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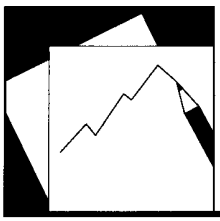

IMF Working Paper

A Toolkit to Assessing Fiscal Vulnerabilities and Risks in Advanced Economies

By a staff team led by Andrea Schaechter

With C. Emre Alper, Elif Arbatli, Carlos Caceres, Giovanni Callegari, Marc Gerard, Jiri Jonas, Tidiane Kinda, Anna Shabunina, and Anke Weber

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Abstract

This paper presents a range of tools and indicators for analyzing fiscal vulnerabilities and risks for advanced economies. The analysis covers key short-, medium- and long-term dimensions. Short-term pressures are captured by assessing (i) gross funding needs, (ii) market perceptions of default risk, and (iii) stress dependence among sovereigns. Medium- and long-term pressures are summarized by (iv) medium- and long-term budgetary adjustment needs, (v) susceptibility of debt projections to growth and interest rate shocks, and (vi) stochastic risks to medium-term debt dynamics. Aiming to cover a wide range of advanced economies and minimize data lags, has also influenced the selection of empirical methods. Due to these features, they can, for example, help inform the joint IMF-FSB Early Warning Exercise (EWE) on the fiscal dimensions of economic risks.

JEL Classification Numbers: E620, H100

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Contents

I. INTRODUCTION[1]

Recent developments in international financial markets have reaffirmed that concerns over fiscal sustainability can precipitate a crisis in advanced as well as emerging economies. Persistent fiscal imbalances eventually result in high levels of general government debt that can raise concerns about sovereign debt rollover and, in the extreme, solvency. High debt can threaten macroeconomic stability and weigh on economic growth. If fiscal weaknesses are not addressed, countries could face difficulties in meeting their funding needs and, in the limit, lose market access altogether. The eventual fiscal adjustment required to restore stability could entail sharp losses in employment and output.

This paper presents a range of indicators and analytical tools for assessing fiscal vulnerabilities and risks for advanced economies.[2][3] As these are complex and evolving issues, there is no single methodology that can summarize all aspects; rather a broad toolkit is needed. To highlight related but conceptually distinct elements of fiscal risks and vulnerabilities, the six tools presented here are organized mainly by their time horizon. Indicators measuring short-term pressures include the size of a country's gross financing needs, with a view to capturing its potential funding risks; high frequency market-based measures of sovereign default risk; and a measure of potential spillovers in distress dependence among advanced economies. Indicators that assess medium- to long-run vulnerabilities use lower frequency data. They include a measure of the required fiscal effort to stabilize debt in the medium and long run; the impact of adverse growth and interest rate shocks on the baseline debt trajectory; and a probabilistic measure of the debt outlook reflecting risks associated with baseline debt projections. Together these tools cover a broad scope and address the different nature of risks to fiscal sustainability, but additional aspects need to be systematically covered going forward, including by assessing the investor base

[1] The authors would like to thank Julio Escolano and Manmohan S. Kumar who have initiated and guided many of the early steps of the analysis presented in this paper as well as Phil Gerson and Martine Guerguil for helpful comments and suggestions. One of the authors (G. Callegari) is currently with the European Central Bank, but the paper was prepared during his time at the IMF and does not reflect views of the ECB.

[2] Underlying vulnerabilities and risks are two different concepts (see e.g. IMF, 2012). Underlying fiscal vulnerabilities—e.g., high rollover needs, high sensitivity to interest rate shocks—is a necessary though not a sufficient, condition for a crisis. Crises are typically triggered by shocks and significant crisis risks reflect a combination of sizable underlying vulnerability and a high likelihood of such shocks.

[3] While linked to the issue of debt sustainability, the paper does not analyze if a country's fiscal policy stance and its public debt trajectory are sustainable. It focuses instead on underlying vulnerabilities and risks that could ultimately impinge on sustainability. For a proposal to modernize the IMF's framework for fiscal policy and public debt sustainability analysis see IMF (2011). The fiscal policy stance is defined in that paper as unsustainable "if, in the absence of adjustment, sooner or later the government would not be able to service its debt." Public debt would become unsustainable "if no realistic fiscal adjustment can prevent this situation from arising."

and level of contingent liabilities.[4] The choice and development of the tools laid out in this paper responds to three additional objectives: first, ensuring wide coverage of advanced economies; second, minimizing the time lag with which data become available; and third, allowing for a relative assessment (ranking) of countries so as to provide input for the joint IMF-FSB Early Warning Exercise (EWE).[5]

