 1831. It is shown in Fig. 3, together with the

overpricing of N35 relative to R35, from the beginning of 1831 to end of 1844, when the Goulburn conversion replaced N35 and R35 with NR. In this figure, the overvaluations that are plotted are averages over the four roughly two-month periods in each year that all the gilts were trading. (See Section 7 for the system of "shuttings" that limits the amount of comparative data we have.) The four averages for each year are plotted, separately for the two differences, but are multiplied by three, in order to show some details of how this overvaluation varied. (Therefore the highest overpricing portrayed is about £0.60, for N35 vs. R35.) Also shown are two interest rates, the long-term one represented by the market yield on CA, and the short-term one by rates on commercial paper at a London discount house.

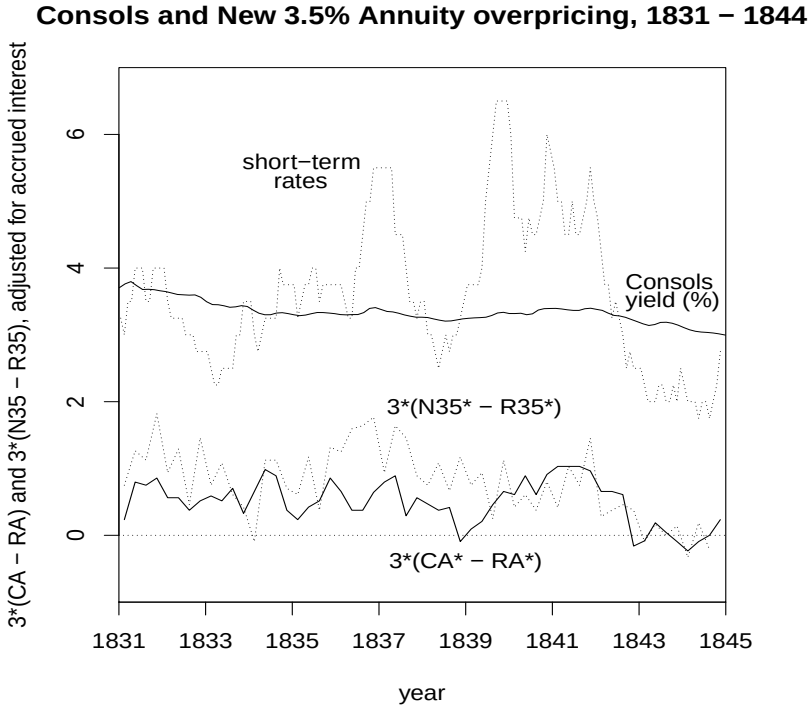

Fig. 3. Overpricing of Consols relative to Reduced Annuities, and of New 3.5% versus Reduced 3.5% Annuities, between 1831 and 1845, in pounds sterling per unit of £100 nominal value, adjusted for accrued interest, multiplied by 3, and averaged over two-month periods when all gilts traded. Also displayed are the market yields on Consols and on short-term commercial loans.

This period was turbulent. At the beginning, there was political turmoil leading to the Reform Act of 1832. Then came the investment mania (centered on railways and joint-stock banks) of 1835–36. Later yet came a crisis associated with the American crash of the late 1830s, with many trading ventures and equivalent of investment banks failing. The late 1830s and early 1840s experienced a very severe depression. However, by 1843 the economy

was on the mend, interest rates were dropping (in the days before paper money and central banks became dominant, interest rates tended to rise in recessions and depressions), and the expectations grew that N35 and R35 would be converted to lower-yield securities, and that even CA and RA might suffer that fate. (The market yield on CA even dipped below 3% in late 1844, the level where the government could find it advantageous to redeem them.)

It is intriguing that for both the 3% and the 3.5% annuities, it was in both cases the larger one and the one with January and July interest payments that was overpriced. The overpricing was never dramatic, especially for CA, so that it was probably not tempting enough for a passive investor in CA to switch to RA. On the other hand, some of the overpricing figures for N35 (see the tables) were high enough to be tempting, for example in August 1837, but such moves might have been inhibited by concerns about conversion. N35 was non-callable until January 1840, and therefore deserved some premium compared to R35. Still, for anyone buying or selling, the market was providing a very clear signal as to which security was less expensive. (The supplementary manuscript [52] considers in detail April and May of 1831, when the first press mention of CA overpricing has been found. The tables have daily pricing data for that period.)

Because of the call protection that N35 enjoyed before 1840, it is natural to break up the period depicted in Fig. 3 into 1831 through 1839, when N35 was not callable, and 1840 through September 1844. The averages of CAm* - RA* over the 284 Fridays of the first period and 126 of the second for which we have data shows average overpricing of £0.17 and £0.18, respectively. For N35* - R35* these averages are £0.33 and £0.15. The correlations between CAm* - RA* and N35* - R35* are 0.22 for the first period and 0.50 for the second.

It might be tempting to run some linear regressions, but it is likely premature, and should await collection of more data of various types. Furthermore, it is not clear how much can be learned from such statistical approaches. One of the biggest puzzles is that the period 1823–30 was by some measures even more turbulent than the one pictured in Fig. 3, yet shows no deviations from economic rationality in the relative pricing of CA and RA. It is discussed in some detail in [52].

It appears that not infrequently, jumps in CA overpricing followed, with some delay, big economic shocks. This applies to the first appearance of CA overpricing in 1831. As is described in [52], in the fall of 1830 there was a dramatic increase in interest rates, followed by more turbulence in early 1831. But the largest overpricing of CA (with daily price data available in the tables) occurred in April and May of 1831, when the markets were rebounding. (There was a very high degree of overpricing of N35 relative to R35 at the end of 1830, right after N35 started trading. That, however, could be ascribed to the call protection that N35 enjoyed and R35 did not, and possible expectations that the jump in interest rates that had just taken place was temporary. More investigation is needed to evaluate that case.)

Another instance of what may be a delayed response to an economic shock is shown in Fig. 4. It depicts CA overpricing during the period 11 October to 10 December 1847, when all the major gilts were trading. This period witnessed the culmination of a long-

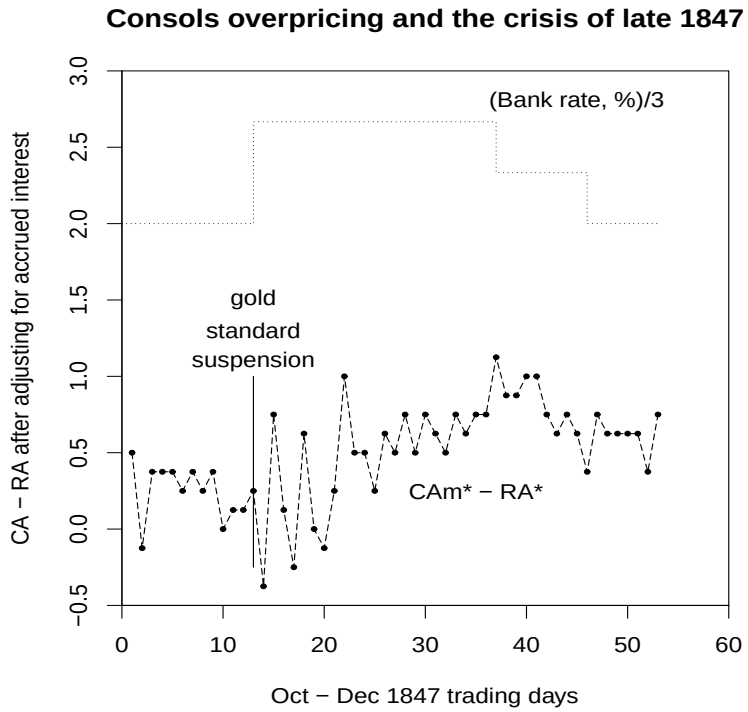

Fig. 4. Overpricing of Consols relative to Reduced Annuities in late 1847, and the rate of discount of the Bank of England divided by 3 to fit on the scale.

feared financial crisis, which led the government to suspend the gold standard (which had been imposed in a strict form just three years earlier, in Peel's Bank Act). The suspension was announced on Monday 25 October 1847, and is marked with a vertical line in the figure. It was accompanied by the rise in the Bank of England rate of discount to what was then an extraordinarily high level of 8% per year. The suspension had a dramatic effect in stabilizing the financial markets. Although the Bank rate continued at the 8% level for a month, other short-term rates dropped very quickly, and so did the market yield on CA (which had actually dropped even before the suspension, as can be seen in the tables, quite likely as a result of panicky "flight to quality"). Yet CA overpricing, after some wild gyrations in the wake of the suspension, experienced a gentle rise during the period following the gold standard suspension.

Yet another example of this phenomenon is associated to the third suspension of the gold standard, in May 1866. That crisis had been brewing for a long time, but was precipitated by the closing of the Overend Gurney discount house. It is discussed, with a chart of the main interest rates and of CA overpricing, in [52]. There was a substantial increase in this overpricing shortly before the crisis, some gyrations during the crisis, and then a gentle rise to very high levels, even as short term rates were collapsing and long term rates were declining.

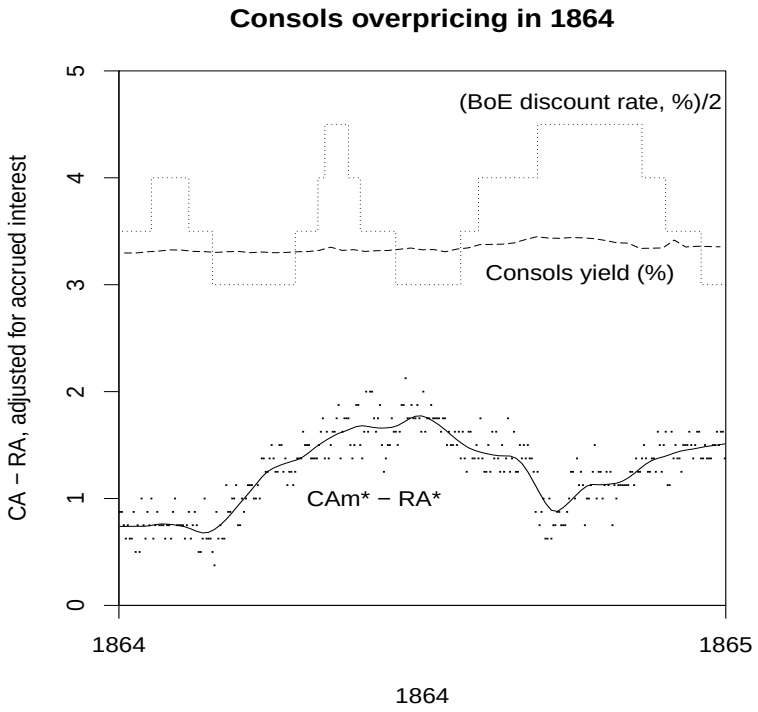

Fig. 5. Overpricing of Consols relative to Reduced Annuities in 1864, based on daily closing prices adjusted for accrued interest, Bank of England discount rate divided by two to fit the graph, and market yield on Consols.

