Making a reality of GDP-linked sovereign bonds

Authored by Bank of England staff with contributions from
the Banco Central de la República Argentina on the Argentine experience with GDP-linked warrants
and the Bank of Canada on sovereign CoCos

While the idea of governments issuing financial instruments whose repayments are indexed to domestic GDP is not new, the current global backdrop of high sovereign debt coupled with low interest rates and weak and uncertain nominal growth prospects suggests the case for doing so may be especially strong now. This paper discusses the pros and cons of GDP-linked bonds, looks at when it might be most beneficial to issue, how investors might benefit, and possible ways of addressing the first-mover problem. The aim is to stimulate debate rather than provide answers. Similar issues arise for other forms of state-contingent debt.

It is useful to distinguish between potential issuance during normal times and in debt restructurings. In normal times, GDP-linked bonds offer additional fiscal space in downturns, another way of de-levering from high debt levels, and a way of preventing solvency crises. These benefits are likely to be largest when debt levels are already high relative to GDP and there is a non-trivial probability of debt reaching an unsustainable trajectory. In restructurings, GDP-linked bonds can help by backloading debt repayments to when recovery is fully underway and help governments insure themselves against subsequent negative growth shocks and having to restructure again.

A critical factor in issuance is the likely size of the GDP risk premium. If there is no intersection between what issuers are willing to pay and what investors expect to receive, then there will be no market for these bonds. It would be important to tailor the instrument to buy-and-hold investors, who are less concerned with liquidity and novelty considerations that might otherwise deter asset managers who may need to liquidate positions at short notice. Standardisation of the instrument's commercial and legal terms would be important for reducing the first-mover problem. Progress has already been made here with the drafting of a model term sheet.

More work is needed to assess the operational viability of GDP-linked instruments. First, further engagement with industry is needed to establish the likely investor base for the instruments and to hone in on a preferred structure that could be used to standardise future issuance. Second, it would be useful to further expand on the role that GDP-linked instruments and other forms of state-contingent debt instruments might play in sovereigns' capital structure outside of restructurings. A broader set of countries and risk-factors should be looked at, including less industrialised countries. Third, and drawing on previous experience with GDP-linked warrants, a set of principles guiding the use of GDP-linked instruments in debt restructurings would also be useful. Fourth, it is important to better understand the issues around pricing, including the circumstances where exchanging conventional debt for GDP-linked debt might support the pricing of the remaining conventional debt. Further research in the area would help shed light on whether there are risk premiums that could satisfy both investors and issuers.

I. Introduction

This paper explores the case for governments issuing GDP-linked bonds as a way of making their liability structures safer, providing additional fiscal space for future downturns and reducing the likelihood of solvency crises. We discuss the pros and cons, when it might be most beneficial to issue, how investors might benefit, and possible ways of addressing the first-mover problem. The aim is to stimulate debate.

While the idea of issuing GDP-linked bonds is not new, the current global backdrop suggests the case may be stronger now. Part of this relates to high public debt globally. For advanced economies, public debt is at a post-second-world-war high (100% of GDP). For emerging markets, where GDP tends to be more volatile, public debt is at its highest since the 1980s (close to 50% of GDP), even before any potential, contingent fiscal liabilities are included such as state-owned enterprises and government-owned banks.

And yet, weak nominal growth is making reducing debt levels difficult. De-levering through fiscal consolidation can drag on global economic growth. An alternative way to de-lever, if it were available, would be to issue equity as corporates do. For governments, an analogue could be to issue GDP-linked bonds. The extra fiscal space that GDP-linked bonds offer in the event of a downturn could be, in principle, especially useful today given the constraints of operating near the effective lower bound to policy interest rates. By providing countries with a form of recession-insurance, GDP-linked bonds have the potential to reduce the incidence of (domestically and internationally) costly sovereign solvency crises and debt restructurings.

However, weighing against these potential benefits are challenges around operational viability, pricing, and the creation of a new market. This paper addresses these and other issues in an effort to weigh up the pros and cons.

In Section II we give a brief overview of the history of GDP-linked bonds. Then in Section III we discuss pros and cons, from the point of view of the issuer, the investor and the overall system. Included in this section is a discussion of pricing. Section IV looks at possible issuance in debt restructurings. A box in this section discusses lessons from Argentina's experience with warrants. Section V discusses obstacles to issuance and Section VI possible next steps. Section VII concludes.

Of course there are other variants of state-contingent debt available that could also be used to de-risk balance sheets. Box A discusses "sovereign CoCos" which are bonds where the contract provides for an automatic extension of maturities when a country enters into an IMF program. Such instruments could be useful to resolve liquidity issues around debt restructurings. Additional instruments with attractive risk-sharing properties include commodity-linked debt and catastrophe bonds. And, for some, deepening local currency bond markets may help to improve debt sustainability by avoiding the de-stabilising dynamics that can be associated with foreign-currency mismatches.

II. A brief history of GDP-linked bonds

GDP-linked bonds and other related state-contingent debt instruments have received support on and off for well over a century. In 1780, the State of Massachusetts issued what is often considered to be the first ever inflation-linked bond, then called a "Depreciation Note", indexing to a basket of goods including corn, beef, wool and leather. More recently, after the debt crises of the 1980s, there were calls, led mostly by academics, for sovereigns to link debt repayments directly to measures of ability to pay such as exports (Bailey, 1983), commodity prices or GDP (Krugman, 1988; Froot et al, 1989; Kletzer et al, 1992).

In the early 1990s, Shiller (1993) proposed an instrument that would be long-term in maturity, perhaps even perpetual, and which would have both its coupon and its principal indexed to nominal GDP. Similar to shares issued by firms, which pay a fraction of corporate earnings in dividends, a GDP indexed bond would pay out a fraction of the "earnings" of the issuing country—its GDP. Barro (1995) argued that, optimally, indexing ought to be to consumption and government expenditure. However, he saw indexing to GDP as a more realistic alternative, given that moral hazard and measurement would be less of a problem.

In the mid-2000s there was another wave of interest. In May 2004, a paper assessing the potential benefits of, and obstacles to, the use of GDP-indexed bonds and related instruments was discussed in an informal seminar at the Executive Board of the IMF.

These intermittent groundswells in policy and academic support for GDP-linked bonds have resulted, over the years, in some incremental progress towards issuance. As early as the 1970s, Mexico issued several bonds indexed to oil prices. GDP "warrants", which contain an element of indexation to GDP—providing holders with a higher coupon if GDP exceeds some threshold level—have been issued by a small number of countries as part of debt restructuring agreements (Costa Rica, Bulgaria and Bosnia and Herzegovina in the 1980s and 1990s; and since then, Argentina, Greece and Ukraine).

No sovereign has yet issued a GDP-linked bond with full risk-sharing between sovereigns and their creditors, with returns that vary symmetrically, falling with lower GDP and rising with higher GDP. A number of coordination and technical issues have been seen as hindering issuance and acceptance of such an instrument. For example, concerns about the timeliness and reliability of GDP statistics are often raised, as well as the challenges of creating a liquid market for any new financial instrument.

However, in the past couple of years, interest in GDP-linked bonds has revived again. They are seen by some as a way of helping to prevent the next sovereign debt crisis and by others as a means of better resolving the debt burdens of post-crisis countries such as Greece (Brooke et al, 2013; Fratzscher et al, 2014; Goodhart, 2015; Honohan, 2011).

While GDP-linked bonds would help reduce the likelihood of solvency crises, sovereign CoCos are designed primarily to tackle liquidity crises. We discuss them more fully in **Box A**.

Box A. Sovereign CoCos

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Sovereign CoCos are bonds that would automatically extend in repayment maturity when a country receives emergency liquidity assistance from the official sector. This predictable and transparent means of bailing-in creditors would increase market discipline on sovereigns, reducing the incidence of crises. They would also reduce the size of official sector support packages once a crisis has hit. Sovereign CoCos were first advocated by Weber et al (2011) in the context of euro-area bonds, building on the 'Universal Debt Rollover Option with a Penalty' (UDROP) proposal by Buiter and Sibert (1999). Other variants of this idea include Barkbu et al (2011) and Mody (2013),

The maturity extension clause would be activated when the sovereign receives emergency liquidity from the official sector. In practice, this will be when the sovereign draws upon credit from the IMF or another bilateral/regional facility (such as the European Stability Mechanism and other similar initiatives).

The maturity extension needs to be long enough to overcome the sovereign's liquidity problems and provide breathing space to put in place required adjustment policies, but not so long that it unduly penalises creditors. This suggests that the length of the maturity extension should match that of typical official sector support programmes. The typical length of an IMF programme is around three years.

If a maturity extension is triggered, coupon payments for each bond will continue at their original level and frequency. 'Amortising bonds' – and other debt instruments that repay the face value in instalments – would have the principal (but not coupon) payments postponed for the length of the maturity extension.

Sovereign CoCos could improve the current arrangements in three ways.

First, they will enhance market discipline. Creditors could no longer anticipate full repayment by the official sector in times of crisis. This, in turn, would reduce the incentive to lend incautiously to sovereigns, thus helping to mitigate moral hazard. Over the medium term, this should contribute to reducing the incidence of sovereign debt crises.

