With or without GDP-linked Bonds?

Simulations of the Greek Government Debt and a Historical Counterfactual

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Abstract

This paper examines the historical counterfactual effect of GDP-linked bonds on the evolution of the Greek government debt, both from the standpoint of the policymaker in 2010 and in hindsight. Monte Carlo simulations are applied to the public debt ratio to test whether partial or full indexation would have led to lower debt-to-GDP ratios than those experienced during the crisis.

Probabilistic fan-charts of the simulated possible future debt-to-GDP ratio paths suggest that the adoption of GDP-linked bonds would not have made sense for the policymaker in 2010, *ceteris paribus*. In line with the literature, this paper concludes that Greece is not a good candidate for the introduction of GDP-linked bonds.

Keywords: *GDP-Linked Bonds; state-contingent debt; sovereign debt; sovereign debt management; Monte Carlo Simulations*

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1. Introduction

The potential for self-fulfilling market-sentiment dynamics in the feedback loop between market interest risk premia and government debt has pointed to the need for an immediate liquidity solution to shield the sovereign from short-run uncertainties that affect the sovereign's debt servicing capacity. Combining the above finding and the insights from the fiscal fatigue literature, in addition to proposals for automatic liquidity crisis assistance, a state-contingent solution that contractually protects the sovereign from adverse economic growth outcomes becomes necessary. As the availability of fiscal space is associated both with current fiscal fatigue but also with potential output and intertemporal debt sustainability, the relevance of policy circles' discussions regarding the introduction of sovereign GDP-linked bonds becomes apparent.

This paper takes note of the acknowledged failure of the IMF and European Institutions to accurately forecast the growth path in relevant debt sustainability analyses prior to the prescription of conditionality measures that accompanied the Greek bailout loans. Therefore, a state-contingent solution that not only shields against uncertain future worst-case scenarios for the rate of economic growth, but also applies a probabilistic 'fan chart'-based method that explicitly accounts for forecasting and measurement uncertainties and errors, is examined.

This paper contributes to the literature on sovereign debt by being the *first to our knowledge to provide a historical counterfactual of the evolution of the Greek public debt/GDP ratio with and without GDP-linked bonds, both from an ex-ante forecasting baseline perspective as in 2010 (prior to the contracting of the first bailout loan) and from an ex-post perspective.* This paper applies the Blanchard et al. (2016a, 2016b) methodology, albeit in a historical counterfactual context, and for the case of Greece. In addition, partial indexation and sensitivities with respect to the percentage of debt-to-GDP being GDP-indexed and with respect to the risk premium charged are added to the procedure developed by Blanchard et al. (2016a, 2016b). The main question raised is whether the evolution of the public debt-to-GDP ratio would have been more favorable with GDP-linked bonds than without.

Using the forecasting input macroeconomic scenario of the IMF prior to the contracting of the first bailout loan in 2010, the evolution of the Greek public debt-to-GDP ratio is examined as a forecasting exercise of regular non-indexed bonds ('plain vanilla') against the path of the public debt-to-GDP ratio under the assumption that a fraction (or all) of the debt were indexed to GDP-linked bonds to provide an *ex ante evaluation*. Sensitivities with respect to the percentage of government debt outstanding being indexed are provided, as well as sensitivities of the risk premium charged on this product. The exercise is repeated based on actual historical data input in lieu of the forecasting macroeconomic scenario for an *ex post evaluation.* A link to regime-switches in sovereign risk is provided, as a threshold of overindebtedness, beyond which a higher risk premium is charged by financial markets, is incorporated endogenously in the dynamic evolution of the public debt. A novelty premium is charged on GDP-linked bonds and analysis of results comments on relevant sensitivities for the evaluation of the state-contingent solution.

This paper is structured as follows: Section 2 provides a brief overview of GDP-linked bonds, and of the advantages and disadvantages of their introduction according to the literature; Section 3 presents the method applied for the simulations of the Greek debt; Section 4 presents data inputs; Section 5 analyzes the model-based results; Section 6 concludes. Results are provided in Appendices 3 and 4. A complementary brief history of state-contingent measures is offered in Appendix 1. A detailed version of the methodology is provided in Appendix 2.

2. Advantages and Disadvantages of GDP-linked Bonds

GDP-linked bonds are state-contingent sovereign debt instruments which feature a continuous adjustment of debt servicing obligations. According to proposed contractual designs in the literature, principal payments may be directly indexed to nominal GDP, and coupon payments may, thus, also be indirectly indexed to nominal GDP by percentage of principal. Indexation to

real GDP is a feasible alternative, yet nominal state variables are preferred as they are both associated with the borrower's repayment capacity while also offering investors an implicit protection against inflation.[1] By tying interest and principal payments to the sovereign's repayment capacity, GDP-linked bonds act as a countercyclical insurance mechanism, contributing to the stabilization of the sovereign's Debt-to-GDP ratio and improving the sovereign's borrowing capacity (IMF,2017).[2]

The literature on GDP-linked bonds has emerged in response to policy circles' quest for alternative financing solutions to sovereign overindebtedness, both in the 1980s[3] and in the 2010s, in the aftermath of the Latin American debt crisis and the Eurozone and Greek sovereign debt crises. Thus, the vast majority is 'policy-oriented' rather than focused on academic or theoretical developments. Across time, models have emphasized and sought to overcome the empirical difficulty of providing a "theoretical price" for GDP-linked bonds and its concomitant effect on the debt-to-GDP ratio in the absence of any relevant bond issuance. Analytical pricing complexity has been suggested as a primary challenge against the introduction of GDP-linked bonds by investor surveys (Chamon and Mauro, 2005). The majority of studies focus on reduced-form models, as these have been deemed to be preferable for modelling the dynamics of sovereign debt (Duffie,2002).[4]

In reflection of continued turmoil with emerging markets sovereign debt, during the 1990s and early 2000s, a number of indexation schemes were proposed at a time when the first

[1] Such inflation protection is associated with the GDP deflator rather than the CPI, as customary with inflation-linked securities.

[2] In contrast to GDP-linked warrants, GDP-linked bonds may offer (symmetric) repayment profiles allowing for differential payments on the upside and downside scenarios for economic growth (Kopf, 2017). Bowman and Naylor (2016) highlight the difficulties involved in pricing GDP-linked bonds in the absence of relevant precedent by indicating that warrant pricing, due to non-exposure to downside scenaria related to economic growth, does not provide an appropriate compass.

[3] In response to the debt crises of the 1980s, Krugman (1988) and Froot et al. (1989) were the first to suggest linking debt repayment to macroeconomic variables to increase risk-sharing and reduce the probability and cost of sovereign default (Borensztein and Mauro, 2002).

[4] Duffie (2002) compares corporate and sovereign debt and builds a case in favour of reduced-form models for the latter, as it involves the possibility of strategic default, often lacks seniority structure, liquidity considerations differ and due to difficulties involved in assessing the repayment capacity of the sovereign.

GDP-warrants were issued during the Brady Plan restructurings of Bulgaria, Bosnia and Costa Rica (IMF, 2017). Shiller (1993,2003) recommended the introduction of "Trills", "perpetual claims on one-trillionth of a country's GDP" for the purposes of increasing risk diversification (Barr et al., 2014). Barro (1995) suggested that the government's optimal debt management strategy would entail linking sovereign debt to government expenditure for tax smoothing purposes. Moral hazard concerns with regard to the potential for direct manipulation of government expenditure shifted the discussion to indexing debt repayments to GDP.

During the 2000s, on behalf of the IMF, Borensztein and Mauro (2002), "revived the Case for GDP-Indexed Bonds" by reflecting upon the advantages of GDP-linked bonds for sovereigns and pricing considerations for international investors, while also hinting at potential challenges and relevant solutions. Borensztein and Mauro (2002) developed the first simple quantitative model of GDP-linked bond simulations, comparing debt profiles with and without indexed debt and forming basic calculations of the risk premium for the sovereign debt of Emerging Markets, Advanced Economies and Developed Countries

The nascent literature on GDP-linked bonds is focused around one or more of the following topics: i. policy papers discussing design characteristics, advantages and disadvantages of those instruments and relevant clauses; ii. the pricing of GDP-linked bonds and particularly the appropriate risk-premium charged; iii. the debt-stabilizing effect of GDP-linked bonds. In addition, the literature distinguishes between the theoretical advantages that would arise by the issuance of GDP-linked bonds during normal times to the advantages arising due to the issuance during debt restructurings.

As this paper develops simulations for Greece, the results of Fratzscher et al. (2014) are noted, which, however, do not represent a historical counterfactual as at the time of writing in 2014 but are relevant in the sense that a portion of the Greek public debt is being simulated. Fratzscher et al. (2014) convert official sector loans, and particularly the Greek Loan Facility (GLF) portion, into GDP-linked bonds. They estimate that in the worst percentile, under the

path of macroeconomic forecasts as in 2014, debt stabilization would be impossible without the introduction of GDP-linked bonds.

The following section summarizes the basic arguments in favor and against the introduction of GDP-linked bonds.

2.1. Advantages Associated with GDP-Linked Bonds

The advantages and disadvantages of GDP-linked bonds are summarized by a number of papers, including, *inter alia*, Borensztein and Mauro (2002), Chamon and Mauro (2005), Brooke et al. (2013), Benford et al. (2016), IMF (2017), and Fournier and Lehr (2018). Advantages are viewed both from the perspective of the issuing sovereign and from that of the investor community and international financial architecture.

i. Countercyclical Fiscal Space

The primary advantage associated with the issuance of GDP-linked bonds relates to optimal debt management and tax-smoothing considerations over the business cycle, as proposed by Bohn (1990) and Barro (1995). According to Barro (1995), optimal debt management should link debt servicing obligations to debt repayment capacity, thereby offering a "natural hedge" against shocks to the government balance. Tax revenues, the tax base or government expenditure were originally suggested as indexation variables. However, given the ability of the government to directly manipulate the above, moral hazard concerns have required the consideration of GDP or economic growth as proxies for debt-repayment capacity and next-best alternatives for the purposes of tax-smoothing and debt stabilization (Chamon and Mauro, 2005).

By linking the level of principal and associated coupon payments to the level of economic activity, GDP-linked bonds operate as automatic stabilizers. They provide additional fiscal space during times of distress, when tax revenues are lower and the need for countercyclical government expenditures is highest, thereby enhancing the potential for repayment and minimizing the probability of default, while also contributing to the prospects of economic

recovery. Therefore, GDP-linked bonds alleviate both the self-fulfilling effects and any long run fiscal insolvency dynamics. The above properties are critical during times of debt overhang (Krugman,1988). By symmetry, during good economic times, they restrain the procyclicality of fiscal policy and allow sovereign debt investors to reap higher yields, while enjoying an 'equity stake' on economic activity, in the conceptual framework by Kamstra and Shiller (2009). Papers which include a fiscal reaction function to changes in the growth rate and endogenous effects on the interest rate on GDP-linked bonds (such as Borensztein and Mauro, 2002) provide evidence in support of such countercyclical properties of GDP-indexed debt.

The benefits of the introduction of GDP-linked bonds have been associated with the level of public debt-to-GDP. GDP growth-indexed bonds are deemed to be "most useful when the debt ratio is 'high but not catastrophically high,'" (Blanchard et al., 2016a) as the decrease in the upper tail of the distribution of possible government debt ratios at each point in time is irrelevant on two occasions: when the level of debt is very low and when it is already extremely high (Blanchard et al., 2016a). During times of economic stress, the fiscal space generated by GDP-linked bonds serves to reduce the probability of default by leading to lower credit premia being demanded by investors and, hence, less explosive debt paths. This beneficial effect is more pronounced for lower-rated sovereigns, whose credit spread is larger (Benford et al., 2016). Chamon and Mauro (2005) are the first to develop a Monte Carlo GDP-linked bond pricing framework for the purposes of estimating the reduction in the probability of sovereign default due to the introduction of GDP-indexed bonds. For their average Emerging Markets case considered for simulations, they find that full indexation reduces the probability of default from 28% to 19% (Chamon and Mauro, 2005). Similarly, GDP-linked bonds may reduce the size of official sector loans required in future sovereign debt crises (Barr et al., 2014) and contribute to the restoration of debt sustainability in sovereign debt restructuring.

As such, under a portfolio of GDP-linked debt, the so-called maximum sustainable debt threshold for the sovereign, namely the level beyond which the public debt becomes explosive, or the maximum level of debt-to-GDP that can be sustainably serviced by the sovereign, is pushed to higher levels as a percentage of GDP (Barr et al., 2014; Benford et al., 2016).[5] Barr et al. (2014) develop a simple model for sovereign debt simulations under investor risk aversion, whereby the debt limit under GDP-linked bonds may almost double under certain circumstances compared to the debt limit under conventional debt. The effect on the maximum sustainable debt threshold depends on the implicit risk premium demanded by investors, and particularly on the relative effects of a decrease in the probability of default due to a larger fiscal space against costs of an additional GDP risk premium charged by investors. Manna (2017) probes into the theoretical effects of GDP-linked bonds on the maximum sustainable debt by suggesting that the latter is not constant as presumed in the majority of papers in the 'maximum sustainable debt level' literature; rather, it is a time-varying function of the growth rate, the interest rate and the shock on the public debt, derived by assuming that the primary surplus reacts to keep the debt-to-GDP ratio constant (Manna, 2017).

ii. Debt Stabilization

The second critical advantage of the issuance of GDP-linked bonds concerns debt stabilization, namely the decrease in the variance of the path of the debt-to-GDP ratio. Clearly, a less variable debt-to-GDP ratio enables enhanced fiscal planning while reducing the need for sharp fiscal consolidations and the frequency of default. A less variable debt-to-GDP ratio also bears a positive effect on investor expectations with regard to the default premium charged on debt issuances (Benford et al., 2016; Blanchard et al., 2016a).

Naturally, the stabilization properties of GDP-linked bonds are greater the more variable GDP is. A simple decomposition of the variance of the Debt/GDP ratio shows that variability in the Debt/GDP ratio comes from the variability of the primary balance, the variability of the

[5] This argument is in line with the Reinhart et al. (2003) "debt intolerance" argument for Emerging Markets, whereby once debt-to-GDP surpasses a critical value, default is triggered.

interest-growth differential and the covariance between the primary balance and the growth-interest differential (Benford et al., 2016; Blanchard et al., 2016a).

Below is the basic equation for the evolution of the dynamics of sovereign debt in the local currency:

$$\Delta d_t = \frac{i_t - g_t}{1+g_t} d_{t-1} - pb_t + sfa_t \quad (1)$$

where Δd_t represents the change in the debt-to-GDP ratio, $i_t$represents nominal interest rates, g_t represents nominal economic growth, d_{t-1} stands for the debt-to-GDP ratio in the previous period, pb_t represents the primary balance and sfa_t corresponds to the so-called "stock flow adjustment" term, a residual capturing, inter alia, market valuation effects and contingent liabilities[6] (Benford et al., 2016; Blanchard et al., 2016a).

A number of shocks may govern the alternative plausible paths for debt-to-GDP, as follows:

$$\Delta d_t = \frac{(i_t + \varepsilon_{i,t}) - (g_t + \varepsilon_{g,t})}{1+(g_t + \varepsilon_{g,t})} d_{t-1} - (pb_t + \varepsilon_{PB,t}) + sfa_t, \quad (2)$$

where $\varepsilon_{i,t}$, $\varepsilon_{g,t}$ and $\varepsilon_{PB,t}$ can be assumed to be drawn from a joint normal distribution (Benford et al., 2016; Blanchard et al., 2016a). Other models use a single error term capturing the accumulation of all the above. Economic literature suggests that this error term plays a significant effect on the debt evolution dynamics (Campos et al., 2006; and Abbas et al., 2011).

Therefore, taking the variance of each side of Equation 1 and omitting the stock-flow-adjustment term for simplicity:

$$\text{Var}(\Delta d_t) = \text{Var}(pb_t) + d_{t-1}^2 \text{Var}(i_t - g_t) - 2 d_{t-1} cov(pb_t, i_t - g_t) \quad (3)$$

(Carnot and Sumner, 2017).

[6] The stock flow adjustment term is explicitly monitored and detailed for EMU countries in the context of EDP (Excessive Deficit Procedure).

Based on estimations for G7 countries, where the dynamics of GDP are inherently more stable, Benford et al. (2016) find that approximately one half of the variance of the public debt-to-GDP ratio is attributed to 'growth shocks' and to the covariance of growth and the cyclical primary balance. The covariance term between the primary balance ratio and the interest-growth differential is generally found to be negative or slightly positive due to the "negative cyclical impact of growth on the primary balance" due to lower tax revenues (Carnot and Sumner, 2017).

Assuming that GDP-linked bonds pay a return of:

$$i_t^{GDP}=g_t + \text{k}\,, \tag{4}$$

namely the return on GDP bonds is equal to the level of nominal growth, plus a constant GDP-risk premium k (Carnot and Sumner, 2017) and given that k is a constant, such that Var(k)=0, and the fact that from (*4*),

$$i_t^{GDP} - g_t = \text{k}, \tag{5}$$

the variance of the interest-growth differential for GDP-linked bonds is stabilized:

$$\text{Var}(i_t^{GDP} - g_t) = Var(\text{k})=0, \tag{6}$$

(Carnot and Sumner, 2017).

This, in turn, implies that under GDP-linked debt, equation 3 for normal debt corresponds to equation 7:

$$\text{Var}(\Delta d_t)= \text{Var}(pb_t)- 2d_{t-1}cov(pb_t, i_t - g_t).^{7} \tag{7}$$

(Carnot and Sumner, 2017).

Based on the above, GDP-linked bonds decrease the overall variance for the evolution of the public debt-to-GDP ratio (Blanchard et al., 2016a; Benford et al., 2016; Carnot and Sumner,

[7] The correlation between the primary balance and 'i-g' is negative for most countries (Blanchard et al., 2016a).

2017). Also, the combination of any imposed primary balance targets[8] and GDP-linked bonds may result in substantial debt-stabilization.

Barr et al. (2014) distinguish a number of determining factors for the extent to which a sovereign may benefit from GDP-linked bonds. Sovereigns with higher levels of debt, more volatile interest-growth differentials and with constraints on the effectiveness of their monetary policy stand to benefit the most (Barr et al., 2014). For countries where monetary policy is constrained or central bank independence has been abandoned due to membership in a currency union, GDP-linked bonds may prove to be even more desirable due to their partial stabilization of the variability in the interest-growth differential (Benford et al., 2016). In contrast, low-debt countries or Emerging Market economies with flexible-exchange-rates will reap less of the benefit associated with GDP-linked bonds (Barr et al., 2014).

However, the simplicity of models underlying the above calculations and benefits requires caution prior to reaching conclusions with respect to the benefits of GDP-linked bonds. For instance, Barr et al. (2014) admit the presence of large uncertainty in their calculations, noting that the benefits of GDP-linked bonds will be lower in the presence of a positive correlation between economic growth and interest rates.

Furthermore, the stabilization properties of GDP-linked bonds are further compromised by: i. a negative correlation between the primary balance and the growth-interest differential;[9] ii. the presence of contingent fiscal liabilities; iii. the incidence of exchange-rate shocks; iv. an

[8] In addition to debt repayment considerations, the imposition of primary balance targets on the Greek government could also be viewed as a debt-stabilizing metric, assuming that the Greek government does reach such targets. However, it should be noted that over the course of the European Semester and the submission of budgetary plans by Euro Area governments, coordinated pressure is applied for targets to be reached and variance in the primary balance to be minimized. To the extent that fiscal targets placed by official loan agreements are stricter, there is marginal value in the debt stabilizing benefits of primary balance targets for Greece.

[9] As GDP-linked bonds reduce the variance of the r-g term, the more variable this term is, the greater the stabilization benefits from the use of such state-contingent bonds. However, such stabilization properties are somewhat reduced if the covariance between interest rates and economic growth is positive, as higher interest rates are offset by higher economic growth, implying that there is less of a need for GDP-linked bonds.

endogenous change in the borrower's behavior due to the introduction of GDP-linked bonds (Blanchard et al, 2016a).

The latter alludes to the political economy of sovereign debt as applicable to GDP-linked bonds, as a sovereign's borrowing behaviour may be altered following the introduction of GDP-linked bonds. Therefore, it is possible that models of strategic default a la Eaton and Gersovitz (1981) be developed for state-contingent debt (Barr et al, 2014).

iii. Insurance against Transitions into a 'Bad Equilibrium'

Based on their stabilization properties, GDP-linked bonds may offer *ex ante* insurance against bad states of the world, limiting the occasions on which the sovereign moves from a "good equilibrium" to a "bad equilibrium". GDP-linked bonds may, thus, avert a liquidity crisis and its transformation into a solvency crisis and associated deadweight losses. This is particularly true when issued during a sovereign debt restructuring (Benford et al, 2016). In the domain close to the maximum sustainable debt threshold, if credit risk premia on conventional non-contingent debt are higher than the GDP-risk premium on GDP-linked bonds, a net decrease in the level of spreads is achieved by indexing sovereign debt to GDP, thereby contributing to more stable equilibrium dynamics. Chamon and Mauro (2005) find that GDP-indexation reduces the probability of default by one third or one-fourth of its initial level for emerging market bonds. Although GDP-linked bonds have been suggested primarily as a solution against *solvency* rather than *liquidity* concerns (IMF, 2017), the reduction of debt servicing obligations during bad states of the world may be particularly important for liquidity-constrained Emerging Market economies, which often respond to low levels of growth via increases in their primary balance to maintain credibility and access in financial markets (Borensztein and Mauro, 2002).

iv. Strengthening the International Financial Architecture

In addition to the above advantages, GDP-linked bonds serve to enhance the resilience of the international architecture. Under the status quo, risk-sharing between the sovereign and

investors under conventional debt is suboptimal due to the large deadweight losses associated with default. De Paoli et al. (2009) find that the mean output loss from default is 15% due to the concurrent effect of banking and currency crises. Benjamin and Wright (2009) find that sovereigns regain market access with debt ratios that are more elevated compared to pre-default ratios, even after having imposed losses on investors. Moreover, the mere anticipation of default may induce large output losses, as evidenced by Levy-Yeyati and Panizza (2011) who suggest that the contraction in output occurs prior to sovereign default. By limiting the frequency and severity of contagious sovereign debt crises, GDP-linked bonds could improve the international financial and fiscal architecture.

In general, GDP-linked bonds serve to strengthen the international monetary and financial system by reducing the probability of solvency crises and associated costs of default or restructuring processes (Benford et al., 2016; IMF, 2017). From a theoretical standpoint, GDP-linked bonds offer improved risk-sharing opportunities, which in the context of the Arrow-Debreu framework, serve to increase the number of states spanned by securities, thereby enhancing market completeness. The increase in risk-sharing and reduction in default risk reduces the need for international bailouts, thereby also mitigating creditor moral hazard (Benford et al.,2016). In addition, GDP-linked bonds replace the burden of a deterioration in economic growth from the shoulders of the domestic taxpayer to those of investors in GDP-linked bonds, which are also more likely to be less risk-averse and more diversified in their financial portfolio (Benford et al., 2016; Kamstra and Shiller, 2009; Fournier and Lehr, 2018).

Furthermore, the issuance of GDP-linked bonds will invite financial markets to conduct further macro research on the appropriate pricing of sovereign risk. This will reduce informational asymmetries currently present in the market of sovereign risk and, thus, also limit abrupt herding behaviour that occurs with sudden shifts in expectations, potentially also reducing the incidence of sudden stops and capital flight, which exacerbate the vicious dynamics of sovereign default. Bikchandani et al. (1992) show that herding behaviour is more prevalent in markets where information is thin. In the context of the discussion on EMU

deepening, Blanchard et al (2016a) suggest that the cross-border holdings of GDP-linked bonds could be a partial alternative to a fiscal transfer union. Also, by increasing fiscal space during times of recession or lower growth, GDP-linked bonds may contribute to a reduction in negative spillovers from one country to another, as these occur predominantly at times of concurrent consolidation efforts and low growth (Benford et al.,2016; Auerbach and Gorodnichenko, 2013).

v. Investor Risk Diversification

From the investors' perspective, current sovereign debt instruments appear to be suboptimal as markets remain largely incomplete, or equivalently, in the Arrow-Debreu framework, there exist states of nature which are not spanned by securities, thus, leading to suboptimal risk-sharing and hedging. This suggests a role for additional risk-sharing opportunities, such as those offered by GDP-linked bonds. Under plain-vanilla bonds, in bad states of the world, losses are "passed on to investors", leading to suboptimal levels of risk-sharing, as these are usually confined to 'tail events', which in turn implies that there is scope for additional risk sharing (Barr et al, 2014). Instead, GDP-linked bonds may also benefit the investor community and global risk-sharing by providing opportunities to invest directly into GDP risk across countries. Economic literature presents evidence of large unrealized gains for international risk sharing with respect to GDP, given the low correlation between GDP per capita across countries, as evidenced by Athanasoulis and van Wincoop (2000) and Athanasoulis et al. (1999). The Capital Asset Pricing Model (CAPM) contends that expected returns should only reflect systematic risk as idiosyncratic risk is diversified away. However, in the context of GDP risk, the systematic portion of risk is relatively small compared to idiosyncratic risk (Borenszein and Mauro, 2002), which in turn implies that if such risk is not diversified, any financial instrument offering direct exposure to it will benefit from international risk diversification. From a risk management perspective, indexation to GDP is also more advantageous for investors in countries where stock markets are not well diversified and stock markets fluctuations exhibit low levels of correlation with a country's

growth rate (Borensztein and Mauro, 2002). These benefits are lower for advanced economies and whose GDP moves in parallel and higher for international portfolios investing in emerging market growth risks, as Capital Asset Pricing Model (CAPM) betas or estimates of emerging-market co-movement with an international "market portfolio" are very low (Borensztein and Mauro, 2002). The above risk-diversification benefits may also serve as an allure to increase the investor base on sovereign debt and hence the liquidity of public debt securities. Investor gains from risk diversification are also evidenced by Cabrillac et al. (2016,2018), who note that the inclusion of GDP-linked bonds in lieu of a stock market index reduces the variance of the portfolio due to GDP-growth being less volatile than most stock markets and due to a lower correlation of nominal GDP growth with relevant 'market portfolios'. Thus, GDP-linked bonds maximize Sharpe ratios (Sharpe, 1994) across 75 percent of simulations performed by Cabrillac et al. (2016, 2018).

