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The Financial Economics of Sovereign Asset Value: Functional Perspectives and Market Outcomes

Abstract

The asset value of government has traditionally been seen as the accounting value of public assets. We develop a detailed financial economics view on sovereign asset values using market measures to arrive at implied sovereign asset values. We establish definition and dependencies within the resulting framework. Unlike the private sector, it is not a necessary public sector objective to maximise functional asset value as such; indeed some wealthier countries can run a habitually lower asset cover. Governments exposed more to economic shocks need to make more provision for buffering implied equity exposure. The ability to do so endows a real option value to budget flexibility. We identify the economic drivers of the implied asset values and the real option value in a broad sample of industrialized countries. Our theoretical framework and empirical results are instructive for market participants as well as for governments.

Key words: Implied asset value; asset volatility; real option; sovereign credit default swaps.

JEL References: H63, H62; G01, G12, G15; E62; D72; C51

1. Introduction

It is a well recognised precept in public finance that government assets should be reported in accounting value terms. Annual statements of financial position are published by all OECD countries and special valuation projects for public assets and liabilities are also mounted from time to time. But what a government is really worth, and what should be encompassed, is a matter of agenda. More recently, financial economists have taken up a functional approach to public sector valuation, arising out of the market pricing of sovereign credit risk via sovereign credit default swaps (CDS) or sovereign bonds. From this perspective, the asset value of government is viewed more as a capacity to pay. Relevant issues have been tackled from two directions in this literature. The first approach (Gapen et al 2005, Gray et al 2006) starts with an *ex ante* definition and measurement of sovereign asset value, inputs this into the standard option based credit pricing formula (Merton 1974) and tests for consistency with observed prices. A second approach (Kalteier & Posch 2013) backs out the implied asset value directly from market CDS prices; one could call this the *ex post* approach to sovereign asset valuation. Both strands have points of reference with existing empirical work on bond spread determinants, investigating such issues as whether country specific or global indicators are of more relevance (e.g. Edwards 1984, Boehmer & Megginson 1990, Caporale & Williams 2002, Longstaff 2009 and Haugh et al 2009).

The underlying agenda of a functional view of government asset valuation has merit for both sides: the government, in how it manages its funding and risk management, and the market, in reacting to those decisions. With this in mind, the present paper takes up the problem of reconciling the above *ex ante* and *ex post* approaches to sovereign asset value, together with the implications for both policy makers and market makers. To do this entails recognising at the outset some fairly fundamental difficulties of principle. In the private sector, the conceptual and practical gaps between accounting and market valuations have long been understood. Much less clear is just how private sector valuation concepts could be extended to the public sector.

This paper first reviews the sovereign asset value concepts in section 2. The specific focus is the extent to which private sector valuation methodology can be applicable and the most effective way to obtain the asset and equity value. The role of asset volatility is discussed, together with its valuation implications for policymakers. Operational perspectives, with some methodological refinements, are discussed in the context of backing out asset volatility from CDS. Sections 3 and 4 turn to the issues of the economic drivers for public asset and equity value. The algorithm for backing out asset values is expounded in the first part of section 3,

followed by econometric specification and the choice of variables, while section 4 contains results. Section 5 offers some concluding remarks.

2. Sovereign asset cover as a prudential statistic

A first group of conceptual issues concerns to what extent standard private sector valuation models, based on Miller/Modigliani (1958), can be used to establish an appropriate *ex ante* sovereign asset value. There are certainly some practical impediments to its computation in terms of the private sector discounted cash flow analogue. One of these is how to determine an equity cost of capital, given that government equity is not traded. Part of it could in principle be valued (*realisable public equity*), e.g. in terms of a notional public asset float. But a substantial *non realisable* part has to do with core operations and could not be consigned to a public asset float; the distinction is in some respects similar to that between 'discretionary' and 'non discretionary' items in Gray *et al* (*ibid*). A literature exists (see section 2.2) on the public sector cost of capital that attempts to deal with issues of this kind. Apart from this, there is a difference of substance in operational objectives. A private sector corporation aims at maximising its asset value. The same is not true of the public sector. In this context, one could imagine sovereign asset value as an outcome of a political game as between the forces of the left and those of the right. Maximisation might well be involved; but (to continue the analogy) it might refer instead to the Nash maximand for a cooperative game, the power parameters of which would shift from time to time, as different parties succeed to political office. The ability to back out a more or less direct estimate of asset value from CDS, as in the *ex post* approach, sidesteps at least some of the foregoing difficulties.

Implications also exist for the division of sovereign asset value as between (public) equity and debt, which in turn have policy importance and welfare implications. The *ex ante* approach requires an upfront definition of equity and a calculation or convention as to its value. The *ex post* method obtains equity value as a residual to debt once the asset value has been backed out of CDS prices. The policymaker angle concerns the role of asset volatility. A higher asset volatility, e.g. because times are seen as more uncertain, need not impact directly upon asset value as such. As in classic corporate finance, debt holders will impose a pricing penalty, which *inter alia* will mean a higher face value requirement in order to raise given amount of cash. A visible manifestation for a government will be a decline in the asset cover ratio, with diminished public equity value as an adverse outcome. There is therefore some gain to the government of the day in maintaining a quick change ability in its budget settings. One could regard such an ability as

the real option to budget flexibility. In some aspects this relates to rules of thumb for the sustainable debt to GDP ratio (cf. Appendix A).

A second group of issues entails a shift in perspective from public sector policymakers to market participants and the way they react to economic news. Whether or not the market gets it right has implications for validating the *ex ante* approach to sovereign asset valuation. In the CDS and related credit markets, the widely used Merton pricing model (*ibid*) draws on a contextual extension of the classic Black Scholes option pricing formula, section 3.1 provides a short review. Two key inputs for the pricing process are the asset cover, defined as the asset value divided by the face value of debt, and the asset volatility. In principle, market players insert their own estimates of these two inputs. In turn, these must be based on some sort of information, whether subjectively based sentiment or economic in nature. From this point of view, the asset cover and the asset volatility can be regarded in the light of sufficient statistics for more primary inputs. This raises the question as to how an independent observer might identify those primary drivers, and whether those drivers are themselves prudential or even sensible. As to the operational question our econometric answer is no, or not entirely. Some of the economic drivers did indeed have the right sign and significance in predicting asset value or volatility. But other drivers that *a priori* one might have considered as warning yielded either insignificant coefficients, or perverse but significant signs. Results of this kind lend credence to an excess of ebullience (or Keynesian 'animal spirits') in the credit market at the time.

As a matter of scope, the term *sovereign asset value* could encompass different perspectives on the activities of government and the powers availability in their exercise. But while in principle the sovereign power of disposition could extend to the entire resources of an economy, this is plainly not the way the financial markets would view things. For there are both practical and political limitations in the ability of governments to change policy settings in response to developing financial distress, and to so within a reasonable timeframe. Thus the first task is to pin down the meaning of sovereign asset value, as it might be assessed by the financial markets and used in the context of the pricing of sovereign credit. The impact of budget exposure risk and other volatility sources can be addressed within this framework.