Second, by maintaining the exposure of existing creditors, rather than transferring it to the official sector, any subsequent debt writedowns would involve a greater proportion of the sovereign's pre-crisis creditors. The burden of the debt writedown will be more equitably distributed amongst creditors and should involve smaller haircuts on each bond to restore debt sustainability. This should reduce the current bias for creditors to increasingly prefer to only lend short term to a sovereign facing mounting financing pressures.

Third, the activation of sovereign CoCos would significantly alter burden-sharing between private creditors and the official sector/taxpayers, reducing the required size of official sector emergency loans. The maturity extension ensures that the official sector liquidity assistance would not have to cover debt amortisation payments. It would, however, need to provide lending to cover the fiscal deficit and any off-balance-sheet liabilities such as bank recapitalisation.

III. Pros and cons of GDP-linked bonds

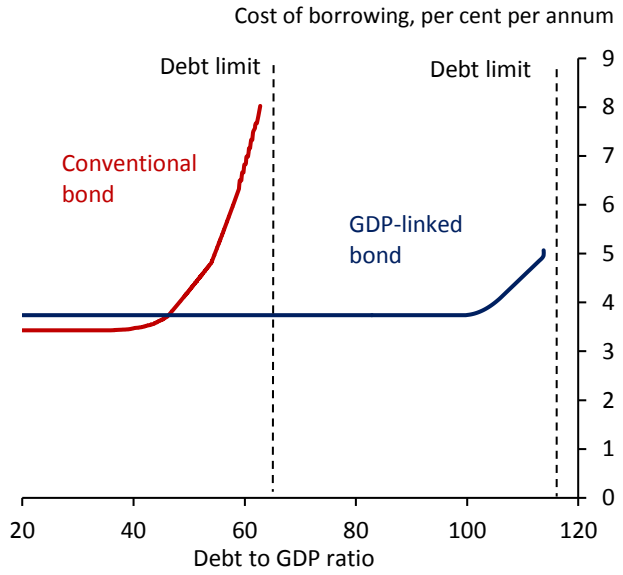
III.A The issuer's perspective

For the issuer, there are a number of attractions to the state-contingency that GDP-linked bonds build into debt repayments. When growth is weak, debt servicing costs would decline, reducing the need for spending cuts. When growth is strong, and the government's revenues are high, the return on the bond would increase in line with repayment capacity.

Issuing GDP-linked bonds when debt is high

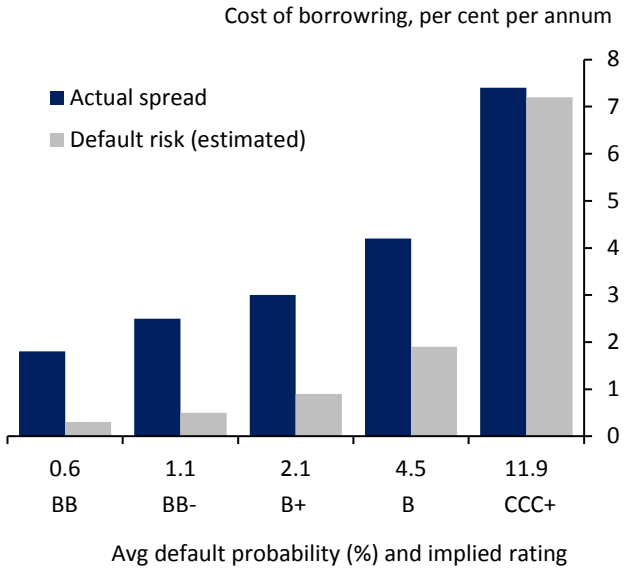
Because GDP-linked bonds lower the probability of default, they should reduce the credit spread on the government's other, conventional debt. Barr et al (2014) suggest that this effect is equivalent to raising the sovereign's maximum sustainable debt threshold (almost doubling it in some circumstances). GDP-linked bonds could, in principle, both reduce credit spreads and be cheaper to issue than conventional bonds. The reason is that when debt approaches the maximum sustainable debt threshold, the credit spread on conventional bonds can exceed the GDP risk premium (**Chart 1**). The benefits of GDP-linked bonds in reducing default risk may be larger for lower-rated sovereigns, where default risk typically accounts for a larger share of overall borrowing costs (**Chart 2**).

Chart 1: Stylised cost of borrowing and level of debt for conventional and GDP-linked bonds



Source: Barr et al. (2015).

Chart 2: Default content of sovereign spreads, by average default probability



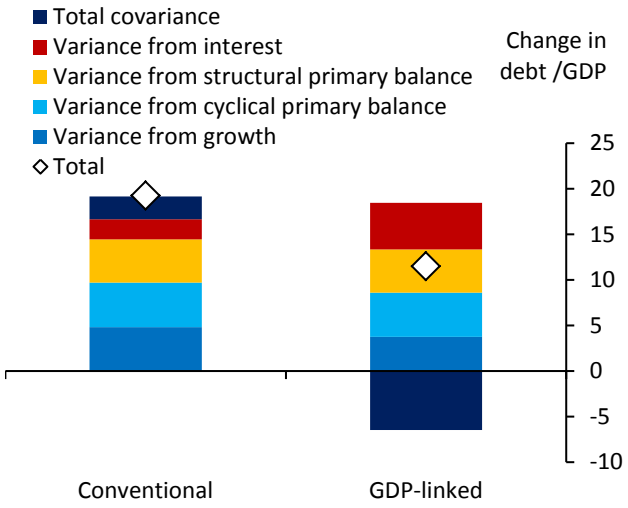
Notes: Chart shows actual EMBI spreads and predicted default spreads from a macroeconomic model, by fitted default probability quintiles. The average default probability for each quintile is on the horizontal axis. *Source*: Hilscher and Nosbusch (2010).

Issuing GDP-linked bonds where GDP is more variable

The more volatile a sovereign's GDP, the bigger the likely benefits from GDP-linked debt. **Chart 3** shows that even for G7 countries, where output is relatively stable, around one half of the variance of government debt to GDP ratios can be accounted for by "growth shocks" (the combined variance of growth and the cyclical primary balance).

The right-hand bar shows how much lower the variance in debt-to-GDP ratios would have been for G7 countries if they had all their government debt indexed to GDP. The variance is reduced by more than 40%, driven by the negative relationship between interest payments on GDP-linked bonds and growth. The less variable the debt-to-GDP ratio is, the less likely a country will be forced to undertake costly fiscal adjustments, or in extreme cases, default. Over and above countries with higher GDP volatility, countries where monetary policy is constrained due to institutional arrangements would likely benefit most from GDP-linked debt (Brooke et al, 2013).

Chart 3: Government debt to GDP variance decomposition for G7 countries, since 1991



Source: Brooke et al (2013).

Quantifying the costs and benefits

We try to quantify some of the costs and benefits of issuing GDP-linked bonds by taking a similar approach to Blanchard et al (2016), estimating how the debt ratio would evolve for a government with either all conventional or all GDP-linked debt in response to a series of shocks to its key debt-creating variables: GDP, interest rates, the primary balance and, where debt is issued in foreign currency, the exchange rate. As case studies, we look at an advanced and an emerging economy whose gross government debt as a share of GDP is halfway between the (unweighted) average and the highest in their respective peer groups (ie, at the 75th percentile). This translates to a government debt ratio of about 100% for an advanced economy and 65% for an emerging one. We think of these as representative *indebted* sovereigns.

Our approach starts with the basic debt dynamics equation for conventional debt, where d_t is the debt-to-GDP ratio in year t; r and g are the real interest and growth rates respectively; and where pb is the primary balance as a share of GDP:

$$\Delta d_t = (r_t - g_t)d_{t-1} - pb_t \qquad (1)$$

We next add shocks to equation (1). Shocks to r, g and pb are calibrated to be similar to those the representative advanced and emerging economy experienced on average every year over the past decade and a half. The shocks are drawn from an empirical joint normal distribution estimated over 1999 to 2015. By implication we are assuming here that the correlations that held in the past between r, g and pb, also hold in the future. Doing this, we can simulate thousands of possible paths for the debt ratio to create fan charts that we describe more fully in **Box 1**.

For GDP-linked bonds, we assume these instruments pay, in real terms, an ex post return of r_t^{gdp} determined by the growth rate g_t plus a constant *k* (the coupon), such that:

$$r_t^{gdp} = g_t + k \tag{2}$$

We set the coupon at a level that ensures that, in the base case where there are no shocks, the debt ratio after 20 years is the same for GDP-linked bonds as it is for conventional debt. In other words, we set the risk premium on GDP-linked bonds equal to zero. We change this assumption later on. In our calculations, both the principal and coupons are indexed to the level of GDP, which is an assumption we keep throughout this paper unless stated otherwise. This and other ways of indexing are discussed in **Annex I**.