Cabrillac et al. (2016, 2018) contend that GDP-linked bonds present an additional advantage, "automatic partial long-run currency risk hedging", as bidirectional feedback loops exist between the nominal exchange rate and nominal GDP growth, even though the exact sign of the relationship is plagued by uncertainty.

The advantages of GDP-linked bonds have also been considered in the context of issuance during sovereign debt restructurings, whereby they serve to 'bridge' the negotiating gap between investors and the sovereign, while also reducing GDP growth-uncertainty (Brooke et al., 2013; Fratzscher, et al., 2014; Goodhart, 2015; Honohan, 2011). Easterly (2002) finds that a one percentage point decrease in average annual GDP growth lead to 1.5 more debt reschedulings over the following 15 years (Borensztein and Mauro, 2004). Benford et al. (2016) distinguish three primary benefits of GDP-linked bonds during debt restructurings: i. they backload the debt repayment schedule to ensure it is in line with repayment capacity; ii. they act as 'deal sweeteners' thereby reducing the costs of delay and associated deal uncertainties; iii. they reduce the need for additional future debt restructurings due to their insurance and debt-stabilizing properties, which is particularly useful in the face of historical

evidence of recurrent debt restructurings and of 'serially defaulting' countries (Benford et al, 2016). [10]

2.2. Disadvantages Associated with GDP-linked Bonds

i. Moral Hazard

A series of complications govern the issuance of GDP-linked bonds, raising impediments to their wide adoption by the investor community. First and foremost is the topic of *moral hazard* (Arrow, 1968). In insurance terminology, *moral hazard* is defined to occur in the "case when people engage in riskier behavior with insurance than they would if they did not have insurance" (Openstax, Chapter 16, 2020) [11] , which in turn increases the probability that insurance is activated and augments expected costs for the insurer. Moral hazard has stood at the heart of public policy debates on sovereign debt restructuring and has given rise to an extensive literature on creditor and debtor moral hazard and institutional solutions that serve to reveal hidden interests or align incentives (Kahan and Leshem, 2017; Ghosal and Miller, 2003). In the context of GDP-linked bonds, given the potential of making lower debt repayments in times of lower economic growth, the sovereign may be partially incentivized to steer away from growth-enhancing reforms and policies (Fournier and Lehr, 2018; IMF, 2017; Bowman and Naylor, 2016; Chamon and Mauro, 2005; Schroder et al.,2004).[12] As the complete elimination of moral hazard is impossible, a number of contractual design characteristics of the GDP-linked bond term sheet may contribute to its minimization. For example, the selection of a state variable which is not directly under the sovereign's influence, as opposed to tax revenues, and a preference towards a variable such as GDP, or if applicable, some commodity price, is noted as a cautionary measure against moral hazard in the literature (IMF, 2017). However, a tradeoff emerges between moral hazard and the degree

[10] Since the 1980s, two thirds of restructurings with private creditors have proven inadequate to restore debt sustainability, thereby leading to repeat restructurings (Benford et al., 2016; IMF, 2017).
[11] https://opentextbc.ca/principlesofeconomics/chapter/16-2-insurance-and-imperfect-information/
[12] This is also true for sovereign-CoCos, where the sovereign may reduce the level of precautions taken against the incidence of the event that the trigger protects the sovereign against.

to which the state variable is associated with the government's repayment capacity for GDP-linked bonds to operate as an effective countercyclical mechanism (IMF, 2017). As a compromise to the above tradeoff, the maintenance of conventional debt may serve to align incentives of creditors and debtor policy. The IMF (2017) suggests two potential 'mitigating factors': i. the maintenance of sufficient 'skin in the game', namely the non-total replacement of conventional bonds, may serve to align creditor and debtor incentives; ii. political incentives to prevent 'bad states of the world' from occurring (IMF, 2017). Furthermore, the contractual inclusion of caps and floors[13] on the indexation formula applied could also mitigate the degree of moral hazard, as these serve to minimize the extent of debt relief granted (IMF, 2017).[14]

ii. Adverse Selection

State-contingent debt, and GDP-linked bonds in particular, are plagued by the problem of adverse selection, which arises in the presence of information asymmetries (IMF, 2017). Given that the sovereign benefits from enhanced information on the sustainability of its debt in view of forthcoming policy choices compared to what may be known in the investor community, investors will assume that sovereigns tapping the GDP-linked bond market are those with the worst macro and growth outlook. The quality of data, enhanced transparency of official statistics, and the presence of an international institution validating official statistics, such as Eurostat in the case of the European Union, may serve to minimize this issue. Adverse selection may also be minimized by the coordinated issuances across sovereigns (Brooke et al., 2013; Bowman and Naylor, 2016), for instance, in the context of the European Semester.[15]

[13] Schinckus (2013) develops a short paper on the pricing of GDP-linked collar bonds applying max-min formulas to the indexation scheme.
[14] The Bank of England has proposed an indicative term sheet for GDP-linked bonds, the so-called "London Term Sheet".
[15] The European Semester refers to the framework of economic coordination among member states of the EMU:
https://ec.europa.eu/info/business-economy-euro/economic-and-fiscal-policy-coordination/eu-economic-governance-monitoring-prevention-correction/european-semester_el

iii. Data Concerns

Furthermore, GDP statistics may be plagued with problems of data availability, integrity and timeliness (IMF, 2017; Cecchetti and Schoenholtz, 2017). In countries with less transparent and credible official data, GDP-linked bonds may generate incentives for GDP data manipulation. However, in an attempt to dispel relevant investor fears about potential losses associated with revisions of GDP statistics, Chamon and Mauro (2005) show that a decline in expected growth by one percentage point is associated with minimal investor losses. The linking of repayment to GDP, particularly in the presence of a payment floor may incentivize the indebted sovereign to report lower levels of GDP (Ceccheti and Schoenholz, 2017). As such, some form of sanction may be applied, potentially via a put option embedded in the design of the bond, such that any delay in official statistics grants the investors the option to buy back the bond at a predetermined price. Put events may also be associated with the fulfilment of policy conditionality (IMF, 2017).

However, basing the index on lagged values involves an additional tradeoff between the countercyclical properties of GDP-linked bonds against solutions to prevent moral hazard. As in the case of inflation-linked bonds, [16] given the frequent revisions of official statistics, proposals suggest indexation to the previous quarter or earlier data reported, which, however, may not be reflective of the prevailing macroeconomic situation. In the event of a sharp reversal to economic growth between two quarters would, thus, result in higher debt repayments, thereby exacerbating procyclical effects on the budget. As such, policy circles have examined indexation to a moving average of the state variable over the business cycle to reduce such cliff effects.

[16] ICMA suggested that timings should be made to be close to those of inflation-linked bonds for quarterly GDP data with six-month lags being used instead of the three-month lags used for inflation data (Kopf, 2017).

iv. Adverse Effects on Conventional Debt

The issuance of GDP-linked bonds may result in the "cannibalization" of the market for conventional non-contingent debt instruments (IMF, 2017). Depending on the level of investor risk aversion and the specific macroeconomic characteristics and terms of the GDP-linked term sheet, investors may display a sustained preference for GDP-linked bonds, resulting in the selloff of conventional debt, which in turn could increase the credit spread on conventional debt. The yields on conventional bonds may be driven to unsustainable levels, such that GDP-linked bonds would have induced the liquidity crisis they were meant to avert. Seniority and cross-default clauses are central to this issue, as is the appropriate management of the percentage of debt indexed to GDP in the total sovereign debt portfolio (IMF, 2017). Thus, a further tradeoff emerges between the level of GDP-linked bonds uptake by the investor community against the credit risk premium on conventional debt (Bowman and Naylor, 2016; Chamon and Mauro, 2005; Manna, 2017).

v. Transfer of Risk to the Private Sector

If GDP-linked bonds are held by financial institutions, they may lead to the migration of sovereign risk back to the sovereign as the sovereign-bank nexus may be reinforced (IMF, 2017). The additional risk premium on GDP-linked bonds may have an adverse balance sheet effect on financial institutions, raising the probability for the need of state aid and for recapitalizations. Therefore, the stabilization potential offered by state-contingent debt may be limited due to a potential associated increase in the size and risk of contingent liabilities for the government.

The above are indicative of the general market failures due to which financial innovation might fail to emerge, thus, suggesting a role of government intervention, as highlighted by Allen and Gale (1994).[17]

vi. The Cost of a GDP-linked Bonds Risk Premium

The above challenges affect pricing via the introduction of additional risk premia compared to conventional debt. Apart from the standard credit risk premium, which depending on the terms and percentage of debt indexed may be substantially lower for GDP-linked bonds than plain-vanilla bonds, additional risk premia, such as a *default/credit risk premium*, a *GDP-risk premium,* a *novelty premium,* and a *liquidity premium* may work in the opposite direction and may lead to a combined premium that is higher than the premium on plain vanilla bonds. The above distinction between the different premia is maintained by a number of papers (Carnot and Sumner, 2017; IMF, 2017; Blanchard et al, 2016a; Fournier and Lehr, 2018; Cabrillac et al., 2016, 2018; Bowman and Naylor, 2016), while others focus on calculating the total risk premium, or *insurance premium,* associated with GDP-linked bonds.[18] The total risk premium corresponds to the addition of the above-mentioned risk-premia, as these are considered to be additive according to Treynor (1961).

GDP-linked bonds have been associated with reduced *credit risk* for the sovereign due to two main properties inherent in their counter-cyclical nature: first, debt increases caused by GDP contractions are limited, thus, stabilizing debt shocks due to the containment of the "growth shock" component of the evolution of public debt-to-GDP and the reduction in the Debt-to-GDP variance (Brooke et al,2013); second, as the maximum sustainable debt for a sovereign increases, more fiscal space is provided for governments to use counter-cyclical pro-growth fiscal policy during crises (Brooke et al,2013). Therefore, as far as the *credit risk premium* is

[17] Borensztein and Mauro (2002) connect the Allen and Gale (1994) framework for financial innovation to GDP-linked bonds by focusing on parallels with respect to product uncertainty, externalities and coordination problems, as well as the highly competitive structure of financial markets.

[18] Barr et al. (2014), Blanchard et al. (2016a) and Fournier and Lehr (2018) distinguish between a credit default risk premium and a GDP risk premium only.

concerned, *ceteris paribus* and assuming no effects on conventional debt or full indexation, in bad economic times, the increase in fiscal space provided by the smoothening of the repayment profile of the sovereign clearly indicates that the probability of default is lower with GDP-indexed debt than conventional debt (Brooke et al,2013). Based on standard bond-pricing, a lower probability of default is associated with a lower credit risk premium. Bowman and Naylor (2016) suggest that the size of the credit risk premium depends on the size of the premiums on existing debt and on how GDP-linked bonds are perceived to affect sovereign debt sustainability. Carbillac et al. (2016) highlight that GDP-linked bonds are usually associated with decreases in default risk, thereby improving long-term solvency.[19]

The *novelty premium* is attached to all new financial market instruments and is considered to subside over time, as a "critical mass" of market volume is attained. From the perspective of public finance economics, the novelty premium alludes to standard market failures (Costa et al., 2008). Externalities and coordination failures arise as investors face high pricing computation costs and do not internalize the social benefit they provide for other investors. A first-mover disadvantage arises for the first sovereign to issue GDP-linked bonds due to the high costs entailed for the first-mover and low imitation costs for market participants based on low barriers to entry, thereby resulting in a socially suboptimal outcome and deadweight losses (IMF, 2017; Chamon and Mauro, 2005). Such collective action problems call for market-making assistance by International Financial Institutions and suggest that coordinated issuances by advanced countries could eliminate first-mover disadvantages (Borensztein and Mauro, 2002; Allen and Gale,1994).

The *liquidity premium* refers to the low depth of the market and small volume of transactions that may prevail for GDP-linked bonds. In response, Brooke et al. (2013) call for international cooperation for the achievement of a critical mass in liquidity of GDP-linked debt, for the establishment of valuation practices and common standards, as well as the build-up of a

[19] However, sovereign CoCos involving an automatic deferral of payments would have been more effective (Cabrillac et al., 2016, 2018).

specialized trading platform (Brooke et al, 2013). As with the novelty premium,[20] the liquidity premium is expected to be high initially, yet to gradually decrease over time, as the GDP-linked bonds market is developed (Bowman and Naylor, 2016).

The *GDP risk premium* arises due to the variability of GDP, which according to the indexation rule applicable in the term sheet, implies that investors will demand a higher premium in compensation against lower debt repayments during good economic times. Considerable uncertainty surrounds the size of the GDP risk premium to be demanded by investors, as there is substantial variability in economic growth and uncertainty about macro forecasts. Across international studies, estimates of the GDP risk premium range between 20 bps and 350 bps. Barr et al. (2014) suggest that the benefits of issuing GDP-linked bonds exceed the costs when the GDP-risk premium is at levels below 200-350pbs. Miyajima (2006) and Kamstra and Shiller (2009) locate the risk premium at lower levels of approximately 150bps. Blanchard et al (2016a, 2016b) use a premium of 100 bps for Advanced Economies and comment that substantial uptake of GDP-linked bonds by internationally diversified investors would serve to gradually reduce this GDP risk premium.

Fournier and Lehr (2018) define a 'critical risk premium' to be the risk premium that would equate the debt-to-GDP ratio with and without GDP-linked bonds.[21] Fournier and Lehr (2018) find the critical risk premium to range between 0 (for Belgium and Netherlands) and 3.32% (for Ireland). Interestingly, the risk premium for Greece is 2.96%. [22] Such high levels of risk premia required by GDP-linked bonds explain why GDP-linked bonds may only be appropriate for counties whose debt levels are "high, but not catastrophically high" as cautioned by Blanchard et al (2016a). Across all methods applied[23], Fournier and Lehr (2018)

[20] Costa et al. (2008) find that the novelty premium associated with Argentina's GDP-linked warrants is reduced by approximately 600 basis points during the eighteen months after issuance (Bowman & Naylor, 2016).
[21] They first estimate the growth process via a simplistic bivariate VAR model of the interest-growth differential and the primary balance for select euro area countries.
[22] Fournier and Lehr (2018) caution that the 90th percentile which has been used for the calculation of the 'critical risk premium' is not associated with sovereign debt crises for most advanced economies.
[23] Fournier and Lehr (2018) also estimate ARMA (p,q) models for the GDP growth rate, as well as a VAR with the OECD Composite Leading Indicator (CLI) and extract the persistence factor for growth

find that the risk premia associated with GDP-linked bonds are lower than CDS default premia, such that, on average, they correspond to a 40% reduction in the perceived probability of default (Fournier and Lehr, 2018). Similarly, Barr et al. (2014), explain that when the sovereign "approaches the debt limit," the default premium on conventional bonds may be lower than the GDP-risk premium on GDP-linked bonds, such that the probability of default is reduced. This is modelled to occur when the implied required GDP risk premium drops below 3.7% (Barr et al., 2014).

The specific design of the GDP-linked bond may bear an effect on the risk premium. Greater complexity in design will entail a greater cost for the pricing of risk and greater uncertainty with respect to the risk-reward profile of the bond, thereby increasing both the novelty and liquidity premia. Similarly, while call options have been used with state-contingent debt in the past, their embedding in the contract may entail a tradeoff between stabilization for the indebted sovereign against investor risk (IMF, 2017). In good states of the world, the sovereign may weigh the cost of making GDP-linked repayments on debt against the cost of buying back the GDP-linked bond and issuing a conventional, non-indexed bond with lower repayment obligations for times of high economic growth. Naturally, the specific design of the option may limit investors' profits in upside scenarios, inducing a *call option premium*, as also typical with inflation-linked bonds (IMF, 2017). For example, in Bulgaria, investors swapped contingent debt for non-indexed debt as the trigger appeared more likely (Borensztein and Mauro, 2002). Clearly, investor concerns with the call option are stronger the earlier the potential to exercise the option.

shocks, as they consider that a persistence highlights the risk of protracted recession and hence investors in GDP-linked bonds would require to be compensated via higher risk premiums. According to Fournier and Lehr (2018), although the novelty and liquidity premia may be substantial, they are by nature temporary and would not concern medium-to-long-term investors, who instead would be focused on the risk premium associated with GDP volatility.

3. Methodology

3.1. Simulation of the Debt-to-GDP ratio

This paper follows the methodology for debt-to-GDP simulations, as used by Blanchard et al (2016a, 2016b), Benford et al. (2016) and Cabrillac et al. (2016, 2018), albeit with differences: partially indexed debt-to-GDP ratios are foreseen in addition to plain-vanilla (non-indexed) and fully-indexed debt; and debt is indexed to real GDP growth, as in Blanchard et al (2016a, 2016b). Furthermore, it goes beyond the above in that sensitivity analysis on levels of the risk premium charged on indexed debt and on the percentage of debt-to-GDP being indexed is provided.

Simulations are performed in *Matlab*[24] and are based on the following standard equation for the evolution of public debt dynamics:

$$\Delta d_t = \frac{i_t - g_t}{1+g_t} d_{t-1} - pb_t + sfa_t \quad (6a)$$

where Δd_t represents the change in the debt-to-GDP ratio for country i, $i_t$represents the level of the nominal interest rate for country i, g_t represents the level of nominal economic growth d_{t-1} stands for the debt-to-GDP ratio in the previous period for country i, $pb_{i,t}$ represents the primary balance ratio for country i and $sfa_{i,t}$ corresponds to the so-called "stock flow adjustment" term for country i, a residual capturing, *inter alia*, market valuation effects and contingent liabilities.[25] In this paper, the code has dropped the stock-flow adjustment term due to data limitations for the early EMU period. As historical counterfactuals do not envisage the PSI, the bias of this omission in the counterfactual should be limited[26]. Thus, the following equation is used for simulation purposes:

[24] The Blanchard et al. (2016b) relevant code has been altered to consider the above differences for the application to this paper.
[25] The stock flow adjustment term is explicitly monitored and detailed for EMU countries in the context of EDP (Excessive Deficit Procedure).
[26] The IMF WEO does not report the Stock-flow-adjustment term (sfa), while AMECO reports of the sfa only provide data for 2010-2016. Clearly, this is an inherent limitation in the results of the present study.

$$d_t = \frac{1+r_t}{1+g_t} d_{t-1} - pb_t \quad (6b)$$

where r_t and g_t are the effective interest rate on government debt and the rate of economic growth in real terms, respectively.

A number of shocks may govern the alternative plausible paths for debt-to-GDP, as follows:

$$\Delta d_t = \frac{(i_t+\varepsilon_t)-(g_t+\varepsilon_{g,t})}{1+(g_t+\varepsilon_{g,t})} d_{t-1} - (pb_t + \varepsilon_{PB,t}) + sfa_t, \quad (7)$$

where $\varepsilon_{i,t}$, $\varepsilon_{g,t}$ and $\varepsilon_{PB,t}$ can be assumed to be drawn from a joint normal distribution. Other models use a single error term capturing the accumulation of all the above shocks at the end of the equation. Economic literature suggests that this error term plays a significant effect on the debt evolution dynamics (Campos et al. (2006) and Abbas et al. (2011)). Naturally, the error terms for each of the three variables may either reinforce each other or partially offset the effect of one another on the evolution of debt dynamics, as opposed to the functioning of a single error term.

Equation (6b) for the evolution of public debt is simulated based on 10,000 paths, a standard number of paths in the relevant literature, with the exception of Chamon and Mauro (2005), who apply 50,000 paths. An algorithm is used for the purpose of generating a forecast distribution across macroeconomic scenaria and over time for debt-to-GDP ratios of i. conventional debt (non-indexed); ii. fully indexed debt; and iii. partially indexed debt. Simulations draw on IMF macroeconomic forecast inputs, simulate macroeconomic data inputs in the equation for the evolution of the public debt ratio, endogenously calculate resulting per-period risk-premia based on the level of sovereign indebtedness, exogenously apply a novelty premium for GDP-growth indexation and exogenously account for some percentage of sovereign debt being indexed.

Historical Counterfactual

The below steps are followed in two cases, which are distinguished according to the baseline macroeconomic scenario input in simulations: *case a*, which uses IMF 2010 forecast data

(IMF, May 2010), and *case b*, which uses the actual historical macroeconomic data as inputs into the baseline. Case a represents a forecast as would have been performed at the time in 2010; case b uses actual historical annual data for 2010-2018 as reported by the IMF, to produce the forecasts which would have been produced by an omniscient analyst as in 2010.

Year-end macroeconomic inputs for real GDP growth, the primary balance ratio and the effective real interest-rate on Greek government debt (up to the end of 2009) are calculated based on reported associated nominal data (see data section 4).

Calculated year-end data for the three macroeconomic variables (for years 2000-2009) are used to compute a variance-covariance matrix of the three variables.

For *case a*, the baseline macroeconomic forecast path of the input variables (as reported by the IMF in 2010) is used to simulate a range of forecast macroeconomic scenaria from the standpoint of 2010. Simulations, therefore, are performed according to the IMF baseline (for 2010-2019) as in the macroeconomic scenario of the IMF Staff Report upon the request of the first bailout programme for Greece in 2010 (IMF, May 2010) and draw shocks from the variance-covariance matrix of historical data up to 2009.

For *case b*, actual macroeconomic outcomes (known ex post) are included as the baseline macroeconomic forecast path, such that baseline simulations are as if perfect foresight were in place.[27]

In each case, semi-parametric Monte Carlo simulations using10,000 macroeconomic paths using shocks drawn from the variance-covariance matrix are performed to derive the paths of each of the three macroeconomic variables (r, g, pb).[28]

[27] Naturally, the ex-post claim of perfect foresight is limited due to the endogenous effect of the ex post bailout loans and conditionality first-order and second-order macroeconomic effects incorporated in historical data over 2010-2018.

[28] Monte Carlo simulations are performed for the three variables via matrices which involve multivariate random number generation, with the historical standard errors superimposed so as for country-specific historical patterns to be preserved, as in Berti (2013) and as in the European Commission (2019). Thus, while random numbers are generated for historical forecasts, the evolution of the variables is not purely stochastic; rather, it is constrained by individual-country historical dynamics via the addition of the country-specific standard error term for each variable. This has been

For indexed (GDP-linked) debt simulations, an additional GDP (novelty) risk premium k is added to simulated paths for the interest rate, as well as the difference between the simulated real growth rate minus the baseline IMF forecast growth rate for each period, according to the following *indexation rule*:

$$r_{indexed,t} = r_t + \omega * (g_t - g_{Base\,t}) + k\ , \qquad (8)$$

where the coupon rate is equal to the (simulated) baseline non-indexed real effective interest rate plus a premium based on the extent to which (simulated) real growth exceeds the baseline forecast for real GDP growth, plus a novelty risk premium (k), which is exogenous to the model and lies in the range of 1% to 3.5%, in line with the relevant literature. This novelty premium captures the combined effect of the novelty premium as well as risk attitudes related to the quality of reported GDP statistics. Alternative values of *k* are input to the model to check for the sensitivity of the resulting debt-to-GDP distribution. A more elaborate setup could have linked the value of k to the degree of transparency and accuracy of GDP statistics.

The selected indexation formula follows Schroder et al. (2004), who first moved beyond "GDP-linked" schemes into "growth-linked rules." More recent literature has also adopted this selection (eg. Blanchard et al., 2016a).

For *case b*, the worse-than-expected-in-2010 actual growth benchmark baseline is expected to increase the distance between simulated growth rates and the baseline. *The hypothesis is that simulations for indexed debt ratios in the historical counterfactual b will be higher than those in a, and that b will result in stronger rejections of the GDP-linked bonds case.* This outcome is expected by the design of GDP-linked bonds and the method of indexation proposed. In particular, we expect the overindebtedness risk premium to dominate any fiscal space generated by the indexation scheme due to lower growth due to the fact that the Greek

incorporated to compensate for the theoretical simplicity of the macroeconomic dynamics included and to ensure that forecasts are more representative of the public debt dynamics of Greece. For each point in time and for each of the 10,000 paths, the value of GDP growth, of the interest rate and of the primary balance ratio is simulated around the baseline.

government is heavily indebted. Therefore, ex ante, it is clear that conclusions are highly contingent on the contractual form of indexation, and as with all derivative financial products, the devil lies in the detail. In turn, this implies an additional layer of uncertainty: the government's main focus on any relevant contracts should be based on the indexation scheme suggested against some set of future path ratios which is highly uncertain, *ex ante*. Different macroeconomic scenaria would be best served by different indexation contracts.

In *equation 8*, the parameter ω represents the degree of indexation, i.e. the percentage of the public debt ratio that is indexed (ω ∈ (0, 25%, 50%, 75%, 100%)). Full indexation corresponds to ω=100% and no indexation (i.e. 'plain-vanilla' debt) corresponds to ω=0%.

The above indexation shields the sovereign against 'unexpected' deviations from the forecast path of GDP growth.

In contrast, the interest rate on conventional non-indexed debt is modelled based on simulated interest rates:

$$r_{non-indexed,t} = r_t \quad (9)$$

where r_t corresponds to the simulated interest rate from the above step.

A major difference in the source of variability between the two cases (indexed and non-indexed) emerges: For indexed debt, the variability of the effective interest rate arises due to the variability of the deviation of the simulated growth rate from the baseline forecast and the degree of indexation plus some novelty premium k. In contrast, for non-indexed debt, variability is based on simulated interest rates, which in turn are partially affected by the history of the variability of the joint distribution of the three macroeconomic variables, and partially random.

