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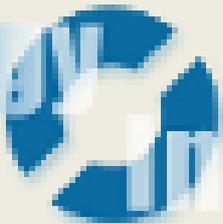
STRATEGIC REPORTS VOL. I

**"Why should Greece Default Once More?
A Stochastic Simulation Approach"**

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Strategic Series Paper Reviews.
Strategic Report Volume 1/2012

"Why should Greece Default Once More? A Stochastic Simulation Approach".

"Γιατί πρέπει η Ελλάδα να πτωχεύσει ακόμα μια φορά; Μια Προσομοίωση Στοχαστικής Προσεγγίσεως".

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Mr. Georgiopoulos is a financial economist with extensive experience in risk management, financial stability and policy. He has graduated from the University of Lausanne and he is defending his PhD at the Vienna University of Economics in financial stability and corporate finance. He has worked as a junior economist at the International Monetary Fund in Washington DC, as a researcher at the Vienna University of Economics and now as an enterprise risk manager at the largest Austrian insurer, Vienna Insurance Group. He is a part time consultant in corporate finance and financial modelling for private clients. He has been interviewed by Greek and international media such as Kerdos newspaper, Flash radio and the Associated Press, while articles of his have shown up in various online media. His professional and scientific work has been presented at the Central Bank of Portugal, the Technical University of Vienna, the Vienna University of Economics and the International Monetary Fund. His interests include risk management and the international financial and monetary system.

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Why Should Greece Default once more?
A Stochastic Simulation Approach

Nikolaos Georgiopoulos
Risk Manager

Introduction

The recent haircut on Greek debt was hailed as a step towards fiscal consolidation of the debt laden Greek economy. As a precondition to IMF/EU financing, Greece had to go through the so called Private Sector Involvement (PSI) program, which was essentially a haircut of 52% of the face value of debt including interest reductions. Although this haircut saved close to 100 billion euros, the question remains whether Greece is the long run a solvent country. An important aspect of the Greek situation is whether after the PSI, Greece can have hopes of reducing its debt burden under a series of reasonable assumptions for growth and deficits. If the debt burden as a percent of GDP does not decrease significantly over some time, a debt laden country cannot perform the necessary reforms with success.

And this is paramount to the need of Greece to perform a series of reforms that will allow the country to grow and stay competitive. Harsh reforms need to be implemented that will enable two things. The first thing is primary surpluses that will be used to repay debt. Primary surpluses, meaning the negative difference between government spending and government revenue before interest and principal payments, can be obtained by a policy mix of slashing spending and raising taxes.

If debt is not sustainable, then extraordinary primary surpluses may have to be sustained over long periods of time. In the meantime if high taxation and low social expenditure persist, a reform fatigue will ensue and the electorate will vote down the government implementing reforms. The second thing that is needed is growth. Growth can be achieved by a combination of policies that do not impede business creation, allow for labor market flexibility, reduce barriers to entry and provide competitive taxation to firms.

An unsustainable debt in this respect is a debt that is unable to be financed with a policy mix that allows policies that attract businesses and that do not cause reform fatigue. The debt stock itself is a determinant for the sustainability of debt. Although there are countries with high debt, exceeding 100% of GDP and they can pay it back, still it remains questionable whether in the long run such debts are viable. In economic history Great Britain was able to pay back a colossal debt due to the Napoleonic wars within a century. Italy pre crisis was serving a more that 100% Debt/GDP ratio and Japan serves an even higher one.

Yet the differences between Greece and the other countries are significant. First, British debt was accumulated due to war whereas Greece accumulated debt in times of peace and strong growth. Second, Greece has a service based economy whereas the other nations are strong industrialized economies with competitive industries capable of producing current account surpluses or deficits which are significantly lower than those of Greece.

Two of the aforementioned countries (Japan and Britain) have independent monetary policies and can monetize their debt through seignorage. Britain was tied to the gold standard and as the dominant power in the world could cover its debt payments through gold extraction from its colonies and more significantly by its position as the leading industrial power in the world. Greece does not qualify either as a big industrial country with competitive products that can create current account surpluses or as a country with independent monetary policy to monetize its debt.

Debt stock itself is a determinant for sustainability for Greece. A recent IMF study has shown correlations between small growth and high debt. Although the study did not establish a causal relationship between low growth and high debt, it is reasonable to assume that large stocks of debt are not a help to the growth rate of an economy with significant structural problems. A debt overhang situation could occur when debt is high. In the public finance literature the ability to pay debt (technical solvency) does not necessarily mean willingness to pay it back. Debt overhang could be a situation where the surplus of the economy leaves the country to pay creditors at such an amount where locals see that it does not pay off to create surpluses.