If we further probe equation (1), we can see how *r*, *g* and *pb* can be expected to influence the relative benefits of GDP-linked bonds. In particular, taking variances of both sides, gives:

$$var(\Delta d_t) = var(pb_t) + d_{t-1}^2 var(r_t - g_t) - 2d_{t-1}\rho_{(r-g,pb)}\sqrt{var(pb_t)var(r_t - g_t)} \tag{3}$$

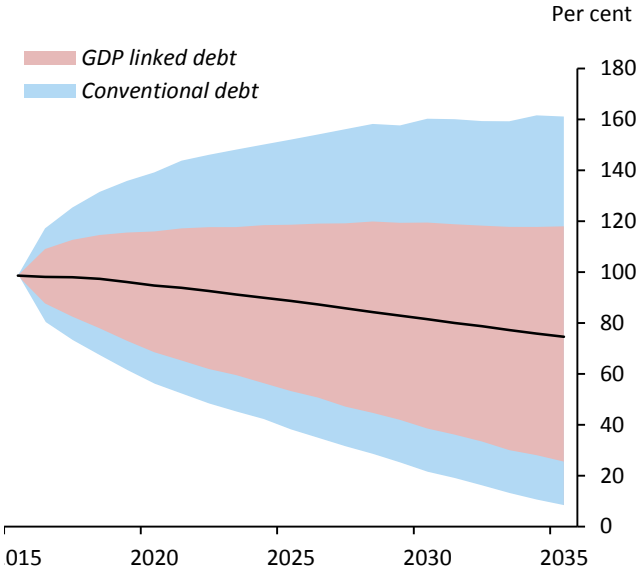
Because $r_t^{gdp} - g_t$ is equal to a constant, *k*, then for GDP-linked bonds equation (3) collapses to $var(\Delta d_t) = var(pb_t)$. From this we can see that anything that increases the value of $d_{t-1}^2 var(r_t - g_t)$ in equation (3) will worsen the debt dynamics of conventional debt, but not GDP-linked debt. The benefits of GDP-linked debt will be higher the more variable is $r - g$, and this, in turn, will be higher if *r* and *g* are negatively correlated (and lower if positively correlated).

We find that GDP-linked issuance helps narrow the range of stressed outturns for the government's debt-to-GDP ratio in both our indebted advanced and emerging economies. Our simulations suggest that indexing debt to GDP could reduce considerably the risk of explosive debt dynamics in the advanced economy, narrowing the upper tail of the debt distribution by around 45ppts (**Chart 4**). That is, an outturn in the 99% tail for the debt-to-GDP ratio puts the ratio at 120% after 20 years in the case where the country issues only GDP-linked bonds, compared with 165% for conventional debt.

For the emerging market, while issuing conventional debt in only local currency offers some reduction in upper tail risk over mixed local and foreign currency issuance[1] (reducing the debt ratio by around 5ppts), local currency GDP-linked debt reduces the upper tail by even more (a 20ppt reduction) (**Chart 5**).

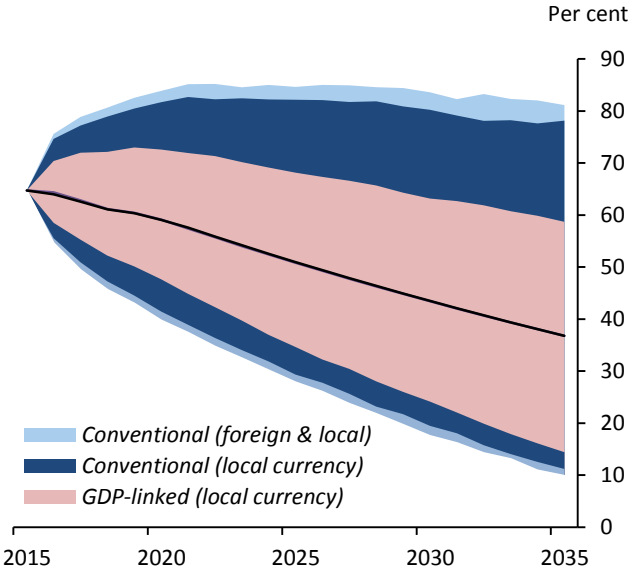
[1] For the emerging market we look at, 25% of government debt is denominated in foreign currency.

Chart 4: Gross government debt under either conventional or GDP-linked debt: for an indebted advanced economy sovereign



Source: Author calculations.
Notes: Chart shows debt-to-GDP ratio paths corresponding to the 1st, 50th (dark line) and 99th percentiles of the joint normal distribution of shocks. The dark line running through the centre of the fans indicates the 50th percentile path for both conventional and GDP-linked debt. The paths are the same by construction: the risk premium on GDP-linked debt is assumed to be zero.

Chart 5: Gross government debt under either conventional or GDP-linked debt: for an indebted emerging market sovereign



Source: Author calculations.
Notes: Chart shows debt-to-GDP ratio paths corresponding to the 1st, 50th (dark line) and 99th percentiles of the joint normal distribution of shocks. The dark line running through the centre of the fans indicates the 50th percentile path for both conventional and GDP-linked debt. The paths are the same by construction: the risk premium on GDP-linked debt is assumed to be zero. Foreign currency debt accounts for 25% of the total.

These estimates come with a number caveats. Benefits from GDP-linked bonds could be smaller or larger depending on a variety of factors.

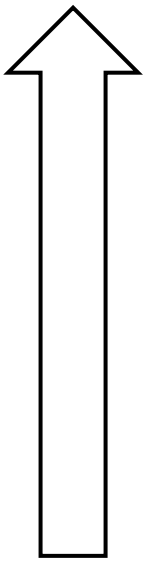
Charts 4 and 5 may overstate the benefits of GDP-linked bonds. First, for both the advanced and emerging economies we look at, the correlation between *r* and *g* is negative over the sample period. If the correlation was positive, some of the adverse impact of slower growth on debt sustainability would be offset by cheaper borrowing costs, and the benefits of GDP-linked debt would be smaller. Reserve currency countries would likely fall into this category. Second, our analysis does not consider how the country's borrowing behaviour may change with the introduction of GDP-linked bonds. Governments could, conceivably, simply increase borrowing. Third, the benefits of moving from foreign to local currency conventional debt could be larger than estimated here, and so the relative benefits of GDP-linked bonds smaller, if exchange-rate shocks get amplified by, say, demand compression or negative balance sheet effects that trigger contingent fiscal liabilities.

On the other hand, future constraints on monetary policy could increase the benefits from issuing GDP-linked debt. Those countries that have in the past been able to borrow more cheaply in low-growth periods (stabilising *r* - *g*) may not be able to do so in future if they now find themselves at the effective lower bound for interest rates or if institutional arrangements constrain the ability of the central bank to reduce interest rates following a deterioration in a country's growth prospects.

Similarly for constraints on fiscal policy, a government whose borrowing is subject to an official debt ceiling would lower the risk of negative growth shocks causing it to exceed that ceiling if it were to issue GDP-linked debt. Finally, our simulations do not allow the default risk premium on conventional debt to depend on the debt ratio. If we were to allow it to increase non-linearly, as it did for many countries in the euro area crisis, the simulated paths for conventional debt would be even worse, and the relative benefits of GDP-linked debt bigger.

Table 1 summarises, qualitatively, some of the issuer characteristics that we would expect to influence the scale of the benefits from GDP-linked bonds.

Table 1. Who might benefit most from issuing GDP-linked bonds

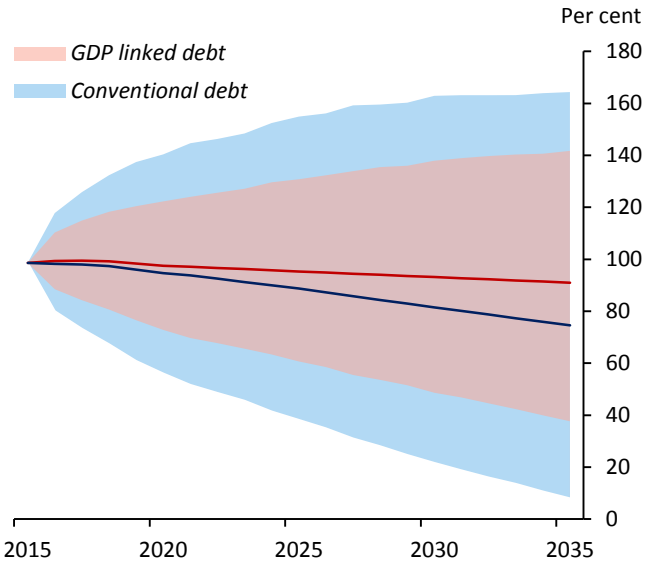
	Advanced economy sovereigns	**Emerging market sovereigns**
More beneficial 	• High debt + Volatile "*r - g*" + Monetary policy constrained • High debt + Volatile "*r - g*" • Volatile "*r - g*"	• High debt (near benchmark risk thresholds or with large contingent fiscal liabilities) + Volatile "*r - g*" + Monetary policy constrained (fixed exchange rate) • High debt + Volatile "*r - g*" (eg, commodity-dependent or prone to natural disasters) • Volatile "*r - g*"
	• Low debt • Low debt + Large monetary policy space • Low debt + Large monetary policy space + Stable "*r - g"* (reserve currency)	• Low debt (+ low contingent fiscal liabilities) • Low debt + Large monetary policy space (exchange rate flexibility)

Source: Author.