2.1 General considerations: asset cover and volatility

It useful to begin with a brief review of the financial economics underpinning the CDS pricing technology, initially in the more familiar context of a private sector company. In the absence of tax advantages from debt, a natural assumption in the sovereign context, the textbook asset value (A) of a levered company is the sum of the market value of its debt and its equity: $A = L +$

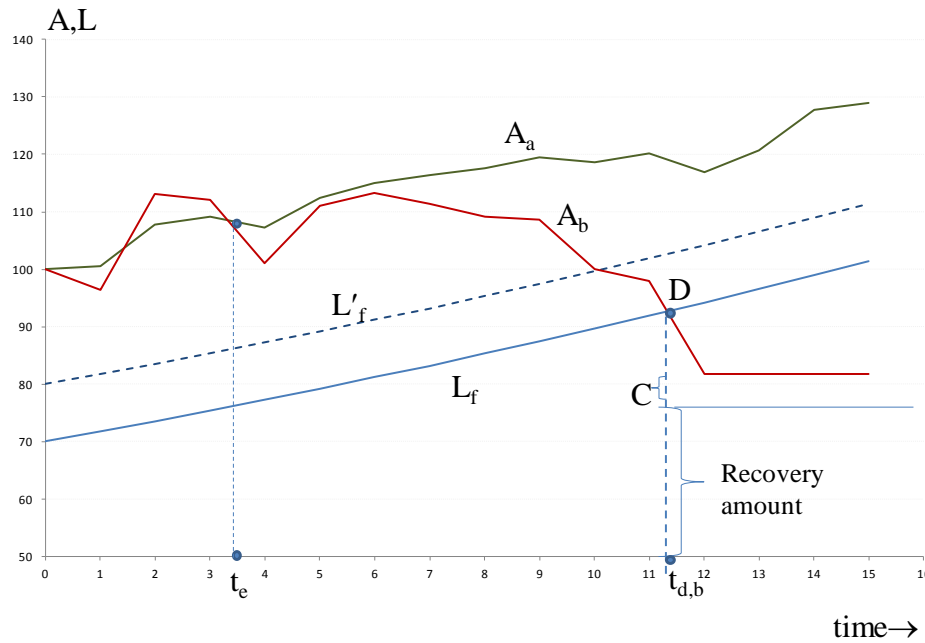
E . In what follows, the market value L of the debt will be distinguished from the face value L_f of the debt, adjusted to reflect the passage of time, which represents the legal liability of the firm. More precisely, L_f can be regarded as the accounting value that stems from the initial issue price of the debt, revalued at each period using the yield curve at the time of original issue. Such an approach forms the basis of general accounting (SNA, GFSM, BPM6) conventions and the World Bank Public Sector Debt (PSD) statistics used in the present study.

In the Merton option based approach to CDS pricing, the spread over the risk free rate is captured in terms of either an implicit call on equity value E or a put option on debt value L . In the former, the equity of the firm can be regarded as a call option on the asset value, which is in the money so long as asset value is greater than the debt liability L_f . In the latter version, the debt holders have effectively been required to write a put option exercisable if and when the asset value falls below the debt's face value: $A < L_f$, i.e. default has occurred. By this time, shareholder equity E is zero, and the market value L of debt is equal to the residual asset value, net of bankruptcy costs and prior claims, collectively C . Key drivers for the implied option value at any given prior time t are the loss given default $[L_f - A - C]_+$, the volatility of asset value σ_A and the risk free rate r_f . In CDS pricing the loss given default enters via the recovery rate, which is the complement of the loss given default relative to the face value L_f .

Figure 1 illustrates. The asset price process is assumed to be a generalised Brownian motion process. Two time paths are depicted with an equal mean drift and the same underlying unit normal stochastic driver. However, the asset value for firm b has been subject to a higher volatility than for firm a : $\sigma_{A,b} = 3\sigma_{A,a}$, creating a different time path (A_b versus A_a). The historical debt liability L_f is assumed to grow at the same rate, so at time 0 there has been little to distinguish the two firms. At time $t_{d,b}$ the higher volatility firm b eventually defaults. The *recovery rate* for debt holders is the recovery amount, divided by the face value of debt D .

Figure 1 Asset cover and debt recovery

The figure shows two possible path of asset values A_a and A_b where the volatility of path b is assumed to be higher than that of path a. L_f denotes the face value of liabilities and L its market value. D is the market value of Debt and C are the cumulative claims in the event of a bankruptcy.



In what follows, the *asset cover* at any time prior to default will be defined as the ratio A / L_f . At time t_e in the figure, the two firms have the same asset cover. In CDS pricing, as for standard corporate finance theory, the asset value A and its volatility σ_A are generally assumed to be independent inputs. A basis for this exists in asset pricing theory where asset volatility can be diversified away, eg. the capital asset pricing model of Sharpe (1964) and Lintner (1965). However, the same need not be true of the asset cover. A higher asset volatility will increase the price of the implied default options. To the purchaser of a new debt offering, the implicit value of this option has to be reflected in the interest rate. A levered firm seeking to raise a given amount of cash to fund an expansion programme, or refinance itself, will therefore have to issue debt with a higher face value L_f , which for any given asset value will diminish the apparent asset cover ratio. Thus in reality the debt face value curve may differ as between firms a and b (respectively L_f, L'_f in the diagram). At time t_e , the two asset cover ratios are no longer the same. Indeed, firm b would have defaulted earlier, at the point where $A_b = L'_f$.

In the foregoing framework, higher volatility σ_A as such does not impact upon aggregate asset value. But it may influence value shares as between debt holders and shareholders. Higher asset volatility will necessitate issuing debt of higher face value, so that in good times higher

coupon payments, or principal repayments, will constitute a burden on cash flows to shareholders. In such terms, there will arise a payoff to shareholders in adopting policies that moderate volatility, or earnings uncertainty, even where there is no penalty to asset value as such. The point has importance in the public sector context, where equity stakeholders are now taxpayers and welfare beneficiaries.

2.2 Sovereign asset value as a valuation concept

As with the private sector, the asset value of government can be constructed in terms of the present value of the expected cash flow outcomes at current policy settings, Appendix 1 illustrates in terms of a simple government cash flow valuation. The model has three policy settings: (1) the tax rate, (2) core government spending, and (3) public investment spending. The core budget surplus or deficit, or operating balance before gains and losses, is the difference between the tax income and expenditure. Given costs of equity and debt capital, the valuation process could proceed much as for the private sector. It would consist of two items, the first the sum of future budget cash surpluses or deficits, discounted at the weighted average cost of capital and the second current cash reserves, or investments in floating rate instruments. In such a process, additional equity is generated in any period if there is a core budget surplus, while deficits must be financed by running down realisable equity or by issuing new debt. An initial point of difference is that new government equity cannot be freely sold on the open market, so in this sense there is shadow price attached to the nonnegativity of sovereign equity capital. The ability to raise public debt removes this constraint.

