

Treasury Occasional Paper No. 10: Debt Management – Theory and Practice

Donna Leong

April 1999

Summary

The primary objective of UK debt management policy is to minimise cost over the long term, taking account of risk, whilst ensuring consistency with the objectives of monetary policy. However defining what makes up the "optimal" portfolio to meet this objective is a difficult problem. The paper examines several different theoretical approaches to the question.

The conclusion is that current research has provided a number of useful insights into the conduct of debt management policy, and that on the whole, these are reflected in current UK policy. However there are also a number of areas where there is a gap between theory and practice, which need to be more carefully explored. Overall, current research does not yet appear to provide sufficient guidance as to the optimal debt portfolio. The paper then suggests some areas for further research, which would help to illustrate the costs and benefits of different debt portfolios. An executive summary is provided at the beginning of the paper.

Acknowledgements

This paper reflects ideas and comments from a number of discussions at HM Treasury and the UK Debt Management Office. The paper benefits from a number of contributions by other officials, particularly David Page at DMO. I would like to thank colleagues for their many useful comments on the paper, and also officials at the Bank of England for their helpful suggestions. However any errors and omissions are my own. The views expressed here should be seen as a contribution to an ongoing debate, rather than a statement of future government policy.

Contents

	page
Executive Summary	1
1. Introduction.....	5
2. Background.....	5
3. The debt management objective	6
4. Does debt management matter?	8
5. Debt management and monetary policy	9
6. Minimising costs.....	11
Improving market efficiency.....	14
Implications for debt management.....	18
7. Taking account of risk	19
Distortionary taxes and the optimal taxation approach	19
Using conventional securities	22
Empirical results	24
Implications for debt management.....	25
8. Role of government in financial markets.....	26
Implications for debt management.....	28
9. Time consistency, government debt and inflation	29
Implications for debt management.....	30
10. Conclusions.....	31
What’s missing from the literature?.....	31
What does the literature tell us?.....	32
Improving debt management policy	33

Executive Summary

The primary objective of UK debt management policy is to minimise cost over the long term, taking account of risk, whilst ensuring consistency with the objectives of monetary policy. However defining what makes up the "optimal" portfolio to meet this objective is a difficult problem. The paper considers several approaches:

- assisting monetary policy;
- minimising cost;
- minimising risk;
- improving the allocation of risk in the economy; and
- improving the credibility of government policy.

Historically, a key concern of debt management policy was its impact on monetary policy. The separation of responsibilities for debt management and monetary policy reflects a practical assessment that monetary policy is no longer a central concern of debt management policy (or vice versa).

The primary concern of debt management policy has now shifted to minimising cost. However, there is generally a trade-off between cost and risk - a risk averse government would be willing to accept higher borrowing costs to avoid greater volatility in its finances. Investors with preferences for particular types of debt may be willing to pay a premium for that debt, but the resulting cost savings need to be assessed against the possible additional risk to the government's finances.

There may also be cost-minimising opportunities which are related to the characteristics of the market for debt. Debt management policy which is predictable and transparent will reduce uncertainty and therefore the "risk" premium attached to government debt. In addition, improvements to market microstructure can help lower costs without necessarily increasing the government's exposure to risk.

The optimal taxation literature suggests that governments could improve welfare if they used debt management to reduce unexpected fluctuations in the tax rate. Changes to taxation are costly, because the welfare loss from taxation rises more than proportionately with changes to the taxation rate. However given shocks to spending and output, taxes will need to change over time to preserve fiscal solvency. Theoretically the government could hedge against the impact of such shocks on its finances by selling debt whose return was contingent on particular shocks (or state-contingent debt), so that the effect of any shock was completely offset by changes in debt servicing costs.

Because of practical difficulties with state-contingent debt, economists have also examined whether the standard set of securities (nominal and index-linked debt) could be used to provide the government with a degree of insurance. For example, nominal debt can help to reduce the impact of a negative supply shock, because the negative effect on real revenues from rising inflation and falling output is compensated for by reduced real debt costs. For the UK, empirical evidence suggests that in fact index-linked debt has provided the best insurance over recent years, because of lower-than-expected inflation and output. These studies also confirm the historical bias against foreign currency debt; not only are the costs of foreign currency debt highly variable, holding foreign currency debt tends to add to the volatility of the government's finances, because the cost of foreign debt tends to rise (the real exchange rate depreciates) with unexpected falls in output and increases in spending.

The optimal taxation literature makes a strong case for focusing debt management on risk management. However the empirical studies do not make a convincing argument for restructuring the portfolio. Shocks are by their nature highly unpredictable. The "optimal" portfolio will therefore vary for different countries and different periods, depending on what sort of shocks is likely to dominate. Nonetheless, a portfolio composed of only one type of debt seems unlikely to be robust against all shocks – diversification should provide a higher degree of insurance.

Government debt may also help to improve the workings of the financial market. For example, the government could improve the allocation of investment by providing a risk-free asset (such as an inflation-indexed bond). However, although such assets have the potential to improve the welfare of investors they may also involve greater cost or risk to the government's finances, and hence taxpayers. This reduces the attractiveness of debt as a risk-sharing device.

Time-consistency arguments for holding index-linked debt and/or foreign currency debt (because they help reinforce a commitment to low inflation) are probably less relevant to the UK at present, given relatively low inflation and debt levels; and also in light of the commitment to low inflation established by the Government's move to give the Bank of England operational responsibility for interest rates.

Not all of these theoretical arguments are reflected in debt management policy – for example, debt managers do not try to use debt management to insure against large macroeconomic risks to the government's finances. However, we can identify a number of areas where UK debt management policy and theory appear to be consistent:

- issuance policy is consistently focused on transparency and predictability. The Government avoids active trading or trying to "beat the market";

- issuance policy is primarily focused on maintaining benchmark issuance at a range of maturities. This exploits the cost advantages of benchmarks, but does not appear to be unduly risky; and
- the portfolio is reasonably diversified, with a relatively high proportion of index-linked debt and also long-term nominal debt. As a result, the debt portfolio provides some insurance against a range of possible shocks. Although this may not maximise the degree of insurance possible, it helps to reduce the risk of unpleasant outcomes.

However, the literature also raises some questions as to the ideal structure of the portfolio. In particular, there may be some cost and/or risk-minimising opportunities that could be exploited further. As yet the literature does not provide us with sufficient guidance as to the best way to move forward – there is no consensus as to what determines the optimal portfolio. However it does highlight some areas where additional work would be useful:

- The most appropriate measurement of risk. Practitioners have tended to concentrate on minimising unexpected variations in debt servicing costs, and also refinancing risk. This conflicts with the optimal taxation literature, which looks for the debt structure that helps to minimise unexpected changes in taxes. The two approaches are likely to result in different recommendations for the optimal risk-minimising portfolio.
- The impact of economic shocks on the government's finances. This would allow an assessment of the relative costs of different portfolios in alternative scenarios.
- The microeconomics of the bond market. For example, it would be useful to quantify the gains from liquidity and the provision of benchmark bonds. Ideally for any debt security we should be able to form an assessment of the potential benefits from lower debt servicing costs, against the potential increase in risk to the government's finances.
- The magnitude of the transaction costs involved in changing the portfolio. If the costs of changing the portfolio composition (other than through new issuance to replace maturing debt) are prohibitively large, the current structure of the portfolio is, to a large extent, historically determined. However if these transaction costs are small, then the government has potentially much greater flexibility in determining the shape of the portfolio. This is likely to be relevant in weighing up the costs and benefits of moving to alternative debt portfolios.

Exploring these areas should help to create a better understanding of the costs and benefits of different portfolio structures, such as a higher proportion of index-linked debt; or whether there are any benefits to targeting a particular duration for the portfolio. In turn, this should help to improve our understanding of what might constitute an "optimal" portfolio.

1. Introduction

1. Over recent years the UK has undertaken a number of reforms to improve the operation of the market for government debt. An extensive review of debt management was completed in 1995, which set out a revised policy objective and introduced a number of reforms to enhance the liquidity and efficiency of the gilts market. The latest reform has been the establishment of the UK Debt Management Office, an executive agency with responsibility for carrying out the Treasury's annual remit on debt management.

2. Given recent changes, it seems an appropriate time to assess current practice in UK debt management policy and in particular, how it relates to the academic literature. Historically theory has focused on the contribution of debt management to monetary policy and stabilisation policy (following Tobin's work in the 1960s). However recent developments have focused on the relationship between debt management and fiscal policy (the optimal taxation literature); market microstructure (reflecting the influence of recent developments in microeconomics, such as models of bargaining and trade); and also the potential for debt management to improve the time-consistency of government policy.¹

3. The aim of this paper is to discuss recent theory and draw out the implications for debt management policy – is current debt management policy consistent with theory? And can the literature offer further insights as to how to improve debt management?

2. Background

4. Gross public debt in the UK was 50.8 per cent of GDP (around £410 billion) in 1997-98 (on a Maastricht basis), and is estimated to have fallen to 49 per cent of GDP at the end of this financial year. This is well within the Maastricht reference level of 60 per cent of GDP for general government gross debt. By comparison, in 1998 the EU average was 70 per cent of GDP. Net public debt is estimated to have fallen to 40.6 per cent of GDP, from just over 42 per cent last year.

5. The composition of UK debt is distinguished by a number of features. The average term to maturity of the debt portfolio has consistently been one of the longest in the OECD - in 1997, the average term to maturity of the UK's debt portfolio, at 9.7 years, was exceeded only by Poland's. Index-linked debt gilts also make up an unusually large proportion of total debt. Index-linked gilts have steadily increased as a proportion of total debt from their introduction in 1980 to around 15 per cent of the marketable debt portfolio at present (or 20

¹ See Missale (1997, 1998) for a comprehensive review of the theory of public debt management.

per cent of total government stock issued). A large proportion of financing is also obtained from sales of non-marketable debt, principally National Savings products.

Table 1: Market and official holdings of national debt²

	Mar-97		Mar-98		Dec-98	
Government stocks	283,404	73.5	291,021	75.2	294,507	75.3
- <i>index linked</i> ³	51,535	13.4	58,729	15.2	61,385	15.7
- <i>other</i>	231,869	60.2	232,292	60.0	233,122	59.6
Treasury bills	4,996	1.3	2,106	0.5	2,353	0.6
National savings	56,916	14.8	58,955	15.2	59,851	15.3
Other	25,716	6.7	23,491	6.1	21,162	5.4
Market holdings of sterling debt	371,032	96.3	375,573	97.0	377,873	96.6
Market holdings of foreign currency debt	14,341	3.7	11,466	3.0	13,114	3.4
Total market holdings of national debt	385,373	100.0	387,039	100.0	390,988	100.0
Official holdings	34,537		32,201		47,107	
Total national debt	419,910		419,240		438,095	

3. The debt management objective

6. The 1995 Debt Management Review established the primary objective of UK debt management policy as "to minimise over the long term the cost of meeting the Government's financing needs, taking account of risk, whilst ensuring that debt management policy is consistent with monetary policy".^{4, 5}

7. The trade-off between cost and risk is a familiar concept to private sector portfolio managers. This suggests that the government might be able to apply corporate finance theory in determining its debt strategy. However there are a number of factors peculiar to the government which may complicate the use of finance theory:

² Source: Bank of England. National debt differs slightly in its definition from general government gross debt (eg gross debt excludes official holdings of national debt), but is closely related. The largest component of both is market holdings of national debt. National Savings' element of the national debt excludes the ordinary account of the National Savings Bank as well as accrued interest and indexing on National Savings products.