How high would the GDP risk premium have to be to outweigh these benefits?

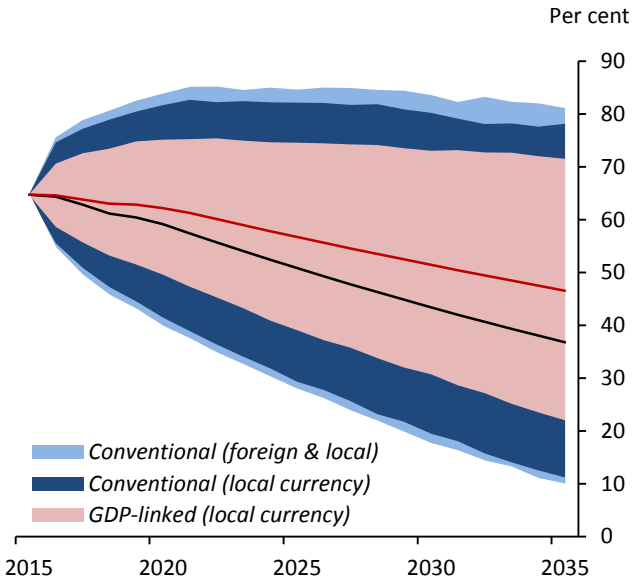
From the issuer's point of view, if investors demand too high a premium to compensate them for the GDP risk they are taking on then in the face of a series of bad shocks, the issuing sovereign could be just as bad off as with conventional debt, ending up with the same debt ratio or higher. To get a sense of where the tipping point might be, we look at the effects of adding a GDP risk premium of 100bps.

Chart 6: Gross government debt under either conventional or GDP-linked debt (100bps premium): for an indebted advanced economy



Source: Author calculations.
Notes: Chart shows debt-to-GDP ratio paths corresponding to the 1st, 50th and 99th percentiles of the joint normal distribution of shocks. The black line shows the 50th percentile path for conventional debt. The red line shows the 50th percentile path for GDP-linked debt.

Chart 7: Gross government debt under either conventional or GDP-linked debt (100bps premium): for an indebted emerging market



Source: Author calculations.
Notes: Chart shows debt-to-GDP ratio paths corresponding to the 1st, 50th and 99th percentiles of the joint normal distribution of shocks. The black line shows the 50th percentile path for conventional debt. The red line shows the 50th percentile path for GDP-linked debt.

Chart 6 shows how the debt ratio for GDP-linked bonds might be affected for the same indebted advanced economy we looked at before. The whole distribution (in pink) tilts upwards, and the central case in red is higher, which is to be expected since the issuer has to pay for this insurance. A bad series of shocks from the 99th percentile now leaves the debt ratio at 140% after twenty years. This is still better than under conventional bonds (165%), but the margin of benefit has narrowed.

Chart 7 shows the same scenario for our indebted emerging economy sovereign. A 100bps risk premium would leave the debt ratio at 70% after the same bad series of shocks. Again the improvement over conventional debt has narrowed compared with the case of zero risk premium.

Box 1. Quantifying the debt-stabilising benefits of GDP-linked bonds

To get a quantitative sense of the benefits to the issuer that GDP-linked bonds could provide in the face of uncertain economic shocks we take a probabilistic approach to estimating future debt paths, simulating thousands of alternative realisations of GDP, interest rates, the primary balance and the exchange rate, and calculate the resulting path for government debt under conventional and GDP-linked bonds.

Conventional debt in local currency

We begin by considering the debt-dynamics equation for conventional debt (d_t^c) in nominal terms, which states that for a sovereign borrowing in their own currency, the change in the debt-to-GDP ratio is a function of nominal interest rates (i_t) nominal growth (g_t^n), the primary balance (pb_t), and any other adjustments to the debt stock ($oadj_t$).

$$\Delta d_t^c = \frac{(i_t - g_t^n)}{1 + g_t^n} d_{t-1}^c - pb_t + oadj_t \qquad \text{(A)}$$

For each country we look at, we construct a baseline projection for the variables in the equation above, covering the period 2016-2035. The first seven years of this baseline projection comes from the IMF's October 2015 World Economic Outlook. Beyond 2022, we assume that real GDP grows at potential (as estimated in the WEO for the final year of the forecast), inflation remains at target (or at the same rate last year of forecast where there is no explicit target), interest rates and primary balances remain at their 2022 levels, and other adjustments are assumed to equal zero beyond 2022. Inserting these paths into the equation above gives us a baseline projection for the debt-to-GDP ratio out until 2035.

We then turn to constructing a range of plausible alternative paths around this baseline. To do this, in each year of the projection period, we allow the baseline values for interest rates, nominal growth and the primary balance to be subject to shocks, drawn from a joint normal distribution.[2] The way these variables co-vary with each other ($\hat{\Sigma}$) is estimated using data covering the period 1999-2015. The joint normal distribution has a zero mean and covariances that come from the data. This gives us the following amended equation for debt dynamics:

$$\Delta d_t^c = \frac{\left(\left(i_{t,base} + \epsilon_{i,t}\right) - g_{t,base}^n + \epsilon_{g,t}\right)}{1 + \left(g_{t,base}^n + \epsilon_{g,t}\right)} d_{t-1}^c - \left(pb_{t,base} + \epsilon_{pb,t}\right) + oadj_{t,base} \qquad \text{(B)}$$

Where $\epsilon_t = \left(\epsilon_{i,t}, \epsilon_{g,t}, \epsilon_{pb,t}\right)' \sim N\left(\mathbf{0}, \hat{\mathbf{\Sigma}}\right)$

[2] For simplicity, we assume that $oadj_t$ is non-stochastic.

Fan charts are constructed by taking draws from this estimated joint distribution to produce thousands of simulations of the debt-to-GDP ratio over the 20 year window. We then plot the 1st and 99th percentiles of these estimated distributions.

Conventional debt in foreign currency

For a sovereign that borrows in both local and foreign currency, we use the following amended debt-dynamics equation

$$d_t^c = d_{t-1}^c \frac{(1+i_t)}{1+g_t^n}\left(\frac{d_{dc,t-1}^c}{d_{t-1}} + \left(1 - \frac{d_{dc,t-1}^c}{d_{t-1}}\right)(1+\Delta s_t)\right) - pb_t + oadj_t \qquad \text{(C)}$$

Where $d_{dc,t-1}/d_{t-1}$ is the share of the the outstanding debt stock denominated in domestic currency, which we assume is non-stochastic, and $\Delta\, s_t$ is the change in the nominal effective exchange rate. To get the fan charts, we add the real exchange rate to the estimated covariance matrix. As before, draws of the shocks to each variable are taken from a joint normal distribution, with zero mean and covariance ($\hat{\Sigma}$).

GDP-linked debt

For GDP-linked bonds, we assume they pay an (ex-post) return i_t^{gdp}, where:

$$i_t^{gdp} \;=\; g_t^n \;+\; k \;+ \theta_{GDP} \qquad \text{(D)}$$

In this expression, θ_{GDP} represents the GDP-risk premium, while *k* represents the coupon on GDP-linked debt. Substituting this expression into equation (A) above, gives the following debt-dynamics equation for GDP-linked debt:

$$\Delta d_t^{gdp} = \frac{k+\theta_{GDP}}{1+g_t^n} d_{t-1}^{gdp} - pb_t + oadj_t \qquad \text{(E)}$$

We initially set $\theta_{GDP} = 0$, and then choose *k* to equalize the 2035 debt-to-GDP in the baseline with that in the conventional debt case. We use the paths for g_t and pb_t to give us estimates of the debt path under the assumption of a fully GDP-linked debt stock. The same method can be used to produce simulations for the case where $\theta_{GDP} > 0$.

Assumptions

Because we use a joint normal distribution we are implicitly assuming that there is a simple, linear dependence structure between our variables. As a result, we are probably underestimating the likelihood of tail events. Empirical work tends to find that distributions of macro-data have fatter tails than would be predicted by normality. Fatter tails, here, would strengthen the benefits of GDP-linked bonds.

We also assume that all shocks are distributed independently and identically over time so that shocks this year have no effect on shocks the next year. That is, weak growth in year one makes it neither more or less likely we will see weak growth in year two. The advantage of this is that the data and computational requirements are relatively low, which mean we can apply the technique to emerging market sovereigns, such as the one in the example, where data are sparse.

There is no explicit fiscal reaction function, only an empirical one. That is, the fiscal response to any shock is determined by the empirical joint normal distribution and so is the average response to growth and effective interest rates seen since 1999.

We work with the effective nominal interest rate, rather than modelling interest rates on new issuance directly. The effective interest rate will reflect both the composition of debt, and the levels of government bond yields of different maturities. By estimating moments of this variable, we effectively assume that the composition of government debt (in terms of type of instruments and maturity) in each of our simulations remains similar to its average composition over the estimation period.