Further differences have to be taken into account before private sector CDS pricing, and inferences to be drawn, can be extended to sovereign asset value. Even if it were possible to measure sovereign asset values, the objective function of government might differ from that of the typical private sector enterprise. In the received theory of corporate finance it is the objective of management to maximise asset value. For sovereigns, as noted in the Appendix, the outcome can be modelled as a Nash type cooperative equilibrium between the forces of the political left and those of the right, i.e. as a social consensus, the precise balance of which may shift from time to time with the political balance. As in the classic Nash theorem, the resulting equilibrium is itself a maximum, from which the asset value emerges as an outcome. It is no longer a simple maximum, but it remains an optimum given the political constraints.

Apart from this, there remain some significant differences between private and public sector valuation that must be taken into account. These imply a number of constraints on the valua-

tion process that do not appear in the private sector context. The first is that not all sovereign equity can be directly priced in the open market. It is useful in this context to distinguish two categories of equity. *Realisable* equity can be spun off and sold according to either necessity, or else to the ideological leanings of the government of the time. The definition is intended to be broad: the label could be applied to either physical or intellectual capital. Privatisations of public assets have become common across many economies. In principle, a cost of equity capital could be ascertained for embodied capital, e.g. from market pricing of comparable private sector companies.

However, other important elements of public sector capital can have no private sector context; one could refer to these as *non-realisable* sovereign capital. The sovereign power in and of itself is of this nature; governments can do things that the private sector cannot. Likewise, externalities (social capital) created by government actions add value to private sector beneficiaries that might nonetheless be difficult to measure. Absent the ability to measure economic value with any degree of precision, a cost of capital cannot be assigned to value benefits that might stem from disembodied sovereign capital. Indeed, the social cost of capital remains an ongoing preoccupation for both the theory of economic growth and on a more practical level, for the activities of government departments concerned with infrastructure development. Much of the literature discussion can be boiled down into two strands: The first is the opportunity cost of social capital: if taxpayers did not have to contribute to the activities of government, they could earn a market rate on their savings. The precise market rate may depend upon the context of the public spending proposed. The second strand originates in the Ramsay theory of optimal growth, and is cast in the context of a presumed steady state balanced growth mode. The subjective rate of time preference, the rate of population growth, and the rate of technological progress are all parametric inputs. For general references on the public sector cost of capital, see e.g. Marglin (1963), Lind (1982,1990), Moore *et al* (2004), Boardman *et al* (2006).

There remains the approach of asking market participants what their valuation of sovereign asset might be; and to make it more convincing, to do it where their own money is at risk, just as for shares or any other form of market based valuation. That is the approach followed here, whereby sovereign asset value is backed out of the yield curve for sovereign debt, measured via sovereign credit default swaps. If asset value (A) can be determined in this way, then given the market value of debt, the value of government equity (E) can be backed out. By proceeding one step further, even the implied cost of equity capital can be recovered, resolving a long standing difficulty in the valuation of public sector projects.

2.3 Credit spreads and the real option to budget flexibility

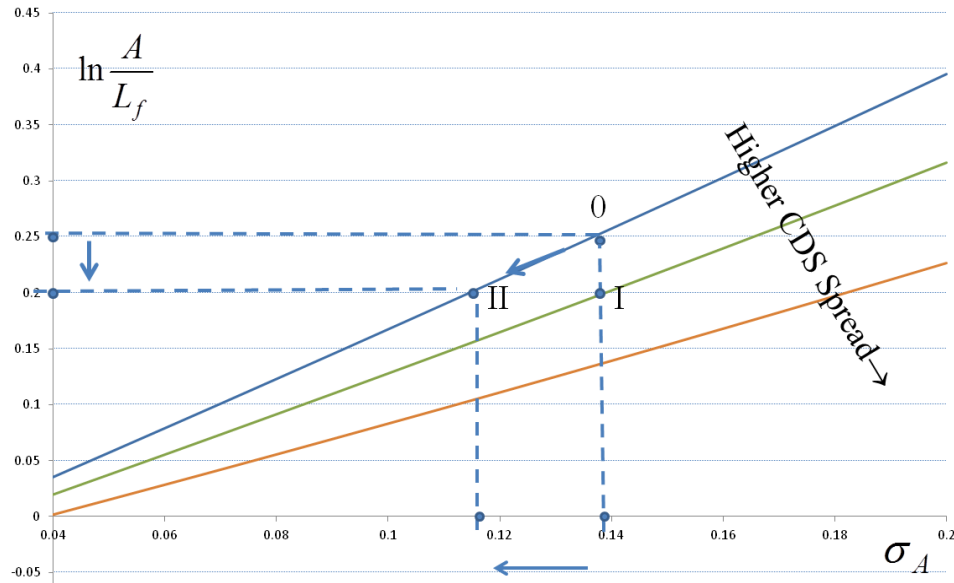
Backing out apparent asset values from CDS may not be universally successful, cf. section 3. Such limitations apart, the link between asset values and credit spreads may be indeterminate for very high grade credits: beyond a certain point, higher asset value conveys no measurable benefit for the yield on country's debt. However, this does not appear to be a common limitation at least not for industrialized countries.

A related issue is just what part of sovereign asset value is being revealed. It may be that market participants price only the embodied asset value, making due allowance for liquidity or time to realise, e.g. cash reserves versus potential privatisations. This should not be interpreted to mean that asset value stemming from the residual power to tax has no intrinsic value. But it may be that the country in question cannot safely raise taxes, or wind back public spending programmes, without serious social unrest. The resulting budget exposure risk will be reflected in its sovereign credit spread. A worst case scenario would be where the country has exhausted both lines of recourse: sold off its realisable assets and stuck with an inflexible budget. On the other hand, a country that enjoys greater budget flexibility can widen the scope of the asset value that is being priced into CDS to encompass the real option stemming from budget flexibility.

The flexibility real option can become manifest in either or both the level of asset value (A) or its volatility (σ_A). The interplay between the two for the revealed asset cover spread is illustrated in figure 2. The curves are constant CDS loci with an increasing CDS (credit) spread as indicated. On the vertical axis is the log asset cover ratio. If this is lower (vertical downward arrow), then other thing being equal, the CDS spread should be higher (as in point I vs. 0). On the other hand, a country that enjoys lower asset volatility can have a lower asset cover ratio but nevertheless just the same credit spread (as in II vs. 0). This might be the case if such a country can adjust its policy settings to cope with any unforeseen and potentially adverse budget pressures. As earlier marked, such an ability amounts to a real option. The real option to budget flexibility does not necessarily augment asset value as such, but it does pay off in favour of the equity value component via the volatility effect.