³ The nominal value of index-linked gilts has been raised by the amount of index-related capital uplift accrued to 31 March each year.

⁴ Report of the Debt Management Review (1995), p. 3.

⁵ The objective was revised slightly in the 1998-99 Debt Management Report to reflect the separation of the Government's monetary and debt management policy objectives. It now reads "to minimise over the long term the cost of meeting the Government's financing needs, taking into account risk, whilst ensuring that debt management policy is consistent with *the objectives* of monetary policy."

- the government will generally have a wider objective than simply maximising its overall wealth. For example, the government's objective function may include the welfare of bondholders and taxpayers;
- the government's largest cashflows are tax revenue and government expenditure. These flows do not have an obvious private sector counterpart – for example, tax and spending decisions have welfare implications, which would need to be included in the analysis;
- the government has the power to tax both current and future generations. Government securities are therefore subject to a lower degree of risk than comparable private sector securities;
- the government can also influence the cost of its borrowing through its macroeconomic policies, which affect interest and inflation rates;
- because of the size and nature of government debt issuance, the government may find it difficult to enter and exit the market without affecting prices; and
- not all government assets and liabilities are fully accounted for. Even where there is a comprehensive list of assets, it may be difficult to value some of those assets (such as the value of a national park). It may also be difficult to judge the impact of changes in the value of those assets on the government's finances. However, a debt management strategy based only on a subset of the government's net liabilities may not be the optimal strategy.

8. This is not to imply that the tools of corporate finance theory are irrelevant. A number of countries have explicitly adopted private sector risk management practices in government debt management.⁶ But careful thought needs to be given, for example, to the definition of risk, and to the wider implications of the debt management strategy. This suggests that an approach that explicitly incorporates the objectives and constraints peculiar to the government is needed.

⁶ See Nars (1997) and Cassard and Folkerts-Landau (1997) for a description of how a number of countries apply modern risk management techniques to government debt management.

4. Does debt management matter?

9. The starting point for many macroeconomic models is the representative agent, infinite horizon model, with complete markets. In these models, the level of government debt does not have any impact on economic activity. Households recognise that for any given path of spending, a higher level of debt today implies higher taxes in the future, and save accordingly. As a result, consumption remains unchanged (in contrast to the more conventional view that increased deficits and debt lead to increases in aggregate demand). This is known as the Ricardian Equivalence theorem.

10. Under similar assumptions, it can be shown that the composition of debt does not have real effects.⁷ Essentially, for any change in the composition of government debt, households are able to choose an appropriate portfolio of assets that preserves their original consumption plan; indeed it is optimal for them to do so, because the relative price of assets (and hence the incentives to save and invest) remains unchanged.

Box 1: A simple example of debt management neutrality

Assume the government issues debt in the form of one-year and two-year bonds, each of which pays £1 at maturity. Assume the current price of the one-year bond is £0.95 and the current price of the two-year bond is £0.90. If the government issues one additional two-year bond and uses the proceeds to buy back 1.055 units of one-year bonds, there is now less one-year debt and more two-year debt, and government spending and taxes are unchanged.

Households have now in aggregate one more unit of two-year debt and have financed that purchase by selling 1.055 units of one-year debt. At the end of the first year, the government can reduce taxes by £1.055 because there is 1.055 units less of one-year debt to redeem. But households also have reduced income of £1.055, so that disposable income is unchanged. Similarly, at the end of the two-year period, households will have £1 more to spend, because they have bought an extra unit of two-year debt. But government liabilities have risen by £1, so that the total tax bill is higher by the same amount. Hence over the two-year period, households' consumption possibilities are unchanged, and so aggregate consumption remains unchanged. That is, the change in debt financing has no real effect.

This example is taken from Sill (1994).

11. However debt management neutrality relies on strong assumptions which are unlikely to hold in practice. These include the assumptions that (1) households are able to internalise the government's budget constraint – they recognise that changes in debt financing costs lead

⁷ In fact, the conditions for debt management neutrality are somewhat less restrictive than that needed for Ricardian Equivalence to hold, since debt management does not affect the current mix of tax and spending. For a detailed exposition, see Wallace (1981), Stiglitz (1983), Sargent (1987), and Gale (1990).

to changes in future tax liabilities;⁸ (2) taxes are non-distortionary (so that changes in taxes do not affect economic behaviour); and (3) the investment portfolio choices available to the private sector must include the same risk-return trade-offs as those provided by government securities (so that government borrowing does not provide new investment opportunities which are otherwise unavailable).⁹

12. If these assumptions hold, then the cost of debt management does not matter. Because taxpayers and bondholders are effectively the same agents (so that distributional concerns are not an issue), and taxes are non-distortionary, debt servicing costs are simply a transfer with no economic implications.

13. Because these models appear to be unrealistic, it may seem reasonable simply to dismiss their relevance to debt management. However these models force analysts to be rigorous about why debt management matters – any alternative must make explicit what imperfection drives the analysis.

5. Debt management and monetary policy

14. Historically a key concern of UK debt management was the relationship between debt management and monetary policy; in particular, whether the size and structure of the debt placed any constraints on the ability of the government to control monetary policy. For example, the Radcliffe Report (1959) took the view that the money stock could be controlled by pressure on the commercial banks' liquid asset ratio. Hence the availability of public sector liquid assets (Treasury bills) could be used to affect monetary conditions and hence economic activity.

15. In the portfolio approach,¹⁰ the importance of debt management for stabilisation policy will depend on how substitutable different types of bonds are, and how the return on bonds varies with changes in other asset prices. If different types of bonds are not perfect substitutes, changing the mix of bonds in the private sector's portfolio could affect relative asset yields, and hence investment and economic activity. For example, suppose the return on long-term debt was positively correlated with the return on equities (that is, the two tended to move together over time) while the return on short-term debt was completely uncorrelated

⁸ Alternatively, if we make the more realistic assumption that agents have finite lives, then they must care about the welfare of future generations.

⁹ That is, the private sector can replicate the state-contingent payoff structure of the government security. This means that either all government bonds have a private sector substitute, or the private sector can undertake unlimited short sales or purchases of government securities.

¹⁰ See Agell and Persson (1992) or Roley (1979) for a description of the approach, utilising the capital asset pricing model framework.

with equity returns. Then investors would prefer to use short-term debt rather than long-term debt to hedge against unexpected changes in equity returns. Reducing the supply of short-term debt and increasing the supply of long-term debt would therefore lead to excess demand for short-term debt and an excess supply of equities (at existing yields). For asset markets to clear, either the return on equities must rise or the return on short-term debt must fall. If short-term rates are fixed for some reason, then equity returns must rise. This "crowds out" investment through a higher cost of capital.

16. Empirical research has yielded ambiguous results. For example, Agell and Persson (1992) find that for the US, although changes in the supply of long-term bonds have a statistically significant effect on the expected return to corporate equity and long-term bonds, the effect is relatively small. In contrast, Friedman (1992) finds significant effects on activity from changing the maturity mix of government debt. The evidence for the UK suggests that changing the maturity mix of government debt has significant, but relatively small, effects on asset yields.¹¹ These are likely to be too small for macroeconomic stabilisation purposes, particularly at current levels of debt. However with higher levels of debt, the potential for debt management to affect asset prices might become more significant.

17. Certainly historical concerns over the interaction of debt management and monetary policy were closely linked to the size of the public debt, which reached almost 280 per cent of GDP in the immediate post-WWII period.¹² The substantial reduction in the public debt ratio since then, together with financial deregulation and reform in capital markets, has helped to reduce concerns over the relationship of debt management to monetary policy.

18. The Debt Management Review noted that "debt management is not a major tool of monetary management; nor is monetary policy the main objective of debt management."¹³ There are still some constraints imposed on debt management by the need to consider consistency with monetary policy - for example, the UK Government would not choose to finance its borrowing by printing money, because this would clearly be at odds with its commitment to price stability.

19. More recent discussions of the link between debt management and monetary policy have concentrated on whether the composition of debt can affect the incentives of the monetary policy authority – for example, nominal debt may increase the incentive to inflate. This is discussed below in Section 9 on time consistency issues and debt management.

¹¹ See Hess (1998).

¹² See Goodhart (1998).

¹³ Debt Management Review (1995), p. 8.

6. Minimising costs

20. Minimising cost is often justified as an objective of government debt management by the fact that taxes are distortionary, and therefore debt servicing costs lead to welfare losses.¹⁴ However, by itself, minimising cost is an unsatisfactory objective – for example, the government could minimise cost by, for example, defaulting on its existing debt, or by printing money. These are unlikely to be optimal policies, because they discourage investors, and hence increase costs over the longer term. For now, we assume that the government is able to commit to policies which do not involve default, either partial (eg through the inflation tax) or complete default.

21. One way forward might be to focus on debt maturity – for example, given that the yield curve in many countries tends to slope upwards, issuing short-term debt might lower debt servicing costs over the longer run.¹⁵ However it is important to understand why such cost-saving opportunities might arise.

22. If there were no uncertainty, the yield on a long-term bond would simply be an average of the relevant current and future short-term rates. This means the composition of debt would have no impact on financing costs – the interest cost of a 10-year bond would be the same as issuing a five-year bond initially, and then rolling it over for a further five years.

23. Given uncertainty, a reasonable starting point is to assume that the term structure reflects the market's expectation of future interest rates. The term structure will also include a term premium (or what might be thought of as the "excess return" for a bond over and above expected future interest rates). This premium reflects the market's assessment of the degree of risk associated with that bond. For example, to the extent that investors associate long-term bonds with greater interest rate risk, they will demand a higher return (or pay a lower price).

24. Ideally, investors would prefer bonds which offer a higher payoff in times of unexpectedly low income (and correspondingly lower payoffs when incomes are unexpectedly high). This means that the cheapest forms of borrowing will be those securities which yield high returns (ie a higher cost of debt servicing) when incomes are unexpectedly low. However this means the borrower (in this case the taxpayer) bears the risk – effectively,

¹⁴ Proportional taxes (such as income taxes) are distortionary because they lead to a wedge between the value to society and the value to the individual of the activity being taxed (such as consumption, investment or employment). This means that there will be less of that activity than the amount a benevolent social planner would choose, so that overall welfare will be lower. This is known as the "deadweight loss" from taxation.