The debt stock is a signal to financial markets and citizens alike. Markets see the reduction of debt as a sign towards fiscal responsibility and will react by lowering the yields on the outstanding debt. Citizens will see that the reduction of the debt stock makes their sacrifices worth of and reform fatigue is soothed.

Given all the above issues, in this sort paper I will try to make a stochastic projection of the Greek debt within the next ten years under a set of assumptions which is public information. I want to make a stochastic projection in order to capture random variations that could cause positive or negative shocks to the debt consolidation process. Moreover I will allow for relatively favorable economic situations such as positive growth rates and sustainable primary surpluses. I will also calculate through a Monte Carlo estimator the probability that the debt level will exceed a series of thresholds. I do not allow for any Laffer effects of taxation on the growth rate and subsequently to the amount of government revenue. Moreover I do not study any general equilibrium issues in prices, wages and the current account.

Model

GDP Process

I assume a lognormal stochastic process for the GDP. In differential form that is:
$$dS_t = gS_t\, dt + \sigma S_t\, dW_t$$

W_t is a Wiener process. The solution to the stochastic differential equation is:

$$S_t = S_0\, exp\left\{\left(g - \frac{\sigma^2}{2}\right)t + \sigma\sqrt{t}Z_t\right\}$$

Z_t is a normally distributed random variable with zero mean and variance 1. This is the GDP scenario generator. Lognormal random variables have been extensively used in various economic phenomena such as the evolution of equity prices. Lognormal random variables are

thin tailed random variables, meaning that extreme events occur with low probability. Therefore I consider that the GDP process does not exhibit jumps and abrupt non continuous fluctuations. I assume that the time period is one year for each GDP change, therefore the above stochastic process can be recursively written as:

$$S_t = S_{t-1} \, exp\left(g - \frac{\sigma^2}{2} + \sigma \cdot Z_t\right)$$

For each year I assume 10.000 scenarios, thus I draw 10000 standard normal variables Z_t, $\forall t = 0, \ldots, T$. T is the projection period, in our case T=10 years. S_0 is the current GDP. The expected growth rate is g and the volatility of the GDP growth rate is σ. For 10 years we need 10×10000=100000 scenarios. Each scenario is conditional on the previous value at time t = t − 1 as the equation shows. Therefore we have matrix of dimension 10000×10 of scenarios.

Public Finance

I assume that government spending is a percentage X_t of the GDP S_t And government revenue (loosely speaking they are the taxes) is a percentage Y_t of the GDP. Thus the primary balance is:

$$(X_t\text{-}Y_t)S_t$$

If this number is positive then we have a primary deficit. On the contrary a negative balance means a primary surplus and a zero value implies a balanced budget. The evolution of debt has to take into account the interest rate r and the inflation rate i. We assume that these are constant throughout the projection period. The debt stock at time t is denoted by D_t and its evolution is governed by the following stochastic process:

$$D_t = (1+r-i)D_{t-1} + (X_t - Y_t)S_t$$

In order to calculate the probability that the debt ratio will exceed a certain threshold u, I use a Monte Carlo estimator.

$$P\left(\frac{D_t}{S_t} > u\right) \cong \frac{1}{N}\sum_{i=1}^{N} 1\left(\frac{D_t}{S_t} > u\right) \; and \; \left(\frac{D_t}{S_t} > u\right) = \begin{cases} 1, if \; D_t/S_t > u \\ 0, if \; D_t/S_t \leq u \end{cases}$$

I only need the terminal debt and GDP values therefore t = T and N = 10000. We now have all the ingredients in place for the stochastic simulation of the Greek debt.

Stochastic Simulation

As a base case scenario I assume the following parameters:

Parameters	
Government Spending %GDP t=1	0.42
Taxes %GDP t=1	0.4
Government Spending Onwards	0.4
Taxes %GDP Onwards	0.4

Current GDP	301
Mean Growth Rate	0.02
Volatility of GDP	0.016
Interest on Debt	0.0365
Inflation	0.02
Debt/GDP Ratio Current	1.4

Government revenue is close to 40% of the GDP from IMF data for 2011 and I allow a primary deficit of 2% for 2011, thus government spending is 42% of the GDP. I assume that afterwards the government balances its budget until the end of the projection by cutting spending and not raising taxes. I assume a mean growth rate of 2% for each year thereafter, an optimistic assumption given that Greece is in the fourth year of recession. I estimate from historical data that the volatility of the growth rate is 1.6%. Inflation is close to 2% and the average interest rate on post PSI debt is 3.65%. The current debt ratio is at 140% of GDP of 301 billion dollars.

