GDP-linked bonds: design, effects, and way forward

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Abstract
GDP-linked bonds have been proposed as a tool to help avoid sovereign defaults and debt restructurings. This article discusses potential advantages underlying the issuance of such an instrument, namely by quantifying the potential benefits that might arise when a country goes through periods of low growth rates and may face difficulties in meeting its financial commitments. The estimates suggest that there are potential benefits in terms of interest expenses. We simulate the correlation between primary balances and GDP growth in two scenarios: one with debt indexation to GDP growth and another one without such mechanism. As expected, the correlation between these two variables is significantly higher with indexation, suggesting that GDP-linked bonds could leave more room for automatic stabilizers to work during recessions. We run a similar exercise, but now considering a scenario where a country has to comply with a fiscal rule, and the main results are consistent. After establishing these facts, we examine recent issuances of GDP-linked bonds and discuss their limitations and weaknesses. This is crucial to understand what needs to be improved in the design of GDP-linked bonds to make them a universally used instrument.
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Introduction

Sovereign debt restructurings have long been a concern both for investors and researchers. Most restructurings occur after sovereign default episodes and may have harmful consequences on the domestic economy and on the financial sector, leading to extended periods of exclusion from capital markets (Trebesch et al. 2012, Cruces and Trebesch 2013). While these concerns have been historically more focused on emerging market economies, the euro area sovereign debt crisis reignited this debate.

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Against this background, discussions on the issuance of GDP-linked bonds have been recently in the spotlight.[1] The most prominent feature of a GDP-linked bond is the indexation of its coupon rate (or even its principal) to the issuer country's GDP growth rate, so that the security's cash flow payments would reflect the evolution of GDP.

This debt instrument could play an important role in helping to avoid solvency crises by, *inter alia*, providing countries with a form of insurance against downturns. It could, therefore, reduce the probability of defaults, debt restructurings and their associated costs. By avoiding high debt levels, it would decrease servicing costs and increase countries' fiscal space, allowing for less procyclical fiscal policies.

Researchers have been discussing GDP-indexed bonds since the 1990s and instruments with growth performance indexation features have already been issued (for instance by Costa Rica, Bulgaria, Bosnia Herzegovina, Singapore, and more recently by Argentina, Greece and Ukraine). However, this type of issuance is still considered an exception and it has not accomplished its full potential as an instrument that could play an important role in helping countries to avoid solvency crises and better risk sharing with private creditors.

This article begins by reviewing the existing literature on GDP-linked bonds. Then we describe the design of GDP-linked bonds, discussing how coupons could be determined. Afterwards we discuss the fiscal effects of GDP-linked bonds. We run three complementary exercises.

First, we try to quantify the potential fiscal benefits of issuing GDP-linked bonds, anchoring our estimates on previous work by Borensztein and Mauro (2004). To do so, we estimate the potential savings or expenses with interest for euro area countries between 2000 and 2015, assuming these countries had issued GDP-indexed bonds throughout the entire period. We also look separately into the potential effects for the countries at the core of the euro area sovereign debt crisis and for the other euro area countries.

Second, we estimate how much additional room countries would have had to pursue less procyclical fiscal policies. This is achieved by calculating, for the period between 2000 and 2015, the correlation between primary balances and GDP growth rates in two scenarios: with conventional bonds and introducing GDP-linked bonds. In the latter case, an "adjusted primary balance" is estimated considering the new interest amounts stemming from the introduction of the new instrument. We run these estimates separately for emerging market and advanced economies.

1. The G20, in the G20 Finance Ministers and Central Bank Governors Meeting of 24 July 2016, recognized that fiscal policy and fiscal strategies are essential in supporting growth. As such, G20 members, in that meeting's communiqué, called for "further analysis of the technicalities, opportunities, and challenges of state-contingent debt instruments, including GDP-linked bonds (…)" (G20 2016).

Finally, we run an exercise that resembles the previous one, but adding one additional feature. Specifically, we run our simulations considering boundaries on fiscal policies, such as those imposed by the Stability and Growth Pact. We run this exercise for France, Spain and Portugal.

All these partial equilibrium estimates rely on a strong set of necessary simplifying assumptions. All estimates should thus be considered as an upper bound on the potential benefits of GDP-linked bonds.

Before concluding, we summarize evidence on previous issuances of GDP-linked instruments and we discuss barriers to the implementation of such a product and possible solutions to overcome them.

Literature review

The international debt crisis in the 1980s led many governments to fail their legal obligation to meet debt repayments, in particular in Latin America and Eastern Europe. Ever since, there has been an interest in finding instruments that improve risk-sharing arrangements between governments and investors, allowing for a reduction of sovereign default probabilities and their corresponding costs. In this context, proposals for innovative financial products began to emerge, including the suggestion of indexing debt repayments to macroeconomic variables such as GDP, exports or commodity prices. As an example, Krugman (1988), in an attempt to solve the trade-off between debt forgiveness and financing, suggested that linking payments to measures of economic conditions could benefit both debtors and creditors.

Nevertheless, to understand better the importance of these types of instruments, it is crucial to describe the broader context in which they assume relevance. Debt restructurings are triggered by a default episode on debt commitments or by a debt-restructuring announcement. This is often when governments start negotiations with creditors, in order to agree on the terms of a debt exchange, providing debtors with debt relief. These debt restructuring processes are described as lengthy, costly and complex, most notably when compared to private sector processes (Bedford et al., 2005, Trebesch et al., 2012, Brooke et al., 2013). According to Forni et al. (2016), sovereign debt restructurings with external private creditors can, in fact, affect per capita GDP growth in the years after a restructuring.

In this context and given the frequency of financial crises, particularly in emerging economies, several authors have suggested ways to reduce inefficiencies of debt restructurings and their costs. For instance, Eichengreen (2003) discusses different approaches to this problem, presenting three main possible reforms: i) maintaining the *status quo*, while promoting the development of more complete and efficient debt agreements – a "contractual approach", falling under the currently used collective action clauses (CAC); ii) a "legislative approach" that would provide some of the functions of an

international mechanism of insolvency; and finally iii) the establishment of a fully-fledged international bankruptcy court. The author suggests that those with reservations about these approaches would want alternatives, such as new forms of debt indexed to countries' real growth rate of their own GDP.