¹⁵ The US government, for example, has stated publicly that it avoids lengthening the average maturity of its debt to reduce borrowing costs - see Gensler (1998).

the borrower offers a form of insurance to the investor, for which the investor is willing to pay a premium. In this case, the government needs to be careful about the degree of risk involved and the implications for the government's finances – there will be a trade-off between cost and risk. The case for redistributing risk from the taxpayer to the investor is considered in section 7, while the government's role in facilitating investment through providing debt instruments with particular risk-return characteristics is discussed in section 8.

25. Alternatively, there may be market imperfections and/or information asymmetries between the government and private agents which give rise to the opportunity to reduce the cost of borrowing without necessarily increasing risk. One possibility is that the expectations hypothesis of the term structure may not always hold. For example, Campbell (1995) argued that in the US, when long rates were high relative to short rates, long rates tended to fall, contrary to the predictions of the expectations hypothesis. This suggested that a "naive" strategy of choosing to fund at the cheaper end of the yield curve could result in cost savings for the government. However Campbell's results have not been replicated for other OECD countries – work for the UK and other OECD countries suggests that the failure of the expectations hypothesis may perhaps be very much a US phenomenon.¹⁶

26. Another possibility is that the government may have superior information regarding the path of future interest rates. One reason for this may be that it is more confident than the market in achieving a particular policy, eg it may be more committed to reducing inflation than the market expects. In this case, existing long-term nominal interest rates could be "unfairly" high, and the government might wish to fund at the shorter end (or issue index-linked debt) until their policies became more credible, and long-term rates adjusted (this would also send a signal to the market that the government considered long-term yields unsustainable). Alternatively, the government might try to benefit from information it holds which is not yet known to the market, but which is likely to affect interest rates eg fiscal outturns.

27. However there are also arguments against trying to exploiting such information asymmetries.¹⁷ First, policymakers may not have an unbiased view of the probability of particular outcomes. The market may be in a better position to make an unbiased assessment of, for example, the government's commitment to low inflation. Second, if the government is able to benefit from privileged information, there is an argument for disclosing such information as soon as possible, if it helps to reduce investor uncertainty. In addition, if market participants are rational, they will begin to anticipate forthcoming policy changes, and will demand higher returns. This is likely to reduce the scope for cost-savings – indeed it may

¹⁶ Anderson *et al* (1996), Ch 9.

¹⁷ See Missale (1998), Chapter 6, and Giovannini (1997) for an exposition of the arguments against activism in government debt management.

be to the government's advantage to establish a reputation for avoiding the use of privileged information, to reduce perceptions that debt management actions are linked in any sense to forthcoming policy decisions.

28. The government may still judge that a more discretionary approach allows the possibility of lower interest costs – if markets are in fact efficient, then at least costs would be no higher on average. However, in attempting to exploit possible arbitrage opportunities, the debt manager must act in a discretionary (unpredictable) manner. Because the government is usually a significant player (particularly in the domestic market) this can create uncertainty over the true price of debt. Conversely, policies which enhance the predictability and transparency of government debt policy may help to lower costs in the long-term by reducing the risk premium attached to uncertainty over issuance policy – this might include, for example, commitment to an auction timetable. This would have the added benefit of reducing perceptions that the government might be tempted to act opportunistically.

29. A stable and predictable opportunity for long-term cost savings may exist if the market is segmented in some way - investors may have "preferred habitats"¹⁸ so that they are willing to pay a premium for particular securities. For example, if investors want to finance a long-term commitment, they will prefer long-term securities, to reduce uncertainty. Regulatory or tax factors may also influence demand for particular maturities. Anecdotal evidence suggests that in the UK, long-term bonds command such a premium, largely because of institutional demand from pension funds.¹⁹ In this case, the debt manager does not face a simple trade-off between risk and return. However, it should be noted that it is a difficult task to demonstrate conclusively that such preferred habitats exist, and empirical evidence on the existence of supply effects is relatively weak.

30. Another area for the UK where there may be evidence of a segmentation effect is that of non-marketable debt, ie, National Savings products. These have tended to offer slightly cheaper financing than the wholesale market, reflecting in part the different nature of the retail market and retail products, and possibly the attractiveness of the government's "brand name" within the retail sector to certain investors.

¹⁸ Modigliani and Sutch (1966).

¹⁹ For example, the UK yield curve has habitually tended to slope downwards at the long end (although this could also reflect the impact of "convexity" - because prices are a convex function of bond yields, the implied forward rate will tend to underestimate expected future rates, biasing the yield curve down). In addition, data on average real holding period returns for the UK for the period 1982-1996 shows that that the return on long-term conventional bonds has tended to be somewhat lower than that of medium-term bonds (Deacon and Derry, 1998, p 72).

Box 2: National Savings

The Government has financed a significant portion of its deficit via the retail savings market throughout this century. National Savings has arisen from an amalgam of the Post Office Savings Bank, which was created to provide accessible, safe, easy to understand saving opportunities, and National Savings Certificates, which were launched as a retail financing tool at a time when capital markets were neither deep nor liquid and when government borrowing, particularly in wartime, relied heavily on selling bonds to the general public. Recent reviews of National Savings have emphasised its role in providing an alternative source of financing to wholesale debt, although it retains the secondary objective of promoting government savings policies and filling any gaps in savings opportunities left by the private sector.

National Savings today is judged largely on its ability to "add value" for the taxpayer by providing slightly cheaper financing than through gilts. The calculation of value-added takes account of the full cost of running the retail savings business and any tax concessions on products such as National Savings Certificates or Premium Bonds.

However, the justification for the retail arm extends beyond a straightforward cost comparison. Even when it would be possible to raise sufficient funds at reasonable cost from the wholesale market through selling gilts alone, there are benefits from spreading the government's financing across both retail and wholesale markets. Gilts and National Savings products have different characteristics and the wholesale and retail markets react in a different way to economic and political developments. This means that financing through National Savings will often be complementary to financing through gilts. Gilts are bought primarily by financial institutions; National Savings products by individuals mostly over the age of 50. These investors react differently to economic developments. Although the average duration of gilts is higher than that of National Savings products, National Savings investors tend to hold their investments for longer than institutional holders. Gilts yields are also more volatile than National Savings interest rates as the tendency is to change National Savings rates only periodically, lagging movements in gilt yields. This has a dampening effect on the fluctuations in overall debt interest costs.

The social role of National Savings remains important though not as dominant as it once was. National Savings provides a means for the Government to encourage the savings habit through the accessibility of post offices, the readiness to cater for low deposits by small savers and through specially designed products such as Index-linked Savings Certificates, Pensioner Bonds and Children's Bonus Bonds. A significant proportion of the public value the relative security offered by such products, without the complication of investing in gilts. In the coming year one of the new main ways in which National Savings will promote the Government's savings policies is the provision of a cash ISA conforming to CAT standards.

Improving market efficiency

31. The government can also reduce costs at the microeconomic level by changing the characteristics of the market for debt. The aim here is both to enhance the overall efficiency

of the market (maximise the gains from trade) but also to try to maximise the government's share of the gains. Microeconomic theory suggests that markets are most efficient when they are highly competitive, with a large number of participants.

32. Governments have introduced a number of policies for the organisation of both primary and secondary markets aimed at enhancing the liquidity and efficiency of the market for debt. These include the establishment of a system of primary dealers, who have an obligation to promote a liquid secondary market; the use of auctions to sell debt rather than placement through banks; the issue of benchmark bonds, that is, large fungible bond issues with the same coupon and maturity date; the establishment of "repo" markets; and the introduction of "strips" (where a bond is separated into its individual cash flows).

33. One motivation for such policy changes has been the desire to increase the market capacity to absorb large tranches of debt. The domestic market may be limited by the ability of individual investors to take on risk. This can be partially alleviated by establishing a system of primary dealers, who may receive certain privileges in return for an obligation to participate actively in bond issues and promote a liquid secondary market. In addition, the establishment of futures markets and also, more recently, repo markets, have allowed market participants to hedge against interest-rate risk.

34. Liquid secondary markets may help to reduce borrowing costs by increasing demand, and by reducing transaction costs and risks. Investors are likely to prefer government securities with easily observable prices and which can be easily traded. This may reflect the existence of search costs, or trading externalities, which make it costly to price less standard debt instruments. Individual dealers may also prefer highly liquid securities, since it reduces their exposure to market risk in taking on unhedged positions in individual securities. Benchmark bonds, because they are a standardised instrument in large supply, may therefore command a liquidity premium over other securities. For the UK, anecdotal evidence suggests that the benchmark premium is often around 3-4 basis points, and sometimes higher.²⁰

35. An alternative argument is that cost savings could be made by tailoring bonds more closely to investor preferences – this would favour issuing smaller numbers of bonds, with perhaps more complicated options. However the trend has been for governments to move towards greater standardisation, and fewer types of securities offered, suggesting that the advantages of liquidity outweigh the potential gains from more exact liability matching. In addition, investor demand for more specialised bonds may have been met at least partially by the introduction of "strips" (although presumably these would also have some cost in terms of lower liquidity).

²⁰ Liquidity is a characteristic which any type of bond could provide, in theory. However in practice bondholders seem to favour conventional fixed price securities.

36. There is a substantial literature on the potential for the choice of auction to affect the cost of debt financing. The recent move by the US to adopt a uniform price mechanism for auctioning all its bonds is motivated by the theory that such an auction mechanism may help to encourage greater participation and improve revenue by reducing the "winner's curse". However this is still an issue of debate among academics and practitioners – uniform price auctions could also reduce revenue, for example, by increasing the risk of collusion.²¹ The UK uses a multi-price auction format for conventional gilts, but has chosen to adopt a uniform price format for auctions of index-linked bonds, because of the different nature of the risks involved to the bidder for each type of security.

Box 3: Auctions

Commonly used auctions are as follows:

- **Dutch auctions** refer to an open outcry auction where the auctioneer calls descending prices until the good is sold.
- **English auctions** are open outcry auctions where the auctioneer calls ascending prices until only one bidder remains to purchase the good.
- In a **first-price sealed bid auction** the good is sold to the bidder who submits the highest bid, at the bid price.
- In a **second price sealed bid auction** the winner is the highest bidder, but he pays the bid of the second-highest bidder.

Under a certain set of assumptions each auction format yields the same revenue to the auctioneer. These assumptions are that (1) the bidders are risk neutral; (2) the auction is for a single good which has a subjective value to the bidder; (3) the bidders draw their valuations from the same probability distribution; and (4) payment is a function of bids alone. This is known as the "revenue equivalence theorem".¹

However, the auction of government bonds involves several deviations from these assumptions. Bonds have a similar intrinsic value to each and every bidder (or common value). Bond auctions are also multi-unit auctions. Bidders submit a demand schedule, which specifies the amount that bidders are willing to buy at each price. In a uniform-price auction, all bidders pay the same price for the entire quantity they are awarded. In a discriminatory auction, bidders pay according to their demand schedule. Bond auctions also differ from most other auctions by the existence of when-issued trading (ie, trading of an issue prior to its auction through forward contracts), active secondary markets, and non-competitive bidding entitlements (non-competitive bids are awarded in full at the price determined by the competitive bidders).