The paper complements other IMF work on fiscal vulnerabilities and risks by adding new tools and covering a larger set of advanced economies. Baldacci, McHugh, and Petrova (2011) use thirteen key fiscal indicators, clustered into three pillars (short and medium-term fiscal developments, long-term fiscal trends, and liability management), to capture rollover risks associated with the fiscal baseline scenario. Going beyond their analysis, our paper also assesses the risks emanating from shocks to baseline projections, it captures market-based risk indicators, and analyzes spillover risks. Moreover, many of the indicators used have a shorter time lag than those used by Baldacci, Mc Hugh and Petrova; thus, allowing to capture more immediate changes to risks. A comprehensive methodology for assessing fiscal risks (baseline vulnerabilities and shocks to the baseline) is outlined by Cottarelli (2011) and applied in the April and September 2011 *Fiscal Monitors*. These risks include also fiscal policy implementation risk, macroeconomic uncertainty, and financial sector risk. However, data availability limits this approach to focusing on country groups rather than individual countries at this stage. Another widespread approach to capture fiscal risks is early warning system models. Baldacci et al. (2011) review the literature and build an index of fiscal stress using the indicators developed in Baldacci, McHugh, and Petrova (2011) as input. Caveats are those associated with early warning models and the already-mentioned data limitations.

The paper is structured as follows. Section II provides an overview of the tools capturing six key dimensions of fiscal vulnerabilities and risks. Section III gives illustrative examples for applying these concepts by using recent advanced economy data. Section IV concludes, highlights caveats of the current methods, and suggests ways forward. The Appendix provides technical details on the key methods.

[4] Work and data collection in both areas are underway. For example, risks emanating from the type of holders of government debt was presented in the September 2011 *Fiscal Monitor* for a subset of countries. For more detailed analysis and a wider dataset see, see Andritzky (forthcoming).

[5] A forthcoming Occasional Paper (IMF, 2012) provides an overview of the EWE process and describes the main analytical tools deployed in the exercise across all dimensions. In addition to fiscal issues, these include external, real, financial sector risks, vulnerabilities and potential spillovers. The current paper provides more details on some of the analytical fiscal tools and expands the methodologies. The EWE does not aim to predict the timing of crises but rather to identify underlying vulnerabilities and imminent tail risks that predispose a system to a crisis, so that corrective policies can be implemented and contingency plans put in place ahead of time.

II. Fiscal Vulnerabilities and Risks: Dimensions, Indicators and Analytical Tools

The analysis of fiscal vulnerabilities and risks includes short-, medium- and long-term perspectives. Of immediate concern, and requiring immediate policy responses, are short-term pressures that could cause financing gaps and impose additional costs if borrowing is only available at sharply higher interest rates. The three tools presented here to capture these vulnerabilities are based on relatively high frequency fiscal and financial market data. The concern arising from medium and long-term pressures on public finances is related more to debt sustainability and is captured through tools using lower frequency data. Policy responses to reduce vulnerabilities typically include fiscal structural reforms, which tend to take some time to be implemented. In practice, however, the distinction between the different time perspectives is less clear cut. For example, persistent liquidity strains may result in insolvency. And policy responses aimed to tackle medium-term vulnerabilities, such as credible growth-friendly fiscal consolidation measures, may also alleviate short-term market and funding pressures. Because of this interconnectedness a comprehensive set of vulnerability indicators is needed.

A. Short-Term Pressures: Gross Funding Needs, Market Perceptions, and Susceptibility to Spillovers

Gross Funding Needs

High gross funding needs make economies more susceptible to changes in market sentiment. Until recently, the possibility that advanced economy governments would be unable to raise the needed funds was considered remote, though the risk was recognized that some borrowers—particularly economies with weaker fiscal positions and less liquid bond markets—may have to pay higher yields. But the recent experience of a number of euro area economies has illustrated that advanced economies are no longer immune to serious funding problems.

Funding needs are determined by the size of the budget deficit and the maturing debt that needs to be rolled over. Thus, even when fiscal deficits are small or shrinking, new borrowing needs may be large if high levels of debt have been accumulated in the past and which a significant part matures in the near term. Factors that may mitigate the risks are the government's level of liquid assets (e.g., deposits held with the central bank or the banking system), privatization proceeds, and availability of non-market funding.

Two complementary fiscal indicators are used to gauge the vulnerabilities associated with funding needs.