Research on GDP-linked bonds dates back to the early 1990s, with a proposal from Shiller (1993), who defends a market for long-term claims on the major aggregate income flows: GDP, occupational income, and service flows from commercial and residential real estate. Furthermore, he argues that instruments whose payments are linked to GDP could help reduce country risk and promote welfare.

One of the most studied advantages of GDP-indexed bonds is its ability to keep the debt/GDP ratio within a narrower range than conventional bonds. As a consequence, these bonds could play a role in preventing future debt crises, representing a way for countries to self-insure against possible growth downturns (Borensztein and Mauro, 2004). In this vein, Carnot and Summer (2017) investigate the reduction in uncertainty when issuing a fraction of public debt through GDP-linked bonds. Using the European Commission Debt Sustainability Monitor framework, the authors evaluate the impact on debt trajectories in the short and longer term. Their results indicate "important potential benefits" from the issuance of this instrument for all European countries, being especially relevant for economies with medium-to-high debt, high macroeconomic volatility and limited tools to smoothen shocks.

Cabrillac et al. (2017) estimate the possible gains for GDP-linked bonds´ issuers and conclude that the debt-to-GDP ratio would be reduced by 15% on average for a 25-year horizon for the 95th percentiles – the 5% least favorable simulated debt paths by 2040. They also defend that the volatility of the investors' portfolio would potentially decrease by 12% on average given the investment of such an instrument instead of investing in equities.

Interacting with the "debt/GDP ratio" effect is the fiscal margin that this product gives to countries to reduce the need to conduct pro-cyclical fiscal policies (Borensztein and Mauro, 2004, Blanchard et al., 2016). Borensztein and Mauro (2004) also investigate the particularly important benefits for countries that belong to economic monetary unions. Carnot and Summer (2017) consider the role of this instrument when monetary policy imperfectly responds to domestic shocks. Blanchard et al. (2016) argue that the introduction of GDP-linked could represent a "partial market-based solution to attain valuable insurance benefits" for euro area countries, ahead of a fiscal union.

Barr et al. (2014) develop a model of endogenous sovereign default, in which they analyze how GDP-linked bonds can raise the maximum sustainable debt level of a government and reduce the incidence of defaults. They use the concept of fiscal fatigue and standard debt dynamics equations to estimate debt limits, which will then be essential to model sovereign default with conventional and GDP-linked bonds. Under different risk aversion

scenarios, the introduction of this security would increase the debt-limit level. In spite of this, investors demand a premium for providing insurance against GDP volatility. As the debt/GDP ratio increases, this specific cost gets overturned because the default premium increases accordingly.

There is also some research on the pricing of GDP-linked bonds. Borensztein and Mauro (2004) conclude that the insurance premium, that is the risk premium for holding bonds indexed to GDP to compensate investors for GDP volatility, would be small. Chamon and Mauro (2006) introduce the risk of default into their model. Firstly, they extract different combinations of probabilities of default and recovery rates from observed yields. Then, using the Monte Carlo framework, they simulate several paths for economic variables, including the debt/GDP ratio. Afterwards, they obtain a default trigger for the debt/GDP ratio and recovery rate that would yield the expected repayments implicit in the spreads. Finally, using the debt/GDP ratio default trigger and the simulated paths for the economic variables, they compute the corresponding payoff for both the growth-indexed bonds and the standard plain-vanilla bonds. The authors conclude that GDP-indexed debt can lower default frequency. When the share of this type of debt increases, both plain-vanilla and growth-linked bonds become less sensitive to GDP volatility and to growth shocks. Miyajima (2006) evaluates GDP-linked warrants (GLWs) considering the issuer's repayment capacity in the pricing formula. The author estimates the expected cash flows of debt payments, assuming that GDP follows a stochastic model, while trigger conditions are also modeled using the Monte Carlo framework. The issuer's capacity to service debt is defined as the difference between the incremental payments of GLWs and the increases in tax revenues due to economic growth. Finally, the author also uses the capital asset pricing model (CAPM) to calculate the size of the indexation premium, also finding it to be low.

Kamstra and Shiller (2009) estimate a risk premium of "only" 1.5 %. This estimate relies on the CAPM to calculate the cost of capital "relevant to issuing Trills" (a security with a coupon indexed to the United States' current dollar GDP, that would pay, for example, one trillionth of the GDP). They also defend that the maturity of this security would be long term, preferably perpetual. They consider that this new instrument would perform an important role as a stabilizer of the public budget.

Broadly speaking, GDP-indexed bonds, as put out by the International Monetary Fund (2017) when analyzing the economic case for state-contingent debt instruments for sovereigns, have the potential to "enhance policy space for sovereigns in bad states of the world, offer diversification opportunities to investors, and generate ancillary benefits for other economic agents and the broader system". Nevertheless, the institution recognizes some possible complications that, for some countries, may outweigh the benefits.

Sharma and Griffith-Jones (2006) also discuss the benefits of introducing GDP-linked bonds for borrowing countries, investors, the global economy and

the financial system, while presenting the main concerns, issues and obstacles to their implementation. They also summarize recent experiences with these types of bonds, explaining their major flaws. Finally, in a similar vein to Borensztein and Mauro (2004) and IMF (2017), the authors defend the support of the official sector to help develop a specific market, suggesting several steps towards to this end.

Finally, sovereign equity-like instruments with some GDP-indexed features have already been issued. However, this type of issuance referred to warrants, attached to and often inseparable from an underlying bond and done in the context of debt restructurings. Benford et al. (2016) distinguish between potential GDP-linked bonds' issuances in normal and in debt restructuring times, with different benefits for issuers. During normal times they would help in preventing solvency crises, giving more fiscal space in downturns. In restructurings, this instrument would allow transferring higher debt repayments to periods when the economy is recovering.

