Managing the UK National Debt 1694-2018
Online Appendix

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A   Sources of quantity data

The quantity data for 1694-1948 are based on the annual *Return relating to the National Debt*, presented to the House of Commons by the Financial Secretary to the Treasury. The return, available online and from the Parliamentary Archive of the Bodleian Library, is a gilt-by-gilt statement of the stock of government debt on the last day of March each year. The situation at 31st March 1940 is shown as an example in Figure A.1. Some detective work is needed to keep track of individual gilts as we move back in time towards 1694, although the task is simplified by the limited number of gilts issued in early periods. For the example month of March 1940 we are able to map all the funded and unfunded debt into specific gilts in our dataset, except for the items which were not traded in the market: Debts to the Bank of England and the Bank of Ireland, Treasury Bills, Ways and Means Advances, National Savings Certificates, National Savings Bonds and Other Debt. To translate the annual positions at the end of March into monthly quantities outstanding we use judgement on a gilt-by-gilt basis. For example, if the market price of a gilt is quoted in the Financial Times prior to its appearance in the return then we assume that it was issued earlier.

Information on the amount of debt outstanding 1949-1974 is collated from sheets produced by *Mullens & Co.* when acting as broker to the government, now held in hard copy in the archives of the Bank of England. The Mullens sheets are not in database form, instead consisting of a mix of press releases and confidential notes circulated and exchanged among members of the Cashier's Department of the Bank of England. Details of new gilt issuance are derived from the collections C132/76, C132/77 and C/90 of Government Broker's files, whereas Cashier's Department Government Broker's files and Friday Stories C132/1-75, C11, C39, C40/1360, C132/1-75, C132/48-56, Eid4/76, C11/1 and C40/1360 are useful for inferring the current quantities of on-the-run gilts.

APPENDIX I.

Statement showing in detail the **Aggregate Liabilities of the State**
on 31 March, 1940.

	£	s.	d.	£	s.	d.
Funded Debt :						
2½ per cent, Consols	276,056,739	12	4			
2¾ per cent. Annuities	2,396,979	5	10			
2½ per cent. Annuities	21,116,285	8	6			
3½ per cent. Conversion Loan	739,347,677	15	7			
4 per cent. Consolidated Loan	400,718,766	11	6			
3½ per cent. War Loan	1,911,150,685	3	3			
Debts to the Banks of England and Ireland (2½ per cent.)	13,645,869	4	8			
TOTAL FUNDED DEBT				3,364,433,003	1	8
Terminable Annuities :						
*Estimated Capital Liability in respect of						
Annuities for Life and Terms of Years						
per 19 & 20 Geo. V. c. 29 (1,591,645*l.* 6*s.*)				14,621,200	–	–

	£	s.	d.	£	s.	d.
Unfunded Debt :						
Treasury Bills	1,427,710,000	–	–			
Ways and Means Advances	61,490,000	–	–			
2½ per cent. Funding Loan (repayable 1956–61)	200,211,030	–	–			
2¾ per cent. Funding Loan (repayable 1952–57) ..	100,561,934	–	–			
3 per cent. Funding Loan (repayable 1959–69) ..	139,932,399	17	–			
4 per cent. Funding Loan (repayable 1960–90) ..	341,694,967	7	5			
2½ per cent. Conversion Loan (repayable 1944–49) ..	206,521,892	11	4			
3 per cent. Conversion Loan (repayable 1948–53) ..	301,835,170	–	–			
4½ per cent. Conversion Loan (repayable 1940) ..	350,340,021	4	–			
5 per cent. Conversion Loan (repayable 1944–64) ..	322,815,687	14	6			
4 per cent. Victory Bonds (repayable by Annual Drawings)	306,003,445	–	–			
2½ per cent. National Defence Bonds (repayable 1944–48)	100,165,105	–	–			
3 per cent. National Defence Loan (repayable 1954–58)	81,220,325	–	–			
3 per cent. War Loan (repayable 1955–59)	99,242,090	–	–			
1 per cent. Treasury Bonds (repayable 1940–41) ..	99,999,600	–	–			
National Savings Certificates	430,506,901	–	–			
National Savings Bonds	3,367,715	18	1			
3 per cent. Defence Bonds..	60,137,281	–	–			
Other Debt under the War Loan Acts 1914–19 and						
National Loans Acts, 1939 & 1940						
Government of Northern Ireland—						
Proportion of proceeds of sales of £						
Ulster Savings Certificates .. 570,000						
Deposits by Trustee Savings Banks .. 624,200						
Loans free of interest 376,302	1,570,502	–	–			
Total Internal Unfunded Debt				4,635,326,067	12	4
	2					
TOTAL INTERNAL DEBT .. ..£				8,014,380,270	14	–

* The Capital Liability is the Amount of Capital included in the remaining instalments of the Annuities.

