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Discovering the GDP-Linked Bonds

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Dissertation presented as partial requirement for obtaining the Master's degree in Statistics and Information Management

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DISCOVERING THE GDP-LINKED BONDS

by

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ABSTRACT

Over the years, economies have been hit by several financial crisis which led to high debt ratios. One solution that has been studied by economists to help governments to stabilize their debt-to-GDP ratio are GDP-linked bonds, which are sovereign bonds that pay a return based on the performance of the gross domestic product of the issuer country.

In this context, this dissertation will address the advantages and disadvantages of GDP-linked bonds that have been discussed in literature as well as the different types of these instruments. Additionally, it will be simulated the coupon indexation to GDP, according to the methodology applied by Borensztein & Mauro (2004), for Portugal, Italy and Greece, which were three of the European countries with the highest levels of debt, in percentage of GDP, during the last months of 2020. Moreover, these results will be compared with 10Y government bonds for each country.

As expected, the results show that in times of financial crisis, GDP-linked bonds could be an attractive solution for financing debt for governments when compared to plain vanilla bonds. Thus, it is possible to conclude that one of the main advantages for the issuer country is the possibility to reduce the cost in case of sovereign default and also a more stable and foreseeable fiscal policy (Barr, Bush, & Pienkowski, 2014b). On the other side, investors have the possibility to benefit from higher interest rates when the economy of the country is improving.

Following the same methodology, it was performed a sensitive analysis on the parameter related to the baseline GDP which was first set on a 20-year average with respect to each reference year and increased and decreased by 5 years.

Finally, although this simulation was only performed for the three European countries mentioned above, which makes it difficult to generalize the results for the remaining European countries, it can contribute for the results of future studies.

Keywords: GDP Linked Bonds; payment structure; premium; sovereign debt

RESUMO

Ao longo dos anos, as economias de todo o mundo têm sido atingidas por várias crises financeiras que conduziram a altos níveis de endividamento. Assim, uma solução que tem vindo a ser estudada para ajudar os países a estabilizar o seu rácio entre dívida e Produto Interno Bruto (PIB) são as obrigações indexadas ao seu PIB, as quais dependem da performance do produto interno do país emitente.

Neste contexto, esta dissertação irá abordar as vantagens e desvantagens da implementação de obrigações indexadas ao PIB que têm vindo a ser estudadas por diversos autores, bem como os diferentes tipos destes instrumentos. Adicionalmente, seguindo a metodologia de Borensztein & Mauro (2004), é simulado o cupão indexado ao PIB para Portugal, Itália e Grécia, os quais eram três dos países europeus com maior dívida pública, em percentagem do PIB, no final do ano de 2020. Adicionalmente, estes resultados são comparados com os cupões das obrigações a 10 anos do respetivo país.

Como esperado, os resultados demonstram que em tempos de crise financeira, quando comparados às obrigações "plain vanilla", as obrigações indexadas ao PIB podem ser um instrumento atrativo para financiar a dívida dos países. Uma das principais vantagens deste tipo de instrumentos, para o país emitente, é a possibilidade de reduzir custos em caso de default e ainda a possibilidade de uma política fiscal mais estável e previsível (Barr, Bush, & Pienkowski, 2014). Por outro lado, os investidores têm a possibilidade de beneficiar de taxas de juros mais elevadas quando a economia do país fortalece.

Assim, seguindo a metodologia aplicada anteriormente realizou-se ainda uma análise de sensibilidade aplicada a um dos parâmetros utilizado na simulação do cupão, nomeadamente ao "baseline GDP", o qual se fez variar 5 anos.

Por fim, apesar de a simulação ter sido apenas realizada para três países europeus e consequentemente tornar difícil a generalização dos seus resultados aos restantes países europeus, poderá contribuir para resultados de estudos futuros

Keywords: Obrigações indexadas ao PIB; Estrutura de pagamento; prémio; dívida soberana

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LIST OF ABBREVIATIONS AND ACRONYMS

bps: Basis points

ILBs: Inflation-linked bonds

IMF: International Monetary Fund

GDP: Gross Domestic Product

GLBs: GDP-linked bonds

PIB: Produto Interno Bruto

SCDIs: State-Contingent Debt Instruments

1. INTRODUCTION

Since the global crisis of 2008 that affected economies worldwide, the issue of restructuring sovereign debt has become, once again, a concern not only for the countries but also market participants (Trebesch et al., 2012). Over the years, financial crises have led to very high sovereign debt ratios on both advanced and emerging countries (Kim & Ostry, 2019). Moreover, should be noticed that most restructurings occur after episodes of default and may lead to undesirable consequences on a country's economy and financial sector as well as to extended periods of exclusion from capital markets (Bonfim & Pereira, 2018). Hence, the way debt is structure has gained more attention, since it influences the regularity of crisis and has implications when hits the economies (Borensztein & Mauro, 2004). One possible solution that has been analyzed by economists are GDP-linked bonds which links the debt of a country to its capacity to pay for the same, ending up acting like an automatic stabilizer which could help reduce the need for procyclical fiscal policies.

According to the International Monetary Fund (IMF), the main purpose of these type of instruments is to help preserve the policy space in moments of "stress", however it presents benefits not only for the issuer country, but also for the investor. On investors' perspective, investing in GDP-linked bonds (hereafter, GLBs) will create new diversification opportunities for their portfolio since it will have a direct link to the economy. Furthermore, this diversification can be increased by including GLBs issued by different countries. On the other hand, on the sovereign's side, there is the possibility to stabilize the debt and reduce the uncertainty related to future debt payments and increase the budget flexibility on the short run. Moreover, when the bonds are hold by foreign investors, it will result in sharing the risk cross border. Finally, it can beneficiate the fiscal policy by making it more predictable and stable (Barr, Bush, & Pienkowski, 2014).

GDP-linked bonds have already been issued as part of debt restructuring processes and additionally, as part of the Brady restructuring program, for example, some countries such as Argentina (in 2005), Greece (in 2012) and Ukraine (in 2015) issued securities with similar characteristics (Bowman & Naylor, 2016). Nevertheless, there are also some challenges and obstacles to the implementation where it is included the importance of defining how the instruments are priced since it can influence the premium requested by investors. This thesis begins by reviewing what is highlighted above and describing some models that have been studied on how to price these instruments, which include Black-Scholes type pricing model, using a single-factor stochastic model when GDP follows a log-normal distribution and interest rates are deterministic (developed by Kruse et al. (2005)); pricing mechanism based on Monte Carlo methods (by Miyajima (2006)), which was calibrated to different sets of parameter values to get projected flow of debt payments and the price of securities and also dividend-discounting method in order to estimate prices and yields (by Kamstra and Shiller (2009)). Nonetheless, there are also two main approaches on how the payments of the GLBs should be structure, if only the coupon should be linked to the growth rate of GDP or if the principal should be included too.

This thesis has as main objective to address the advantages and disadvantages of GLBs that have been discussed in literature as well as the different types of these instruments. Additionally, it is simulated the coupon indexation to GDP, according to the methodology applied by Borensztein & Mauro (2004), for three European countries with the highest levels of debt during the last months of 2020 and compared the results with 10-year government bonds.