Taking 2009 as the last historical known annual data point, 10,000 simulations of the evolution of the public debt ratio according to Equation *5.6b* are taken for years 2010-2018, using the above-mentioned inputs for simulated growth rates and interest rates as inputs. To

use the above notation, simulations follow the below equations for the evolution of the public debt ratio:

For non-indexed debt, the following formula is applied:

$$d_{non-indexed,t}=\frac{1+r_{non-indexed,t}}{1+g_t} d_{t-1}\text{-}pb_t \quad (10)$$

For fully indexed debt, the following formula is applied:

$$d_{indexed\ t}=\frac{1+r_{indexed,t}}{1+g_t} d_{t-1}\text{-}pb_t \quad (11)$$

For partially indexed debt, the following formula is applied:

$$d_t=(1-\omega)\left(\frac{1+r_{non-indexed,t}}{1+g_t} d_{non-indexed,t-1}\right)+\omega*(\frac{1+r_{indexed,t}}{1+g_t} d_{indexed,t-1})\text{-}pb_t \quad (12)$$

According to the outcome of simulations for each period, an additional *credit risk premium* (RP_t) is calculated. The level of the estimated risk premium depends on whether the simulated public debt ratio exceeds a threshold of overindebtedness. This risk premium is subsequently added to the debt-to-GDP simulations of *equation 6b* as follows:

$$d_t=\frac{1+r_t+RP_t}{1+g_t} d_{t-1}\text{-}pb_t \quad (13)$$

This premium is related to the level of debt-to-GDP in the previous period (as observed by financial markets when forming expectations) and its deviation from the IMF forecast,[29] according to the following non-linear rule:

$$RP_t=\beta*(d_{t-1}-d\_IMF_{t-1}), \quad (14)$$

[29] The above equation is suggested in the methodology employed by Blanchard et al. (2016). Alternatively, in line with standard interest-rate feedback rules used in Debt Sustainability Analysis (DSA) models, a linear function of the risk premium against the debt-to-GDP ratio could have been used as follows:

$$RP_t=0.04*\left(d_{\_,t-1}-60\%\right)$$

where the risk-premium increases by 4 percentage points for each deviation of the debt-to-GDP ratio above the 60% debt-to-GDP threshold (also the Maastricht limit), following Laubach (2009), Ardagna, Casseli, Lane (2006) and Engen and Hubbard (2005).

where β=0.03 if d_t>140% and β=0.02 if d_t≤140%.

The non-linearity introduced by the value of the parameter β captures the higher sensitivity of government bond yields for very highly indebted countries. 140%[30] was used as an arbitrary *debt threshold of 'overindebtedness'*, as in Blanchard et al (2016a, 2016b).

Therefore, a two-stage procedure of simulations is applied for the calculation of default risk premia on government debt.

For all years in the forecast horizon under each case, the distribution of debt-to-GDP ratios, and its percentiles (1st, 5th, 35th, 50th, 65th, 95th and 99th percentiles) correspond to simulated values generated by the 10,000 simulations in each case (non-indexed, partially indexed, fully indexed debt). The 1st percentile (0.01) corresponds to the lowest 1% of simulated debt-to-GDP ratios for each year. Similarly, the 99th (0.99) percentile corresponds to the highest 1% of simulated debt-to-GDP ratios for each year. In the fan charts, the upper path corresponds to the 99th percentile whereas the lowest path corresponds to the 1st percentile of the forecast GDP-linked and conventional debt-to-GDP ratio distribution for each country.

Naturally, forecast uncertainty increases with the forecast horizon, thus, explaining the resulting shape in fan-charts for public debt-to-GDP ratios, as standard in debt sustainability models. The 'opening' of the fan-chart portrays an increase in the range of debt-to-GDP ratios provided between the 1st and 99th percentiles of the simulated debt-to-GDP ratios for each year. By construction and via the setup of the indexation rule, GDP-linked debt ratios shall, in most cases, lie above those for conventional debt due to the additional premium (k) added to the debt dynamics under indexed debt. However, the following opposite effects are in place compared to conventional debt: when GDP growth is high (compared to the forecast baseline), debt repayment obligations under GDP-linked bonds are higher even though debt dynamics are more favourable as the interest-growth differential (r-g) is likely to shrink,

[30] 140% has been selected based on Blanchard et al. (2016b). This threshold is also validated by our analysis of a threshold model of the Greek sovereign spread with debt-to-GDP as the threshold transition variable.

which in turn decreases the multiplier on public debt. The opposite is true when GDP growth is relatively low (compared to forecasts). The novelty premium counteracts some of the increase in the fiscal space granted when worse-than-expected GDP-growth outcomes emerge under indexed debt.

Under the applied *symmetric rule of indexation* (which need not be the case in reality), GDP-linked bonds provide insurance during times of lower-than-expected economic growth yet compensate for this via higher debt repayments during 'good economic times'. Due to the additional novelty premium, *it is expected that only under the worst macroeconomic scenario will debt-to-GDP ratios under GDP-linked debt be lower to the case of conventional debt.*

The above methodology was selected due to the lack of precedence of any GDP-linked bond issuance, which would have potentially enabled the use of more standard methods such as the Synthetic Control Method (SCM).[31]

3.2. Implicit Model Assumptions and Limitations

The following assumptions are implicit to the model and responsible for certain limitations in results. Firstly, as cautioned by Benford et al. (2016), due to the use of a joint normal distribution, the model implicitly assumes a simple, linear dependence structure between variables, thus, underestimating the probability of tail events (fat tails), which have been deemed to be critical for macroeconomic variables (Fagiolo et al., 2008). In the presence of fatter tails, the benefits of GDP-linked bonds should be probably even more pronounced (Benford et al., 2016).[32]

Secondly, as detailed above, the effective interest rate is used instead of the actual modelling of interest rates on new debt. Naturally, forecasts will diverge from real-time results;

[31] The Synthetic Control Method (SCM) has recently been applied in the context of the historical evaluation of Greek debt sustainability by Alcidi and Gros (2020), albeit with respect to GDP-per capita. GDP-linked bonds are not the focus of this paper.
[32] Bootstrapping techniques could be applied to the residuals of a VAR on public debt to capture a more realistic distribution for the standard errors used to generate the simulated variables.

however, due to severe data constraints in constructing an extended debt-sustainability analysis model, which in turn, would contain additional assumptions about the type of bonds issued in each period, the effective interest method is a standard compromise in similar macroeconomic models. It implicitly assumes that public debt is composed of similar type, currency and maturity bonds, which is a simplification compared to reality. On this note, it is worth mentioning that unlike previous models in the literature (except for Blanchard et al (2016a, 2016b)), the default risk premium on debt is an endogenous function of the level of debt-to-GDP. Nevertheless, no additional risk premium is modelled on conventional bonds due to the introduction of GDP-linked bonds in the case of a 'mixed debt' portfolio, i.e. we do not consider cross-interactions between the interest rate charged on indexed and non-indexed debt, when both are present in the government debt structure.

Thirdly, all public debt is assumed to be in the domestic currency, such that external debt and exchange-rate effects are not explicitly considered in the model. Clearly, this represents a drawback with respect to insights, yet the vast majority of advanced countries' debt, and in particular EMU public debt is denominated in the domestic currency (the euro).

Fourthly, shocks are assumed to be constrained to one standard error of identical and independent distributions over time, such that shocks in period t do not affect shocks in period t+1.

Furthermore, simulations of the debt-to-GDP ratio under indexed and non-indexed debt implicitly assume that the same dynamics govern the joint distribution of growth and the primary balance in the case of indexed and when conventional debt is used. This may not be realistic, as the change in fiscal space generated in the presence of GDP-indexed debt could affect growth levels (Benford et al, 2016).

A zero stock-flow adjustment is assumed in the equation applied to government debt ratio simulations.

In addition, the model assumes no fiscal reaction function, such that the primary balance is determined solely by the historical joint distribution of growth and effective interest rates since 1999, as in Benford et al. (2016) and Blanchard et al. (2016a).

Unlike the majority of papers on GDP-linked bonds, this paper has extracted nominal data, yet indexation is based on the real effective interest rate on government debt outstanding rather than on the nominal interest rate. This choice follows Blanchard et al (2016a) to be line with the Blanchard et al. (2016b) proposed method followed in the simulations.

Last but not least, the proposed methodology emphasizes the stock of public-debt-to-GDP ('stock perspective') without accounting for Gross Financing Needs. The latter requires detailed data on bond maturity dates, *inter alia*, and constitutes a complimentary approach ('*flow perspective'*).[33]

3.3. Summary of Code

Summarizing the above, the following steps are taken by the code applied:

- *Set number of simulations to 10,000.*
- *In case a set the baseline equal to the IMF macro baseline as in 2010; for case b set the baseline equal to actual reported data for 2010-2018. Force long-term baseline forecasts (beyond t+5) to be constant and equal to their t+5 value for the real interest rate, the real GDP growth rate and the primary balance-to-GDP ratio.*
- *Based on historical data (2000-2009), calculate the variance-covariance matrix.*
- *Perform semi-parametric Monte Carlo simulations for the real interest rate, the real GDP growth rate and the primary-balance-to-GDP ratio.*
- *Calculate the simulated indexed bonds interest rate according to Equation 8.*

[33] Alcidi and Gros (2018) offer an overview of Debt Sustainability Analysis, as currently applicable by policymakers. For the flow perspective and an application to Greece (also in relation to the Greek sovereign spread), see Gabriele et al. (2017). For an evaluation of the Debt Sustainability Analysis applied on the Greek government debt over the course of three Economic Adjustment Programmes, see Alcidi and Gros (2020). For an examination of the Greek government debt sustainability as in 2018, see Eichengreen et al. (2018).

- *Based on simulated macroeconomic variables, simulate the evolution of debt: i. if all debt is conventional; ii. if all debt is indexed to GDP growth; iii. if debt is partially indexed to GDP growth.*
- *Calculate an appropriate risk premium based on the ensuing debt-to-GDP ratio under each model according to an overindebtedness threshold*
- *Find the simulated distribution of Debt-to-GDP of all paths*

A more elaborate version of the exact steps taken is presented in Appendix 2.

3.4 Testable Hypothesis

In a world plagued with sunspots and regions of multiple equilibria, the reduction in the range of possible public debt ratios and the shielding from growth-shock effects could prove to be beneficial-particularly for the worst 1 percent of simulated debt paths. Namely, in the parlance of multiple equilibria, GDP-linked bonds are expected to shrink the size of the intermediate region of fundamentals. Therefore, *we expect the indexation of debt to GDP growth to result in a lower variance and smaller range of simulated debt ratios for indexed debt, as opposed to non-indexed debt.*

In line with panel-based findings, we expect the worst percentile of simulations (at least for some low risk premium) to benefit from the introduction of GDP-linked bonds. Cabrillac et al. (2016, 2018) find that GDP-linked bonds also provide some stabilization for the 95^{th} and 99^{th} percentiles of paths of simulated debt ratios across time. Therefore, *we expect lower government debt ratios for the 99^{th} percentile of simulated indexed debt-to-GDP than for the equivalent percentile for non-indexed simulated debt-to-GDP ratios.*

As the actual macroeconomic baseline scenario for the historical counterfactual was far worse to that of the baseline forecast by the IMF in 2010, *we expect debt ratios under case b to be much higher on average compared to case a.*

Overall, following the literature on GDP-linked bonds and the caution against examples of "catastrophically" heavily indebted countries by Blanchard et al (2016a), *we expect the*

overall outcome of sensitivity analysis not to present a strong case in favor of GDP-linked bonds for Greece. Furthermore, *for median paths of debt, the highly indebted status of Greece should not suggest that indexation to GDP-linked bonds would make sense.*

4. Data

Post-1999 annual data for Greece on nominal GDP at market prices, the GDP Deflator, Public Debt, Interest Payable on Debt and the Primary Balance has been obtained from the IMF World Economic Outlook (WEO) database. Historical counterfactual simulations use 2009 as the starting point (t=0), drawing on IMF Review annual data for 2009, such that the value of 2010 (which is affected by the interim 2010 bailout loans) is the first forecast value.

For case a, the IMF WEO forecasts for each macroeconomic variable for years up to t+5 have been incorporated in simulations, namely forecasts for years 2010-2015. For years t to t+5, these IMF WEO forecasts have been included as the baseline scenario, as in the IMF Staff Report on Request for a Stand-By Agreement by Greece in May 2010 (IMF, May 2010). Thereafter, forecasts are kept constant to the last reported figure. For case b, actual reported data were incorporated as the macroeconomic baseline, as extracted from the IMF World Economic Outlook (WEO) database.

The following calculations are applied under both cases (a and b):

Real GDP at time period t has been calculated based on GDP at market prices and the GDP Deflator according to the following formula:

$$GDP_{real,t} = \frac{GDP_{nominal,t}}{GDP\ Deflator_t} * 100 \quad (15)$$

Real GDP growth has been calculated as the percentage change in real GDP as follows:

$$Real\ GDP\ growth_t = 100 * (\frac{GDP\ real\ _t}{GDP\ real\ _{t-1}} - 1) \quad (16)$$

Inflation has been calculated as the percentage change in the GDP Deflator as follows:

$$GDP\ Deflator_t = 100 * (\frac{GDP\ Deflator_{\ t}}{GDP\ Deflator_{\ t-1}} - 1) \quad (17)$$

Debt-to-GDP and the primary balance as a percentage of GDP have been calculated as simple ratios of respective data obtained from the WEO.

The Nominal Implicit Rate on public debt has been calculated as the ratio of the interest payable on public debt in period t over the previous period's public debt:

$$Nominal\ implicit\ rate_t = \frac{Interest\ Payable_t}{Debt_{t-1}} * 100 \quad (18)$$

The real implicit rate for country i in period t has been calculated based on the Fisher Equation as follows:

$$\text{Real implicit rate}_t = \frac{1+Nominal\ implicit\ rate_t}{1+inflation_t} - 1 \quad (19)$$

Due to the various categories and maturities of public debt, the implicit interest rate has been used as the effective interest rate on total public debt for the purpose of simulations.

The two baselines for the three main variables feeding into the simulations, namely the primary balance surplus (as a percentage of GDP), the real effective interest rate on the Greek government debt and the Greek public debt-to-GDP ratio are depicted in *Figures 1* and *2*.

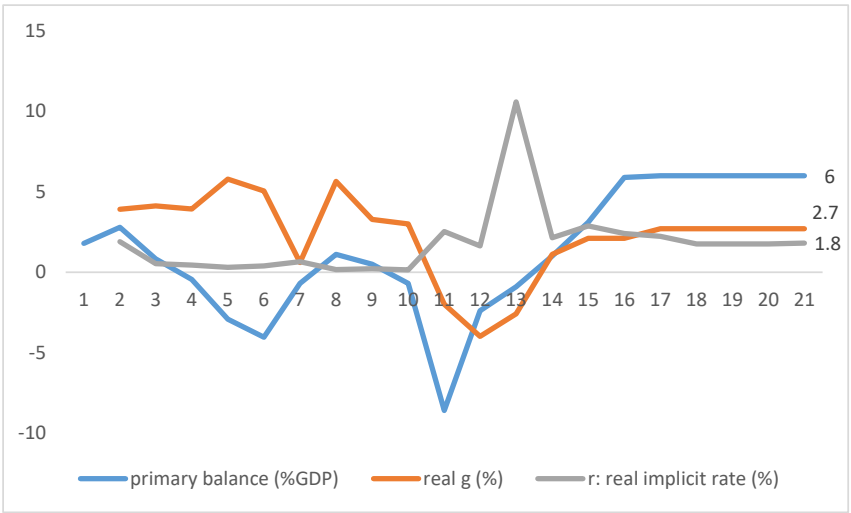

Figure 1. IMF 2010 Baseline

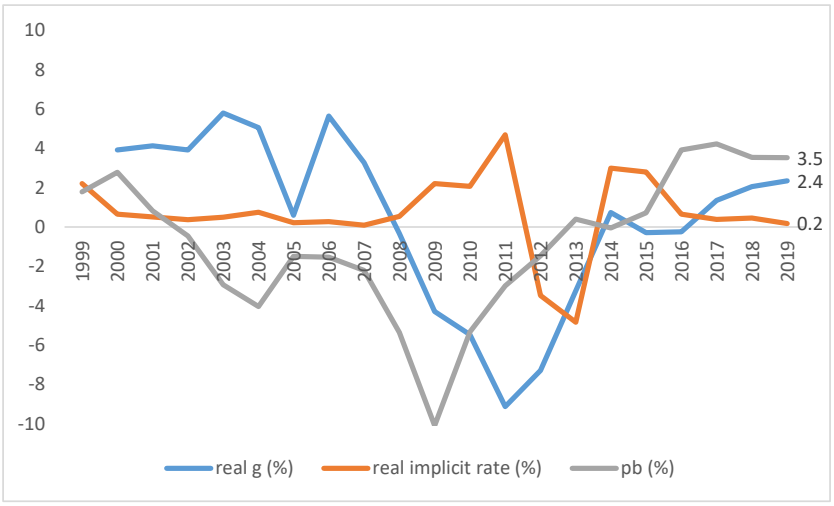

Figure 2. Actual Historical Data Baseline

5. Analysis of Results

The results of simulations and sensitivities with respect to the degree of indexation (ω) and novelty risk premium (k) are presented in the Appendices 3 and 4. As the only model outcome is the year-end public debt stock, evaluation in the analysis is restricted to this criterion, which is clearly limiting for the analysis of results compared to the multifaceted scope of debt sustainability. Nevertheless, the broad consideration of uncertainty, serves to compensate for the otherwise limited number of model variables.

5.1. Historical Counterfactual (ex ante Baseline Macroeconomic Scenario)- Case a

Results for case a are presented in Appendix 3.

First, the actual path of the historical Greek government debt ratio is mapped onto the distribution of simulated non-indexed government debt ratios as follows: Across all years, actual data were worse than the 99th percentile of the simulated distribution, except for 2012, when actual data correspond to the region between the 65th and 95th percentiles. Therefore:

- *The actual historical path of the Greek government debt ratio turned out to correspond to the worst 1 percent of possible forecasts as in 2010.*

- *Actual data in 2012 were slightly better than the worst of worlds simulated for other years, due to the short-lived and insufficient effect of the PSI.*[34]

Second, simulations of non-indexed debt ratios show that in the best 1 percent of future paths envisaged in 2010, the Greek government debt could have been on a declining path. The median path points to a peak of the Greek government debt in 2012 at approximately 140 % GDP and subsequent decline in debt ratios. The 99th percentile of simulated non-indexed public debt ratios points to a peak in the Greek non-indexed government debt ratio at approximately 178% GDP in 2014, and subsequent decline in public debt ratios.

Third, it is worth asking whether a policymaker with the baseline macroeconomic scenario of the IMF prior to the programme would have had any reason to opt for GDP-linked bonds, and if so, under which circumstances. Simulations based on the ex-ante IMF baseline show that *for a policymaker in 2010, it would be worthwhile to recommend GDP-linked bonds to the Greek government if and only if the novelty premium on such bonds were less than or equal to 200 bps (k≤200bps) and if and only if, the policymaker were certain that the worst one percent of possible future government debt paths would materialize* [35]. For the worst percentile, small improvements are obtained if novelty premia remain under 200bps. These conclusions are based on a comparison of equivalent indexed and non-indexed percentiles for each novelty premium.

Fourth, with respect to the shape of the backtested public debt ratio path and debt stabilization, the following are noted: actual data pointed to a multipeaked path in time and some degree of stabilization to levels close to 175%-180% GDP by the end of the third programme for Greece; constantly increasing public debt ratios and, thus, explosive debt dynamics are noted solely in the following cases: for a risk premium k=250bps under the 99th percentile path with 100%-indexed debt (ω=100%); for k=250bps under the 95th and 99th

[34] The short-lived positive impact of the PSI on Greek debt sustainability, countenanced by adverse growth dynamics thereafter is also shown in Alcidi and Gros (2020).
[35] The policymaker would also marginally recommend GDP-linked bonds based on the 95th percentile under a novelty premium of k=100bps.

percentile for ω=100%; for k=250bps under the 99th percentile for ω=100%; for k=350bps for the 50th-99th percentiles with ω=100%; for k=350bps for the 99th percentile with ω=50%; for k=350bps for the 95th and 99th percentiles with ω=75%. *Therefore, only at low levels of indexation does GDP-linked debt stabilize the public debt ratio (ω=25%).*

Fifth, considerable losses in terms of higher percentage points of GDP for the public debt ratio emerge under optimistic paths of the Greek government debt ratio.

Sixth, *in the absence of a guarantee of 200bps as a cap to the novelty premium associated with GDP-linked bonds, a policymaker in 2010 with the baseline forecast of the IMF at the time would not have taken the initiative to recommend a risky novel financial product, even if he believed in the worst of worlds for the future path of the Greek government debt.* This cut-off point is selected to avoid the emergence of explosive paths.

Seventh, the range of the public debt ratios between the 1st and 99th percentiles is lower the higher the degree of indexation. Narrower fan charts are depicted under GDP-linked bonds, yet the median of associated distributions is higher to that under non-indexed debt.

Eighth, non-indexed debt ratios never exceed 200%GDP. In contrast, the 99th percentile under ω=100% and for k ≥350 bps exceeds 200% GDP at some point.

5.2. Historical counterfactual (ex-post baseline Macroeconomic Scenario)- Case b

Results are presented in Appendix 4.

This case repeats the above exercise assuming that some omniscient policymaker would have based the macroeconomic baseline input scenario on data equal to the actual historical data, as reported at the end of the programme in 2018.

The following remarks are made based on the output of simulated non-indexed and actual public debt ratios: First, a mapping of actual 2010-2018 data to the distribution of simulated non-indexed debt ratios shows that actual data corresponded to the following: the range

between the 65th and 95th percentiles in 2011, the 5th percentile in 2012 due to the effect of the PSI on actual data, the 35th percentile in 2013, the range between the 50th and 65th percentiles in 2014-2016, the 65th percentile in 2017, the range between the 65th and 95th percentiles in 2018. Therefore:

- *In spite of all exogenous interventions, bailout loans and reforms, actual Greek data started off at values corresponding to the 65th to 95th percentile of simulations and ended in the same percentile range at the end of the programmes in 2018.*
- *The PSI was highly successful in placing the Greek debt ratio back into the best 5 percent of possible world outcomes as in 2010, yet the underlying dynamic or possible endogenous feedback effects threreafter proved to be sufficiently detrimental to push the Greek debt ratio into its original location in terms of percentiles of possible outcomes.*

Second, in contrast to the simulated non-indexed debt counterfactual based on the IMF 2010 macroeconomic baseline (i.e. in contrast to case a), which presents the Greek government debt to be stabilizing by 2019 (albeit at high public debt ratios), *non-indexed debt simulations that draw on the actual macroeconomic baseline (case b) show that the 99th percentile of non-indexed debt depicts an explosive dynamic* (i.e. it is constantly increasing for the foreseen years). In retrospect, actual public debt ratios proved to correspond to the worst 99th percentile of simulated non-indexed public debt ratios. Therefore, prior to the contracting of the bailout loans, *if the policymaker had perfectly foreseen the actual macroeconomic path, they would have concluded that the path of the public debt ratio was explosive.*

Third, simulations of non-indexed debt using ex ante macro inputs show that under the 95th and 99th percentile, the Greek debt exceeds 200% GDP as early as in 2011 and reaches 250% GDP by the end of the backtesting horizon for the worst percentile.

Fourth, when examining the 65th-95th percentile of debt-ratio paths (which most closely corresponds to the majority of actual debt outcomes), some degree of indexation may have

made sense if and only if the risk premium were capped at k=100bps. The only case when the simulated non-indexed median path is close to a median path that includes some degree of indexation to economic growth occurs when k=100bps and ω=25%. *Beyond k=150bps, the introduction of GDP-linked bonds would have worsened the final debt outcome, even when comparing the worst 1 percent of worlds.*

Fifth, across all outcomes, GDP-linked bonds reduce the 1st-99th percentile range of simulated outcomes, compared to non-indexed debt, as foreseen in the literature.

Sixth, for the Panglossian policymaker, for the approximately 30% best of possible future worlds prior to the first adjustment programme,[36] GDP-growth indexation of the Greek government debt would have resulted in substantially worse debt ratios than actual. The imposition of a novelty premium reduces the benefits of GDP-linked bonds.

Seventh, *a novelty risk premium of 350bps, which according to the literature is internationally possible under the introduction of a new financial product, would have yielded a debt ratio in excess of 300% GDP by 2019 if the Greek debt were made to be fully indexed to GDP growth.*

Eighth, the higher-than-non-indexed debt ratios for GDP-linked debt in median and good outcomes of the world show that from the standpoint of the policymaker in 2010, any gains potentially achieved in a worst percentile path of future government debt ratios are eroded by substantially heavier losses in the event that a median or good state of the world emerges. Therefore, *only under "maxi-min" expectations (i.e. the desire to shield oneself against the worst case) would a policymaker even consider GDP-linked indexation. It is for this reason that the partial indexation sensitivities considered in this study (unlike elsewhere to date)[37] are important.*

[36] Or, for even higher percentage of optimistic paths depending on the assumed risk premium k.
[37] The sole exception is Fratzscher (2014), who however envisages partial indexation to correspond to the indexation of one particular category of debt in the Greek loan structure, namely that corresponding to the Greek Loan Facility (GLF), i.e. no sensitivities of the degree of indexation with respect to future paths are foreseen as in this paper.

Therefore, if economic policy were to rely on this tool for policy decisions in 2010, no policymaker with the benefit of hindsight (perfect foresight of the future macroeconomic scenario) would have opted for the introduction of GDP-linked bonds for Greece. This conclusion is based on a direct comparison of the percentiles to which actual historical data lie for non-indexed debt simulations over time against the equivalent percentiles under GDP-linked debt. Clearly, equivalent percentile debt ratios are higher under indexed debt than under non-indexed in the overwhelming majority of future worlds. Nevertheless, nobody could have precluded a very limited probability of a world where some degree of GDP-linked bonds in the government debt structure could have been slightly beneficial.