Figure A.1: Return relating to the National Debt, 1940

The information in the Mullens sheets is supplemented and cross-checked with data for 1964-2018 from the *British Government Securities Database* maintained at Heriot-Watt University by the Institute and Faculty of Actuaries, which contains details of all gilts that have been in circulation from March 1964 onwards. We match the two data sources where they overlap, but for gilts redeemed or converted prior to March 1964 we have to rely on the Mullens sheets alone. For these gilts, we assume that the amount outstanding did not vary between their issuance date and the first time they are specifically referenced in the Mullens sheets. We believe that most conversion offers are registered in the sheets, although we have no guarantee that all have been reported. Another technical issue that affects gilt issues around WWII is that, in the past, the UK government has issued a number of double-dated gilts with a band of maturity dates. The government could choose to redeem these gilts in whole, or in part, on any day between the first and final maturity date. It appears that not all partial redemptions occurring between 1946 and March 1964 have been recorded in the Mullens sheets, since only some of them can be inferred by cross reference to the Cashier's Department's Notes. In total, 37 gilts maturing between 1946 and 1964 have been identified from information in the Mullens sheets.

B Sources of price data

The price data for 1698-1809 are derived from the primary sources collected under an NSF grant by *Larry Neal* in Neal (1990). From 1729 we supplement Larry Neal's data with the UK 2.5% Consol Yield (IGGBRCD) from the *Global Financial Data* database, which continues through to the final redemption of all consols in 2015. For 1888-2009 we transcribe end-of-month prices from microfiches of the *Financial Times Historical Archive* held in the British Library.[1] The prices appear under the section for 'British Funds' or 'Gilt-Edged', and from 1963 onwards are sorted by maturity into 'Shorts' (Lives up to Five Years), 'Five to Fifteen Years', 'Over Fifteen Years' and 'Undated'. In 1981 a further distinction was made for index-linked gilts. The prices in the scans are not always clear, as is evident in Figure B.2 for the closing prices on 29th March 1940 that match with the quantities in the Return relating to the National Debt for the same month in Figure A.1. On some occasions we deduce prices with the aid of closing prices for the previous or following working days.

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[1] The *Financial Times Historical Archive* has been made available online since we collected our data.
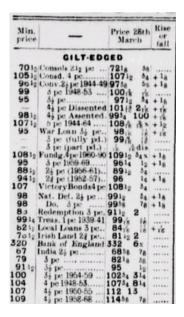
Figure B.2: London Closing Prices 28th March 1940, from *Financial Times* 29th March 1940

We obtained 1975-2018 prices from the *British Government Securities Database*, maintained by the Institute and Faculty of Actuaries at Heriot-Watt University. Their data come from a variety of sources. For 1975-1984 they are derived from prices collected by A.D. Wilkie while responsible for checking and parallel running of the Financial Times Actuaries Indices. Prices for 1984-1996 are transcribed from printouts and photocopies of the Financial Times held in the Edinburgh Public Library and at Watson Wyatt Partners. Disks and online data from the Debt Management Office are the source from 1996 onwards.

C   Call and conversion provisions

The price data we record is an accurate measure of the market value of government debt outstanding at any point in time. When gilts are subject to call or conversion provisions, their prices in the market reflect not only the cost of borrowing but also components that capture option values. UK gilts are callable at par value, so the government has an incentive to redeem a gilt if its market price rises above par. The expectation that this may happen depresses the market price of gilts, a call option of value to the government. The option is most likely triggered if gilt prices rise following a fall in interest rates. In contrast, conversion provisions often played a role in the financing of wars when interest rates might be expected to rise. Worried that later buyers would get a better deal,

investors were often reluctant to purchase gilts at the start of wars; thus governments issued gilts with conversion provisions early in wars to insure investors from rising interest rates. The market price of such gilts is inflated by the option of conversion, in this case a value accruing to investors.

