

PIRAEUS BANK



Understanding Greek Government Bond Spreads: A different perspective



Ilias Lekkos lekkosi@piraeusbank.gr

Irini Staggel staggelir@piraeusbank.gr

Haris Giannakidis giannakidisch@piraeusbank.gr

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Since the outbreak of the Great Financial Crisis in 2008 and especially after the escalation of the Greek Crisis in 2010, both academics and investment analysts have devoted a lot of effort in exploring the behavior of Greek as well as other periphery economies bond rates vs their corresponding German yields. In what follows we revisit the issue of the behavior, pricing and risk management of Greek Government Bonds (GGBs) spreads and try to address a number of unresolved issues.

The additional contribution we make to the already available body of research is twofold:

First, we estimate our models using the quantile regression (QR) methodology instead of the usual OLS method. QR offers a number of advantages vs more traditional methods, the most important of which is that it allows different factors with varying degree of sensitivity on the likely outcomes of Greek Bond spreads. This is of particular significance in the Greek case as spreads vary from a low of 9 bps to a high of 3313 bps.

Second, in defining the explanatory variables we follow what we call the “FX Analogy”, which simply means that all explanatory variables enter our model as “spreads” or “ratios” to their corresponding German ones.

The aim of our research is to enhance our understanding on the fundamental behavior of the Greek Government Bond Spreads both before and after the Greek economic crisis. We do that by trying to address the following issues:

- Which are the **fundamental drivers** of GGB spreads?
- Is this set of **driving factors constant or it varies** relative to the situation in the Greek bond market and the size of the spreads?
- Even for factors that are significant across the spreads distribution do they **maintain a constant influence (constant betas) on the spreads or this varies** as well?
- Are Greek Government Bonds **fairly valued** given the levels of their fundamentals?
- Are the **risks around their fair value** always symmetric or can we identify periods of positive (i.e. increased probability for narrower spreads) and negative (i.e. increased probability for wider spreads) risks?
- Can we use the enhanced flexibility of the model for **risk management** purposes? That is, can we produce more accurate **Value-at-Risk analysis** for GGB spreads?
- Finally, can we employ our model to explore the **behavior** of GGB spreads **under** various **macroeconomic scenarios**?

- According to our analysis, the main drivers of GGB spreads are the gap in economic performance and competitiveness between the Greek and German economies as well as the widening differences in the debt-to-GDP ratios. In addition, contagion from movements in other Peripheral bond markets is evident, especially in periods of widespread market stress.
- Our model also reveals substantial variation on the magnitude and direction (sign) of the influence of the above mentioned factors. Economic Activity and Competitiveness have a significant impact in a regime of medium and low levels of conditional spreads while Fiscal Sustainability and especially Periphery Risk are of increased importance in a regime of high conditional spreads.
- At the current juncture, Greek Bonds are, by and large, aligned to their fundamentals but our Misalignment Index is able to identify periods of substantial divergences between spreads and their fundamentals while the Balance of Risk Indicator highlights periods of highly skewed risks.
- Finally, we demonstrate how our methodology can be utilized to produce more accurate value-at-risk estimates as well as forecasts of the distribution of GGB spreads under various economic scenarios.



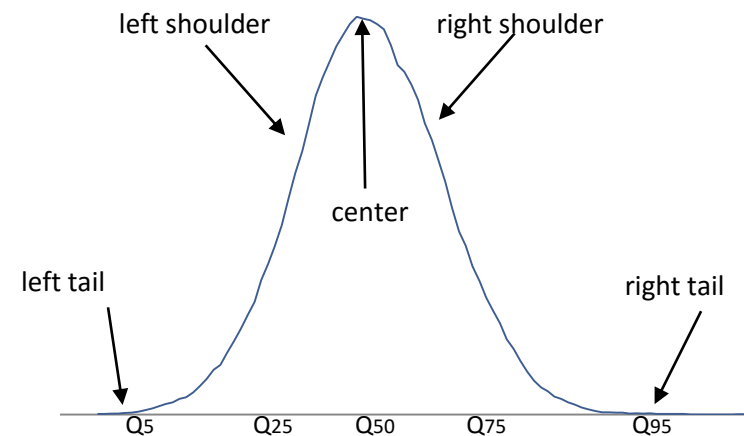
Quantile Regression is a statistical methodology that models the distribution of the response variable conditional on observed underlying factors. Specifically, we relate each specific part of the distribution of responses (using quantile functions) to a number of explanatory variables. Consequently, we are able to produce estimates or projections for the location, dispersion and shape of the variable's distribution.

As in standard regression models, quantile regression enable us to analyze the impact of a number of economic variables on the response variable, the difference being that their influence is not restricted only on the center of the spread distribution but also on other parts such as its tails and shoulders.

$$Q_{\tau}(y_t|x_t) = a_{\tau} + \beta_{\tau} * x_t$$

for each quantile $\tau = 5th, 10th, \dots, 95th$

Conditional Probability Density



Even though quantile regression does not differ from standard methods in the fact that they use past information to capture a relation that is assumed to hold in the future, the method does offer a number of advantages relative to the more standard least squares regression:

- The most important is robustness with respect to extreme outcomes (outliers) observed in the past that are unlikely to occur in the future at least in a medium term horizon.
- Quantile regression may result to a more rational asymmetric estimate for the spread distribution compared to the standard normal distribution that is assumed by least squares which is restricted by the fact that under OLS, “adverse” outcomes are equally likely to “good” outcomes.
- We are able to categorize underlying factors with respect to their influence on each individual quantile of the spread distribution. For example, we can specify those factors that are associated strongly with the dispersion of the distribution and those that drive its center or tails. In that way we can isolate the information that is relevant to the indented use of the model e.g. risk management or sensitivity under stress scenarios.
- By construction, quantile regression provides a natural ranking of the fitted outcomes for the variable of interest. For example, the median corresponds to the value for bond spread where there is a 50% probability to observe a higher or a lower outcome. Similarly, the 25th quartile indicates the value for bond spread where there is a 25% probability to observe lower and 75% probability to observe higher values.
- QR allows us to construct indices that benefit from improved information extracted from the whole conditional distribution of bond spreads.

Therefore, by estimating the conditional quantile functions of Greek Bond Spreads we effectively model their whole distribution as a function of several economic state variables. Consequently, by using the QR method we are able to determine location shifts, changes in uncertainty or changes in market stress for all possible spread outcomes.

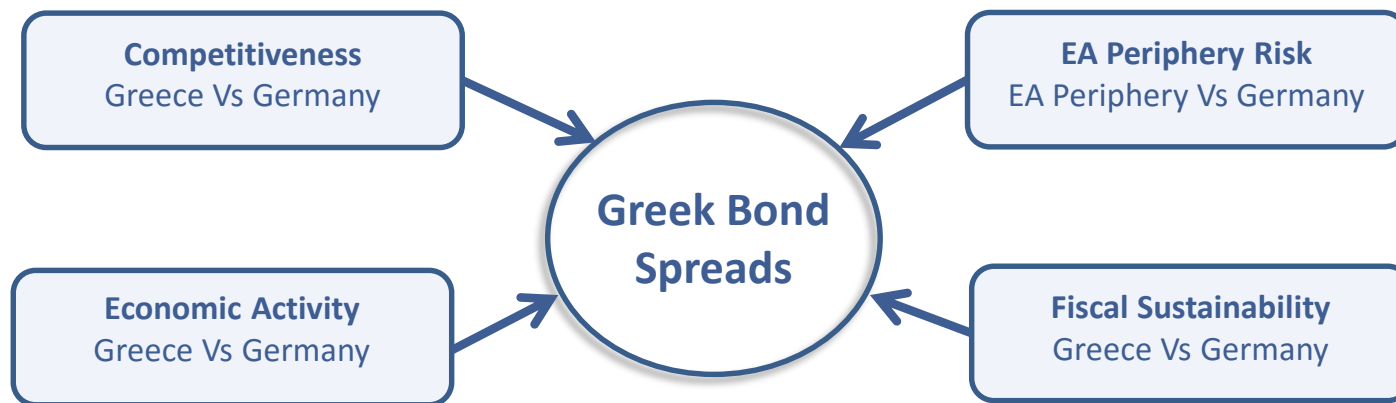
Quantile regression provides a more complete picture for Greek spreads dynamics than would be offered by a simple average estimate. For example, if we want to investigate what is the impact of an increase in the debt to GDP differential on the probability of a large surge in spreads, then standard regression methodologies are of little use.

Most studies try to analyze sovereign spreads as a function of a number of variables (fiscal, growth, etc) that characterize the economy under examination.

Here we follow a slightly more nuanced approach following what we call the “FX Analogy”. Following a line of reasoning similar the one used when modelling FX rates, we view all explanatory variables as relative to the benchmark i.e. all variables are viewed relative to their German counterparts.

Our final model is based on 4 factors, chosen according to qualitative, statistical fit and model parsimony criteria.

The explanatory variables cover the four main areas of: Economic Activity, Competitiveness, Periphery Risk and Fiscal Sustainability.