Conclusions are riddled by a number of limitations, inherent in the methodology applied: The counterfactual analysis is based on a world without the PSI debt write off and its second order endogenous effects, a world without bailout loans, and has not incorporated endogenous effects between simulated public debt ratios and macroeconomic outcomes, nor has it included the growth-enhancing impact of structural reforms that were imposed on Greece in the interim nor the negative impact of austerity and fiscal consolidation measures. More importantly, individual bond data, debt maturities and short-term liquidity effects, which in reality are crucial, have been left outside the scope of this method. Furthermore, the basic insurance effect of lower debt servicing under lower growth outcomes is not explicitly shown, such that simulations of indexed debt are biased asymmetrically towards higher debt outcomes via the novelty premium. This is due to the stock perspective adopted in simulations (as opposed to a complementary flow perspective, which would have been offered in the standard Debt Sustainability Analysis (DSA) excel template analysis with formal inputs of per-period bond data). Lastly, lower degrees of indexation ($\omega<25\%$) or a case under zero novelty risk premia ($k=0$) has not been examined.

Differences across the two counterfactuals (cases a and b) rest on the fact that the underlying macroeconomic inputs in the ex post data case (case b) are far worse than those expected under the baseline in 2010. Overall, across all cases, the shape of the path of the non-indexed

government debt ratio (i.e. whether it is increasing, decreasing, single-peaked or multipeaked) depends on the dominance of the terminal growth input assumption over the overindebtedness premium.

At first sight, given the worse actual input scenario for economic growth in case b, it seems counterintuitive that the ex post scenario-based simulations more strongly reject GDP-linked bonds than under case b. However, this result may be attributed to the stronger effect on the increase in the stock of government debt due to the 'overindebtedness' risk premium arising from higher levels of public debt against any per-period insurance benefit considerations due to lower levels of economic growth.

The application of judgement across the majority of possible simulations and input scenarios for the ex ante and ex post macroeconomic narrative for Greece would conclude that GDP-linked bonds would not have been beneficial for Greece; yet, due to the Lucas Critique, inter alia, such a claim cannot be made with absolute certainty.

This conclusion for GDP-linked bonds is in line with the literature that recommends GDP-linked bonds for highly indebted advanced economies, but not for "catastrophically" indebted cases (e.g. see Blanchard et al, 2016a). Greece is probably classified as a highly indebted country and requires *ad hoc* treatment. As simulations appear to penalize overindebtedness more heavily than they ease the adversity of the interest-growth dynamic due to GDP-linked bonds, similar conclusions would be expected for Greece as at the end of the Third Economic Adjustment Program in 2018 due to the high starting levels for the public debt to GDP ratio.

6. Conclusion

This paper has probed into the question as to whether historically (prior to the contracting of bailout loans), the introduction of GDP-linked bonds would have had any merit for Greece based on the criterion of the stock of debt outstanding as a ratio to GDP. The methodology of Blanchard et al (2016a, 2016b) has been reformulated to account for partial indexation and

sensitivity analysis. An application to the Greek debt and to counterfactual analysis has been offered.

Two sets of historical simulation outcomes of the counterfactual distribution of the Greek government debt ratio for years 2010-2018 are provided: a. based on the pre-programme IMF baseline; and b. based on post-programme actual macroeconomic data. Sensitivity analysis for various degrees of indexation as a percentage of the debt outstanding and for various levels of novelty premia associated with GDP-linked bonds was performed.

In spite of the various limitations of the method applied and expressed in the analysis section 5, neither of the historical counterfactuals would have validated the introduction of GDP-linked bonds in 2010. However, GDP-growth-linked debt could prove to act as an insurance against tail outcomes. In contrast, median outcomes would not have validated GDP-growth indexation of the Greek public debt. These results are in line with the literature, which points to indebted but not "catastrophically" indebted advanced economies as best candidates for the introduction of GDP-linked bonds.

The contribution of the paper has been to provide a historical counterfactual for the Greek public debt ratio both from an ex ante and an ex post perspective. To date, the single GDP-linked bonds study on Greece by Fratzscher et al. (2014) has not enabled such a distinction, nor has it examined the entire Greek debt as from the viewpoint prior to the first bailout loan. Furthermore, this study is the first to provide sensitivity analysis on the percentage of indexation and the GDP-risk premium.

Future research could combine a fiscal reaction function with the model's features to reveal the relative merits of GDP-linked bonds in countering reform fatigue. Debt Sustainability Analysis (DSA)-based outcomes using more elaborate, and potentially confidential, data on the detailed historical profile of the Greek government debt could prove more illuminating for the per-period stock and flow implications of GDP-linked bonds. Thus, a combination of the above method, with official data in a DSA excel template, could improve the analysis. In

addition, medium-term projections over the cycle and potential output growth could be accounted for. Future papers could endogenously search for the level of indexation that yields an optimal outcome according to well-specified criteria and mix of assumptions. Moreover, the effect of GDP-linked bonds on the maximum sustainable debt ratio and the probability of sovereign default could be examined, as in Barr et al. (2014). An application to other less heavily indebted Advanced Economies, with less complicated government debt structures, could prove more insightful and relevant to this instrument.

Notwithstanding the conclusions in this paper, which relate to a contractual market-based solution, an ad hoc political agreement of lower debt repayment on official loans under worse-than-envisaged economic growth outcomes could still be valid for the long-run debt restructuring measures and growth-adjusted mechanism discussed by policy circles on Greek loans. Furthermore, although the highly indebted status of Greece may not be welcoming to GDP-linked *bonds*, the findings in this paper do not preclude some degree of future debt indexation of the Greek government, once GDP-linked bonds have become mainstream by other advanced economy debt issuances, such that the novelty premium has been reduced.

Overall, and irrespective of any future simulation-based conclusions on GDP-linked bonds, as highlighted by Chamon and Mauro (2005), "financial engineering is not a substitute for sound institutions and good policies" (Chamon and Mauro, 2005). Clear and undisputed, credible commitment to growth-enhancing reforms and macroeconomic policies, which also facilitate the issuance of longer duration bonds, decreasing liquidity risks, is always a complement to any market-based solution.

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Appendix 1: A Brief History of State-Contingent Debt Instruments

State-Contingent Debt Instruments (SCDIs) are debt instruments which "bear a contractual debt service obligation tied to a pre-defined state variable and are designed to alleviate pressure on sovereign indebtedness and/or financing needs in a bad state of the world" (IMF, 2017). Different categorizations of state-contingent debt have been used, including inter alia, the distinction between *continuous adjustment debt* and *discrete adjustment debt*, or *indexed debt* versus *Contingent Convertible debt* or the distinction between *linkers* (principal-indexed), *floaters* (coupon-indexed), *and extendibles (IMF, 2017).*

State contingent bonds are bonds making payments based on the attainment of a particular state.[38] State-contingent bonds specify repayment terms in bond contract clauses ex ante, so as to improve the predictability in burden-sharing between the official sector (de facto senior) and the private sector, and allow for capital markets to incorporate these elements into risk analysis (Brooke et al, 2013). Two primary categories of state-contingent bonds include *sovereign CoCos* and *GDP-linked bonds,* which can be applied in a complementary fashion given that the former deal with liquidity issues while the latter resolve solvency concerns (Brooke et al., 2013).

State contingencies have long been considered in the context of debt instruments, associating repaying profiles with a variety of state variables. The first state-contingent bond, a 'Depreciation Note' was issued in 1780 by the State of Massachusetts (Benford et al., 2016). This constituted the first inflation-linked bond in history, indexing repayments to a basket of goods, such as corn, beef, wool and leather (Benford et al., 2016). In the aftermath of the sovereign debt crisis of the 1980s, academics called for the issuance of instruments tying repayment to exports (Bailey, 1983), commodity prices or GDP (Krugman, 1988; Froot et al., 1989) and evaluated the merits of state variables which are out of the direct control of a

[38] To some extent, all debt is state-contingent as the sovereign retains the right to default (Barr et al., 2014)

sovereign (commodity prices) against those which may be partially influenced by government choices (exports, GDP) (Borensztein and Mauro, 2002).

In the 1990s, Shiller (1993) proposed the creation of "macro markets" for a perpetuity, namely claims on one trillionth of a country's GDP, granting creditors an equity-like stake in the economy while broadening the portfolio risk diversification and hedging options for investors (Borensztein and Mauro, 2002). Obstfeld and Peri (1998) further elaborated on Shiller's proposal and called for European governments to issue perpetual euro-denominated liabilities indexed to nominal GDP-per-capita growth (Borensztein and Mauro, 2002).

Given that repayment capacity is more closely associated with other state variables (e.g. tax revenues or the primary balance), Barro (1995) suggested that sovereign debt should be optimally indexed to government expenditure and consumption. Haldane (1999) suggested that debt should be indexed to commodity prices. Caballero (2002) examined the indexation of Chile's debt to the price of copper.

During the late 1990s and early 2000s, academics called for growth-indexation clauses to be introduced into debt instruments. Dreze (2000) examined the use of GDP-indexed bonds for sovereign debt restructuring in poor countries. Similarly, Varsavsky and Braun (2002) called for the conversion of Argentina's debt into GDP-indexed bonds (Borensztein and Mauro, 2002).

During the "Brady bond" deals of the 1980s and 1990s in Latin American countries, so-called "Value Recovery Rights" (VRRs), which were linked to commodity prices were issued (IMF, 2017). Value Recovery Rights allowed commercial banks to swap their holdings of government debt into those tradable instruments, removing these liabilities off their balance sheets (IMF, 2017). VRRs rested on the premise that restructured debt acquire "equity-like" characteristics, such that any improvement in the terms of trade or general economic conditions be associated with increased debt service payments on the part of the debtor (IMF, 2017). Sovereign bonds were essentially swapped into the equivalent of today's warrants,

promising repayment only on the upside. VRRs were embedded into bonds or issued as detachable instruments, often including some form of payment cap or call option. The state variables used for indexation were GDP, some commodity prices, or the terms of trade. Oil producers favoured indexation to the price of oil (IMF, 2017). In Chile, private firms issued bonds indexed to the price of oil (Borensztein and Mauro, 2002).

As such, GDP-indexed VRRs were issued by Honduras in 1989, Costa Rica in 1990, Bulgaria in 1993, Cote d' Ivoire in 1997 (IMF, 2017). In 1997, Bosnia & Herzegovina issued a detachable GDP-indexed warrant (IMF, 2017). Detachable commodity-price indexed VRRs were issued by Venezuela in 1990, Nigeria in 1992 and Mexico in 1990 (IMF, 2017). Bolivia in 1992 issued a non-detachable warrant. In 1991, Uruguay also issued a detachable VRR indexed to the terms of trade (IMF, 2017).

In more recent times, GDP-linked warrants were issued in the context of sovereign debt restructurings in Argentina (2005 and 2010), Greece (2012) and Ukraine (2015). Warrants contain contract clauses, according to which the payoff to the holder increases as a critical threshold in the state variable is surpassed. These derivative instruments therefore only share on the upside scenario for the sovereign. In the case of Argentina, indexation was to the level of real GDP, while Greece and Ukraine warrants were linked to the growth in Real GDP. The Ukraine warrant also entailed a more complex structure of caps and floors. A detailed analysis of the Argentinean GDP-linked warrants[39] is offered by Datz (2009) and Guzman (2016), who highlight the lower haircuts on investors who accepted these instruments in the context of sovereign debt restructuring. Xafa (2013) and Zettelmeyer et al. (2012) present the details of the Greek PSI deal, including the warrants issued as "sweeteners".

In 2015, Granada issued a revenue-indexed bond, linked to the revenues of its "Citizenship by Investment Program" (IMF, 2017). In the aftermath of the European sovereign debt crisis,

[39] The Argentinean GDP-linked warrants paid investors if all three conditions were met: 1. If actual real GDP exceeded the base case GDP of the previous reference year; ii. If the annual rate of real economic growth exceeded the reference rate and iii. payments did not exceed a cap (Costa et al., 2008).

policymakers and academics are further exploring the issuance of state-contingent bonds, particularly in the form of GDP-linked bonds.[40] In addition, as part of the reprofiling of the Greek official sector debt, a state-contingent mechanism was explored for official sector loans.

Other forms of sovereign state-contingent debt issued include Turkey's revenue-indexed bonds, which were non-interest-bearing to match the needs of sharia-compliant investors, non-tradable debt by the UK, Portugal and India, and the nominal-wage-linked bonds issued by Uruguay's public social security fund to match long-term liabilities (IMF, 2017).

Another major form of indexed debt and precursor to the idea of GDP-linked bonds are inflation-linked bonds. Inflation-linked bonds are a widely traded form of sovereign debt, issued primarily during normal times to ward off the erosion of investments by inflation. Building upon the so-called "Canadian model" design, liquidity costs associated with inflation-linked bonds have been reduced. However, novelty premia are still present despite the large volumes being traded (IMF, 2017). Inflation linked sovereign bonds have, thus, been issued successfully both by Advanced and Emerging Market economies. Argentina, Brazil, Chile, Colombia, Hungary, India, Mexico, Peru, Poland, Russia, South Africa, Thailand and Turkey, as well as Australia, Belgium, Canada, France, Germany, Hong Kong, Israel, Italy, Korea, Spain, Sweden, the United Kingdom and the United States (IMF, 2017). Major investors in inflation-linked bonds are pension funds and other long-term institutional investors. When GDP-linked bonds are linked to nominal GDP (or nominal GDP-growth or nominal GDP-growth per capita), they entail an additional advantage, as they not only protect investors against the shocks to GDP but also offer protection against inflation.

In the context of Official Sector Loans, sovereign debt restructurings have also involved the use of state-contingent sovereign debt: the concessional loans to post-HIPC countries by

[40] Building on seminars and work by the Bank of England and Bank of Canada, a London Term Sheet has been developed for GDP-linked bonds. In 2016, the G20 explored the primary issues associated with state-contingent debt.

Agence Francaise de Development (AFD) which involved a “floating grace period” for principal payments, which was not triggered; and Venezuela’s Petrocaribe PDVSA loans (IMF, 2017). In 2015, prior to the contracting of the third economic adjustment program by Greece, Fratzscher et al. (2014) suggested that the interest on loans under the Greek Loan Facility (GLF) be linked to the level of GDP growth, while caps and floors could also be included in the design to reduce the overall level of future uncertainty.

More recently, academics have suggested the use of existing instruments to replicate the features of GDP-linked bonds as a “second best” case to GDP-linked bonds. They suggest replicating the effects of GDP-linked bonds through a combination of other existing financial instruments. As such, variable rate debt including inflation-linked debt to hedge against demand and monetary policy shocks and Euribor-linked debt to hedge against demand and supply shocks could be used. Fenz and Holler (2017) find evidence of the potential for both state-contingent instruments for Austria over 1999 and 2016.

Appendix 2: Methodology

The method applied in this paper follows the code of Blanchard et al. (2016b), albeit with minor modifications. As an overview, semi-parametric Monte-Carlo estimations (Berti et al., 2013). The baseline for non-indexed debt is simulated. An overindebtedness risk-premium is added. Two additional risk premia (a GDP risk premium and a novelty risk premium) are included. 10,000 senarios for the forecast paths of the public debt ratio are simulated for indexed and non-indexed debt. The outcomes of the simulated distributions of indexed and non-indexed debt over time are compared. The above are repeated for sensitivity analysis with respect to the exogenous novelty premium (k) imposed on GDP-linked bonds and with respect to the percentage of debt-to-GDP being indexed to growth (ω).

<u>Exogenous inputs: (for each of sensitivities)</u>

- Number of years (T=10), number of scenarios (N=10,000)
- Data: r, g, pb/GDP (2000-2009 & Baseline forecast for 2010-2019) Baseline (Base)= IMF_2010 (Case a), ex-post data (Case b)
- Exogenously specify percentage of debt-to-GDP to be indexed: ω=0%, 25%, 50%, 75%, 100%
    - For mixed debt-to-GDP: ω % indexed, (1- ω) % non-indexed
- Exogenously specify the formula (not inputs) for GDP-linked effective interest rate:
    - Include a GDP-growth risk premium ($g_t - g_{IMF\,t}$) & an exogenously specified novelty premium (k) (k=100,150, 200, 250, 300, 350 bps)

$$r_{indexed\,t} = r_t + \omega * (g_{i,t} - g_{base\,t}) + k\,, \qquad \text{(A.1)}$$

$$r_{non-indexed\,t} = r_t \qquad \text{(A.2)}$$

Preliminary Calculations

Stochastic simulations of alternative inputs to scenarios (r, g, pb, r_indexed): apply random-number generation around the variable inputs (real g, real r, pb/GDP)-actual data and IMF baseline; semi-parametric Monte-Carlo & var-covar-based shocks are drawn from historical data (2000-2009).

For each scenario number 1-10,000:

• Set **initial values** ($debt\_sim/GDP_{t=2010}$, $debt\_ind\_sim/GDP_{t=2010}$, $debt\_mix\_sim/GDP_{t=2010}$, $debt\_imf\_sim/GDP_{t=2010}$) for the first data input of the debt-dynamic

• Use actual $debt/GDP_{2009}$ & simulated inputs for the other variables (r, g, pb, r_ind), setting values for t-1=2009 for initial debt/GDP ratios for *equations A.3-A.5*

$$d_{non-indexed,t}=\frac{1+r_{non-indexed,t}}{1+g_t} d_{t-1} - pb_t \quad \text{(A.3)}$$

(non-indexed debt) t-1=2009

$$d_{indexed,\,t}=\frac{1+r_{indexed,t}}{1+g_t} d_{t-1} - pb_t \quad \text{(A.4)}$$

(indexed debt) t-1=2009

$$d_t=(1-\omega)\left(\frac{1+r_{non-indexed,t}}{1+g_t} d_{non-indexed\ t-1}\right)+\omega * \left(\frac{1+r_{indexed,t}}{1+g_t} d_{indexed,t-1}\right) - pb_t \quad \text{(A.5)}$$

(partially indexed debt) t-1=2009

$$d_{Base,t}=\frac{1+r_{Base,t}}{1+g_{Base.t}} d_{Base,t-1} - pb_{Base,t} \quad \text{(A.6)}$$

(Baseline) t-1=2009

• **Endogenous Credit Risk Premium**: For N=2-10, i.e. t=2010-2019 as in Blanchard et al (2016b)

Based on $debt\_sim/GDP_{t-1}$, :

$$\boldsymbol{RP_t} = \beta * \left(debt_{sim_{t-1}} - d_{Base_{t-1}}\right) \quad \text{(A.7)}$$

where β=0.03 if $debt\_sim_t$>140% and β=0.02 if $debt\_sim_t$≤140%.

Based on $debt\_ind\_sim/GDP_{t-1}$:

$$\boldsymbol{RP\_ind_{i,t}} = \beta * \left(debt\_ind\_sim_{\_t-1} - d_{Base_{t-1}}\right) \quad \text{(A.8)}$$

where β=0.03 if $debt\_ind\_sim_t$>140% and β=0.02 if $debt\_ind\_sim_t$≤140%.

(also for baseline)

- **Perform debt-simulations** by updating the debt dynamic:

$$d_{non-indexed,\,t} = \frac{1+r_{non-indexed,t}}{1+g_t} d_{t-1} - pb_t \quad \text{(non-indexed debt)} \quad \text{(A.9)}$$

$$d_{indexed\,t} = \frac{1+r_{indexed,t}}{1+g_t} d_{t-1} - pb_t \quad \text{(indexed debt)} \quad \text{(A.10)}$$

$$d_t = (1-\omega)\left(\frac{1+r_{non-indexed,t}}{1+g_t} d_{non-indexed,t-1}\right) + \omega * \left(\frac{1+r_{indexed,t}}{1+g_t} d_{indexed\,t-1}\right) - pb_t \quad \text{(A.11)}$$

(partially indexed debt)

$$d_{Base\_t} = \frac{1+r_{Base,t}}{1+g_{Base.t}} d_{Base,t-1} - pb_{Base,t} \quad \text{(Baseline)} \quad \text{(A.12)}$$

- Update r_sim, r_ind_sim using estimated credit risk premium

$$r_{indexed,\,t} = r_{indexed,\,t} + RP_{ind,t}, \quad \text{(A.13)}$$

$$r_{non-indexed,t} = r_{non-indexed,t} + RP_{\,t} \quad \text{(A.14)}$$

- Update the Baseline with new $\boldsymbol{r\_sim_{\_non-indexed,t}}$
- Repeat for scenario path 2…10,000. **END**
- Estimate percentiles of non-indexed debt, of indexed debt and of mixed debt (simulated distributions)→Use to create **fan charts**
- **Sensitivity Analysis:** Repeat the entire process for alternative combinations of **novelty premia (k)** & **percentage of debt indexed (ω)**
- Repeat entire process and the sensitivity analysis for **alternative baseline scenarios**

Appendix 3-Historical Counterfactual Results (Case a)

k=100bps

Greece_Simulations of Non-Indexed Debt-to-GDP (%)								Greece_Simulations of Fully Indexed Debt-to-GDP (%) ω=100%								Actual
	0.01	0.05	0.35	0.5	0.65	0.95	0.99		0.01	0.05	0.35	0.5	0.65	0.95	0.99	
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90	2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10	2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90	2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50	2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90	2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40	2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60	2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10	2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40	2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70	2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	109.76	114.07	121.89	124.27	126.74	134.69	139.16	2010	117.54	119.92	124.15	125.46	126.79	130.96	133.24	147.50
2011	119.80	126.22	138.09	141.74	145.68	158.43	166.55	2011	132.35	135.82	142.61	144.67	146.66	153.35	157.17	175.20
2012	116.34	123.48	137.92	142.48	147.25	163.32	173.37	2012	131.90	136.14	144.20	146.75	149.20	157.56	162.36	161.90
2013	109.97	118.48	135.20	140.48	146.22	165.27	177.12	2013	128.78	134.03	143.36	146.36	149.29	159.14	164.48	178.40
2014	101.35	110.21	128.72	135.22	141.31	163.62	178.27	2014	123.11	128.70	139.17	142.61	145.81	157.09	163.77	180.20
2015	91.78	101.22	121.74	128.50	135.35	161.09	177.03	2015	115.92	122.15	133.76	137.53	141.24	153.78	160.76	177.00
2016	82.48	92.12	114.24	121.51	128.97	156.61	175.20	2016	108.80	115.15	127.86	131.90	136.07	150.05	157.68	180.80
2017	73.09	83.39	106.46	114.50	122.11	152.41	172.37	2017	101.11	108.12	121.93	126.33	130.65	146.10	154.36	179.20
2018	65.13	75.55	99.14	107.17	115.68	147.94	169.59	2018	94.17	101.46	116.08	120.64	125.33	142.33	151.32	186.20
2019	56.72	67.49	91.79	100.20	109.16	143.75	166.11	2019	87.21	94.74	110.26	115.01	120.01	138.16	148.31	180.50

Greece_Simulations of Indexed Debt-to-GDP (%) ω=25%							
	0.01	0.05	0.35	0.5	0.65	0.95	0.99
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	117.13	119.86	124.81	126.41	127.91	132.74	135.51
2011	123.11	128.69	139.26	142.50	145.89	156.90	163.84
2012	120.23	126.89	139.57	143.49	147.73	161.64	170.07
2013	115.02	122.58	137.33	141.99	146.93	163.43	173.41
2014	107.28	115.18	131.48	137.04	142.40	161.30	174.23
2015	98.60	106.77	124.94	130.74	136.73	158.83	172.20
2016	89.37	98.23	117.76	124.10	130.68	154.26	170.67
2017	80.84	90.07	110.51	117.44	124.10	150.16	166.61
2018	73.16	82.65	103.54	110.53	118.09	146.10	163.59
2019	65.10	74.70	96.66	104.02	111.79	141.81	160.67

Greece_Simulations of Indexed Debt-to-GDP (%) ω=50%							
	0.01	0.05	0.35	0.5	0.65	0.95	0.99
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	117.13	119.86	124.81	126.41	127.91	132.74	135.51
2011	126.29	131.19	140.39	143.24	146.16	155.52	161.44
2012	124.67	130.19	141.14	144.62	148.21	160.12	167.21
2013	119.81	126.56	139.38	143.50	147.69	161.59	170.08
2014	113.18	119.95	134.19	138.82	143.47	159.46	169.93
2015	104.78	112.25	127.96	133.01	138.20	156.61	167.60
2016	96.27	103.96	121.29	126.81	132.42	152.33	165.96
2017	88.09	96.45	114.56	120.37	126.24	148.35	161.48
2018	80.28	89.28	107.90	114.13	120.38	144.39	158.61
2019	72.47	81.69	101.32	107.70	114.57	140.00	155.80

Greece_Simulations of Indexed Debt-to-GDP (%) ω=75%							
	0.01	0.05	0.35	0.5	0.65	0.95	0.99
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	117.13	119.86	124.81	126.41	127.91	132.74	135.51
2011	129.58	133.62	141.53	143.95	146.36	154.26	159.16
2012	128.25	133.31	142.70	145.68	148.68	158.57	164.21
2013	124.33	130.60	141.43	144.96	148.39	160.06	166.92
2014	118.48	124.52	136.67	140.69	144.61	157.98	166.25
2015	110.81	117.37	130.97	135.32	139.71	154.79	163.83
2016	102.89	109.68	124.66	129.34	134.15	150.88	160.96
2017	94.92	102.32	118.35	123.35	128.51	147.02	157.03
2018	87.40	95.55	112.04	117.42	122.78	143.02	154.14
2019	80.01	88.21	105.91	111.38	117.22	138.41	151.30

