COLUMBIA UNIVERSITY: SCHOOL OF INTERNATIONAL AND PUBLIC AFFAIRS
CENTRAL BANK OF ARMENIA: MONETARY POLICY DEPARTMENT

WP08/12-01E

Is Greece on the Right Track?

Debt Sustainability with Stochastic Approach

Paloma Alonso García-Puente **Zeina El Khoury** **Vahagn Grigoryan** **Tomoyuki Yamada**

5/7/2012

Abstract

The aim of our paper is to analyze the sustainability of the Greek public debt from a risk management point view. We use a VAR model that takes into account the stochastic nature of the variables in the debt accumulation equation and their close interrelation and compute the probability of debt being above a specific threshold under different scenarios or conditions currently required by the IMF. The scenarios include specific primary surplus levels, privatization, and the inclusion of contingent liabilities. We find that even though debt under these requirements is sustainable in its mean, there are non-trivial probabilities where it is clearly unsustainable.

We are grateful for excellent research assistance to Guillermo Calvo, Ernesto Talvi and especially Pablo Ottonello.

CONTENT

I. Introduction 3

A. Economic Developments in Greece 2000-2012 3
B. Our Research Questions 4

II. Different Approaches to Debt Sustainability 5

A. Standard Approach (Buiter-Blanchard): 5
B. Endogenous Debt Dynamics (IMF-WB method): 6
C. Sudden Stop approach (Calvo-Izquierdo-Talvi): 6
D. Natural Debt Limit approach (Mendoza-Oviedo): 6
E. Stochastic simulations - Fan charts model: 7

III. Data and Estimations 7

A. The Choice of the Model 7
B. Data description 9
C. Vector Auto Regression (VAR) Model: 10

IV. Stochastic Simulations 13

A. Baseline scenario 14
B. IMF scenario 1 15
C. IMF scenario 2 16

V. Challenges to our model 18

A. Additional risks 18
B. Sustainable level of Debt-to-GDP 19

VI. Conclusion 21

VII. Appendix 23

VIII. References 31

I. Introduction

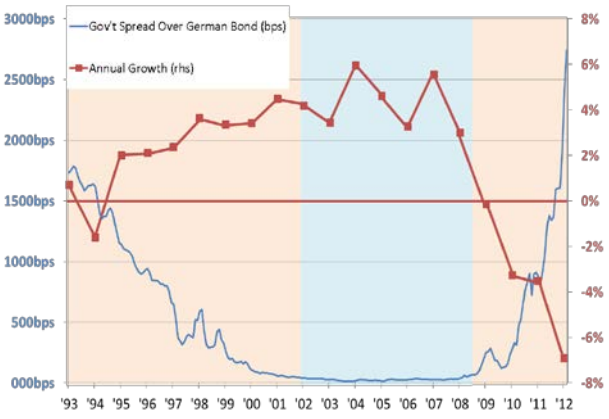
A. Economic Developments in Greece 2000-2012

After its accession to the Euro zone, Greece had an easy external finance with cheaper interest rate; the government interest spread over German government bond dramatically dropped from 1,784bps March 1993 to 34bps in March 2002. Supported by a fast growth of 3 to 6 percent, the primary balance has been around zero during the period 2004-2007 even though the government expanded its spending.

Since the global financial crisis hit the Hellenic republic, its economic growth turned into negative. This fact, combined with the raise of interest demanded for the new issued debt, rapidly increased the fiscal deficit from 0.38% of GDP in 2007 to 9.5% of GDP in 2009. With a shrinking economy, Greek fiscal balance improvement in 2010 was not sufficient to turn itself into positive, and the debt swelled promptly from 107% of GDP in 2007 to 164% of GDP in 2011.

Figure 1

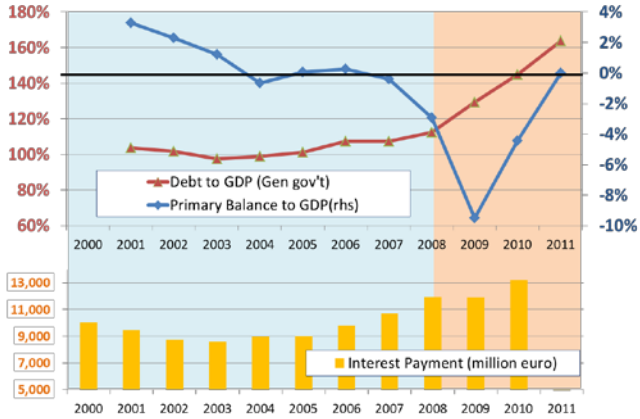
Greek growth rate and government bond yields



(Source: IMF)

Figure 2

Greek Debt to GDP, Primary Balance and Interest Payments



(Source: IMF and Statistics Office)

Facing increasing government bond yield day by day, Greek government has had troubles with refinancing its debt and meeting its repayment obligations for the last 3 years; the yield on

government bonds reached historical records of 29.2 percent in February 2012. The increasing tension was temporally released in March 2012 by means of the private sector involvement (PSI), or "hair cut"[1], together with Official Sector Involvement (OSI)[2] and the International Monetary Fund's (IMF) finance arrangement[3].

As conditions for this new finance package, the Greek government, together with the Bank of Greece, committed to implement new economic and financial reform policies in March 9, 2012[4]. Greek government adjustment program includes not only fiscal targets, but also restructuration of the revenue administration and public management system, privatization and structural reforms. The primary surplus of Greek general government is projected to reach 4.5 percent of GDP starting year 2014. Finally, the IMF estimates that overall debt would fall to 116.5 percent of GDP in 2020 if all the reforms and requirements are met[5].

B. Our Research Questions

The main question that we attempt to answer is whether sovereign debt of Greece would be sustainable or not in 2020 under different scenarios, including the IMF requirements and predictions under the adjustment program. In the case of finding unsustainability of Greek debt, we are as well interested in discussing the additional austerity measures that could be implemented and into what extent.

The market certainly doubts about sustainability of Greece debt, despite the IMF forecasts that it will be sustainable with a level of 120 percent to GDP in 2020; Greek government bond yield is still high, around 20 percent, in March 2012 even after PSI and OSI (Funk Kirkegaard, March 21, 2012).

---

[1] Private Sector Involvement(PSI) : (i)a reduction in the nominal value of eligible Greek government bonds by 53.5 percent (15 percent paid up-front with EFSF short-term notes acquired by Greece, with the remaining 31.5 percent exchanged into 30-year bonds amortizable after 10 years); (ii) coupons of 2 percent in 2012-15, 3 percent in 2016-20, 3.65 in 2021,, and 4.3 percent from 2022 onwards; (iii) a GDP-linked additional payment; and (iv) a co-financing structure with EFSF concerning the 15 percent upfront payment

[2] Official Sector Involvement (OSI) : (i) reduction in the margin of the Greek Loan Facility(GLF) to a uniform 150 basis points (reduction of finance needs of 1.4 billion Euro), (ii) Greece to receive, until 2020, the income accruing on bonds held by national central banks in their investment portfolio.

[3] IMF approved a 4 year SDR23.8billion (28 billion euro) arrangement under the Extended Fund Facility (EFF) for Greece in support of the economic adjustment program by the government

[4] Memorandum of Economic and Financial Policies (MEFP) that outlines the economic and financial policies that Greek government and the Bank of Greece will implement during 2012-2015 was agreed on March 9.

[5] IMF country report No. 12/57

There are two sources of doubts on Greek debt sustainability: a distrust of the adjustment program's realization, and uncertainty on debt evolution due to future unpredictable shocks. Our question refers to the latter source of doubt; how Greek debt will look like if the primary surpluses in the adjustment program are realized.