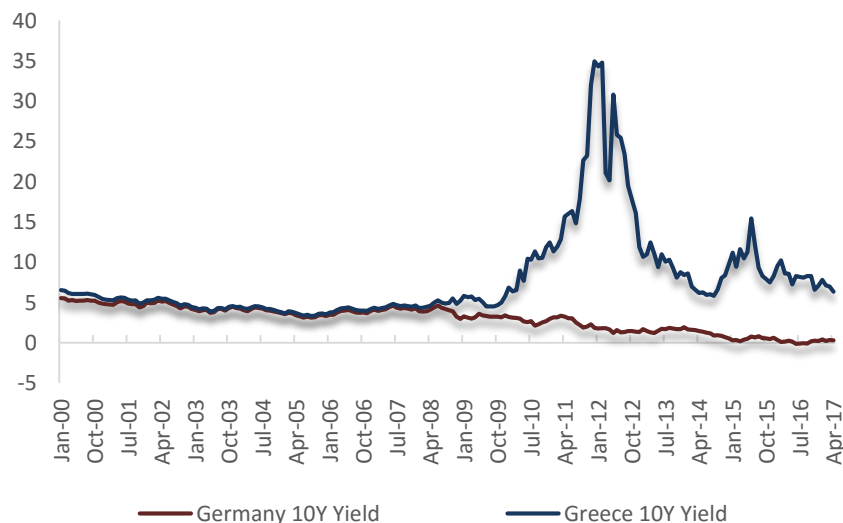


German 10-Year yield has gradually decreased from 5.54% in January 2000 to 0.32% in April 2017.

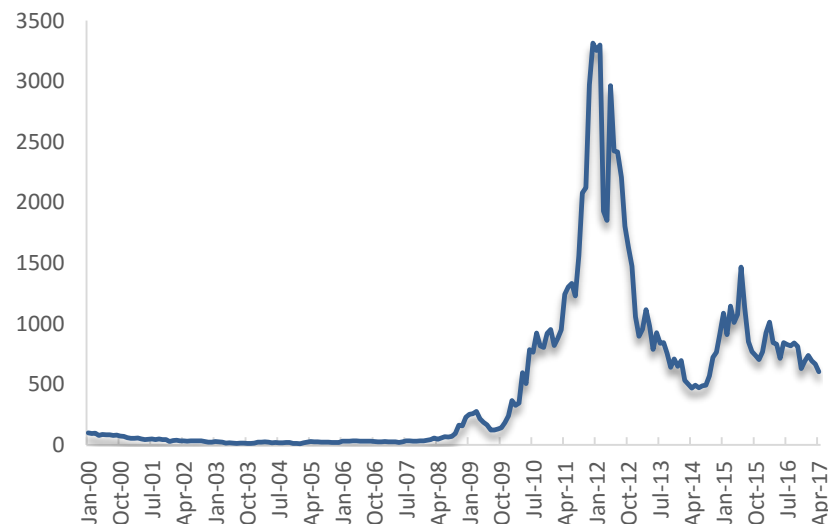
In contrast Greek 10-Year bond yields surged after 2009 recording remarkably high levels in February 2012, due to PSI. Afterwards yields declined gradually reaching 5.82% in August 2014. In 2014, Greece returned to the bond markets after a 4-year period, in April with a 5-year bond and in July with a 3-year bond.

However, political risk during 2015 that culminated to the June referendum, drove 10-Year Greek bond yields to levels higher than 30%. After a period of delays in the first and second review of the 3rd Economic Adjustment Programme, the Greek economic environment showed signs of an apparent stabilization that led Greek 10-Year bond yield to reach 6.34% in April 2017.

**10-Year Bond Yields
Greece vs Germany (%)**



Greek 10-Year Spread vs Germany (bps)



Based on our econometric model ⁽¹⁾, the evolution of GGB Spreads (GGB_SPRDS) depends on:

- The **Relative Economic Activity Indicator** calculated as the difference between the logarithms of **Real GDP** volume index (2010 =100) of Greece versus Germany (REL_ECACT).
- The **Relative Cost Competitiveness Indicator**, calculated by comparing the real trade weighted exchange rates between Greece and Germany and defined as the difference between the logarithms of **Real Effective Exchange Rate** of Greece versus Germany (REL_CCOMP)
- The **EA Periphery Risk Indicator**, calculated as the average 10-Year bond spreads for **Italy, Spain, Portugal and Ireland** versus German 10-Year bond Yield. (EAPER_RISK)
- The **Relative Fiscal Sustainability Indicator**, calculated as the ratio of **Debt to GDP** of Greece versus Debt to GDP of Germany (REL_FSCI)

The data are collected from key databases such as Bloomberg, Oxford Economics, BIS and Eurostat.

Wherever is appropriate, the variables are adjusted for seasonality.

Data are monthly and cover the period January 2000 – April 2017.

In the case that only quarterly data are available (i.e. Real GDP, Debt to GDP), whereas the prerequisite is monthly data, then temporal disaggregation under a cubic spline is used as an interpolation technique.

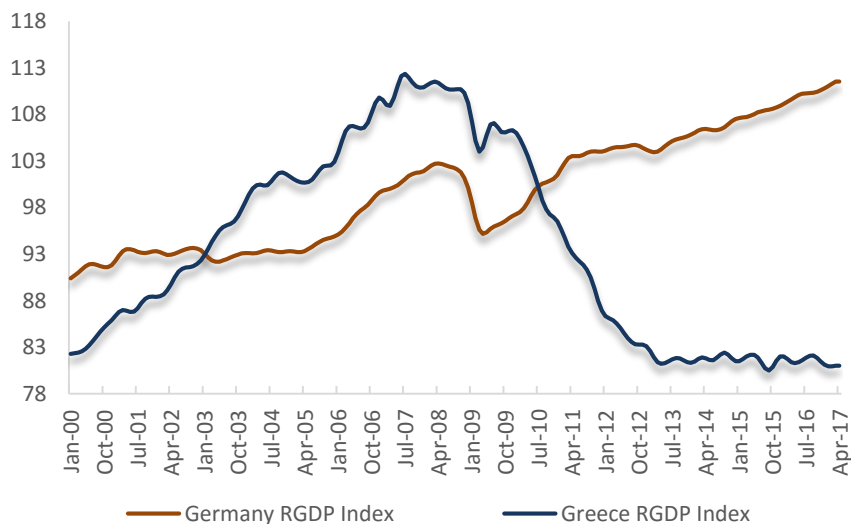
⁽¹⁾ Our analysis was performed on a wider range of relative variables (such as HICP in constant tax, economic sentiment indicator, the proportion of the banking sector capitalization relative to the aggregate market capitalization etc).

Clearly, the Global Financial Crisis had a large impact in the economic growth of Germany, as in mid-2009 real GDP declined by 7% on a YoY basis. However, the German economy returned to a sustainable growth path in late 2009.

On the other hand, Greek real GDP has deteriorated since 2009. During 2009 -2016 real GDP declined by 23%.

Consequently, the Relative Economic Activity Indicator plunged almost 4 times relative to its historical high recorded in August 2009.

**Real GDP Volume Index (2010=100)
Greece vs Germany**



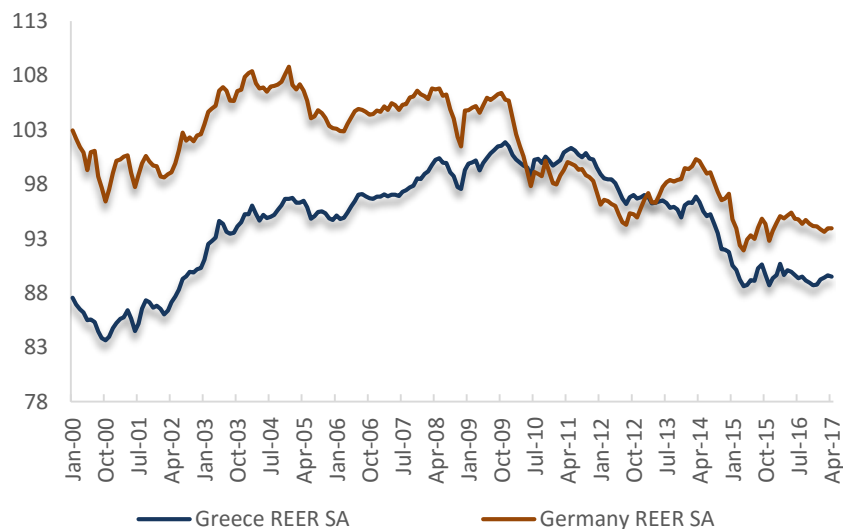
**Relative Economic Activity Indicator
(REL_ECACT)**



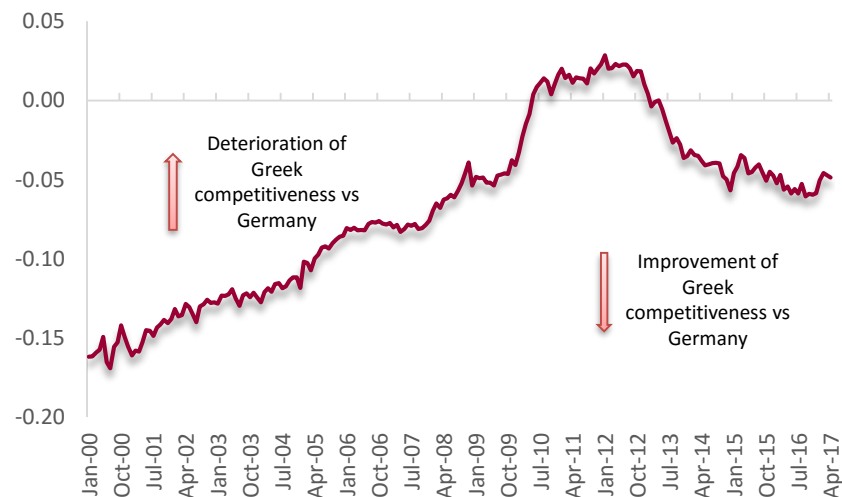
An increase in the real effective exchange rate implies that the economy is losing in terms of competitive advantage relative to its external trade counterparts.