For GDP-linked bonds, we assume that the joint distribution of growth and primary balances is the same as for conventional debt. Fiscal policy might, though, have more scope for counter-cyclical measures with GDP-linked bonds, which would imply a different distribution, and which may lead to less volatile growth. Our simulations simply demonstrate the lower volatility of debt under unchanged distributions.

III.B The investors' perspective

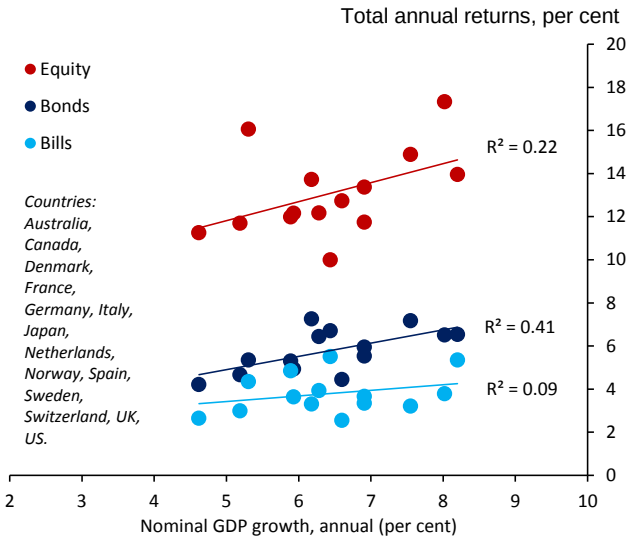
For the investor, GDP-linked bonds provide an equity-like stake in a country's economic fortunes, giving a broad-based claim on not just corporate earnings but also wages, salaries and other labour income. Pension funds that invest only in equity are restricted to those returns that come from corporate profits—which are a smaller and more volatile part of GDP (private corporate profits after tax account for around 10% of advanced economies' GDP while labour income is about 60%). And for countries, such as some emerging market economies, where equity markets are less developed, GDP-linked bonds may offer a much broader claim on corporate profits than currently available.

Linking to nominal GDP therefore offers investors a broader hedge than offered through inflation-linked instruments.[3] For pension funds, GDP-linked bonds also protect against changes in relative standards of living, since they are a constant share of GDP—unlike inflation-linked bonds, which over time offer a declining real share of national income. This might be attractive to funds with future pay-outs tied tied to aggregate earnings in addition to inflation protection.

[3] Of course investors in inflation-linked bonds may just be looking to match their inflation-linked liabilities so may not want this broader hedge.

Traditional investment classes do not capture well the benefits of GDP growth, which we can see from the weak correlation between nominal GDP growth and the total returns from equity, government bonds and treasury bills over the past hundred years (**Chart 8**). Of course, with the sophisticated financial markets that exist today, investors that do want exposure to GDP would be able to find a constellation of assets and derivatives that mimic the relevant risk characteristics. However, any such an approach would lack standardisation and tradability, compared with holding a single, benchmark instrument.

Chart 8: Nominal GDP growth and equity, government bonds and treasury bill returns since 1900



Source: Dimson et al (2011); Schularik and Taylor (2012).
Notes: GDP growth and asset returns (total) are nominal and in domestic currency.

What might investors demand as a premium?

In exchange for taking on the risk of holding an asset that would pay out lower returns during a period of declining GDP, investors would probably want to be paid a premium (a "GDP risk premium") over the risk-free rate. How big this premium might be is difficult to predict. Domestic investors holding GDP-linked bonds would want to be compensated for the systematic risk that they are exposed to, and that the government is insured against. But foreign investors, if their income is not closely correlated with the GDP of the issuing country, might require only a small premium.

Theoretical models do not have a good track record of estimating risk premia (historical equity premia can be an order of magnitude greater than those predicted by theoretical models) and empirical approaches typically draw on information contained in existing prices, which for GDP-linked bonds, because they do not yet trade, are absent. Taking a "relative pricing" approach can help, but to do this we require a set of other assets that "span" the risk characteristics of GDP well.

The few academic studies that do attempt to calculate the GDP risk premium give estimates ranging from 35 to 150 basis points (**Table 2**).

Table 2. Estimates of the GDP risk premium

Authors	Approach	Estimate (bps)
Barr et al (2014)	Specify a utility function for risk averse investors, set expected utility from holding risky GDP bond and risk-free bond to be equal, then insert into a debt sustainability model of endogenous default (for advanced economies).	35
Kamstra & Shiller (2009)	Estimate a capital asset pricing model for the US.	150
Borensztein & Mauro (2004)	Estimate a capital asset pricing model model for Argentina, where the GDP risk premium is set equal to the systematic portion of risk involved in Argentina's GDP.	<100

As a rule of thumb, investors might expect the GDP risk premium to be higher the more volatile is GDP, and the greater is the correlation between the issuing country's GDP and the investor's "market portfolio" return, where the market portfolio could be US stocks or world GDP.

The first of these approximations stems from portfolio theory, in which volatility is generally used as the proxy for risk. Since the volatility of GDP is much lower than for equities—less than an eighth if we look at the standard deviation of nominal GDP growth and equity returns for advanced economies over the past 30 years (3 versus 25ppts)[4]—a first approximation might suggest the GDP risk premium ought to be an eighth of what the equity risk premium is, so for the US, 0.8ppts rather than 6ppts.[5]

Thinking of the GDP risk premium as being equal to the amount of systematic risk in a sovereign's GDP that the investor needs to be compensated for, lends itself to a Capital Asset Pricing Model (CAPM) framework. Taking this approach, Kamstra and Shiller (2009) estimate that the GDP risk premium for the US ought to be at most 1.5ppts. The amount of systematic risk in GDP of course varies from country to country. Even so, Borensztein and Mauro (2004) show that simple regressions of individual countries' GDP growth rates on worldwide growth indicate that unsystematic variation is far larger than systematic. Updated estimates from their paper show that the R-squared from regressions of individual country GDPs on world GDP is just 0.04 for emerging market economies. For advanced economies, comovement is higher, with an average R-squared of 0.20. These give estimates of the GDP risk premium of close to 1.4ppts (on average) for advanced economies and 0.8ppts for emerging markets.

[4] These estimates are based on annual returns data since 1980 sourced from the Dimson Marsh and Staunton Global Asset Returns Database, and on GDP data from Schularik and Taylor (2012).
[5] Averaging results from 20 different models of the equity risk premium for the US over 1960 to 2013, Duarte and Rosa (2015) find a premium of 5.7ppts. For 19 countries over 111 years, Dimson et al (2011), find the equity risk premium relative to Treasury bills was 4.5% per annum.

Default risk premium

The GDP risk premium is over and above the risk-free rate and on top of it there may also be a separate premium for default risk. However, a key benefit of GDP-linked debt is that by making the debt-to-GDP ratio much less volatile, this reduces the probability of unsustainable debt dynamics, and so lowers default risk. As a result, there should be a lower default premium on all government debt—conventional as well as GDP-linked. How much lower is difficult to gauge, but the more GDP-linked debt that is issued and the larger the initial debt-to-GDP ratio (and so the closer a country is to the point of debt becoming unsustainable), the larger the likely fall.

In addition, the default risk premium on GDP linked bonds could be systematically lower than on conventional debt. This could be the case because, when growth falls, the issuer should be better able to stay current on its GDP-linked debt as a result of the repayments due on it having fallen. Ex post, GDP-linked bonds could be seen as senior. Ex ante, this could be strengthened by relieving GDP-linked bonds of any legal obligation to cross-default when conventional bonds do.

Liquidity and novelty premiums

In addition to the GDP risk premium there may also be a liquidity premium and, at the outset, a novelty premium.

Liquidity is highly prized by asset managers who want to be able to liquidate positions and adjust portfolios at short notice, but is of less concern to pension funds and sovereign-wealth funds who prefer to hold assets to maturity. Sufficiently large issuance, either by a single sovereign or more effectively by many, would lower the liquidity premium. In theory it should not require many sovereigns to issue in order to generate diversification benefits: Callen et al (2015) find that pools of fewer than 10 countries can provide the bulk of worldwide risk-sharing gains. Standardised contracts can also help mitigate illiquidity, and progress has been made on a what a common term sheet might look like.[6]

Even if GDP-linked bonds were sufficiently liquid they may also attract a novelty premium—that is, an initial premium to compensate investors for uncertainties about the instrument and how it might perform due to its newness. Although the size of this premium might decay fairly rapidly, it is likely to be more persistent if the structure of the instrument is complex, valuation is difficult, statistical agencies are not trusted or risk aversion is high—all factors that contributed to Argentina's GDP warrants being charged a high novelty premium (Costa et al, 2008).

On the one hand, then, liquidity, novelty and GDP risk lead to a higher premium on GDP-linked bonds. On the other, lower default risk should drive down the default premium on all debt.