²¹ See Das and Sundaram (1996) and Nandi (1998) for discussion on this point.

If the good has a common (resale) value to all bidders, then the revenue equivalence theorem no longer holds. In a first-price, sealed bid auction, the risk of the "winner's curse" leads to bid-shading – because buyers are uncertain over the true price, they bid less than they think the good is worth, in order to avoid the risk that they pay more for the good than it is worth. By contrast, in a second-price auction, bidders are willing to pay more because if they win, they only pay the second-highest bid. Using similar logic, a number of economists have argued that uniform-price auctions should yield higher revenues than the discriminatory format.

However, it is not clear whether these results carry over to multi-unit auctions. In particular, the use of a uniform-price format in a multi-unit auction may encourage more strategic behaviour by bidders. By submitting steep demand schedules, bidders may actually lower revenues below that of a discriminatory auction. The uniform-price format may also encourage collusion, because there is a much larger return to co-operation among bidders. Finally there may be less incentive under a uniform-price format to actively trade in the secondary market, since all bidders receive the market-clearing price. These effects could outweigh the benefits from reducing the winner's curse. While empirical evidence is limited, so far there appears to be little difference between the two formats.

The UK uses a discriminatory or multi-price auction format for conventional gilts, but has chosen to adopt a uniform-price format for auctions of index-linked bonds, because of the different nature of the risks involved to the bidder for each type of security. Conventional gilts are viewed as having less primary issuance risk. There is a mature when-issued market to perform price revelation functions; there are often similar existing bonds to allow ease of pricing (or indeed a re-opening of a presently existing bond); bonds can be hedged using futures; and the secondary market is liquid. This suggests that participation is not significantly deterred. Multi-price auction formats also reduce the risk to the government of implicit collusion at auction.

In contrast, index-linked gilts cannot be hedged in the same way as conventional gilts. The secondary market for index-linked gilts is also not as liquid as for conventional gilts. Both of these factors increase the uncertainty of index-linked auctions and would increase the cost of the winner's curse. Uniform price auctions thus reduce this uncertainty for auction participants and encourage participation.

¹ For a review of the literature on Treasury auctions, see Malvey, Archibald, and Flynn (1995), Das and Sundaram (1996), and Chari and Weber (1992). McAfee and McMillan (1987) and Milgrom (1989) provide a more general overview of auction theory.

37. The advantage of implementing cost minimisation policies at the "microeconomic" level is that they are largely independent of the type of bond sold – hence they should allow reductions in cost without adverse implications for risk. However, a concern for liquidity may place some constraints on the types of bond sold. New or novel instruments may be quite costly to introduce to the market. This may narrow the range of instruments available. In turn, this might limit the degree to which government debt can offer insurance against particular risks, either to the government or to bondholders.

Implications for debt management

38. The Treasury has generally avoided taking views on interest rates, as it does not have an intrinsic advantage over the market in assessing the future path of interest rates. In addition, because it is a large issuer, it is unlikely that it could enter and exit the market without affecting prices. Hence the Treasury does not try to actively trade to "beat the market". Instead, the Treasury primarily looks for cost savings that can be achieved through the underlying structure of the market for government debt.

39. In order to enhance predictability and transparency, the Treasury publishes an annual remit for the Debt Management Office covering issuance policy (amount, maturity, and timing of auctions). Because it is not a rigid calendar, the Debt Management Office retains some discretion over the amount and type of bond to be sold at each auction; however there is a quarterly pre-commitment to stocks. The Treasury also retains the right to issue on "tap" for market management reasons. Variations to the auction programme may be justified in light of market conditions or unexpected events (for example, to avoid clashes with the timing of Budget announcements). The Treasury tries to ensure that any such variations are clearly explained and understood by the market. It also tries to signal in advance through the remit how its issuance policy might change in the light of new information, eg changing fiscal forecasts. This is to avoid the perception that such discretionary actions might be undertaken for more opportunistic reasons.

40. Issuance policy is focused on supporting benchmark issues, because of the perceived cost advantages. The Treasury generally concentrates issuance policy on building up benchmarks in three areas – the 5, 10, and either the 25 or 30-year maturities. While issuance has been fairly evenly spread over these maturities, there has been a slight bias towards the short and long end – although it is difficult to establish conclusively the existence of "preferred habitats", anecdotal evidence suggests a willingness to pay a premium at both the short end (from banks) and at the long end (from pension funds).

41. The market for index-linked gilts tends to be less liquid than that of conventional gilts. Turnover is lower than in the conventional market, with fewer traders.²² This may reflect the fact that index-linked gilts tend to be bought by end-investors who hold them for liability-matching reasons, rather than as an actively traded financial instrument. There is a question as to whether the relative illiquidity of index-linked gilts is costly for the Government. Over the recent past, index-linked gilts have tended to be a cheaper form of financing than conventional gilts, reflecting either forecast error and/or the willingness of

²² In the UK, for the year up to March 1999, turnover in the conventional gilts market was over 30 times that of the index-linked market by value.

investors to pay a premium to avoid inflation risk.²³ However, other countries have in the past found index-linked gilts a relatively expensive form of financing, possibly because of the lack of liquidity.²⁴

7. Taking account of risk

Distortionary taxes and the optimal taxation approach

42. If the government is risk averse, it will be willing to trade off higher borrowing costs in order to lower the variability of its finance costs. But how risk averse should the government be? Tobin (1963) argued that the government should focus debt management on cost minimisation and macroeconomic stabilisation, ignoring risk: "If anyone is in the position to be his own insurer, it is the Secretary of the Treasury."²⁵ Conversely Wheeler (1997) argued that governments should follow the risk preferences of the median voter, who is typically risk averse. Cassard and Folkerts-Landau (1997) argue that the government should define its risk tolerance level in terms of the maximum interest rate cost and excess volatility that can be sustained on the debt portfolio without jeopardising the budget targets and medium-term objectives of the government.

43. The insight of the optimal taxation approach is to show that because of the nature of the loss function from taxes, the government should act as if it were risk averse, even if all households are risk neutral. This means that the government should be willing to accept higher debt servicing costs, if it reduces unexpected fluctuations in tax rates.

44. The optimal taxation approach²⁶ begins by assuming that the main reason for changes in taxes is to meet the government's long-run financing constraint; to ensure the government remains solvent, the present value of primary surpluses (taxes less expenditure, excluding debt-servicing costs) needs to be sufficient to pay off the existing debt (this is called the government's intertemporal budget constraint). However, this could be met by a variety of deficit paths – the government could choose to balance the budget at every period, or it could

²³ See Townend (1997), p 4, and Deacon and Derry (1998), p 72. For the period 1982-1996, real holding period returns on index-linked bonds have been at least 200 basis points lower than those of conventional gilts. Inflation expectations (as derived from the term structure) have also tended to underestimate the decline in inflation.

²⁴ For example, Persson (1997) notes that in Sweden, the real interest rate for index-linked bonds issued in 1995 was 5-5.5 percent, compared with the historical average of 3-4 percent.

²⁵ Tobin (1963), p 192.

²⁶ The seminal article is that of Lucas and Stokey (1983). Chari and Kehoe (1998) provide a comprehensive survey in their chapter for the forthcoming Handbook of Macroeconomics.

run deficits for a while, followed by surpluses. If it balanced the budget at every point in time, then taxes would rise and fall with changes to spending.

45. However, taxation lowers welfare, because it creates a wedge between the value to the individual of an activity, and the value to society. Optimal taxation models try to find the path for taxes that minimises the total welfare loss. Because the welfare losses from taxation increase more than linearly with changes in taxes, the total loss from raising taxes in one period and then lowering them in the next period will tend to be higher than if taxes were the same over both periods (for a given total amount of taxation over the two periods). The exact characterisation of the optimal tax policy will depend on the specification of the consumption, investment and labour supply functions (because these determine what the exact welfare loss is in each period for different tax policies), and the type of debt the government can issue.

46. A common simplification is to assume that the loss function from taxation is a quadratic function, so that the expected loss is proportional to the square of the tax rate. Then the optimal policy for the government is to set the tax rate so that it remains the same over all future periods, given expected future developments in income and spending (hence the term "tax smoothing").²⁷ In this case, the government would expect to run a deficit when spending requirements were expected to be high, and surpluses when spending requirements were relatively low. However as unanticipated shocks hit the economy, the tax rate would need to change in order to ensure that the government continued to meet its intertemporal budget constraint; this means the tax rate would actually fluctuate randomly over time.

47. If however the return to debt could be made dependent on such shocks (or state-contingent), then theoretically the government could smooth out its spending commitments through the changing return on debt, rather than by changing the tax rate. In Lucas and Stokey (1983) the government can issue debt instruments of any maturity, contingent on the outcome for government spending. Because markets are complete, it can issue a full set of instruments to "insure" against any possible shock. This means that whatever the shock to government spending in future periods, the government can always meet its intertemporal budget constraint. If state-contingent debt were available, then debt (and taxes) need not change very much at all in response to fiscal shocks – debt management could provide full fiscal insurance.²⁸

²⁷ Barro (1979).

²⁸ Scott (1997), in a model with labour and capital taxes, provides an explanation of the different dynamics of taxes with and without state-contingent debt. With state-contingent debt, the government has a non-distortionary means of meeting its intertemporal budget constraint in the face of shocks. In this case, he shows that ex ante capital taxes are optimally set to zero while labour taxes fluctuate predictably with changes to employment. Debt itself follows a path which is a predictable function of government spending. If debt is not state-contingent, then

48. Using the debt portfolio to insure against shocks to the government's intertemporal budget constraint looks very similar to the rationale for a diversified portfolio in the portfolio management literature. Risk-averse investors will try to minimise the variation in their portfolio (for a desired level of return) by investing in a range of securities to reduce the unique risk associated with any particular stock. State-contingent debt's return is inversely related to shocks to the government's assets and liabilities (that is, future tax flows and spending commitments); as a result, it minimises variations in the value of the government's portfolio. This is however a much wider definition of the government's portfolio than conventional measures (such as the public sector balance sheet).

49. In practice, while governments have access to a range of different securities with different risk characteristics, most governments do not issue state-contingent debt. Making the return on debt contingent on government spending outcomes would create a strong incentive for the government to consistently overspend – it is unlikely that any government would be able to find a buyer for such bonds at a sensible price. This still does not explain why governments could not issue securities whose returns were linked to output or consumption. However new and novel debt instruments may, at least initially, be relatively costly to introduce because of illiquidity. In addition, there might be considerable data problems involved in ensuring that any index used in such a bond would be acceptable to all investors, easily measured and not subject to revision.