The relative competitiveness indicator deteriorated from 2000 to mid-2012. Since then the competitiveness of the Greek economy relative to the German one has been gradually improving. In April 2017, the real effective exchange rate in Greece decreased by 11.7% (improvement in competitiveness) relative to its highest levels (May 2011), when at the same period the respective index in Germany declined by 6% (improvement in competitiveness). As a result, in April 2017 the Relative Cost Competitiveness Indicator returned to levels observed at end - 2009.

**Real Effective Exchange Rates
Greece vs Germany**



**Relative Cost Competitiveness Indicator
(REL_CCOMP)**

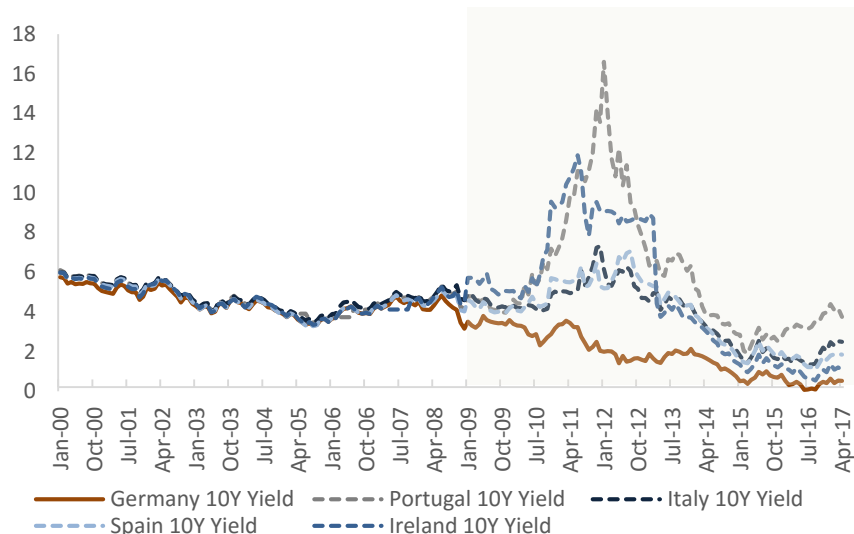


We constructed the EA Periphery Risk Indicator, in order to map the average 10-Year bond spread of selected Euroarea periphery countries (Portugal, Italy, Spain and Ireland) versus Germany and consequently the impact of peer countries on the Greek bond market.

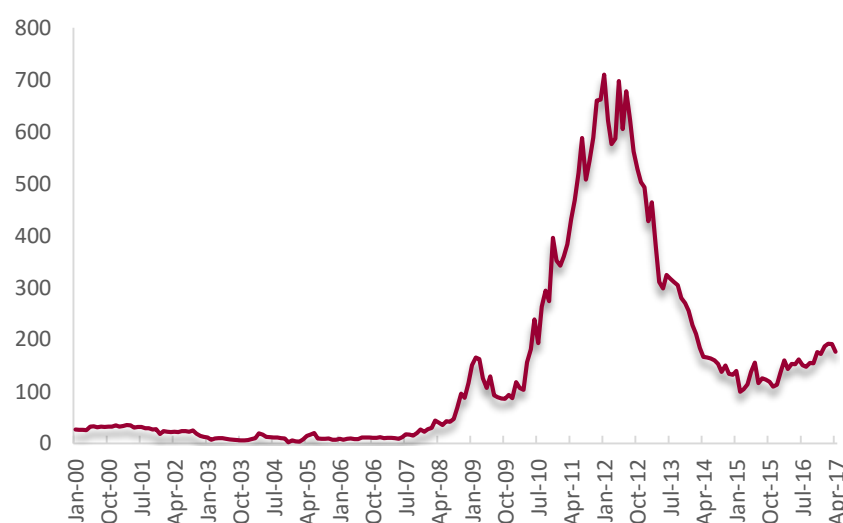
Due to similar structural features underlying the economies of Euroarea periphery as well as the common sensitivity of these countries to fiscal shocks, such as the EU debt crisis, there is a strong positive cross-correlation. The average periphery bond spreads were materially low during 2000-2007, but increased dramatically after the global financial crisis and reached a peak in early 2012.

Bond spreads especially for Portugal and Ireland skyrocketed during the period 2011- 2012 when they were forced to agree to their Economic Adjustment Programmes, signed in May 2011 and December 2010 respectively. However, the successful implementation of the MoU's in Portugal and Ireland and the ECB accommodative monetary policy, reduced the pressure and led to a gradual decline in periphery bond spreads. Still, it is clear that this specific risk factor remains elevated compared to the pre-financial crisis period and has recorded an upward trend in 2016 and the beginning of 2017.

**Periphery 10Y Bond Yields
vs Germany Benchmark**



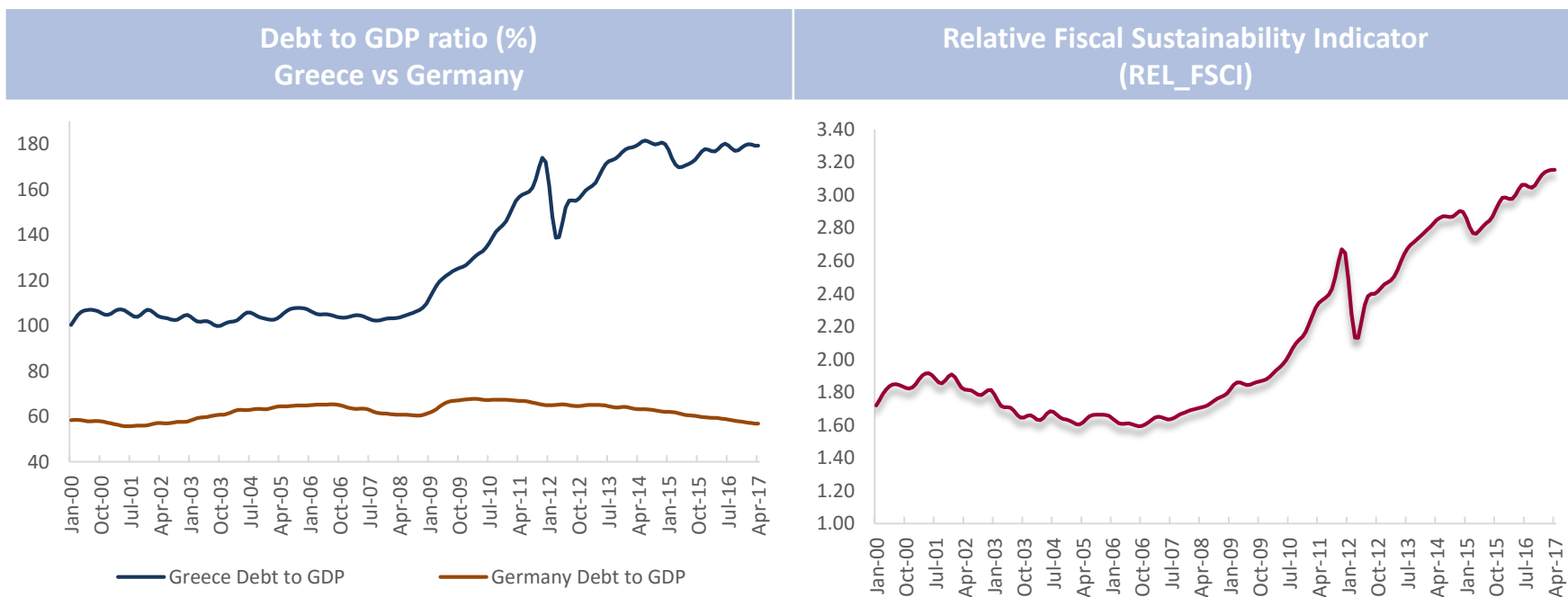
**EA Periphery Risk Indicator
(EAPER_RISK)**



Fiscal sustainability usually plays an important role on the medium term fluctuations of financial variables since it is related with the aggregate expectations for the country's financing prospects.