Figure 2 The real option to budget flexibility

This figure shows the impact of higher CDS spreads on the log asset cover ($\ln A/L_f$).



A separability principle underpins much of the preceding discussion, namely that sovereign asset volatility as such does not impact directly upon asset value; the effect is instead indirect, via an implicit pricing penalty on debt. However, the underpinning argument, namely that volatility can be diversified away, may not hold with respect to sovereign debt, there could be a negative direct impact: higher volatility is accompanied c.p. by lower asset value. On the other hand, it might be that governments recognise this as an exposure to the pricing of their debt and respond with habitually conservative policy settings intended to compensate for cyclical budget pressures. Viewed as a between country effect, higher asset values might then be associated with countries that have habitually more variation in GDP and therefore tax income and welfare spending. For any given country, this can nevertheless be quite consistent with a negative effect on asset cover of a perceived increase in uncertainty over time.

2.3 Operational perspectives

Backing out an implied asset cover and volatility from current CDS spreads can be regarded as a form of economic factor analysis. For instance, a sovereign issue for country X that is trading with an implied asset cover the same as position 0 in figure 2, but only half the revealed volatility, would enjoy a much lower spread than a comparator at position 0 (country O, say). In figure 2 the credit spread for country X would lie on a pricing curve above that for country O. An independent observer might observe that country X traded above country O, identify the reason as a very low implied volatility, and decide that this is unwarranted – country X is

simply not that safe in terms of exposures to potential shocks. That would be a signal for the analyst to go short on country X or a spread trade versus country O, as better able to withstand a shock impacting in common. As an alternative scenario, a sovereign Treasury might discover the market appears to be pricing in much lower asset cover than warranted by its budget exposure risk, and take steps to remedy an evident perception problem.

A second perspective arises from term structure considerations. Drawing on the model of Appendix I, sovereign asset value can be regarded as the present value of a cash flow profile. As such, it will have a duration¹ incorporating its sensitivity response to shifts in the discount rates for equity and debt. Differential sensitivity of measured asset value might result, so that the asset value backed out of 1 year sovereign debt may well differ from that obtained using 10 year debt. In operational terms, the ability of a country to respond to adversity in the short run might be limited by adjustment costs and political impediments. The asset value as it appears backed out of one year debt might therefore appear lower, relative to that from longer debt, where the country has had more opportunity to fully adjust.

3. Asset value and economic factor analysis

Market pricing of a sovereign's credit can be regarded as a form of applied factor analysis. Participants will follow a number of primary economic statistics, news, and subjective assessments of sentiment. These can be referred to as the economic drivers; candidate variables are discussed in section 3.3. In the pricing process, their separate influences are then condensed into just two factors of primary pricing interest, namely the asset cover ratio and the volatility. In this sense the pricing factors can be loosely viewed as sufficient statistics for the underlying economic drivers. Section 3.1 reviews their entry as such into the CDS pricing formula. The empirical work will then be concerned with identifying economic drivers that contribute to or influence one or other of the primary factors. These can encompass both between-country perceptions and variation over time within any given country; the difference is outlined in section 3.2.

3.1 *The algorithm for computing asset value*

The pricing model widely used in the markets for CDS has its origin in the Merton option pricing model for corporate debt (Merton 1974). The method for backing out the implied asset

¹ Which version of duration, whether Macaulay (1938), Fisher-Weil (1971), or directional (Bowden 1997), depends on the observer's concerns about possible term structure shifts.

values, given the CDS price, solves iteratively for both the asset value and its volatility, in this respect a further development of that in Kalteier & Posch (2013) to encompass endogenous asset value volatility.

The key expressions are the probability of default (PD) and the distance to default (DD), which are related to the CDS spread by the equations:

$$(1) PD = \frac{CDS \text{ spread}}{1 - \mu}; \quad \mu = \text{recovery rate}$$

$$(2) DD = -\Phi^{-1}(PD)$$

In expression (1), (2), μ is the recovery rate when a default occurs, and Φ is the inverse standard normal distribution function. In market CDS pricing the recovery rate is conventionally taken to be 40% and this will be used in what follows. Given the observed CDS spread, the asset

cover $y = \frac{A}{L_f}$ and the asset volatility σ_A then satisfy the Merton equation:

$$(3a) \quad DD = \frac{1}{\tau \sigma_A} (\ln y + r_f \tau - \frac{\tau}{2} \sigma_A^2), \text{ where } \tau \text{ is maturity and } r_f \text{ is a risk free rate.}$$

For computational purposes, expression (3a) can be written as

$$(3b) \quad \ln y = \frac{\tau}{2} [(y \sigma_E + DD)^2 - (DD + 2 r_f \tau)] ;$$

where

$$(3c) \quad \sigma_E = \frac{1}{y} \sigma_A \text{ is the volatility of equity.}$$

Given σ_E , equation (3b) has a single real root y^* in the zone $0 \leq y < 1$, which can be solved numerically giving $A = y L_f$. The historical sequence of monthly estimated asset values can be used to derive empirical estimates of σ_A , and hence updated estimates of σ_E from (3c) and y from (3b). The iteration continues until convergence has been achieved. In practice, a seed value for σ_E can be taken as the volatility of junior debt. However a point of departure from Gray *et al* (2007), Kalteier and Posch (2013), is that junior debt is not taken as tacit sovereign equity value; it is simply an iterative starting point. Indeed, in the empirical work that follows, the face value concept is that of total government debt. While offshore reputation is indeed important (Eaton *et al* 1986), political unrest would likely follow from giving offshore holders preference, in the absence of any ex ante commitment to do so. Thus no distinction is made between internal and externally raised public debt unless there is formal (legal) documentation

as to seniority in the event of financial distress. In practice, the market follows a number of conventions in pricing CDS, cf. Löffler and Posch (2011). Sovereign CDS are traded denominated in USD for all countries but the USA for which EUR CDS are typically traded. The CDS with a maturity of 5 years is the so called on-the-run quote and is the most liquid contract. For market pricing the risk free rate is commonly taken as the 10 year US T bill rate, notwithstanding that the CDS in question may refer to a bond of much shorter maturity, or that a 10 year T bill is not really risk free. However in the current context, the objective is simply to back out the asset value that the market is evidently employing at the time, given their pricing conventions.

3.2 *Linking asset cover to country characteristics*

The objective in the empirical work that follows is to identify a number of observable variables that might influence market participants in valuing sovereign liabilities. As earlier mentioned, the economic influences are vectored via two pricing factors of primary interest, empirically backed out from observed CDS spreads. The asset cover ratio A / L_f constitutes the first of these dependent variables. This is generally fitted as $y = \ln(A / L_f)$ both as a welfare metric, and in log terms, to conform with the integration status of the chosen explanatory variables. The volatility σ_A is the second dependent variable.