The presence of call and conversion provisions does not change our measure of the market value of the national debt, although we need to be careful when interpreting gilts as 'long' if they can be called or converted early. The calculation of holding period returns in Section 3 and the assessment of long bonds in Section 4 are still valid, with the proviso that call and conversion provisions are likely to reduce the fiscal insurance property of long-term debt. More concretely, such provisions have the potential to corrupt the estimates of the yield curve in Section 3. To counter this, we adjust the market prices of gilts affected by call and conversion provisions using the approach of Harley (1976), Klovland (1994) and Cecchetti (1998) before we estimate the zero coupon yield curves. The idea is to identity option values by comparing the yields of these gilts to the yields on similar alternative gilts that not subject to call and conversion provisions.

The most significant call option exercised by the UK government over the period 1915-2018 was the conversion of war loans in 1932.[2] In late 1931 there was a run on the pound, and the following year interest rates fell from 5% in February to 2.5% in May and 2% in June. As interest rates fell, bond prices soared and Chancellor Neville Chamberlain announced a conversion of the entire stock of war loans into a new issue of 3.5% consols. The top row of Figure C.1 shows the yield to maturity on 4.5% and 5% War Loans, assuming that the loans would mature at their last respective callable dates of 1945 and 1947. The spread in yields between war loans that were likely to be called and the 2.5% Consols that were not is a measure of the value of the government's call option and the difference in term premia payable on loans maturing at different dates. The spreads are stable until the beginning of 1932, at which point they begin to rise as it becomes increasing likely that the call options would be exercised. The middle row of Figure C.1 fits a trend to the spread through 1932. The bottom row of Figure C.1 corrects for this trend and shows what the market prices of war loans would have been had they not been subject to call provisions. We use these corrected prices when estimating the zero coupon yield curves.

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[2] The other notable call of UK gilts is the Goschen Conversion of 1888, see Harley (1976) and Klovland (1994). This is outside the period for which we are able to estimate the yield curve, so we do not adjust prices to account for any call option value.
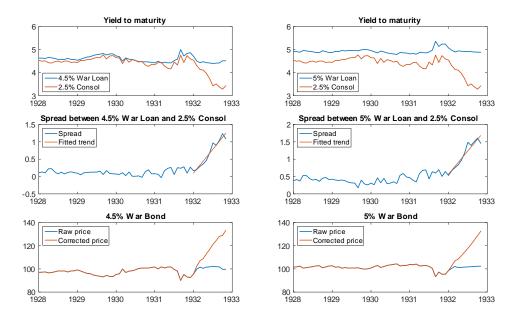
Figure C.1: Adjusting the prices of war bonds in the run up to the 1932 conversion

The most important conversions in 1915-2018 relate to gilts issued by the UK government to fund World War I. The 4.5% War Loan issued in June 1915 raised £901m, of which £137m came from conversion of the 3.5% War Loan issued in November 1914 and £152m came from conversion of 2.5% and 2.75% Consols. There is no clear evidence that option values were incorporated in gilt prices before conversions took place in June 1915. In contrast, the issuance of 5% War Bonds in January 1917 was widely anticipated by gilt markets. Only £845m of the £2.08bn raised was new funding, £820m instead coming from conversions of the 4.5% War Loan, £280m from converting exchequer bonds and £130m from converting treasury bills.
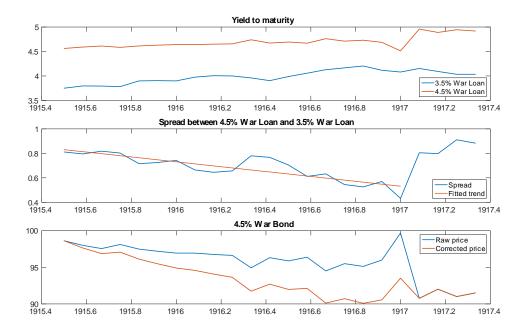
Figure C.2: Adjusting the prices of 4.5% War Bonds in the run up to the 1917 conversion