To achieve what is mentioned above, it was collected data regarding the real GDP growth, considering the annual percentage change, from the World Economic outlook published by the International Monetary Fund, for the period of 1980-2020, as well as data regarding annual data of 10Y government bond yields for each of the countries analyzed from the Federal Reserve Bank of St. Louis. Following the data collection, it was applied the coupon indexation methodology used by Borensztein & Mauro (2004) for Portugal, Italy and Greece, for the period between 2000 and 2020. In this formula, one of the variables considered is the baseline growth rate which is agreed between the contracting parties before the issue of the bond, which for simplicity reasons is considered to be the average of GDP growth rate of the previous 20 years. So, when the economy grows above this rate, the coupon rate will be higher than the 10y government bond coupon rate, and similarly, when the economy decreases below, the coupon rate will be lower but never below zero. Following the same methodology, it was performed a sensitive analysis on the parameter related to the baseline GDP which was increased and decreased by 5 years.

The results reached show that for the countries analyzed, the implementation of GDP-linked bonds could be beneficial since that in times of financial distress, such as the financial crisis of 2008 or the crisis caused by Covid-19, could be possible to lower the sovereign's payments obligations in the following years. On the other hand, when the economy is rapidly growing, the coupon payments will also be higher.

Borensztein & Mauro (2004) performed the coupon simulation for Mexico and Argentina where they also concluded that when economies grew over their 20-year average, they would have paid higher-than-average coupon rates and in times of economic crisis, such as the Tequila crisis, countries would have managed to decrease its coupon payments however, never below zero. Hence, we will see that the results reached in our simulation are in line with the results presented in literature.

Finally, conclusion is presented as well as the limitations of this study and recommendations for future research.

2. LITERATURE REVIEW ON GDP LINKED BONDS

2.1. Overview of State Contingent Debt Instruments

For a long time, almost 4000 years, i.e. since the times of Babylon, countries have been issuing public debt so they can finance their public expenditures. When the levels of debt get too large, part of this debt stock might be needed to pay down current debt obligations, which raises concerns regarding the possibility of the start of a self-feeding vicious cycle, in which the new debt to be issue will have higher interest rates and will subsequently increase the debt service. The country will only be able to stop this loop once it either manages to interrupt the debt spiral, by either growing at a higher level than its debt or increasing its primary balance, or by stopping payments to its bondholders for example (Bado, 2018).

Presently, most of the countries in the world are capable to issue public debt, nonetheless only the largest economies are able to issue debt in local currency on international markets. Bonds issued internationally usually take the form of fixed-rate bonds and have high maturities, while the composition of debt that is issued domestically will be different across countries. Although only a few emerging markets issued large amounts of fixed-rate bonds with a large maturity associated and in domestic currency, a little more have been relying on domestically issued alternatives to foreign currency debt, such as inflation-indexed debt, short-term debt and floating-interest rate debt (Borensztein et al., 2004).
Since countries are not able to issue shares, unlike companies, it will issue a debt instrument which is able to reflect the ability of the sovereign to pay its payment obligations. This type of instruments is known as "state-contingent debt instruments" (SDCIs) and is defined as being debt instruments whose payoff is linked to pre-defined state variables, such as price indexes, inflation or crude oil, or linked to trigger events and is designated to reduce the pressure on countries indebtedness (Novikova et al., 2017).

2.1.1. Equity Component

Equity and debt are the two basic categories of financing tools in corporate history.
The stability of future income as well as the phase of which the company is in its life cycle, can be determinant when choosing between the amount of debt and equity to finance the company. In early stages of the cycle, companies have higher grow opportunities and consequently a bigger uncertainty regarding future cash flows nonetheless they can rely on the equity component to finance themselves. This type of instrument offers the possibility to make contractual obligations more flexible or lower the payments without suffer legal consequences.
In this context, if we think about countries, more specifically advanced economies, these will follow a more stable growth and consequently will find easier to raise funds to finance themselves when compared to emerging economies. However, as mentioned earlier, while corporations are able to issue shares and consequently this will be a way for investors to take control over decisions, this is not an option for countries, since they cannot be owned by investors (Bado, 2018).

2.1.2. Indexing to inflation

Linking the principal amount of debt to the variation in consumer price level is an idea that have been studied for the last couple of centuries and a few countries have already had the opportunity to issue this type of instrument. According to Eduardo Borensztein et al. (2005), it does not appear to exist an association between the characteristics of a country and the introduction of inflation-linked bonds (ILBs). As per the authors, indexed debt has been issued by both advanced and emerging economies. United Kingdom, Brazil and Israel are some examples of countries that have issued these instruments in high inflation periods, unlike United States, Sweden or Canada which have begun to issue ILBs during low inflation periods (see appendices 1).
While the value of nominal bonds is determined by variations in real interest rates and inflation expectations, the value of ILBs is only impacted when real interest rates oscillate. Therefore, if expectations regarding inflation remain constant, the returns of these two types of bonds will be only affected by changes in inflation expectations. Following this, if inflation expectation rises, ILBs will outperform nominal bonds, as well as if expectation decreases, ILBs performance will also be lower (Credit Suisse).

2.1.3. Indexing to GDP

Economies all over the world have been impacted by financial crisis over the years, which led several economists to focus their attention on GLBs in more recent years. Nevertheless, the concept of indexing debt to gross domestic product is not new, since it first emerged in the 1980s. Robert Shiller (1993), Eduardo Borensztein and Paolo Mauro (2004) and Griffith-Jones and Sharma (2006) are some of the economists that have supported and studied these financial instruments.

GDP-linked bonds are sovereign bonds that pay an interest rate based on the performance of the gross domestic product of the issuer country. This instrument can help stabilize the debt-GDP ratio since the coupons that will be paid to the investor oscillate positively with the level of the gross domestic product of the country (Barr et al., 2014).

Hence, when the economy is improving, investors will have the possibility to benefit from higher interest rates, contrarily to when the economy is weaker. In this last case, the value of the coupon will be lower and thus, the debt servicing cost. This mechanism can be viewed as an "insurance" against recession, since it will make the country less likely to enter into default (Barr et al., 2014).

2.2. Advantages of GDP-Linked Bonds

Borensztein and Mauro (2004) are among the authors that discuss in their paper the major benefits of this type of instrument. Firstly, it is argued that it helps reducing the likelihood of crisis and the need for procyclical policies, since GLBs act as an "automatic stabilizer" type mechanism. Although, it is mentioned that this can be very beneficial for emerging markets, the authors defend that this can also be promising for advanced economies. If a country falls in a path of weak growth, the smaller increases in debt/GDP ratio providing from indexation could lead to a smaller likelihood of default and debt crisis, which normally imply high costs in terms of financial sector distress, increase of unemployment

and further drop in the gross domestic product (Borensztein and Mauro, 2004). Moreover, it is referred benefits like being easier to maintain a smoother path for tax rates, and thus reducing the uncertainty related to consumption and investment (Bank of England, 2014) and the higher interest payments related to a higher growth of GDP that will reduce the likelihood of over-spend by governments. Thus, on the short run, GLBs could help to stabilize the debt and reduce the uncertainty related to future debt payments and increase the budget flexibility of sovereigns. On the other end, on the long-run, GDP-linked bonds could be beneficial in terms of solvency and resistance to shocks which, according to Carnot & Pamies Summer (2017) can be important to countries that belong to the Euro area.

Although the benefits above are mainly for the borrowing countries, there are also benefits for investors.

By investing in GLBs, investors would have the opportunity to diversify their portfolio and also take position on a country's future growth prospect (Griffith-Jones & Hertova, 2013). Although this might be already possible in a way through countries' stock markets, it is not representative of the country's economy as a whole, mainly in the case of emerging markets according to Borensztein and Mauro (2004). Furthermore, since growth rates tend to be quite uncorrelated this would also enhance diversification benefits for investors. Lastly, another benefit mentioned in literature is the lower frequency of defaults and financial crisis, which frequently lead to costly litigation/renegotiation and occasionally to large losses (Griffith-Jones & Sharma, 2016).