Not all increases in CA overpricing can be associated to obvious economic or financial shocks. In particular, the record high levels of CAm* - RA* that were found in this study occurred in 1864, and are depicted in Fig. 5. (The scatter plot there presents the values of CAm* - RA* for each of the 305 trading days that year when prices of both CAm and RA were available, and the solid line is a smoothed version of the scatter plot.) The only unusual feature of the economic scene, although one that attracted considerable attention in the press, was that short-term interest rates were high, and were fluctuating with great frequency. However, there were no serious economic or political threats. It was clear by then that the North would win the American Civil War, and that Britain would not get involved in a military conflict there. (The Second Schleswig War, between Denmark on one hand, and Austria and Prussia on the other, was a source of some, but not very serious worry.) The shortage of cotton caused by the Union's naval blockade of the South, which led to the disastrous "cotton famine" and substantial shutdown of the textile industry of England's North-West, was on the way to being solved by developing alternate sources of supply in Egypt and India. Britain was very prosperous, with few bankruptcies, and widespread speculation, primarily in new banks and railroads. (There were frequent warnings about a crash of the mania, but it took another two years to arrive, culminating in the Overend, Gurney crisis of 1866 mentioned above.) Yet in the space of about three months, CA

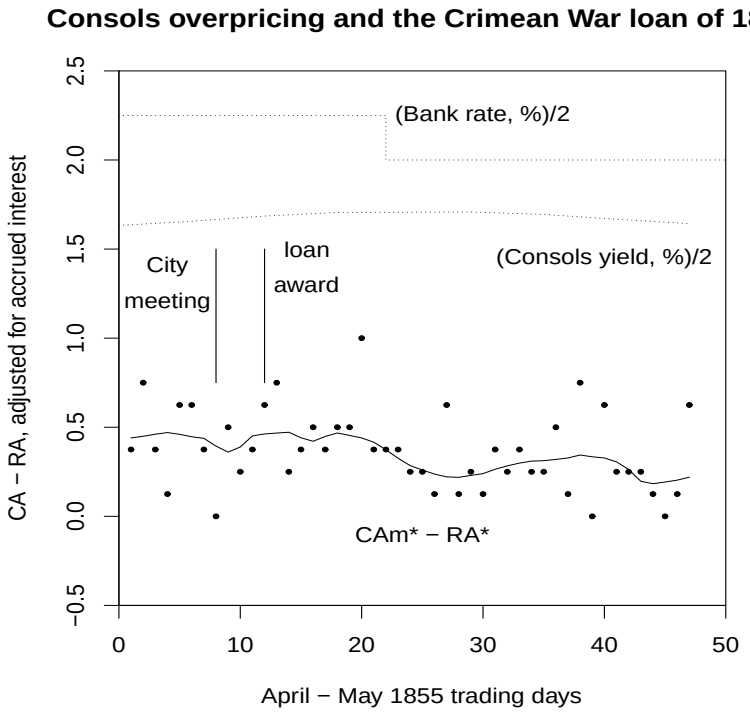

Fig. 6. Overpricing of Consols relative to Reduced Annuities in 1855, based on daily closing prices adjusted for accrued interest, Bank of England discount rate divided by two to fit the graph, and market yield on Consols, also divided by two.

overpricing doubled from an already high level. Then there was a substantial dip in this overpricing in September, just as interest rates spiked, and then the overpricing increased again.

If CA was more highly valued than RA (and NR, after 1854), what happened when the supply of CA increased? (As will be shown later, the British government for the most part, but not always, behaved rationally, in that when it had to borrow, it sold the overpriced CA, and when it had surplus funds to spend on redeeming debt, it bought the undervalued RA and NR.) One large increase took place in early 1847, primarily to provide funds for the relief of the Irish Famine. It increased the volume of CA by about £9 million (of nominal value), or about 2%. This may have been a significant factor in the temporary suppression of CA overvaluation, as is discussed in [52]. Another large increase took place in 1855, to provide funds for the Crimean War, and it created an additional £16 million of CA, or an increase of about 4% of the total volume of that security. Fig. 6 shows CA overpricing based on daily closing prices of CAm and RA between 7 April and 1 June 1855. The scatter plot shows the values of CAm* - RA* for each day, the solid line is a smoothed version, and the dotted lines are the Bank of England discount rate and the market yield on Consols, each scaled by two to fit the figure. The first vertical line marks the meeting of the Chancellor of the Exchequer with leading financiers on Monday 16 April to announce the terms of

the auction. Accurate estimates of how much money the government would need had been made by various observers, but there was uncertainty as to the financial instrument that might be used, and it was at this meeting that the official announcement was made. The second vertical line marks the auction day, Friday 20 April. The CA overpricing was not very large at that time, so the pricing increments of 0.125 lead to substantial scatter. Still, the impression one obtains, say by looking at the smoothed curve, or taking runnning averages that discard outliers, is that the overpricing did decrease after the loan award, but not very much. One could also attempt to attribute this development to the declining interest rates and perception that the Crimean War was going to be concluded soon.

There were two additional loans that the British government took out to cover the final expenses of the Crimean War, in the following year, 1856. They were both again in the overpriced CA, and together created £11 million more of this security. They are discussed in [52]. The conclusion there is that they had little noticeable effect on CA overpricing, which seems to have increased slightly after each.

The supplementary manuscript [52] contains discussions and graphs for several more examples of how CA overpricing behaved during various political, economic, or financial shocks. The tables have detailed pricing data for those and a number of additional periods. The hope is that with more data and deeper investigations, we will obtain insights into gilts mispricings. (For example, daily data, including both closing prices and closing quotes, can provide us with insights into the efficiency of the market in dealing with unexpected developments, insiders leaks, and the like, as is shown in a few examples in [52].) The data we already have show that these mispricings tended to rise and fall in gentle waves. To what extent can we relate those to measurable economic factors, and to what extent are they just products of psychological dynamics of the kind that seem to govern popularity of first names, as in [28,33]?

5 Gilts mispricing and other financial anomalies

Before delving into the details of gilts pricing, data sources, and other background information, we first relate the results of this study to the existing literature on pricing anomalies and challenges to the Efficient Markets Hypothesis.

There are several important features to the mispricing of the major gilts documented in this paper:

- lasted for decades
- involved risk-free government bonds
- mispricing was relative, not absolute
- securities were fundamentally perfect substitutes
- securities were widely held, actively traded, and represented huge capital
- there were no short selling constraints
- trading was completely transparent, with prices widely publicized
- trading was on the same exchange

(This list is a bit simplified. For example, while there was no practical restriction on selling CA short, there were the usual risks of short squeezes, as well as, until 1860, the clearly

purely theoretical possibility of prosecution, as the practice was officially illegal until then, even though it was extensively practiced. Also, RA could not be shorted easily, as it did not trade "for account," but this was irrelevant, as RA was the underpriced security.) There do not appear to be any anomalies in the literature that come close to having all or even most of these features.

On the other hand, major gilts mispricings were rather modest, almost always under 2%, and most of the time under 1%. Many of the well-publicized anomalies, such as the closed end fund puzzle, or the twin shares mispricing, were often far larger.

There is a large literature on mispricings and bubbles. Most papers are devoted either to documenting the existence of an anomaly, and trying to fit it into some model, or else to explaining away the observations as outcomes of rational trading. A few references, which, with their references, provide an overview of this literature, are [4,8,20,31,58,59,60,72,73].

Most of the proposed anomaly mechanisms in the literature clearly do not apply to the gilts mispricings of this paper. As just one example, rational bubbles require high growth rates, which are not relevant to the case of CA and RA, which paid constant interest rate, and so had limited upside. Instead of taking a lot of space explaining why various other concepts are not applicable to gilts, let us consider the few that appear to have some relevance.

Fads and investor sentiments in principle certainly cover the proposed explanation of CA being the more prestigious and therefore more valuable security. However, fads and investor sentiments are usually presented in the economics and finance literature as resulting in high turnover, as investors chase after the next Facebook or Google, and trade in and out. In the 19th century gilts market, though, the problem was not excessive trading, but lack of trading. The long-term investors who owned overpriced CA were simply not switching to underpriced RA and NR. For example, Chapter 5 of [59] builds a model based on underreactions and overreactions to news. Some such mechanism may have been involved in gilts mispricings (if the tentative observation about rises of CA overpricing following economic shocks hold up as more evidence is collected), but to a small degree. What we see in the data is not high volatility, but a stable preference for CA, with the strength of that preference changing slowly.

Similarly, the concepts of noise traders and herding are most commonly applied to short-term moves in the market. We do see evidence of herding among British gilts investors in the 19th century, but it this mechanism seemed to operate in different ways, far more slowly.

The role of heterogeneous beliefs in bubbles and crashes has received considerable attention lately, cf. [72,73]. This phenomenon was certainly at the core of gilts mispricing, with different groups having different valuations. The results of this paper should add depth to the current literature, since they show several heterogeneous beliefs coexisting for a long time, and distorting market prices away from the fundamental values that are unambiguously determined by standard theory.

As is noted in [59] (p. 25), much research has been devoted to limits to arbitrage, but little is known about the psychological bases of shifting investor sentiments. It also appears that little attention has been paid to even learning what information was possessed

by investors when they traded so as to perpetuate and intensify such well-known pricing anomalies as the Royal Dutch/Shell twin share mispricing, or the closed end mutual fund discount. Just how much effort did investment advisors, the press, and the academic community put into alerting the public to the mistakes they were making? This paper explores those issues in depth for 19th century gilts, and it would be interesting to compare to what has happened in more recent, supposedly more sophisticated, times.

6 Relative pricing of gilts in an economically rational world

In this study, CA* denotes the value of CA after subtraction of accrued interest, with CAm* and CAa* specifying whether we are dealing with CA "for money" or "for account" (see the next section for more details), and similarly for RA*. In practice, we are interested almost exclusively in the difference CAm* - RA*, which in a rational market should have been zero. The values of CAm* - RA* that are used were computed by taking the difference of CAm and RA and either adding or subtracting 0.75, depending on where the date fit in between dividend due dates. As we next show, this is not exact, but good enough for the purposes of this study, where the granularity of the data is 0.125.

What should have been the relation in prices of CA and RA, if they were both truly perpetual and risk-free? (We will consider their callability later.) They, and all the other gilts, were sold with the accrued interest (at least until early 1861, when a slight modification described in the next section was introduced). Hence on dividend day (as interest on gilts was called a dividend), the price should have dropped by £1.50, and then (if interest rates remained constant) started climbing. If the four dividend days for CA and RA were spread evenly through the year, and interest accrued evenly each day and did not compound, we should therefore expect that just before CA's dividend was paid, it should have been priced £0.75 higher than RA, and right after the dividend, £0.75 lower, and should have remained £0.75 lower than RA until the RA dividend.

For CA and RA, the assumptions above were not quite correct, but violations of them do not change the conclusions by much. Standard interest computation shows that the difference between interest accruing and compounding each day as opposed to accruing in a linear fashion comes to less than £0.003 (assuming a 3% annual interest rate). Uneven intervals also do not create much error, in that moving the dividend rate by 5 days (and still holding the discount factor at constant 3%) leads to a difference in value of not much more than £0.02. (Dividend days were 5 January, 5 April, 5 July, and 10 October through 1869, and after that, the October date was moved to 5 October.)

Finally, we consider the effect of the term structure of interest rates. By modern theory, each interest payment should be discounted using the interest rate appropriate for that maturity. The interest rate curve is usually either positively or negatively sloped for short and intermediate maturities, and then levels off. Let's consider the effect of two extremes. Suppose that right after CA dividend is paid, interest rates half a year or more out are all taken at 3% per year, while that for a quarter out (corresponding to the next dividend due, on RA) are either zero or 10% (the highest that the Bank of England rate of discount reached, and for only a brief period, in the 19th century). That means the value of that one impending RA dividend varies between £1.50 (for zero discount rate) and £1.46 (for a

10% annual rate), for a range of just £0.04. Thus almost all the time the term structure of interest rates could not have been responsible for more than £0.01 of a difference in price of CA and RA. (Furthermore, any differences in prices caused by a constant term structure would mean that the roles of CA and RA would switch at every interest due date, instead of CA being consistently overpriced relative to RA.)