The design of GDP-linked bonds: the coupon formula

The specific feature of a GDP-linked bond is the indexation of its coupon rate to the issuer country's GDP growth rate, so that the security's cash flow payments would reflect the evolution of GDP. In other words, the debt redemption's value would reflect the country's growth performance. If a government only issues this type of bond, all of its debt payments will change in line with growth. A GDP-linked bond coupon rate would equal:

$$coupon_t = \max(r + (g_t - \overline{g}); 0) \tag{1}$$

In order for the coupon rate to reflect the evolution of the GDP growth rate, an indexation factor, which would correspond to the difference between the observed growth rate (g_t) and a baseline growth rate ($\overline{g}$), would be added to the baseline coupon rate (r), thus linking coupon payments to economic performance.[2] This baseline growth rate, to be agreed at the moment of the contract, would reflect a trend growth rate and would adjust the economic performance of the year t to a period of growth of sufficient length. As such, if the economy in year t grows above the baseline growth rate, the indexation factor would be positive and the coupon rate would be higher than the baseline coupon rate. If the economy grows below the baseline, the indexation factor would be negative and the coupon rate would be lower than r. Finally, in order to protect investors from periods of particularly weak economic

2. For simplicity and in order to avoid another layer of risk, only the coupon rate – and not the principal – is adjusted. For further details, see for instance Borensztein and Mauro (2004).

performance – when, by adjusting the baseline coupon rate to a sufficiently negative indexation factor, the coupon rate would be negative – and thus also avoiding disincentives to investments in this kind of performance-linked security, a minimum of 0 would be applied to the coupon rate formula.

Therefore, the indexation of a bond to a country's economic performance would give governments a certain degree of insurance against periods of low growth rates. The magnitude of this protection would depend on the maturity of the bond and on the sensitiviness of coupon payments to growth. According to Barr et al. (2004), GDP-linked bonds with longer maturities offer sovereigns a better hedge against lower trend growth.

Fiscal effects of GDP-linked bonds

In order to quantify the insurance effect and to understand other potential fiscal benefits of GDP-linked bonds, a set of scenarios is presented, following some of the exercises laid out by Borensztein and Mauro (2004). We begin by estimating interest bill savings or expenses for euro area countries, should they have issued GDP-indexed bonds. Afterwards we run two exercises to estimate how much additional room countries would have had to pursue less procyclical fiscal policies: first we run a general exercise for advanced and emerging market economies; second we introduce fiscal constraints, running similar simulations but now assuming that there is a fiscal deficit limit of 3% of GDP (we run these estimations for France, Spain and Portugal).

We collect data from the IMF on the GDP real growth rate, on primary and overall balances as a percentage of GDP, on gross interest expenses as a percentage of GDP and on general government gross debt, also as a percentage of GDP.

Interest bill savings/expense

This first exercise is an attempt, through a simple approach, to illustrate how GDP-indexed bonds could affect a sovereign's interest bill. Following Borensztein and Mauro (2004), we consider a floating-rate bond with a coupon rate that follows a country's economic performance.

In this context, using equation 1, we simulate a new coupon rate and, accordingly, the amount of interest savings (or expenses) accumulated (or incurred). Underlying these simulations is the hypothesis that since the beginning of 1999 all the government debt of euro area countries consisted of GDP-linked bonds. It is also assumed that the new coupon rate and interest bill would have no impact on other variables, such as GDP, total deficit or debt, which, although unrealistic, could provide a measure of the expected potential amount of interest savings or expenses. Moreover, the baseline growth rate used corresponds to the average growth rate in the period 1992-2015, which

should be long enough to provide a representative figure of the growth trend of a country.

As regards GDP growth, we use data in real terms, i.e. adjusted for inflation effects. It is true that indexing to GDP in nominal terms (as suggested by Benford et al. (2016)) would protect investors also from inflation fluctuations. However, it seems more prudent to spare both investors and issuers of another layer of complexity and risk, focusing solely on the countercyclical potential effect of real GDP-linked bonds.

As such, the actual implicit coupon rate is computed as the ratio of gross interest expenses of year *t* to the average of that same year's debt and the one of year *t-1*. However, it should be noted that this ratio does not consider that the actual debt stock also includes other instruments (such as currency and deposits and loans) and, more importantly, bonds issued in the past, under different market conditions. Also, one should take into account that countries that were under financial assistance were excluded from the bond market, leading to a less meaningful coupon rate. Finally, it is possible that GDP-linked bonds could have an additional risk premium, which is not considered in these estimates. All in all, these simplifying assumptions should make us cautious in interpreting the results, which should be regarded as the maximum savings awarded by this instrument.

The difference between each year's GDP growth rate and the baseline growth rate is added (or subtracted) to the coupon rate and the maximum of the adjusted coupon rate and 0 is computed. The new interest amount can thus be determined by applying the new coupon rate to the average of year *t* and year *t-1* debt.

In Figure 1 we present the results obtained for euro area countries, for the period between 2000 and 2015. The baseline growth rate of GDP considered in the exercises is 1.49%. Using equation 1, if euro area countries had issued GDP linked bonds throughout this period, they would have paid an average coupon rate of 4.34%. This is actually quite similar to the average coupon rates observed during this period (4.37%). As such, the aggregate savings on interest paid during this period would be negligible (0.13% of GDP).

However, these aggregate effects for the whole period hide important differences over time. Our estimates show that euro area countries would have been able to pay significantly less interest in 2008-2009 and in 2012-2013. This would have been compensated by higher interest expenses in several years, notably 2000, 2006 and 2007. This clearly illustrates the countercyclical mechanism embedded in GDP-linked bonds. Governments would have paid less interest in recessions, while paying more in periods of robust growth.