2.3. Obstacles and Limitations of GDP Linked Bonds

Nevertheless, as mentioned earlier, there are some concerns regarding the issue of this securities. According to Stephany Griffith-Jones and Dagmar Hertova (2013) one potential problem is moral hazard, since governments might report inferior numbers of GDP, when the same is higher than usual. Moreover, since sometimes there are some adjustments to the reported GDP, it could be necessary to define a formula that measures GDP on contracts in order to incorporate those revisions.

In Cecchetti and Schoenholtz's (2017) opinion, the biggest obstacle is also related to the computation of the GDP index itself mainly because, as said above, governments could disclose underestimated values of the nominal GDP and also due to data revisions. Nonetheless, in Boreinsztein and Mauro's (2004) opinion the concern with disclosure of underestimated values should not be overemphasized, since high growth is what is considered an achievement, instead of low growth, and it is what will have politicians re-elected. The authors also refer the fact that would be very complicated for a country to under report its GDP growth for several consecutive years. Secondly, concerning data revisions, this should also not be seen as an obstacle, as long as two conditions are met: an ex-ante established and clear method to deal with revisions and countries do not use revisions deliberately to cheat investors. The same authors would even recommend ignoring these revisions after a certain time, i.e., settle that coupon payments for date x, are based on GDP as estimated on date y.

Griffith-Jones and Sharma (2006) argue that it is difficult for investors to price instruments that might be illiquid and thus, it is necessary an effort to obtain market liquidity for the same. Furthermore, the authors mention that the premium charged by investors can also be a dissuasive factor for the issuer countries. Hence, there is a necessity for standardization, so all instruments have similar characteristics and it can facilitate the creation of a liquid secondary market. For example, countries with a more

volatile GDP, such as Greece, would be requested to pay a higher premium than countries with a lower one, such Germany (Milas, 2020).

Lastly, it might also have reputational impact since GLBs have been issued by countries coming out of sovereign-debt crisis, which can lead to an adverse market perception and consequently to an increase in volatility and funding costs (Cardoso, 2018).

2.4. PREVIOUS ISSUES OF GLBS

Until today, the use of GLBs and other State Contingent Debt Instruments (SCDIs) have been limited, since it usually corresponds to a complement of the existing portfolio of conventional debt instruments and it is often discontinued after some issuances (IMF, 2017).

Nonetheless, countries have issued securities with similarities to GLBs as part of debt restructuring programs, mainly as part of the Brady restructuring process that initiated in 1989. Some examples are Bulgaria, Bosnia and Costa Rica (in the mid-1990s), which issued bonds with attached GDP guarantee and included clauses to increase coupon payments at predetermined limits of GDP rather than in sync with gross domestic product (Kamstra & Shiller, 2009).

More recently, there is the case of Argentina (2005), Greece (2012) and Ukraine (2015) where sovereigns issued GDP-linked securities.

2.4.1. The case of Argentina

Looking at Argentina's example, in 2005, the government issued GDP-linked securities as part of its debt restructuring program. This issuance allowed to exchange USD 82 billion in bonds on which the sovereign had defaulted. In 2010, this type of securities was issued once again as part of the restructuring for creditors that have not accepted the first offering in 2005. Financial markets as well as the country's creditors did not see much value on GDP-linked securities, and consequently it represented a low gain for Argentina. Nonetheless, there was an unexpected GDP growth of the country (see figure 1) which led these securities to exceed expectations and therefore to an increase of their prices. These securities followed three conditions: first real GDP had to be higher than the base-case GDP; second real annual GDP growth had to be higher than the GDP base-case GDP growth and the threshold for real GDP growth begins at 4.26% and it progressively decreases to 3% and onward; finally, total payments are not higher than the payment cap, which was set at 0.48 per unit of currency of the security. Once these conditions are met, the payment will be as follows (Griffith-Jones & Hertova, 2013):

$$Payment = 0.05 \times excessGDP \times currencyCoefficient \times notionalGLS \quad (1)$$

Where "excessGDP" defines the amount by which actual GDP exceeds the base case GDP, "currencyCoefficient" the unit of currency coefficient and "notionalGLS" defines the notional value of GDP-linked securities. Due to the lag that exists in publishing GDP data, the payment based on the GDP performance in a given year is paid at the end of the following one.

Since Argentina experienced a rapidly grow in the years following the debt exchange, the base GDP level was exceeded early, resulting in high payments on the securities. The level of GDP is more probable to stay above the base level when there is a high early growth, and consequently this can

lead to an increase of future payments and its value which means that the value of the security will also increase.

For Argentina, the payments on the securities became very costly, rising from USD 395 million in 2006 to USD 3.5 billion at the end of the year of 2012, which represented more than 30 percent of the total amount of interest on public sector debt. Nonetheless, Argentina was able to pay around a third of its total GDP securities payments in the first seven years (Griffith-Jones & Hertova, 2013).

Figure 2: Argentina GDP Growth (annual % change) (1980-2012). Source: International Monetary Fund (IMF)

2.4.2. The case of Greece

In 2012, Greece issued GDP-linked securities, which corresponded to EUR 172 billion private debt, as part of its debt restructuring program. These securities offered an annual payment every year between 2015 and 2042 of an amount up to 1% of their notional if the conditions are met, more specifically if nominal GDP exceeds the reference real GDP and if GDP growth in real terms is positive and in excess of specified targets (Hellenic Ministry of Finance, 2012).

In the case that conditions are met, the government will make payments as follows:

$$Payment = 1.5 \times (realGDP - referenceGDP) \times notionalGLS \quad (2)$$

Where “realGDP” defines the real GDP growth rate, “referenceGDP” the reference real GDP growth rate, and “notionalGLS” equals the notional value of GDP-linked securities.

Similarly to Argentina, the payment based on growth of a certain year, will be made on the following year.

2.4.3. The case of Portugal

Also, Portugal issued treasury certificates with premium indexed to real GDP growth (Treasury Certificates Saving Plus (*Certificados do Tesouro Poupança Mais*) (CTPM)), in 2013, with maturity of 5 years and with premium linked to the real GDP growth in the final 2 years. In October 2017, Treasury Certificates Savings Growth (*Certificados do Tesouro Poupança Crescimento*) (CTPC) were also issued but this time with a final maturity of 7 years and the premium was indexed to 40% of real GDP growth rate since the second year. Both issuances were redeemable after 1 year and had a coupon floor equal to zero. However, the CTPC also included a cap equal to 1.2%.

2.5. Procyclical Fiscal Policy

GDP indexation of bond repayments could create a smoother path for primary surplus, primary spending and taxes over the cycle and thus, could be possible to reduce the necessity for sovereigns to carry out procyclical fiscal policies. So in the cases that GDP growth is inferior to the trend, the country will be able to have higher primary spending and lower taxes, (i.e., a lower primary surplus) with indexation than without it while in times when GDP is higher than the trend the opposite of the described will happen (Boreinsztein & Mauro, 2004).

To demonstrate what is mentioned above, the authors Eduardo Boreinszein and Paolo Mauro performed a small exercise for 20 advanced economies and 25 emerging economies, where they checked how much space would sovereigns have had for countercyclical fiscal policy if their debt had been indexed to GDP since the beginning of the 1990s. Following this, primary surplus with indexation between 1992 and 2001 was calculated and lastly, correlation between GDP growth and primary balance was computed. The authors found that correlation (which is a measure of the sovereigns' ability to conduct countercyclical fiscal policy) between the two variants would be significantly higher with indexation, than without it, and that it is more evident for emerging countries than for advanced countries.