Given the £0.125 granularity in pricing, we can therefore conclude that the simplifying assumptions in the first paragraph are appropriate, and that economically rational pricing does call for CA to be priced close to £0.75 either above or below RA, depending on where the date falls between dividend payments. That is indeed what various early 19th century observers saw as proper, and at least some knew this was an approximation, but one that was good enough [71].

The argument above about the negligible effect that the term structure of interest rates could have had on gilts mispricing applies just as well to seasonality. There were certainly substantial seasonal effects (explored for the first time in a scientific fashion by Jevons in the 1860s). The rhythm of the harvest seasons caused increased pressure on interest rates in the fall, for example. Perhaps most important, the quarterly interest payments on the national debt caused some perturbations in the financial system. Table 1 shows that in the early 1840s, interest payments amounted to about 5% of the GDP (since interest was at 3% on most of the debt, which is shown in that table at its nominal amount, not market value), and were about half of the national budget in a still primitive economy. These large fund flows led to complaints about tightness of money just prior to those payments, the provision of special loan facilities from the Bank of England for such events, and the like. One of the features of the Goulburn conversion of 1844 was that it equalized interest payments, from a state where about 71% went out in January and July, necessitating extensive short-term borrowings, to almost exact equality. Goulburn boasted of this feature in his speech, and was applauded by the MPs who listened to it[8]. For individuals, though, there continued to be inconveniences, as many payments, for rents, in particular, fell on 25 March, while the interest on gilts was not due till 5 April, and was not paid until a couple of days later[9]. Still, these were effects that caused some inconvenience and some perturbations in interest rates, but relatively mild ones that the British banking system was able to accommodate routinely. They were nowhere near sufficient to account for the CA overpricing that has been discovered. Further, if seasonality were a factor, why were there extended periods of rational pricing?

The rational relation in prices of N35 and R35 should have followed the pattern of CA and RA, except that the difference should have been close to £0.875 in favor of one or the other. Hence the values of N35* - R35* computed in this study were obtained by either adding or subtracting £0.875 from N35 - R35.

7 Gilts trading and "shuttings"

The price records for gilts that were used in this study came from the London Stock Exchange, the only organized place for gilts trading in Britain. (As is sketched in [52], there was also some gilts trading in Dublin, Ireland, and some informal trading elsewhere in Britain.) This exchange operated 6 days a week, excepting a few holidays, and each of

the major gilts has an official record of trades on almost every trading day that it was open for trading. (For minor gilts, as well as for most joint-stock company shares, including those of the Bank of England, there were often extended periods with no trades, a reflection of the low turnover rates of 19th century markets.) Except for CA, gilts traded "for money" (or "for delivery"), meaning with the transaction taking place and money changing hands right then, although there were some variations. In contrast, joint-stock company shares almost invariably traded "for account," with the transactions completed at the twice-a-month settlement days. (This was futures trading, in effect.) In gilts, trading "for account" was officially done only in CA for most of the 19th century. CA account settlement days, initially somewhat irregularly spaced at an average of about 6 weeks apart, were moved in the late 1840s to a more regular monthly schedule. In this paper and in the tables, prices for CA are often denoted CAm when referring to prices "for money" and CAa when referring to "for account" transactions.

For a long time, trading in gilts "for money" was suspended ("shut," standing for the transfer books being shut) for about a month before the dividend due date, to allow the Bank of England to prepare its accounts for the payouts. Starting in June 1861, this was dropped, in that the Bank of England would declare a date about a month before the dividend was due, and the dividend would be paid to owners of record as of that date, while that gilt would trade on ex-dividend basis. Hence from that point, we have a continuous series of CA and RA prices "for money" to compare. (The valuation formula changes slightly when a security goes ex-dividend before the due date, but the difference between the simplified formula that adds or subtracts 0.75 from CA - RA to compute CA* - RA* and the correct formula with compounding at a constant 3% per year is still under £0.005 so was neglected in the tables and figures.) Until 1861, though, there were about 4 months each year when it was impossible to compare prices of CA and RA "for money," as one or the other was shut. The data collected for this study, and available in the tables, lists prices for both CAm and CAa. Use of CAa would enable comparison of prices of CA and RA during two of the four months that are missing. However, it was decided not to do this. Differences between CAm and CAa depended on a variety of factors, such as the remaining time until the next CAa settlement day, the interest rate on the Stock Exchange (for which we have only sporadic records), and the volume and direction of speculative activity. Any attempt to compensate for all these factors would have some elements of choice that could be questioned, and so it was decided to stick to the unambiguous comparisons of gilts trading "for money," even though that limits the coverage. Similarly, even when the official record show some trades in gilts when they were shut, this was recorded in the tables, but not used in the study. Such trades most likely represented unusual transactions, various distress sales or purchases, and so probably are not representative of what an active market would produce.

8 Sources of data

The data for this study came primarily from two sources. The *Course of the Exchange,* abbreviated as *CoE*, provided most of the data for the period 1823–60, primarily in the form of closing prices on all Fridays. The *Economist* was used to obtain the Friday closing

quotes for 1861–87 (for some years for all Fridays, for some for samples of 16, usually 4 from each of February, May, August, and November). However, for some periods additional, more detailed, data sets were collected (such as the daily closing prices used to prepare Fig. 5). At this point we just remark that these sources are standard ones that have been used for previous studies (*CoE* for [6] and *Economist* for [29], for example). An extended discussion of these sources and other ones is available in [52]. That discussion contains some comparisons, as the data sets that were assembled are far more extensive than mentioned above. Here we just mention that when closing quotes were used to compute CA mispricing, it was just the bid prices that were used. This resulted in a slight upward bias for the estimates of CA overpricing that were produced, since bid-ask spreads for RA, discussed in the next section, were larger than standard ones somewhat more frequently than for CA. However, the difference is small enough (under £0.01 for most years where it was computed) that it was ignored in the interests of simplicity. (The tables for this project contain the bid-ask spread data.)

Almost all British newspapers of that era carried one of the two sets of data, either actual transaction prices, as in *CoE*, or closing quotes, and in some cases, both. While there are differences between them (as explained in [52]), they provide essentially identical estimates of CA overpricing. Thus the British public had the raw data demonstrating the pricing anomaly presented to them on a constant basis by the press. Most of them may not have known how to interpret that data, and, in an environment of very limited information (by our standards), may not have known how to find out how to interpret it. Still, they had the basic data readily at hand.

Several of the figures in this paper include statistics on interest rates, to provide some indication of the monetary conditions that might have influenced the observed mispricings. They are standard ones that have been used by other scholars, and are explained in [52].

In Fig. 1, the dotted line is drawn at 3%. This was a critical level for government policy, as it was the yield on the nominal value of CA and RA (and of NR, after 1854). It was only when the market yield on CA came close to that level that there was a substantial prospect of redemption of either CA or the other major gilts.

9 Transaction costs

Transactions in almost all joint stock company shares were subject to a stamp tax, which was about 0.5% of the value. However, gilts (as well as shares of the Bank of England, and a few other securities) were free of that tax (e.g., [65], pp. 724–25).

The income tax, which was brought back in 1842, after its first test in the French and Napoleonic Wars, was at a low rate (a bit under 3%, somewhat more than doubling on a temporary basis during the Crimean War, and then moving up and down, but never exceeding 5% through the end of the 19th century, except for the Crimean War period). In any case, income tax did not apply to capital gains, and so would not have inhibited arbitrage. Hence taxes are disregarded in considering trading of the major gilts[10].

CA, RA, and NR were all conventionally quoted in units of £100 of nominal value. For company shares, or even so-called "stock" of such companies (which, like the gilts, were

book-entry entities, normally without issuance of paper certificates), brokerage charges were based on market value. For the gilts, broker commissions were based on nominal value. In the 19th century, the standard commission on the London Stock Exchange was 1/8, or £0.125 for a unit of a gilt with nominal value £100. (Rates were higher for shares of companies.) This commission rate was not enforced by the Exchange, and one can find occasional ads for brokers who advertised discounted rates, but those were rare, and contemporary investment guides throughout that period all cited this standard rate of £0.125 as the prevailing one. But this was only for small investors.

Large investors could obtain brokerage commission discounts ([62], p. xxxii), but there does not seem to be any information on how often this happened. The *Economist* claimed that "large transaction in [CA] can always be effected at a commission of [half the standard level]" but it did not quantify what it meant by a large transaction[11]. Investors could also have their own broker, as admission to the London Stock Exchange was easy, with no need to buy an expensive "seat" as on the New York Stock Exchange, for example. As is shown in [52], the Court of Chancery paid less than 40% of the standard rate, while the government employed a salaried broker, so its marginal brokerage costs were zero. Some investors were members of the Stock Exchange just as speculators for their own account so also did not have to bear the costs of commissions.

In considering regular retail investors, on the other hand, it appears best to assume that they paid the standard £0.125 rate. It is certainly a safe upper bound on their expense. However, when they sold a security and immediately purchased another one, they usually paid only one commission[12].

Short sales of gilts were generally done only in CA, since it was the one that traded "for account." That would not have been an impediment to arbitrage aimed at eliminating CA overpricing, since that called for selling CA short and buying RA or NR. However, transaction costs would have been a heavy burden for a retail investor if the short position were maintained for any significant length of time. At each account day, half of the regular commission was charged ([34], p. 215).

The London Stock Exchange had brokers who transacted business on behalf of the public, and jobbers (in other venues or other times also called specialists, dealers, or market makers) who bought and sold to brokers. Retail investors would go to brokers to buy or sell gilts. Brokers (assuming they were members of the London Stock Exchange, otherwise they would have to go through corresponding brokers who were members) would then go to the floor of the Exchange, and ask the jobbers for quotes. The usual rule was that the jobber would give a quote, without knowing whether the broker was interested in selling or purchasing. If the broker found the quote acceptable, he would then reveal whether he wanted to buy or sell at the quoted price, and the transaction would be completed. Thus retail investors had an additional cost, on top of the commission, namely the jobber's bid-ask spread, known then as the "turn." For CA, RA, and NR, the jobbers' spread was almost always £0.125, equal to the brokerage commission. Occasionally, especially in times of panic, it would get wider, but this was infrequent. (See [52] for some statistics in the section on liquidity. Not unexpectedly, this happened more frequently for RA than for

the larger CA.) Large investors could do better, and jobbers and speculators who were members of the Stock Exchange could also limit that cost.

The general conclusion is that small retail investors usually faced transaction costs of £0.25 for a unit of nominal value £100, but seldom more than that. Larger traders, and of course members of the Stock Exchange, could profitably exploit much smaller mispricings. But a small investor who had CA and wished to exchange into RA could do so with profit once CA overpricing exceeded £0.25, since he or she would pay a single commission and a single "turn," each of £0.125.

The language of various investment guides from the 19th century makes it clear that the writers regarded most of their readers as very unsophisticated, and unlikely to be familiar even with the simple calculations needed to compute accrued interest. However, even the least sophisticated investors should have seen the advantage of exchanging CA for RA once overpricing reached £1.00, as it did for extended periods. At that point, say in February of some year, after CA interest had been paid, the quoted price of a £100 unit of CA that was printed in any newspaper would be at least £0.25 higher than the price of RA. So, the commission and jobber's "turn" involved in swapping a unit of CA for a unit of RA would be covered by that £0.25, potentially with a bit of cash to pocket if the overpricing exceeded £1.00. Afterwards, the amount paid out in interest would stay exactly the same, but the next interest payment would come on 5 April, instead of 5 July. Afterwards, all other interest payments would be similarly accelerated by a quarter. The benefits of that should have been clear to anyone, even those not able to do simple interest accrual computations.