50. In addition, it is not clear that fiscal policy is principally driven by tax-smoothing considerations –while Barro has shown that the tax-smoothing model can explain much of US and British fiscal history over the past 200 years, it cannot explain, for example, the increase in debt over the past two decades.²⁹ If governments do not smooth taxes, should debt management support a tax-smoothing approach?

51. However these models help to distinguish a particular role for debt management, which is entirely focused on risk minimisation. Debt management can be used to hedge against exogenous shocks to the government's finances, to avoid unexpected changes in taxes. This is likely to be robust to different specifications of labour supply functions or consumer preferences.

tax policy must adjust in response to stochastic shocks. As a result, the process for labour taxes will contain a unit root (that is, its level in any period will reflect the last period's level, plus or minus some random element arising from the shock), while ex ante capital taxes will no longer be zero but will depend on the stochastic properties of the excess burden of taxation and its covariance with the net real interest rate. In this case, the path for debt will also contain a unit root.

²⁹ Alesina, Roubini and Cohen (1997) p 229. The authors argue that theories which take into account the political motives which influence governments are more successful than a pure tax-smoothing approach.

Using conventional securities

52. Since governments do not issue state-contingent debt, a number of papers have looked at whether the optimal fiscal policy could be supported by conventional debt instruments. Bohn (1990) assumes a quadratic loss function for taxes and derives the optimal debt policy in the presence of uncertainty in the rate of return on different debt instruments. The optimal tax policy is to stabilise taxes across all possible states of nature. This means that the optimal debt policy should be structured to minimise against sources of uncertainty in taxes (unforeseen changes in spending and output), and hence minimise the variation in tax rates.

53. The precise structure depends on the composition of shocks that hit the economy. Aggregate supply shocks lead to a negative correlation between prices and (real) output. This leads to a positive correlation between the return on nominal debt (as measured by the holding period return) and tax revenues (as inflation rises, the cost of nominal debt falls, offsetting the impact of falling tax revenues). Aggregate demand shocks on the other hand lead to a positive correlation between prices and output. In this case, nominal debt adds to the overall variation in finances, because the cost of nominal debt rises when output and tax revenues decline. These effects are increased as the maturity of the debt lengthens; persistent changes in the price level will have a greater effect on long-term nominal debt than on short-term nominal debt.

Box 4: A simple model of tax smoothing with more than one debt instrument

This is a simple two-period model, which seeks to explain why the choice of debt is affected by the covariance between inflation and output. The government wants to smooth the cost of taxation over different states of the world. In the current period 0, taxes are already set. However the government can choose between nominal debt and index-linked debt. The government must repay all debt in period 1.

Expected returns are equal across all types of bonds. However realised returns depend on the price level in the next period. For nominal bonds, the realised real return is $(1+i)/(1+\pi)$. The real return on index-linked bonds is $(1+r)$. This means the government faces the following financing constraint:

$$\tau_1 Y_1 = G_1 + (1+r)(1-m)D_0 + \frac{(1+i_1)}{(1+\pi_1)} mD_0$$

where

τ = average tax rate

Y = real GDP

G = real public expenditure
 D = real government debt

m = fraction of debt to be financed with nominal bonds

i = nominal interest rate

π = inflation rate

r = real interest rate

Assuming the Fisher equation holds, the nominal rate of return is a combination of the expected real return and expected inflation $(1+i_t)=(1+r)(1+E_{t-1}\pi_t)$. Assuming the real interest rate is constant, and linearising the budget constraint, we can write the government's problem as follows:

$$\text{Min } \text{Loss} = E_0 \tau_1^2$$

$$\text{s.t. } \tau_1 = g_1 + [1 + r - \hat{y}_1 - m(\pi_1 - E_0 \pi_1)]d_0$$

where \hat{y} is the rate of real output growth, and g and d are the ratios of public spending and debt to GDP respectively.

Maximising with respect to m , the share of nominal bonds, and taking expectations gives:

$$m \text{Var}(\pi_1)d_0 = \text{Cov}(g_1, \pi_1) - \text{Cov}(\hat{y}_1, \pi_1)$$

This means that the optimal share of nominal bonds is increasing in the covariance of inflation with public spending, and decreasing in the covariance of (real) output and inflation. If output and inflation are negatively correlated, then this increases the optimal share of nominal bonds. If however inflation and output are positively correlated, this reduces the optimal share of nominal bonds – if the correlation is strong enough, then it may be optimal to hold nominal assets (a negative share). A rise in the variability of inflation will also reduce the attractiveness of nominal bonds (since their real return will be more volatile).

In an infinite horizon model, the government will be concerned with hedging against unexpected changes to permanent output and spending.

This example is taken from Missale (1998).

54. This line of reasoning can also be extended to foreign-currency debt. Because the return to foreign-currency debt is affected by unexpected variations in the real exchange rate, its return (in domestic currency) is more volatile than domestic debt. For this reason, the UK has tended to avoid issuing substantial amounts of foreign-currency debt, except to the extent that it is used to hedge foreign currency reserves. However, if the real exchange rate tended to appreciate when output fell, (so that the domestic cost of debt also fell) and depreciate when output was unexpectedly high, then foreign-currency debt could potentially be used to hedge against shocks to output and tax revenue.

55. Debt maturity can also partly compensate for the absence of contingent debt. In general, a change in interest rates will affect the intertemporal budget constraint, because it changes the price at which new debt is issued. If interest rates rise, taxes may also need to increase in order to meet the intertemporal budget constraint (the exact amount will depend on the exact pattern of surpluses relative to debt repayments, since a change in the real interest rate also affects the net present value of surpluses). In this case, long maturities provide some insurance against real interest rate changes – in the extreme, issuing (index-linked) perpetuals insulates the government entirely against random interest rate changes.³⁰

56. However if real interest rates are correlated with changes in output and government spending, then shorter maturities could also potentially provide a degree of insurance, depending on what sort of relationship holds. Issuing short-term debt effectively indexes the cost of debt-servicing to the interest rate. Conversely, long-term debt leads to a negative correlation between real interest rates and debt servicing costs, in the sense that if real interest rates rise, then the holding-period return on long-term debt falls. This means that if increases in real interest rates are associated with higher output (and higher tax revenues), then short-term debt is a better hedge than long-term debt – long-term debt worsens the intertemporal budget constraint. Alternatively, if higher real interest rates are associated with weaker output and higher government spending, then long-term debt is a better hedge, since the holding-period return on long-term debt and government financing needs will be positively correlated.

57. This means that the optimal debt structure will depend on the interaction between changes in inflation and changes in government spending and revenue, and will vary from country to country, depending on the structure of the tax system, the nature of the government's spending commitments and the different types of shocks the economy is subject to. But this also suggests that it is difficult to pick any particular type of debt as being more or less risky than another, since this will depend on assumptions as to what sort of shock is most likely to occur – and shocks are inherently unpredictable.

Empirical results

58. Empirical studies have so far yielded mixed results. Missale (1998) calculates the optimal portfolio mix for a range of OECD countries over the period 1985-1997. The optimal share of nominal debt, foreign currency and index-linked debt is estimated from the conditional covariances of their returns with permanent output, spending, inflation and the exchange rate. For most countries, nominal debt performs a useful hedging role. However, these results can be period-specific – for example, for the UK, although nominal debt is a

³⁰ Barro (1998).

useful hedge over the period as a whole, there appears to be no role for nominal debt since 1991 - lower than expected inflation and permanent output, and higher government spending, support the issue of index-linked debt. Missale (1998) also considers the role of short and long-term nominal debt, using data on the yield to maturity to approximate holding-period returns. For the majority of countries, long-term nominal debt plays some role in minimising budgetary risk, but it tends to be small. For the UK, it depends on whether holding a large share of foreign assets is feasible – holding some long-term nominal debt is optimal only if it is not possible to hold substantial amounts of foreign assets. However as Missale notes, these results may be biased against long-term debt because they implicitly assume the real interest rate is constant (and so they ignore the potential role for long-term debt to hedge against refinancing risk).

59. Dale, Mongiardino and Quah (1998) look for the debt structure which hedges against variations in the net present value of the primary deficit (that is, deficit smoothing). This is a somewhat different approach than that of Bohn or Missale, who look for the policy which supports a smooth path for taxes. Dale et al justify this by arguing that the optimal fiscal policy is indeterminate unless particular assumptions are made as to the basic parameters of the model (as noted above). They find that for the UK, the optimal portfolio is entirely composed of index-linked debt. However, the optimal mix of maturities is indeterminate.

60. One message from the empirical work is that (at least for the UK) the exclusion of foreign currency debt appears to be justified. Not only is foreign currency debt more variable in real terms than other forms of debt (because of the volatility of the real exchange rate), but because the real exchange rate tends to depreciate (leading to a rise in the cost of servicing foreign debt) when output is unexpectedly low and spending is unexpectedly high, it exacerbates overall budgetary volatility. Missale (1997) notes that "This finding is quite robust, as it holds for different sub-samples and forecast horizons".³¹ (Conversely, this means that foreign assets might be useful as a hedging instrument.)

Implications for debt management

61. Overall, evidence for the UK highlights the potential value of index-linked debt, but is less convincing on what might be the optimal maturity mix. However the results are sensitive to the period chosen. The experience of the 1990s has been very different from the 1980s, which is not surprising, given the substantial fall in inflation and the impact of structural reform on the economy. As a result, it is not clear whether debt managers could rely strongly on the empirical results from these models. The incidence of any particular type

³¹ Missale (1997), p 85. This is not necessarily true for all countries – Fowlie and Wright (1997) show that in NZ foreign currency debt helps to reduce overall volatility of the government's finances, because, unlike other countries, the exchange rate varies positively with output.

of shock is difficult to predict. Historical covariances can change over time, particularly if the economy is subject to structural change and/or policy changes. This makes it difficult to pin down the optimal risk-minimising portfolio. As Missale (1997) concludes after looking at evidence for the UK and for Italy, "choosing debt instruments to minimise budget risk appears to be quite a difficult task" (p. 86).

62. Another caveat is that for most empirical studies of tax-smoothing, the optimal share of particular bonds is often many times in excess of GDP. For example, Bohn (1990) finds that for the US over the period 1954 - 1987, the best outcome would have been to hold index-linked bonds as an asset, and issue around 2680 percent of GDP in nominal bonds. This is because the calculations are made using quarterly data. Over a three-month period, the variance of inflation is very small relative to output, so that any hedging instrument must be held in very large quantities to provide a sufficient hedge against output fluctuations and spending shocks. One strategy is to calculate the optimal share constraining the share of debt issued in any one instrument to be non-negative. However, if debt levels are low, and governments are reluctant to hold large quantities of assets, the ability of debt management to hedge against variations in the government's finances may be limited.