In addition to the debt sustainability itself, attention should be paid to interactions between specific variables: the primary balance, interest rate and growth of economy. In the context of Greek debt, the effect of contractionary fiscal policy over economic growth is considered as one of the key issues. On one hand, some economists argue that it will take long time for the debt to GDP to get sustainable if the fiscal contraction deteriorates the country's growth so much: "Still, the story is far from over. Even with this debt relief, Greece — like other European nations forced to impose austerity in a depressed economy — seems doomed to many more years of suffering" (Paul Krugman, March 11,2012). On the other hand, price and wage adjustment is considered as a path to gain competitiveness and get the growth back to Greece. We would like to provide some evidence on this issue from empirical analysis.

I. Different Approaches to Debt Sustainability[6]

There are several approaches to assess the sustainability of Public Debt, below is a brief description of the main ones.

A. Standard Approach (Buiter-Blanchard):

$$ps = \frac{(r-g)}{(1+g)}d$$

This approach constitutes the starting point of fiscal sustainability. It uses the discrete time equation of debt. It is based on the estimation of the primary surplus required to stabilize the debt to GDP at a given level, usually the current debt levels, or any specified level that is considered appropriate. The difference between the required primary surplus and the actual primary surplus gives us the adjustment needed to stabilize the debt.

[6] "Template for Fiscal Sustainability", IDB, 2011

B. Endogenous Debt Dynamics (IMF-WB method):

$$d_t = [\alpha \frac{(1+r_t^d)}{(1+g_t)} + (1-\alpha)\frac{(1+r_t^f)(1+\Delta e)}{(1+g_t)}]d_{t-1} - ps_t$$

This approach traces the path of the Debt/GDP ratio over time as a function of the primary surplus, interest rate, exchange rate and growth rate. The starting point is the same discrete time equation of debt, but it incorporates the decomposition of debt into domestic and foreign currency. It has a shorter term focus than the standard approach, and allows to introduce temporary changes in the determinants of debt, and to test the sensitivity of the debt path to these changes.

C. Sudden Stop approach (Calvo-Izquierdo-Talvi):

$$d = \frac{d + Ed^*}{Y + EY^*}$$

The Sudden stop approach provides estimates of the impact of a sudden stop on debt sustainability. The model considers various channels through which a sudden stop affects debt sustainability, mainly through the real exchange rate channel and the resulting valuation effects on debt. The valuation effects do not only depend on the composition of debt between domestic and foreign currency, but also on the share of tradable output in the economy, or the currency mismatch between debt and output. If the share of foreign currency debt is higher than share of tradable output, this will result in a currency mismatch and that will lead to high valuation effects and will require a higher fiscal adjustment to have a sustainable debt.

D. Natural Debt Limit approach (Mendoza-Oviedo):

$$d \leq d^* = \frac{(t^{min} - e^{min})}{r - g}(1+g)$$

This formula calculates the maximum level of debt that the government would be able to service with certainty or zero probability of default even if faced with a crisis (“credible commitment”) and compares it with the actual debt levels. In this approach the maximum debt that the

government could afford is the annuity value of primary surplus calculated with the minimum tax revenues to GDP and the minimum non interest expenditure to GDP that can be sustained if the country were to have a fiscal crisis and tax revenues are at minimum levels.

E. Stochastic simulations - Fan charts model:

This approach incorporates the important fact that the future evolution of the direct determinants of the evolution of debt, such as interest rates, growth rates, and primary balance is uncertain, and thus this uncertainty extends to the evolution of the debt to GDP ratio. It can also take into account that the variables in the debt accumulation equation are correlated and the historical correlations are likely to continue in the future. Thus, the approach utilizes any model for external forecast to derive the dynamic interrelationship among the variables, and uses stochastic simulations to generate probability distributions for debt-to-GDP ratio dynamics. This allows to compute the probabilities that the debt will exceed a given threshold or calculate the necessary policy adjustments for a specific debt target level with given confidence level.

II. Data and Estimations

A. The Choice of the Model

In this paper we assume that the variables used in the debt accumulation equation are stochastic and closely interrelated. Thus, we apply the mentioned stochastic simulations approach, using a Vector Auto Regression (VAR) model for the external forecast of the interrelation of the variables and Monte Carlo simulations to generate the probability distributions. This approach will let us find out not only the independent impact of each variable on debt, but also the impact of each variable on the other variables and on debt, simultaneously. For instance, if GDP growth systematically worsens when the interest rate increases, this means that debt will not only deteriorate because of the increase in interest rates but the effect will be larger due to the negative impact that the increase in interest rates has on growth. Such correlations, both positive or negative, will allow for a better assessment of debt sustainability.

From the literature of different applications of stochastic simulation analysis[7], we based our analysis of the Greek debt on a paper by Garcia and Rigobon (2004), because of its relative simplicity.

Our model departs from the standard debt dynamics equation of Talvi (2012)[8]:

$$DT_t = \frac{1+R_t}{1+G} \cdot DT_{t-1} - PS_t + Z_t^m$$

Where:

DT_t = Real debt to GDP on year t

PS_t = Real primary surplus to GDP on year t

Z_t^m = Seigniorage and inflationary tax revenues on year t

G = Steady state growth of GDP

R_t = Real interest rate on year t

We do not consider the term Z_t^m, because the Central bank of Greece does not have an independent monetary policy and thus cannot print money, which deprives Greece from seignorage and inflation tax revenues.

Our equation becomes:

$$DT_t = \frac{1+R_t}{1+G_t} \cdot DT_{t-1} - PS_t$$

In addition, we assume that the stochastic variables are distributed multinomial[9] with conditional mean μ and conditional covariance matrix ϑ.

$$\{PS_t, G_{t,} R_t\} \sim \mathrm{N}\ (\mu, \vartheta)$$

[7] Barnhill and Kopits, 2003; IMF, 2003; Garcia and Rigobon, 2004; Hostland and Karam, 2005; Celasum, Debrun and Ostry, 2006; Tanner and Samake, 2008; Di Bella, 2008; Budina and van Wijnbergen, 2008.

[8] From "Inflation, Revenues from Money Creation and Debt Dilution; A case study of the United States". Ernesto Talvi, 2012, with different notation.

[9] We assume the variables to be normally distributed even though some of them (i.e. interest rate) cannot get negative values. This simplification can be easily corrected in the Monte Carlo simulations.

B. Data description

Variable	Description	Unit	Source
Net Debt per GDP	General government net debt (face value of debt divided by CPI) divided by seasonally adjusted real GDP	Million Euro	IMF
Inflation	Inflation rate q-o-q calculated from seasonally adjusted harmonized quarterly CPI with the base year of 2005		IMF
Interest rate	Seasonally adjusted quarterly interest payments divided by outstanding debt at face value	Million Euro	IMF
Growth rate	Rate of quarterly increase of real GDP in 2005 prices	%	Eurostat
Primary balance	General government net lending/borrowing plus interest payment	Million Euro	IMF

Some of the variables displayed strong seasonality (interest payments, consumer price index and real GDP), thus they have been seasonally adjusted. We have used X12 multiplicative method for CPI and real GDP, and Tramo/Seats for interest payments, as the latter changes its pattern of seasonality during the observed period, which X12 failed to capture.

Debt and primary balance were deflated by CPI index and calculated in real terms ("DT" and "PS" accordingly). Dividing quarterly nominal interest rate on the quarterly rate of inflation we get the quarterly real interest rate ("R") which corresponds with the quarterly growth of real GDP ("G").