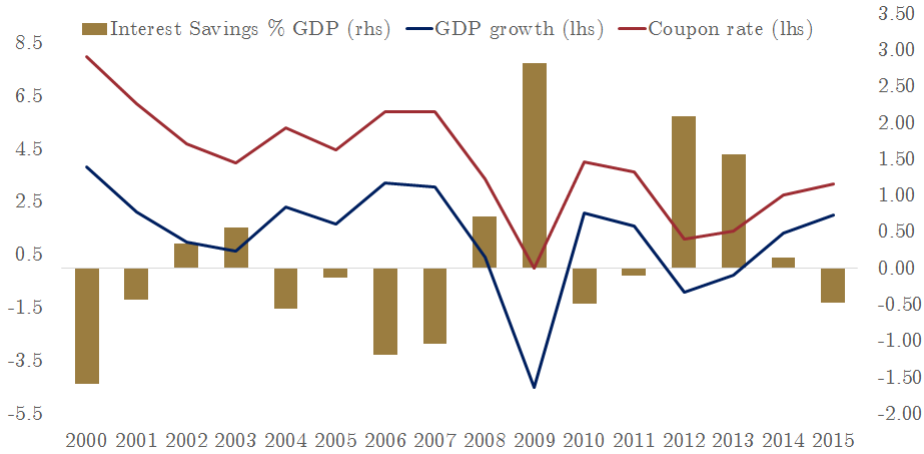

FIGURE 1: Interest savings as a % of GDP - Euro area

Source: IMF and authors' calculations.

Beyond the differences over time, it might also be interesting to consider differences between euro area member states. In Figures 2 and 3 we present the results of the same simulation exercise for two groups of euro area countries: those most affected by the sovereign debt crisis (Greece, Ireland, Italy, Portugal and Spain), and the remaining ones. The differences are striking.

For the crisis countries, the average coupon rate would have been 4.09%, significantly below the effective 4.35% observed during this period. This would entail savings with interest close to 0.3% of GDP. These savings would have been concentrated in the crisis years (2008-2014). In all the other years in the period under analysis, these countries would have paid more interest on their debt. [3]

For the remaining euro area countries, the pattern is much more irregular (Figure 3). There would have been interest savings in 2002-2003, 2008-2009 and 2012-2015. However, these are generally compensated by additional interest expenses in other years. The average coupon rate would have been 3.81%, only slightly below the observed average coupon of 3.91%. This would entail savings of 0.09% of GDP, i.e., one third of those potentially achieved by the crisis countries. These results suggest that GDP-linked bonds can generate interest savings even for advanced economies. However, given the caveats discussed above coming from the assumptions underlying this exercise (including the absence of a risk premium for these bonds), it is possible

3. We should note that the larger interest expenses for 2015 reflect to a large extent the strong economic recovery recorded by Ireland in this specific year.

that these benefits would be much smaller (or inexistent) in a more realistic scenario. As mentioned before, all these estimates are anchored on a set of simplifying assumptions that require some caution in their interpretation. To some extent, these numbers represent an upper bound to the potential interest savings achieved with GDP-linked bonds, for these countries, in this period.

One important assumption that can be relaxed is the inexistence of a risk premium attached to GDP-linked bonds (Benford et al., 2016). There is a lot of uncertainty on what this risk premium for euro area countries could be, most notably considering that at least initially there could be a novelty and a liquidity premium. We use the estimates provided by Kamstra and Shiller (2009) and re-estimate interest savings/expenses using a risk premium of 150 basis points. The average interest savings for the entire period would decrease from 0.13 to 0.08% of GDP in the euro area (from 0.30 to 0.22% in the GIIPS countries and from 0.09 to 0.05% of GDP in the other countries). Still, even with a 150 basis points risk premium, GDP-linked bonds could potentially yield interest savings across the board.

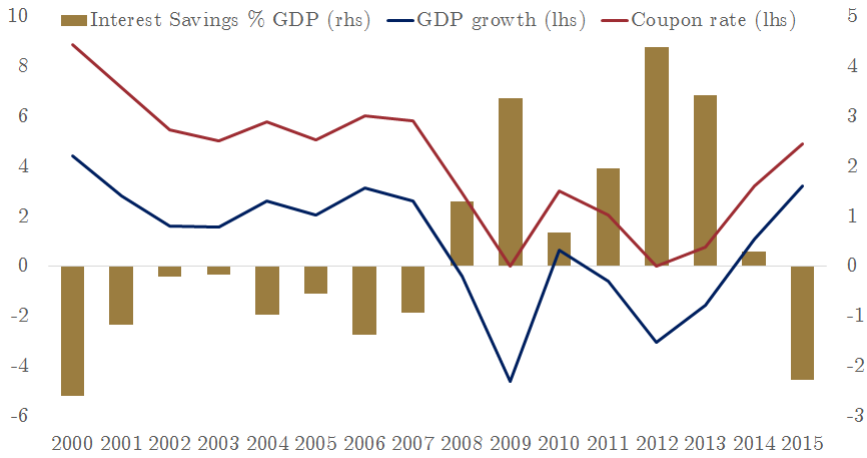

FIGURE 2: Interest savings as a % of GDP - Euro area crisis countries

Source: IMF and authors' calculations.

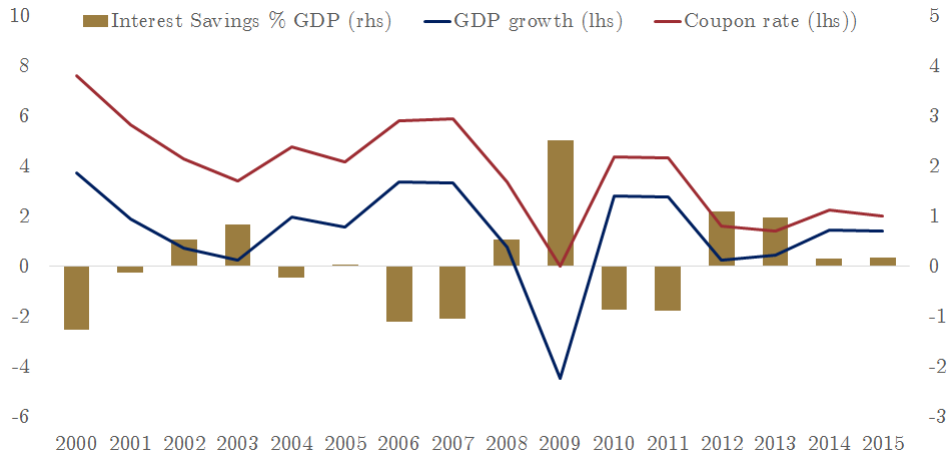

FIGURE 3: Interest savings as a % of GDP - Euro area non-crisis countries

Source: IMF and authors' calculations.