Thus, by requiring a lower payment than usual in the years that the economy has a weak growth and a higher payment than usual when economy is stronger, GLBs would act as an automatic stabilizer and therefore would help countries to reduce their need for procyclical fiscal policies (Chamon & Mauro, 2006).

2.6. The design of GDP-Linked Bonds

Over the years, different types of models on how to price GLBs have been developed.

Kruse et al. (2005), for example, developed a Black-Scholes type pricing model, using a single-factor stochastic model when GDP follows a log-normal distribution and interest rates are deterministic. The authors developed this method with the objective to estimate returns on linked and plain bonds for Venezuela and Indonesia.

Miyajima (2006) developed a pricing mechanism based on Monte Carlo methods, which was calibrated to different sets of parameter values to get projected flow of debt payments and the price of securities.

Kamstra and Shiller (2009) follow a dividend-discounting method in order to estimate prices and yields for GLBs. On the other hand, Bowman and Naylor (2016), used the Capital Asset Pricing Model (CAPM) to get a range of premia for countries that belong to G20 (Consiglio and Zenios, 2018).

Two main approaches on how the payments of the GDP-linked bonds should be structure have been proposed over time: if only the coupon should be linked to the growth rate of GDP or if the principal should be included too (Benford, Best, Joy, & Kruger, 2016).

2.6.1. Principal-indexed Bonds

Schiller (1993) proposed the idea of creating long-term bonds indexed to sovereign debt, to what he named "the trills". The author argues that this idea would help reducing the risk of the issuer country and also, be a potential vehicle for retirement savings.

Based on this, Kamstra and Schiller (2009) developed the idea of Principal-indexed bonds, where principal grows with the nominal GDP over time while the coupon would be a fixed fraction of the principal. Principal would follow:

$$B_t = B_0 \times \frac{Y_t}{Y_0} \tag{3}$$

Where B_0 represents the amount issued, Y_0 and Y_t are the nominal GDP values at the issuing date and date t (Consiglio and Zenios, 2018). In this case, coupon payments satisfy the following expression:

$$(1 + c_0) \times B_t = (1 + c_0) \times B_0 \times \frac{Y_t}{Y_0} \tag{4}$$

being c_0 the baseline coupon.

Once all the coupon payments are made, at maturity t, B_t will be paid to bondholders as the principal reimbursement.

This type of payment structure created by Schiller (1993), which focus on the principal, can be more familiar to investors and governments, nonetheless has also a disadvantage to it which is the fact that even though debt becomes more stable, debt payments will become less sensible to recent economic performance over time, since the most recent growth rate will not impact the principal significantly (Bado, 2018).

2.6.2. Coupon-indexed bonds

Borensztein and Mauro (2004) proposed to link the coupon payments to the real growth of the GDP (Coupon-indexed bonds). In their model, the principal would stay fixed and the actual coupon rate would be:

$$Coupon_t = \max\left[r + (g_i - g^*), 0\right] \quad (5)$$

where r corresponds to the coupon rate, g_i to the actual growth rate of GDP and g* defines the baseline growth rate of GDP. So, for the coupon rate to reflect the performance of the GDP growth rate, it is necessary to consider an indexation factor, which will correspond to the difference between the actual growth rate and the baseline growth rate of the GDP, which will be added to the coupon rate.

This baseline growth rate is agreed between the contracting parties before the issue of the bond. So, when the economy grows above this rate (g*), the coupon rate will be higher than r, and similarly, when the economy decreases below g*, the coupon rate will be lower than r, but never below zero. This type of indexation method is referred as "floaters" by the IMF (2017).

On this indexation approach, the annual GLBs payments fluctuate more when compared to the Schiller version, since it allows a stronger linkage between recent economic performance and debt expense.

Cecchetti and Schoenholtz (2017) mentioned in their paper that the difference between GDP-principal-indexed bonds and GDP-coupon-payments is the timing of payments. In the first, the largest part of the compensation for nominal growth happens at maturity, while on the second it will come with the periodic payments. Consiglio and Zenios (2018) computed premium for both principal-indexed and coupon-indexed bonds with zero based coupon and compared the risk premia in which they observed that for the first ones there is a higher premium which difference can reach 200bp for high expected economic growth. Nonetheless, the results can be significantly impacted by the design parameters.

2.6.3. Premium

Although GLBs present benefits, these can be weakened by a high risk premium, when compared to conventional bonds. As mentioned by the European Commission (2017), as there is no historical precedent, value of risk premium is empirically unknown and consequently, the novelty and liquidity premium can be high initially however, it is likely to decrease over time as has already happen with inflation-linked bonds. According to the International Monetary Fund (2017), potential investors for this type of instruments believe that the creation of a well-defined and standardized instrument could help containing such premium.

Additionally, is referred the attempts on the literature related to estimate the growth risk premium, which is considered critical. For instance, Kamstra and Schiller (2009) have estimated a risk premium of 150 bps on a GLB for the US, in 2009, based on the capital asset pricing model. Also, although based on different model, Pienkowski (2017) reaches similar estimates for advanced economies.

Lastly, it is mentioned the default risk premium. With a significant issuance of GLBs, public debt would be more sustainable and a reduction in the default premium could be observed.

2.7. WOULD GDP-LINKED BONDS BE BENEFICIAL DURING THE CORONAVIRUS' PANDEMIC?

In March 2020, a pandemic was declared by the World Health Organization due to the spread of coronavirus, which has led economies into a severe contraction all over the world.

In response to this pandemic, most sovereigns have implemented fiscal stimulus programs which have conducted public debt to one of the highest levels in history (Roch and Roldán, 2021).

For Gallo and others (in Financial Times, 2020), this is the time to implement GDP-linked bonds, as a response that would provide a long-term relief for countries. Governments should swap the current debt instruments into GLBs since would allow enough cashflow relief in the early stage. Additionally, the authors mention that these types of instruments should be marketable as soon as possible, by developing pricing models and allowing for their incorporation in existing indices.

3. DATA & METHODOLOGY

In this chapter, it will be presented the methodology and data used to simulate the coupons of GDP-linked bonds for Portugal, Greece and Italy which results are presented on chapter 4.

3.1. METHODOLOGY

Following the designs present earlier, the coupon-indexed approach is going to be implemented to study the possible impact on three selected countries which belong to advanced economies.

Remembering what was illustrated before, Borensztein & Mauro's (2004) propose an approach to estimate the coupon rate for coupon-indexed GDP bonds (which the authors applied to the example of Mexico and Argentina in their article). According to the authors, considering a floating rate bond with a coupon that changes according to the performance of the country, the formula to calculate a coupon rate will equal to:

$$Coupon_{\,t} = \max\left[r + (g_i - g^*), 0\right] \tag{5}$$

where r corresponds to the 10-year government bond yield of the country; g_i equals the actual growth rate of GDP; g* is the baseline growth rate of GDP, which is agreed between the contracting parties before the issue of the bond, nonetheless for simplicity the authors assumed to be the average GDP growth rate over the previous 20 years with respect to each reference year.

Thus, the coupon payments will fluctuate according to the economy evolution: in times of economic downturn, the coupon rate offered to investors will be lower than the 10-year government bond yield, while in times of economic growth, this rate will be higher.

For example, if we consider r to be equal to 7%, and economy is growing at the baseline growth rate, the coupon rate will be 7%. Therefore, if economy is growing above g*, the coupon rate will be higher than 7% and if it is below g* the coupon payment will be lower but never below zero.