[6] A draft *London Term Sheet* for an indicative GDP-linked bond was presented at a recent Bank of England workshop. See http://www.bankofengland.co.uk/research/Pages/conferences/301115.aspx

III.C Strengthening the international monetary and financial system

GDP-linked bonds could have important benefits for the international monetary and financial system as a whole. Broadening the set of available financial instruments to include GDP-linked bonds could allow risk to be shared across borders both more efficiently and safely. Ultimately this could help to manage demands on the global financial safety net.

By reducing default risk, capital flows and therefore risk-sharing could, in theory, increase (Bai and Zhang, 2012). With private creditors playing a greater role in risk-sharing, this should also reduce the need for international bail-outs of sovereigns and so reduce moral hazard. More broadly, the large dead-weight costs associated with disorderly and protracted debt restructurings could be avoided. Typically, contagion abates only once policy responses to address sovereign distress have been embarked upon (IMF, 2014) but with GDP-linked bonds the response is automatic.

Because the capital structure of governments is currently made up of fixed-income debt obligations, then outside of a restructuring, domestic taxpayers, rather than investors, have to bear the risk of a deterioration in a country's growth prospects. However, investors are likely to be less risk averse than the average tax payer and so better able to shoulder the risk of a fall in growth prospects, particularly if they hold a geographically diverse portfolio of assets. As a result, adverse spillovers to other countries from fiscal consolidation may be smaller with GDP-linked bonds, especially when growth is low and-or many countries are consolidating at the same time, which are times when we would expect spillovers to be high (Auerbach and Gorodnichenko, 2013; Goujard, 2013).

Another attractive feature of GDP-linked bonds is that they complement other existing initiatives to reform and strengthen the international monetary and financial system. Firstly, they are consistent with the revealed preference for contract-based, market solutions to prevent and resolve sovereign debt crises. For instance, stronger collective action clauses, introduced last year with support from the IMF, reduce the leverage of disruptive, "holdout" creditors. Second, they complement recent reforms to the IMF's lending framework that introduce debt "reprofilings" for governments with uncertain debt sustainability. While reprofilings are designed to tackle liquidity crises, GDP-linked bonds help reduce the likelihood of solvency crises. This in turn can help to reduce demands on the global financial safety net (Denbee et al, 2016).

IV. Issuance in debt restructurings

Over and above the benefits that GDP-linked bonds offer during normal times, there may be further advantages for sovereigns who issue them during debt restructurings and for the investors who take them up. Crucially, GDP-linked bonds may help bridge the gap between negotiating parties by: (i) giving investors an incentive to provide upfront debt relief in exchange for a potentially higher payoff in later years; and (ii) making the debt restructuring robust to uncertainty about future GDP prospects and avoiding the need for later restructurings.

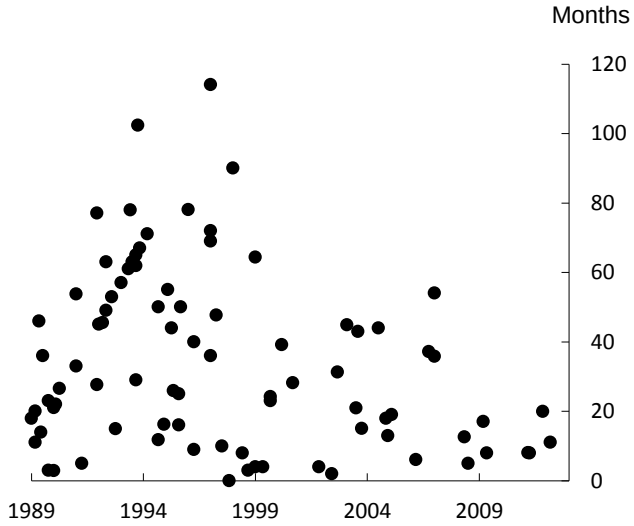
As part of their Brady Plan restructurings in the 1980s and 1990s, Costa Rica, Bulgaria and Bosnia and Herzogovina issued bonds that included GDP clauses or (detachable) "warrants" that increased

their coupon payments when GDP exceeded some predetermined set of thresholds. Also known, at the time, as "value recovery instruments," these GDP-linked debt instruments were designed in part to appeal to those commercial banks involved in the debt restructurings who felt that their concessions, in terms of debt relief, to the sovereign borrowers should be only temporary, and that they should be repaid when the sovereigns' financial health improved (Buchheit, 1991). Argentina, Greece and Ukraine have all issued similar instruments in their more recent restructurings (Costa et al., 2008; Zettelmeyer et al., 2013; Ministry of Finance of Ukraine, 2015).

To investors, these instruments are attractive because they offer an opportunity to claw back the losses incurred in the restructuring—much like an "equity kicker" acquired through an option to purchase shares following corporate debt restructurings. They have arguably "sweetened" debt exchanges that might otherwise have taken longer to agree on.

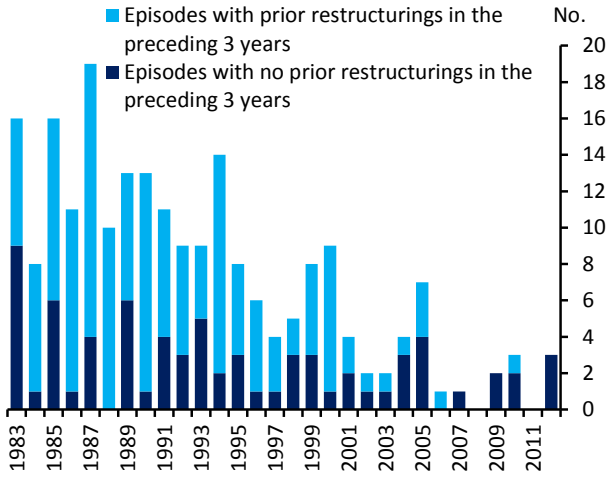
For the issuer, GDP-linked bonds are beneficial in debt restructurings for three reasons: (i) they backload debt repayments to when recovery is fully underway, while ensuring repayments move in line with the sovereign's (GDP) repayment capacity; (ii) by acting as a deal sweetener, they may reduce costly delays in reaching an agreement and unnecessary bouts of uncertainty (negotiations since the 1980s have averaged more than two years in length) (**Chart 9**); (iii) so long as they are symmetric in their risk-sharing characteristics, GDP-linked bonds help governments in debt restructurings to insure themselves against subsequent negative growth shocks and so lessen the risk of having to restructure again. IMF (2014) staff find that two-thirds of all sovereign debt restructurings with private foreign creditors since 1980 failed to successfully re-establish debt sustainability and led to repeat restructurings (**Chart 10**).

Chart 9: Sovereign debt restructurings negotiation duration in months, by year of exchange



Source: Author calculations. Notes: Dataset covers 86 sovereign debt restructurings with private sector external creditors since 1989.

Chart 10: Repeat sovereign debt restructurings, 1983-2012



Source: IMF (2014).

In practice, however, GDP warrants have often turned out to be poorly designed, overly complex in terms of payment formula (typically including a range of caps and floors that determine when payments will or will not be made), and as a result have been difficult to price (trading "out of the money" for long periods) and so attractive only to niche investors (Bank of England, 2015).

A number of lessons can be drawn from Argentina's experience with warrants, discussed in Box B. The most important was that the design of the instrument was too complicated, with coupon payments depending on both growth and the level of GDP compared with a "base case" or expected trend that the government set at the outset, for the rate of real GDP growth, and on the evolution of the exchange rate relative to the GDP deflator. There was also a lifetime cap. The payment structure, as a result, was not only complex but the coupon amounts were divorced from the state of the economy. In the event, the path of GDP exceeded the "base case" by a long way, implying that Argentina had to make high payments even in years when the economy was performing only moderately.

Box B. Argentina's experience with GDP warrants
Research Department, Central Bank of Argentina

Argentina defaulted on $82bn of sovereign debt in December 2001, after three years of negative growth (and a 20% fall in GDP per capita between 2000 and 2002) that ended in a devaluation of the peso and the abandonment of its hard currency peg against the US dollar in early 2002. In 2003, the country presented a debt-restructuring proposal to bondholders, which was rejected. In June 2004, the Argentine authorities made a second proposal, which was accepted by 76% of holders of the defaulted debt in June 2005. The exchange included 30-year "GDP warrants" that were attached, for a period of 180 days, to the three varieties of new bonds that were offered to investors (Par, Discount and Quasi-Par), and then they detached, and began to trade independently. They had no principal and instead acted as series of standalone, state-contingent coupons.

Payment structure
The GDP warrants were issued in different currencies and jurisdictions for a total notional amount of $62bn in 2005 (76% of the $82bn of eligible debt). The warrants promise to pay out if the following three conditions are met:

i. For the reference year, actual real GDP must exceed Base Case real GDP. This was a threshold for GDP measured in constant terms (1993 pesos). The reference year is the year before the one in which payments occur. It is also the year on the basis of which payments are calculated. Base Case real GDP over the lifetime of the warrant is defined in advance by a projected path set by the authorities (**Chart B1**).
ii. For the reference year, annual growth in actual real GDP must exceed the growth rate in Base Case GDP for this year. This growth rate was set at 4.3% for 2005, declining after, reaching a constant 3% from 2015 to 2034.
iii. Total cumulative payments made on the GDP warrant should not exceed the payment cap for

that security of 48 cents per dollar of notional amount.