Generally, these results reinforce the conclusions of Borensztein and Mauro (2004), showing that when the GDP growth rate is below the baseline growth rate, the government generates interest savings with GDP-linked bonds. This would give room for pursuing policies that would result in a lower primary surplus (higher spending and/or lower taxes). It could also allow countries, in particular those that are following a short-term fiscal adjustment path, to achieve their fiscal goals faster. This would have been especially true for the countries at the core of the euro area sovereign debt crises, which underwent strong fiscal adjustments in order to regain market access. GDP-indexed bonds would thus provide countries with more fiscal space in times of crisis (allowing more room for the typical automatic stabilizers to work, without jeopardizing fiscal sustainability), while providing disciplinary mechanisms in times of growth (Brooke et al., 2013).

Fiscal policy

Mitigating procyclical fiscal measures. To better illustrate the countercyclical potential of GDP-linked bonds on fiscal policy, we replicate another exercise of Borensztein and Mauro (2004). The goal of this exercise is to explicitly quantify how much additional room would countries have had for countercyclical fiscal policy if their debt had been indexed to GDP. This is calculated by simulating the primary surplus that would have been obtained if all of a country's debt had been indexed to GDP growth. For that purpose, it was assumed that the total deficit/surplus, debt paths and economic growth would be the same as observed. It is thus assumed that, *ceteris paribus*, the interest savings or expenses stemming from the issuance of GDP-linked bonds

would have a direct and proportional impact on the fiscal policy and thus on the primary balance. Other effects of a different fiscal policy, such as those relating to economic growth or risk premia, are not considered. These are of course very strong assumptions. While they are necessary to keep the simulations simple and tractable, they imply that these estimates are possibly not the same as those that would be obtained in a general equilibrium framework. We might thus interpret these estimates as an upper bound of the potential benefits of GDP-linked bonds.

We consider that in 1999 the entire debt stock had been indexed to GDP for 23 advanced countries and 15 emerging market countries.[4] The implicit interest rate is calculated as a ratio between the interest bill (taking gross interest expenses into consideration) and the average between the previous and the current year's debt stock. The "new interest rate" is simulated by applying equation (1) and adding the implicit interest rate to the "indexation factor", as previously described. The new interest amount is computed by multiplying that "new interest rate" by that year's debt. The baseline GDP growth rate corresponds to the geometric mean of the growth rates between 1980 and 2015.

The next step entails calculating the "adjusted primary balance", by using the new interest payments (maintaining the strong assumption that economic growth and fiscal variables are unaffected by the introduction of GDP-linked bonds). Finally, we compute the correlation between the simulated primary balance and the GDP growth rate. A positive and high correlation between these two variables can be interpreted as an indicator of a government's space to implement countercyclical fiscal policies. This correlation is compared to the correlation between the variables, but based on actual data. The results are reported in Table 1.

4. Advanced economies include Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, United Kingdom, and the United States. Emerging market economies include Argentina, Brazil, Bulgaria, Chile, Colombia, Hungary, Indonesia, Latvia, Lithuania, Morocco, People's Republic of China, Peru, Poland, South Africa, and Turkey.

	Emerging markets			Advanced economies		
	Without indexation	With indexation		Without indexation	With indexation	
		Full indexation	Partial indexation (30% of debt stock)		Full indexation	Partial indexation (30% of debt stock)
	(1)	(2)	(3)	(4)	(5)	(6)
Mean	0.43	0.67	0.56	0.50	0.74	0.61
Median	0.51	0.75	0.67	0.50	0.77	0.59

TABLE 1. Correlation between the primary balance and real GDP growth, 2000-2015
Source: IMF and authors' calculations.

In fact, and in line with the conclusions of Borensztein and Mauro (2004) for a quite different period, in Table 1 we see that the correlation between the primary balance and GDP growth would be significantly higher with indexation than without it (comparing columns 1 and 2 for emerging markets and columns 4 and 5 for advanced economies).

To further enhance the realism of our estimates, we consider an alternative scenario, where instead of assuming that all the debt stock is composed of GDP-linked bonds, we consider that only 30% of the debt stock would be composed of this instrument. The results are also displayed in Table 1 (columns 3 and 6) and show that the correlation would still be higher than without indexation (though of course smaller than with full indexation).

This stabilization effect of GDP-linked bonds can be considered an automatic tool given their immediate and countercyclical fiscal reaction to growth - giving room for the typical automatic stabilizers to work freely during downturns and upturns. It can be argued that GDP-linked bonds offer a symmetric fiscal adjustment. They allow the channeling of fiscal revenues to interest expenses in good times, thus reducing the risk of overheating and at the same time relieving governments from the pressure of interest payments in bad times. [5]

5. According to the IMF (2015), fiscal stabilization reduces the volatility of growth over the business cycle. The institution estimates a potential decrease of around 20% of overall growth volatility for advanced economies, stemming from the move from average to high fiscal stabilization and a reduction of around 5% in the case of emerging market and developing countries. This is particularly important considering that higher fiscal stabilization and thus a lower level of growth volatility results in higher medium-term growth: "an average

Introducing fiscal constraints. We implement one final exercise, once more along the lines of the work by Borensztein and Mauro (2004). The aim of this exercise is to illustrate the ability to mitigate the effects of pro-cyclical fiscal policies by using GDP-indexed bonds for countries that belong to currency unions, such as the euro area, where the Stability and Growth Pact imposes boundaries on fiscal policy.