It may well be that the true, underlying values (A^* , say) that market participants might use in valuing debt are subjective and therefore not directly observable, but a maintained hypothesis will be that the difference $A - A^* = \varepsilon$ is uncorrelated with the observable right hand characteristics. Likewise, bearing in mind that both pricing factors are themselves the result of an estimation process, it will be assumed that estimation errors are uncorrelated with the disturbances in the regression that explain the primary factors in terms of their economic drivers.

Turning to the right hand or explanatory variables, the country data takes the form of combined cross section-time series for number of selected variables (section 3.3). A point of departure in the present study is that both fixed and variable effects appear in the fitted equations. In this context, the generic decomposition $x_{i,t} = x_i + (x_{i,t} - \bar{x}_i)$ into fixed and variable effects can reveal differences in the way that the market perceives both general level effects for each country and the impact of changes from quarter to quarter. The econometric representations are therefore fitted in the general form:

$$(4) \quad y_{i,t} = \alpha_o + \sum_{i,k} \beta_k z_{k,i} + \sum_{i,k} \gamma_k (x_{k,i,t} - \bar{x}_{k,i}) + \varepsilon_{i,t},$$

with the first two terms on the right hand side giving the mean \bar{y}_i for each country. The variables generically indicated as $z_{k,i}$ can include the means $\bar{x}_{k,i}$, as well as further indicators, and can be referred to generically as 'country' or 'fixed' effects.

To see the possible relevance of mean versus variable components, a given country might be viewed as having sufficient political stability or budget flexibility to justify a lower asset cover ratio, on the average, as compared to other countries. This is the fixed effect and is measurable via the coefficient β_k for some variable z_k . It might be that $z_k = \bar{x}_k$ where time series observations are also available, as $x_{k,i,t}$. But the sovereign's ability to cope might be diminished following adverse developments at any given time. Indeed, the coefficient of the variable part (as deviations from the mean) might well be of opposite sign to that of the fixed effect: $\beta_k > 0; \gamma_k < 0$. A further subclass of variables generating γ coefficients can include interactions between country effects (i) and time series effects (i,t) of the form $z_{k,i} \times (x_{k,i,t} - \bar{x}_{k,i})$ where z_k does not coincide with x_k . Specific examples are given in table 1. For example $z = \text{GDP volatility}$, together with $x = \text{government consumption: GDP ratio}$, would reflect a higher exposure to government expenditure where the nation has a more variable GDP.

The dependent variables (y) can be either the asset cover ratio or the volatility. An issue is to be explored is whether the primary impact of a designated economic driver is vectored via the asset cover or the volatility. As pointed out in section 2, volatility can impact on asset cover via the face value of the debt, and possibly via other channels. One way of checking this channel will be to include the volatility as a right hand variable in the equation for the asset cover, in addition to the designated driver. If the latter then offers no marginal significance, it could then be that its primary impact is via the volatility with no independent influence on the asset cover ratio.

In what follows, the generic model (4) is explored using quarterly time series-cross section data on 15 countries, from Q4 2004 to Q4 2009. This period spans the start of liquidity in the CDS market (around 2004) until the shakeout associated with the financial crisis 2007-09, where liquidity collapsed. CDS data is collected from Bloomberg on a daily basis for the most liquid 5 year maturity contract. Monthly estimates for A, σ_A are prepared as outlined in section 3.1. The CDS data is averaged to a monthly basis and robustness checks conducted on the

aggregation methods (mean, median, weighted) show stability of the results. The monthly estimates of the asset value and volatility A, σ_A are then averaged quarterly to become consistent with the availability of the economic data. The World Bank (IBRD) is the source of most economic driver data, while political index (cpg) series is sourced from Woldendorp (2011). In some cases the economic data are annual and have been interpolated to match the quarterly basis. Table 1 contains more detailed data specifications. Abbreviated symbols appear in column 1 with the full names and definitions in column 2, and data sources in column 3. Table 2 contains summary statistics for averages over the data period. Most variables appear as logs or log changes, with the remainder either as ratios or in one case (cpg) as a proxy indicator for political leanings. In particular, the volatilities conform to the volatility of log changes, as required by the Brownian motion.

3.3 *The economic drivers*

As noted in connection with equation (4), a given variable (indexed k) can enter in two different forms: a country effect (indexed i), and as a time series deviation from the mean (indexed i, t). The suffix 'de-mean' indicates that the relevant variable has been expressed as a deviation from its time series mean. As an instance, logGDPcapitaPPP can enter both as the country average over the sample period (indexed i), and also as the time series deviation from the mean. The latter is denoted as lngdGCapitaPPP_demean, and indexed i, t . Thus it could be that richer countries are viewed by the market as better able to adjust to adverse events, and therefore able to support sovereign borrowing with a comparatively low asset cover ratio. The beta for the country effect GDP variable (indexed i) might even be negative. But rich or not, any country will be adversely affected when times get worse. Thus the coefficient of the de-meaned GDP variable could end up positive.

The variable marked vol_gdp×lngdpCapitaPPP_demean is an interaction effect. The volatility of per capita GDP is indexed by i as a country mean, while the second term captures the time series variation in the same variable, so indexed i, t . The variable vol_gdp×govcon2GDP_demean is similarly an interaction between a country effect and a time series effect, but this time between two different economic indicators. Its inclusion would test whether a country with more unstable GDP's would be more exposed to core government spending deteriorations, such as might arise from unemployment benefits when times are bad.

The potential impact of the government budget balance (*balance*) appears in the form of two government budget variables, namely $I\{\text{deficit}\} \times \text{balance}/\text{GDP}$ and $I\{\text{surplus}\} \times \text{balance}/\text{GDP}$. The indicator $I\{\}$ distinguishes whether there is budget surplus ($\text{balance} > 0$) or a

deficit (balance<0). *A priori* both coefficients should be positive, but it may be that traders pay more attention to deficits than to surpluses.

Table 1 Economic drivers; definitions, sources

This Tables gives the used abbreviations of variables, gives details on their definition and source.

Abbreviations of variables	Details	Source
lngdpCapitaPPP	Log per capita GDP , based on purchasing power parity, expressed in USD.	World Bank
govcon2GDP	General government consumption to GDP. Includes all government current expenditures for purchases of goods and services incl. compensation of employees, most expenditures on national defense and security, but no military expenditure.	World Bank
Indcredit2gdp	Log of domestic credit to GDP. Credit provided by the banking sector to various sectors on a gross basis. Only credit to central government is net. The banking sector comprises monetary authorities and banking institutions where data are available.	World Bank
reserves2gdp	Total reserves to GDP. Comprises holdings of monetary gold, special drawing rights, reserves of IMF members held by the IMF, and holdings of foreign exchange under the control of monetary authorities.	World Bank
lnunemploy	Log proportion of labor force without work but available for and seeking employment.	World Bank
vol_gdp×lngdpCapitaPPP_demean	Interaction between the GDP volatility and the ln of the GDP per Capita adjusted for purchasing power parity.	World Bank/own calculation
cpg	Ideological complexion of parliament (CPG) is an indicator for left-right wing flavour as per parliament seats. Scale is from 1 to 5 Right to Left wing.	Woldendorp et al (2011)
I{surplus}×balance/GDP	Cash surplus to GDP. Cash surplus is defined as revenue minus expenses. Dummy surplus=1 if surplus>0, zero otherwise.	World Bank
I{deficit}×balance/GDP	Cash deficits to GDP. Cash deficit is defined as revenue minus expenses. Dummy deficit=1 if surplus<0, zero otherwise.	World Bank
vol_gdp	STD of log changes in GDP	Own calculation
vol_gdp×govcon2GDP_demean	Interaction between GDP volatility and government consumption	