10 Differences among the major gilts

This section considers differences among the major gilts. They were not quite identical. Hence we need to consider whether the variations among them could have led in a rational market to the differences in prices that have been observed.

Each of CA, RA, and NR carried the full faith and credit of the British government. Furthermore, ever since their creation in the middle of the 18th century, CA and RA were regarded as the basic financial instruments of the government, and were treated as fully equal. For example, the government determined the price of annuities it sold to individuals by averaging the prices of CA and RA after adjusting for accrued interest (pp. 26-27 of the 1840 edition of [45]).

The most obvious difference between CA and RA (and after 1844 also NR) was in the dividend payment dates. Many investment guides suggested splitting investments between CA and RA in order to obtain quarterly payments (for example, [24], p. 250, which was reprinted in [37]; [10], p. 60; and [34], p. 116). The general opinion seemed to be that this tactic was widely practiced, but there are some reasons to doubt whether this was correct.

Until 1861, the "shuttings" at the Bank of England (described in Section 7) provided a strong incentive for large institutional investors to split their holdings between CA on one hand, and RA and NR on the other. This is reflected in the advice of James William Gilbart, a banker and prominent writer on banking, who wrote in the 1840s ([19], vol. 1,

pp. 82-83) that CA was the best security for a bank to hold, since it was the most liquid. However, because of the approximately two months in the year when trading in it was restricted,

> [i]t is not advisable, however, that all the stock a banker holds should consist of [CA]. ... it is better he should divide his stock [i.e., gilts], and hold half the amount in [CA], and half in [RA or NR].

After mid-1861, this advice was not as relevant, and so it is possible that institutions, such as banks and some insurance companies, which might be faced with sudden demands for cash, may have preferred to put most of their reserves in CA.

The other major differences among CA, RA, and NR concerned their callability. All were redeemable by the government, but not by investors. But the government was constrained by the magnitudes of these instruments, as well as by some legal conditions, discussed in the next section. In order to redeem them, it had to borrow, and the only place it could borrow enough was in effect from the people who were about to receive the cash (even if those sums went through banking intermediaries). So in effect it was a strategic game, in which the investors had some power. This was already apparent in the 18th century, when national debt was far smaller [11]. In the 19th century, the government usually tried for voluntary conversion with the implicit or explicit threat of forced redemption. Details of some of those operations are presented in [52].

NR could not be redeemed at all until the end of 1874. After that, though, it was subject to immediate redemption. CA and RA, on the other hand, could be redeemed before as well as after 1874, but both required a year's notice. This long notice period was felt to be a major constraint by many Chancellors of the Exchequer, since monetary conditions could change drastically in a year[13]. This pretty much limited them to quasi-voluntary measures. Edward Hamilton provided a very interesting and apparently completely frank account by a high-level insider of the deliberations that went into planning the Goschen conversion [23]. He wrote that a variety of combinations were considered, and that there was some thought given to having different treatment for RA than for CA, since the amount of money in RA was much smaller. In the end, NR was redeemed with a couple of weeks' notice. (The default, in the absence of specific request from an investor for cash, was conversion into the new "Goschen Consols," as they were sometimes colloquially called. Very few holders made such requests.) On the other hand, CA and RA holders were treated equally, and were invited to voluntarily switch into the Goschen Consols, with a £0.25 bonus in cash (for £100.00 of nominal value of their security). This offer was accepted by an overwhelming majority of CA and RA holders[14].

Could the different conversion features account for the gilts mispricing that is documented in this paper? This possibility has to be considered seriously, since a speech in 1884 by Hugh Childers, the Chancellor of the Exchequer, made the price of NR rise by more than 1% relative to CA and RA for a few days, and it took a few weeks for the earlier pricing relationship to be restored. Childers proposed a voluntary conversion of the major gilts, and in presenting it to Parliament he put forth his interpretation of the laws and precedents, which made it appear that NR might be much harder to convert. (Details are in [52], as is market reaction to his proposal as well as to the actual conversion.) However,

this was an anomaly, and had a substantial (although short-lived) impact largely because it occurred in a low interest rate environment where a conversion was widely anticipated, and where CA overpricing was slight. The largest CA overpricing occurred in the 1860s, when redemptions did not seem to play a major role in investors' thinking. We can see this quantitatively by comparing pricing of NR and RA. NR had the advantage of being absolutely irredeemable until 1874, and of being larger, so that it was harder to redeem than RA. After 1874, though, it could be redeemed quickly (although size still made that harder than for RA), whereas RA required a year's notice, with its attendant risks. Yet, as the tables show, prices for NR and RA were essentially identical from 1858 until the Childers speech in 1884, a period of 26 years that saw record levels of CA overpricing and the expiration of NR call protection. They were also essentially identical in 1885–87, after the disturbance occasioned by the Childers speech had died down. Given this disregard by investors for the differences between RA and NR, it seems safe to conclude that the different conversion features did not provide a rational basis for CA overpricing as compared to RA. That was also the view of contemporary observers. Giffen wrote that the major gilts were "indistinguishable in their legal conditions of value" (see the full quote in Section 15.3), and others made similar comments.

11 Gilts ownership

Most of the contemporary rationalizations for CA overpricing relied on the greater liquidity of this security, or on its use by speculators and other financial institutions. This argument would be persuasive if the supply of CA had been limited, and the financial sector were the main holders of them. But that was clearly not the case. It is not plausible even from a very high level point of view. Table 1 shows that as late as 1860, the volume of CA was close to half of the UK GDP, which is far more than what one could imagine would be needed for liquid reserves. But there are other ways to see this argument could not be correct.

We have little solid knowledge of the distribution of gilts ownership. (Studies such as [25], which looks at gilts ownership in the 18th century, are based on records of a few individual investors only.) However, we do have precise data about the number of accounts, and somewhat less precise data about the distribution of account sizes. For example, in early 1860, there were 131,990 CA accounts, 35,695 RA accounts, and 85,334 NR accounts[15]. If we compare that to the capital of each of these annuities, as given in Table 1, we see that the average size of an account was around £3,000 in each. More detailed studies, covering several decades, and considering also the distribution of account sizes, are presented in [52], and show that all three gilts were similar in those respects, and varied similarly with time. This suggests that the holders of these accounts did not differ much, and is therefore not consistent with claims that CA was owned primarily by the financial sector. Had that been true, we would surely see far more large accounts in CA than in the other gilts.

Total turnover (thus not just market transactions, but also gifts, bequests, and the like) over the period 1855–79 averaged 34% for CA, 27% for RA, and 32% for NR. (Details are again in [52].) This is consistent with contemporary claims that speculators and other financial institutions used primarily CA to park their cash. However, the effect was not huge, so this again suggests that the financial sector was not the dominant holder of CA.

We do have some comprehensive and apparently reliable figures for British joint-stock banks. In 1884, the *Economist* estimated they held about £46 million of various forms of British government securities, and that of this slightly under £40 million was in gilts[16]. One can imagine that insurance companies might have held similar amounts. But that is still far from the total volume of CA. Further, we do have snippets of evidence that demonstrate that banks and insurance companies did hold substantial amounts of both RA and NR[17].

The general opinion was that gilts were held primarily by trusts and very cautious individuals. There are certainly many examples of both classes, as is shown later in this paper and in [52]. It would be nice to know what fraction of various gilts, and in particular of CA, was held by such investors. But for the purposes of this paper, that is not essential. It is enough to show that there were many long-term gilts holders who owned CA. In an economically rational world they would all have switched from CA to RA or NR during periods of CA overpricing. That they did not demonstrates the main point of this paper, that the market was inefficient.

12 Fiscal repression and gilts held by public agencies

Many developed economies are facing extremely high and growing debt levels. In the search for solutions, fiscal repression is increasingly being proposed as one tool. Drelichman and Voth [14] have argued that fiscal repression was also a key reason for Britain's success in sustaining a huge debt burden in the 18th century. By itself, of course, fiscal repression is not enough, as a large pool of savings is needed to have something to repress, as Gelderblom and Junker [16], for example, show for the Dutch in the 17th century. But it is interesting to consider just how important a tool this was.

In the 1823–1187 period of this study, the bluntest tool of fiscal repression discussed by Drelichman and Voth, namely the usury limit on interest rates, was not a factor. Usury laws were gradually relaxed. More important than that, though, interest rates dropped, so usury ceilings were simply not relevant. However, there were other inducements that operated to push investments into gilts, primarily the limitations on how various trust and public funds could be invested (cf. [12]). Although the restrictions on trust investments were gradually relaxed, trustees were very conservative (as is shown through the examples of Cambridge and Oxford universities, and of the Greenwich Hospital, among the cases discussed in [52]) in taking advantage of them. Further, investments made by the government on behalf of savings banks had to go into gilts. Contemporary observers seemed unanimous in claiming such measures had a large impact in raising the price of gilts. A very strong opinion in this direction was expressed by Francis Playford, a broker, in 1855 ([54], p. 40) and then in a revised version of his pamphlet in 1865. Giffen expressed a similar opinion in 1899 ([18], vol. 2, Chapter XXI). However, that is not the topic of this paper, and we are interested primarily in large owners of gilts, and the degree to which they took advantage of CA overpricing.

We can get interesting insights by considering an accounting of the gilts held by some public agencies at the Bank of England[18]. This document shows that in February 1870, those bodies held £93.4 million, or over 12% of the entire national debt of the UK. Almost 90% of this amount was held by just two organizations, the Court of Chancery and the

Commissioners for the Reduction of the National Debt, which will be discussed below. All the other institutions in that list accounted for just £11.4 million, but that was still 1.5% of the national debt. In most cases, these were long-term holdings, whose steady interest income was used to fund various long-term activities. The rational income-maximizing strategy would have been to concentrate all holdings in RA and NR. However, we find that of this £11.4 million, 55% was in CA (with 38% in RA and 7% in NR), which was far from optimal.

It is striking that the agencies in that 1870 compilation seemed to be following different policies in their gilts investments. For example, Queen Anne's Bounty (a charity to support the poorer clergymen in the Church of England) had only about 20% of their gilts in CA, with the rest in RA and NR. On the other hand, the Ecclesiastical Commissioners held about 84% of their gilts in CA. Why the disparity? Was this just because the management of Queen Anne's Bounty was more financially sophisticated? Hopefully some further research will shed light on this question.

Greenwich Hospital was among the most rational investors among the agencies discussed above. In the 1870 accounts, it showed up with just 24% of its substantial (£2.3 million) gilts investments in CA. The supplementary manuscript [52] presents some additional information that has been found in other Blue Books about its accounts from 1859 to 1882. During that period it went from having over 40% of its gilts investments in CA down to 10%. What happened is that it held onto its underpriced RA, and funded its investment diversification and other expenses by selling the overpriced CA. This certainly suggests some awareness of income maximization opportunities. However, no trace has been found of any attempt to simply switch from CA to RA.

The Court of Chancery was surely the largest holder of gilts for most of the 19th century. It was also among the most irrational. In 1870, it controlled £57.7 million in gilts (most apparently on behalf of over 20,000 trust accounts that it administered), and 75% of that was in CA. There is a separate section devoted to it in [52]. It was a complicated institution. Reformers spent much of the 19th century trying to reduce its corruption and inefficiency. Until some time in mid-century, it apparently had a rigid rule that, except in unusual circumstances, all financial investments had to be in CA. That did change, but in practice the change in investment direction was slow. As an interesting observation, this court controlled two funds with uncertain ownership. The income from those two funds was at the disposal of the court, and did not go to trust beneficiaries or lawsuit litigants. In 1861, those funds were invested in a more rational mix of 45% CA and 55% RA.