In Greece, during the public debt crisis, the debt to GDP ratio surged, surpassing 170% in 2011. In sharp contrast, the conservative fiscal policy of the German government and the low debt refinancing rates contributed to the downward trend of the respective debt to GDP ratio after 2009. Consequently, the debt to GDP ratio in Germany decreased by more than 10 ppts since 2009, while the respective Greek ratio increased by more than 50 ppts.

Following this trend, the Relative Fiscal Sustainability Indicator increased exponentially since 2007, reaching its highest level in April 2017.





Optimal Specification of the GGB Spread Model

$$Q_{\tau}(GGB_{sprds_t}) = \beta_{0,\tau} + \beta_{1,\tau}REL_EACT_t + \beta_{2,\tau}REL_CCOMP_t + \beta_{3,\tau}EAPER_RISK_t + \beta_{4,\tau}REL_FSCL_t$$

for each quantile $\tau = 5th, 10th, \dots, 95th$

Where,

REL_EACT: Relative Economic Activity Indicator

REL_CCOMP: Relative Cost Competitiveness Indicator

EAPER_RISK: EA Periphery Risk Indicator

REL_FSCI: Relative Fiscal Sustainability Indicator

The Relative Economic Activity Indicator (REL_ECACT) is statistically significant (at a 5% confidence level) only in the left tail of the spread distribution.

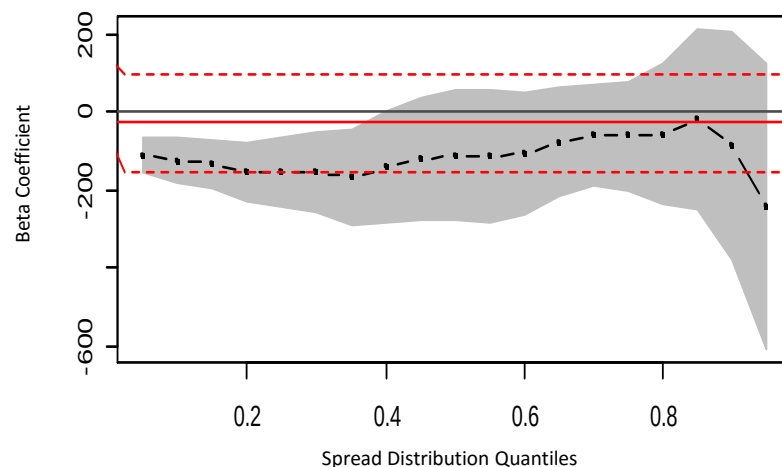
The regression coefficients (beta) have the expected sign, stating a negative correlation between the Greek-German economic activity gap and spreads. However, it tends to vary across the different parts of spreads distribution.

In contrast to the OLS method, where the coefficient (beta) is constant, under the QR method we observe a stronger impact as we move towards the left tail of the spread distribution.

In other words, the Relative Economic Activity Indicator is more strongly associated with the probability of an unexpected decline in Greek spreads (upside risk).

For example, **an increase in the real GDP index in Greece compared to the real GDP index in Germany, not only implies a downward location shift for the spread distribution but also a higher probability in observing lower spreads.**

**Relative Economic Activity Indicator
(beta coefficient in each Spread Distribution Quantiles)**



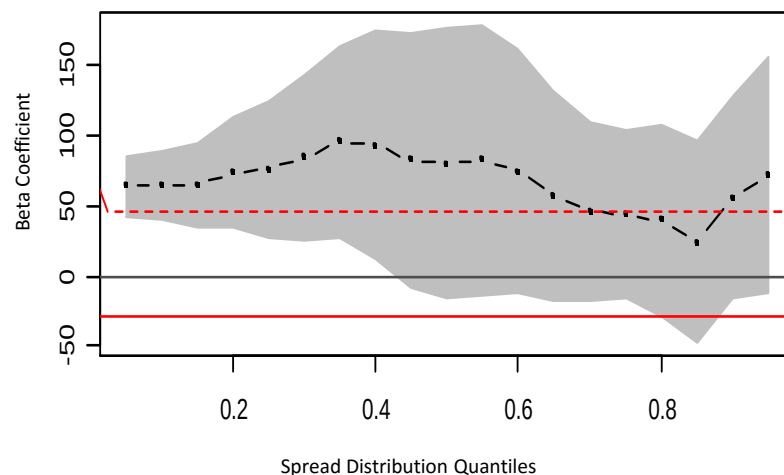
The solid red line indicates the beta estimate under OLS while the dash-dot black line denotes the QR estimate. The area between the dashed red lines denote 95% confidence intervals for OLS while the grey shaded area indicates the respective confidence interval for QR beta estimates.

Similarly, the Relative Cost Competitiveness Indicator (REL_CCOST) is also statistically significant (at a 5% confidence level) at the left tail of the spread distribution.

As expected, the sign of the coefficient (beta) indicates a positive correlation between cost competitiveness and bond spreads, i.e. **a decrease in the indicator (improvement of Greece's relative competitiveness) increases the probability for a decline in Greek bond spreads.**

Notably, the OLS and QR estimation methods produce quite different beta estimates as the two methods produce betas with opposite signs.

Relative Cost Competitiveness Indicator (beta coefficient in each Spread Distribution Quantiles)



The solid red line indicates the beta estimate under OLS while the dash-dot black line denotes the QR estimate. The area between the dashed red lines denote 95% confidence intervals for OLS while the grey shaded area indicates the respective confidence interval for QR beta estimates.

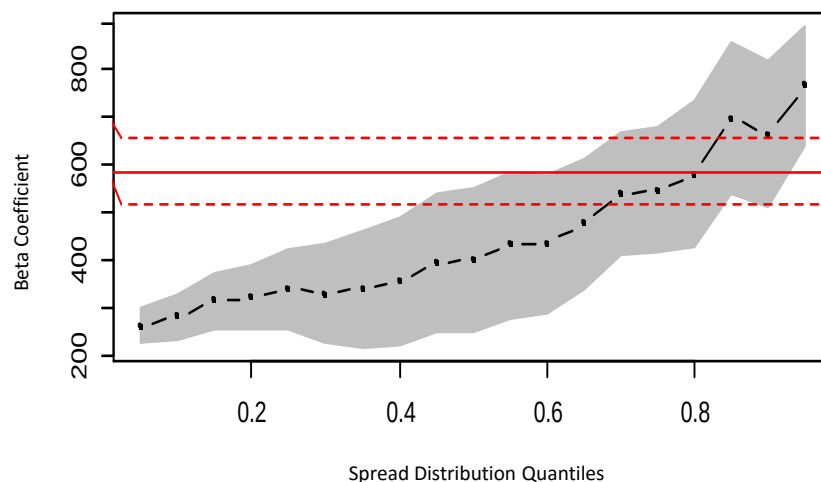
The Relative EA Periphery Risk Indicator (EAPER_RISK) is statistically significant (at a 5% confidence level) throughout the whole spread distribution.

The regression coefficient (beta) states a positive correlation between EA periphery risk and spreads. However, in contrast, with the OLS method, where the coefficient (beta) is constant, under the QR method we observe a gradually increasing impact as we move from the left to the right tail of the distribution.

In other words, the **Relative EA Periphery Risk is likely more strongly associated with the probability of an unexpected increase in Greek spreads (downside risk).**

Consequently, an increase in the periphery risk indicator not only implies an upward location shift for the spread distribution but also a higher probability in observing higher GGB spreads.

Relative EA Periphery Risk Indicator
(beta coefficient in each Spread Distribution Quantiles)



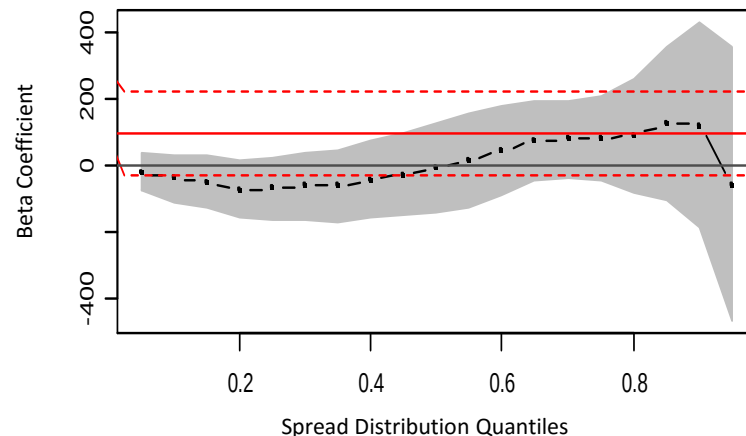
The solid red line indicates the beta estimate under OLS while the dash-dot black line denotes the QR estimate. The area between the dashed red lines denote 95% confidence intervals for OLS while the grey shaded area indicates the respective confidence interval for QR beta estimates.

The Relative Fiscal Sustainability Indicator (REL_FSCI) is statistically significant (at a 10% confidence level) only at the left tail of the spread distribution.