The results of the simulation are the following:

Mean Debt/GDP	1.37249088
Probability of Success 120%	0.00370037
Probability of Failure 120%	0.99629963
Probability of Success 100%	0
Probability of Failure 100%	1

Mean Debt/GDP is the expected debt ratio or the sampling average $\frac{1}{N}\sum_{i=1}^{10000}\frac{D_{T,i}}{S_{T,i}}$ of all

Terminal scenarios which calculates the expectation of the terminal distribution of the debt ratio. Probability of failure 120% is the probability $P(D_t/S_t > 120\%)$. Likewise for 100%. What we see from this exercise is that with modest growth rates and balanced budgets, Greece does not reduce its debt ratio. On the contrary it increases it. The main driver is the interest service which nullifies the effect of growth, even if the budget is balanced. I will now allow for primary surpluses of 2% throughout the projection period except t = 1. I reduce government spending at 38%.

Parameters	
Government Spending %GDP t=1	0.42
Taxes %GDP t=1	0.4
Government Spending Onwards	0.38
Taxes %GDP Onwards	0.4
Current GDP	301
Mean Growth Rate	0.02
Volatility of GDP	0.016
Interest on Debt	0.0365
Inflation	0.02
Debt/GDP Ratio Current	1.4

The results are the following:

Mean Debt/GDP	1.19494108
Probability of Success 120%	0.541454145
Probability of Failure 120%	0.458545855
Probability of Success 100%	0.00070007
Probability of Failure 100%	0.99929993

The debt ratio remains close to 120% the same as in 2009, even if primary surpluses persist for 9 consecutive years. An important issue underlying this result is that growth is expected to be positive at 2% per year and that surpluses are sustainable for 9 years. And even with these favorable conditions, the debt ratio is not better than the 2009 one. In policy terms this means that government should cut spending only to see its debt ratio reverting to 2009 levels which were supposed to be non-viable.

Reform fatigue may ensue since citizens will notice that no matter how much they sacrifice they are not better off in terms of their debt ratio after ten years of austerity. The probability that the final debt ratio will exceed 119% is 54%, with the probability that the debt ratio will stay below 100% being close to zero. This projection shows that even with primary surpluses, the debt is so high that does not lead to reductions of the ratio below of 100% of GDP.

The importance of a debt ratio below of 100% can be founded on option pricing theory. A debt contract is an option on the economy's "cashflow" which can be considered to be the GDP. Debt holders have a priority on this cashflow. A debt ratio of 100% means that the option is at/or in the money since governments are in principle capable of taxing their citizens and extracting the GDP of the economy. An out of the money debt contract means that the government even if it confiscates the entire GDP is still unable to pay back its borrowers.

Of course in practice solvency does not mean that the government needs to confiscate the entire GDP to pay back its liabilities, however debt ratios are indicative and predictors of financial distress. One would argue that even at 120% the debt could be sustainable given the long term growth rates of the economy and the evolution of interest rates and inflation. Yet there is a series of issues to consider:

1. Time frame of the horizon. When the time frames are very long projections are laden with sampling errors. If debt is projected at 120% after 10 years, its sustainability has to be assessed for the next 20 or 30 years, causing significant estimation errors on inflation and interest rates.
2. The 120% result is based on very favorable projections, i.e. 2% average growth, low inflation and sustainable primary surpluses. In reality nothing is guaranteed to last. In fact this projection is very optimistic in its assumptions.
3. No general equilibrium results have been considered such as the effect of primary surpluses to the growth rate. If taxation is Laffer suboptimal then we would expect growth rates to decline. Moreover reform fatigue has not been considered at all.
4. There is no consideration of real exchange rate misalignment. If the real exchange rate is overvalued then the real debt ratio is much higher, since the GDP has to decrease through internal devaluation to the level where the real exchange rate is at its

equilibrium value. With Greece going through an internal devaluation, the real debt ratio is in fact higher.

A good success threshold for debt reduction is the 100% level. As soon as debt reaches this level, the debt contract is in the money. Psychologically (and this has to do with reform fatigue) it is important to convey to the citizens that sacrifices pay off and this will retain public support on the reform process.

Given the 100% threshold, I am interested to see which primary surplus as a percent of the GDP will reduce the debt ratio below 100%. From trial and error I find that a 5% primary surplus has the following results:

Mean Debt/GDP	0.92861638
Probability of Success 120%	0.99989999
Probability of Failure 120%	0.00010001
Probability of Success 100%	0.882388239
Probability of Failure 100%	0.117611761

However the real issue whether such surpluses are sustainable. I also considered a second haircut on the debt which would decrease the current debt ratio from 140% to 110%, with 2% primary surpluses until the end of the projection.