Table 2 Descriptive statistics

This table gives descriptive statistics for the variables defined in Table 1 for the dataset. The data spans from Q4 2004-Q4 2009.

countryname	lngdpCapPPP	govcon2GDP	lndcredit2GDP	reserves2GDP	lnunemploy	cpg	vol_gdp
Australia	10.498	0.173	4.850	0.047	1.568	2.857	0.007
Austria	10.535	0.185	4.866	0.041	1.523	2.857	0.025
Belgium	10.472	0.229	4.695	0.035	2.060	3.000	0.021
Denmark	10.526	0.266	5.270	0.136	1.462	2.000	0.032
France	10.387	0.236	4.765	0.040	2.136	2.000	0.023
Germany	10.458	0.186	4.878	0.039	2.218	4.000	0.026
Greece	10.224	0.182	4.698	0.011	2.194	2.000	0.026
Italy	10.352	0.201	4.785	0.043	1.952	3.238	0.024
Netherlands	10.589	0.253	5.240	0.035	1.301	2.857	0.028
Norway	10.885	0.196	4.424	0.146	1.312	3.385	0.021
Portugal	10.077	0.206	5.083	0.052	2.053	3.619	0.022
Spain	10.344	0.187	5.217	0.015	2.330	4.000	0.038
Sweden	10.517	0.263	4.835	0.070	1.933	2.667	0.028
Switzerland	10.688	0.111	5.167	0.164	1.366	3.000	0.025
United States	10.720	0.163	5.444	0.019	1.699	4.000	0.028

4. Results and discussion

The econometrics reported in what follows examines the impact of economic drivers. The data span late 2004 to late 2009. After that date the CDS market virtually collapsed for a space of time, showing signs of resurrection only in 2012. A particular focus within the chosen time span is whether the market responded to warning signs in the economic indicators. Further agendas concern a dichotomy between country effects and time series effects for the same variable, and interdependence between asset cover and asset or driver volatility.

The economic drivers listed in Table 1 were fitted, with inclusion/ exclusions where appropriate to minimise likely multicollinearity. Table 3 gives the results from a reasonably typical time series-cross section regression with the log asset cover as the dependent variable. Several features are apparent, most robust to alternative inclusions in accompanying right hand variables.

The country effect for GDP is negative and significant: the asset cover diminishes for richer countries. The effect remains if σ_A is included among the right hand variables: for any given country asset value volatility, richer countries need maintain a lower asset cover for any given credit spread. The country effect for reserves relative to GDP is negative i.e. necessitating a lower habitual asset cover ratio. As the reserves rise over the economic cycle, the asset cover rises, or the face value of debt falls, indicating a lower credit spread. The fitted asset cover appears unaffected by a rising budget surplus, but will be progressively lowered where there is a rising budget deficit, i.e. a deterioration. Traders are less impressed by a better budget balance than they are unimpressed by a deteriorating one.

Driver effects such as those above are consistent with a priori expectations as to prudence on the part of the credit market. Much less consistent are the responses to cyclical indicators such as unemployment and credit. High unemployment countries are perceived as having a lower average asset cover ratio, as one would expect. But as unemployment rises over the cycle the perceived asset cover paradoxically rises; and this remains the case for a given asset volatility, as in column 3. The same effect is apparent for credit expansion, another cyclical variable. On prudential grounds one would expect perceived asset cover to fall as credit expands in an economy. To this extent, the results the idea that the credit market suffered historically from unwarranted optimism

As to infectious optimism or 'animal spirits', an apparently perverse response to cyclical expansion is consistent with a general concordance of fitted sovereign asset cover with the stock market. Figure 3 illustrates. The heavier shaded locus is the MSCI World index, while

log asset cover ratios for Spain, Italy and Greece are included, all rescaled with common origin value as 100. In the expansion phase, there is fair degree of concordance between the asset cover for those southern European (S.E.) countries and world stock markets. However in the period after 2008 when the stock market was falling the perceived asset cover for the S.E. countries were slow to follow.

Perhaps contrary to expectations, conservative governments (smaller cpg) do not appear to assist asset value. However, there may be causal effects at work here – conservative governments tend to be elected following expansionary spending episodes, when things have already deteriorated. Finally, none of the country effect–time effect interactions (e.g. $vol_gdp_i \times govcon2GDP_demean_{i,t}$) are significant.

The regressions for σ_A reported in the two rightmost columns tend to be more responsive to time series effects. The coefficient for time series (de-meanned) GDP is negative, as one would expect; uncertainty drops in better times. Likewise, volatility falls with an improved budget balance. On the other hand, the coefficient for the time series government consumption is negative, suggesting that the market ignored a potential hazard sign.

Some evidence for a reinforcing interaction of the time effect with the country effect appears for the gdp variable, though not for interaction involving government consumption. Adding the interaction variable $vol_gdp \times \ln gdpCapitaPPP_demean$ produces a near significant negative effect, suggesting that the volatility response to improving GDP is more marked in countries that chronically suffer from more income volatility.