If at least one of these three conditions is not met, the warrants pay nothing. If they are met, the warrants pay 5% of "excess GDP", defined as the difference between actual real GDP and Base Case real GDP, converted to nominal pesos. This 5%, called "available excess GDP," is calculated as follows: Available Excess GDP = (0.05 x Excess GDP) x unit of currency coefficient.

Context

Warrants were included in a context where creditors were arguing that Argentina was not negotiating in good faith. Argentina's official position was that the long term real GDP growth was close to 3% per year. Creditors meanwhile argued that trend real GDP was nearer 4.5%, implying the sovereign had greater payment capacity than it was acknowledging, and that haircuts were larger than necessary to re-establish fiscal solvency. In an attempt to demonstrate good faith, Argentina offered payments contingent on higher GDP.

Pricing

The instrument was new, difficult to value and the "novelty premium" turned out to be high. Ahead of the exchange, the warrant was valued around $2 (per 100 units) by most of the research that circulated among investors. For the first 180 days, the price of the warrant could not be directly measured because it was still attached to the underlying bond. The first quotes of the security after the holding period were around $4.8 per 100 units. Most recently they have been trading around $8-12 (**Chart B2** and **Table B1**).[7]

Lessons

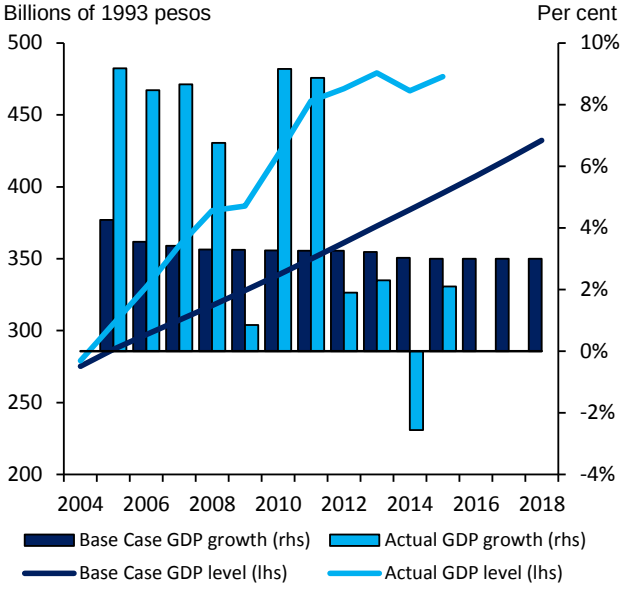
For Argentina's warrants, which are still trading, there is a lag of 350 days between the reference date when the payment is calculated and the effective date of payment. A lag of this length reduces the warrant's counter-cyclical properties. In 2009, against the backdrop of an international financial crisis, Argentina made relatively large payments of 0.42% of GDP on its GDP warrants. This effect was compounded by the fact that the baseline scenario for computing payments underestimated growth.

Since the warrants pay out only when growth is above 3%, this introduces an important payment discontinuity. A growth rate of 3.1% could result in a large payment, while growth of 2.9% would result in none. This discontinuity fuelled price volatility. The complexity of the derivative instrument with different strike prices for determining the contingency of payment and for computing the payoff made the instrument difficult to price.

On 28 June, 2016, Argentina's Ministry of Finance announced an offer to buy back the warrants from existing holders in a voluntary debt exchange.

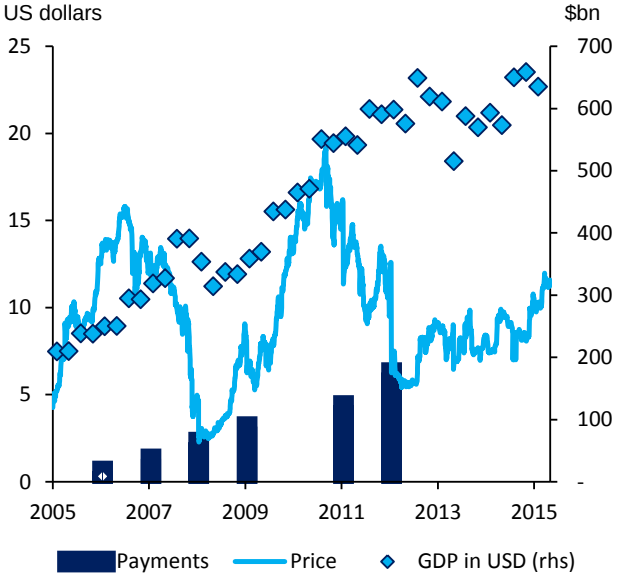
[7] Volatility in pricing, while stemming in large part from uncertainties around whether or not payment conditions would be triggered, could also have reflected more general difficulties in estimating a future path based on theoretical models or past GDP performance, especially for a small and volatile economy like Argentina's. This could also, in principle, be significant for advanced economies at times of heightened growth uncertainty.

Chart B1: Argentina's actual real GDP and Base Case real GDP as defined in its GDP warrant



Source: Banco Central de la República Argentina.

Chart B2: GDP warrant price history, payments and quarterly GDP



Source: Banco Central de la República Argentina. Notes: Prices and payments are expressed per 100 units. GDP is quarterly.

Table B1. Payment history for Argentina's GDP warrants

Year	Payment per 100 units	Payment, $mn	Payment, % of GDP
2006	0.62	396.3	0.17
2007	1.32	814.8	0.28
2008	2.28	1,322.5	0.36
2009	3.17	1,409.8	0.42
2010	-	-	-
2011	4.38	2,476.3	0.47
2012	6.27	3,534.1	0.61
2013	-		-
2014	-		-
2015	-		-
Total	*18.04*	*9,953.7*	*2.31*

Notes: Note: Payment per unit corresponds to GDP warrants issued in US dollars under New York Law. Accumulated total payments as % of GDP are expressed in terms of GDP of 2015.

V. Impediments to issuance and take-up

Given that the theoretical case for GDP-linked bonds appears strong, a natural question to ask is, Why do they not exist already?

A commonly cited concern is that GDP is difficult to measure, with estimates that are prone to revision, re-basing, and in extreme cases manipulation. Borensztein and Mauro (2004), Council of Economic Advisers (2004), Griffith-Jones and Sharma (2006) and Brooke et al (2013) suggest that

these concerns are surmountable. Revisions can be addressed by linking repayments to lagged data (a six month' lag should be suitable in most cases) which incorporate one or two revisions; after this, subsequent revisions would have no effect on the coupon and principal payments of the GDP-linked bonds.

Rebasing and method-of-calculation changes can be dealt with by requiring governments or outside agencies to keep separate GDP series based on the old method (so that payments are based on a "notional" series rather than the actual one). Manipulation, arguably, will be addressed by the market—those countries that cannot demonstrate data-credibility will be charged a higher yield. However, as a backstop, a clause in the instrument's contract could be included outlining a set of "put events", one of which could be the issuer ceasing to meet IMF data quality standards (Special Data Dissemination Standards), which would trigger early redemption.

Questions over how payments should be structured—for instance, whether they should be linked to the level or rate of growth of GDP, and whether just the coupon should be linked or the principal too—have seldom in the past been raised by investors as being critical impediments to take-up (Griffin, 2013). However, if illiquidity is to be avoided in any nascent market, answers to these questions require further convergence of thought among both potential issuers and investors. Some progress has been made in this direction recently by a working group including private sector representatives from both the legal profession and financial markets, convened in 2015 to draft up a model contract, or "term sheet", for a GDP-linked bond.

The two canonical models of GDP-linked bonds are Shiller's (1993) original version which indexes both the coupon and the principal to the level of nominal GDP, and Borensztein and Mauro's (2004) later variant which links just the coupon to the growth rate with the principal remaining fixed. The recently drafted *London Term Sheet* follows Shiller's (1993) payment structure.

The *London Term Sheet* includes a collective action clause (twin-limb) and schema for dealing with cross-default (no cross default with conventional bonds), but further iteration of these may be required to satisfy market participants and legal experts in key issuance centres. For instance, where a debt restructuring is needed, there may be a question over whether conventional debt (subjected to a haircut) could be in the same collective-action-clause pool as GDP-linked bonds (which provides debt relief through lower state-contingent payments). If separate pools are used, this could imply a subordination of conventional debt with possible pricing implications.

Other concerns include whether GDP-linked bonds might reduce the stock of "safe assets" (conventional government bonds) in the international monetary and financial system. There are two effects here. For a given default risk, indexed bonds are more risky than conventional debt. However, if they act to reduce default risk, GDP-linked bonds may make remaining conventional "safe assets" safer.

Another concern is whether GDP-linked bonds could be particularly prone to herd behaviour among investors, amplifying rather than damping government debt cycles. On the surface evidence from mutual funds suggests herding is no worse for equity-like instruments than it is for debt (IMF, 2015).

Herding does tend to be worse in markets where information is thin (Bikhchandani et al, 1992), but for GDP-linked bonds, so long as concerns around data manipulation can be addressed, this is less likely to be a problem since growth forecasts and commentary on them are freely available.