In the case of the relative Fiscal Sustainability, the sign of the coefficient (beta) varies across quantiles, as it declares a positive correlation between debt ratio and bond spreads in the right tail of the spread distribution and a negative correlation in the left tail.

This reversal of the impact across quantiles is related to the Greek bond spread volatility. Specifically, an increase in Relative Fiscal Sustainability (worsening in Greek debt ratio compared to Germany) leads to a wider spread distribution and therefore higher uncertainty about the actual bond spread outcome.

**Relative Fiscal Sustainability Indicator
(beta coefficient in each Spread Distribution Quantiles)**

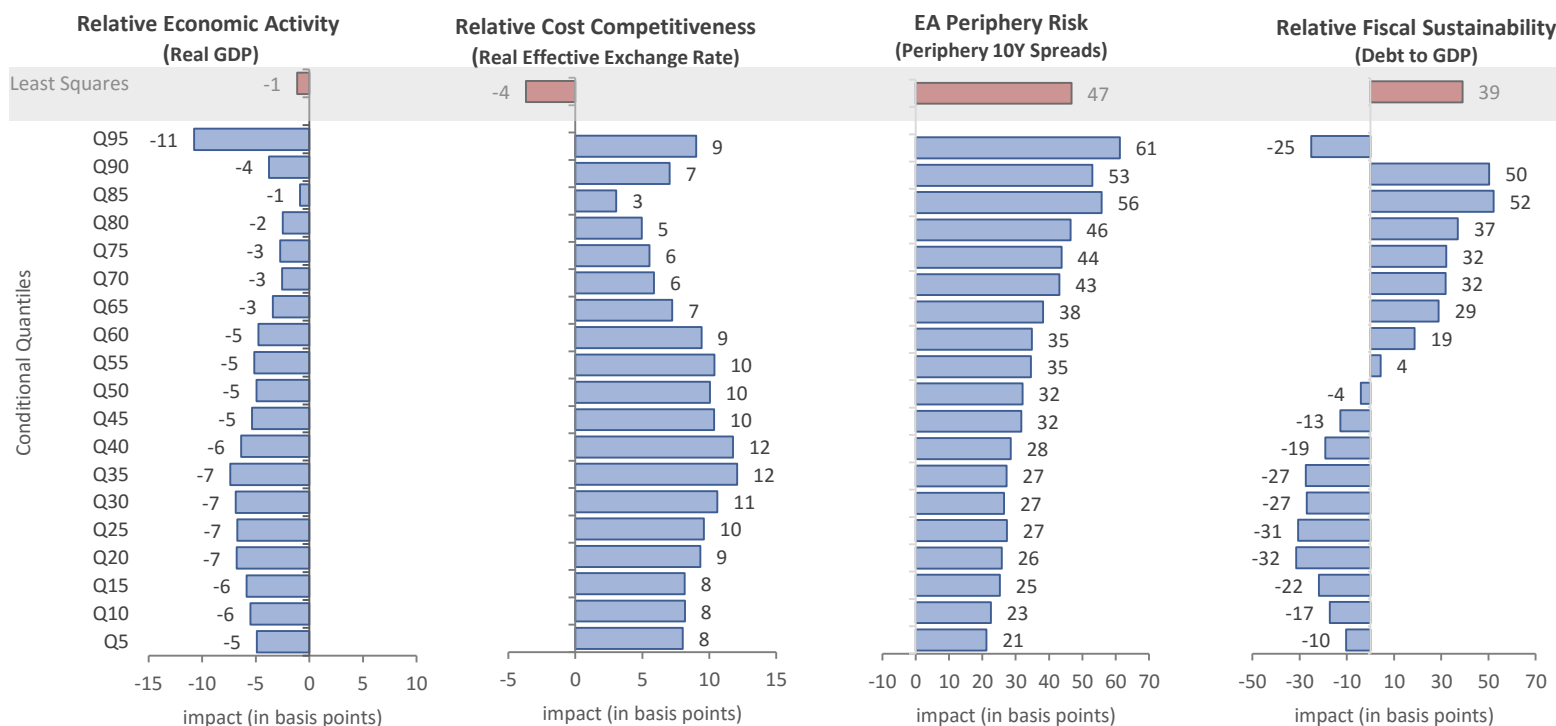


The solid red line indicates the beta estimate under OLS while the dash-dot black line denotes the QR estimate. The area between the dashed red lines denote 95% confidence intervals for OLS while the grey shaded area indicates the respective confidence interval for QR beta estimates.

Impact on Government Spreads from a 10% increase in each indicator

1. An improvement of the Greek GDP growth and competitiveness relative to Germany compresses GGB spreads almost at a uniform manner across the distribution of spreads but the coefficients are statistically significant only at the low-end of the conditional spreads distribution.
2. The high impact of the Periphery Risk provides concrete evidence of contagion or systemic risk between EA periphery bond markets and economies especially on the high-end of the spread distribution.
3. Increases in borrowing designate as more likely both the event of lower and higher bond spreads. This somewhat counterintuitive outcome indicates an increase in uncertainty about spreads possibly due to the fact that at different periods an increase in debt can either be perceived as a sign of unexpected growth or as an episode associated with the difficulty of providing sustainable disbursement of a funding tranche. In any case our model indicates that debt increases are associated with a more volatile path for Greek bond spreads.

Impact on Greek Government Spread from a 10% increase in ...

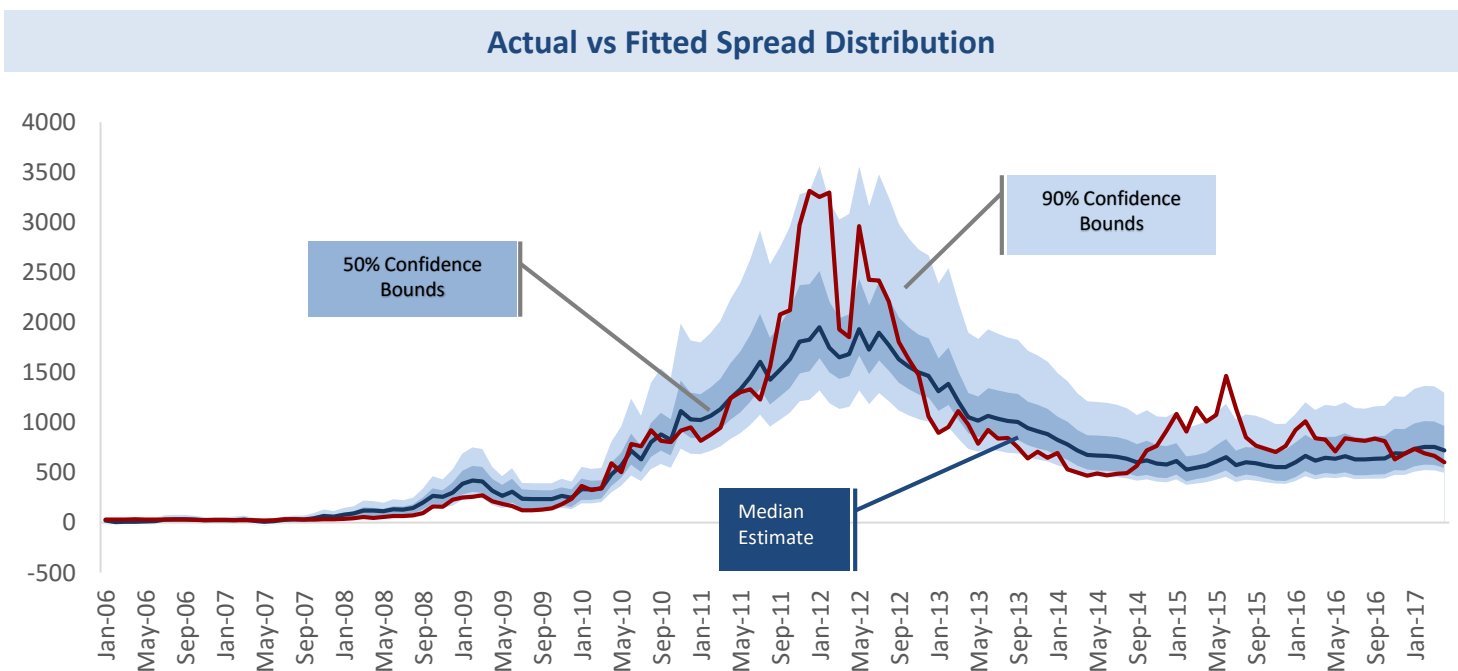


The added flexibility of our model allows us not only to assess its ability (solid blue line) to track the actual evolution of GGB spreads (solid red line) over the period 2000-2017 but also to capture periods of substantial misalignments in the GGB market.

By plotting the area in which there is a 50% chance (90% chance) of occurrence of GGB spreads based on their fundamentals, we can visually identify periods when actual spreads deviated substantially from their fundamentals.

Apparently in the run-up to the Greek crisis in 2008-2009 Greek bonds were substantially overpriced (spreads too low vs model estimate) as well as in the period around 2013-2014.