In this context, the exercise assumes that France, Spain and Portugal would have fully complied with the 3% of GDP limit on the fiscal deficit during the whole period. This is artificially achieved by imposing this limit each time that it was exceeded in actual data. The mechanics of the exercise are then quite similar to the previous one. We calculate the implicit interest rate as a result of the ratio of current year gross interest to the average of the previous and current year debt stocks. For simplicity, we assume that there is no feedback from the different deficit and debt levels on the interest rate or on growth.[6] A new debt path is computed following equation (2). This allows us to consider an adjusted primary balance that takes into account the 3% of GDP deficit limit.

$$\frac{D_t}{Y_t} = (1 + r - g_t)\left(\frac{D_{t-1}}{Y_{t-1}}\right) - S_t \tag{2}$$

In this equation, D_t refers to the debt stock, Y_t is GDP, and S_t is the primary balance as a share of GDP.

Following those same paths for debt and total deficits, a new primary balance is computed, but now supposing that all the debt stock was indexed to GDP growth. For the three countries considered in the exercise, we compute the correlation between primary balance and growth in a combination of two scenarios: (i) with and without GDP growth indexation; (ii) with and without the Stability Growth Pact limit. The four possible combinations of these two scenarios are reported for each country in Table 2.

strengthening of fiscal stabilization – that is, an increase in the fiscal stabilization measure by one standard deviation in the sample – could on average boost annual growth rates by 0.1 percentage points in emerging economies and 0.3 percentage points in advanced economies".

6. Again, imposing these assumptions requires a cautious reading of the results. To fully capture all these effects, a general equilibrium approach would be necessary.

	France		Spain		Portugal	
	Without indexation	With indexation	Without indexation	With indexation	Without indexation	With indexation
Baseline estimates	0.63	0.82	0.92	0.96	0.17	0.66
With Stability and Growth Pact	0.51	0.87	0.78	0.90	-0.28	0.97

TABLE 2. Correlation between the primary balance and real GDP growth, 2000-2015

Source: IMF and authors' calculations.

When we compare the results with and without indexation, without imposing any limits on the deficit, the results obtained for France, Spain and Portugal are entirely consistent with those obtained for advanced and emerging economies in the previous exercise. The indexation of sovereign bonds to GDP significantly increases the correlation between primary balances and GDP growth. The largest increase is seen for Portugal, where this correlation is historically very low.

We can also gain some understanding about how fiscal boundaries within a currency union may limit the scope for countercyclical fiscal policy by comparing the results with and without the Stability and Growth Pact constraint. When we do so without indexing debt to GDP growth, we find that imposing a deficit limit of 3% of GDP would reduce a country's ability to conduct countercyclical fiscal policies, compared to the unrestricted baseline scenario. For France, applying this constraint would reduce the correlation between the primary balance and growth from 0.63 to 0.51, in the case of Spain from 0.92 to 0.78 and for Portugal, from 0.17 to -0.28. This is understandable, given that during downturns the possibility to increase the fiscal deficit (decreasing taxes and/or increasing expenditure) would be constrained.

Finally, we can quantify the benefits of indexation when the deficit constraint is active. We find that the correlation between primary balances and GDP growth is actually at its highest in this scenario for France and for Portugal (where this correlation actually reaches 0.97). However, for Spain, where the correlation is already quite high, there would be no apparent benefits from indexation in a scenario with fiscal constraints.[7] The benefits of GDP-linked bonds in terms of enhancing the space for countercyclical fiscal policies clearly depend on the starting point.

7. In the case of Spain, the indexation would entirely offset the procyclical effects imposed by the Stability and Growth Pact, according to our estimates.

It is important to note that all the exercises are anchored on assumptions that are necessary to conduct the simulations. However, these assumptions are specially strong in this third exercise, as both in the case of France and Portugal, the 3% GDP limit would have been binding for a large period of the sample (for Portugal it would have been biding throughout the entire sample period), making the comparison with the standard scenario more challenging.

Previous issuances, barriers to implementation and possible solutions

The introduction of GDP-linked bonds, as laid out in the previous sections, could be beneficial for borrowing countries. They could play an important role in avoiding solvency crises by, *inter alia*, increasing countries' fiscal space and allowing for countercyclical fiscal policies. As such, defaults, debt restructurings and their associated costs could be mitigated. Notwithstanding these advantages, the fact is that the issuance of instruments with these characteristics is considered an exception and has not been common on financial markets (Cabrillac et al. 2017). In this section we summarize evidence on previous issuances and discuss their shortcomings and barriers to implementation.

Previous issuances of sovereign's equity-like instruments

As the literature about equity-like instruments has been evolving, the issuance of this kind of products has also been somewhat progressing. In the end 1980s, as part of its debt relief within the "Brady Plan", Mexico pursued a debt-equity conversion program under which creditors (in this case, commercial banks) would be entitled to receive oil revenues owned by the country if its price exceeded a certain amount.[8] Also within the Brady Plan, other countries, such as Venezuela, Nigeria or Uruguay, have issued similar equity-like instruments. Later in the 1990s, and still part of the same plan, other countries such as Costa Rica and Bulgaria issued bonds for sovereign funding purposes, whose repayment was indexed to GDP, i.e. its payoff increased if GDP (or GDP per capita) of those issuing countries rose above a certain

8. The Brady Plan was announced in 1989 by US Secretary of Treasury, Nicholas Brady, in the context of the developing countries' debt crisis in the 1980s, which led some of them to default. As such, countries were settling rescheduling agreements with commercial banks, but without haircuts. The Plan, which was later (financially) supported by the IMF and the World Bank, consisted of debt reduction programs as a contribution to solving the above-mentioned crisis. The Brady Plan foresaw (i) exchange of outstanding bank loans into new sovereign bonds, partially collateralized by US Treasury bonds; (ii) a range of options of new instruments, such as discount bonds with a reduction in the face value, and par bonds with long maturities and below-market interest rates but no debt reduction and (iii) capitalization of interest in arrears to commercial banks into new short-term floating rates (Trebesch et al. 2012).

threshold. There are other examples of GDP-linked warrants' issuance, such as Bosnia Herzegovina and Singapore and more recently by Argentina, Greece and Ukraine.[9] The characteristics of some of those issues are summarized in the Appendix.