Table 3 Time series – cross sectional regression results

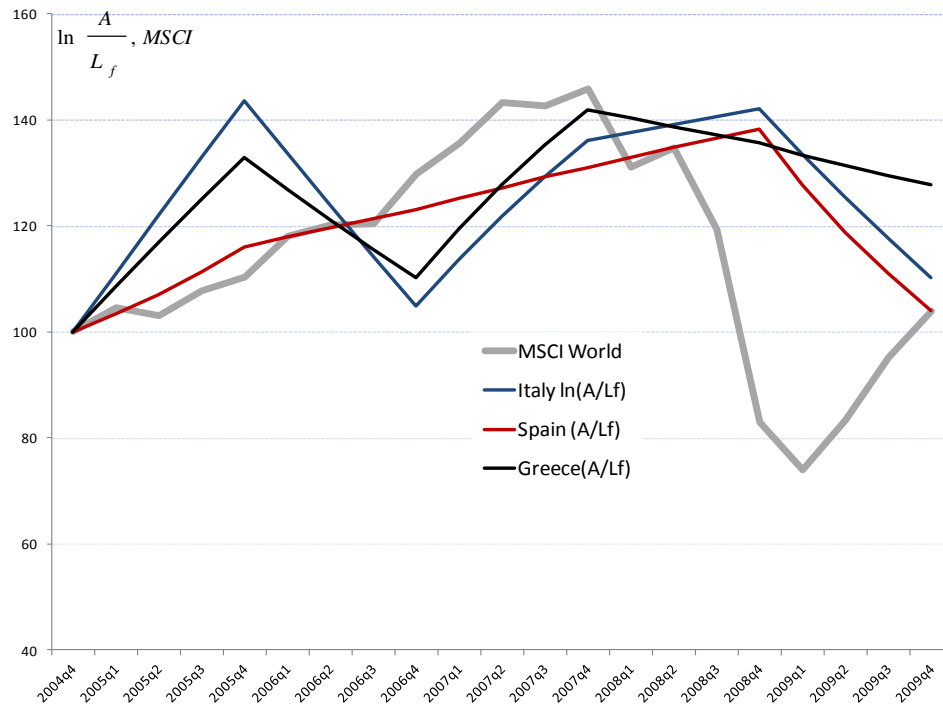
This table gives the results for four models, two explaining the log asset cover and two for the asset volatility. Regressions were estimated with country fixed effects using cluster robust standard errors. The robust t-statistics are given in parenthesis. *** denotes 1%, ** 5% and * a 10% significance of the coefficients.

VARIABLES	$\ln(A/L_f)$	$\ln(A/L_f)$	σ_A	σ_A
lngdpCapitaPPP	-0.57*** (-7.00)	-0.65*** (-7.76)	0.73*** (5.93)	0.73*** (5.86)
lngdpCapitaPPP_demean	0.14 (0.57)	0.44* (1.67)	-2.65*** (-4.89)	-2.28*** (-2.84)
govcon2GDP	-1.15*** (-4.37)	-0.99*** (-3.52)	-1.42*** (-2.80)	-1.46*** (-2.85)
govcon2GDP_demean	-0.28 (-0.12)	0.82 (0.36)	-9.49*** (-2.76)	-9.10*** (-2.59)
lndcredit2gdp	-0.78*** (-15.30)	-0.80*** (-15.21)	0.17* (1.94)	0.17** (1.97)
lndcredit2gdp_demean	1.03*** (4.83)	0.97*** (4.62)	0.48 (1.32)	0.47 (1.30)
reserves2gdp	-2.45*** (-8.11)	-2.64*** (-8.77)	1.61** (2.55)	1.57** (2.44)
reserves2gdp_demean	4.42*** (6.25)	4.45*** (6.59)	-0.25 (-0.18)	-0.19 (-0.14)
lnunemploy	-0.58*** (-12.01)	-0.58*** (-12.17)	0 (-0.01)	0 (0.02)
lnunemploy_demean	0.77*** (7.77)	0.77*** (8.02)	-0.01 (-0.03)	-0.01 (-0.08)
cpg	0.06*** (4.44)	0.06*** (4.50)	-0.02 (-1.06)	-0.02 (-1.15)
dumpos×balance2GDP	0.34 (0.81)	0.58 (1.34)	-2.04*** (-2.60)	-1.97** (-2.43)
dumneg×balance2GDP	6.18*** (12.68)	6.02*** (12.49)	1.36** (2.18)	1.42** (2.21)
vol_gdp	21.89*** (12.15)	22.52*** (12.30)	-5.42* (-1.79)	-5.41* (-1.79)
vol_gdp×lngdpCapitaPPP_demean				-14.96 (-0.59)
σ_A		0.12*** (3.30)		
Constant	11.07*** (11.92)	11.96*** (12.35)	-7.79*** (-4.71)	-7.76*** (-4.67)
Observations	299	299	299	299
R ²	0.71	0.72	0.49	0.49

0.48

Figure 3 Asset cover vs. stock markets (MSCI World)

This figure compares the asset covers of three European countries over time along with the return of the MSCI world equity index. All variables are indexed to 100=Q4 2004.



5. Concluding remarks

The functional approach to government asset value is positivist in nature; it aims at identifying what the financial community thinks about sovereign asset value, as backed out from a market instrument, namely CDS. At any given time there may not be agreement between what the market thinks is government value and government's own accounting based valuations. Potential reasons for this have been surveyed in the present paper. In addition to the long standing book value vs. market value dichotomy, there are divergences specific to the public sector. Intangible or unrealisable public assets cannot be priced, and the discount rate is either indeterminate or controversial.

This is not to say that the Treasury should pay exclusive attention to either one or the other. Traditional accounting valuations remain an essential prudential check on public spending. However, the ability to back out market value, using methodology such as that in section 3, facilitates some new dimensions in public sector financial management. Unlike the private sector it is not a necessary, or even desirable, public sector objective to maximise asset value as such. Thus it should not be a surprise to find that some wealthy countries run a habitually lower asset cover. But what the market can reveal that might be of more concern is the implied volatility of asset value as it is jointly backed out from CDS. Asset volatility does impact on the

division of asset value as between debt holders and equity stakeholders such as taxpayers and welfare beneficiaries. Governments more exposed more to economic shocks, whether external or internal, need to make more provision for buffering the resulting equity exposure. The ability to do so endows a real option value to budget flexibility.

Context aside, some of the ideas of corporate sector financial risk management can apply with equal force to sovereign fiscal management. Duration matching provides one such context. Core budget operating balances ('obegals') can be exposed at different wavelet levels: short run, business cycle and longer run structural pressures. Matching asset side responses might draw first on short run cash reserves, followed by spending and tax changes, with asset floats as a longer run recourse. A level of adjustment capability at all maturities enhances the real option value and should by that token require less overall asset cover for any given level of debt.

A further point of reference is to the economic literature on fiscal rules versus flexibility, and the issue of whether statutory or constitutional constraints actually increase the severity of real output fluctuations in the economy and hence fiscal pressures (e.g. Bayoumi & Eichengreen 1995). On this view statutory constraints would serve to diminish the value of the implied real option to budget flexibility.

Finally, none of the foregoing should be taken to imply that the market is always right in its assessment of asset value. Indeed, the econometric results in section 4 indicate that in the lead up to the GFC, some *a priori* economic warning signals were either insignificant or the wrong sign altogether. Relating the backed out asset value or cover to selected economic drivers can be a useful exercise for market participants as well as for governments.

Appendix: The conceptual basis of sovereign asset value

Any extension of private sector corporate valuation techniques to the public sector will encounter the problem of scope as well as structure. For instance, the *ex ante* approaches (e.g. Gapen *et al* 2005, Gray *et al* 2007) propose to include domestic debt and base money among equity items. But few legislatures would have the political courage to legally rank domestic debt as junior to external debt. And domestic base money, while technically a liability to the nation's central bank, is unlikely to be callable should the government default on its own debt. Nor could seignorage, as an asset of the central bank, ever be called upon. A further difficulty with the *ex ante* approach, namely the choice of equity cost of capital to value net fiscal assets, will be discussed below.