All the agencies cited above were under some degree of oversight by the British government, so their irrational investment policies could be ascribed to a general tendency for governments to be inefficient. However, we find the same phenomena among independent charities, such as the universities of Cambridge and Oxford, which are discussed in [52].

13 The Chancellor of the Exchequer and the gilts market

Among the agencies whose gilts holdings were included in the 1870 compilation cited in the preceding section were the Commissioners for the Reduction of the National Debt. In practice, the decisions of that body were made mainly by the Chancellor of the Exchequer.

The 1870 gilts holdings of these Commissioners amounted to £24.3 million, and consisted of 38% CA, 31% RA, and 31% NR. Thus on the surface, these investments are more rational than average. But why have even 38% CA?

The gilts holdings of the Commissioners for the Reduction of the National Debt represented primarily funds coming from savings banks, Friendly Societies, the Post Office Savings Bank, and similar bodies. Starting early in the 19th century, the British government started offering fixed interest rates on money deposited with it by such organizations, rates that were revised periodically and were typically comparable to the market rates on gilts. The money coming in from these institutions was held in special accounts. However, as was widely recognized, this was basically an accounting fiction. The government was guaranteeing the value of the deposits as well as the interest rates. Since the market value of the deposits was overwhelmingly below the nominal amount, the deposited money was really the government's, and the better it could do at investing those funds, the lower the losses that had to be covered from general tax revenues. Thus the rational policy would seem to call for investing in the underpriced RA and NR. However, these funds had special challenges. They tended to see inflows when times were prosperous, and outflows when there was economic turmoil. Hence they had to think of their gilts holdings not just as long term income producing investments, but to a large extent also as liquid reserves. So the Chancellors of the Exchequer may have felt that it was worth paying extra for the additional liquidity that CA offered. They may also have decided rationally that since markets were irrational, the hard times that led to withdrawals from savings banks, say, would lead to the underpriced RA and NR becoming even more underpriced. Therefore until a deeper investigation is carried out into the deliberations and policies of the Commissioners for the Reduction of the National Debt, we cannot be sure they were acting irrationally by having a substantial part of those funds in CA.

Aside from managing the funds for savings banks and similar bodies, the Chancellor of the Exchequer interacted with the money market in two other ways. One was in borrowing, either for short-term needs, or longer term. The second was in reducing debt. As was mentioned in the Introduction, Table 1 suggests some economic rationality, in that it was the underpriced RA and NR that were reduced the most during the period covered there. The bulk of the changes that are visible in that table, however, will need to be investigated in more detail before we can say much about them. They involved moves such as converting gilts held by the courts or by the Commissioners for the Reduction of the National Debt into terminable annuities, or else repurchases of Exchequer bills that were followed by conversion into gilts and cancellation. The precise terms on which these maneuvers were carried out will need to be found, and their effects evaluated. A complicating factor is that many of the operations of the Chancellor of the Exchequer in the money market were not necessarily motivated by simple financial considerations (and were often criticized for that reason by the press and even by Parliamentary committees, such as [67]).

Here we consider just a few operations where a clear choice between CA and RA had to be made. First we look at increases in debt. Heavy long-term borrowing by the British government basically stopped with the end of the French and Napoleonic Wars in 1815. But there were a few exceptions, and we consider the five largest ones.

In 1835–36, £20 million was borrowed to compensate slave owners for the emancipation of their labor force. Of this amount, £15 million was contracted for in 1835, in a mixture of CA and RA. (The 1836 loans were in 3.5% bonds, the R35 cited earlier, so are ignored here, as we are only interested in the relative pricing of CA and RA. A deeper investigation would consider the 1836 loans, as well as various other government financing operations, such as issuance of life annuities and short-term financing operations.) For each £100 in cash, the investment bankers received £75 in CA and £25 in RA, plus a terminable annuity to make up for the fact that both CA and RA were trading below par. Since CA was only mildly overpriced that year (an average of £0.17, as is shown in the tables), this choice of securities cannot be criticized too much.

The next large addition to the national debt occurred in early 1847, in order to provide funding for the relief of the famine in Ireland (and to a lesser extent in Scotland, where large regions were as severely affected as Ireland). The loan provided for the supply of £8 million in cash (in installments) for approximately £9 million of nominal value CA. The supplementary manuscript [52] provides more details and a graph of the behavior of CAm* - RA*. Since CA was then overpriced, using it in preference to RA was rational. The award of the loan appears to have eliminated CA overpricing for a few days.

Then there were the three Crimean War loans of 1855–56. The one in 1855 is discussed in Section 4, the two of 1856 are presented in [52]. All three were in CA, which was overpriced at that time. Thus in all these cases of large scale gilts issuance, the government did the rational thing, namely issue the overpriced CA.

A remarkable phenomenon is that no comments have been found, in either Parliamentary debates, or in the press, about the reliance on CA as opposed to RA or NR in any of those last four loans. There were debates about the loans, with some ardent advocates of other means of financing the government's needs, such as terminable annuities. But nothing appeared to be said about selling CA instead of RA. Hopefully further research will identify some internal government documents that will reveal how the decisions were made.

Large scale debt issuance came on only a few occasions in the 19th century. But for much of that period, the government was reducing its debt by using budget surpluses to repurchase gilts and other securities in the market. The Commissioners for the Reduction of the National Debt were set up for just this purpose, and their operations are summarized in [70].

Government purchases of gilts were handled by a salaried employee, often cited in the press as the "government broker" ([67], p. 269). His purchases for debt reduction purposes were announced in advance for each quarter, and occurred on a regular basis during that quarter[19]. The table on pp. 46-47 of [70] presents market repurchases of bonds from 1829 to 1890. Much of the activity was in various short term financial instruments, which we ignore. We also ignore repurchases of gilts with interest rates other than 3%, and of minor gilts, in order to concentrate on the major gilts.

The direct repurchases of CA, RA, and NR over the entire 1829-90 period amounted to £6.6, 13.9, and 7.6 million, respectively. Thus, at first sight, they do appear to have been concentrated in the undervalued RA and NR. An even more favorable picture of the finan-

Table 2. Government repurchases of the major gilts, 1871–76.

All figures in millions of pounds sterling.

year	CA	RA	NR
1871	-	1.154	0.897
1872	-	0.064	0.750
1873	-	1.001	2.024
1874	1.212	1.771	1.253
1875	0.100	0.528	0.191
1876	0.031	0.248	0.078

cial sophistication of the British government emerges when we consider these repurchases year by year. The period 1829-90 included some stretches when CA and RA were priced at equivalent levels. When we look at individual years, we find that, generally, CA was bought during such periods (at least based on the limited data available for some years), and so this shows rational behavior. But there are some puzzles. Fig. 1 shows that CA was consistently overvalued relative to RA during 1872–74. (NR was priced almost exactly the same as RA.) So it would have made sense for the British government to purchase RA and NR only. And indeed that is what it did in 1872 and 1873, as is shown in Table 2. But in 1874 it repurchased a substantial volume of CA. That invites a deeper exploration. The reason might possibly be just the financial sophistication of the relevant officials. During 1871–73, Gladstone was the Prime Minister. Robert Lowe was the Chancellor of the Exchequer until the middle of 1873, when Gladstone took on this position himself. Both Gladstone and Lowe were regarded as sagacious financiers. However, in February 1874, Gladstone's government was replaced by Disraeli's, and Northcote became the Chancellor of the Exchequer. "There is general agreement that Northcote was an able and innovative chancellor," but there were also some negative opinions about his performance [36]. The 14 June 1875 letter addressed to him by C. Rivers Wilson, the Controller of the National Debt Office[20], which is discussed in [52], could be taken to imply that the writer was trying to educate his boss about the overpricing of CA. But more research is needed into this issue before we can be sure.

14 The gilts investments of Post Office Savings Bank customers

After considering gilts investments of some large public agencies and of the government itself, we next look at an intriguing example of the decisions of very small investors.

In 1880, Parliament passed a law allowing customers of the Post Office Savings Bank to invest directly in gilts. From the start of operations of this new service on 22 November 1880 through 31 March 1881, customers made the investments shown in Table 3. Data is from the annual report of the Postmaster General[21].

Table 3. Post Office Savings Bank customer investments in gilts, 22 Nov. 1880 to 31 March 1881.

gilt	number of investments	aggregate investments	average investment
CA	3,202	£173,133	£54.07
RA	481	26,301	54.68
NR	3,291	187,309	56.92

As was noted in Section 11, the average size of an account in the major gilts was around £3,000. The accounts represented in Table 3 on average were less than 2% of that. So they represented holdings of much poorer strata of the population[22]. The report of the Postmaster General did note that the high prices of gilts seemed to discourage investments. It even cited some of those prices, noting that on 27 November 1880, CA was at 100.625, while RA and NR were at 98.875. However, it did not make any remarks at all about the disparity in these prices, which meant that CA was overpriced by £1.00. Over the four-month period of the report, CA was overpriced by a minimum of £0.615 and a maximum of 1.063, and by 0.82 on average[23]. Hence these poor customers do show some, although limited, rationality. CA was a noticeably smaller fraction of their portfolios than among the entire population of investors, about 45% as opposed to 57%. But why the preference for NR over RA? It would have been unreasonable for anyone at that time to anticipate that Goschen in 1888 would offer holders of RA more than the holders of NR (even if only £0.25 more), but there did not seem to be any reason to regard RA as less desirable than NR. Market transactions and jobber quotes around 1880 were identical for the two.

The next few Post Office annual reports do not contain information about which gilts customers were investing in, only about totals. However, we can make some inferences from the first Post Office report that deals with the inevitable changes caused by the Goschen conversion[24]. It mentioned that of about 43,000 accounts holding £3.8 million, there had been "over 21,000" (and thus almost surely under 22,000) in NR. That suggests that NR investments had been about half of the total in 1888, which is what we observe during the initial account opening period depicted in Table 3. Also, at the end of 1888, the Post Office Savings Bank held £270,784 of CA (in nominal value), and £40,386 of RA. Those amounts could only have belonged to customers who owned those gilts through the Post Office Savings Bank and who refused the Goschen offer to convert, and were waiting to be paid off in the summer of 1889. If those refusing to convert were the same fraction among CA owners as among RA owners, we could extrapolate that in early 1888, before the conversion, all the Post Office gilts accounts held about 7 times as much CA as RA, which is again remarkably similar to the ratio we find in Table 3. This suggests that the biases among Post Office customers which determined where among the gilts they put their

money were stable over the entire period from the end of 1880 to early 1888. So far nothing has been found in the literature about those biases, and where they came from.

15 Contemporary views on gilts mispricing

The supplementary manuscript [52] has much more comprehensive coverage and many more citations from 19th century publications. This section presents a brief overview.

15.1 Early expectations of rationality

The regular relation of CA and RA prices, which was to be expected in an efficient market, was also understood to be natural, and typical, in the early 19th century. Thus, for example, a pamphlet published in 1806 by Robert Wade, a member of the London Stock Exchange, mentioned that in principle one should compute the accrued interest exactly, but in practice it sufficed to add or subtract £0.75 from the price of RA to get the equivalent price of CA ([71], pp. v–vi). A few years later, Robert Hamilton wrote in 1814 ([24], p. 250) that

> [t]he price of Stock [i.e., any of the gilts], therefore, rises gradually, *ceteris paribus*, from term to term, and when the dividend is paid, it undergoes a fall equal thereto. Thus [CA] should be higher than [RA] by [£0.75] from 5th April to 5th July, and ..., and this is nearly the case. Accidental circumstances may occasion a slight deviation.