Overall, these issuances were mainly done in the context of debt restructurings, attached to (and often inseparable from) a conventional bond. Furthermore, their indexation formulas and conditions have usually been exceedingly complex, lacking standardization and clarity on the underlying reference data, as in the case of Bulgaria. In the case of Argentina, for example, as put out by Benford et al. (2016), the 350-day time lag between the reference (when payment is calculated) and payment date reduces the countercyclical effect and also suffers from great complexity. As such, despite all the apparent advantages of GDP-linked bonds described and quantified in this article, this instrument has rarely been used.

Barriers to implementation and possible solutions

There are important obstacles to the implementation and operationalization of GDP-linked bonds that explain why this instrument is not widely used, despite its conceptual advantages.

The main concern regards GDP data, in particular inaccuracies in its measurement and constant revisions (both due to revisions and updates in the underlying information and in methodologies), as discussed by Cecchetti and Schoenholtz (2017). The possibility of misreporting is also an important consideration. Indeed, data transparency and integrity is crucial from the investor point of view. In this context, increased independence of statistical agencies and technical support from international institutions could be decisive in guaranteeing the reliability of data, the accomplishment of statistical standards and in conveying credibility to investors. The risk of reporting manipulated data, however, seems somewhat contained by eventual reputational effects to the issuing sovereign. According to Borensztein and Mauro (2004), politicians' re-elections are supported by high growth rates, and thus it would not be reasonable to report, at least for several years, understated growth rates. Concerning data revisions, several authors suggest similar solutions to overcome this obstacle (Borensztein and Mauro, 2004, Sharma and Griffith-Jones, 2006, Brooke et al., 2013). The most important would be establishing ex ante (i.e. in the bond contract) the reference period for GDP data. Benford et al. (2016) suggest a six-month lag, but Cecchetti and Schoenholtz (2017) consider this period "inadequate". In any case, this lag

9. Portugal has issued a debt instrument called Treasury Certificates Savings Growth. This debt instrument is sold mainly to retail savers and part of its remuneration is indexed to GDP growth, thus having some features of a GDP-linked bond.

period should be long enough to have more accurate/precise estimations, but not so long so that the countercyclical effect would be lost.

Another obstacle is the absence of such market for these instruments and the corresponding concern with sufficient liquidity. According to Sharma and Griffith-Jones (2006), markets could be illiquid for this type of relatively new instrument. In this vein, and in line with these authors, there may be the need for a coordinated approach of several borrowers and institutions. This coordination should be both in terms of timing of issuance and conditions, following a standard design.

Moreover, it is arguable that such a new product, with an additional layer of complexity when compared to a plain vanilla bond, would be difficult to price, thus alienating investors. A possible way to overcome this obstacle could be by designing a simple and standard instrument, while having the technical support in pricing such a product.

Finally, as defended by Sharma and Griffith-Jones (2006), there could also be a moral hazard effect. Since higher GDP growth leads to higher interest payments, governments could have less incentive to implement policies to foster growth. This, however, as the risk of data manipulation, does not seem likely in the sense that lower growth would cost politicians both credibility and popularity. The IMF (2017) also mentions potential adverse selection problems coming from the fact that the countries which anticipate more negative macroeconomic scenarios might be the ones who are more eager to issue these instruments, thus raising their premia.

Given the solutions to the obstacles presented above, it is clear that international institutions could play a crucial role in overcoming them, namely by giving statistical support, monitoring data integrity, or using its published data as a reference. They could also help in designing a GDP-linked bond prototype, which could act as a standard model, and use its technical knowledge to enhance pricing. Their role, however, could be pushed even further. Sharma and Griffith-Jones (2006) argue that multilateral or regional development institutions could develop a portfolio of loans, whose repayments would be linked to the debtor country growth rate. These loans could be then securitized and sold on the international financial markets. International institutions already play an important role by giving financial assistance to countries. As such, when a country loses access to financial markets and needs financing from an international institution, this could be an opportunity for the country to sell to the institution GDP-linked bonds and for the institution to build the above mentioned loan portfolio. These financial assistance programs are accompanied by a reform package that, in principle, would increase potential growth. This does not preclude, however, the above-mentioned coordinated approach (in which these institutions could take a leading role). International institutions could also have a coordination role by, *inter alia*, guaranteeing that a sufficient volume of GDP-linked bonds is issued in order to reduce the liquidity premium (Cabrillac et al. 2017)

and gathering a group of issuer countries that would allow to eliminate any potential reputational risk associated to countries with higher debt levels.

A recent noteworthy initiative to foster the GDP-linked bonds market is the London Term Sheet. This document describes in detail a template for the issuance of GDP-linked bonds, thus promoting the standardization of this product. This tool was developed by an ad hoc working group consisting of investment managers, lawyers from the private sector and economists from the Bank of England. This might provide the grounds for a standardized and transparent approach, with a direct involvement from the public sector.

Concluding remarks

Researchers have been discussing GDP-linked bonds since the 1990s and some sovereign equity-like instruments have been issued. However, this type of issuance is still considered an exception and has not, by far, accomplished its full potential as an instrument that could play an important role in helping countries to avoid solvency crises.

Theoretically, indexing a country's debt payments to its economic performance could give governments a certain degree of insurance against periods of low growth rates. As such, this article is an attempt to illustrate the potential advantages of the issuance of GDP-linked bonds, building up on previous work by Borensztein and Mauro (2004). Through three simulation exercises relying on a set of simplifying assumptions, we illustrated and quantified this insurance effect.