- A measure of gross financing needs in the current and following year: the simultaneous need for large new issuance of debt to finance a fiscal deficit, together

with the need to refinance large amounts of maturing debt, could signal a vulnerability to short-term financing pressures.[6]

- The current stock of general government debt divided by the average debt maturity: This indicates the average amount of debt that needs to be refinanced or repaid in future years and thus provides an indicator of medium-term vulnerability. Countries with a high stock of debt and low average maturity are more exposed to financing pressures.

Markets' Perceptions of Sovereign Default Risk

Investors' concerns about fiscal sustainability are captured by high-frequency financial market indicators. Two widely used indicators are sovereign Credit Default Swap (CDS) spreads and Relative Asset Swap (RAS) spreads.

- CDS spreads measure the direct cost of seeking insurance against sovereign default. A sovereign credit event may include debt restructuring, missed payments and other types of breaches of the original contract. CDS spreads are quoted as a percentage of the notional amount insured. For sovereign issuers, this spread is often considered as the default risk premium associated with insurance against a specific type of government bond. Indeed, in deep competitive markets, CDS spreads should reflect the expected default-related loss, i.e. the probability of default times the loss given default.[7]

- The RAS spread indicator corresponds to the spread between sovereign bond yields and the fixed interest rate arm in interest rate swap contracts.[8] Because the swap rate and the bond yield are applied to principals denominated in the same currency, the RAS spread allows for a comparison of the risk premia attached to various government bonds by abstracting from exchange rate risk or other currency-specific

[6] In practice, two assumptions are used for calculating gross financing needs. First, for the current year it is assumed that the fiscal deficit is financed linearly over the year (i.e., when the indicator is calculated at end-June, it is assumed that half of the projected deficit for the current year still needs to be financed). Second, short-term debt projected to mature in the current year is assumed to be refinanced by new short-term debt, which then falls due in the next year.

[7] Sovereign CDS contracts are quoted in U.S. dollars, except for the United States for which they are quoted in euros. Five-year sovereign CDS contracts are generally the most liquid markets. Sovereign CDS contracts do not trade on their local currency due the potential of the country issuing money to prevent a credit event. Protection bought in local currency tends to be cheaper than in the standard currency because of the absence of protection against this risk

[8] The RAS indicator is computed as follows: $RAS_i = R_i - RSW_i$ with R_i indicating the yield on 10-year government bonds issued by country i*;* and RSW_i indicating the 10-year fixed rate on interest rate swaps in the currency of country *i.*

factors.[9] Negative RAS spreads indicate that investors assess government paper to be less risky than the flow of funds exchanged between big commercial banks as part of the interest rate swaps.

Caution is needed when interpreting high-frequency financial market indicators and they should only be viewed as a relative assessment of countries' sovereign default risk. A recent empirical analysis (Alper, Forni, and Gerard, 2012) covering 22 advanced economies during 2008-11 suggests that both indicators provide consistent pricing across the cash and derivatives market, although the risk measured by these indicators depends not only on fiscal vulnerabilities but also on global and financial factors. These include short-term interest rates, large scale sovereign bond purchases of major central banks, the relative perceived strength of financial sectors as evidenced by relative stock price movements and expected global growth, and volatility of equity prices as measured by the VIX index. Another caveat is that financial market indicators tend to lag rather than lead the deterioration of the fiscal outlook. Compared to CDS and RAS spreads, government bond yields are an even weaker measure of sovereign default risk since they depend on a wider range of economic and financial developments, including the current position in the business cycle, inflation expectations and exchange rate risks.

Distress Dependence Among Sovereigns

Sovereign CDS spreads have in the past few years exhibited not only a significant degree of volatility but also high synchronicity. This strong co-movement may partly be explained by strong links across sovereigns. That is, an increase in the distress level of one country can be accompanied by an increase in the distress level of other countries. This distress dependence among sovereigns might be due to several factors. For instance, trade linkages might play an important role in an environment of slowing global demand. Capital flow linkages represent another possibility. And, most importantly in the current environment, many sovereigns had to almost simultaneously provide support to banks and other systemic financial institutions operating on their domestic markets. Furthermore, financial institutions tend to engage in important cross-border activities, and can therefore be another channel of contagion. Nevertheless, common factors, such as an increase in global risk aversion (or risk appetite), could also affect the different sovereign CDS markets concurrently.