In their explanation, the authors also point out that continuity, where small changes in realized growth results in small changes in coupon payments, seems to be desirable so incentives to misreports are minimized. Furthermore, it is explained why a minimum of zero is imposed for the coupon rate in their exercise: many institutional bond investors are only allowed to hold assets in their portfolio that pay a positive interest rate.

The results of this simulation in the author's paper show that GLBs could be beneficial for both countries. In Mexico's example, when the output contracted more than 6% during the Tequila crisis of 1995, the coupon rate would have fallen to zero, allowing Mexico to obtain a reduction in interest bill and consequently, leaving more room to avoid procyclical fiscal measures. Similarly, Argentina would have managed to decrease its coupon payments in 1995 (Tequila Crisis) and 1999 (Brazil crisis). Nonetheless, when economies grew over their 20-year average, they would have paid higher-than-average coupon rates.

Finally, after following Borensztein & Mauro's (2004) approach, the payment obligations of simulated GDP-linked bonds will be compared to the 10-year government bond for each country with the objective to understand which one provides a cheaper financing option for the nations.

In order to apply this method and reach the results, Microsoft Excel was used.

3.2. DATA

Portugal, Greece and Italy were the countries selected to simulate the coupon indexation to GDP in this dissertation. This selection had as criteria the highest debt as percentage of GDP within European Union, apart from Portugal, information that was accessed on FMI's website.

In October 2020, several nations had 100% or more gross debt position when compared to the respectively GDP (See appendices 2.).

The evolution of gross debt in percentage of GDP for each of the three chosen countries, can be seen on the figure below. As expected, due to Coronavirus' pandemic, the debt levels in 2020 are the highest ever registered.

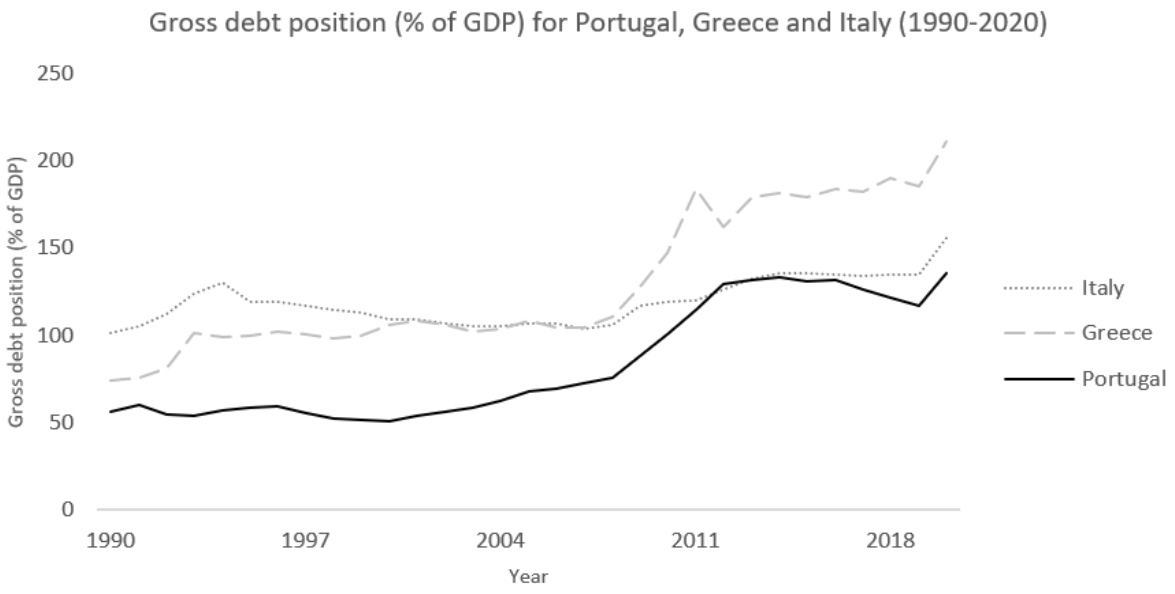

Figure 2: Gross Debt position % GDP for Portugal, Greece and Italy. Source: Fiscal Monitor 2020, International Monetary Fund website: https://www.imf.org/external/datamapper/G_XWDG_G01_GDP_PT@FM/JPN/PRT/GRC (accessed on 8th December 2020)

Annual data of 10Y government bond yields for each of the countries analyzed were collected from the Federal Reserve Bank of St. Louis for the period between 2000-2020 and information regarding the real GDP growth, considering the annual percentage change, was accessed on the World Economic outlook (October 2020) published by the International Monetary Fund, for the period of 1980-2020.

The period analyzed is between 2000 and 2020, where is possible to observe how the coupon indexation to GDP oscillates during years of both economic downturn and growth. The data regarding 1980-1999 is used to compute g* for the first year of the period analyzed.

4. RESULTS

4.1. COUPON SIMULATION

In this chapter, the results of the coupon simulation, following Borensztein & Mauro's methodology, for each of the three countries selected (Portugal, Greece and Italy) are presented.

4.1.1. Portugal

Figure 3 below, displays the comparison of the Portuguese 10-year government bond with the Portuguese GDP-linked Bond that was simulated. On the same figure, is also possible to see the annual percentage change of GDP and the 20-year average GDP growth.

When analyzing the figure, we see that for most of the time, more specifically between 2001 and 2014, GLBs are offering a lower payment obligation than the Portuguese 10-year government bond. Moreover, if we look to 2008, the year of the financial crisis, and the year after, we see a significant difference between both payment obligations, in which the payment for GDP-linked bond reaches zero. During these years and the following ones when a country is trying to recover, would be interesting for the government to be able to finance its public debt with these instruments, instead of plain vanilla bonds.

In 2020, due to the impact of coronavirus pandemic, Portuguese's GDP had a significant decrease, which takes the payment of GDP-linked bonds to zero once again. Nonetheless, for the first time, the 10-year government bond yield fell below zero on 26th November 2020, since there were expectations regarding new asset purchases by the European Central Bank which had allowed a recovery in Eurozone debt (FT, 2020). As mentioned earlier, the coupon paid by the GLBs never falls below zero.

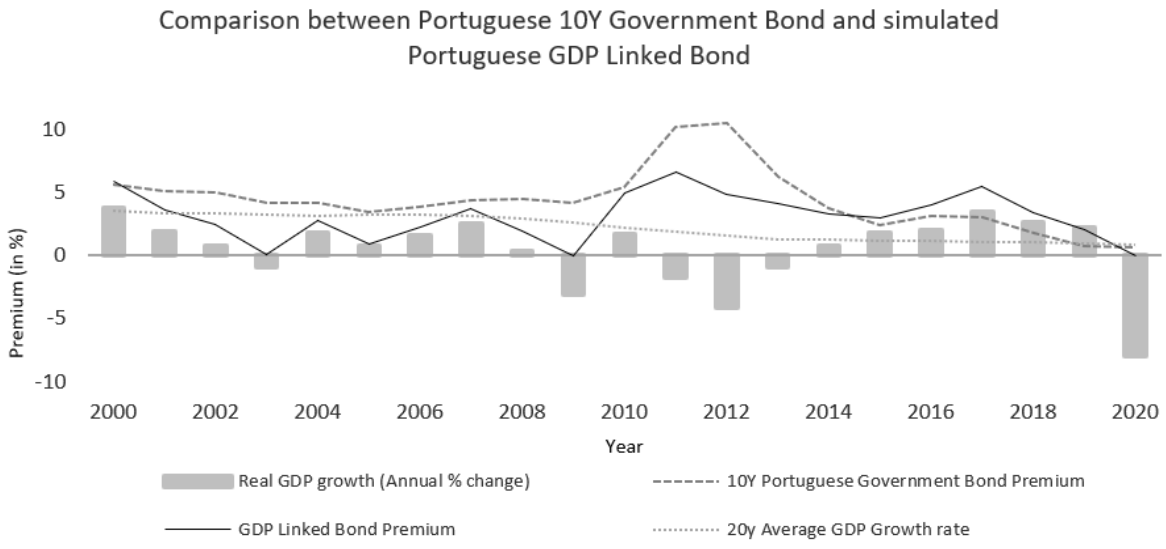

Figure 3: Comparison between Portuguese 10Y Government Bond and simulated Portuguese GDP Linked Bond