This was also noted in [3], p. 29; [10], pp. 59–60; and [56], p. 8 of "British Funds" section.

15.2 Transition from rational to irrational pricing

The first occurrence of CA overpricing that was discovered in this project was in 1831, and a few press mentions of it were found. They are cited in [52]. They came a few weeks after the overpricing reached noticeable levels, and treated it as an abnormal phenomenon that was bound to be quickly eliminated by arbitrage.

After 1831, relatively few press notices of gilt pricing anomalies were found until the Railway Mania of the mid-1840s. This may very well reflect the still low degree of digitization of 19th century British press as well as the inadequacies of OCR and search tools. But it may also reflect the still small size and lack of sophistication of financial journalism of that period. The Railway Mania led to a change, as the increase in the number of tradeable securities and of invested capital led to much more detailed and deeper coverage of financial markets. It is rather noteworthy that no comments about the mispricing of N35 as compared to R35 have been found so far anyplace in the press. However, the relatively low levels of major gilts mispricing during this period may also have contributed to the lack of coverage.

During this period, we find an amusing demonstration of the tendency of people to invent rationalizations for whatever happens in the market. In July 1839, after about a year of rational CA vs. RA pricing, CA overpricing reappeared. The *Spectator* was surprised by the anomaly. But the anomaly persisted. When it it vanished in October 1842, this paper was surprised again, as it argued that since "all the speculative operations" were confined

to CA, CA overpricing was normal. Then, when CA became overpriced yet again during the Railway Mania, the *Spectator* was surprised once more in April 1846, as it had gotten used to rational pricing, and expected the anomaly to be quickly eliminated by arbitrage[25].

The early ebullient phase of the Railway Mania reached a climax in late 1845. As is visible in the tables, CA overpricing started cropping up early in 1845, a good half a year before that climax, after a couple of years of rational pricing. Some press coverage started appearing soon afterwards. Some examples are cited in [52]. Especially noteworthy is the very vocal stance taken by the *Illustrated London News,* at that time the paper with the largest circulation in the UK. Between the end of 1846 and the end of 1849, the financial column of this paper printed over two dozen notes about gilts mispricings, pointing out that RA (or, sometimes, NR) was a less expensive security than CA.

Another extensive campaign to alert readers to the seemingly great arbitrage opportunity offered by CA overpricing was mounted by the *Economist* in 1859–61. It is also discussed in some detail, with quotes, in [52]. But there was coverage elsewhere as well. Here is a sampling of citations that were found just in London daily newspapers. They were not very frequent. Still, they do show that the public, in addition to seeing the discrepancy with their eyes in almost every issue of every newspaper for much of the time, in the price quotations, was getting explicit alerts from financial journalists. In essentially all the cases that were discovered, the journalists either wrote explicitly, or implied, that they found the pricing anomalous, and exchanges of CA for RA or NR, or purchases of the latter, of advantage to investors. (We should note that the relative pricing of CA and RA was rational from mid-1850 until late 1853, and therefore that period is not represented in the sequence of quotes.)

All the quotes below are from the financial column (usually labeled "Money market and City intelligence") in each paper:

- *Daily News,* 24 June 1854: "We hear of numerous exchanges from [CA] into [RA and NR], the latter stocks, after computing the accruing dividend, being relatively cheaper than [CA]."
- *Daily News,* 24 Feb. 1857: "It is noticed that [NR and RA] are now relatively cheaper than [CA], after making allowance for the dividend accrued."
- *Daily News,* 23 April 1858: "The government broker continues to make small investments in [RA], that stock being relatively cheaper than [CA], at present prices."
- *The Times,* 29 May 1858: "... [RA and NR] are considerably below their proper value relatively to [CA], and an advantage may be gained by changing from [CA] into either of them."
- *Morning Chronicle,* 1 Dec. 1858: "It may not be out of place to notice that [RA] is relatively cheaper than [CA]. Investments can, therefore, be made with more profit to the investor in [RA] than in [CA]."
- *Daily News,* 21 Nov. 1859: "The disproportion between the prices of [CA] and that of [NR and RA] continues to attract attention. The difference, after allowing for accrued dividend, amounts to upwards of ..."
- *The Times,* 11 June 1860: "[RA and NR], which carry more than two months' dividend and are disproportionately below [CA], were firm at ..."

- *Morning Post,* 23 Jan. 1863: purchases of gilts "appear to be principally confined to [NR and RA], they being cheaper than [CA] and more advantageous to investors."
- *The Times,* 1 Jan. 1864: "... [RA and NR] ..., both these stocks being [£1.25] below [CA], although a dividend will be paid upon them in April, and [CA] will have no fresh dividend till July."
- *Morning Post,* 14 Nov. 1865: "[RA and NR] being still somewhat cheaper than [CA], purchases are made in those stocks in preference to [CA]."
- *Pall Mall Gazette,* 4 May 1868: "... in consequence of the accrued interest upon [RA and NR] making them relatively cheaper than [CA] at ..., a rise ... was established."

15.3 Later acceptance and explanations for irrational pricing

By the late 1860s, there seem to have been fewer mentions of CA overpricing, although it is hard to be certain until more newspapers from that period are digitized, and search tools are improved to the point that we can make reliable quantitative estimates. It appears that the pricing anomaly became accepted as normal, and a variant of the standard rationalization for it was cited from time to time. For example, a popular arithmetic textbook noted (citing its 6th edition of 1881, p. 333 of [5]) that "the price of [RA and NR] ought therefore to be always the same, but ought to differ from that of [CA] either in excess or defect by [£0.75]: but owing to the comparative scarcity of [CA] on the Stock Exchange, their price is adventitiously higher than that of [NR and RA]."

The need for people to come up with a rationalization, however flimsy, is illustrated well by a leader in the *Economist* on 19 February 1870. It was an evaluation of the Lowe debt conversion proposal (see the first three sections of [52] for more details), and as a leader, may have been written by Walter Bagehot, the main editor of that paper. Robert Giffen was then the financial editor, so he might have been the author, too. The leader was about the Lowe proposal as a whole, so gilts mispricing played a minor role in it. (The passage about CA overpricing is reproduced in the section "Explanations and justifications for gilts mispricing" in [52].) The author's argument can be summarized (almost caricatured) as follows:

- a larger security is in general more valuable than a smaller one, other things being equal, because it provides higher liquidity
- RA is large enough that size should not matter for it, it provides enough liquidity
- the market value of CA is higher than that of RA
- therefore the conclusion that RA is large enough must be wrong, the overpricing of CA must be due to its larger size

Clearly this author felt compelled to come up with a rational explanation of the pricing anomaly, and did not bother to think seriously about the logic of the argument. Anything that seemed remotely plausible was apparently going to suffice.

Similar, and similarly questionable, views were shared by financially sophisticated government officials. In his account of the Goschen conversion, Hamilton ([23], p. 6) included a table of average prices (adjusted for accrued interest) for CA, RA, and NR for each month from January 1887 to February 1888, and noted that the prices of CA were slightly more than 0.25% higher than those of the others:

> This superiority, which was the normal characteristic of [CA], was due to their being the largest stock, and consequently offering a more ready market.

A couple of years later, an official government report made a similar claim, although it tossed in the qualifier "perhaps" ([70], p. 127). Others were also uncertain. Goschen, in presenting his conversion proposal to Parliament in 1888, was clearly unsure of the cause of the disparity, but put the greatest weight on "the fact that [CA] is the great stock." (See [52] for an analysis of what he said and what he probably meant.) Similarly, when in 1870 Robert Lowe, the then Chancellor of the Exchequer, proposed another conversion of the gilts, he said that RA and NR were underpriced relative to CA, "probably through being a smaller amount." As with Goschen, it is not clear whether he thought it was a case of pure irrationality, or, probably more likely, as the *Economist* claimed in February 1870, that the liquidity argument applied. It is probable that neither Goschen nor Lowe bothered to think deeply about the subject, it was simply not very important for them.

A good picture of how much the educated public knew about pricing of gilts is presented by a leader in *The Times* that was prompted by the Lowe proposal. This leader is reprinted in full in [52]. This leader claimed that

> [t]his superior value of [CA] as a Stock is caused by the greater demand for it, and the greater demand for it is caused by its relative magnitude. The demand for Stock proceeds from two classes of persons–investors, who buy to hold; and jobbers or speculator, who buy to sell again. The latter class confine their dealings mostly to [CA], because there is a larger amount of the Stock in the market, and the area for operations is wider and more favourable. Thus the two smaller stocks, generally speaking, are in request for investments only, whereas [CA] are in demand for investments and speculations too.

The writer of this piece, and apparently most contemporary observers, did not ask the logical question, namely why those who held CA for investment did not switch into RA and NR. It it seems people are ready to grasp at any rationalization when they run into unusual but persistent phenomena.

Still, even during this period, one does occasionally find quotes such as these:

- *The Times,* 19 June 1876: "[NR and RA] being relatively cheaper than [CA], ..."
- *Daily News,* 15 June 1878: "[NR and RA] were also pushed down ..., being now ..., and having regard to the accrued interest are cheaper than [CA]."
- *The Times,* 23 June 1880: "A certain amount of changing from [CA] into [NR] is taking place, the latter stock, which remains steady, having been permitted to fall relatively below the former in price."
- *The Times,* 30 April 1884: "We understand that a few exchanges of [CA] into [RA] were made, as the latter are rather the cheaper of the two."

Usually these are short quotes, and do not explain what the financial journalists responsible for them were thinking. However, even if they accepted the standard explanation for CA overpricing, it remained the case that RA and NR were less expensive than CA. Hence for long-term investors, such as trusts, it made sense to put their money into RA and NR.

Those journalists may have felt it was a worthwhile public service to point this out to their readers every once in a while. Their attitude may be similar to those of modern journalists towards tobacco. They don't spend a lot of effort talking about all the harm that smoking does. It is not illegal, and generally speaking most people are aware it is bad for their health. But every once in a while, when a new study documenting additional harm from smoking is published, or a campaign is being waged to pass laws restricting smoking in public places, newspapers will provide some coverage of the topic. Similarly, the Victorian financial journalists may have felt that occasionally, prompted by space they had to fill, or some comment from a broker or investor, it was worthwhile reminding their readers that they were wasting their money by keeping their long-term investments in CA. However, this is speculation, we do not know what the motivations of those writers was.

A few contemporary observers have been found who clearly thought about CA overpricing and decided the standard explanation was not adequate, and that this phenomenon was the result of irrational mass psychology. The most thoughtful of these analyses was printed in 1876 by the *Leeds Mercury*[26]. A similar conclusion was reached by a very interesting person, one very knowledgeable, inquisitive, and willing to entertain non-standard ideas. Robert Giffen was one of the most eminent economists, statisticians, and financial journalists of his time. (See [52] for more information about him.) Today he is best remembered as the discoverer of "Giffen goods," ones that violate the basic law of demand because increases in price lead to increases in consumption. He wrote ([17], p. 95):

> ... there is no doubt, I think, from the peculiar value of some stocks, that there grows up at times a species of customary appreciation of which a distinct account can hardly be given. Custom, for instance, keeps [CA £0.5 or 0.75] higher than [NR and RA], although they pay exactly the same rate of interest and are indistinguishable in their legal conditions of value. The speculative 'account' is in [CA] by virtue of ancient custom, and for this and for no other reason, I am assured, [CA] are always fractionally higher than [NR and RA].