The top panel of Figure C.2 compares the yield to maturity on 3.5% and 4.5% War Loans from June 1915 to March 1917. The 4.5% War Loans were eligible for conversion to 5% War Loans whereas the 3.5% War Loans were not, so the spread between the yield on 4.5% and 3.5% War loans includes a component that measures the option value of conversion. As the middle panel of Figure C.2 shows, the spread narrowed through 1916 as it became more likely that a higher coupon War Loan would be issued. It is at its most compressed at the date of conversion in January 1917, returning to its previous level in February 1917 once the option to convert has expired. As before, we fit a trend to the spread in yields that occurs before conversion and use it to adjust the market price of the 4.5% War Bond in the bottom panel of Figure B.3. The corrected price is used for the 4.5% War Loan in the estimation of the zero coupon yield curve.

D Calculation of counterfactuals

The counterfactuals describe alternative fiscal histories when the government changes its strategy for issuance of fixed-term nominal debt.[3] The first input is the original cash flow associated with historic issuance, coupon payments and redemptions of nominal debt, extracted from our dataset. Positive cash flow is associated with issuance, where receipts depend on the market price of the total face value of debt issued, and negative cash flow occurs with the payment of coupons and redemptions at face value. The second input is the estimates of the zero coupon nominal yield curves for the UK 1915-2018 from Section 3, which define the market price of debt issued under alternative debt management strategies.

The calculations begin with the issue of the first fixed-term nominal gilts after 1915 for which we have quantity data. Under the alternative strategy, the government no longer issues the "4% Funding Loan" with total face value £408.9 million it did in September 1919. The market price of these gilts at issuance was £$76\frac{5}{8}$ so government receipts are missing £313.3 million that needs to be covered by alternative issuance. The precise face value of gilts to issue depends on the market price of the preferred maturity. For example, if the strategy is to always issue 3-year zero coupon nominal bonds then the government needs to issue total face value of £373.0 million, which at the September 1919 zero coupon bond price estimate of £84 brings in the required government receipts of £313.3 million.

The change in maturity of debt issued has implications for future payments and redemptions, hence we need to define counterfactual cash flows. The negative original cash flow associated with the eventual redemption of the 4% Funding Loan in October 1972 becomes a future *positive* counterfactual cash flow as the government no longer needs to redeem the original gilt. The same also applies to any coupon payments due. Conversely, issuing the alternative gilt creates a future *negative* counterfactual cash flow at maturity as the government will need to raise money for its redemption.

The construction of the counterfactuals continues recursively month-by-month. There are two situations in which the government will need to issue new debt under the alternative debt management strategy. The first is when the original cash flow was positive because of historic issuance receipts, the second when the alternative strategy creates a negative counterfactual cash flow because debt needs to be repaid. There is scope for these situations to offset each other, so a sufficient condition for the government to issue new debt is that the sum of the original cash flow and the negative of the counterfactual cash flow is greater than zero. If the sum is zero or negative, so no debt needs to be issued, then any cash on hand is carried over to the next month at an interest

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[3]The calculations abstract from debt specifically linked to World War I since it was converted to undated debt in 1932.

rate of zero. We assume that the government never over-issues debt.

Proceeding to the end of the sample completes the calculation of the counterfactual for 1915-2018. If the start date of interest is after 1919 we reset the total market value of government debt at that date to the level that historically prevailed at the time. This is achieved by adjusting the face value of debt outstanding at the start date, which ensures comparability across counterfactuals by initialising them at a common market value of debt and debt maturity distribution that is consistent with the alternative issuance strategy.

References

[1] Cecchetti, Stephen G. (1988) "The Case of The Negative Nominal Interest Rates: New Estimates of the Term Structure of Interest Rates During the Great Depression", *Journal of Political Economy*, 96, 1111-1141

[2] Harley, C Knick (1976), "Goschen's Conversion of the National Debt and the Yield on Consols", *Economic History Review*, 29, 101-106

[3] Klovland, Jan Tore (1994) "Pitfalls in the Estimation of the Yield on British Consols, 1850-1914", *Journal of Economic History*, 54, 1, 164-187

[4] Neal, Larry (1990) *The rise of financial capitalism: international capital markets in the Age of Reason*, Cambridge University Press