4.1.2. Greece

Unlike Portugal, the Greek GLBs' premium is higher than the vanilla bonds payment mostly until 2007 (except for 2005), since the growth rate is higher than the previous twenty-year growth average. From this moment on, it becomes lower than the 10Y Government bond premium until 2016. For sovereigns this last scenario would be the ideal since they would be able to finance itself at a lower cost. On the other hand, for bondholders, they have a higher incentive to invest in periods similar to the first described.

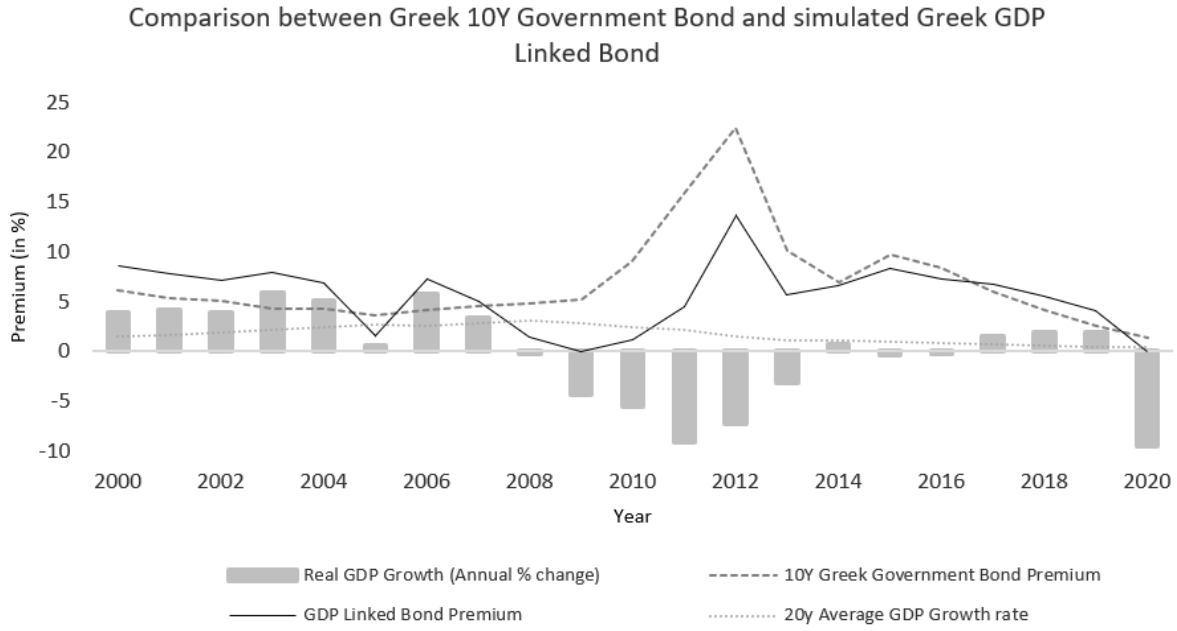

Figure 4: Comparison between Greek 10Y Government Bond and simulated Greek GDP Linked Bond

4.1.3. Italy

Finally, the figure below, displays the comparison between each bond for Italy. Similarly, to what occurred in Portugal's case, GLBs' payments are lower at the beginning of the period in analysis, while between 2015 and 2018 are higher. During the financial crisis, is also noticeable the difference between payment obligations of Italy for GLBs and the 10-year government bond, as it was also in both countries previously mentioned. So, in this case, Italy could have lowered its payments obligations drastically in 2008 and on most of the following ones.

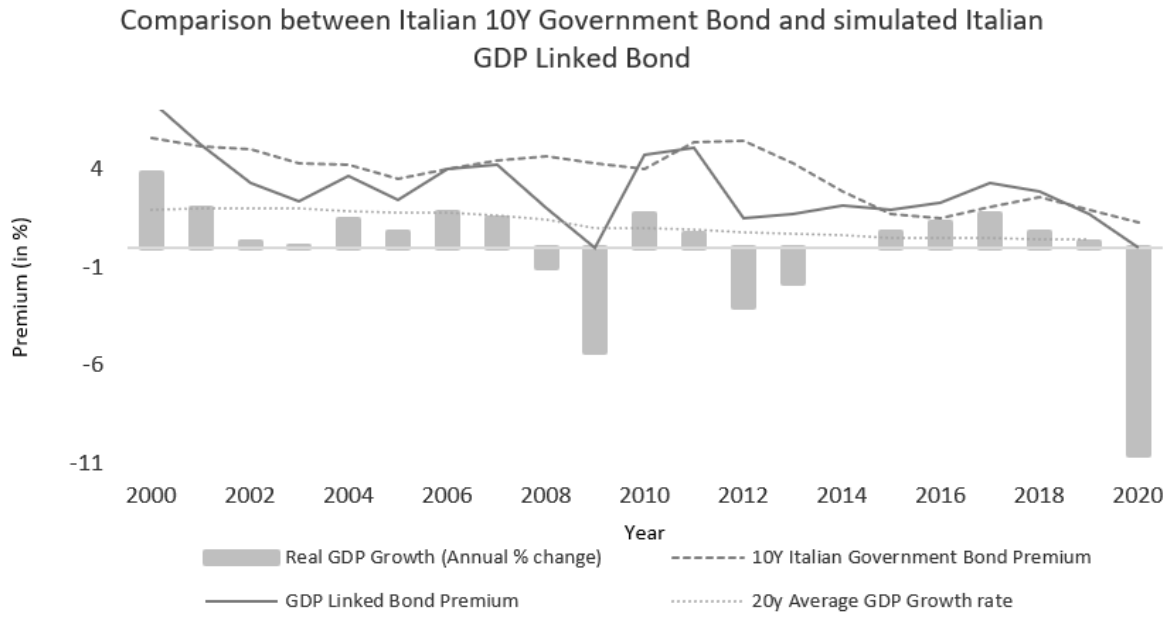

Figure 5: Comparison between Italian 10Y Government Bond and simulated Italian GDP Linked Bond

The results obtained in this dissertation are in line with the findings in literature described earlier. In fact, according to Griffith-Jones and Hertova (2013) it is important to implement market-based instruments, such as growth-linked bonds, since there is a need for more stable capital flows in order to smooth the boom-bust patterns that are disruptive for the real economy and consequently can lead to costly financial crisis.

4.2. COUPON SIMULATION SENSITIVE ANALYSIS

Looking back at the formula implemented to compute the coupon simulation and its variables (equation 5), we can notice that one of the variables g*, which corresponds to the baseline growth rate of GDP and should be agreed between the contracting parties before the issue of the bond, was assumed to be the average GDP growth rate over the previous 20 years with respect to each reference year. Thus, on this subsection, we will take the Portuguese case and see what are the impacts on GDP-linked bonds premium if we change this parameter.