Duration goes from 2nd quarter 2000 to 1st quarter 2012 (47 observations after adjustment) and the sample can be considered as short. This imposes significant constraints on our specification, as we will explain below.

For 1st quarter of 2012 to incorporate the "haircut" imposed on private investors we used the IMF staff report on Request for extended arrangement under Extended Fund Facility program dated in

March 2012[10]. This program is based on the agreement reached by the Greek Government and private investors. All the 1st quarter variables are based on IMF annual program quarterly seasonal adjustment, except for debt figure, for what the almost total downward adjustment imposed in the 1st quarter, considered as the "haircut".

We have also calculated so called "skeletons" as residuals from the debt equation to be sure that the errors are not large (except for the "haircut" quarter).

C. Vector Auto Regression (VAR) Model:

The variables (R, G, PS) are stationary[11], thus we use a reduced-form VAR instead of Vector Error-Correction model. As our sample is not long, we were constrained to choose the specification with only one lag[12].

Therefore, our VAR model specification is:

$$\boldsymbol{X_t = c + A * X_{t-1} + \nu_t}$$

$$\boldsymbol{X_t \equiv (PS_t, G_t, R_t)}$$

$$\boldsymbol{\nu_t \sim N(0, \Omega)}$$

Where:

c= constant vector

A= matrix of coefficients of the lags

ν_t *= reduced form residuals distributed multinomial with mean zero and covariance matrix Ω*

X_t *= vector of the variables at time t*

Expressed in matrix form:

$$\begin{pmatrix} PS_t \\ G_t \\ R_t \end{pmatrix} = \begin{pmatrix} c1 \\ c2 \\ c3 \end{pmatrix} + \begin{pmatrix} a11 & a12 & a13 \\ a21 & a22 & a23 \\ a31 & a32 & a33 \end{pmatrix} * \begin{pmatrix} PS_{t-1} \\ G_{t-1} \\ R_{t-1} \end{pmatrix} + \begin{pmatrix} \nu_1 \\ \nu_2 \\ \nu_3 \end{pmatrix}$$

[10] "Greece: Request for Extended Arrangement under the Extended Fund Facility—Staff Report; Staff Supplement; Press Release on the Executive Board Discussion; and Statement by the Executive Director for Greece." IMF, March 2012

[11] Stationarity test is presented in Appendix 1

[12] Lag structure test and discussion is presented in Appendix 2.

For our analysis we are interested mainly in the covariance matrix of the residuals (Ω). The point estimates of the VAR (coefficients of matrix A) do not have economic interpretation by themselves, because they don't act independently, but rather only as a system whole. We also did not present different impulse responses, as it will demand the imposition of the ordering of structural shocks. Any ordering of structural shocks will raise the question of the endogeneity and their impact sequence, a question that is not directly related to our analysis. Thus, we don't estimate structural VAR but rather use the reduced form VAR just as the best predictor of the joint dynamics of our variables.

After estimation of reduced form VAR[13], we performed different econometric tests on residuals, such as normality, autocorrelation and heteroscedasticity [14] .
From historical data (2000-2011) we compute the covariance matrix Ω, obtaining the correlation path of the residuals, and use it (and the coefficients of the lags) to forecast PS, G and R quarterly till 2020 through equation (7).

VAR reduced form shocks correlation matrix

	R	G	PS
R	1.0000	0.3634	0.1558
G	0.3634	1.0000	-0.0096
PS	0.1558	-0.0096	1.0000

From the correlations matrix[15] of the reduced form residuals we can derive the following:

- R and G are positively correlated, which can suggest mostly the effect of G on R (higher growth brings higher interest rate), rather than the effect of R on G (in which case we would expect that higher interest rates lead to lower growth). In terms of shocks, a positive correlation between shocks of R and G shows that demand shocks were more

[13] The estimation output of VAR is presented in Appendix 3
[14] Presented in Appendixes 4 to 7
[15] These correlations reflect partial correlations, as to compute the total effect of variables one must impose ordering and look at impulse responses

important (stronger, prevalent, usual) in the past than financial shocks, when we would expect negative correlation between R and G.

- R and PS are positively correlated, which can suggest an accommodating fiscal policy: for a given fiscal income the changes of interest payments were accommodated through changes in primary surplus. The hypothesis of expansionary fiscal contraction seems not to work, as in that case we would expect a negative relationship between PS and R, when the increase of primary surplus leads to the decrease of interest payments on public debt through anchoring expectations on sustainability of future fiscal policy[16]. In terms of shocks, a positive correlation between shocks of R and PS shows that financial shocks were more important (stronger, prevalent, usual) in the past than fiscal policy shocks. When the latter shocks occur we can expect negative correlation between R and PS (expansionary fiscal contraction).
- The correlation between G and PS is very small and negative. Therefore it suggests that we are observing the classic effect of fiscal policy on growth (higher primary surplus leads to lower growth) and not vice-versa. When public budget reflects all changes in economic growth through taxes, keeping expenditures more or less neutral, we would expect positive relationship between G and PS, which is not our case. In terms of shocks, a negative correlation between shocks of G and PS shows that fiscal policy shocks were more important (stronger, prevalent, usual) in the past than supply shocks, when we can expect positive correlation between G and PS.

The fact that a variable has not been explicitly considered in the model does not mean that it is not included in Ω. In this setup, even though there might be many other variables that affect the behavior of primary surplus, interest rates and growth, which are not included in the VAR, this does not mean that their effect is not included in our model.

[16] In any case, the reservation should be made for this conclusion, as interest rate is the average on total public debt, and changes of the market interest rate affect average rate very slowly over time, only through new public borrowing.

III. Stochastic Simulations

After estimating VAR, we run Monte Carlo simulations (1000 replications of 36 quarters) to generate the probability distributions (normal distributions) of the forecasts of PS, G and R. Including them into the debt equation (6) we get the normal distribution of debt to GDP (DT).

As initial conditions for our debt paths we used the data of the first quarter of 2011, which incorporates the haircut conducted on Greek debt.

We calculate the expected value of DT (the mean, which equals the forecast from VAR) and the bounds of two standard deviations, getting the 95% confidence interval of debt to GDP for different scenarios. For each scenario we calculate also the probability that the Greek debt exceeds IMF target level of 120% of debt to GDP in 2020.

It is important to mention that the debt identity did not always hold in the past. There are skeletons, which impede the debt equation to hold as an identity. This is why, in calculating debt dynamics, we assume that the debt equation is not a pure identity, but rather a stochastic process with a standard deviation of errors equal to that of the historical skeletons. This standard deviation is sufficiently low compared to historical standard deviation of the debt (2.0 compared to 19.0).