Tables A.1-A.5 Simulated Indexed and Non-Indexed Debt Ratios, Case a, k=100bps

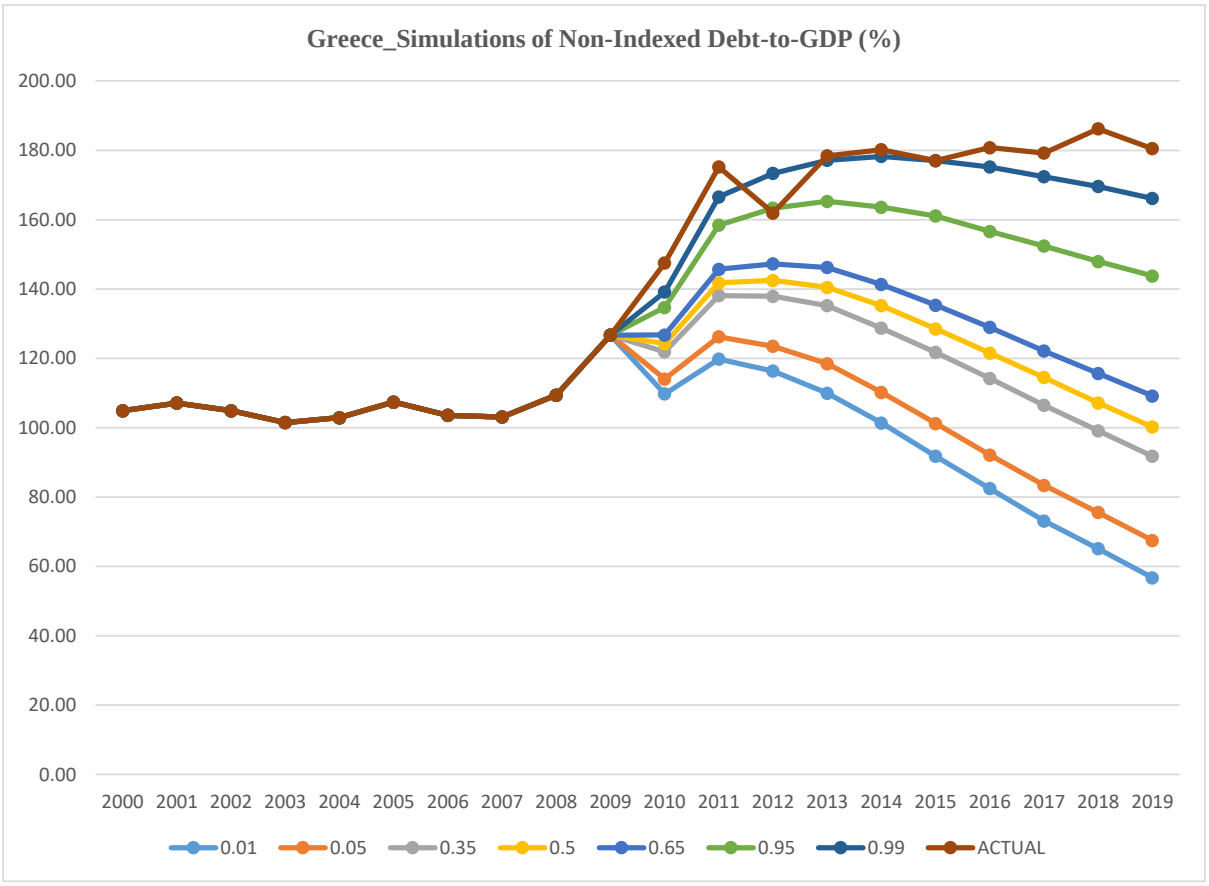

Figure A.1: Greece_Simulations of Non-Indexed Debt-to-GDP (%), Case a, k=100bps

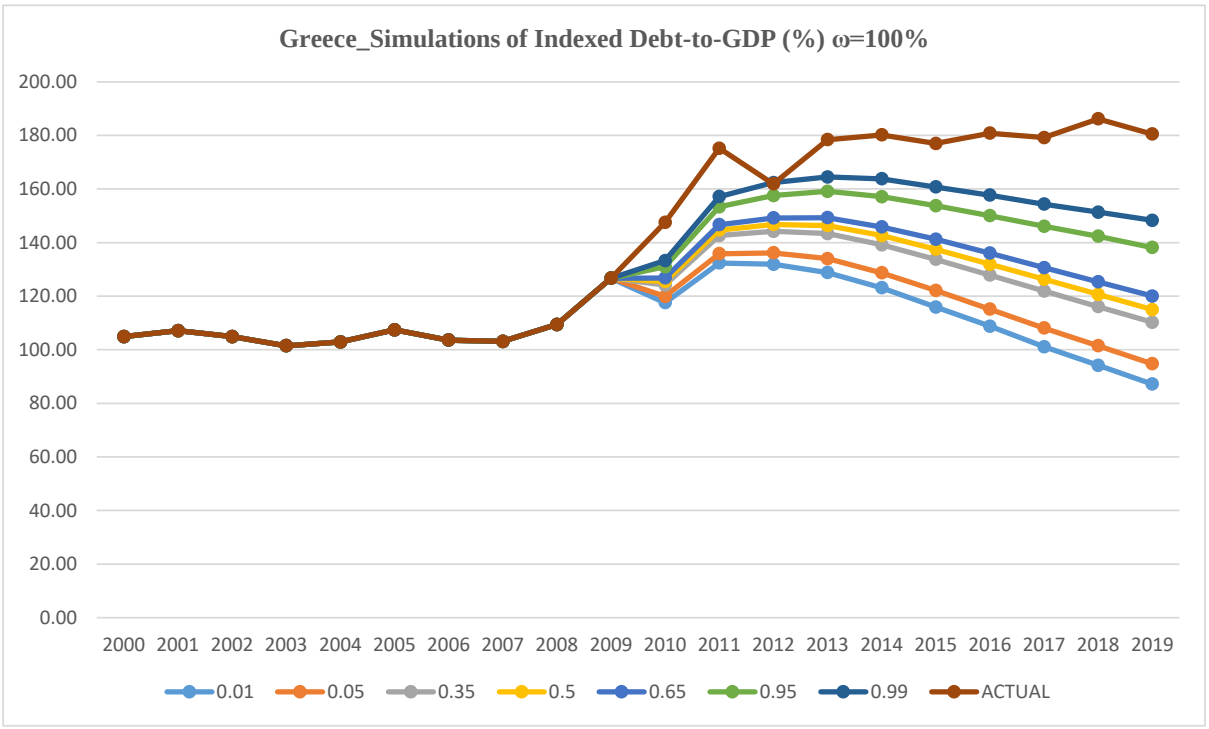

Figure A.2: Greece_Simulations of Indexed Debt-to-GDP (%), Case a, k=100bps

k=150bps

Greece_Simulations of Non-Indexed Debt-to-GDP (%)							
	0.01	0.05	0.35	0.5	0.65	0.95	0.99
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	109.76	114.07	121.89	124.27	126.74	134.69	139.16
2011	119.80	126.22	138.09	141.74	145.68	158.43	166.55
2012	116.34	123.48	137.92	142.48	147.25	163.32	173.37
2013	109.97	118.48	135.20	140.48	146.22	165.27	177.12
2014	101.35	110.21	128.72	135.22	141.31	163.62	178.27
2015	91.78	101.22	121.74	128.50	135.35	161.09	177.03
2016	82.48	92.12	114.24	121.51	128.97	156.61	175.20
2017	73.09	83.39	106.46	114.50	122.11	152.41	172.37
2018	65.13	75.55	99.14	107.17	115.68	147.94	169.59
2019	56.72	67.49	91.79	100.20	109.16	143.75	166.11

Greece_Simulations of Indexed Debt-to-GDP (%) ω=100%								Actual
	0.01	0.05	0.35	0.5	0.65	0.95	0.99	
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	118.11	120.50	124.75	126.06	127.40	131.57	133.86	147.50
2011	133.64	137.12	143.95	146.01	148.03	154.74	158.59	175.20
2012	133.93	138.20	146.33	148.89	151.38	159.81	164.68	161.90
2013	131.53	136.87	146.34	149.39	152.37	162.32	167.74	178.40
2014	126.67	132.30	143.01	146.52	149.79	161.28	168.12	180.20
2015	120.16	126.52	138.52	142.38	146.17	159.00	166.23	177.00
2016	113.72	120.27	133.48	137.69	141.98	156.29	164.15	180.80
2017	106.83	114.00	128.38	132.97	137.65	153.43	162.00	179.20
2018	100.46	108.10	123.35	128.20	133.17	150.69	160.27	186.20
2019	94.01	101.96	118.29	123.41	128.78	147.94	158.28	180.50

Greece_Simulations of Indexed Debt-to-GDP (%) ω=25%							
	0.01	0.05	0.35	0.5	0.65	0.95	0.99
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	116.84	119.57	124.51	126.11	127.61	132.43	135.20
2011	123.42	129.02	139.60	142.83	146.24	157.25	164.20
2012	120.73	127.39	140.10	144.03	148.27	162.20	170.66
2013	115.71	123.28	138.07	142.74	147.70	164.23	174.23
2014	108.17	116.08	132.44	138.01	143.40	162.35	175.29
2015	99.64	107.88	126.11	131.95	137.96	160.14	173.56
2016	90.62	99.49	119.19	125.55	132.15	155.82	172.30
2017	82.26	91.53	112.12	119.13	125.80	151.96	168.53
2018	74.77	84.26	105.35	112.41	120.05	148.19	165.76
2019	66.79	76.54	98.70	106.13	113.99	144.24	163.22

Greece_Simulations of Indexed Debt-to-GDP (%) ω=50%							
	0.01	0.05	0.35	0.5	0.65	0.95	0.99
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	116.84	119.57	124.51	126.11	127.61	132.43	135.20
2011	126.93	131.84	141.06	143.91	146.84	156.22	162.16
2012	125.67	131.23	142.21	145.69	149.30	161.26	168.37
2013	121.17	127.96	140.87	145.01	149.21	163.19	171.69
2014	114.95	121.75	136.10	140.78	145.47	161.54	172.09
2015	106.92	114.44	130.33	135.44	140.64	159.17	170.30
2016	98.72	106.52	124.09	129.72	135.35	155.47	169.21
2017	90.96	99.39	117.80	123.70	129.75	152.08	165.32
2018	83.40	92.54	111.54	117.91	124.30	148.68	162.95
2019	75.98	85.35	105.36	111.89	118.96	144.82	160.71

Greece_Simulations of Indexed Debt-to-GDP (%) ω=75%							
	0.01	0.05	0.35	0.5	0.65	0.95	0.99
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	116.84	119.57	124.51	126.11	127.61	132.43	135.20
2011	130.53	134.59	142.52	144.96	147.38	155.32	160.25
2012	129.77	134.85	144.30	147.30	150.31	160.28	165.92
2013	126.36	132.72	143.67	147.23	150.70	162.43	169.42
2014	121.12	127.26	139.57	143.64	147.61	161.09	169.47
2015	114.00	120.69	134.54	138.94	143.39	158.70	167.87
2016	106.53	113.60	128.85	133.68	138.57	155.56	165.77
2017	99.21	106.72	123.19	128.37	133.73	152.51	162.73
2018	92.03	100.50	117.51	123.11	128.71	149.37	160.76
2019	85.26	93.69	111.96	117.68	123.83	145.83	158.84

Tables A.6-A.10 Simulated Indexed and Non-Indexed Debt Ratios, Case a, k=150bps

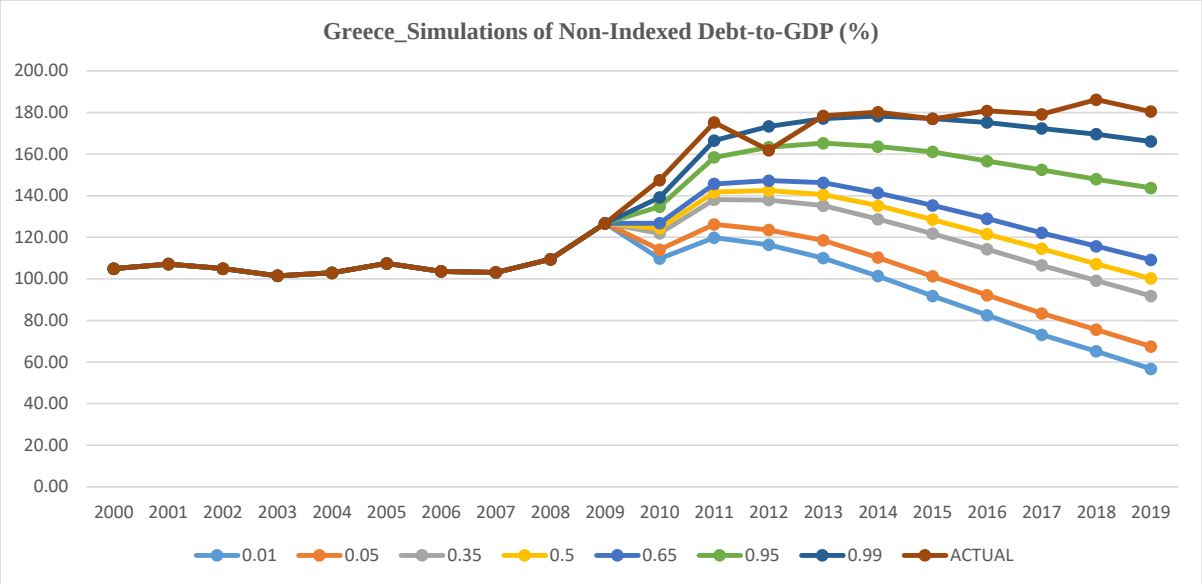

Figure A.3: Greece_Simulations of Non-Indexed Debt-to-GDP (%), Case a, k=150bps

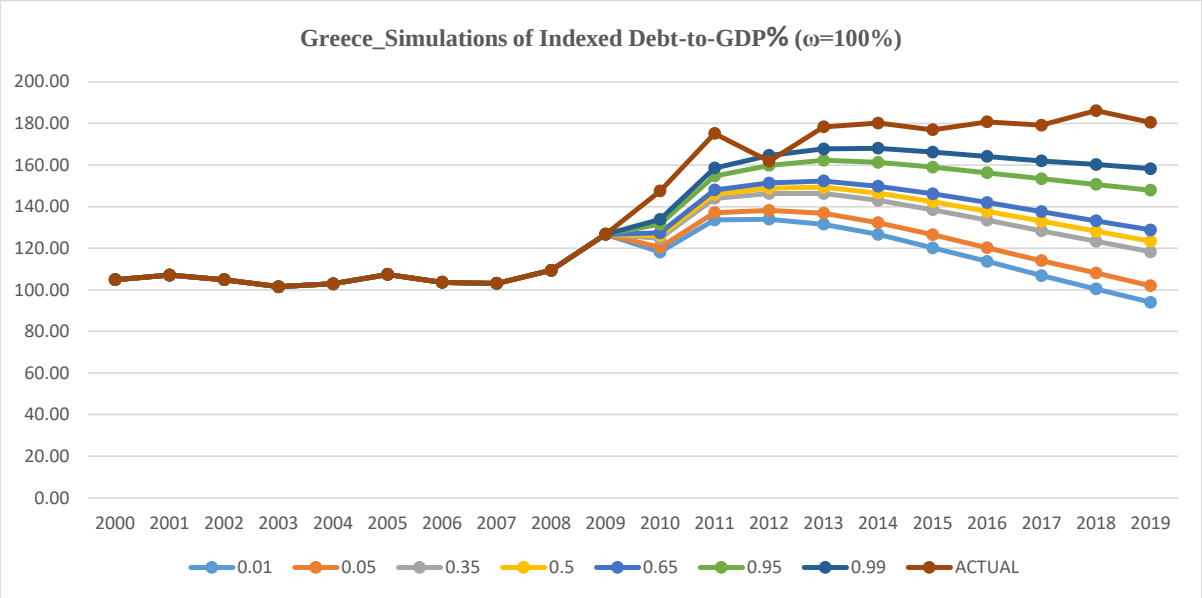

Figure A.4: Greece_Simulations of Indexed Debt-to-GDP (%), Case a, k=150bps

K=200bps

Greece_Simulations of Non-Indexed Debt-to-GDP (%)							
	0.01	0.05	0.35	0.5	0.65	0.95	0.99
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	109.76	114.07	121.89	124.27	126.74	134.69	139.16
2011	119.80	126.22	138.09	141.74	145.68	158.43	166.55
2012	116.34	123.48	137.92	142.48	147.25	163.32	173.37
2013	109.97	118.48	135.20	140.48	146.22	165.27	177.12
2014	101.35	110.21	128.72	135.22	141.31	163.62	178.27
2015	91.78	101.22	121.74	128.50	135.35	161.09	177.03
2016	82.48	92.12	114.24	121.51	128.97	156.61	175.20
2017	73.09	83.39	106.46	114.50	122.11	152.41	172.37
2018	65.13	75.55	99.14	107.17	115.68	147.94	169.59
2019	56.72	67.49	91.79	100.20	109.16	143.75	166.11

Greece_Simulations of Indexed Debt-to-GDP (%) ω=100%								Actual
	0.01	0.05	0.35	0.5	0.65	0.95	0.99	
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	118.69	121.08	125.34	126.66	128.00	132.19	134.48	147.50
2011	134.92	138.44	145.29	147.37	149.39	156.15	160.02	175.20
2012	135.97	140.29	148.49	151.07	153.58	162.09	167.00	161.90
2013	134.40	139.76	149.37	152.46	155.48	165.56	171.03	178.40
2014	130.32	135.96	146.97	150.52	153.88	165.56	172.54	180.20
2015	124.62	131.10	143.41	147.34	151.23	164.35	171.77	177.00
2016	118.82	125.54	139.40	143.69	148.03	162.74	170.81	180.80
2017	112.83	120.18	135.31	140.12	144.85	161.15	170.09	179.20
2018	107.07	115.04	131.14	136.37	141.67	159.58	169.68	186.20
2019	101.24	109.54	127.11	132.67	138.61	158.28	169.08	180.50

Greece_Simulations of Indexed Debt-to-GDP (%) ω=25%							
	0.01	0.05	0.35	0.5	0.65	0.95	0.99
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	117.42	120.15	125.11	126.71	128.21	133.05	135.82
2011	123.74	129.35	139.93	143.17	146.58	157.60	164.57
2012	121.23	127.90	140.64	144.58	148.82	162.77	171.25
2013	116.41	124.00	138.83	143.51	148.47	165.03	175.06
2014	109.07	117.01	133.43	139.01	144.41	163.41	176.38
2015	100.73	108.99	127.34	133.20	139.22	161.45	174.93
2016	91.94	100.85	120.65	127.01	133.68	157.46	173.99
2017	83.74	93.04	113.86	120.88	127.61	153.85	170.51
2018	76.42	85.95	107.33	114.44	122.15	150.43	168.05
2019	68.62	78.54	100.89	108.41	116.42	146.84	165.93

Greece_Simulations of Indexed Debt-to-GDP (%) ω=50%							
	0.01	0.05	0.35	0.5	0.65	0.95	0.99
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	117.42	120.15	125.11	126.71	128.21	133.05	135.82
2011	127.58	132.49	141.72	144.59	147.52	156.92	162.89
2012	126.67	132.27	143.29	146.78	150.40	162.41	169.54
2013	122.58	129.39	142.37	146.56	150.78	164.82	173.35
2014	116.77	123.63	138.09	142.79	147.49	163.70	174.27
2015	109.17	116.72	132.78	137.93	143.17	161.88	173.09
2016	101.32	109.22	127.06	132.71	138.39	158.74	172.45
2017	93.95	102.49	121.27	127.26	133.34	155.88	169.33
2018	86.74	95.97	115.50	122.02	128.50	153.08	167.48
2019	79.76	89.19	109.81	116.54	123.82	149.98	166.13

Greece_Simulations of Indexed Debt-to-GDP (%) ω=75%							
	0.01	0.05	0.35	0.5	0.65	0.95	0.99
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	117.42	120.15	125.11	126.71	128.21	133.05	135.82
2011	131.49	135.57	143.53	145.98	148.41	156.38	161.34
2012	131.31	136.40	145.91	148.94	151.96	162.00	167.67
2013	128.46	134.87	145.95	149.53	153.04	164.87	171.94
2014	123.78	130.06	142.51	146.65	150.66	164.27	172.77
2015	117.29	124.09	138.21	142.67	147.22	162.76	172.02
2016	110.48	117.58	133.26	138.16	143.11	160.47	170.80
2017	103.71	111.30	128.39	133.68	139.14	158.22	168.82
2018	97.07	105.70	123.37	129.24	135.06	156.03	167.70
2019	90.86	99.45	118.56	124.64	131.17	153.50	166.87

Tables A.11-A.15 Simulated Indexed and Non-Indexed Debt Ratios, Case a, k=200bp

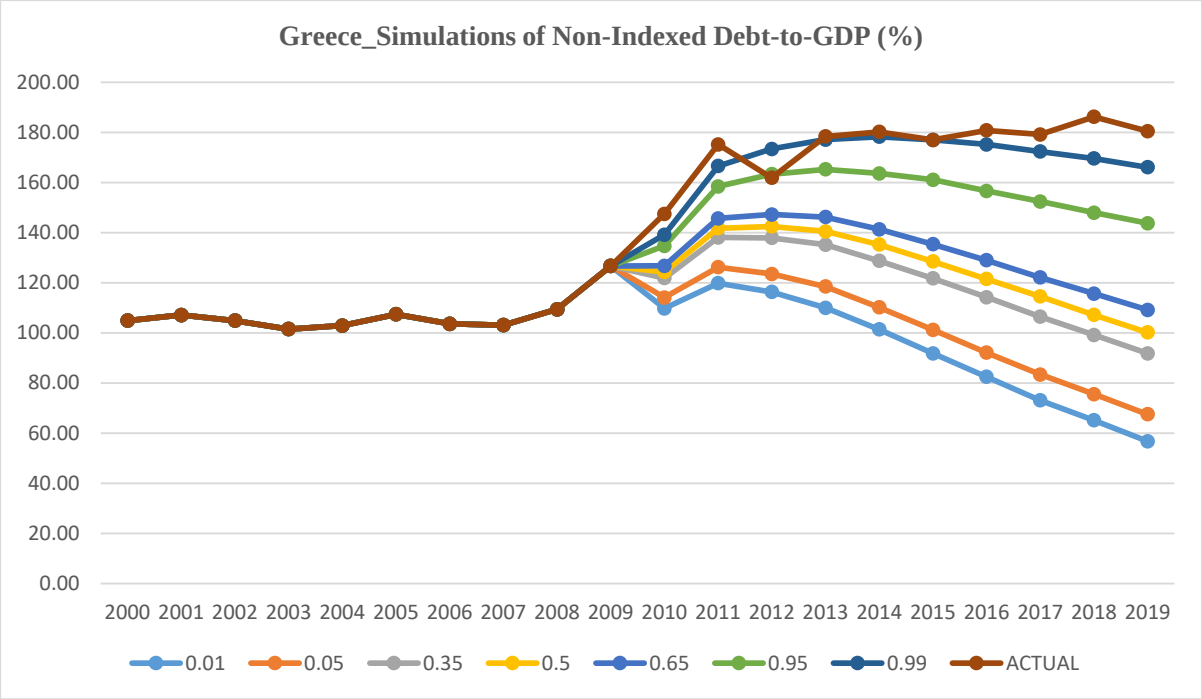

Figure A.5: Greece_Simulations of Non-Indexed Debt-to-GDP (%), Case a, k=200bps

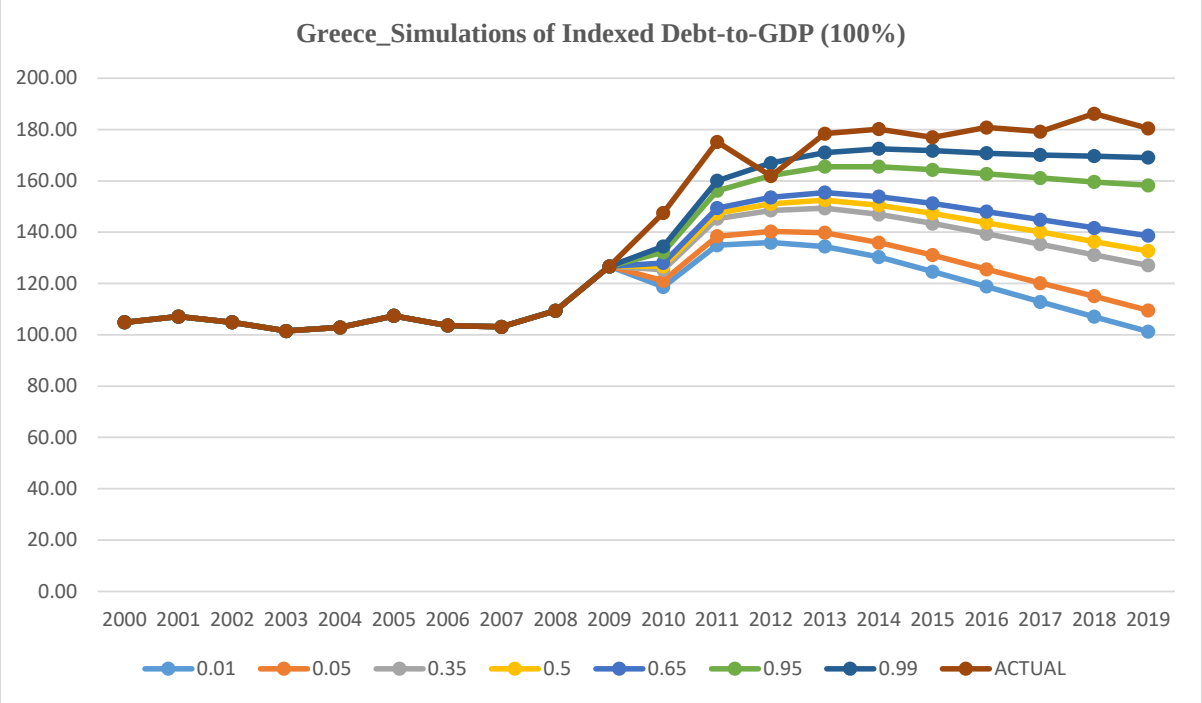

***Figure A.6: Greece_Simulations of Indexed Debt-to-GDP (%), Case a,* k=200bps**

K=250 bps

Greece_Simulations of Non-Indexed Debt-to-GDP (%)								Greece_Simulations of Indexed Debt-to-GDP (%) ω=100%								Actual
	0.01	0.05	0.35	0.5	0.65	0.95	0.99		0.01	0.05	0.35	0.5	0.65	0.95	0.99	
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90	2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10	2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90	2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50	2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90	2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40	2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60	2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10	2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40	2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70	2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	109.76	114.07	121.89	124.27	126.74	134.69	139.16	2010	119.27	121.67	125.94	127.26	128.61	132.80	135.11	147.50
2011	119.80	126.22	138.09	141.74	145.68	158.43	166.55	2011	136.19	139.75	146.64	148.73	150.77	157.57	161.45	175.20
2012	116.34	123.48	137.92	142.48	147.25	163.32	173.37	2012	138.04	142.38	150.68	153.28	155.80	164.39	169.31	161.90
2013	109.97	118.48	135.20	140.48	146.22	165.27	177.12	2013	137.28	142.68	152.45	155.57	158.63	168.84	174.36	178.40
2014	101.35	110.21	128.72	135.22	141.31	163.62	178.27	2014	133.99	139.77	151.00	154.61	158.05	169.95	177.04	180.20
2015	91.78	101.22	121.74	128.50	135.35	161.09	177.03	2015	129.01	135.86	148.43	152.46	156.44	169.85	177.44	177.00
2016	82.48	92.12	114.24	121.51	128.97	156.61	175.20	2016	124.09	131.11	145.47	149.85	154.35	169.48	177.76	180.80
2017	73.09	83.39	106.46	114.50	122.11	152.41	172.37	2017	119.11	126.63	142.50	147.43	152.31	169.22	178.45	179.20
2018	65.13	75.55	99.14	107.17	115.68	147.94	169.59	2018	113.98	122.29	139.67	145.02	150.38	169.04	179.62	186.20
2019	56.72	67.49	91.79	100.20	109.16	143.75	166.11	2019	109.20	117.79	136.88	142.88	148.72	169.22	180.82	180.50