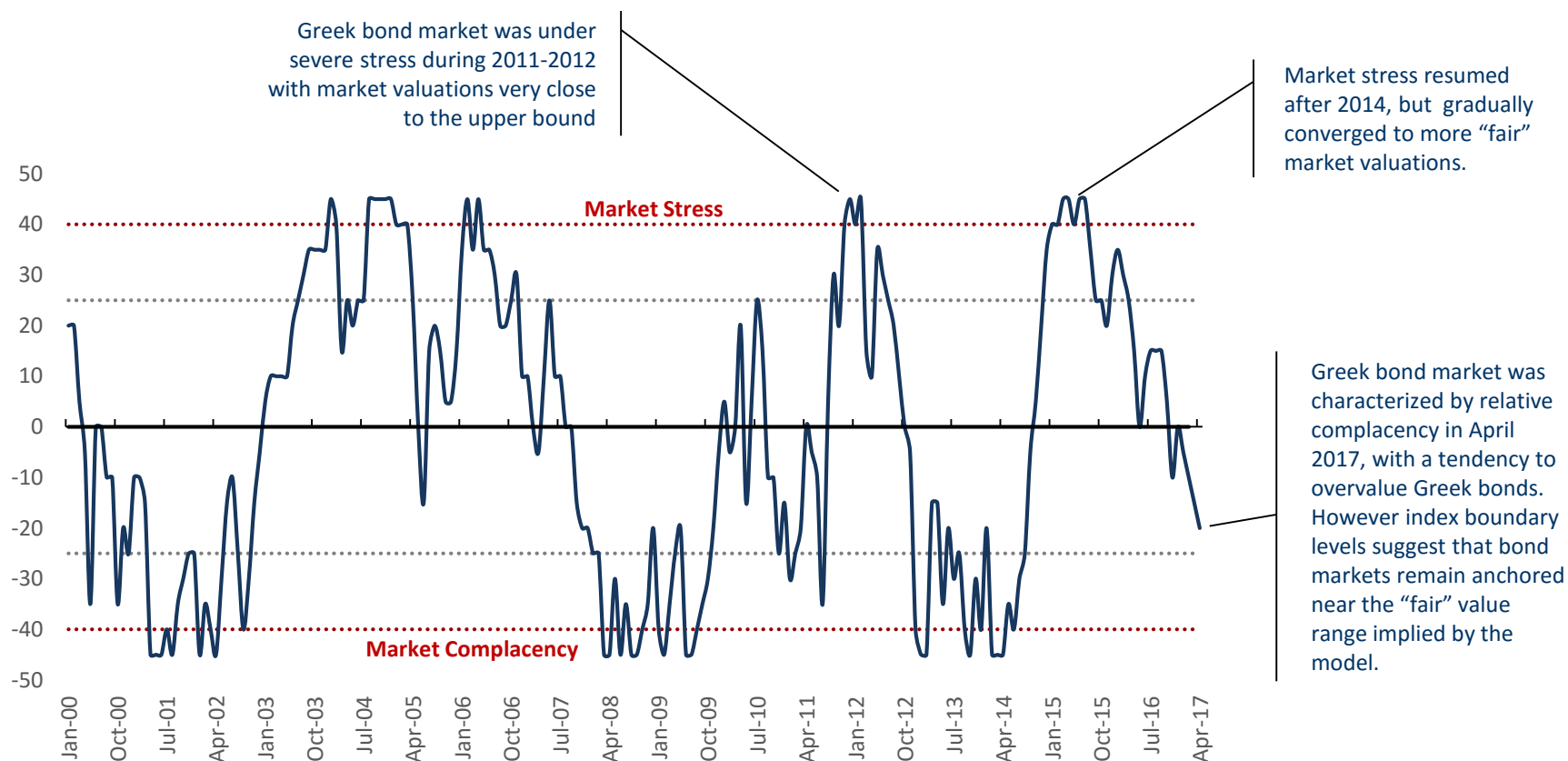
On the contrary, **extreme uncertainty led to record undervaluation of GGBs (spreads too high) in 2011-2012 as well as around mid-2015.** In all cases, **prices corrected by returning into the middle of their theoretical range after a while.**





We construct the Greek Bond Market Misalignment Index which depicts the past evolution as well as the current level of market assessment about the Greek Bond Market. By construction the index is bounded between 50 and -50 points. When the index moves close to its 50 ceiling (i.e. market valuations start to deviate positively from the model's "fair" value) the Greek bond market is under stress and Greek government bonds are undervalued. In contrast, negative values suggest that the bond market overvalues Greek government bonds probably due to greater confidence about the Greek economy future prospects.