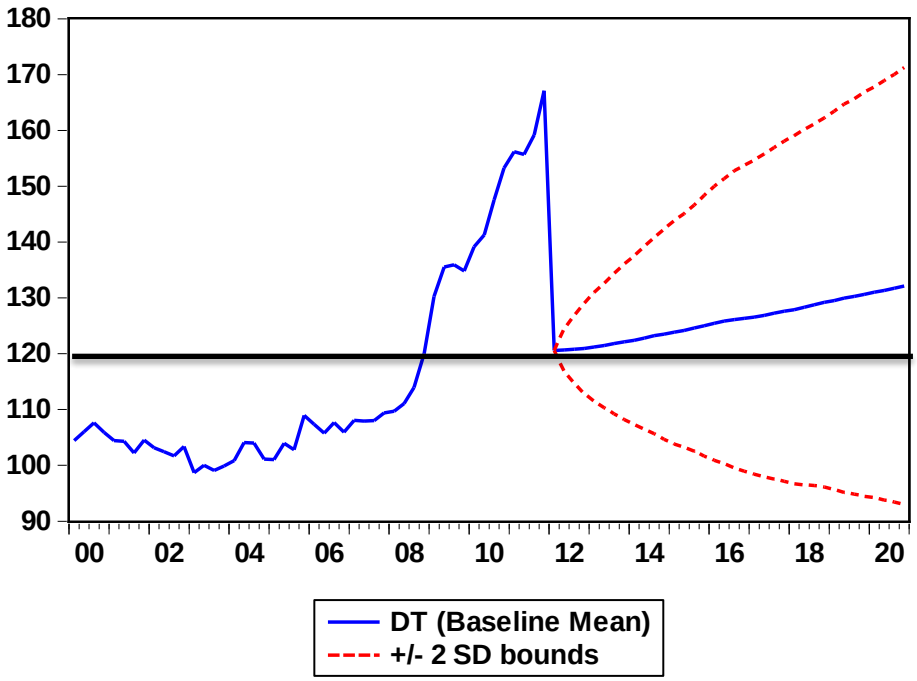
We apply the methodology explained above to three different scenarios:

1. Prediction of DT using the historical behavior of the variables PS, G and R (*"Baseline scenario"*)
2. Prediction of DT using the historical behavior of G_t and R, but imposing the adjustment on primary surplus required by the IMF to reach a 120 percent of debt to GDP in 2020[17]. (*"IMF scenario 1"*)
3. "*IMF scenario 1*" plus contingent liabilities and privatization according to the IMF ("*IMF scenario 2*")

We end our project calculating the necessary adjustment to ensure that debt-to-GDP ratio will be lower than 120%[18] with 97.5% confidence. This adjustment could be done via an additional adjustment on the primary surplus or a "new haircut".

A. Baseline scenario

In this scenario it is assumed that all stochastic variables (R, G, PB) return to their long-run averages derived from their historical series. VAR captures the adjustment to the means and stochastic simulations based on historical standard deviations of variables. The results of Baseline scenario are presented in the graph below and in Appendix (7).

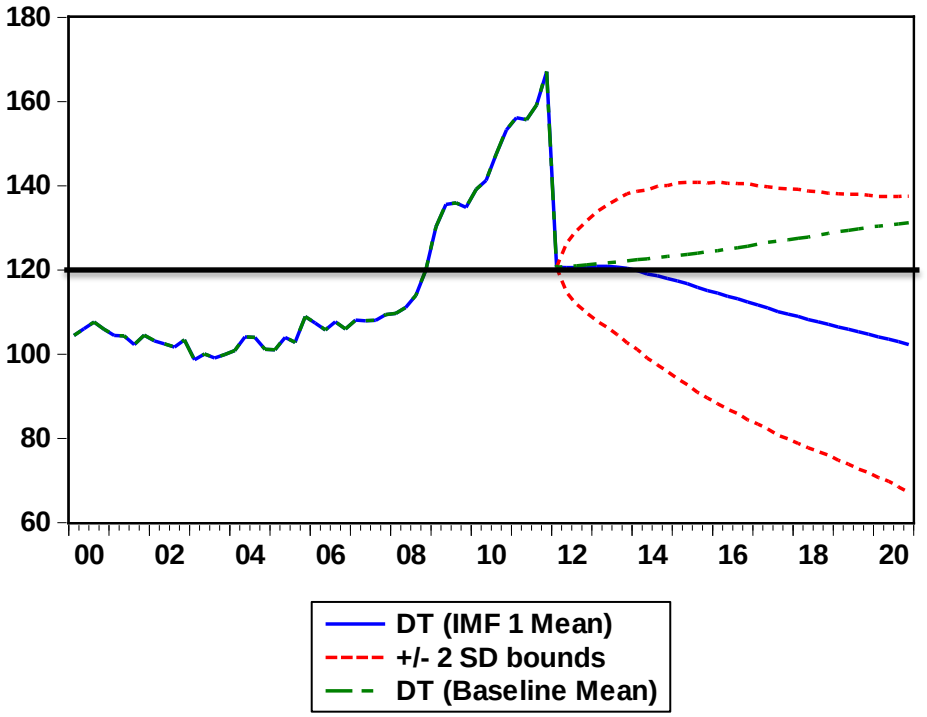


The graph shows that the future path of debt is not sustainable. From the probability distribution of debt at the end of 2020, we obtain that the probability that debt will exceed 120 percent of GDP is 71 percent.

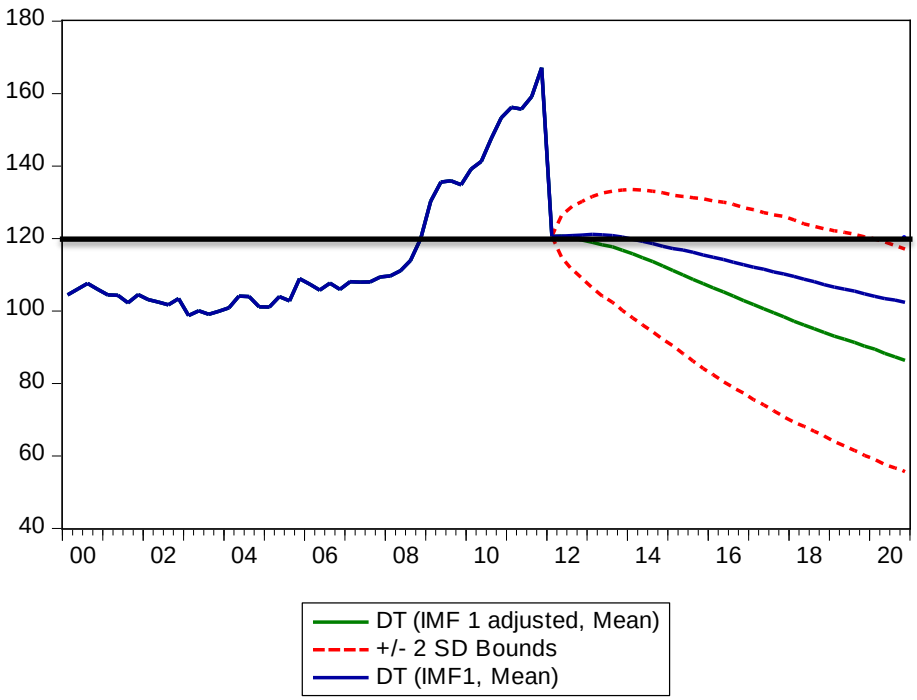
[18] "Greece: Request for Extended Arrangement under the Extended Fund Facility—Staff Report; Staff Supplement; Press Release on the Executive Board Discussion; and Statement by the Executive Director for Greece." IMF, March 2012

B. IMF scenario 1

By incorporating the IMF scenario, which assumes 120 percent of debt to GDP ratio in the end of 2020, we include the adjustment of primary balance (around 4 percent of GDP). The IMF target mainly refers to the mean of forecasted debt to GDP ratio. Our results are:



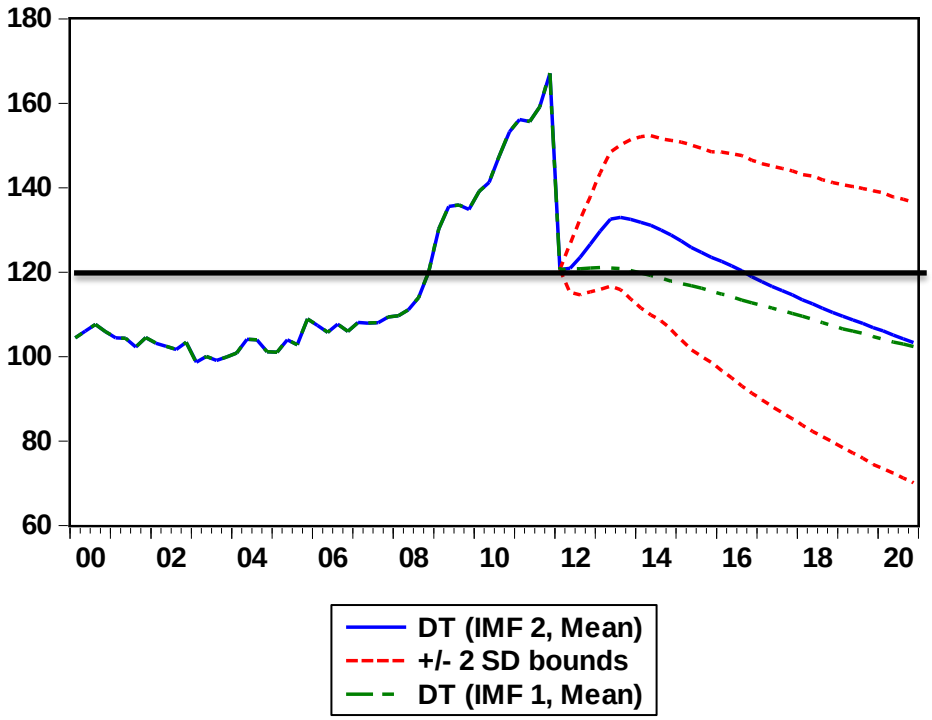
So, we can see that even though the mean forecast is substantially lower than the 120 percent target level, there is a significant probability, more than 16 percent, that debt to GDP ratio may exceed the 120 percent threshold at the end of 2020. If we want to ensure, that Greek debt-to-GDP ratio will be lower than 120 percent with a 97.5 percent probability, a new adjustment of the primary surplus of around an additional 4 percent of GDP quarterly would be needed. However, this adjustment looks not politically feasible, a new "haircut" of around 18 percent of GDP will be needed to achieve the targeted debt level with 97.5 percent confidence.



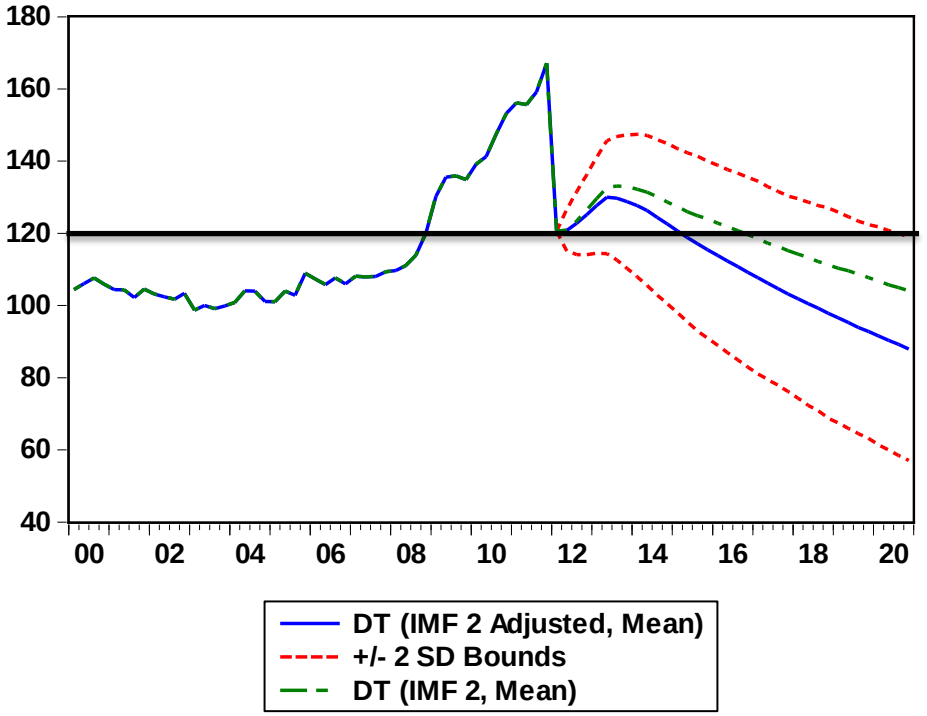
C. IMF scenario 2

In addition, Greece has large contingent liabilities, which total to around 29 percent of GDP[19] in 2012. Combining this figure with the projected privatization receipts (more than 2 percent of GDP) we can calculate the mean and bounds of debt projections.

[19] This figure includes the needs for bank recapitalization, which are assumed at 3.3 percent of GDP.



It seems that privatization receipts cover all the contingent liabilities, because at the end of 2020 the projected mean of debt-to-GDP ratio returns close to the one of the IMF scenario 1. However, there is still a high probability (almost 20%) that debt will be higher than the 120 percent target given the stochastic interrelationship of the variables. To ensure that the debt-to-GDP ratio will reach lower than 120 percent with 97.5 percent confidence, an additional adjustment is needed, by near the same magnitude as in previous scenario.



As shown in the graph above, the same 4 percent of GDP quarterly adjustment is enough to pin the debt-to-GDP ratio down to 120 percent in the end of 2020 with 97.5 percent confidence. In case of no feasibility, this adjustment can be substituted by a "new haircut" of around 21 percent of GDP.

IV. Challenges to our model

A. Additional risks

It is worth mentioning that there are many sources of risks not captured in our model that may even suggest tougher adjustments.

First, the possible downside risks on growth. In the IMF debt sustainability analysis, they assumed that the average real GDP growth for 2012-2020 will be slightly higher than 1 percent with an initial recession of around 6 percent in 2012-2013. According to our model's prediction, which is based on historical patterns, real GDP growth averages to 3 percent in 2012-2020 and the initial recession in 2012-2013 is equivalent to 10 percent, when considering the full adjustment program or IMF Scenario 2. Taking this difference into consideration, we can state,

that there are additional downside risks on growth not considered in our model which may even worsen the necessary adjustment of required primary surplus.

Another risk is the vulnerability of debt in the short term. We can see that debt to GDP ratio will remain above the 120 percent level until the end of 2016. This means that in the short-run debt can still be considered as unsustainable. If during this period Greece faces a negative exogenous shock, debt can easily explode and diverge from the predicted path.

B. Sustainable level of Debt-to-GDP

We need to pay attention, as well, to the theoretical ambiguity of 120 percent of debt to GDP ratio as a threshold of debt sustainability.

The sustainability of debt and public finance has been discussed for quite a long time in economic and financial literature, but it still remains an imprecise concept and there is no agreed definition of what precisely is a sustainable debt position, or what is an optimal level of debt that the country should have.

According to the IMF's typical analysis, a debt to GDP ratio of 60% is a prudential limit for developed countries and a 40% debt to GDP ratio for developing and emerging economies (on a long-run basis).20 This suggests that crossing this limit will threaten fiscal sustainability.

The European Union Maastricht treaty sets a 60% debt threshold to all EU members.

Other economists, such as Reinhart, Rogoff and Savastano have argued that for emerging economies 35% debt to GDP ratio is the threshold for sustainability.21

Also in terms of the debt-growth relationship, other studies have shown that there are levels of debt beyond which the country will face a declining growth. Most recently Reinhart and

[20] "From Stimulus to Consolidation: Revenue and Expenditure Policies in Advanced and Emerging Economies", IMF, p. 7-8

[21] "Debt Intolerance", Reinhart, Rogoff and Savastano, 2003

Rogoff22 found that for debt levels greater than 90% there is a negative link between debt and growth.