Greece_Simulations of Indexed Debt-to-GDP (%) ω=25%							
	0.01	0.05	0.35	0.5	0.65	0.95	0.99
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	117.99	120.74	125.71	127.31	128.80	133.66	136.44
2011	124.06	129.68	140.27	143.51	146.92	157.96	164.93
2012	121.74	128.42	141.19	145.13	149.37	163.34	171.83
2013	117.13	124.74	139.61	144.28	149.25	165.84	175.91
2014	110.01	117.97	134.44	140.04	145.44	164.50	177.49
2015	101.85	110.19	128.59	134.48	140.54	162.82	176.33
2016	93.33	102.29	122.16	128.56	135.26	159.15	175.74
2017	85.25	94.65	115.67	122.71	129.49	155.82	172.54
2018	78.11	87.76	109.45	116.59	124.31	152.80	170.46
2019	70.59	80.63	103.33	110.89	119.01	149.57	168.78

Greece_Simulations of Indexed Debt-to-GDP (%) ω=50%							
	0.01	0.05	0.35	0.5	0.65	0.95	0.99
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	117.99	120.74	125.71	127.31	128.80	133.66	136.44
2011	128.23	133.14	142.40	145.27	148.21	157.63	163.62
2012	127.68	133.31	144.38	147.88	151.51	163.56	170.71
2013	124.00	130.83	143.92	148.12	152.36	166.46	175.05
2014	118.60	125.54	140.10	144.83	149.56	165.89	176.50
2015	111.43	119.05	135.30	140.49	145.76	164.64	175.94
2016	104.01	112.02	130.09	135.81	141.51	162.13	175.92
2017	97.08	105.71	124.84	130.91	137.07	159.91	173.58
2018	90.23	99.57	119.72	126.31	132.86	157.78	172.31
2019	83.81	93.30	114.73	121.58	128.92	155.39	171.85

Greece_Simulations of Indexed Debt-to-GDP (%) ω=75%							
	0.01	0.05	0.35	0.5	0.65	0.95	0.99
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	117.99	120.74	125.71	127.31	128.80	133.66	136.44
2011	132.46	136.55	144.54	147.00	149.44	157.46	162.42
2012	132.87	137.95	147.54	150.58	153.63	163.71	169.45
2013	130.61	137.05	148.25	151.86	155.41	167.30	174.49
2014	126.54	132.96	145.55	149.74	153.77	167.54	176.15
2015	120.57	127.65	141.98	146.50	151.13	166.91	176.23
2016	114.45	121.78	137.82	142.80	147.84	165.51	176.00
2017	108.41	116.21	133.82	139.19	144.73	164.27	175.05
2018	102.33	111.17	129.74	135.73	141.55	163.17	175.01
2019	96.77	105.76	125.87	132.24	138.75	161.61	175.39

Tables A.16-A.20 Simulated Indexed and Non-Indexed Debt Ratios, Case a, k=250bps

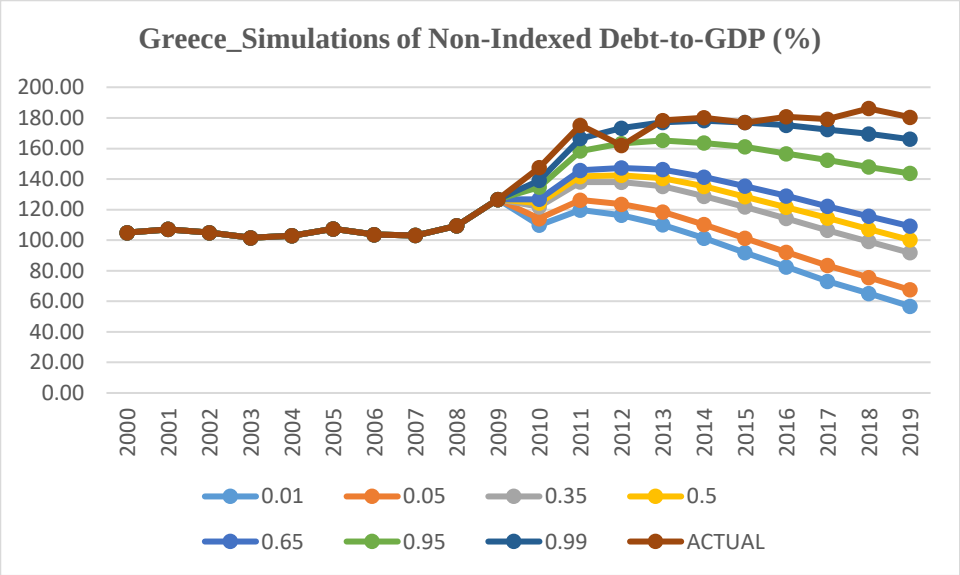

Figure A.7: Greece_Simulations of Non-Indexed Debt-to-GDP (%), Case a, k=250bps

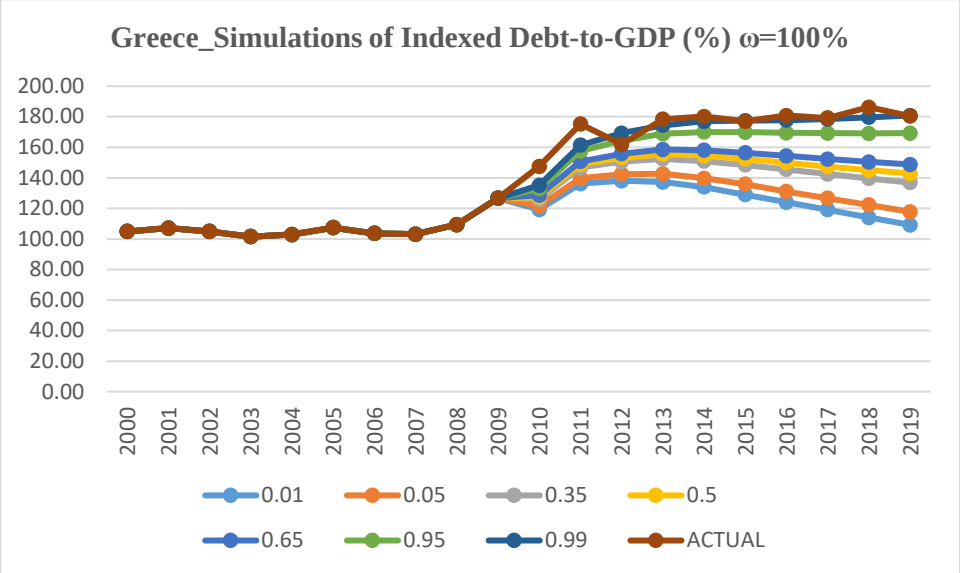

Figure A.8: Greece_Simulations of Indexed Debt-to-GDP (%), Case a, k=150bps**k=250bps**

K=300bps

Greece_Simulations of Non-Indexed Debt-to-GDP (%)							
	0.01	0.05	0.35	0.5	0.65	0.95	0.99
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	109.76	114.07	121.89	124.27	126.74	134.69	139.16
2011	119.80	126.22	138.09	141.74	145.68	158.43	166.55
2012	116.34	123.48	137.92	142.48	147.25	163.32	173.37
2013	109.97	118.48	135.20	140.48	146.22	165.27	177.12
2014	101.35	110.21	128.72	135.22	141.31	163.62	178.27
2015	91.78	101.22	121.74	128.50	135.35	161.09	177.03
2016	82.48	92.12	114.24	121.51	128.97	156.61	175.20
2017	73.09	83.39	106.46	114.50	122.11	152.41	172.37
2018	65.13	75.55	99.14	107.17	115.68	147.94	169.59
2019	56.72	67.49	91.79	100.20	109.16	143.75	166.11

Greece_Simulations of Indexed Debt-to-GDP (%) ω=100%								Actual
	0.01	0.05	0.35	0.5	0.65	0.95	0.99	
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	119.84	122.26	126.53	127.86	129.21	133.41	135.73	147.50
2011	137.49	141.07	148.00	150.10	152.15	159.00	162.88	175.20
2012	140.10	144.49	152.87	155.51	158.07	166.73	171.65	161.90
2013	140.17	145.69	155.59	158.75	161.84	172.16	177.78	178.40
2014	137.76	143.71	155.14	158.80	162.31	174.38	181.62	180.20
2015	133.68	140.74	153.61	157.72	161.79	175.46	183.25	177.00
2016	129.69	137.11	151.70	156.24	160.85	176.49	184.95	180.80
2017	125.63	133.49	149.96	155.02	160.09	177.57	187.20	179.20
2018	121.26	130.23	148.40	153.89	159.48	179.01	189.93	186.20
2019	117.73	126.82	147.20	153.24	159.30	180.85	193.03	180.50

Greece_Simulations of Indexed Debt-to-GDP (%) ω=25%							
	0.01	0.05	0.35	0.5	0.65	0.95	0.99
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	118.56	121.33	126.31	127.91	129.41	134.28	137.07
2011	124.38	130.01	140.61	143.86	147.27	158.32	165.29
2012	122.26	128.95	141.74	145.68	149.93	163.92	172.43
2013	117.88	125.48	140.39	145.08	150.06	166.67	176.77
2014	110.94	118.95	135.47	141.08	146.51	165.62	178.63
2015	103.00	111.41	129.88	135.78	141.87	164.20	177.78
2016	94.75	103.75	123.76	130.17	136.91	160.92	177.55
2017	86.92	96.36	117.55	124.62	131.42	157.94	174.72
2018	79.95	89.79	111.65	118.85	126.60	155.29	173.02
2019	72.73	82.92	105.86	113.47	121.67	152.52	171.71

Greece_Simulations of Indexed Debt-to-GDP (%) ω=50%							
	0.01	0.05	0.35	0.5	0.65	0.95	0.99
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	118.56	121.33	126.31	127.91	129.41	134.28	137.07
2011	128.89	133.80	143.08	145.95	148.90	158.35	164.36
2012	128.70	134.37	145.47	148.99	152.62	164.72	171.89
2013	125.43	132.31	145.48	149.70	153.95	168.13	176.76
2014	120.48	127.51	142.16	146.92	151.69	168.13	178.77
2015	113.78	121.55	137.89	143.11	148.43	167.45	178.86
2016	106.75	114.99	133.21	139.01	144.74	165.56	179.48
2017	100.38	109.17	128.56	134.74	140.96	164.06	178.06
2018	93.96	103.55	124.12	130.78	137.42	162.75	177.39
2019	88.02	97.76	119.86	126.73	134.18	161.17	177.86

Greece_Simulations of Indexed Debt-to-GDP (%) ω=75%							
	0.01	0.05	0.35	0.5	0.65	0.95	0.99
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	118.56	121.33	126.31	127.91	129.41	134.28	137.07
2011	133.42	137.54	145.55	148.02	150.47	158.53	163.51
2012	134.44	139.53	149.18	152.25	155.32	165.46	171.24
2013	132.86	139.26	150.60	154.25	157.81	169.81	177.07
2014	129.42	135.90	148.67	152.89	156.97	170.93	179.65
2015	123.98	131.36	145.87	150.45	155.13	171.19	180.60
2016	118.61	126.24	142.52	147.62	152.74	170.69	181.31
2017	113.36	121.44	139.41	144.89	150.55	170.56	181.56
2018	107.91	117.14	136.37	142.41	148.37	170.54	182.79
2019	102.91	112.39	133.64	139.95	146.66	170.24	184.44

Tables A.21-A.25 Simulated Indexed and Non-Indexed Debt Ratios, Case a, k=300bps

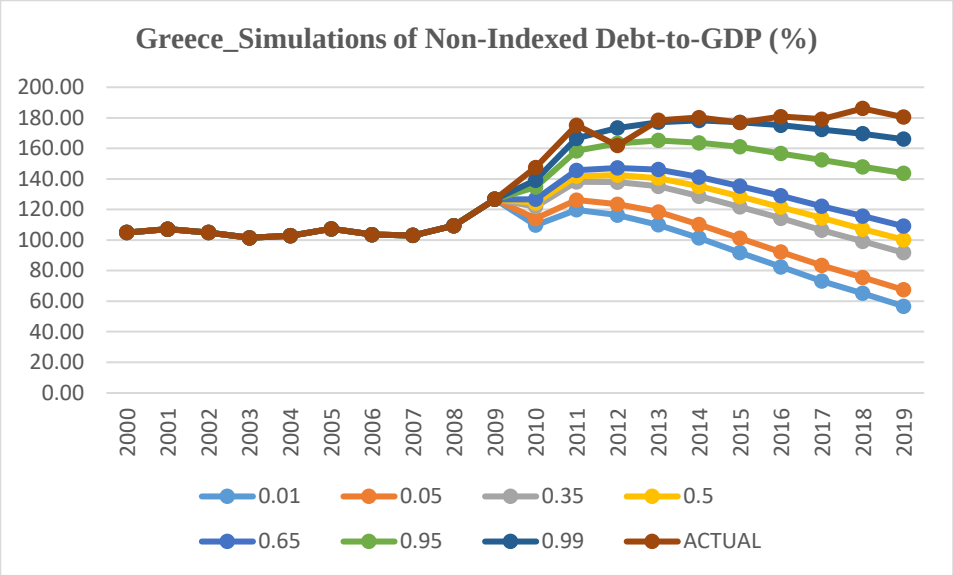

Figure A.9: Greece_Simulations of Non-Indexed Debt-to-GDP (%), Case a, k=300bps

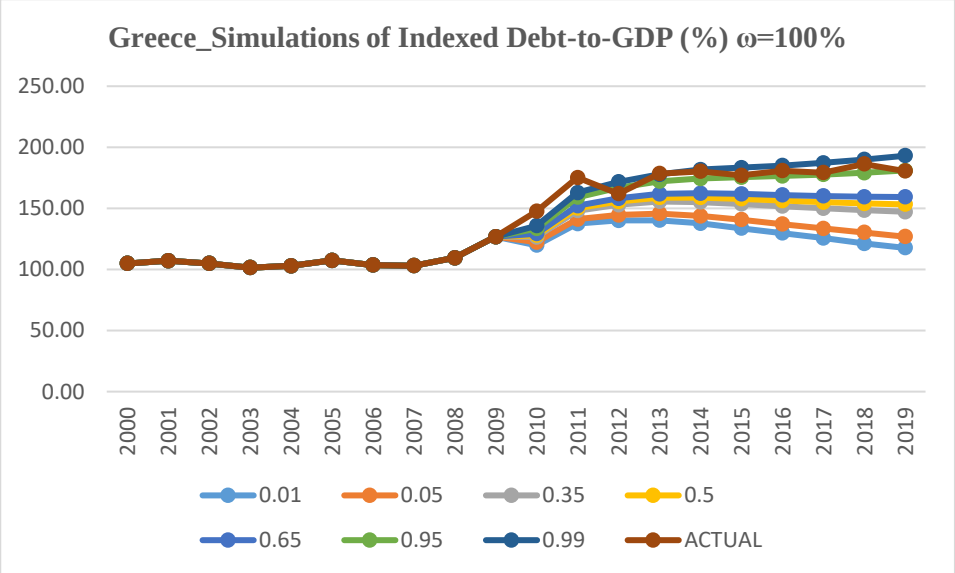

Figure A.10: Greece_Simulations of Indexed Debt-to-GDP (%), Case a,

***k=150bps*k=300bps**

k=350bps

Greece_Simulations of Non-Indexed Debt-to-GDP (%)							
	0.01	0.05	0.35	0.5	0.65	0.95	0.99
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	109.76	114.07	121.89	124.27	126.74	134.69	139.16
2011	119.80	126.22	138.09	141.74	145.68	158.43	166.55
2012	116.34	123.48	137.92	142.48	147.25	163.32	173.37
2013	109.97	118.48	135.20	140.48	146.22	165.27	177.12
2014	101.35	110.21	128.72	135.22	141.31	163.62	178.27
2015	91.78	101.22	121.74	128.50	135.35	161.09	177.03
2016	82.48	92.12	114.24	121.51	128.97	156.61	175.20
2017	73.09	83.39	106.46	114.50	122.11	152.41	172.37
2018	65.13	75.55	99.14	107.17	115.68	147.94	169.59
2019	56.72	67.49	91.79	100.20	109.16	143.75	166.11

Greece_Simulations of Indexed Debt-to-GDP (%) ω=100%								Actual
	0.01	0.05	0.35	0.5	0.65	0.95	0.99	
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	120.42	122.85	127.12	128.46	129.82	134.03	136.36	147.50
2011	138.80	142.39	149.37	151.47	153.54	160.41	164.32	175.20
2012	142.16	146.62	155.09	157.76	160.33	169.07	174.03	161.90
2013	143.10	148.75	158.76	161.97	165.11	175.53	181.28	178.40
2014	141.72	147.69	159.37	163.07	166.66	178.95	186.29	180.20
2015	138.56	145.77	158.91	163.12	167.32	181.26	189.23	177.00
2016	135.51	143.23	158.19	162.85	167.57	183.69	192.39	180.80
2017	132.49	140.81	157.72	162.94	168.17	186.29	196.31	179.20
2018	129.22	138.90	157.52	163.25	169.05	189.44	200.70	186.20
2019	126.54	136.63	157.80	164.08	170.56	193.39	205.95	180.50

Greece_Simulations of Indexed Debt-to-GDP (%) ω=25%							
	0.01	0.05	0.35	0.5	0.65	0.95	0.99
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	119.14	121.91	126.90	128.51	130.01	134.91	137.69
2011	124.70	130.34	140.95	144.20	147.61	158.68	165.66
2012	122.79	129.49	142.29	146.25	150.49	164.52	173.03
2013	118.64	126.24	141.18	145.89	150.88	167.51	177.64
2014	111.88	119.95	136.52	142.15	147.60	166.76	179.79
2015	104.21	112.66	131.21	137.12	143.25	165.61	179.26
2016	96.26	105.28	125.39	131.85	138.59	162.71	179.42
2017	88.77	98.22	119.49	126.64	133.45	160.13	177.02
2018	81.94	91.92	113.94	121.21	129.00	157.89	175.73
2019	74.96	85.46	108.51	116.20	124.45	155.64	174.96

Greece_Simulations of Indexed Debt-to-GDP (%) ω=50%							
	0.01	0.05	0.35	0.5	0.65	0.95	0.99
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	119.14	121.91	126.90	128.51	130.01	134.91	137.69
2011	129.54	134.46	143.76	146.63	149.59	159.06	165.10
2012	129.76	135.43	146.58	150.10	153.75	165.90	173.09
2013	126.94	133.80	147.06	151.31	155.58	169.79	178.50
2014	122.41	129.50	144.29	149.03	153.87	170.38	181.12
2015	116.26	124.08	140.54	145.81	151.19	170.31	181.90
2016	109.69	118.11	136.47	142.36	148.11	169.18	183.10
2017	103.86	112.82	132.44	138.72	145.01	168.41	182.66
2018	98.05	107.88	128.70	135.39	142.20	167.94	182.83
2019	92.53	102.83	125.18	132.19	139.81	167.29	184.22

Greece_Simulations of Indexed Debt-to-GDP (%) ω=75%							
	0.01	0.05	0.35	0.5	0.65	0.95	0.99
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	119.14	121.91	126.90	128.51	130.01	134.91	137.69
2011	134.38	138.53	146.57	149.06	151.51	159.60	164.60
2012	136.04	141.12	150.84	153.93	157.01	167.22	173.06
2013	135.10	141.54	152.99	156.66	160.25	172.35	179.68
2014	132.31	138.94	151.82	156.11	160.25	174.30	183.20
2015	127.58	135.12	149.85	154.52	159.24	175.57	185.04
2016	123.08	130.86	147.35	152.60	157.82	176.10	186.86
2017	118.62	126.94	145.24	150.83	156.64	177.12	188.41
2018	114.05	123.60	143.23	149.45	155.60	178.41	190.82
2019	109.69	119.75	141.58	148.17	155.06	179.56	194.25

Tables A.26-A.30 Simulated Indexed and Non-Indexed Debt Ratios, Case a, k=350bps

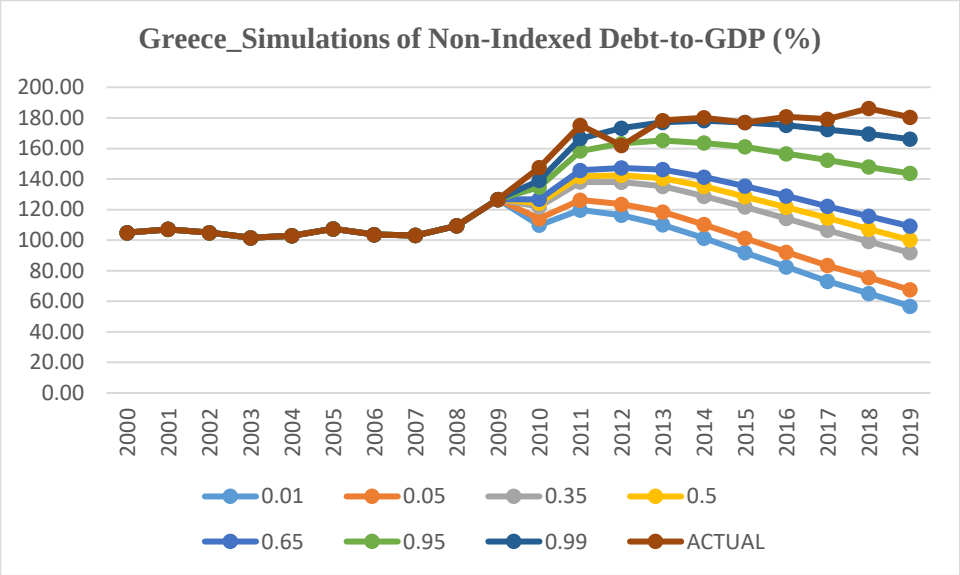

Figure A.11: Greece_Simulations of Non-Indexed Debt-to-GDP (%), Case a, k=350bps

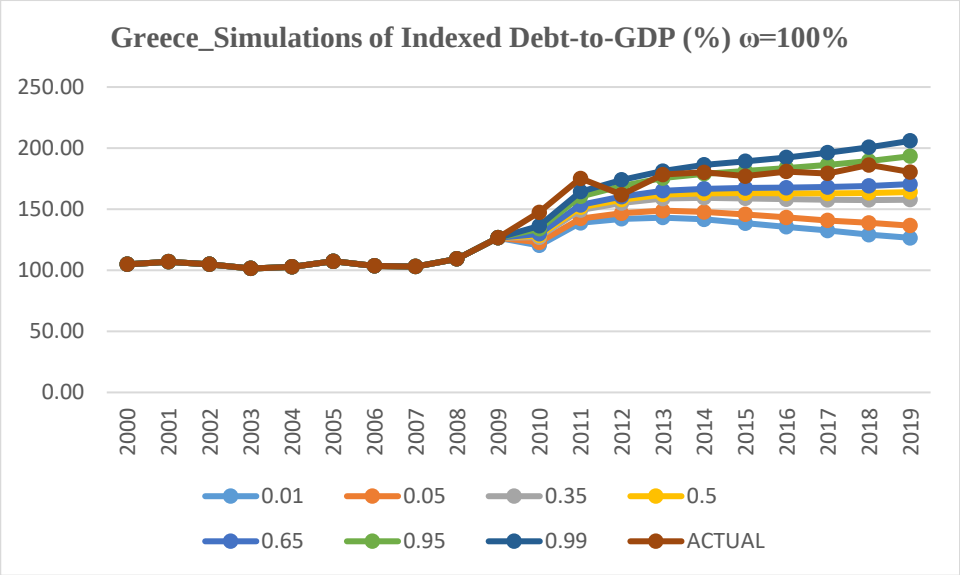

Figure A.12: Greece_Simulations of Indexed Debt-to-GDP (%), Case a, k=350bps

Appendix 4: Historical Counterfactual (Case b), k=100bps

Greece_Simulations of Non-Indexed Debt-to-GDP (%)							
	0.01	0.05	0.35	0.5	0.65	0.95	0.99
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	125.62	130.57	139.21	142.13	144.94	154.78	160.38
2011	136.76	143.47	157.58	161.98	166.58	183.00	191.80
2012	149.97	160.07	179.62	185.99	192.61	215.50	228.88
2013	144.12	154.71	177.96	185.40	193.17	220.25	235.95
2014	131.08	142.53	167.04	175.18	183.71	213.88	231.95
2015	127.20	140.43	167.61	176.93	186.05	221.12	241.72
2016	120.70	134.69	164.46	174.75	185.81	225.85	249.50
2017	112.24	126.15	158.31	169.60	181.55	224.97	253.41
2018	103.49	118.18	151.32	163.30	176.05	222.95	254.61
2019	95.07	109.86	144.23	157.04	170.80	221.20	255.32