A tool has been designed to quantify the dynamics of distress dependence between different sovereigns; it computes a spillover coefficient that measures the probability of sovereign distress in one country given default in another country. The methodology is based on empirical estimates of the linkages among different countries on the basis of sovereign CDS spreads as follows (see Caceres, Guzzo, and Segoviano, 2010): (1) for each country,

[9] Interest rates on swaps are effectively free from the risk of default of sovereign issuers, although they entail some residual counterparty risks. Swap contracts specify agreements to exchange a flow of interest payments at a fixed rate for one at a floating rate.

marginal probabilities of default are extracted from each individual CDS spread series at each point in time; (2) joint and conditional probabilities of default are computed using a non-parametric technique; (3) the spillover coefficient is computed as the weighted sum of the probability of distress of each country given distress in the other countries in the sample. The spillover coefficient can be seen as a measure of exposure of each country to distress dependence from the other countries in the sample (see Appendix B for more details).

The tool has two main caveats. First, since the spillover coefficient uses market CDS spreads as an input, market perceptions of the vulnerability of each of these countries play an important role in the ranking. As discussed in the previous section, these market perceptions reflect more than national fiscal vulnerabilities. Nevertheless, this measure provides important information as market tensions can, at some point, become self-fulfilling. Second, the country coverage of this tool is currently restricted to fourteen countries at a time due to computational/program limitations.

B. Medium- and Long-Run Pressures and Susceptibility to Shocks

Medium- and Long-Term Adjustment Needs to Ensure Fiscal Sustainability

Large primary deficits and high debt levels can become unsustainable if not corrected. The scale of the fiscal adjustment required to achieve certain debt targets can be used as an indicator for this type of vulnerability. It indicates the size of fiscal consolidation that needs to be undertaken over a long time horizon, if these illustrative benchmarks are to be achieved. Since entitlement spending, in particular for pensions and health care, is projected to rise significantly in most advanced economies in the coming years, this additional spending pressure needs to be accounted for in the calculations.

Two indicators help gauge the medium and long-term adjustments needs. The first indicator targets a given *level* of debt to be reached in a given period of time; the second indicator specifies the required primary balance to stabilize the *path* of the debt-to-GDP ratio. The methodology used for both indicators (see for details Appendix C) is similar to the one applied by the European Commission to calculate sustainability indicators in its regular *Sustainability Report* for EU member states. Practical applications have been calculated as follows.

- The first indicator (I_1) shows the cyclically-adjusted primary balance needed to reach a certain debt target by a reference date. For illustrative purposes, the calculations shown in Section III cover the next two decades, i.e. the primary balance that has to be realized by 2020 and maintained until 2030 so as to achieve a given debt ratio by 2030. The gross debt target is set at 60 percent of GDP by 2030 (which corresponds to the pre-crisis median of advanced economies) or the end-2012 level if the gross debt-to-GDP ratio that year is less than 60 percent. For some countries with large

financial assets net debt targets are assumed.[10] The required primary balance (I_1) is a function of (i) the initial and target level of debt; (ii) the path of the cyclical component of the primary balance; (iii) the projected increase in age-related spending; and (iv) the initial level of the cyclically adjusted primary balance. Section III illustrates how these sources of the medium-term spending pressures differ across countries.

- The second indicator (I_2) shows the primary balance in 2016 that would be consistent with stabilizing the debt level in the very long run, in order to satisfy the intertemporal budget constraint. Since this indicator includes an infinite-horizon projection, it gives much more weight to long-run rather than short- or medium-term projections of the primary balance. As a consequence, countries with larger increases in age-related spending will tend to have a higher required primary balance.

Vulnerabilities to Adverse Growth and Interest Rate Shocks

Debt dynamics are sensitive to the economic outlook. Since the interest rate-growth differential is key for the future debt path, countries can be analyzed according to their susceptibility to changes in both variables. Uncertainty regarding the likely pace of economic recovery and the impact on countries' public finances has increased during the summer months of 2011. At the same time, with the increase in debt levels, most advanced economies have become more sensitive to interest rate shocks even though yields are still low for many of them.

Growth shocks

The impact of a "low growth" scenario can be gauged by adjusting the real GDP assumptions that enter the debt dynamics equations. Shocks of different sizes can be considered, for example based on historical growth patterns, by accounting for the level of debt[11] or by applying the same relative or the same absolute shock to all economies. The latter approach has the advantage of allowing to compare countries' susceptibility to the same size of shock. A practical assumption is to lower real GDP growth by one percentage point compared to the baseline projections,[12] and to assume that potential GDP is not affected by the adverse growth developments and that governments do not take any corrective discretionary actions to smooth their impact. As a consequence, the shock affects the deficit and debt-to-GDP ratios

[10] In line with calculations for the September 2011 *Fiscal Monitor*, for Japan, the net debt target is 80 percent, which corresponds to a gross debt target of 200 percent. For Australia, New Zealand and Canada, the net debt target is 40 percent.