63. The literature highlights the need to be aware of the performance of different debt instruments, given a range of possible shocks. Nonetheless, given uncertainty, the optimal portfolio seems unlikely to be a "corner solution" where all of the portfolio is held in a particular debt instrument. In the UK, although the proportion of index-linked debt has been gradually increasing, the government has continued to issue substantial quantities of conventional debt, and in particular long-term nominal debt. The issue of retail debt provides another instrument with quite different market characteristics. This mix can be seen as an attempt to hedge within the debt portfolio the different impacts on financing costs and risks from particular types of debt. This may not be an "optimal" response, but it avoids substantial exposure to any one type of shock.

8. Role of government in financial markets

64. An alternative argument for the government to issue particular types of debt is that the government can facilitate risk sharing in the private sector. For example, the provision of a safe or risk-free asset (such as an index-linked bond) could potentially improve the allocation of risk – relatively risk averse investors would prefer to hold the risk-free asset, while less risk averse investors could short the risk-free asset, and buy more risky assets with a higher

rate of return.³² This may also lower the cost of borrowing - because investors value the inflation insurance, they would be willing to pay a premium for such bonds.

65. However if the government provides such an asset, it is not clear that it necessarily leads to an improvement in overall welfare. The problem is that if the government takes on risk, this is reflected in greater uncertainty in the tax burden. This in turn creates a welfare loss. So any risk-sharing scheme must generate a sufficient welfare gain to offset the loss from a possible increase in distortionary taxation.³³

66. Gale (1990) is one example of a model where risk-sharing can be welfare-enhancing, because it allows risk-sharing across generations. In his model, consumers live for two periods. In the first period, consumers invest in an asset whose return is uncertain. In the second period, they "retire" and live off the income from the asset. Introducing a government bond which offers a certain real return gives the young a risk-free investment which guarantees some consumption when they retire. The government pays off the debt by selling debt to the next generation. This improves overall welfare if the variability of investment returns is large enough.

67. However, in Gale's model, government debt only brings about a welfare gain if the rate of return is negative - that is, investors pay the government for the privilege of holding the bond. As a result, the government is able to reduce taxes. If this is not the case, then government-provided insurance may not always increase welfare, because it increases the deadweight loss from taxation.

68. Another problem is that the role for government debt in such models is not unique - it can be fulfilled by a durable asset which can be stored for the next period, or through private securities which offer close substitutes for government bonds (although government bonds are still likely to be seen as less risky than corporate bonds). Hence they do not provide a convincing explanation for why the government should be involved in financial intermediation.

69. One approach is to identify explicitly the imperfection which provides a unique role for government debt. In Holmstrom and Tirole (1998), firms hold liquid assets as protection against adverse liquidity shocks, which would otherwise force the firm to abandon profitable

³² See for example Campbell and Viceira (1998) who demonstrate that provision of a long-term index-linked bond provides substantial welfare gains to long-term investors by eliminating inflation risk.

³³ Debt plays a slightly different role here than in the previous sections. Here it is assumed that the sole reason for issuing debt is to allow risk-sharing. There is no government spending, so there is no role for debt to smooth taxes. Hence any improvement in overall welfare arises solely from the role of debt in improving the allocation of risk.

projects. In the event of such shocks, the firm can sell the liquid asset and gain sufficient funds to continue investing. The private sector can insure itself against idiosyncratic shocks, because firms can hold claims on other firms, which can be liquidated in the event of a liquidity shock. This is not true for aggregate shocks, because there is a possibility that the demand for liquidity will exceed the value of the private sector. However in this case, the government can meet the demand for liquidity (through government bonds) because it can commit future consumer endowments through taxation. To compensate for the deadweight loss from taxation the government issues debt at a premium - firms are willing to pay for liquidity as it is complementary to production.

70. In this model, the value of government debt to the private sector lies in its liquidity-providing services. To the extent that this premium is large enough to compensate for the additional deadweight loss from taxation, then the issue of government debt is welfare-enhancing.³⁴ While the model does not address the question of the optimal maturity of debt, it suggests one way of approaching the trade-off between cost and risk - cost reductions which incur more risk are worthwhile if the value in terms of reduction of distortion in investment offsets the potential welfare loss from the extra volatility of taxes.

Implications for debt management

71. A common argument is that public debt instruments provide "infrastructure" for financial markets, because they are issued in large quantities, in standardised form and with essentially no risk of default.³⁵ This implies that the government should aim to issue a range of financial instruments which could be used to help financial markets hedge particular risks.

72. This is perhaps one area where theory lags behind the discussion. The theoretical models are not developed sufficiently to suggest that private sector markets require the government to provide financial "infrastructure", only that the issue of debt itself may be welfare-enhancing under particular assumptions. There is as yet very little to be said about issuing a range of instruments with different maturities or risk-return characteristics.

73. Welfare considerations may potentially support the case for introduction of new and novel debt instruments (such as index-linked bonds) because they offer a valuable form of insurance, which is not available in the private sector. On the other hand, the value of a debt instrument might be intrinsically linked to its liquidity characteristics – hence new and novel instruments might not be valued by the private sector because they are harder to price and

³⁴ Although as Holmstrom and Tirole point out, we need to be careful of welfare analyses in credit-constrained models - in fact overall welfare is maximised by redistributing all wealth from consumers to producers, since one unit of net worth creates more than one unit of output.

³⁵ Campbell (1998).

harder to trade. Overall, the analysis suggests that the welfare gains are closely linked to the premium that bidders are willing to pay for such instruments – if close substitutes exist (either in the government or the private sector) then both the potential welfare gain and the premium that investors are willing to pay will be small.

74. Index-linked bonds have an advantage in that not only can they reduce risk for investors, they also reduce the variability of the government's real borrowing costs, so that they benefit both borrower and lender (if both are primarily concerned with real rather than nominal returns). However if index-linked bonds are not sufficiently liquid, then this is likely to reduce their value to the private sector, which may make them a more expensive form of financing. In turn, if they are too costly then governments may not find it worthwhile to issue them. In the UK, index-linked bonds appear to command a premium, not least because they meet a particular institutional demand by pension funds. But this may also reflect regulatory factors which may be unique to the UK.

9. Time consistency, government debt and inflation

75. Another aspect of debt management which has been emphasised in the academic literature is that of time consistency and whether the government can improve policy outcomes through particular debt structures. Public debt creates the potential for time inconsistency of fiscal and monetary policy – once investors have committed to holding a certain amount of government debt, the government has an incentive to reduce its costs by renegeing on its promise to pay back the investor, either through inflation, unexpected changes in interest rates, explicit taxation, or outright default. However the maturity and composition of debt can potentially help to enforce time-consistent behaviour. For example, the government could reduce the incentive to inflate by issuing either foreign-currency debt or index-linked domestic debt - in either case, it cannot inflate away its debt obligations. Alternatively, it could issue short-term nominal debt or floating-rate debt.

76. However while such strategies may reduce the incentive to inflate, they can also increase the probability of default, because the government will find it more costly to service the debt in times of financial stress. For example, short-term debt increases the frequency of refinancing. If refinancing coincides with an adverse fiscal shock, this increases the burden of debt servicing. In turn, this increases the risk of default, and hence further increases the cost of debt servicing. In an extreme situation, it could lead to a self-fulfilling "confidence crisis" where the loss of investor confidence increases the burden of debt servicing to such an extent that the government is forced to default (fulfilling investor expectations), even if initially it was fiscally solvent.

77. To see how this might happen, suppose the cost of debt-servicing were to increase suddenly due to an adverse interest-rate shock. This increases the probability that the government might prefer to default on its debt-servicing repayments rather than increase taxes. If investors expect default, they may refuse to roll over the debt, forcing the government to repay its debt immediately. This would increase substantially the potential tax burden, which could then lead to default. This might occur even if the government was previously financially solvent – the problem is triggered by investors' refusal to roll-over the debt. In contrast, issuing long-term debt limits the costs faced by government, by reducing the amount of new debt that needs to be financed at any one time - if all debt were composed of perpetuals then a confidence crisis would be much less likely because the debt would never be rolled over.³⁶

78. Time-consistency issues may be more important when debt levels are high. At low levels of debt the incentive to inflate is likely to be relatively small, and time consistency issues are likely to be less important. Missale and Blanchard (1994) argue that countries have tended to use short-maturity debt to enhance credibility when debt levels are high, but that this is likely to be less important at low levels of debt. Hence, those countries with high levels of debt tend to have shorter average maturity structures.

Implications for debt management

79. These models provide an interesting theoretical role for debt management. But while long-term nominal debt may increase the temptation to inflate, it is not clear that it is the dominant factor in determining a country's predilection for inflation, particularly at the level of indebtedness experienced by the UK (although the argument may have had greater relevance in the past). Nor is there strong evidence that risk premia are strongly related to the level or maturity of debt.³⁷ The UK, like many other countries, has now moved to resolve the time-inconsistency problem for inflation by giving operational autonomy over interest rates to the Bank of England. Such institutional solutions are likely to be more sustainable.

80. Models of confidence crises are interesting in that, unlike other models of government debt management, they focus on re-financing risk. These models may help to explain the

³⁶ This example is taken from Alesina, Prati and Tabellini (1990). The experience of Mexico in 1994 provides a real-time example of how the issuance of short-term foreign debt can contribute to a liquidity crisis.

³⁷ See Alesina, De Broeck, Prati and Tabellini (1992). Alesina et al find that the default risk premium (as measured by the differential between private and public debt yields) is positively related to the level of debt as a percentage of GDP, but is very small; and that it has no relationship to the maturity of the debt. One caveat is that their measure of the risk premium may be somewhat flawed. However Dornbusch (1998) also comments that the risk premium related to the level of debt seems small, and certainly suggests that there is no expectation of an old-style inflationary escape from debt.

attractiveness of long-term nominal debt. Very few governments ever default outright – partial default (through the inflation tax) is much more common. Clearly, the costs of outright default (such as a loss of creditworthiness) are perceived by most governments to be extremely high. If outright default is ruled out as being too costly, then nominal debt provides a unique form of insurance in times of severe financial stress, albeit at a cost. Long-term debt also helps to reduce refinancing risk – this is likely to be most important in times of financial crisis.

10. Conclusions

What's missing from the literature?

81. The academic literature covers a wide range of possible factors which might affect debt management. However although the practice of debt management now reflects some of these factors, there is still a gap between theory and practice; for example, no country has yet attempted to use debt as a macroeconomic hedging device.