There may also be concerns that GDP-linked bonds could end up with retail investors whose risk preferences are ill-suited to them. The instruments discussed in this paper may be most suitable for and targeted at sophisticated wholesale investors who understand the risks involved. Even so, investors may require educating through outreach programmes.

Issuance and acceptance of GDP-linked bonds is also hampered by a collective action problem. The first country to introduce these instruments is likely to have to pay the greatest premium. The more countries that issue, the lower the premium and the greater the diversification benefits to potential investors. One way to overcome this collective action problem, as Brooke et al (2013) suggest, would be for a group of interested sovereigns to coordinate their issuance, enhancing the development of market infrastructure and standards.

A related concern is illiquidity. As with any new security, an important initial challenge would be to establish sufficient liquidity so that GDP-linked bonds can be actively traded and investors do not exact a large "novelty" premium from issuers. Standardised contractual terms, from the outset, would help reduce this premium.

VII. Potential next steps

Term sheet

In the past, it has been argued that many of the potential concerns over GDP-linked bonds could be addressed by drafting a sample term sheet setting out the basic features of a GDP-linked bond, clarifying exactly how each concern would be dealt with in practice. The *London Term Sheet* now offers a first step in this direction. It is well placed to be iterated on further including, for example, through engagement with the relevant investor trade bodies such as the International Capital Market Association, the Institute of International Finance and the Emerging Markets Trade Association.

There is precedent on how countries could best come together to further map out the term sheet and other issues. For sovereign CACs, a small working group led by the US and IMF and involving legal, market and official sector participants in both key issuance centres of London and New York, initially led discussions on drafting the new contractual language in 2013. Key priorities were legal and market acceptability, which were secured in large part through engagement, at an early stage, with the International Capital Market Association (the ICMA). In late 2014, the G20 gave its endorsement to the new CACs. Shortly after this, a number of emerging market issuers, including Mexico, issued international bonds including the clauses.

A similar approach could be adopted for GDP-linked bonds, taking the *London Term Sheet* as a starting point and iterating further with a similar roll call of working group participants that led on CACs, with support from the IMF. Key areas of work, focused on the investors side, could include

(i) drafting up a companion version of the term-sheet in New York and domestic law; (ii) exploring the sensitivity of GDP-linked bonds to data-revisions and establishing confidence in the mechanism to deal with them; (iii) identifying natural investors for the instruments and refining the term-sheet to ensure it is sufficiently tailored to meet their needs and identifying other steps (such as potential inclusion of bonds in indices) that would support the liquidity of the instrument.

Article IVs and debt sustainability analysis

As described in this paper, some sovereigns are likely to benefit more from issuance of GDP-linked debt than others, and ultimately any decision on how to include GDP-linked bonds in a sovereign's capital structure would need a careful cost-benefit analysis. The IMF would be well placed to provide assistance and thought leadership here. Once an assessment of the role of the instruments in sovereigns' capital structure had been made that would be a natural platform to give advice to sovereigns, through Article IVs assessments for example, on the scale of the gains that could be obtained from issuance.

When countries go to the IMF for exceptional access financing, particularly in cases where the IMF's Executive Board require a restructuring of the outstanding debt stock, this could be a natural point to engineer a wholesale re-shaping of a sovereigns' capital structure. Experience with GDP-linked warrants points to the desirability of much simpler instruments, such as the GDP-linked bond described in this paper. Again the Fund would be well placed to offer thought leadership here given their special role and experience in debt restructurings.

It was regulatory incentives that helped kick-start a market for contingent convertible debt (CoCos) for banks at the end of the first decade of the 2000s. For GDP-linked bonds, similar incentives could be provided by international official institutions with, for instance, the IMF amending its debt sustainability analysis framework to make clear, for example through stress testing, the benefits offered through GDP-linked, or other forms of stage-contingent, debt.

Further research

A further possible action would be to commission research on the pricing of GDP-linked bonds. While history shows that a formal pricing model is not prerequisite for a financial market to operate, a model (or better, a set of rival models) could be beneficial for guiding investors and sovereigns on new issues. Another area warranting further work is the non-linear dynamics in the cost of borrowing for conventional debt. We expect GDP-linked debt to be particularly effective near the point where these effects start to take hold. While we have looked quantitatively at the suitability of GDP-linked bonds for advanced and emerging market sovereigns, further work could be done on their relevance for riskier emerging markets and less industrialised countries (LICs).

VIII. Conclusions

While this paper has weighed up some of the pros and cons of GDP-linked bonds, there is more work to be done on gauging operational viability and possible ways forward. We have suggested four practical next steps.

First, there is scope to build on the work that has been done already on a draft term sheet. Further engagement with the private sector will be needed to identify the likely investor base for such instruments and, given that, to refine the structure.

Second, it would be useful to have a set of guidelines outlining under what circumstances GDP-linked bonds are most beneficial to a sovereign issuer outside of a restructuring. The IMF may be in a position to assist here: its Article IV assessments offer a natural platform to give advice to sovereigns on the scale of the gains that could be to be obtained from issuance.

Third, a set of principles for use of GDP-linked debt as part of an exchange in debt restructurings could usefully be assembled. Lessons are available to be drawn here from past experience with GDP-linked warrants. Again the IMF would be well placed to play a leadership role here, given their special role and experience in debt restructurings.

Fourth, it is important to understand better issues around pricing. If there is no intersection between what issuers are willing to pay and what investors expect to receive, then there will be no market for these bonds, however good the macroeconomic case. Key here is establishing the circumstance where GDP-linked issuance is likely to support the price of remaining conventional debt securities.

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Annex I. GDP-linked bonds: payment structure

The payment structure of GDP-linked bonds plays an important role in determining how much insurance the issuer would receive, how it would receive it (eg, whether the stock of debt repayments or the flow is insured, or both), and whether or not the instrument would be both attractive and acceptable (not running counter to restrictions on investment mandates) to investors.

The main proposed payment structures envisage that the coupon and/or the redemption value is indexed to GDP of the issuing country. Indexing the redemption value ensures the debt-to-GDP ratio is stabilised in the face of GDP shocks. Indexing the coupon stabilises interest costs. Typically it is proposed that indexation is in local currency, to align better with the sovereign's tax revenues and repayment capacity. Indexing to GDP growth rather than its level results in more variable repayments and requires payment floors for when growth drops below zero. Indexing to nominal GDP, rather than real, provides the investor with additional protection against inflation.

Borensztein and Mauro (2004) propose indexing the coupon to real GDP growth, with the principal remaining fixed. Shiller (2009) suggests that both the coupon and the principal should be indexed to the level of nominal GDP, similar in structure to inflation linked bonds. This paper uses the Shiller design, outlined below, as the basis for its numerical examples and simulations.

Principal and coupon indexed to the level of nominal GDP

Assume that the bond's principal and coupon are indexed to the level of nominal GDP, in local currency, such that the annual coupon payment and redemption value in year *t*, per 100 face value, given a coupon of *c* per cent, evolve according to the following formula (ignoring any indexation lag that we might want to include in practice):

$$coupon_t = c * 100 * GDP_t / GDP_0$$

$$redemption_t = 100 * GDP_t / GDP_0$$

For example, consider a GDP-linked bond issued on 15 April 2016 with coupon of 0.1 per cent and a maturity date of 16 April 2026. Assume the base level of nominal GDP is 105 and GDP in 2026 is 160, the final coupon and principal repayment per 100 face value will be:

$$coupon_t = 0.001 * 100 * 160 / 105 = 0.15$$

$$redemption_t = 100 * 160 / 105 = 152.4$$

Further considerations

Because many countries have long-run nominal GDP growth rates that are high relative to government bond yields, a debt instrument whose redemption values are indexed to nominal GDP would provide an attractive expected return to investors through the higher redemption value alone, even with a very low (or zero) coupon. There is a question over whether some investors would prefer more of the expected return to come from the coupon. Issuers might prefer the same, in as much as it may help smooth cash flows.

Various technical devices could be employed to shift the expected return from redemption to coupon. The *London Term Sheet* proposes a "principal factor", a simple scalar, which adjusts the redemption amount downwards at maturity by some amount defined at issue. Similarly, a "growth factor" can be incorporated. Another alternative is to issue bonds with both a generous approach to indexing the principal and a high coupon, but with the issue price well above par.

Growth factor

The final Redemption Amount payable by the Issuer on the Maturity Date shall be determined in accordance with the following formula:

Redemption Amount = Principal Amount x Index Ratio

Where the Index Ratio, rounded to the nearest 5th decimal place, for a given date is defined as the ratio of the Reference GDP applicable to that date ("Ref GDP $_{Date}$") divided by the Reference GDP applicable to the first issue date of the instrument ("Ref GDP $_{Issue}$"), minus an amount defined in the formula below that incorporates a Growth Factor, such that:

$$Index\ Ratio_{Date} = \frac{Ref\ GDP_{Date}}{Ref\ GDP_{Issue}} - \left(1 + \frac{Growth\ Factor}{365}\right)^{Days}$$