Greek Bond Market Misalignment Index

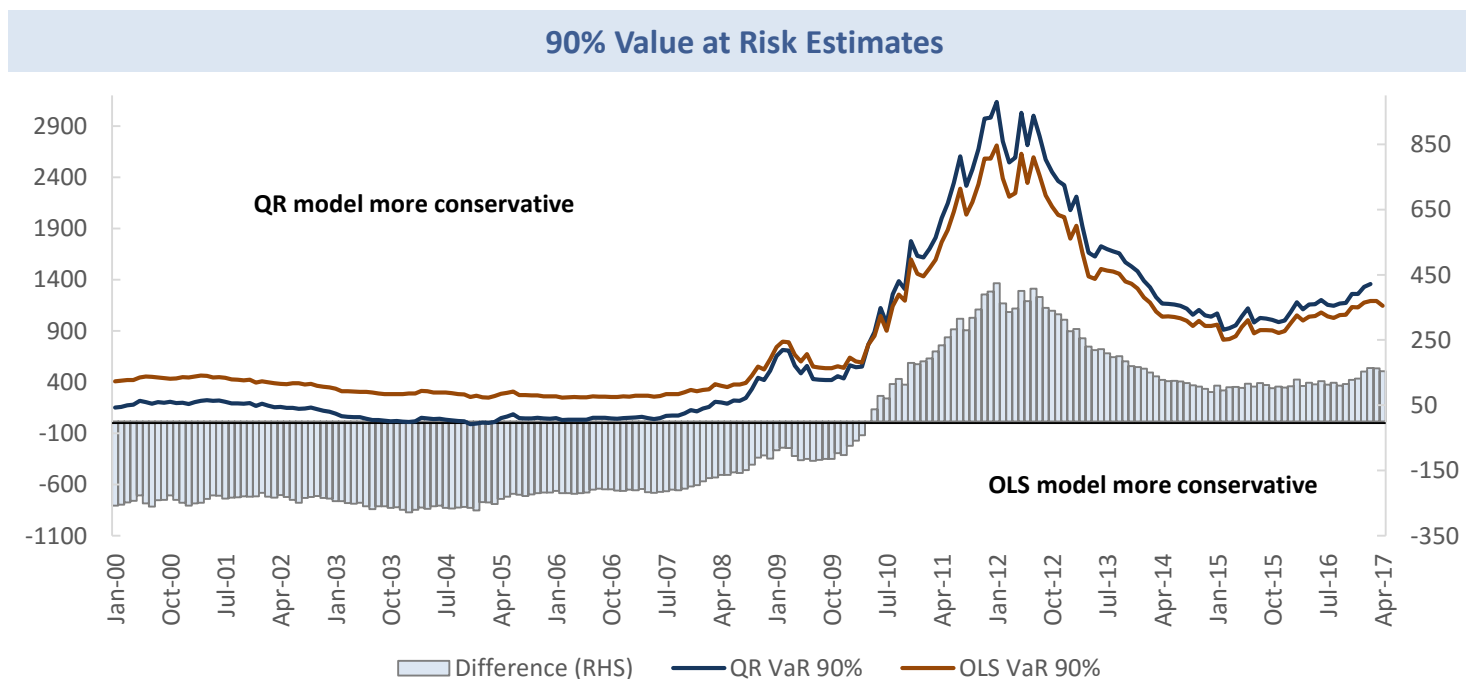




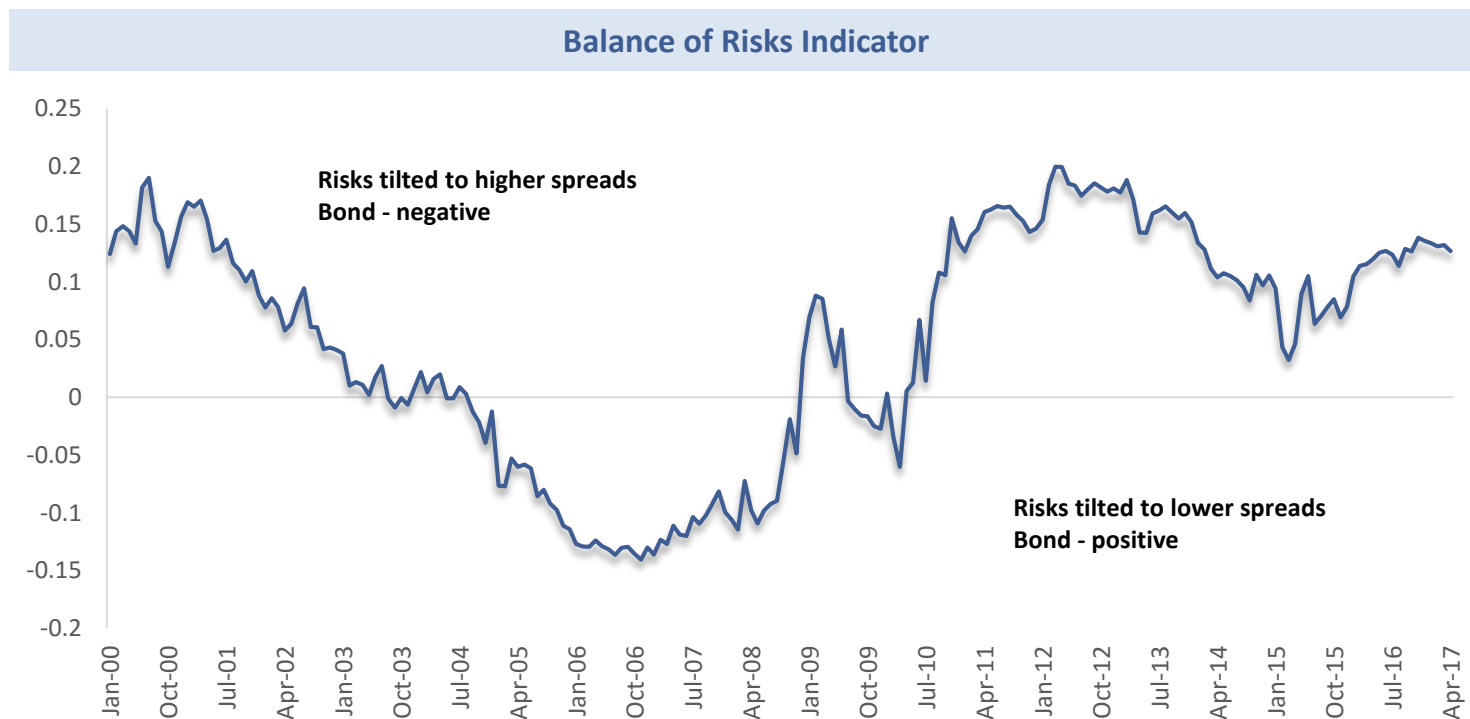
Value at Risk (VaR) estimates are perhaps the key input in the risk management decision process. Since this measure relates to the odds of an extreme surge in bond spreads it can be considered as a worst-case scenario for Greek bonds.

However, as implied by the differences in the VaR estimates between the least squares and QR regression, the two methods result in economically important deviations. Specifically, the standard least squares consistently indicated higher VaR 90% estimates relative to QR for the period starting from 2000 up to 2010. Similarly, least squares estimates were on average more than 180 bps lower than QR in the post-crisis period.

As a result, the QR methodology dictates a considerably different stance when making risk management decision. **In periods of low market stress QR signals a more benign stance relative to more standard estimates, while in periods of high market stress it indicates a more conservative stance towards risk.**



From the Fair-Valuation chart on page 25, the careful reader would have realized that the 50% & 90% confidence bounds are not symmetric around the median estimate. The direct implication of that asymmetry is that our model specification can provide not only an indicator of the fair-valuation of GGBs but also an assessment of the directional balance of risks around the fair-value estimate. According to the Balance of Risk Indicator positive values imply increased risks for higher spreads (downside risk for GGBs). Conversely, negative values signal increase possibility for lower spreads creating potential for GGBs. **The index shows that the Greek bond market was under severe pressure after 2009** with the model signaling that risk was skewed towards the left tail (downside risk) of the implied spread distribution. **In April 2017, the indicator shows that risks remain balanced towards wider Greek bond spreads.**

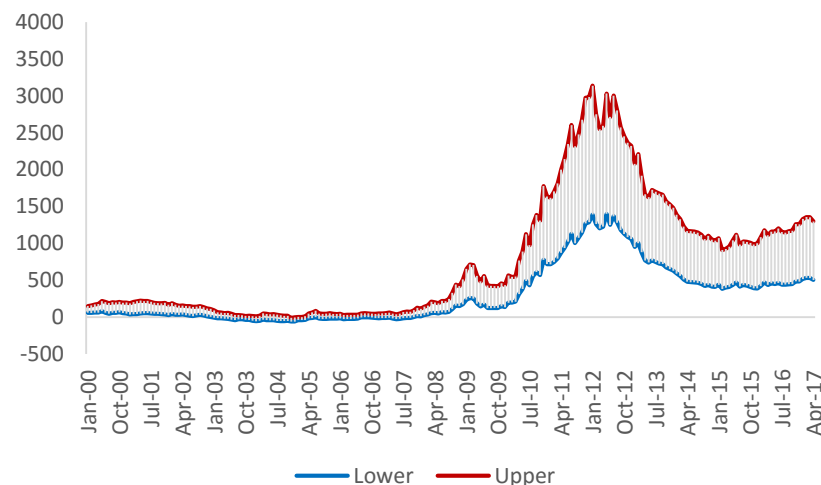


During the period before 2009, the model-implied 80% confidence bounds for Greek bond spreads ranged between 160-345 bps. Immediately after the first Economic Adjustment Programme signed in May 2010 model estimates pointed to a much wider range between 520 – 1024 bps. Greek bond volatility (and hence the width of the confidence bound) increased gradually, peaking in early 2011. Seven years later, in April 2017, the implied uncertainty in Greek bond spreads lies at approximately the same levels as in June 2010.

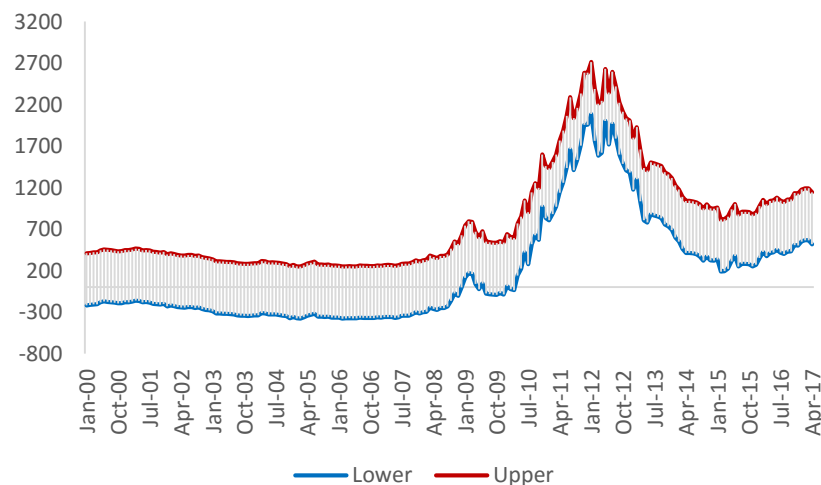
Evidently, a “fair” value for the volatility in bond spreads is more accurate and intuitively less prone to irrational interpretations compared to the OLS estimates. **Specifically, least squares bounds are wider (higher volatility) than the QR bounds in the pre-crisis period and considerably lower than QR bounds in the post-crisis period. Consequently, standard regression methods overestimate volatility under normal circumstances and underestimate volatility in periods of severe market stress.**

Furthermore, the estimated lower bound under OLS is negative for Greek bond spreads, implying that Greek 10-Year yields could be lower than the respective yields for German bonds of the same maturity. On the contrary, the lower bound under QR is always positive and thus more sensible in terms of economic intuition.

QR 80% Confidence Intervals



Least Squares 80% Confidence Interval





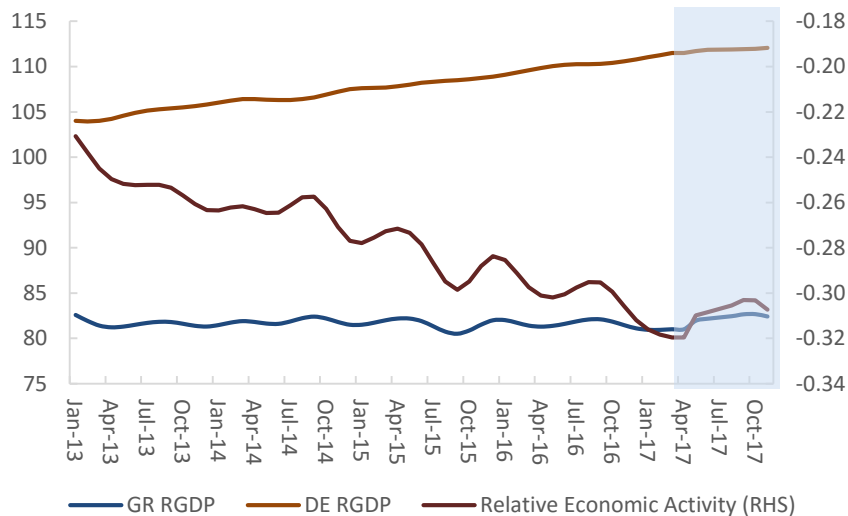
Bond Spread Projection over the next 6 –months: Scenario Assumptions