In a partial equilibrium analysis and relying on a set of assumptions, we show that the interest bill savings for the euro area countries at the core of the sovereign debt crisis could have been significant if they had issued GDP-linked bonds. These savings could have created room for less pro-cyclical fiscal policies, without jeopardizing fiscal sustainability. At the same time, interest bill expenses would have been higher during growth periods, thus contributing (albeit marginally) to promote a disciplining device to avoid excessive public spending during these periods.

Moreover, we find that the correlation between primary balance and real GDP growth is substantially larger when GDP linked bonds are used. This is true both for advanced economies and emerging markets.

These results should be read without forgetting the caveats and limitations of the simulation exercises conducted. For instance, the calculation of the (implicit) coupon rate (as a ratio of interests paid and the debt stock) does not take into account that the actual debt stock also includes other instruments (such as currency and deposits and loans). Furthermore, all the exercises hinge on the assumption that changes in some fiscal variables (e.g. interest amount) would not affect economic growth and other fiscal aggregates. Most of the exercises abstract from the existence of a risk premium that should be attached

to these bonds. While these assumptions are necessary to keep calculations simple and intuitive, they necessarily imply caution in the interpretation of the results and of the policy implications.

That said, our results reinforce a vast literature illustrating the potential benefits of GDP-linked bonds. In this article we also discuss the main barriers to implementation and potential remedies to address them. These barriers are not unsurmountable and the recent interest from scholars and policymakers may offer the necessary solutions to widen the use of these instruments worldwide.

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Appendix. Characteristics of bonds with GDP-indexed features issued so far

Issuer country	Main features
Bulgaria[1]	- As a consequence of Bulgaria's (external) debt crisis. - In 1994 Bulgaria signed a Brady contract for the reduction and restructuring of its debt. - Within the restructuring deal there was a clause for recovery of the value and payment was triggered if: (a) current GDP was equal or higher than 125% of GDP in 1993 and (b) there was a GDP increase compared to the previous year. - If those conditions were met, the extra interest rate would be half of the GDP percentage increase (paid in the addition to the underlying plain vanilla coupon). - According to (Miyajima 2006) the source of reference data and GDP measurement units is "ambiguous" and the corresponding term sheet is not clear in the units of measurement. - These warrants were 'callable' and were inseparable from the plain vanilla bonds.
Bosnia and Herzegovina[2]	- In the sequence of the war in Bosnia (1992-1995) that, among other disastrous consequences, led to a significant fall in GDP. The country inherited a legacy of disadvantageous conditions from Yugoslavia, among which, (partially) a considerable high external debt. - In 1997 an agreement on the debt restructuring was achieved and a GDP-performance bond was "settled". - According to (Miyajima 2006) payment on these GDP-warrants would be triggered if: (a) GDP would hit a predetermined target level and would remain at such level for two years and (b) GDP per capita would rise above US$2.80 in 1997 units, adjusted for German consumer price inflation - Also according to the same author, this instrument suffered from poor design and low quality data. - As the Bulgarian GDP-linked warrants (GLWs), were also inseparable from the plain vanilla bonds.
Singapore[3]	- Issuance to low-income citizens of two sets of shares linking payments to GDP-growth (neither tradable nor transferable and could be exchanged only for cash with the government). - The first share – the New Singapore Shares (NSS) – was introduced in 2011 with the purpose of helping the lower-income group during economic downturns. - It consists of annual dividends (on outstanding balances) in the form of bonus shares with a guaranteed 3% minimum rate. An extra dividend, when applicable, corresponds to the real GDP growth rate (if positive) of the previous year.

[1] (Pirian 2003), (Miyajima 2006).

[2] (Stumpf 2010), (Miyajima 2006).

[3] (Government of Singapore - Ministry of Finance 2008), (Miyajima 2006).

	- The second share – the Economic Restructuring Shares (ERS) – was issued with the aim of subsidizing citizens given the Goods and Services Tax increase from 3% to 5%. - Calculation of bonuses is similar to the one of NSS.
Argentina[4]	- Following a period of a severe economic and financial crisis, Argentina defaulted on its sovereign debt obligations by US$82 billion. - After a period of hard negotiations with bondholders of the defaulted debt, in 2005 a debt restructuring was accepted by 76% of them, leading to a bond exchange of US$62 billion in principal. - It included 30-year GLWs that were attached, for a period of 180 days, to the new bonds. - GLWs had no principal and, after the above-mentioned period, could act as "series of standalone, state-contingent coupons". - These instruments were issued in different countries and currencies. - The GLWs would pay annually 5% of excess GDP (defined as the difference between actual real GDP and Base Case real GDP, converted to nominal pesos[5]) if all the following conditions were to be met: (a) actual GDP, expressed in constant peso terms as of the reference date (the year before the one in which payments occur) exceeds the Base Case GDP; (b) the annual growth rates of actual GDP, expressed in constant peso terms as of the reference date, also exceed the Base Case GDP for that year. The growth rate was set at 4.3% for 2005, declining thereafter, reaching 3% from 2015 to 2034; and (c) total cumulative payments should not exceed a payment limit of 48 cents per dollar of notional amount.
Greece[6]	- The Greek sovereign debt crisis led to the 2012 debt restructuring, which included a debt relief of over 50% of that year's GDP. - Within the restructuring package, the new bonds included a set of detachable GDP-linked securities, which could yield an increase in the coupon of up to 1%[7] if (a) nominal GDP in the previous year equals or exceeds the Reference Nominal GDP; (b) real GDP growth equals or exceeds the Reference Real GDP Growth Rate; (c) real GDP growth equals or exceeds 0. - The warrants have a face value, which first equals the face value of the new bond and is reduced by about 5% per year from 2024 to 2042. The principal is used to determine the annual payments, i.e., holders are not entitled to receive it. - The warrants are callable from 2020 on, based on a trailing 30-day market price.

[4] (Benford et al. 2016), (Miyajima 2006).

[5] Excess GDP =(0.05 Excess GDP) x unit of currency coefficient.

[6] (Zettelmeyer et al. 2013).

[7] Payment amount = ⌊1.5 (Real GDP Growth Rate – Reference Real GDP Growth Rate)⌋ x Notional