Greece_Simulations of Indexed Debt-to-GDP (%) ω=100%								Actual
	0.01	0.05	0.35	0.5	0.65	0.95	0.99	
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	134.55	137.18	141.97	143.45	144.91	149.85	152.68	147.50
2011	151.39	155.41	163.00	165.22	167.55	175.42	179.71	175.20
2012	172.31	177.66	188.35	191.70	194.88	205.84	211.64	161.90
2013	170.99	177.12	189.49	193.18	197.09	209.39	216.31	178.40
2014	161.27	167.66	180.96	184.87	188.87	202.40	209.55	180.20
2015	161.51	169.45	184.56	188.89	193.48	209.13	217.51	177.00
2016	158.87	167.83	184.58	189.81	194.84	212.34	221.78	180.80
2017	153.10	162.90	181.27	186.87	192.53	211.74	222.08	179.20
2018	147.19	157.19	176.99	182.91	189.28	209.79	221.24	186.20
2019	140.63	151.84	172.55	178.98	185.72	208.13	220.33	180.50

Greece_Simulations of Indexed Debt-to-GDP (%) ω=25%							
	0.01	0.05	0.35	0.5	0.65	0.95	0.99
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	135.31	137.76	142.09	143.43	144.78	149.24	151.75
2011	140.65	146.67	158.97	162.81	166.73	181.02	188.36
2012	155.97	164.63	181.89	187.41	193.13	212.70	224.30
2013	151.34	160.72	180.94	187.38	194.08	217.27	230.59
2014	139.37	149.21	170.74	177.62	184.86	210.51	225.89
2015	136.49	148.20	172.03	179.90	187.79	217.43	235.29
2016	131.11	143.21	169.72	178.61	187.87	221.50	242.38
2017	122.80	136.17	164.29	174.00	183.97	221.06	244.61
2018	115.00	128.64	157.84	168.51	179.32	218.56	245.01
2019	107.43	120.80	151.53	162.62	174.28	216.50	245.50

Greece_Simulations of Indexed Debt-to-GDP (%) ω=50%							
	0.01	0.05	0.35	0.5	0.65	0.95	0.99
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	135.31	137.76	142.09	143.43	144.78	149.24	151.75
2011	144.30	149.89	160.34	163.64	166.97	178.90	185.24
2012	161.78	169.18	184.06	188.78	193.73	210.08	219.78
2013	158.47	166.35	183.85	189.33	195.07	214.37	224.97
2014	147.16	155.67	174.32	180.01	186.06	207.16	219.53
2015	145.68	155.69	176.31	182.82	189.69	214.35	228.57
2016	141.22	151.82	174.86	182.35	190.10	218.22	234.61
2017	133.60	145.80	170.19	178.44	186.71	217.36	235.69
2018	127.11	138.68	164.33	173.37	182.56	214.92	235.67
2019	119.10	131.69	158.71	168.15	177.96	212.65	236.59

Greece_Simulations of Indexed Debt-to-GDP (%) ω=75%							
	0.01	0.05	0.35	0.5	0.65	0.95	0.99
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	135.31	137.76	142.09	143.43	144.78	149.24	151.75
2011	147.95	152.64	161.73	164.46	167.25	177.02	182.32
2012	167.22	173.63	186.27	190.21	194.30	207.84	215.34
2013	164.94	171.84	186.75	191.26	196.05	211.64	220.08
2014	154.72	162.04	177.74	182.45	187.49	204.46	213.68
2015	153.87	162.69	180.51	185.92	191.51	211.61	222.28
2016	150.63	159.92	179.84	186.00	192.63	214.34	227.19
2017	143.83	154.57	175.93	182.55	189.53	214.02	228.22
2018	137.36	148.18	170.94	178.07	186.08	211.78	227.58
2019	130.35	141.93	165.90	173.59	181.84	209.54	227.64

Tables A.31-A.35 Simulated Indexed and Non-Indexed Debt Ratios, Case b, k=100bps

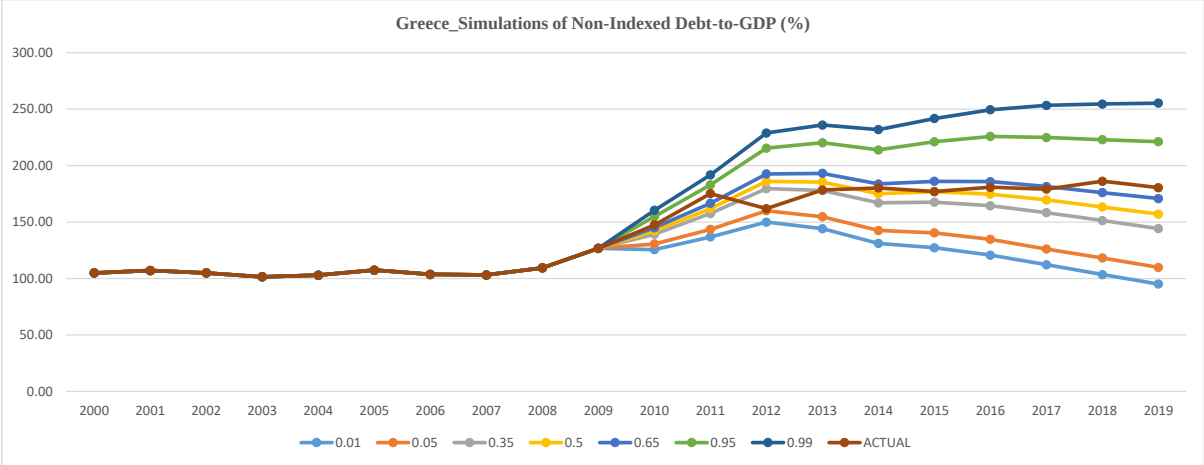

Figure A.13: Greece_Simulations of Non-Indexed Debt-to-GDP (%), Case b, k=100bps

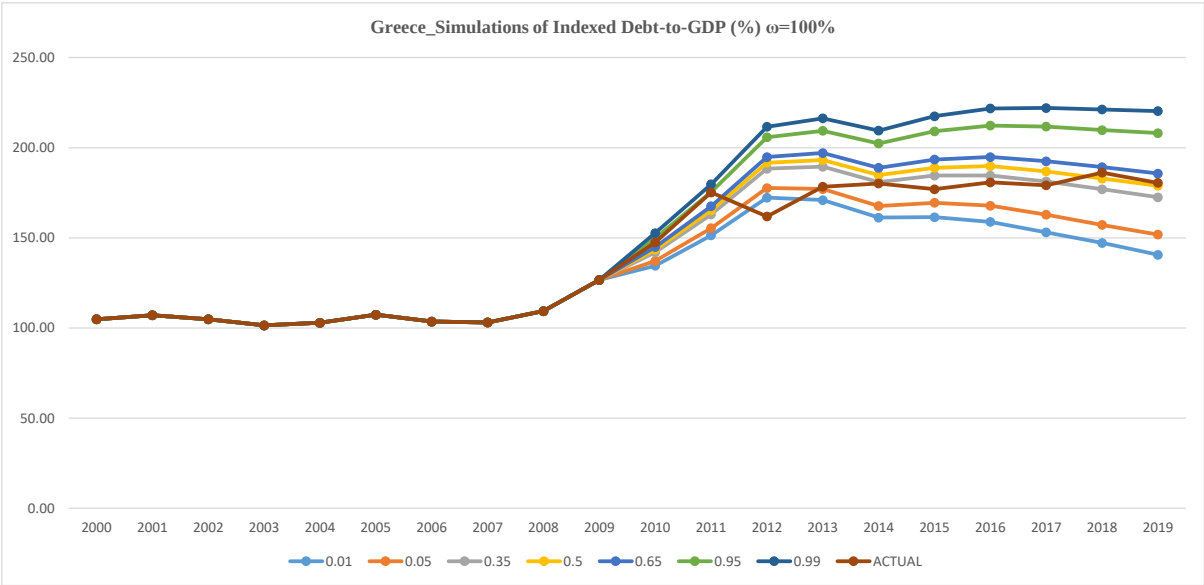

Figure A.14: Greece_Simulations of Non-Indexed Debt-to-GDP (%), Case b, k=100bps

k=150bps

Greece_Simulations of Non-Indexed Debt-to-GDP (%)							
	0.01	0.05	0.35	0.5	0.65	0.95	0.99
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	125.62	130.57	139.21	142.13	144.94	154.78	160.38
2011	136.76	143.47	157.58	161.98	166.58	183.00	191.80
2012	149.97	160.07	179.62	185.99	192.61	215.50	228.88
2013	144.12	154.71	177.96	185.40	193.17	220.25	235.95
2014	131.08	142.53	167.04	175.18	183.71	213.88	231.95
2015	127.20	140.43	167.61	176.93	186.05	221.12	241.72
2016	120.70	134.69	164.46	174.75	185.81	225.85	249.50
2017	112.24	126.15	158.31	169.60	181.55	224.97	253.41
2018	103.49	118.18	151.32	163.30	176.05	222.95	254.61
2019	95.07	109.86	144.23	157.04	170.80	221.20	255.32

Greece_Simulations of Indexed Debt-to-GDP (%) ω=100%								Actual
	0.01	0.05	0.35	0.5	0.65	0.95	0.99	
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	135.18	137.82	142.64	144.12	145.58	150.56	153.38	147.50
2011	152.86	156.91	164.56	166.80	169.15	177.09	181.45	175.20
2012	174.88	180.29	191.11	194.49	197.73	208.84	214.67	161.90
2013	174.66	180.84	193.43	197.20	201.18	213.74	220.73	178.40
2014	165.78	172.35	185.96	189.91	194.03	207.86	215.10	180.20
2015	167.18	175.32	190.85	195.31	200.03	216.06	224.68	177.00
2016	165.80	174.96	192.33	197.74	203.00	221.09	230.78	180.80
2017	161.26	171.42	190.46	196.26	202.22	222.21	233.20	179.20
2018	156.34	166.89	187.61	193.85	200.58	222.22	234.20	186.20
2019	150.82	162.63	184.62	191.38	198.52	222.47	235.59	180.50

Greece_Simulations of Indexed Debt-to-GDP (%) ω=25%							
	0.01	0.05	0.35	0.5	0.65	0.95	0.99
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	135.95	138.40	142.75	144.11	145.46	149.94	152.46
2011	141.01	147.04	159.36	163.20	167.13	181.44	188.79
2012	156.60	165.28	182.58	188.12	193.84	213.45	225.06
2013	152.27	161.67	181.93	188.38	195.09	218.35	231.68
2014	140.52	150.38	171.97	178.88	186.15	211.89	227.29
2015	137.96	149.67	173.60	181.53	189.41	219.20	237.06
2016	132.79	145.04	171.67	180.62	189.92	223.75	244.68
2017	124.75	138.27	166.62	176.38	186.36	223.73	247.29
2018	117.29	131.12	160.53	171.20	182.10	221.64	248.22
2019	110.05	123.53	154.58	165.70	177.50	219.96	249.28

Greece_Simulations of Indexed Debt-to-GDP (%) ω=50%							
	0.01	0.05	0.35	0.5	0.65	0.95	0.99
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	135.95	138.40	142.75	144.11	145.46	149.94	152.46
2011	145.03	150.63	161.12	164.43	167.77	179.74	186.11
2012	163.06	170.48	185.45	190.18	195.15	211.58	221.32
2013	160.29	168.22	185.81	191.33	197.11	216.50	227.22
2014	149.39	158.01	176.81	182.53	188.63	209.87	222.38
2015	148.57	158.61	179.43	186.03	192.96	217.85	232.29
2016	144.68	155.46	178.75	186.33	194.16	222.57	239.10
2017	137.58	150.05	174.79	183.12	191.52	222.59	241.26
2018	131.67	143.59	169.66	178.79	188.16	221.13	242.11
2019	124.28	137.14	164.83	174.36	184.41	219.76	244.16

Greece_Simulations of Indexed Debt-to-GDP (%) ω=75%							
	0.01	0.05	0.35	0.5	0.65	0.95	0.99
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	135.95	138.40	142.75	144.11	145.46	149.94	152.46
2011	149.03	153.76	162.89	165.65	168.46	178.27	183.60
2012	169.15	175.61	188.35	192.31	196.43	210.10	217.64
2013	167.61	174.65	189.71	194.27	199.10	214.87	223.37
2014	158.12	165.57	181.44	186.24	191.33	208.59	217.88
2015	158.21	167.09	185.21	190.71	196.45	216.87	227.68
2016	155.82	165.33	185.66	191.96	198.72	220.90	234.04
2017	149.87	160.84	182.82	189.61	196.84	221.94	236.49
2018	144.31	155.46	178.94	186.31	194.48	221.03	237.30
2019	138.15	150.23	174.98	183.01	191.53	220.30	238.96

Tables A.36-A.40 Simulated Indexed and Non-Indexed Debt Ratios, Case b, k=150bps

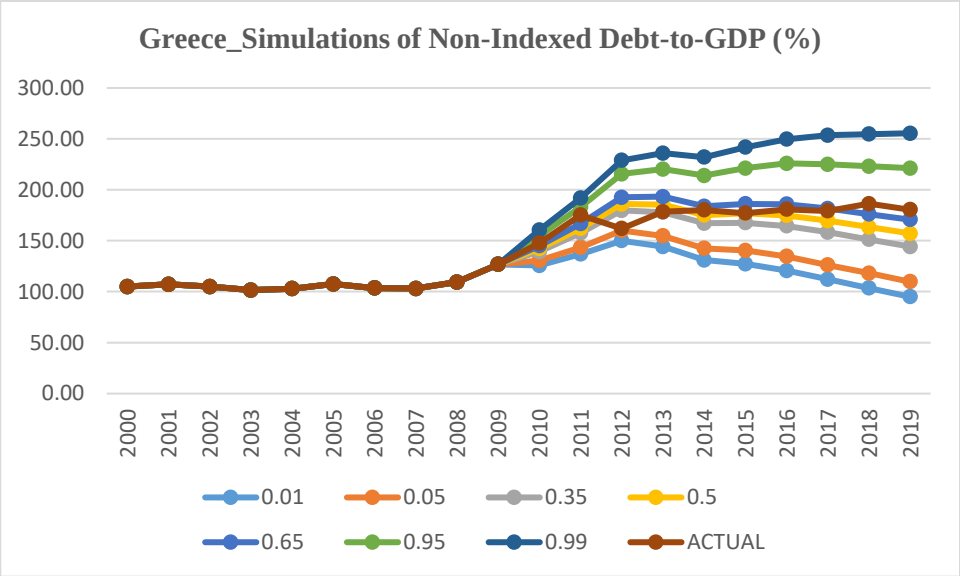

Figure A.15: Greece_Simulations of Non-Indexed Debt-to-GDP (%), Case b, k=150bps

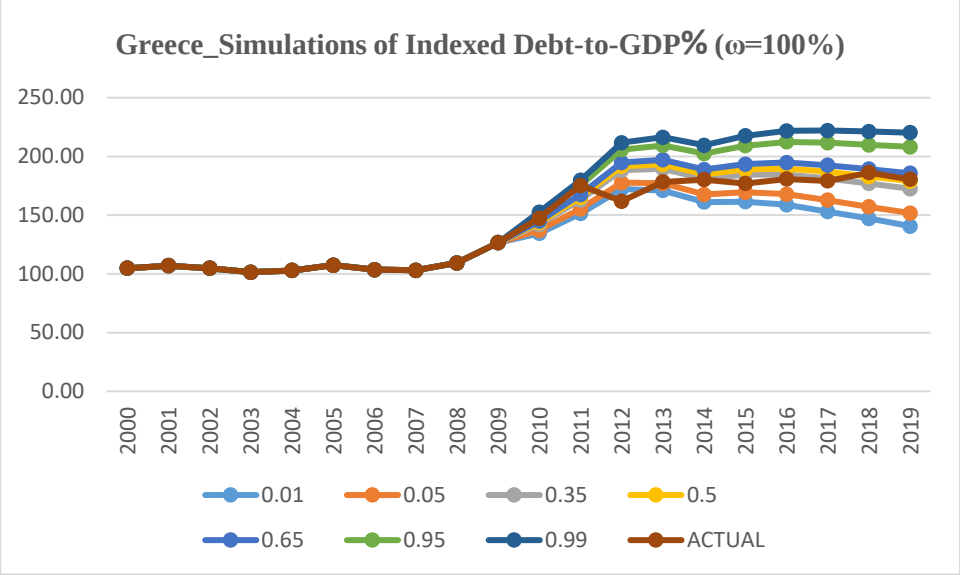

Figure A.16: Greece_Simulations of Non-Indexed Debt-to-GDP (%), Case b, k=150bpsv

k=200bps

Greece_Simulations of Non-Indexed Debt-to-GDP (%)							
	0.01	0.05	0.35	0.5	0.65	0.95	0.99
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	125.62	130.57	139.21	142.13	144.94	154.78	160.38
2011	136.76	143.47	157.58	161.98	166.58	183.00	191.80
2012	149.97	160.07	179.62	185.99	192.61	215.50	228.88
2013	144.12	154.71	177.96	185.40	193.17	220.25	235.95
2014	131.08	142.53	167.04	175.18	183.71	213.88	231.95
2015	127.20	140.43	167.61	176.93	186.05	221.12	241.72
2016	120.70	134.69	164.46	174.75	185.81	225.85	249.50
2017	112.24	126.15	158.31	169.60	181.55	224.97	253.41
2018	103.49	118.18	151.32	163.30	176.05	222.95	254.61
2019	95.07	109.86	144.23	157.04	170.80	221.20	255.32

Greece_Simulations of Indexed Debt-to-GDP (%) ω=100%								Actual
	0.01	0.05	0.35	0.5	0.65	0.95	0.99	
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	135.81	138.48	143.30	144.79	146.25	151.26	154.10	147.50
2011	154.34	158.40	166.13	168.39	170.77	178.76	183.16	175.20
2012	177.42	182.94	193.90	197.33	200.60	211.83	217.76	161.90
2013	178.36	184.66	197.45	201.26	205.33	218.07	225.23	178.40
2014	170.37	177.21	191.05	195.04	199.31	213.40	220.89	180.20
2015	173.01	181.33	197.35	201.92	206.80	223.30	232.18	177.00
2016	172.98	182.37	200.42	205.99	211.38	230.24	240.47	180.80
2017	169.58	180.24	200.09	206.14	212.37	233.24	244.77	179.20
2018	166.15	177.19	198.88	205.37	212.47	235.20	248.22	186.20
2019	161.78	174.20	197.50	204.72	212.32	237.76	251.56	180.50

Greece_Simulations of Indexed Debt-to-GDP (%) ω=25%							
	0.01	0.05	0.35	0.50	0.65	0.95	0.99
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	136.59	139.04	143.41	144.78	146.14	150.64	153.18
2011	141.38	147.41	159.75	163.60	167.54	181.86	189.22
2012	157.24	165.94	183.27	188.82	194.56	214.21	225.84
2013	153.20	162.62	182.94	189.41	196.10	219.45	232.79
2014	141.69	151.59	173.24	180.18	187.46	213.30	228.74
2015	139.44	151.20	175.21	183.16	191.09	220.99	238.89
2016	134.57	146.95	173.69	182.66	192.04	226.06	247.06
2017	126.87	140.50	169.05	178.86	188.91	226.47	250.10
2018	119.78	133.70	163.33	174.11	185.06	224.87	251.57
2019	112.79	126.40	157.84	169.06	180.98	223.73	253.34

Greece_Simulations of Indexed Debt-to-GDP (%) ω=50%							
	0.01	0.05	0.35	0.5	0.65	0.95	0.99
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	136.59	139.04	143.41	144.78	146.14	150.64	153.18
2011	145.76	151.38	161.90	165.23	168.57	180.59	186.98
2012	164.34	171.80	186.85	191.60	196.59	213.10	222.87
2013	162.13	170.14	187.82	193.35	199.18	218.68	229.50
2014	151.69	160.39	179.34	185.13	191.27	212.66	225.29
2015	151.51	161.65	182.69	189.36	196.32	221.46	236.00
2016	148.27	159.27	182.75	190.45	198.38	227.12	243.64
2017	141.74	154.46	179.60	188.03	196.56	228.02	247.13
2018	136.36	148.62	175.34	184.53	194.09	227.65	249.14
2019	129.73	142.90	171.33	181.00	191.31	227.25	252.29

Greece_Simulations of Indexed Debt-to-GDP (%) ω=75%							
	0.01	0.05	0.35	0.5	0.65	0.95	0.99
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	136.59	139.04	143.41	144.78	146.14	150.64	153.18
2011	150.12	154.88	164.06	166.84	169.68	179.53	184.89
2012	171.07	177.63	190.44	194.43	198.59	212.36	219.95
2013	170.37	177.49	192.73	197.32	202.22	218.17	226.72
2014	161.61	169.11	185.26	190.11	195.30	212.84	222.18
2015	162.56	171.63	190.08	195.68	201.51	222.33	233.28
2016	161.25	171.01	191.73	198.17	205.07	227.75	241.05
2017	156.27	167.51	190.08	197.04	204.43	230.22	245.24
2018	151.61	163.17	187.37	194.97	203.40	230.80	247.58
2019	146.36	158.89	184.59	192.99	201.86	231.81	251.13

Tables A.41-A.45 Simulated Indexed and Non-Indexed Debt Ratios, Case b, k=200bp

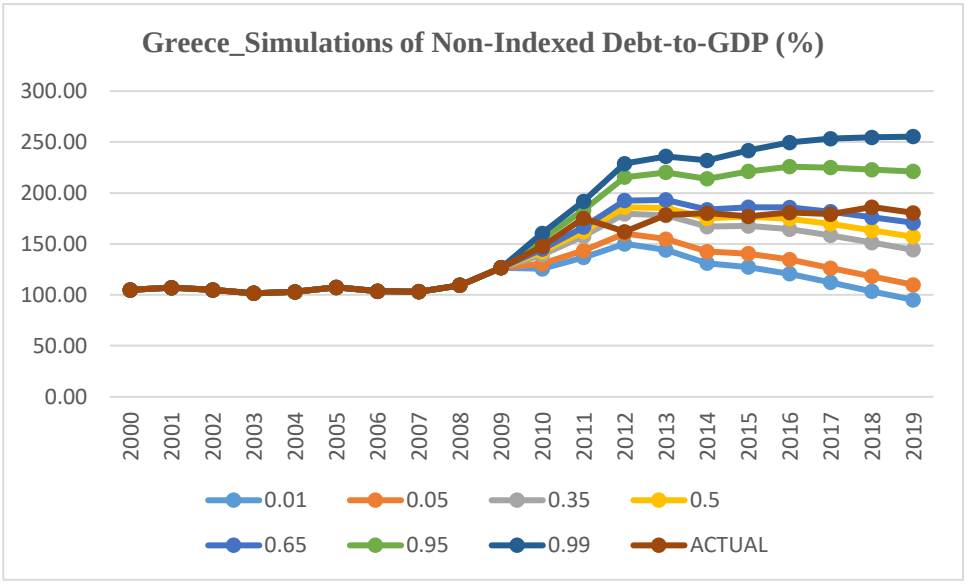

Figure A.17: Greece_Simulations of Non-Indexed Debt-to-GDP (%), Case b, k=200bps

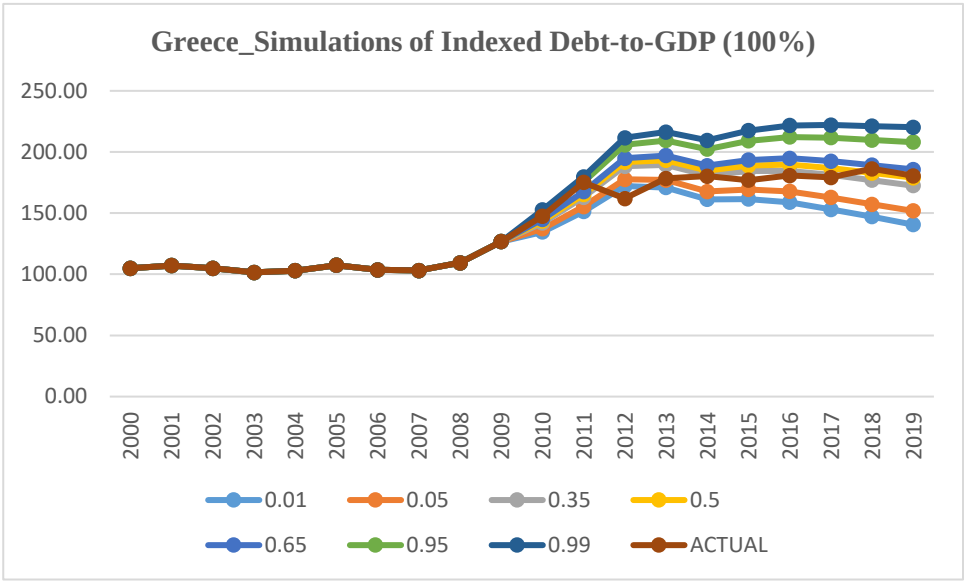

Figure A.18: Greece_Simulations of Indexed Debt-to-GDP (%), Case b, k=200bps

k=250bps

Greece_Simulations of Non-Indexed Debt-to-GDP (%)							
	0.01	0.05	0.35	0.5	0.65	0.95	0.99
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	125.62	130.57	139.21	142.13	144.94	154.78	160.38
2011	136.76	143.47	157.58	161.98	166.58	183.00	191.80
2012	149.97	160.07	179.62	185.99	192.61	215.50	228.88
2013	144.12	154.71	177.96	185.40	193.17	220.25	235.95
2014	131.08	142.53	167.04	175.18	183.71	213.88	231.95
2015	127.20	140.43	167.61	176.93	186.05	221.12	241.72
2016	120.70	134.69	164.46	174.75	185.81	225.85	249.50
2017	112.24	126.15	158.31	169.60	181.55	224.97	253.41
2018	103.49	118.18	151.32	163.30	176.05	222.95	254.61
2019	95.07	109.86	144.23	157.04	170.80	221.20	255.32