It is clear from this passage that Giffen had thought carefully about the CA overpricing issue, and even asked around for an explanation. ("Giffen was known throughout his life as a lover of paradoxes," [35], p. 59.) Although he did not say this explicitly, it appears (especially when one considers the context in which he was writing, namely in a book that attempted to explain variations in prices of financial instruments) that he had his doubts about the liquidity arguments, and tended to think CA overpricing was a mysterious quirk of mass psychology.

As time went on, though, even Giffen seemed to accept the consensus view. In a speech prepared in 1899 (thus over a decade after the mispricing went away as a result of the Goschen conversion), he wrote ([18], vol. 2, p. 193):

> It was noticed at the time when English Government securities were divided into two large classes, one [CA] and the other [NR and RA], that although these two stocks were identical in every respect in their conditions, yet the fact of the speculative dealings being in [CA] permanently raised the price about [£0.50 to 1.00] above that of [NR and RA], which was identical in every respect except that of being called by [a different] name.

16 Causes of gilts mispricings

The usual rationalizations offered by contemporaries for CA overpricing are not credible. Even if speculators or banks preferred CA, that could only have caused the price of CA to rise relative to RA if other holders of CA refused to switch to RA. And, as we have seen, there were plenty of such holders. Liquidity in RA was more than adequate for the vast majority of investors. And the notion that RA and NR were the "quieter Stocks" (in the words of *The Times* of 1870) is simply incorrect, they were just as volatile as CA.

Modern thinking would tend to look for causes of gilts mispricings in government action. But it is hard to make a credible argument along those lines. As was mentioned in the Introduction, a high level examination of the financial moves of the British government shows that in an economically rational world, they should have served to reduce CA overpricing. More detailed examination of policies of various government and quasi-government bodies in sections 12–13 shows that while some agencies, such as the Court of Chancery, were pursuing irrational investment strategies, the government itself was largely rational in selling overpriced CA and buying underpriced RA and NR, which should have reduced the pricing anomaly. While the government did take advantage of the mispricing, it had no incentive to maximize it, as its main goal was to have a liquid market with low interest rates in order to be able to borrow easily in emergencies. The changes it introduced, or tried to introduce, were aimed in that direction, and culminated in the Goschen conversion that produced a single security.

As another argument absolving the government from responsibility for CA overpricing, we find that the prospect of a government move, or an actual move, led to greater pricing rationality. This was true on occasions such as the Lowe conversion proposal of 1870, or the Childers moves in late 1883 and in 1884, both detailed in [52]. Once those moves were gone, irrational pricing resumed.

Finally, the 19th century was in many days the heyday of *laissez faire,* with widespread suspicion and disdain for government. Yet we do not find contemporary observers blaming the government for gilts mispricing. All they could think of were the liquidity and speculative funds arguments cited above. Hence it seems safe to conclude that the government was not the cause of the observed mispricing. So we have to look for the reasons elsewhere.

There were surely many contributors to gilts mispricings. Even though there was a very sophisticated financial market, many of the investors appeared to be uncomfortable even with basic arithmetic. This mattered, since there was no large mutual funds or pension funds industry, and so decisions were being made by large collections of individuals. Furthermore, they made investment decisions infrequently. Although the volume of gilts was huge, turnover was low. So most of them did not have an intimate knowledge of how the Stock Exchange functioned. In the English market, there was the complication that prices of gilts were quoted with accrued interest. As a result, to compare CA to RA, it was necessary to have some knowledge of just how prices varied over time. Perhaps the reason the Irish market for gilts appeared to be slightly more rational than the English one in the late 1840s (see [52]) was that in Dublin prices of gilts were quoted without accrued interest. (The essentially identical pricing of RA and NR after 1860 may be due to interest on them being payable on the same days, so their prices could be compared easily.)

There was widespread suspicion and ignorance of that market. The "financialization" that is often talked about was still in the early stages. As Karl Marx, Max Weber, Werner Sombart, Karl Polanyi, and others have pointed out, capitalism required not just institutional, but also sociological changes. (See [55] for some modern treatment of this issue.)

The approach to investments, especially of trusts, was extremely conservative. As has been documented by many scholars, British investors were slow to put their funds into novel types of ventures (aside from mania periods). The heavy presence of CA in various trusts (discussed in this paper, and with more examples, in [52]), as well as the rarity of NR, may often have reflected simply the nature of the original donation, often made decades earlier, and left untouched.

The basic conservatism of British society was reinforced by prejudices involving money. Some ways of making money were more acceptable than others. Gilbart, the banker and prominent writer on banking who was quoted in Section 10, wrote ([19], vol. 1, p. 77) that "[i]t is not deemed creditable for a bank to speculate in the funds, or to buy and sell stock frequently, with a view of making a profit by the difference of price." This might be taken for fluff. However, there is evidence that the Victorians were influenced in their financial decisions by non-monetary considerations. As just one example, the paper [53] presents the example of railways splitting their common shares into A and B shares. This was an accidental innovation of the late 1840s. Yet, even though it showed an obvious way to "unlock shareholder value," to use a popular modern term, it took several decades before it became widespread, as the prejudice against something that seemed to encourage speculation was very strong.

It is likely that the principal-agent problem was a contributor to the reliance on CA by charities and general trusts. As many contemporary observers noted, trustees were often negligent in performing their duties. It was common for a change in investments by a trust to require the consent of the beneficiaries, but those beneficiaries could not compel trustees to make a change.

Still, while all these reasons likely contributed to the (economically) irrational overvaluation of CA, they do not seem to provide a plausible way for this overvaluation to arise. There had to be something that made British investors value CA more than RA or NR.

Most likely that missing factor was one that Giffen himself noted in his 1877 book [17] for another security. Before concluding that CA overpricing was "a species of customary appreciation of which a distinct account can hardly be given," he discussed market prices of Bank of England shares. He decided they were overvalued on the basis of fundamentals, and maintained their market price because of

> the extraneous value some securities come to acquire through their giving a status or some such advantage. It is, for instance, 'respectable' to hold bank [i.e., Bank of England] stock, as giving an ownership in the national bank, and – the list of holders being published – as an indication of the wealth of the holder. No poor man can afford to hold bank stock: and important city firms who wish to have a partner in the bank direction, or to be in a certain kind of credit, will accordingly invest in bank stock when they would not otherwise do so.

It appears possible that a similar effect operated to distinguish CA from RA and NR. It may be that as the 19th century progressed, the word "Consols" acquired an exalted status, and also that to a large extent it came to encompass all gilts. A simple example of that is connected with the Post Office Savings Bank scheme allowing customers to purchase gilts that was discussed in Section 14. Many newspapers hailed it as offering a chance for the small savers to invest in CA (although many others listed all three major gilts). The *Glasgow Herald* was unusual in that it went to some lengths to explain that it was not just CA that could be invested in, but also RA and NR, which were "almost identical save in name" to CA, all three "following each other very closely in fractional rises or falls in the market; so that they not only yield the same annual interest, but afford almost precisely the same chance of profit or loss of principal when they are sold"[27]. What is interesting here is that this paper felt it had to explain that RA and NR were not inferior to CA, but seemed to be unaware that they were in fact superior, about 1% less expensive than CA. (They thus offered slightly higher rates of interest. Further, as we know in retrospect, they provided higher capital gains if held until the Goschen conversion of 1888. The prospects of such a conversion, and its necessarily higher payoff for RA and NR than for CA, were something that it would not have required any special leaps of the imagination for investors to realize, since interest rates were declining, and CA was close to par.) There are many more examples of this phenomenon of CA being treated as special in [52]. There is some discussion there of more quantitative studies that would map how usage of various words and phrases changed over time. Similar studies with modern media, press, TV, email, Twitter, and the like, arare beginning to yield interesting insights into diffusion of information and opinions. With a growing corpus of digitized material from the 19th century, we might be able to obtain some insights into what led British investors to place irrational valuations on gilts.

The scenario sketched above, or CA assuming a higher status than RA and NR in the minds of investors, is consistent with much of the evidence we see of market action. For example, the preference for CA was very deep, as even large additional supplies of it (as in the loans of 1847 and 1855–56) had only modest and short-lived effects in suppressing its overpricing. Prospects of government moves that would eliminate the distinction between CA and RA served to reduce CA overpricing, but only temporarily.

Generally changes in CA overpricing were not sudden. Further, in quite a few cases CAm* - RA* increased after a financial shock (such as the crises that led to the suspension of the gold standard in 1847 and 1866), but again at a measured pace. One could imagine this might be the result of dialogs such as the following (purely imaginary) one:

- Investor: Please sell £1,000 of my RA holdings, I need the money to pay for an extension to my house.
- Broker: But why don't you sell CA instead? It's more expensive, you will not need to sell as much of it.
- Investor: But I prefer to keep my CA.
- Broker: It's your choice, but you would only need to sell £995 of CA to get the same cash as £1,000 of RA would give you.

– Investor: Well, if the difference is just £5, I would rather keep the CA. My friends all tell me it is the best investment.

Turmoil in the markets, or some wild rumors going around, might then have led to increased preferences for CA, so that our imaginary investor might not change his or her instructions even if the difference was £10. Such a scenario would help explain the slow changes in CA overpricing (along with slow communication in the 19th century). Most investors would not have rushed to change their investments, only the marginal customers would have increased or decreased the pressure on the supply of CA.

While the above scenario is purely imaginary, it might be possible to test its plausibility with more material and the improved tools that are being developed for textual analysis.

Much more intensive study of 19th century materials, both printed, and in personal correspondence, government or bank archives, and other sources, is also desirable to illuminate a striking phenomenon associated to gilts mispricings. That is the existence of several communities that had divergent views on gilts valuations. This is covered mostly in Section 18. But first we look at one of those communities, that of 19th century economists.

17 Contemporary economists and gilts mispricing

That many individual owners of CA might ignore the pricing anomaly and not switch to RA or NR, can easily be ascribed to inertia. The gains were not large, and *Homo sapiens* is prone to procrastination. On the other hand, it is surprising that economists did not pay more attention to this phenomenon. The mispricing is a curious intellectual puzzle, and one might think it would catch the attention of some of the people working in what was then called political economy. Yet, aside from Giffen, it does not appear that any of them wrote about it. Perhaps deeper investigations, possibly ones looking into archives of personal correspondence, will turn up some discussion.

The period of persistent CA overprising, 1854 through 1887, overlaps the careers of perhaps the last of the great classical economists, John Stuart Mill (1806–1873), and of Alfred Marshall (1842–1924), perhaps the most famous of the founders of neoclassical economists.

Classical economists were anything but empirical. But even among them, silence on CA overpricing is somewhat surprising, especially for John Ramsay McCulloch. McCulloch (1789–1864) was perhaps the most prominent British economist of the second quarter of the 19th century [36,51], partly because of several series of reference works he edited. The most famous of these series was the *Commercial Dictionary* [37], first published in 1832. It was extremely popular, and went through more than 10 editions. (The exact number depends on how one counts minor revisions, or additions of a supplement to what was basically a reprint. There were also several slightly modified U.S. editions, revised by American scholars.) The original publication and the revisions involved prodigious labor of collecting information from a variety of sources, much of it very quantitative. In particular, the data about the volumes of various gilts, and about the numbers of accounts of various sizes, was updated regularly. Yet all the editions of this work that were checked (more than half), starting with the initial one of 1832, and including the posthumous ones of 1869 and 1875,

which were edited by H. G. Reid, have an extended passage from [24] about gilts pricing, a small piece of which, about CA and RA differing almost always by plus or minus £0.75 was cited in Section 15.1. This suggests that neither McCulloch nor Reid was aware that the relation of CA and RA prices had changed, or that they decided to ignore this awkward fact.