Two scenarios will be tested: the first one where the variable g* will assume a lower number of years in order to compute the respective average, more specifically 15 years, and a second scenario where we will consider a 25 years average.

4.2.1. Decreasing the variable g* in 5 years

On this first scenario, we considered that the contracting parties agreed on an average of 15 years, with respect to each reference year, instead of the 20-year average that was presented on the base scenario. Looking at figure 6 and table 3, we see that a 5-year difference between the scenarios, represents a small impact on the premium between 2005 and 2008 and also between 2013 and 2019,

nonetheless this difference can always be significantly for sovereigns depending on the debt that was issued. For the remaining periods we see that the premium is very identically to the base scenario.

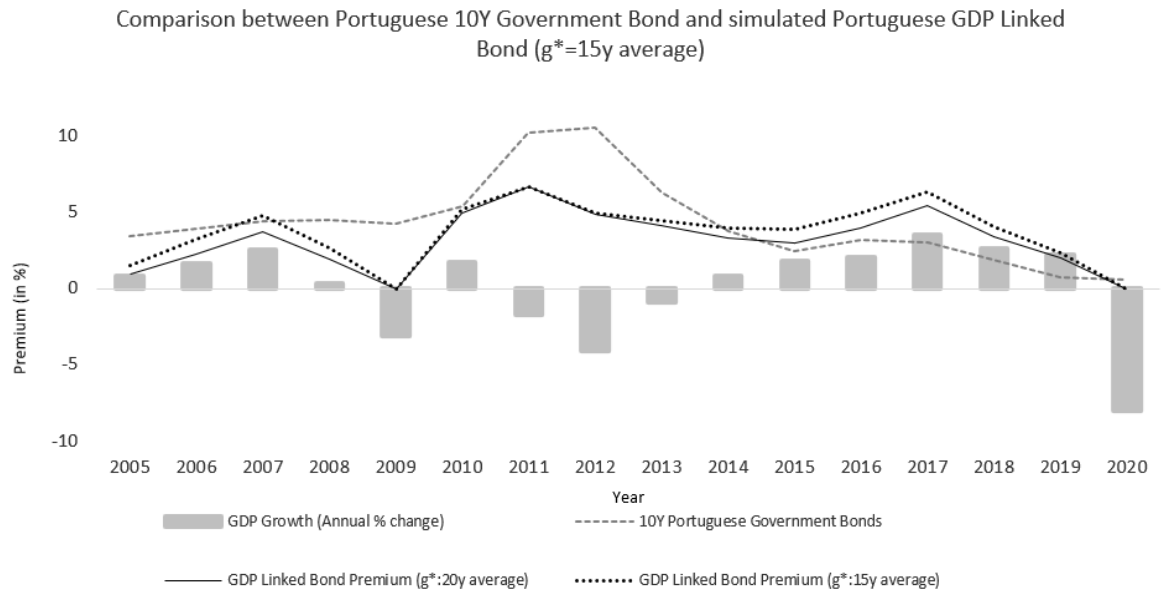

Figure 6: Comparison between Portuguese 10Y Government Bond and simulated Portuguese GDP Linked Bond for both g*=20y average and g*=15y average.

	15y average (%)	20y average (%)	Difference (%)
2005	1,47	0,94	0,53
2006	3,22	2,26	0,96
2007	4,75	3,75	1,00
2008	2,69	1,90	0,78
2009	0,00	0,00	0,00
2010	5,20	4,92	0,29
2011	6,69	6,67	0,02
2012	4,94	4,83	0,11
2013	4,45	4,14	0,32
2014	3,99	3,31	0,69
2015	3,87	3,01	0,86
2016	4,95	3,99	0,97
2017	6,33	5,44	0,88
2018	4,03	3,37	0,66
2019	2,32	2,00	0,32
2020	0,00	0,00	0,00

Table 3: Difference between premiums for g*=15y average and g*=20y average

4.2.2. Increasing the variable g* in 5 years

In this scenario, we increased g*in 5-years, meaning we considered a 25-year average with respect to each reference. As it can be observed in the figure and in table below, for most of the time the premium is very similar to the base scenario. During the period 2010-2015 and in 2019 is where the difference is slightly higher, being the maximum difference computed inferior to 1% in 2012.

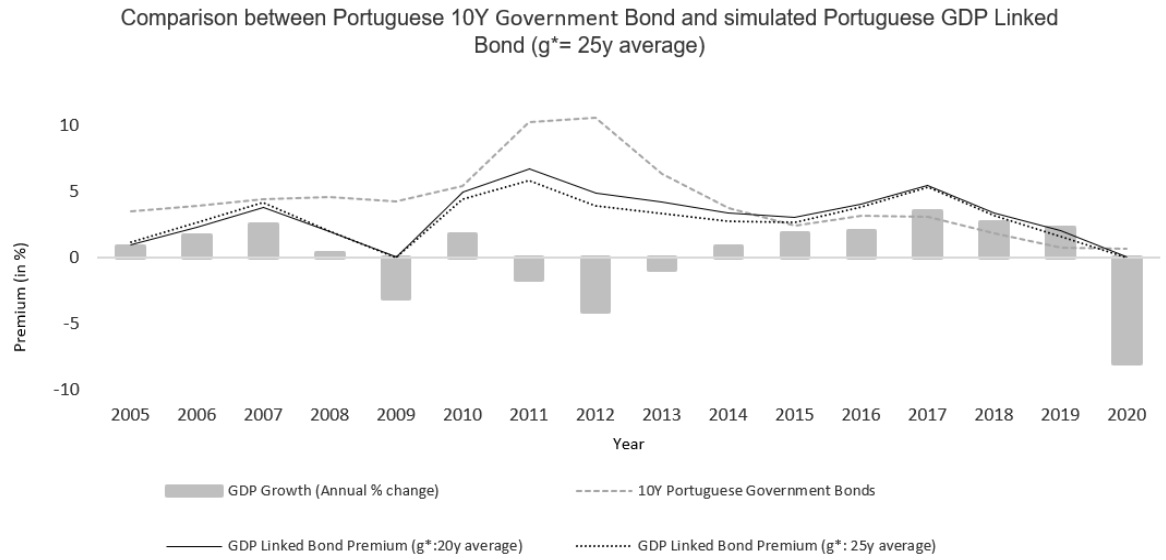

Figure 7: Comparison between Portuguese 10Y Government Bond and simulated Portuguese GDP Linked Bond for both g*=20y average and g*=25y average.

	20y average (%)	25y average (%)	Difference (%)
2005	0,94	1,11	-0,16
2006	2,26	2,62	-0,36
2007	3,75	4,10	-0,35
2008	1,90	1,99	-0,08
2009	0,00	0,00	0,00
2010	4,92	4,38	0,54
2011	6,67	5,82	0,85
2012	4,83	3,92	0,91
2013	4,14	3,34	0,80
2014	3,31	2,75	0,56
2015	3,01	2,65	0,37
2016	3,99	3,84	0,15
2017	5,44	5,28	0,17
2018	3,37	3,15	0,23
2019	2,00	1,53	0,47
2020	0,00	0,00	0,00

Table 4: Difference between premiums for g*=25y average and g*=20y average

4.2.3. Comparing previous scenarios

Although the change in parameter is small (only five years), it is possible to observe slightly changes in obligation payments when increasing or decreasing five years to g*. Even a small change in obligation payments can be determinant both for sovereigns when it is time to issue debt or for investors to invest.

This exercise shows that even small changes in one parameter in the coupon formula can influence the value of premium, which is in line with literature regarding the importance of underlying assumptions and design of instrument.