Nevertheless, the *ex ante* approach to thinking about sovereign asset value can remain valuable to policy makers, for two reasons. The first is to show that a public asset value concept can exist, in theory. Moreover, thinking about what classes of asset or liability should qualify as debt backing (as it might be seen by CDS traders), is a valuable exercise in itself. In this view, the ultimate origin of public equity lies in the taxing power of government, and the further income it can create via the medium of state owned enterprises. To see or what should (or should not) be included as to equity, the best analogy is to align the government valuation process as closely as possible to textbook discounted cash flow valuation. One could imagine CDS market makers doing just this as mental exercise, bearing in mind the limits as to the recourse available to them in the event that the government cannot service its debt.

To fix some ideas, a simple framework may be helpful in capturing the essentials of some complex structures, decisions processes and outcomes. Suppose at any given time t the government has three economic decision variables: the tax rate (τ_t), a single index for income, wealth and consumption taxes; current expenditures (c_t) on public goods and services, including welfare payments; and investment expenditure on social infrastructure (I_t), the latter creating social capital (K_t), after adjusting for annual depreciation. Impacts of these settings on economic activity are moderated via a set of environmental state variables, $s_t = s_t(\omega)$ where ω is an underlying event space. These will represent the stochastic state of the world, outside the government's direct control.

Government current revenue each period is $y_t = y(\tau_t, Y_t; s_t)$ where Y_t is the nations' GDP, which in turn may depend upon social capital K_t . The government's operating cash flow in

each period is therefore $y_t - c_t - I_t$. In addition there are cash flow financing constraints, considered below. The budgeting problem (choice of τ_t, c_t, I_t) can evidently be considered a stochastic programming problem. In such terms, the government of the day can be imagined to have a collective intertemporal utility function expressible² in reduced form as $U_g(\{\tau_t, c_t, I_t\}_{t=1,2,\dots}; \omega)$. Here U_g might represent an expected social utility function. The precise welfare weighting will depend upon the political complexion of the party in power. Thus a left leaning regime will likely attach greater weight to social consumption, while a right leaning regime will prefer lower taxes. Alternatively, the outcome might correspond to a Nash cooperative bargaining process between the left and right preferences weighted by their respective voting power at the time.

Corresponding to private sector equity value are government reserves, denoted R_t such that $R_t \geq 0$. It is useful to divide these into realisable or embodied reserves, which can be turned into cash; and non realisable (disembodied) reserves, which cannot, either inherently or by political consensus, be sold off.

Realisable reserves will include cash (C_t) and other liquid investments as well as prospective privatisations of public assets, which can be turned into cash if needed, though generally with a transactions lag. Realisable reserves, or the public equity reserves can be measured at market valuation. To the extent that investing in the public equity reserve (R_t) is done at the opportunity cost of public capital, one should expect that the required return on reserves is equal to the sovereign equity cost of capital (denoted r_e in what follows).

Among non realisable public equity might be the human capital created by expenditure on education, or more precisely, the value of the taxing power that stems from it. Likewise, public services such as transport, health, policing or defence all have potential payoffs in GDP and hence for the tax base. The formal valuation of non realisable public equity will necessarily be a historical accounting concept. So far as the CDS market is concerned, their preoccupation will more likely be with realisable public equity, representing what can be liquidated towards any debt default.

In all-equity mode, there is a cash financing constraint

$$(A1) \quad -\Delta C_t + y_t = c_t + I_t; t = 1, 2, \dots; \quad C_t \geq 0.$$

² More precisely, a function $V: R_{3+} \otimes \mathfrak{S} \rightarrow R$ where \mathfrak{S} is the underlying event space.

In other words, the Treasury can run down cash balances but never to less than zero. If necessary, the government's intertemporal budgeting program will have to include a planned liquidation of realisable assets to create the necessary cash balance at each stage.

In mixed debt- equity mode, the possibility of borrowing removes the strict cash constraint (A1). If r is the coupon or other nominal yield on government debt L_f , then budget cash flows must satisfy

$$(A2) \quad \Delta L_{ft} - \Delta C_t + y_t = rL_{ft} + c_t + I_t.$$

The objective is to maximise political welfare $U_g(\{\tau_t, c_t, I_t\}_{t=1,2,\dots}; \omega)$, as earlier defined, subject to either (A1) or (A2), depending upon the chosen financing mix.

Analogously with the private sector, the unlevered asset value of government at current or chosen policy settings could be defined as the sum of future net cash flows discounted by a notional asset cost of capital. A more operational version for mixed financing mode is

$$(A3) \quad A = \sum_{t=0}^{\infty} \frac{1}{(1 + r_{wacc})^t} E_0[y_t - c_t - I_t]$$

where the weighted average cost of capital r_{wacc} is given by combining the equity cost of capital r_e with the debt cost of capital r , the respective weights corresponding to the chosen combination of equity (E) and debt (L_f) at each stage. But as outlined in § 2.2, it is by no means clear in the public sector context just what the equity cost of capital should be. For the non realisable part of public equity, the social opportunity cost approach is arguably appropriate, but this leaves open the choice for the non realisable component. The ex post approach of backing out asset value from CDS written on the total public debt sidesteps many of the above problems. In principle one could even proceed further and back out an implied equity cost of capital, resolving a long standing problem in public finance.

Market rules of thumb

As a pricing signal for CDS, market commentary often focuses on selected prudential indicators, among which the sovereign debt to GDP ratio is probably the most widely quoted. Like most rules of thumb it can be very imprecise and circumstantial. Thus while 120% debt to GDP was regarded during the GFC as a crisis for Italy, more recently Japan has been running at 200% without too much negative impact. Whether or not a given sovereign debt to GDP ratio is perceived as a crisis is evidently depends upon whether country concerned retains a corrective budgeting facility when times do improve.

That the debt to GDP rule of thumb can be reconciled with the above DCF approach can be demonstrated with a simple model of proportional growth formulated in Bowden (2012). Suppose that net government expenditure is a proportion θ of total government spending (G) the remainder $G - rL_f$ being debt servicing at coupon rate r . Debt L_f is at face value. The implied

value of government equity is then $E = \frac{NG}{r_e} = \frac{r}{r_e} \frac{\theta}{1 - \theta} L_f$. Asset value $A = L + E$, so with

$L = L_f$ in steady state, the asset cover is $\frac{A}{L_f} = 1 + \frac{r}{r_e} \frac{\theta}{1 - \theta}$. If the costs of debt and equity are

equal, then the ratio reduces to just $1/(1 - \theta)$ the capitalisation of all core government budget surpluses; in other words government saving.

In reality few, if any, countries can be considered to be in a steady state growth mode. Economic drivers such as those of section 3 influence the degree or budget savings or savings capability, and align the outcome with further risk exposures not encompassed in the debt to GDP rule of thumb. In such a framework, the steady state can be considered as an idealised special case. But both approaches remain consistent with the DCF framework as above.

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