Greece_Simulations of Indexed Debt-to-GDP (%) ω=100%								Actual
	0.01	0.05	0.35	0.5	0.65	0.95	0.99	
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	136.44	139.14	143.97	145.47	146.93	151.97	154.82	147.50
2011	155.83	159.92	167.70	170.00	172.39	180.45	184.92	175.20
2012	179.99	185.66	196.75	200.21	203.51	214.88	220.90	161.90
2013	182.15	188.52	201.52	205.39	209.56	222.54	229.77	178.40
2014	175.13	182.11	196.22	200.31	204.71	219.11	226.84	180.20
2015	179.10	187.52	204.02	208.74	213.75	230.76	239.75	177.00
2016	180.41	190.07	208.80	214.55	220.18	239.69	250.35	180.80
2017	178.50	189.52	210.14	216.50	222.97	244.76	256.73	179.20
2018	176.34	188.04	210.78	217.57	225.00	249.14	262.84	186.20
2019	173.70	186.57	211.31	218.97	226.98	254.03	268.67	180.50

Greece_Simulations of Indexed Debt-to-GDP (%) ω=25%							
	0.01	0.05	0.35	0.5	0.65	0.95	0.99
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	136.59	139.04	143.41	144.78	146.14	150.64	153.18
2011	141.74	147.78	160.14	164.00	167.95	182.28	189.65
2012	157.89	166.60	183.97	189.54	195.29	214.97	226.62
2013	154.14	163.58	183.96	190.44	197.16	220.57	233.92
2014	142.87	152.81	174.54	181.49	188.80	214.74	230.21
2015	140.96	152.78	176.87	184.86	192.84	222.85	240.80
2016	136.43	148.86	175.76	184.81	194.24	228.49	249.48
2017	129.14	142.84	171.58	181.46	191.55	229.38	253.05
2018	122.46	136.43	166.27	177.15	188.24	228.31	255.08
2019	115.69	129.57	161.31	172.64	184.62	227.80	257.69

Greece_Simulations of Indexed Debt-to-GDP (%) ω=50%							
	0.01	0.05	0.35	0.5	0.65	0.95	0.99
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	136.59	139.04	143.41	144.78	146.14	150.64	153.18
2011	146.49	152.13	162.69	166.03	169.37	181.43	187.85
2012	165.63	173.14	188.25	193.04	198.04	214.63	224.44
2013	164.00	172.06	189.85	195.42	201.29	220.94	231.83
2014	154.05	162.79	181.93	187.77	193.98	215.50	228.27
2015	154.51	164.77	186.06	192.78	199.79	225.20	239.70
2016	152.04	163.18	186.94	194.72	202.76	231.79	248.53
2017	146.17	159.07	184.64	193.24	201.86	233.78	253.19
2018	141.43	154.08	181.28	190.67	200.35	234.50	256.40
2019	135.65	149.11	178.26	188.09	198.68	235.26	260.80

Greece_Simulations of Indexed Debt-to-GDP (%) ω=75%							
	0.01	0.05	0.35	0.5	0.65	0.95	0.99
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	136.59	139.04	143.41	144.78	146.14	150.64	153.18
2011	151.22	156.00	165.24	168.04	170.89	180.80	186.17
2012	173.02	179.62	192.56	196.58	200.77	214.63	222.28
2013	173.18	180.39	195.77	200.41	205.40	221.50	230.13
2014	165.17	172.76	189.15	194.07	199.35	217.14	226.58
2015	167.06	176.28	195.07	200.75	206.75	227.88	239.07
2016	166.75	176.82	197.97	204.58	211.64	234.85	248.57
2017	162.88	174.54	197.65	204.82	212.37	238.92	254.27
2018	159.42	171.27	196.28	204.14	212.80	241.15	258.47
2019	155.18	168.15	194.88	203.64	212.92	244.22	263.97

Tables A.46-A.50 Simulated Indexed and Non-Indexed Debt Ratios, Case b, k=250bps

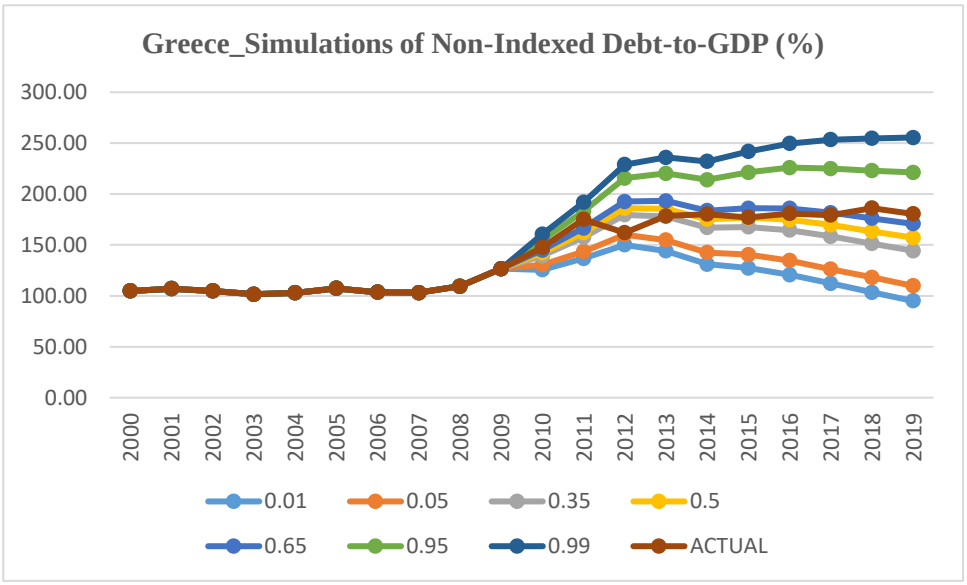

Figure A.19: Greece_Simulations of Non-Indexed Debt-to-GDP (%), Case b, k=250bps

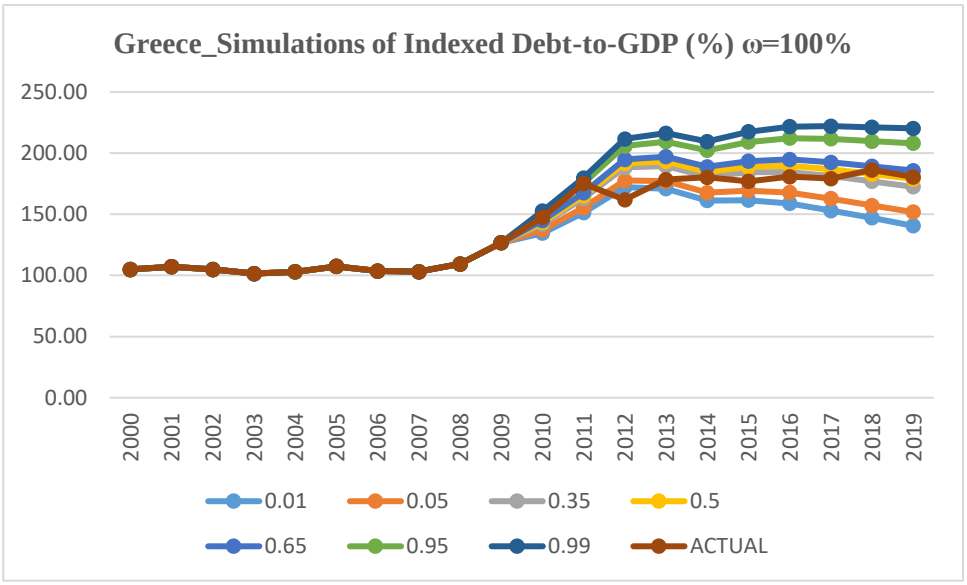

Figure A.20: Greece_Simulations of Indexed Debt-to-GDP (%), Case b, k=250bps

k=300bps

Greece_Simulations of Non-Indexed Debt-to-GDP (%)							
	0.01	0.05	0.35	0.5	0.65	0.95	0.99
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	125.62	130.57	139.21	142.13	144.94	154.78	160.38
2011	136.76	143.47	157.58	161.98	166.58	183.00	191.80
2012	149.97	160.07	179.62	185.99	192.61	215.50	228.88
2013	144.12	154.71	177.96	185.40	193.17	220.25	235.95
2014	131.08	142.53	167.04	175.18	183.71	213.88	231.95
2015	127.20	140.43	167.61	176.93	186.05	221.12	241.72
2016	120.70	134.69	164.46	174.75	185.81	225.85	249.50
2017	112.24	126.15	158.31	169.60	181.55	224.97	253.41
2018	103.49	118.18	151.32	163.30	176.05	222.95	254.61
2019	95.07	109.86	144.23	157.04	170.80	221.20	255.32

Greece_Simulations of Indexed Debt-to-GDP (%) ω=100%								Actual
	0.01	0.05	0.35	0.5	0.65	0.95	0.99	
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	137.08	139.79	144.63	146.14	147.62	152.67	155.53	147.50
2011	157.31	161.44	169.30	171.61	174.02	182.14	186.69	175.20
2012	182.64	188.39	199.62	203.09	206.44	217.96	224.12	161.90
2013	185.97	192.44	205.65	209.58	213.84	227.12	234.37	178.40
2014	180.00	187.13	201.54	205.72	210.24	225.01	232.87	180.20
2015	185.29	194.01	210.90	215.76	220.91	238.41	247.65	177.00
2016	188.11	198.08	217.52	223.40	229.24	249.48	260.59	180.80
2017	187.59	199.17	220.71	227.37	234.12	256.87	269.35	179.20
2018	187.20	199.36	223.30	230.51	238.30	263.82	278.25	186.20
2019	186.31	199.71	225.95	234.11	242.72	271.58	287.32	180.50

Greece_Simulations of Indexed Debt-to-GDP (%) ω=25%							
	0.01	0.05	0.35	0.5	0.65	0.95	0.99
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	137.85	140.32	144.74	146.12	147.50	152.05	154.63
2011	142.11	148.15	160.54	164.40	168.35	182.71	190.08
2012	158.55	167.28	184.68	190.26	196.02	215.75	227.41
2013	155.09	164.55	185.01	191.50	198.22	221.71	235.07
2014	144.07	154.05	175.86	182.83	190.17	216.19	231.72
2015	142.51	154.38	178.60	186.61	194.62	224.76	242.80
2016	138.37	150.89	177.94	187.05	196.51	230.98	252.01
2017	131.46	145.25	174.21	184.18	194.31	232.38	256.16
2018	125.23	139.33	169.38	180.36	191.56	231.94	258.80
2019	118.86	132.89	164.93	176.44	188.50	232.10	262.21

Greece_Simulations of Indexed Debt-to-GDP (%) ω=50%							
	0.01	0.05	0.35	0.5	0.65	0.95	0.99
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	137.85	140.32	144.74	146.12	147.50	152.05	154.63
2011	147.23	152.89	163.48	166.83	170.18	182.27	188.72
2012	166.93	174.52	189.68	194.48	199.51	216.18	226.03
2013	165.90	174.00	191.92	197.52	203.43	223.23	234.19
2014	156.49	165.25	184.56	190.47	196.73	218.42	231.33
2015	157.61	168.01	189.49	196.32	203.37	229.03	243.57
2016	156.00	167.22	191.31	199.15	207.32	236.63	253.66
2017	150.90	163.88	189.94	198.60	207.41	239.90	259.32
2018	146.68	159.78	187.58	197.15	207.04	241.78	264.15
2019	141.93	155.65	185.63	195.70	206.47	243.92	269.93

Greece_Simulations of Indexed Debt-to-GDP (%) ω=75%							
	0.01	0.05	0.35	0.5	0.65	0.95	0.99
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	137.85	140.32	144.74	146.12	147.50	152.05	154.63
2011	152.32	157.15	166.42	169.25	172.11	182.08	187.47
2012	175.04	181.63	194.69	198.74	202.98	216.93	224.64
2013	176.06	183.32	198.87	203.57	208.60	224.90	233.64
2014	168.77	176.51	193.12	198.11	203.50	221.57	231.08
2015	171.66	181.07	200.23	206.02	212.12	233.66	244.97
2016	172.49	182.87	204.45	211.29	218.45	242.19	256.20
2017	169.80	181.76	205.55	212.92	220.67	248.00	263.73
2018	167.63	179.85	205.66	213.80	222.78	252.16	270.05
2019	164.38	178.01	206.00	214.96	224.69	257.39	277.83

Tables A.51-A.55 Simulated Indexed and Non-Indexed Debt Ratios, Case b, k=300bps

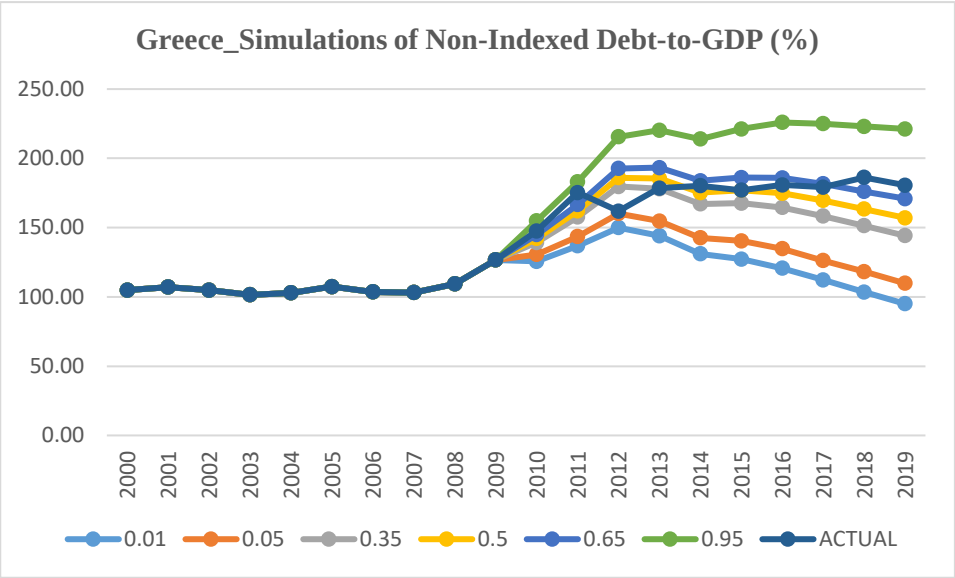

Figure A.21: Greece_Simulations of Non-Indexed Debt-to-GDP (%), Case b, k=300bps

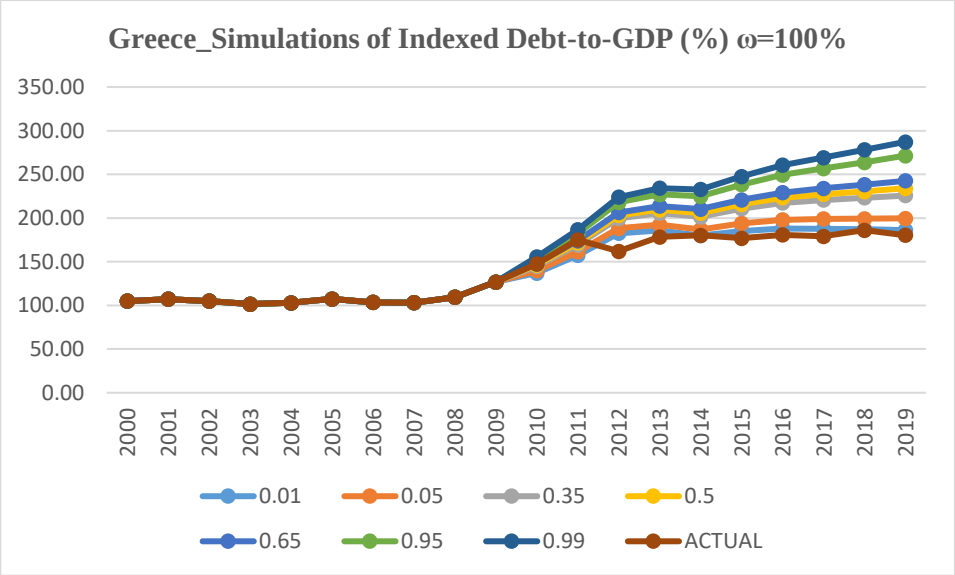

Figure A.22: Greece_Simulations of Indexed Debt-to-GDP (%), Case b, k=300bps

k=350bps

Greece_Simulations of Non-Indexed Debt-to-GDP (%)								Greece_Simulations of Indexed Debt-to-GDP (%) ω=100%								Actual
	0.01	0.05	0.35	0.5	0.65	0.95	0.99		0.01	0.05	0.35	0.5	0.65	0.95	0.99	
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90	2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10	2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90	2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50	2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90	2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40	2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60	2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10	2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40	2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70	2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	125.62	130.57	139.21	142.13	144.94	154.78	160.38	2010	137.71	140.43	145.29	146.81	148.29	153.37	156.25	147.50
2011	136.76	143.47	157.58	161.98	166.58	183.00	191.80	2011	158.78	162.97	170.89	173.21	175.65	183.84	188.43	175.20
2012	149.97	160.07	179.62	185.99	192.61	215.50	228.88	2012	185.34	191.13	202.50	206.01	209.40	221.08	227.37	161.90
2013	144.12	154.71	177.96	185.40	193.17	220.25	235.95	2013	189.82	196.40	209.84	213.85	218.19	231.70	239.03	178.40
2014	131.08	142.53	167.04	175.18	183.71	213.88	231.95	2014	185.00	192.25	206.98	211.25	215.90	231.01	239.08	180.20
2015	127.20	140.43	167.61	176.93	186.05	221.12	241.72	2015	191.70	200.67	217.94	223.00	228.29	246.35	255.87	177.00
2016	120.70	134.69	164.46	174.75	185.81	225.85	249.50	2016	196.18	206.43	226.54	232.59	238.69	259.73	271.29	180.80
2017	112.24	126.15	158.31	169.60	181.55	224.97	253.41	2017	197.22	209.30	231.77	238.68	245.79	269.55	282.65	179.20
2018	103.49	118.18	151.32	163.30	176.05	222.95	254.61	2018	198.78	211.46	236.51	244.18	252.35	279.28	294.63	186.20
2019	95.07	109.86	144.23	157.04	170.80	221.20	255.32	2019	199.52	213.71	241.65	250.37	259.55	290.53	307.11	180.50

Greece_Simulations of Indexed Debt-to-GDP (%) ω=25%							
	0.01	0.05	0.35	0.5	0.65	0.95	0.99
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	138.48	140.95	145.40	146.78	148.17	152.75	155.35
2011	142.48	148.53	160.94	164.81	168.76	183.14	190.52
2012	159.22	167.96	185.39	190.99	196.77	216.52	228.22
2013	156.05	165.55	186.07	192.56	199.30	222.86	236.24
2014	145.30	155.35	177.23	184.22	191.58	217.66	233.26
2015	144.12	156.02	180.37	188.41	196.45	226.72	244.86
2016	140.38	153.07	180.20	189.37	198.86	233.53	254.64
2017	133.84	147.84	176.97	187.04	197.21	235.57	259.52
2018	128.10	142.39	172.71	183.76	195.06	235.84	262.75
2019	122.30	136.52	168.88	180.52	192.67	236.81	267.03

Greece_Simulations of Indexed Debt-to-GDP (%) ω=50%							
	0.01	0.05	0.35	0.5	0.65	0.95	0.99
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	138.48	140.95	145.40	146.78	148.17	152.75	155.35
2011	147.98	153.65	164.28	167.63	171.00	183.13	189.59
2012	168.24	175.86	191.10	195.95	200.99	217.74	227.63
2013	167.84	175.98	194.03	199.66	205.61	225.52	236.58
2014	158.94	167.79	187.30	193.23	199.57	221.44	234.42
2015	160.81	171.34	193.02	199.91	207.07	233.00	247.66
2016	160.06	171.35	195.78	203.79	212.05	241.73	259.02
2017	155.67	168.98	195.41	204.26	213.25	246.30	266.01
2018	152.46	165.86	194.23	203.99	214.10	249.47	272.41
2019	148.65	162.72	193.49	203.78	214.91	253.22	279.76

Greece_Simulations of Indexed Debt-to-GDP (%) ω=75%							
	0.01	0.05	0.35	0.5	0.65	0.95	0.99
2000	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2001	107.10	107.10	107.10	107.10	107.10	107.10	107.10
2002	104.90	104.90	104.90	104.90	104.90	104.90	104.90
2003	101.50	101.50	101.50	101.50	101.50	101.50	101.50
2004	102.90	102.90	102.90	102.90	102.90	102.90	102.90
2005	107.40	107.40	107.40	107.40	107.40	107.40	107.40
2006	103.60	103.60	103.60	103.60	103.60	103.60	103.60
2007	103.10	103.10	103.10	103.10	103.10	103.10	103.10
2008	109.40	109.40	109.40	109.40	109.40	109.40	109.40
2009	126.70	126.70	126.70	126.70	126.70	126.70	126.70
2010	138.48	140.95	145.40	146.78	148.17	152.75	155.35
2011	153.44	158.29	167.62	170.46	173.33	183.38	188.78
2012	177.06	183.66	196.85	200.92	205.21	219.26	227.03
2013	178.95	186.31	202.01	206.78	211.86	228.35	237.25
2014	172.45	180.33	197.19	202.28	207.73	226.08	235.68
2015	176.43	186.03	205.53	211.44	217.69	239.64	251.06
2016	178.49	189.11	211.20	218.21	225.53	249.82	264.27
2017	177.04	189.29	213.79	221.40	229.46	257.59	273.61
2018	176.28	188.92	215.67	224.01	233.34	263.81	282.21
2019	174.41	188.61	217.79	227.18	237.22	271.61	292.78

Tables A.56-A.60 Simulated Indexed and Non-Indexed Debt Ratios, Case b, k=350bps

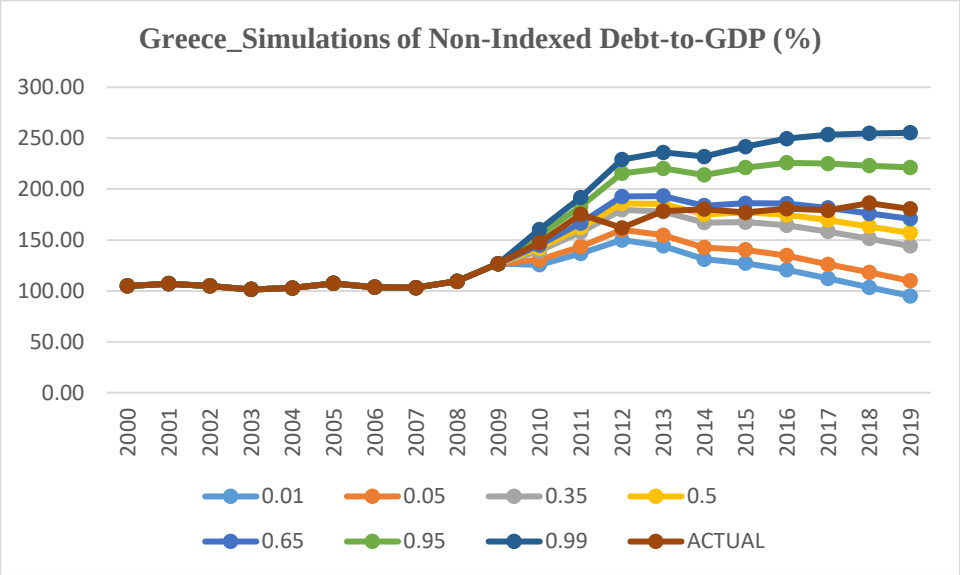

Figure A.23: Greece_Simulations of Non-Indexed Debt-to-GDP (%), Case b, k=350bps

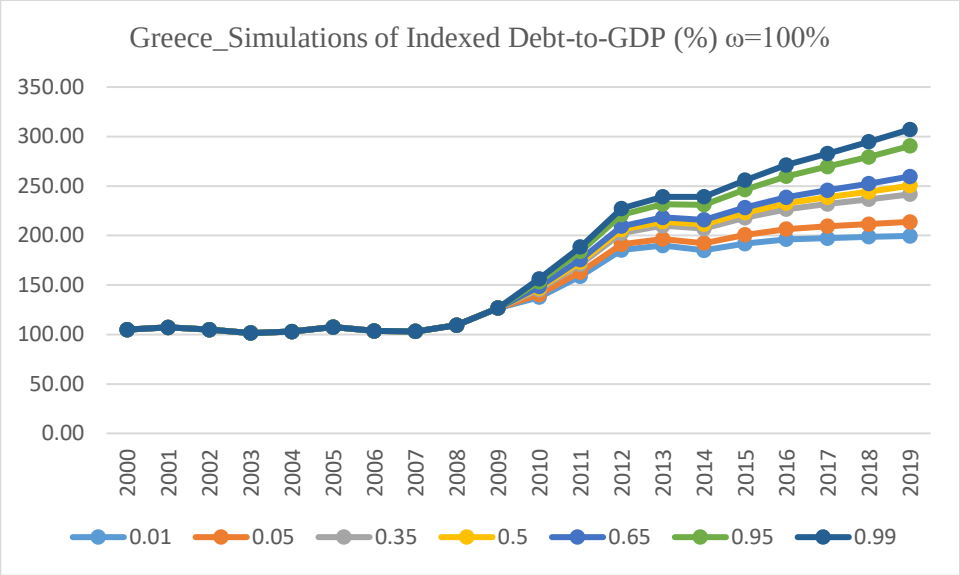

Figure A.24: Greece_Simulations of Indexed Debt-to-GDP (%), Case b, k=350bps