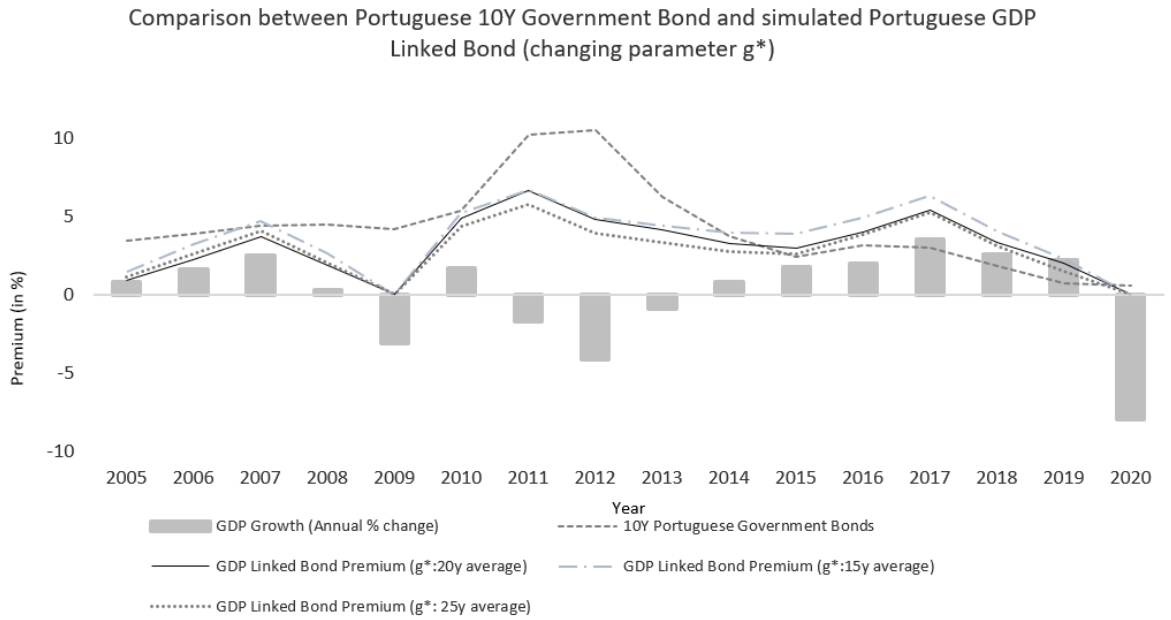

Figure 8: Comparison between Portuguese 10Y Government Bond and simulated Portuguese GDP Linked Bond for both g*=20y average, g*=15y average and g*=25y average.

5. CONCLUSION

The purpose of this dissertation is to understand GDP-linked bonds, by getting to know its designs, benefits for both issuer and investor and finally obstacles to implementation. Additionally, a coupon simulation based on coupon-indexed approach is performed for three developed economies namely Portugal, Greece and Italy and finally compared to the 10Y government bond of each respective country. This coupon simulation, performed following Borensztein & Mauro's approach of indexing the coupon payment to GDP, shows that in times of financial distress, such as the financial crisis of 2008 or the crisis caused by Covid-19 pandemic, could be possible to lower the debt payments obligations in the following years. On the other hand, we see that when economy is growing rapidly, coupon payments will also increase their value.

In literature we see that GDP-linked bonds can be favorable for both emerging and advanced economies, since it is a way for sovereigns to have a type of insurance against low GDP growth rates, and consequently help to reduce their procyclical fiscal policy since countries would have lower payment obligations when economy is weak and higher payments when economy is stronger. Thus, we can see that our results are in line with literature.

Nonetheless, looking at past attempts of implementation of this type of instruments we see it has not been employed very often. According to the International Monetary Fund (2017), some issuances in the past corresponded to a complement of an existing portfolio of conventional debt instruments, reason why it was often discontinued. It is important to notice that there is not yet a pricing model defined, which could be important in order to contribute to standardization of this instrument.

There are several limitations to this study that should be kept in mind. The first limitation is the fact that GDP figures are subjected to adjustments in subsequent years. So, is not possible to guarantee that it will not change significantly and consequently change premiums. For this reason, it is necessary to establish which figures the premium will be based on so investors can feel more secure. Additionally, one assumption made in this analysis is how the baseline GDP is calculated, which can impact the premium to be paid by sovereigns or received by investors. Finally, the simulation was only performed for three European countries, namely Portugal, Greece and Italy. Therefore, it is difficult to generalize the results for the remaining European countries, nonetheless it can contribute for the results of future studies.

Finally, following the coupon simulation, it was performed a sensitive analysis on the parameter related to the baseline GDP which was first set on a 20-year average with respect to each reference year, and increased and decreased by 5 years. Although the impacts were small, it could be interesting to perform the same analysis in future studies but in the short term (e.g. quarters or semesters) to observe how premium would be impacted.

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7. APPENDIX

7.1 **Introduction of Inflation-Indexed Securities by Sovereigns**

Source: Borensztein, E., & Mauro, P., Chamon, M., Jeanne O. & Zettelmeyer J. (2005). Sovereign Debt Structure for Crisis Prevention. In *IMF Occasional Paper* 237.

	Period of Issue	Average CPI Inflation Rate in Three Years Prior to Introduction (In percent)	Indexed Public Debt Outstanding in 1999	
			In millions of U.S. dollars	In percent of total government debt
Argentina	1972–1989	18.6	0	0
Australia	1985–1988	8.4	...	...
	1993–	3.8	27,860	29.5
Brazil	1964–	...	45,291	19.6
Canada	1991–	4.6	6,636	1.5
Chile	1956–	39.6	14,960	62.0
Colombia	1967–	13.7	4,949[1]	13.2[1]
Czech Republic	1997–	9.3	150	1.7
Finland	1945–	...	0.7	0
France	1998–	1.7	3,994	0.6
Greece	1997–	7.6	197	0.2
Hungary	1995–	23.2	394	3
Iceland	1955–	4.3	494[2]	11.5[2]
India	...	...	166	0.2
Ireland	1983–	18.6	260	1.1
Israel	1955–	32.7	79,037	80.2
Italy	1983[3]	18.5	0	0
	2003[4]	2.2	11,938	0.9
Japan	2004[5]	–0.6	900	0.0[6]
Mexico	1989–	110.7	2,528	8.4
New Zealand	1977–1984	14.2	...	...
	1994–	1.4	361	2.3
Norway	1982–	9.8	30	0.1
Poland	1992–2000	292.2	0[7]	0.0[7]
Sweden	1952[3]	8.2	...	...
	1994–	5.4	15,475	12.5
Turkey	1994–	80.8	8,561	24.3
United Kingdom	1975– [8]	10.7	...	...
United Kingdom	1981–	13.2	55,288	12
United States	1997–	2.8	57,014	0.8

Sources: Campbell and Shiller (1996); Kopcke and Kimball (1999); Price (1997); Deacon and Derry (1998); official websites of country authorities; and IMF staff estimates.

[1]January 2003.

[2]February 2003.

[3]Only one issue of inflation-indexed bonds.

[4]One issue in September 2003, indexed to euro area inflation measured by Eurostat.

[5]One issue in March 2004.

[6]From March 2004.

[7]From April 2000.

[8]Index-linked national savings certificates.

7.2 **Gross debt position % GDP, Fiscal Monitor (October 2020)**

Source: International Monetary Fund website:
https://www.imf.org/external/datamapper/G_XWDG_G01_GDP_PT@FM/ADVEC/FM_EMG/FM_LIDC/JPN