82. In fact, almost all government debt managers focus on minimising cost. Yet most of the literature is focused on issues of risk (the time-consistency literature is an exception). This may reflect in part the nature of the specific models used - in the optimal taxation literature, for example, taxpayers and bondholders are basically the same agents, so that distributional issues do not matter. In reality, governments are concerned with the distributional implications of debt servicing costs. Taxpayers and bondholders are perceived to be different groups. Consequently, the government will care about the cost of insurance and weigh up the gains from cheaper financing (and hence lower taxes) against the possible gains to taxpayers from a smoother path for the government's finances. This rules out expensive forms of insurance (such as state-contingent bonds).

83. Governments may also be sensitive to different types of risks than those explored in the literature. Governments have traditionally focused on the annual budgetary impact of debt servicing costs, and have tended to ignore changes in the market value of the debt portfolio.³⁸ In contrast, the optimal taxation literature focuses on the contribution of changes in the market value of the debt portfolio to the overall variation in government finances. This has potentially quite different implications for the optimal portfolio – although a portfolio composed of floating rate bonds might have a relatively stable market value, it would have potentially the greatest variability in annual debt servicing costs.

³⁸ See Nars (1997) and Cassard and Folkerts-Landau (1997) for a description of public debt management in a number of countries. There are a growing number of countries who try to take account of changes in the market value of the debt. However the majority of countries concentrate on the implications of debt servicing costs for annual budget costs.

84. One reason for the divergence may lie in accounting conventions – for most countries, changes in the value of the market portfolio of the debt are not usually reflected in measures of the government's financial balance. It may also reflect a difference in the assumptions made about what matters for government solvency. It may be more appropriate to consider the change in the market value of the portfolio when the relevant measure of solvency is the intertemporal budget constraint. But governments may pay more attention to the deficit, if investors and credit-rating agencies take the deficit measure as the relevant measure of fiscal sustainability. This bias will be reinforced by fiscal rules (such as the Maastricht criteria) which focus on deficit or debt measures, whereby the government adjusts spending or tax measures to meet the fiscal rule.

85. In addition, because governments are not small traders on the market, they may be concerned about the impact of financing large quantities of debt at any one time. Lumpy issuance may also be costly because it reduces liquidity and predictability. Selling and buying back debt involves transaction costs, which may not be insignificant. In contrast, most of the literature assumes a perfectly competitive (world) market where governments are able to sell and buy back debt at the prevailing market price.

86. Finally policymakers may be more sensitive to the need to insure against extreme risks. In normal circumstances, the composition of the portfolio may not matter very much. At low levels of debt, the gains to changing the portfolio composition in terms of lower cost and/or risk may be relatively low. However in times of extreme financial stress, the composition of the outstanding portfolio may matter a great deal, and issues of, for example, refinancing risk, may become very important. This is likely to bias the policymaker towards longer maturities.

What does the literature tell us?

87. Overall, it appears that the literature is some distance from being able to determine the optimal portfolio. However, a number of conclusions can be drawn from the literature:

- the first step towards lower financing costs is likely to be a liquid and efficient secondary market for government debt. In addition, the government may be able to reduce the cost of financing through its choice of institutional design for the market;
- if debt management policy is predictable and transparent, then it will help to reduce uncertainty over the "true" price for government debt – this reduces the risk premium attached to government debt. This suggests that more opportunistic behaviour (trying to "beat the market") may be counter-productive;

- if markets are efficient, there will be a trade-off between cost and risk. The most attractive debt instruments for investors are likely to be those which provide the greatest insurance against bad outcomes (such as unexpectedly low incomes). To the extent that investors and the government face similar risks, this means that the cheapest debt instruments are likely to be the most risky for the government;
- the optimal taxation literature makes a strong case for the objective of minimising budgetary risk (ie, insuring against unexpected fluctuations in government revenue and expenditure). However further work is needed before it could be used to provide a practical basis for debt management. In particular, given uncertainty over the nature of future shocks, and also practical constraints on the size of government financial asset holdings, there does not yet appear to be a consensus on the optimal risk-minimising portfolio.

88. On this basis, UK debt management policy appears to be consistent with a number of aspects of the literature:

- issuance policy is consistently focused on transparency and predictability. The Government avoids active trading or trying to "beat the market";
- although the Government's objective is that of cost minimisation, this is primarily focused at the microeconomic level, eg concentration on benchmarks, introduction of repo and strip markets, choice of auction format;
- the portfolio is reasonably diversified, with a relatively high proportion of index-linked debt and also long-term nominal debt. As a result, the debt portfolio provides some insurance against a range of possible shocks. Foreign-currency debt forms only a minimal proportion of the portfolio, and is used primarily to hedge the Government's foreign currency reserves;
- because the level of debt is relatively low (both historically and internationally), and the average maturity of the debt portfolio is relatively long, this provides some insurance against possible "confidence crises". In addition, issuance policy tends to result in a relatively smooth redemption profile, which reduces the degree of exposure at any point in time to unpleasant shocks.

Improving debt management policy

89. Looking at the literature also raises questions as to what might be the optimal structure of the portfolio. At the very least, current debt management policy appears to avoid the worst possible outcomes: because the portfolio is relatively diversified, it does not seem unduly risky, and, because the UK market seems reasonably efficient, the debt portfolio has probably not been too costly (government debt is likely to have been fairly priced). This does not mean that there might not be insurance and/or cost-minimising opportunities which could be exploited further – the current portfolio would equate to the 'optimal' portfolio only by chance and could be some distance away. As yet the literature does not provide us with sufficient guidance as to the best way to move forward – there is no consensus as to what determines the optimal portfolio. However it does highlight some areas where additional work would be useful:

- What is the most appropriate measurement of risk?

Practitioners tend to focus on variations in the debt portfolio alone. To the extent that they try to hedge against risk, they will tend to focus on risks relating to the portfolio itself. In particular, they have tended to concentrate on minimising unexpected variations in debt servicing costs (often ignoring changes in the market value of the portfolio), and also refinancing risk. This is at odds with the academic literature, which looks for the debt structure which helps to minimise unexpected changes in taxes, and tends to ignore refinancing risk. This may reflect different assumptions as to the government's objectives. As a result, they tend to give very different results as to the appropriate risk-minimising portfolio - reconciling the two would help to narrow the gap between theory and practice.

- What is the impact of shocks to the economy on the government's finances?

We know theoretically how demand and supply shocks should affect the economy, at least in a very broad sense. But it would be useful to know more specifically how different types of shocks were likely to affect interest costs for different portfolios, and how these were correlated with changes in taxes and spending. In turn, this would allow an assessment of how the costs of different portfolios fluctuated with particular shocks, and hence an assessment of the riskiness of different portfolios.

- Can we improve our knowledge of the microeconomics of the bond market?

For example, is it possible to quantify the gains from liquidity and the provision of benchmark bonds? Is it possible to improve the liquidity of the market for index-linked gilts or is illiquidity an intrinsic attribute of such bonds? Are there other insurance possibilities which would be valued sufficiently by the market to offset any increase in risk? Ideally for

any debt security we should be able to form an assessment of the potential benefits from lower debt servicing costs, against the potential increase in risk to the government's finances.

- How large are the transaction costs involved in changing the portfolio?

If the costs of changing the portfolio composition (other than through new issuance to replace maturing debt) are prohibitively large, the current structure of the portfolio is, to a large extent, historically determined. However if these transaction costs are small, then the government has potentially much greater flexibility in determining the shape of the portfolio. This is likely to be relevant in weighing up the costs and benefits of moving to alternative debt portfolios.

90. Exploring these areas should help to create a better understanding of the costs and benefits of different portfolio structures, such as a higher proportion of index-linked debt; or whether there are any benefits to targeting a particular duration for the portfolio. In turn, this should help to improve our understanding of what might constitute an "optimal" portfolio.

Reference List

Agell, Jonas, Mats Persson, and Benjamin M. Friedman. *Does Debt Management Matter?* Oxford University Press, 1992.

Alesina, Alberto, Mark De Broeck, Alessandro Prati, and Guido Tabellini. "Default Risk on Government Debt in OECD Countries." *Economic Policy: A European Forum*, October 1992, no. 15, pp. 427-51.

Alesina, Alberto, Alessandro Prati, and Guido Tabellini. "Public Confidence and Debt Management: A Model and a Case Study of Italy," in Rudiger Dornbusch and Mario Draghi, eds, *Public Debt Management: Theory and History*. Cambridge; New York and Melbourne: Cambridge University Press, 1990, pp. 94-118.

Alesina, Alberto, Nouriel Roubini, and Gerald D. Cohen. *Political Cycles and the Macroeconomy*. Cambridge, Massachusetts: MIT Press, 1997.

Anderson, Nicola, Francis Breedon, Mark Deacon, Andrew Derry, and Gareth Murphy. *Estimating and Interpreting the Yield Curve*. Wiley and Sons Ltd, 1996.

Anderson, Nicola, Rebecca Emerson, and Simon Price. "The Objectives of Debt Management." Mimeo, Bank of England, April 1998.

Barro, Robert J. "On the Determination of the Public Debt." *Journal of Political Economy*, 1979, 87(5), pp. 940-91.

Barro, Robert J. "Optimal Funding Policy," in Guillermo A. Calvo, and Mervyn King, eds, *The Debt Burden and Its Consequences for Monetary Policy: Proceedings of a Conference Held by the International Economic Association at the Deutsche Bundesbank, Frankfurt, Germany*. MacMillan Press, 1998.

Bohn, Henning. "Tax Smoothing With Financial Instruments." *American Economic Review*, December 1990, 80(5), pp. 1217-30.

Bohn, Henning. "Why Do We Have Nominal Government Debt?" *Journal of Monetary Economics*, January 1988, 21(1), pp. 127-40.

Brown, E. Cary. "Episodes in the Public Debt History of the United States," in Rudiger Dornbusch, and Mario Draghi, eds, *Public Debt Management: Theory and History*. Cambridge; New York and Melbourne: Cambridge University Press, 1990, pp. 229-54.

Calvo, Guillermo A., and Pablo E. Guidotti. "Indexation and Maturity of Government Bonds: An Exploratory Model," in Rudiger Dornbusch, and Mario Draghi, eds, *Public Debt Management: Theory and History*. Cambridge; New York and Melbourne: Cambridge

University Press, 1990, pp. 52-82.

Calvo, Guillermo A., and Pablo E. Guidotti. "Management of the Nominal Public Debt: Theory and Applications," in Harrie A. A. Verbon, and Frans A. A. M. van Winden, eds, *The Political Economy of Government Debt*. Amsterdam; London; New York; Tokyo: North Holland, 1993, pp. 207-32.

Calvo, Guillermo A., and Pablo E. Guidotti. "Optimal Maturity of Nominal Government Debt: An Infinite-Horizon Model." *International Economic Review*, November 1992, 33(4), pp. 895-919.

Campbell, John Y. "Asset Prices, Consumption, and the Business Cycle." National Bureau of Economic Research Working Paper, No. 6485, March 1998.

Campbell, John Y. "Some Lessons From the Yield Curve." National Bureau of Economic Research Working Paper, No. 5031, February 1995.