Similarly, the World Bank estimated a tipping point for public debt level above which economic growth will be negatively affected. They estimated a threshold of 77% of public debt-to-GDP ratio for advanced economies and 64% in emerging markets. If debt is above these thresholds, each additional percentage point of debt costs 0.017 percentage points of annual real growth for the former and a loss of 0.02% for the latter.23

So as we can see there is no agreed definition among economists and researchers.

In the case of Greece, the IMF set 120 percent debt to GDP ratio to be a sustainable ratio and forecasted that it will be reached in 2020, if the adjustment program is implemented.

The table below shows the threshold of debt sustainability or the break-even point of the debt negatively affecting the growth and the probabilities of debt being higher those levels in the IMF scenario (included contingent liabilities and privatization receipts).

Source	**Threshold**	**Probability D>D-threshold**
IMF program	120	19.50
Maastricht, IMF	60	99.10
Reinhart, Rogoff 2003	35	99.99
Debt and Growth		
WB	77	92.66
Reinhart, Rogoff 2010	90	77.41

Is 120 percent really sustainable, or was this number set for mere political purposes, in an effort to signal the sustainability of the Italian debt, which is around 120 percent of GDP, and try to

[22] "Growth in a Time of Debt" Reinhart and Rogoff, 2010
[23] "Finding the Tipping Point—When Sovereign Debt Turns Bad" World Bank, 2010

prevent additional turbulence in the financial markets which would have huge impact not only on Italy but on all Europe?

As we see above most academic literature suggest significantly lower sustainable debt levels in terms of GDP.

If we consider the next value: a 90% threshold to be the sustainable level for Greece, we see that there is still a 77.41% probability that debt will be higher than this ratio, or in other words unsustainable. Given the social unrest and pressures resulting from the adjustment plan to reach the 120 percent level, we believe that 90 percent is clearly an unfeasible target.

V. Conclusion

Our simulation based on the VAR model shows that when we incorporate the uncertainty and interrelationship of variables into the debt equation, there is a significant probability that the Greek debt will exceed the IMF target level of 120 percent of GDP at the end of the program. According to our calculations, an additional yearly 4 percent to GDP primary surplus (equivalent to 21 percent of GDP "new haircut") is needed to ensure that the public debt will be below 120 percent of GDP with 97.5 percent confidence level. This means that the total Primary surplus needed should be around 8 percent of GDP per year. But for us, if the 120 percent will be sustainable for Greece after 2020, or which target should be considered as sustainable remains broadly open to further discussion.

Taking into account the additional risks not contemplated in our model, as well as the theoretical ambiguity of 120 percent of debt to GDP ratio as a threshold of debt sustainability, we can suggest that most probably Greek debt is still not on a sustainable track. Therefore, for economic and political reasons, Greece may need to consider other policy alternatives.

One of these alternatives is harsher primary balance adjustment. However, this solution will face obvious domestic political constraints, not only in face of upcoming elections, but also because of the lack of successful historical evidence (the only successful cases are Baltic countries after the recent global financial crisis).

Another alternative is the exit from the Euro zone and the devaluation of the “new drachma”. This scenario is hard to implement because of external political constraints. Worrying about possible contagion, core European countries try to keep the Eurozone intact by paying any price. Also, in this scenario Greece must convert all existing public and private debt to residents and non-residents into the “new drachma” before devaluation, otherwise devaluation can do more harm than cure through increasing debt service payments to intolerable levels (so called “contractionary devaluation”). Of course, Eurozone governments will try to avoid conversion scenario as much as possible, because it will lead to write offs of all Greece debt, which this time will affect not only private sector, but also public sector and supranational institutions, like ECB. Besides, Greece debt will be left out of the capital markets for long time.

The alternatives for Greece are not easy and will take long. Greece should be prepared to suffer uncertainty, hard conditions, social unrest and distrust from investors. The policymakers that lead through the recovery should accept it and be prepared to face it.

VI. Appendix

1. Unit root tests (Augmented Dickey-Fuller test)

Null Hypothesis: Unit root (individual unit root process)
Series: R, PS, G
Date: 04/15/12 Time: 14:07
Sample: 2000Q1 2020Q4
Exogenous variables: Individual effects
Automatic selection of maximum lags
Automatic lag length selection based on SIC: 0 to 3
Total number of observations: 138
Cross-sections included: 3

Method	Statistic	Prob.**
ADF - Fisher Chi-square	31.5743	0.0000
ADF - Choi Z-stat	-4.10274	0.0000

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

Intermediate ADF test results UNTITLED

Series	Prob.	Lag	Max Lag	Obs
R	0.0000	3	9	44
PS	0.0351	0	10	48
G	0.0805	1	9	46

Stationarity Test: Augmented Dickey-Fuller test

(1) Growth/G/ is stationary I(0): significant at the 10 percent level (P-value is 0.0805)
(2) Primary surplus/PS/ is stationary I(0): significant at the 5 percent level (P-value is 0.0351)
(3) Real interest/R/ is stationary I(0): significant at the 1 percent (P-value is 0.0000)
(4) Skeletons/S/: failed to reject the stationarity – process has unit root

Without the "haircut" quarter series is stationary I(0) at the 1% significant level (P-value is 0.0000)

All series are I(0) at 10% significance level, which let us skip the test of co-integration and process directly to VAR.

2. Lag structure test

VAR Lag Order Selection Criteria
Endogenous variables: R G PS
Exogenous variables: C
Date: 04/15/12 Time: 14:05
Sample: 2000Q1 2020Q4
Included observations: 39

Lag	LogL	LR	FPE	AIC	SC	HQ
0	345.9950	NA	4.61e-12	-17.58949	-17.46152	-17.54357
1	376.9980	55.64634	1.49e-12	-18.71784	-18.20598*	-18.53419*
2	387.3117	16.92509*	1.41e-12*	-18.78521	-17.88945	-18.46382
3	389.1717	2.766092	2.08e-12	-18.41906	-17.13940	-17.95993
4	401.1404	15.95827	1.87e-12	-18.57130	-16.90774	-17.97443
5	415.2240	16.61153	1.55e-12	-18.83200*	-16.78454	-18.09739
6	418.0859	2.935188	2.39e-12	-18.51722	-16.08586	-17.64487
7	431.2420	11.46948	2.31e-12	-18.73036	-15.91510	-17.72027
8	438.9139	5.508001	3.22e-12	-18.66225	-15.46309	-17.51442
9	446.8691	4.487572	5.06e-12	-18.60867	-15.02562	-17.32310

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Schwarz and Hannan-Quinn information criteria suggests 1 lag, while Likelihood Ratio and Final prediction error tests proposes 2 lags. We treated Akaike criterion as non-informative, because it recommends something very different from other tests - 5 lags. Due to our very short sample size, we preferred to include only 1 lag in the VAR, not to have a very low degree of freedom and to be able to estimate the coefficients of VAR.