Parameters	
Government Spending %GDP t=1	0.42
Taxes %GDP t=1	0.4
Government Spending Onwards	0.38
Taxes %GDP Onwards	0.4
Current GDP	301
Mean Growth Rate	0.02
Volatility of GDP	0.016
Interest on Debt	0.0365
Inflation	0.02
Debt/GDP Ratio Current	1.1

The results are:

Mean Debt/GDP	0.90499212
Probability of Success 120%	1
Probability of Failure 120%	0
Probability of Success 100%	0.96239624
Probability of Failure 100%	0.03760376

This is a much better picture. Success probabilities are higher and the expected debt ratio is 2% lower than that with 5% primary surpluses but this 2% can be considered as a reasonable sampling variance; therefore I consider the results equivalent. This debt haircut implies that under more sustainable primary surpluses which can cause lesser Laffer effects and reform fatigue, debt reduction below 100% debt ratio is feasible.

Finally I am interested in checking the effect of the interest rate. I assume that the interest rate falls to 2% and the primary surplus remains at 2% for t > 1 and no debt haircut.

Parameters	
Government Spending %GDP t=1	0.42
Taxes %GDP t=1	0.4
Government Spending Onwards	0.38
Taxes %GDP Onwards	0.4
Current GDP	301
Mean Growth Rate	0.02
Volatility of GDP	0.016
Interest on Debt	0.02
Inflation	0.02
Debt/GDP Ratio Current	1.4

Mean Debt/GDP	0.999055957
Probability of Success 120%	0.99959996
Probability of Failure 120%	0.00040004
Probability of Success 100%	0.515451545
Probability of Failure 100%	0.484548455

With a real rate of 0% and modest assumptions, the debt ratio is expected to be at 100% at the end of the projection. A more bold policy of interest and principal reductions (110%) has the following effects:

Mean Debt/GDP	0.752878815
Probability of Success 120%	1
Probability of Failure 120%	0
Probability of Success 100%	1
Probability of Failure 100%	0

Discussion and Policy Recommendations

From the previous stochastic projection it became evident that the reduction of the debt ratio to levels below 100% is a very difficult task. First the real debt ratio is higher due to real exchange rate misalignment. This misalignment is being treated by an IMF/EU sponsored internal devaluation program. The internal devaluation has two conflicting targets. On the one hand debt sustainability and on the other hand real exchange rate alignment through a recession that will cause the price level to fall.

A recession overshoot (like an external devaluation overshoot) may create a vicious cycle of decreasing government revenue, primary deficits and growth of debt. In my opinion the internal devaluation will only work once debt becomes sustainable, meaning that it should require relatively low primary surpluses, modest assumptions on the growth rate and the ability of the government to conduct discretionary tax policy to attract new businesses. The tax policy should be such as to mitigate Laffer effects that will enforce the vicious cycle of the

recession. Moreover the policy mix should not cause reform fatigue in order to retain popular support.

In this respect the Greek government should:

1. Redefine and communicate to the interested parties a renewed definition of debt sustainability in terms of discretionary business friendly tax policy, modest primary surpluses, and moderate growth assumptions.
2. Clearly set debt ratio targets as a benchmark both for the conditions of financing and its progress. IMF/EU financing terms should be aligned as much as possible to the Greek government's targets. The target should be ambitious but attainable according to the Government's definition of debt sustainability.
3. IMF/EU should be accountable on how their financing requirements facilitate or not fiscal adjustment. The Greek government should voice a concern when the financing conditions do not meet at least two of the prerequisites for sustainable debt.
4. Propose a policy mix of a secondary haircut that will reduce the debt to 110% debt ratio and negotiate interest reductions. In this way according to the calculations, Greece will reduce its debt ratio under 100% of GDP within 10 years with modest growth rate and primary surpluses.

On the other hand IMF/EU should recognize that the danger of reform fatigue and the rise of extreme anti-IMF/EU parties which will hinder the Troika ability to recommend policy to Greece as Greece will become more and more politically volatile. It is in Troika's best interest to recognize that a fast and orderly reduction of principal and interest can guarantee the long term ability of Greece to repay its debt.

There are many lessons to be learned from the sovereign debt crisis. The first lesson is that acting late equals to no acting at all. If the Greek crisis had been contained early enough, the costs would have been much lower. Of course there is always the issue of moral hazard but governments should weigh the costs of moral hazard with the costs of a full blown sovereign debt crisis. A second lesson to be learned is that unsustainable debts will never be repaid; therefore the faster debts are reduced through haircuts, the better.

A final lesson for policy makers is that reform fatigue and deterioration of the political parties supporting reform is crucial. Therefore future IMF/EU programs should target immediately to the underlying factor. If there is suspicion of insolvency, don't think! Cut debt as soon as possible, finance the debt laden economy with the necessary liquidity and allow breathing space for the economy in order not to suffer from reform fatigue.

-End of Report-