Campbell, John Y. "Testimony Before the Committee on Ways and Means: Hearing on Managing the Public Debt in an Era of Surpluses." June 1998.

Campbell, John Y. and Robert J. Shiller. "A Scorecard for Indexed Government Debt." Cowles Foundation Discussion Paper, No. 1125, Yale University, May 1996.

Campbell, John Y. and Luis M. Viceira. "Who Should Buy Long-Term Bonds?" Mimeo, October 1998.

Cassard, Marcel and David Folkerts-Landau. "Risk Management of Sovereign Assets and Liabilities." IMF Working Paper WP/97/166, December 1997.

Chari, V. V., and Patrick J. Kehoe. "Optimal Fiscal and Monetary Policy." Federal Reserve Bank of Minneapolis Research Department Staff Report 251, July 1998.

Chari, V. V., and Robert J. Weber. "How the U.S. Treasury Should Auction Its Debt." *Federal Reserve Bank of Minneapolis Quarterly Review*, Fall 1992, 16(4), pp. 3-12.

Dale, Spencer, Alessandra Mongiardino, and Danny Tyson Quah. "A Modest Proposal for Setting the Public Debt Structure." CEPR/ESRC Workshop on Optimal Fiscal Policy, April 1997.

Das, S. R., and R. K. Sundaram. "Auction Theory: A Survey With Applications to Treasury Markets." *Financial Markets, Institutions and Instruments*, December 1996, 5(5), pp. 1-36.

De Cecco, Marcello, Lorenzo Pecchi, and Gustavo Piga. *Managing Public Debt: Index-Linked Bonds in Theory and Practice*. Cheltenham, UK, and Brookfield, US: Edward Elgar

Publishing Ltd, 1997.

De Fontenay, Patrick, Gian Maria Milesi-Ferretti, and Huw Pill. "The Role of Foreign Currency Debt in Public Debt Management." IMF Working Paper WP/95/21, February 1995.

Deacon, Mark, and Andrew Derry. *Inflation-Indexed Securities*. Prentice Hall Europe, 1998.

Dornbusch, Rudiger. "Debt and Monetary Policy: The Policy Issues," in Guillermo A. Calvo, and Mervyn King, eds, *The Debt Burden and Its Consequences for Monetary Policy: Proceedings of a Conference Held by the International Economic Association at the Deutsche Bundesbank, Frankfurt, Germany*. MacMillan Press, 1998.

Fischer, Stanley. "Welfare Aspects of Government Issue of Indexed Bonds," in Rudiger Dornbusch, and Mario Henrique Simonsen, eds, *Inflation, Debt and Indexation*. Cambridge, Massachusetts; London, England: MIT Press, 1983.

Fowlie, Kerry and Julian Wright. "Optimal Currency Denomination of Public Debt in New Zealand." *New Zealand Economic Papers*, December 1997, 31(2), pp. 137-51.

Gale, Douglas. "The Efficient Design of Public Debt," in Rudiger Dornbusch, and Mario Draghi, eds, *Public Debt Management: Theory and History*. Cambridge; New York and Melbourne: Cambridge University Press, 1990, pp. 14-47.

Gensler, Gary. "Testimony before the House Committee on Ways and Means: Hearing on Managing the Public Debt in an Era of Surpluses." June 1998.

Giavazzi, Francesco, and Marco Pagano. "Confidence Crises and Public Debt Management," in Rudiger Dornbusch, and Mario Draghi, eds, *Public Debt Management: Theory and History*. Cambridge; New York and Melbourne: Cambridge University Press, 1990, pp. 125-43.

Giovannini, Alberto. "Government Debt Management." *Oxford Review of Economic Policy*, Winter 1997, 13(4), pp. 43-52.

Goodhart, Charles A. E. "Monetary Policy and Debt Management in the UK: Some Historical Viewpoints." Mimeo, Bank of England Conference on the Relationship between the Level and Composition of Government Debt and Monetary Policy, June 1998.

Hess, Gregory. "The Maturity Structure of Government Debt and Asset Substitutability in the UK." mimeo, Bank of England Conference on the Relationship between the Level and Composition of Government Debt and Monetary Policy, May 1998.

HM Treasury. *Debt Management Report 1998-99*. 1998.

- HM Treasury and Bank of England. *Report of the Debt Management Review*. 1995.
- Holmstrom, Bengt, and Jean Tirole. "Private and Public Supply of Liquidity." *Journal of Political Economy*, February 1998, 106(1), pp. 1-40.
- Kroszner, Randall S. "Global Government Securities Markets: Economics and Politics of Recent Market Microstructure Reforms," in Guillermo A. Calvo, and Mervyn King, eds, *The Debt Burden and Its Consequences for Monetary Policy: Proceedings of a Conference Held by the International Economic Association at the Deutsche Bundesbank, Frankfurt, Germany*. MacMillan Press, 1998.
- Levhari, David, and Nissan Liviatan. "Government Intermediation in the Indexed Bonds Market." *American Economic Review*, May 1976, 66(2), pp. 186-192.
- Lucas, Robert E. Jr., and Nancy L. Stokey. "Optimal Fiscal and Monetary Policy in an Economy Without Capital." *Journal of Monetary Economics*, July 1983, 12 (1), pp. 55-93.
- Malvey, Paul F., Christine M. Archibald, and Sean T. Flynn. "Uniform Price Auctions: Evaluation of the Treasury Experience." Department of the Treasury, October 1995.
- Marcet, Albert, Thomas J. Sargent, and Juha Seppälä. "Optimal Taxation Without State-Contingent Debt." CEPR/ESRC Workshop on Optimal Fiscal Policy, April 1997.
- McAfee, R. Preston, and John McMillan. "Auctions and Bidding." *Journal of Economic Literature*, June 1987, 25(2), pp. 699-738.
- Milgrom, Paul. "Auctions and Bidding: A Primer." *Journal of Economic Perspectives*, Summer 1989, 3(3), pp. 3-22.
- Missale, Alessandro. "Managing the Public Debt: the Optimal Taxation Approach." *Journal of Economic Surveys*, September 1997, 11(3), pp. 235-265.
- Missale, Alessandro. "Public Debt Management." Mimeo, 1998.
- Missale, Alessandro. "Tax Smoothing With Index-Linked Bonds: A Case Study of Italy and the United Kingdom," in Marcello De Cecco, Lorenzo Pecchi, and Gustavo Piga, eds, *Managing Public Debt: Index-Linked Bonds in Theory and Practice*. Cheltenham, UK, and Brookfield, US: Edward Elgar Publishing Ltd, 1997.
- Missale, Alessandro, and Olivier Jean Blanchard. "The Debt Burden and Debt Maturity." *American Economic Review*, March 1994, 84(1), pp. 309-19.
- Modigliani, Franco, and Richard Sutch. "Innovations in Interest Rate Policy." *American Economic Review*, May 1966, vol 56, pp. 178-197.

Myles, Gareth D. *Public Economics*. Cambridge, Great Britain: Cambridge University Press, 1995.

Nandi, Saikat. "Treasury Auctions: What Do the Recent Models and Results Tell Us?" *Federal Reserve of Atlanta Economic Review*, 1997, pp. 4-15.

Nars, Kari. *Excellence in Debt Management: the Strategies of Leading International Borrowers*. Euromoney Publications, 1997.

Pecchi, Lorenzo, and Gustavo Piga. "Does Debt Management Matter? A Market-Oriented Response From the Italian Case." *Economic and Financial Review*, Spring 1995, 2(1), pp. 29-36.

Peled, Dan. "Stochastic Inflation and Government Provision of Indexed Bonds." *Journal of Monetary Economics*, May 1985, 15(3), pp. 291-308.

Persson, Mats. "Index-Linked Bonds: the Swedish Experience," in Marcello De Cecco, Lorenzo Pecchi, and Gustavo Piga, eds, *Managing Public Debt: Index-Linked Bonds in Theory and Practice*. Cheltenham, UK, and Brookfield, US: Edward Elgar Publishing Ltd, 1997.

Piga, Gustavo. "In Search of an Independent Province for the Treasuries: How Should Public Debt Be Managed?" *Journal of Economics and Business*, May-June 1998, 50(3), pp. 257-275.

Sargent, Thomas J. *Dynamic Macroeconomic Theory*. Cambridge, Massachusetts, and London, England: Harvard University Press, 1987.

Scott, Andrew. "Does Tax Smoothing Imply Smooth Taxes?" CEPR/ESRC Workshop on Optimal Fiscal Policy, April 1997.

Shiller, Robert J. "Public Resistance to Indexation: a Puzzle." *Brookings Papers on Economic Activity*, 1997, no. 1, pp. 159-211.

Shiller, Robert J. "The Term Structure of Interest Rates," in B. M. Friedman, and Hahn F.H., eds, *Handbook of Monetary Economics*. Elsevier Science Publishers, 1990, pp. 627-672.

Sill, D. Keith. "Managing the Public Debt." *Federal Reserve Bank of Philadelphia Business Review*, July 1994-August 1994, no. 4, pp. 3-13.

Stiglitz, Joseph E. "On the Relevance or Irrelevance of Public Financial Policy: Indexation, Price Rigidities, and Optimal Monetary Policies," in Rudiger Dornbusch, and Mario Henrique Simonsen, eds, *Inflation, Debt and Indexation*. Cambridge, Massachusetts; London, England: MIT Press, 1983, pp. 183-222.

Taylor, Mark P. "Modelling the Yield Curve." *Economic Journal*, May 1992, 102(412), pp. 524-537.

Tobin, James. "An Essay on Principles of Debt Management," in *Fiscal and Debt Management Policies*. Englewood Cliffs, N.J.: Prentice-Hall, 1963, pp. 143-218.

Townend, John. "Index-Linked Government Securities: the UK Experience," in Marcello De Cecco, Lorenzo Pecchi, and Gustavo Piga, eds, *Managing Public Debt: Index-Linked Bonds in Theory and Practice*. Cheltenham, UK, and Brookfield, US: Edward Elgar Publishing Ltd, 1997.

Vahey, Shaun P. "The Optimal Structure of Government Debt." mimeo, December 1994.

Viard, Alan D. "The Welfare Gain From the Introduction of Indexed Bonds." *Journal of Money, Credit, and Banking, Part 2*, August 1993, 25(3), pp. 612-28.

Vickrey, William. "Counterspeculation, Auctions and Competitive Sealed Tenders." *Journal of Finance*, March 1961, pp. 8-37.

Wallace, Neil. "A Modigliani-Miller Theorem for Open-Market Operations." *American Economic Review*, June 1981, 71(3), pp. 267-274.

Wheeler, Graeme. "Sovereign Debt Management in New Zealand," in Kari Nars, ed, *Excellence in Debt Management: The Strategies of Leading International Borrowers*. Euromoney Publications, 1997.