3. VAR output

Vector Autoregression Estimates
Date: 04/14/12 Time: 20:17
Sample (adjusted): 2000Q3 2012Q1
Included observations: 47 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	R	G	PS
R(-1)	0.268782	-0.236234	-1.003029
	(0.15183)	(0.62923)	(0.96448)
	[1.77026]	[-0.37543]	[-1.03997]
G(-1)	-0.053280	0.178479	0.301123
	(0.03736)	(0.15483)	(0.23732)
	[-1.42616]	[1.15276]	[1.26886]
PS(-1)	0.014083	0.104576	0.715194
	(0.01590)	(0.06589)	(0.10099)
	[0.88577]	[1.58715]	[7.08156]
C	0.003300	0.005183	-0.003809
	(0.00094)	(0.00389)	(0.00596)
	[3.51918]	[1.33342]	[-0.63928]
R-squared	0.105235	0.096301	0.566727
Adj. R-squared	0.042810	0.033252	0.536499
Sum sq. resids	0.000699	0.012007	0.028211
S.E. equation	0.004032	0.016711	0.025614
F-statistic	1.685776	1.527407	18.74822
Log likelihood	194.5318	127.7107	107.6375
Akaike AIC	-8.107737	-5.264286	-4.410105
Schwarz SC	-7.950278	-5.106827	-4.252646
Mean dependent	0.003952	0.002351	-0.022670
S.D. dependent	0.004121	0.016996	0.037623

Determinant resid covariance (dof adj.)	2.51E-12
Determinant resid covariance	1.92E-12
Log likelihood	433.9083
Akaike information criterion	-17.95354
Schwarz criterion	-17.48117

4. Normality test

VAR Residual Normality Tests
Orthogonalization: Cholesky (Lutkepohl)
Null Hypothesis: residuals are multivariate normal
Date: 04/22/12 Time: 22:30
Sample: 2000Q1 2020Q4
Included observations: 47

Component	Skewness	Chi-sq	df	Prob.
1	0.666651	3.481321	1	0.0621
2	-0.393392	1.212263	1	0.2709
3	-0.089630	0.062930	1	0.8019
Joint		4.756514	3	0.1905

Component	Kurtosis	Chi-sq	df	Prob.
1	6.836635	28.82621	1	0.0000
2	4.175578	2.706386	1	0.0999
3	2.679925	0.200628	1	0.6542
Joint		31.73323	3	0.0000

Component	Jarque-Bera	df	Prob.
1	32.30753	2	0.0000
2	3.918649	2	0.1410
3	0.263558	2	0.8765
Joint	36.48974	6	0.0000

We can see that the residual of the first equation (equation of R) is not normal. The problem mainly is in the kurtosis of the errors of the first equation. We think that the problem is due to the short sample size used, and can be solved with longer time periods and data.

5. Heteroscedasticity test

VAR Residual Heteroskedasticity Tests: No Cross Terms (only levels and squares)
Date: 04/22/12 Time: 22:37
Sample: 2000Q1 2020Q4
Included observations: 47

Joint test:

Chi-sq	df	Prob.
39.10060	36	0.3323

Individual components:

Dependent	R-squared	F(6,40)	Prob.	Chi-sq(6)	Prob.
res1*res1	0.083978	0.611176	0.7199	3.946950	0.6839
res2*res2	0.095533	0.704154	0.6480	4.490037	0.6107
res3*res3	0.274520	2.522658	0.0364	12.90246	0.0446
res2*res1	0.099156	0.733804	0.6253	4.660352	0.5881
res3*res1	0.178283	1.446431	0.2214	8.379324	0.2116
res3*res2	0.092648	0.680724	0.6660	4.354476	0.6288

White test for Heteroscedasticity without cross-terms

H0: Homoscedasticity.

H1: Heteroscedasticity

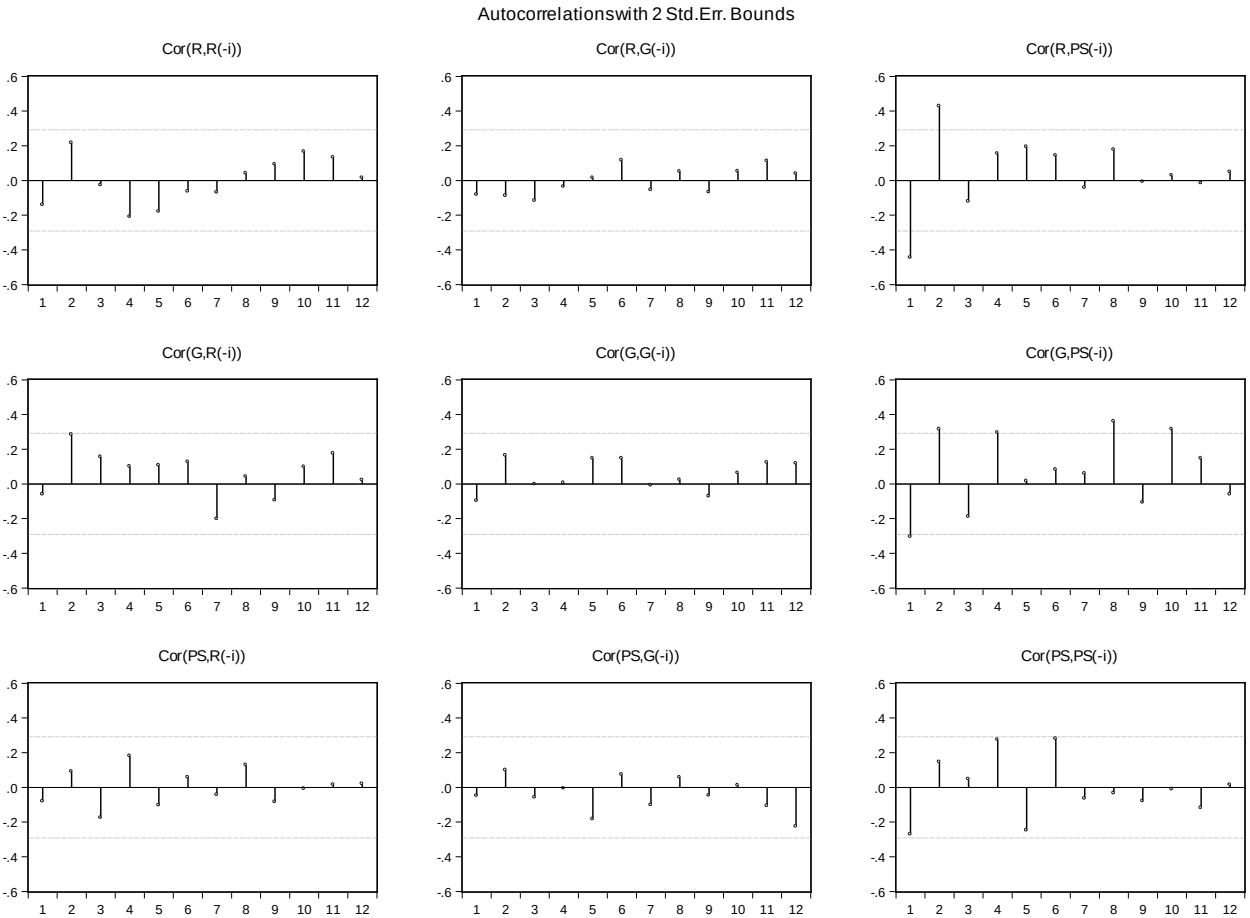
Joint test fails to reject the null at the 5 % significant level. At individual level, the heteroscedasticity exists in the residuals of the third equation (PS).

6. Autocorrelation test

VAR Residual Serial Correlation LM Tests
Null Hypothesis: no serial correlation at lag order h
Date: 04/22/12 Time: 22:40
Sample: 2000Q1 2020Q4
Included observations: 47

Lags	LM-Stat	Prob
1	34.92660	0.0001
2	21.01454	0.0126
3	6.552832	0.6836
4	14.75859	0.0978
5	15.83852	0.0703
6	8.597320	0.4752
7	4.271965	0.8926
8	9.284684	0.4114
9	3.573209	0.9372

Probs from chi-square with 9 df.