Even other economists of that era do discuss money markets. For example, Mill in his *Principles of Political Economy* ([39], vol. 2, Chapter XXIII, "Of the rate of interest") wrote:

> The public funds, shares in the joint stock companies, and all descriptions of securities, are at a high price in proportion as the rate of interest is low. They are sold at the price which will give the market rate of interest on the purchase money, with allowance for all differences in the risk incurred, or in any circumstance of convenience. Exchequer bills, for example, usually sell at a higher price than consols, proportionally to the interest which they yield; because, although the security is the same, yet the former being annually paid off at par, the purchaser (unless obliged to sell in a moment of general emergency) is in no danger of losing anything by the resale, except the premium he may have paid.

Mill was also an MP for a couple of years in the 1860s (starting when CA overpricing was near its peak), and spoke and wrote about current affairs. But there does not seem to be anything in his collected works about gilts mispricings.

Should we interpret the silence of contemporary economists about gilts mispricings as indicating either striking ignorance of an obvious and large-scale economic anomaly, or as willful suppression of inconvenient facts? Those would seem the obvious choices from our modern perspective. However, if we look at the situation from the context of 19th century thought, another choice appears. Contemporary observers regarded markets as full of inefficiencies and irrational behavior. For example, the financial column of *The Times* on 1 January 1870, in a New Year's look backwards and forwards, at a time of great prosperity and quiet in the markets as well as in political arenas, noted that

> "[i]f a general disposition to hopefulness can exert much influence, 1870 should be a prosperous year. By the time it shall have run its course we shall be half-way between the troubles of 1866 [when giant mania culminated in a crash that forced a suspension of the gold standard] and the period when, according to all experience, a new inflation [i.e., another mania] will be due. It is, therefore, just about the date for an average and rational condition of trade and enterprise.

The supplementary manuscript [52] provides more information from that period, to demonstrate that Victorian observers regarded not just manias and crashes, but everyday behavior by investors that was economically irrational as normal. It is therefore possible that the contemporary economists shared this view, and so did not think that CA overpricing was particularly noteworthy. But if they did, and were logical, they should have understood their theories and models to be very idealized and far removed from reality. To what extent is that reflected in their work? Some further investigation of this issue seems desirable.

18 Diverse views on gilts valuations

The previous section considered the views of 19th century political economists about gilts mispricing, and unfortunately almost nothing about them is known so far. The opinions that have been found, and are documented in this paper and in [52] come primarily from financial journalists, and to a lesser extent from other journalists and government officials (such as Chancellors of the Exchequer). They all appeared to share the modern view of what the economically rational relative pricing of CA and RA should have been. Some strove to convince investors to take advantage of the underpricing of RA and NR, some did not, and many accepted the rationalizations that were offered for this underpricing. But it seems that all recognized that RA and NR were underpriced, and so were the better holdings for long term investors. Had their views been widely shared, there would have been no pricing anomalies.

Differences of opinion are of course the reason that markets and horse races exist. What we find in 19th century Britain is that the market was inefficient, in that the interaction of various investors did not produce the correct valuation (as predicted by economically rational methods, which were known then just as well as now). Unfortunately no comments have been found so far from any of the investors whose valuations resulted in that skewing of market results away from rationality. There are a handful of letters to newspapers, quoted in [52], which express bewilderment, but that is all. Still, statistics do provide some intriguing tidbits.

As was mentioned earlier, and as is discussed in [52], the Irish gilts market in the late 1840s appeared to be somewhat more rational than the English one. The very small investors who bought gilts through the Post Office Savings Bank (see Section 14) did show a smaller bias towards CA than the general investor public, but also showed a surprising bias against RA. Another interesting sample is provided by the Friendly Societies, which again represented mostly the poor. As is noted in [52], in the section on various non-profit organizations, they seemed to be perhaps the most rational among all classes of investors that have been found so far. Based on a sample of 24 cases (which is very small, as there were thousands of Friendly Societies, but chances are that this sample is unbiased), they had just 21% of their gilts investments in CA, and the rest in NR. Thus we do see economic rationality, but also a very strong bias against RA, even stronger than among Post Office Savings Bank customers. A challenge for the future is to learn what produced such biases.

A more general challenge is to understand how such divergent opinions could coexist. But perhaps that looks at the problem from the wrong direction. As modern research on news media and on various types of social communication is showing, viscosity of information is the rule, and it is usual for human society to have groups that view the same political, social, and other problems from different perspectives. So perhaps the challenge is to understand how such divergences affect market valuations and lead to divergences from economic rationality, and might be contributing to bubbles and crashes.

19 Conclusions

The main conclusion from this research is that far more work is called for on 19th century gilts pricing. The research documented here has just scratched the surface. Complete price records of gilts (and other securities, for comparative purposes) are needed, both realized prices and quotes, to map the patterns of mispricings. Far more intensive searches should be made of various contemporary sources, printed or not, to find out how various people thought about this phenomenon.

But we can already draw some conclusions, beyond adding to the literature what seem to be the most striking counterexamples known to the Efficient Markets Hypothesis and the Law of One Price. Starting from the most concrete, to the five pitfalls identified by Klovland in his work on the estimation of the yield on CA [29], we can add a sixth, namely that CA is not sufficient to give a complete picture of risk-free long-term interest rates. Other gilts (primarily RA) are in principle just as valid, and produce different answers. The effect is not very large, just a couple of basis points, but it is comparable to some of the adjustments that have been made by Klovland and other investigators on earlier calculations.

Next, various studies that assume market rationality in pricing of government bonds (such as [1,29], to cite just two that rely on data about gilts in the 19th century) should be reconsidered. The irrational relative pricing of CA and RA means that we cannot assume the existence of a well-defined term structure of interest rates. for example. More generally, the presence of long-term pricing anomaly among the most important financial instruments of the 19th century adds weight to the findings of modern behavioral finance in suggesting there is far less rationality in the markets than is often assumed. It is easy to dismiss CA overpricing in the 1831–87 period as irrelevant, due to the lack of sophistication of investors during the early formative period of corporate capitalism. But that attitude is questionable. Sophistication is a relative term. It is not clear that modern investors, faced with far more complicated choices (often deliberately obfuscated) than those faced by gilts investors in the 19th century, are making better decisions. Much of what is explained away as result of rational investors operating on imperfect information may well be the result of the whims of crowd psychology.

Finally, additional emphasis should be placed on viscosity of information, with different groups possessing different information and different viewpoints, yet with little communication. That seemed to be a key to gilts mispricings in the 19th century, and also appears to have been at the foundations of many modern economic crises.

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Notes

[1]The last mention of it that has been found was in a 1912 report on a shareholder meeting of the Stock Conversion and Investment Trust, where the chairman recalled Giffen's comments about it. *The Times*, 26 January 1912, p. 16.

[2]Figures for GDP come from [42], and are at current market prices. The data for total national debt, and volumes of major gilts are taken from Parliamentary Papers such as 1850 (169) XXXIII.1, and represent the nominal value, not the market value, of each. National debt given is the sum of the funded and unfunded components.

[3]Table on p. 291 of the 5th edition, published in 1855, of [45]. There is a mistake in addition in that table, as the total of the entries comes to £1,295.514 million, not 1,035.514.

[4]The 1825 volume [64], p. 27, noted that CA "is THE GRAND PUBLIC BAROMETER of the current rate of INTEREST; it greatly influences the price of all government securities, ..." Even though capitalization was used far more liberally in those times than today, what this author did was unusual, and was clearly intended to emphasize the dominant role of CA.

[5]*Hansard's Parliamentary Debates,* ser. 3, vol. 126, 1853, c. 350 and c. 359.

[6]See, for example *The Times*, 11 March 1844, p. 5, or *Bankers' Magazine,* April 1844, pp. 45-47, or some of the sources cited in [52] in the section on the minor gilts.

[7]Less than a decade later, Northcote, who would later serve as Chancellor of the Exchequer, seemed to regard those expectations as preposterous [50]. But that was the usual hindsight.

[8]*The Times,* 9 March 1844, p. 4.

[9]*Pall Mall Gazette,* 24 February 1870, p. 6, letter of W. R. Smee.

[10]However, the income tax should be considered in evaluating pricing of terminable annuities, which are discussed briefly in [52]. This tax was applied to the full payment from such annuities, which were partially repayments of capital.

[11]The *Economist*, 10 March 1888, pp. 307–8.

[12]See [66], p. 14 and [62], p. xxxii, as well as the ad of the Marvel, Geary, and Co. brokerage firm in *Herapath*, 20 Jan. 1849, p. 49.

[13]The potential losses were illustrated well by the Gladstone conversion of 1853. By the time the various minor gilts that were subject to redemption were paid off at the beginning of 1854, interest rates had risen by about 10%. See [52] for more detail.

[14]The small but substantial minority who refused, and were paid off a year later, were winners, as long term interest rates rose in the meantime.

[15]*Parliamentary Papers* 1861 [2895] LXII.397, p. 200. However, these were likely just the accounts at the Bank of England, and so excluded the ones at the Bank of Ireland.

[16]The *Economist*, 25 October 1884, pp. 1289–90, "The amount of government securities held by banks." The source used by this paper, which was the semi-annual statistical compilation of finances of joint-stock banks, did not distinguish between different government securities. As a point illustrative of the lack of solid knowledge among financial journalists, the *Daily News* had earlier that year estimated that perhaps £200 million of gilts was in the hands of country bankers, 8 August 1884, p. 2.

[17]For example, the *Salisbury and Winchester Journal* of 12 February 1870, p. 2, had an ad from the Eagle Insurance Company reporting its financial results for the year to mid-1869, and at that time it had, among assets valued at £3.2 million, £200 thousand of nominal value of CA, and an equal amount of RA. The *Daily News* of 24 September 1884, p. 2, even claimed that "[NR] are the favourite stock among bankers."

[18]*Parliamentary Papers* 1870 (52) XLI.213.

[19]Thus the financial column of *The Times* of 12 July 1844, p. 6 mentioned that "[t]he Government broker continues a purchaser, and took both [CA and RA] at advanced prices." The *CoE* also sometimes listed this broker's purchases. On 19 April 1873, the *Economist* wrote that "[o]n Tuesday the Government brokers commenced buying [RA and NR] for the sinking fund, on which account [£1.624 million] has to be invested during the current quarter." The *Economist* of 30 July 1870, p. 943, argued that it was foolish to spread the purchases evenly over a quarter, and that the Commissioners for the Reduction of the National Debt should be clever enough to engage in effective market timing.

[20]*Parliamentary Papers* 1875 (261) XLII.665.

[21]*Parliamentary Papers* 1881 [C.3006] XXIX.583, p. 27. There were also some liquidations, which are not shown in this table. The next few reports in this series do give the total amount invested by customers in gilts, but without providing separate figures for CA, RA, and NR, so they provide no useful information for us.

[22]By the mid-1880s, gilt investments by customers of the Post Office Savings Bank averaged about £80, as opposed to about £15 for regular savings accounts.

[23]Based on weekly figures from the *Economist*, for the 20 Fridays from 19 November 1880 to 1 April 1881.

[24]*Parliamentary Papers* 1889 [C.5850] XXVIII.573.

[25]Financial ("money market") column, *Spectator*, 27 July 1839, p. 702; 22 October 1842, p. 1017; 11 April 1846, p. 346. Quotes from those columns about CA overpricing are presented in [52].

[26]*Leeds Mercury*, 26 July 1876, p. 4. It is reprinted, together with some others, in [52].

[27]*Glasgow Herald*, 19 November 1880, p. 4.

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