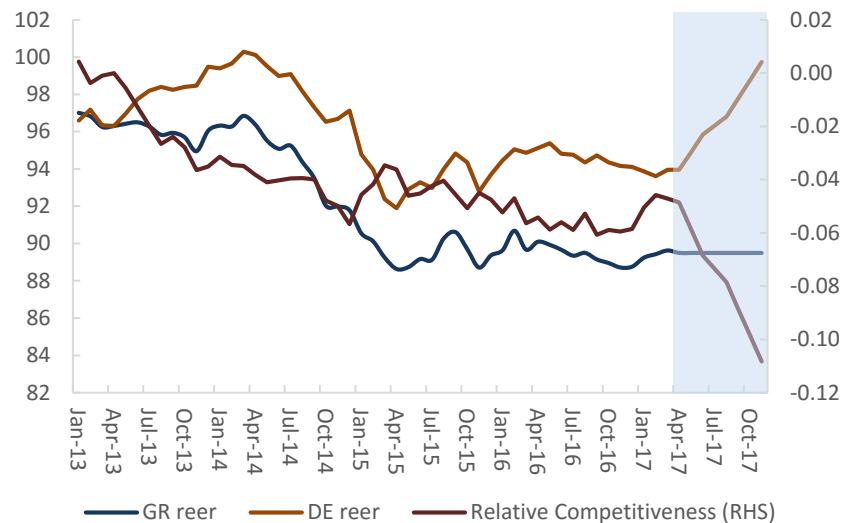
The scenario is constructed upon the assumptions that:

- ☐ The Relative Economic Activity indicator is assumed to improve as the Greek economy will return to growth and real GDP increases by 0.7%. For Germany we assume a 1.5% YoY growth rate.
- ☐ The Relative Cost Competitiveness Indicator will increase as a more hawkish ECB policy affects export oriented countries such as Germany more compared to Greece, causing only the German REER to increase by 1% on a monthly basis for the next 6 months.
- ☐ The Relative EA Periphery Risk Indicator will decline gradually towards 2014 levels as the German 10 - Year yield will increase faster than the yields in the periphery. Moreover the ECB will continue the QE programme in 2017 for the periphery in order to support economic growth prospects for periphery countries in 2017.
- ☐ The Relative Fiscal Sustainability Indicator will remain unchanged as the debt ratios will remain stable at current levels over the next 6 months.

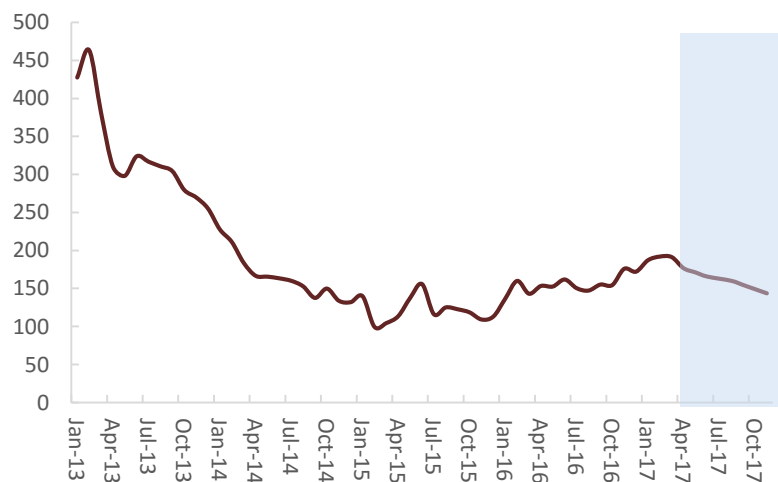
Assumptions - Relative Economic Activity Indicator



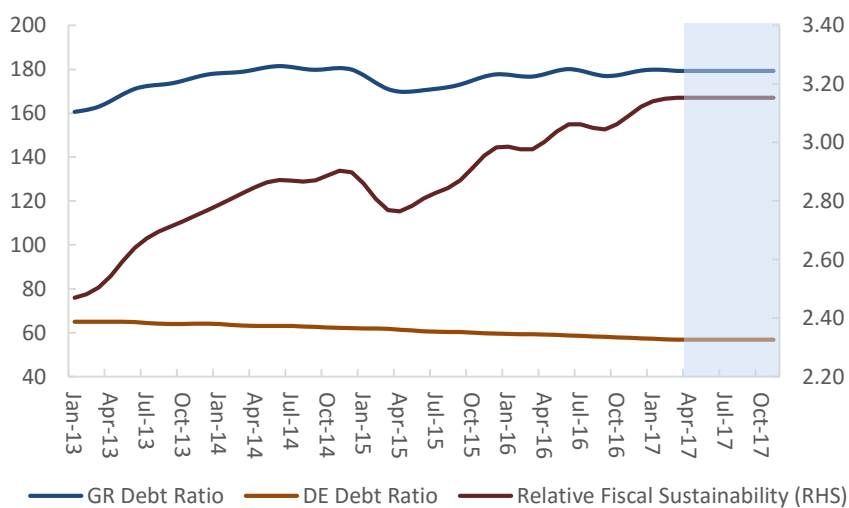
Assumptions - Relative Cost Competitiveness Indicator



Assumptions - EA Periphery Risk Indicator

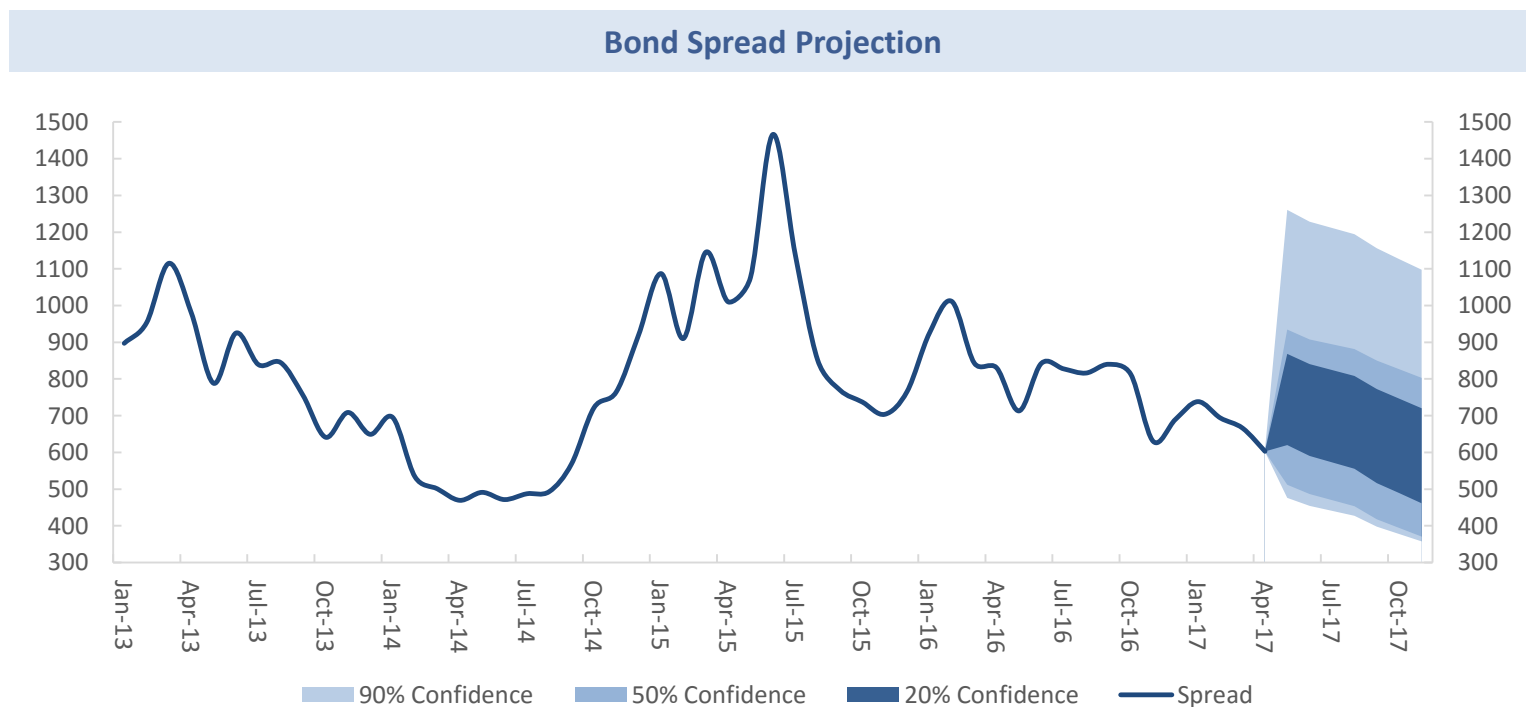


Assumptions - Relative Fiscal Sustainability Indicator



According to the scenario assumptions for the underlying factors of Greek bond spreads, there is a 20% chance that spreads will lie in the range 460-720 bps until November 2017.

Nevertheless, the risk for higher spreads is still substantial and negative surprises may lead bond spreads towards the 900-1100 bps range while based on the model's projections there is only a 10% probability that spreads will fall below 400 bps over the next 6 months.



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