Autocorrelation LM Test

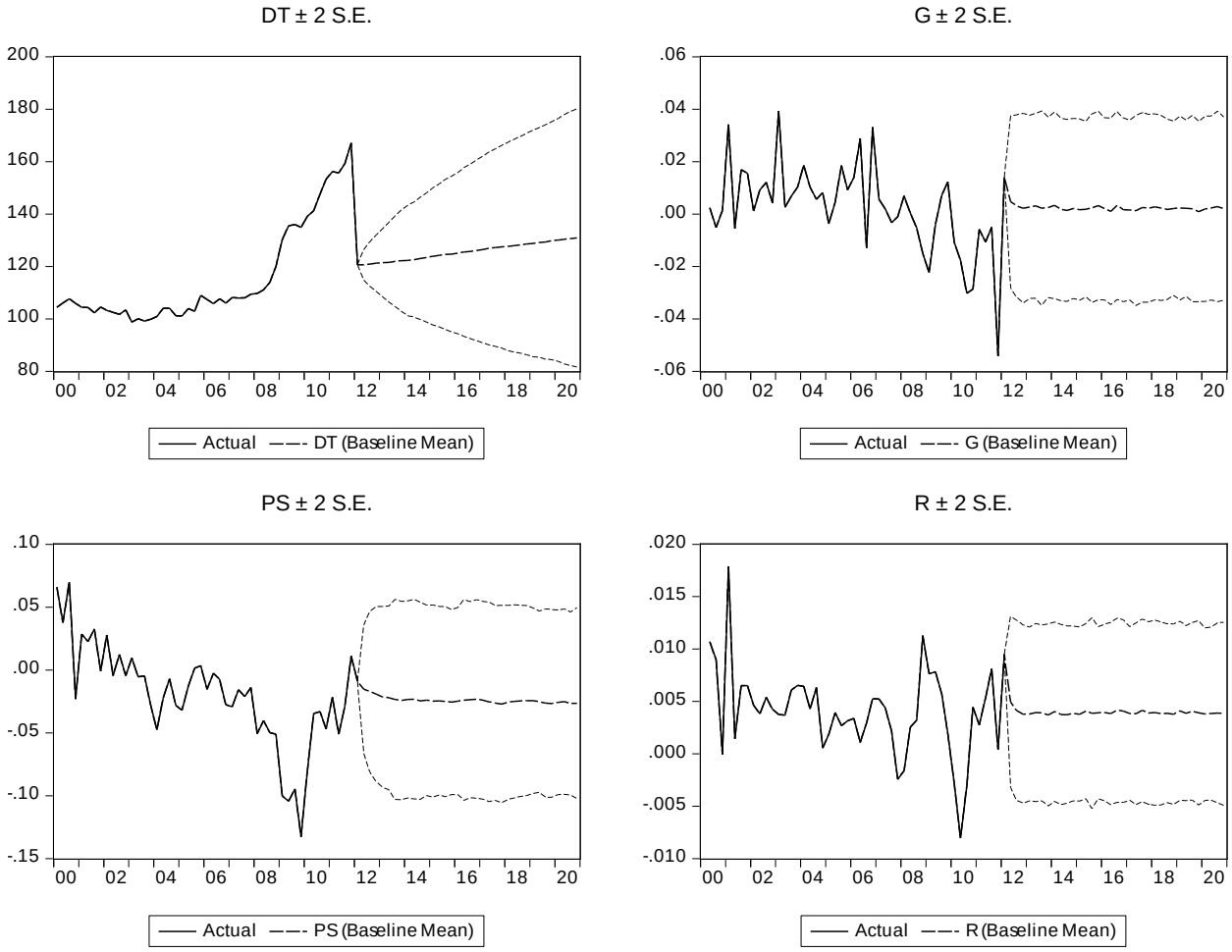
H0: No serial auto correlation

H1: Serial auto correlation

Up to 3 lags we reject the null hypothesis at the 5% significant level.

In order to solve the problem of autocorrelation, as well as some concerns on heteroscedasticity and normality of errors, one should perform VAR with 2 lags included. We tried 2 lags, and it solved the problem of autocorrelation and normality, while the heteroscedasticity transformed and remained at very low levels. But as the results of a VAR with 2 lags did not differ substantially from the 1-lag specification, we opted for a higher degree of freedom, and decided to keep the structure of the model simple.

7. Baseline scenario



VII. References

- Garcia and Rigobon, 2003: "A Risk Management Approach to Emerging Market's Sovereign Debt Sustainability with an application to Brazilian data"
- Goldstein, 2003: "Debt Sustainability, Brazil, and the IMF", Number WP 03-1
- Wyplosz, 2007: "Debt Sustainability Assessment: The IMF Approach and Alternatives", HEI Working Paper No: 03/2007
- Inter-American Development Bank, 2010: "Template for Debt Sustainability"
- IMF, Fiscal Affair Department, 2010: "From Stimulus to Consolidation: Revenue and Expenditure Policies in Advanced and Emerging Economies**"**
- Reinhart, Rogoff, and Savastano, 2003: "Debt Intolerance", NBER Working Paper 9908
- Reinhart and Rogoff, 2010: "Growth in a Time of Debt", NBER Working Paper 15639
- World Bank, 2010: "Finding the Tipping Point—When Sovereign Debt Turns Bad", Policy Research Working Paper 5391
- Calvo, Izquierdo and Talvo, 2003: "Sudden Stops, the Real Exchange Rate, and Fiscal Sustainability: Argentina's Lessons"
- Talvi, 2012: "Inflation, Revenues from Money Creation and Debt Dilution; A case study of the United States".
- Rothenberg and Stock 1997: "Inference in a nearly Integrated Autoregressive Model with Nonnormal Innovations", Journal of Econometrics, 80 (1997), 269-286.
- Kirkegaard Funk Jacob 2012: "Greece's new bonds: Is another default coming?", VOX, http://www.voxeu.org/index.php?q=node/7750
- Krugman Paul:2012, "What Greece Means", The New York Times, March 11, 2012
- IMF, March 2012:"Greece: Request for Extended Arrangement Under the Extended Fund Facility—Staff Report; Staff Supplement; Press Release on the Executive Board Discussion; and Statement by the Executive Director for Greece.", Country Report NO. 12/57
- IMF, September 2003: "Public Debt in Emerging Markets: Is It Too High?", World Economic Outlook, Ch.3
- Barnhill, Kopits 2003: "Assessing Fiscal Sustainability Under Uncertainty", IMF WP 03/79
- Hostland, Karam 2005: "Assessing Debt Sustainability in Emerging Market Economies Using Stochastic Simulation Methods", IMF WP 05/226

- Celasum, Debrun, Ostry 2006: “Primary Surplus Behavior and Risks to Fiscal Sustainability in Emerging Market Countries: A “Fan-Chart” Approach, IMF Staff Papers Vol. 53, No. 3
- Tanner, Samake 2008: “Probabilistic Sustainability of Public Debt: A Vector Autoregression Approach for Brazil, Mexico and Turkey”, IMF Staff Papers Vol. 55, No. 1
- Di Bella 2008: “A Stochastic Framework for Public Debt Sustainability Analysis”, IMF WP 08/58
- Budina, van Wijnbergen 2008: “Quantitative Approach to Fiscal Sustainability Analysis: A Case Study of Turkey since the Crisis of 2001”, The World Bank Economic Review