[11] For example, Kumar and Woo (2011) find that for countries with debt ratios above 90 percent of GDP, a 10 percentage point increase in the initial debt-to-GDP ratio is associated with a slowdown in annual real per capita GDP growth of around 0.2 percentage points per year.

[12] Section II. F describes a methodology that allows assessing the debt dynamics under stochastic shocks.

through higher automatic stabilizers and the change in the GDP base (see Appendix D for more details).

The impact of lower growth varies depending on structural country differences, in particular, with respect to three main factors: trend growth, the size of the pre-shock stock of public debt, and the size of the automatic stabilizers. The first factor, trend growth, matters particularly for countries with projected low average growth rates such as Italy and Japan. The second factor, the initial stock of debt, is also relevant for these two countries as well as several countries where debt ratios have surged as a result of the crisis (for example Greece, Ireland, Portugal, the United Kingdom, and the United States). The third factor matters more for many European countries, where the size of automatic stabilizers is bigger.

Interest rate shocks

A country's sensitivity to an interest rate shock in the short to medium run depends on its gross financing needs. For any given maturity structure of debt, countries with higher debt levels or higher fiscal deficits will face higher financing needs, thus exposing them to higher interest rate risk. The nature of interest rate shocks also matters. In particular, the persistence of the shock and whether there are feedback effects from higher debt levels or higher gross financing needs to interest rates in the form of a risk premium can potentially be very important.

Similarly to the adverse growth scenario, calibrating the size and duration of the shock involves trade-offs. Countries may be sensitive to shocks of different magnitudes given the differences in their debt levels, maturity structures, and budget balances. Applying country-specific shocks would require making assumptions on the determinants of interest rates and risk premia. While the literature provides some guidance on these links,[13] such an exercise adds a level of uncertainty and complicates a country comparison. Thus, a simpler, and possibly more transparent, option is to apply a common shock, e.g. 100 basis points over the medium term, to all countries.

To assess the vulnerability to interest rate shocks, two indicators are particularly useful. The first indicator measures the impact of a permanent increase in interest rates on average financing costs over the next five years (in percent of GDP) compared to the baseline. The second indicator measures the total average level of financing costs during the five year period. Although the first indicator reflects the impact of a permanent increase in interest rates, the implied total financing costs are relevant as they capture the magnitude of resources that need to be channeled towards financing the debt as opposed to other types of

[13] See for example, Baldacci and Kumar (2010), Gale and Orszag (2002), and Engel and Hubbard (2004).

government expenditures.[14] The level of financing costs certainly depends on the baseline projections as well as the impact of the interest rate shock. Therefore, countries with high financing costs in the baseline scenario will also tend to show higher average financing costs under the shock scenario.

The impact of the interest rate shock over time depends on the amount of new borrowing that becomes subject to the higher interest rates, which is related to the gross financing needs and the structure of issuance. The impact of the interest rate shock accumulates over time as a larger fraction of debt becomes subject to the higher interest rate. To calculate the total impact one needs to account for the amount of debt maturing each year and being refinanced at a higher rate, thus the future maturity structure of debt (see Appendix D). In practice, however, such details are not always available, requiring instead to make an assumption, such as a constant maturity structure. This simplification could be a potential shortcoming of the computations as countries may actively seek to lengthen their average maturity to reduce existing vulnerabilities.

Finally, one needs to account for the fact that some countries hold assets which generate interest income. Depending on the nature and the term to maturity of these assets, higher interest rates would also have an effect on interest income. For transparency and comparison reasons, it is practical to assume that interest rates for financial assets and new liabilities increase by the same amount.

Stochastic Simulations: Medium-Term Risks to Public Debt Trajectories

Assessing the uncertainties around countries' debt projections through stochastic simulations is another tool to analyze their vulnerabilities. Unlike the previous tool, where a common shock is applied to the baseline growth and interest rate projections and fed through to debt dynamics assuming unchanged policies, this approach uses a stochastic model of debt sustainability. It relies on simulations calibrated on past constellations of macroeconomic and financial shocks affecting debt dynamics (growth, interest rates, and the exchange rate) and on the average policy response to these shocks. Uncertainty surrounds particularly the magnitude, timing, and composition of the future medium-term course of fiscal policies as well as the future path of growth-adjusted effective interest rates, especially if it will be fundamentally different in the aftermath of the crisis.[15]

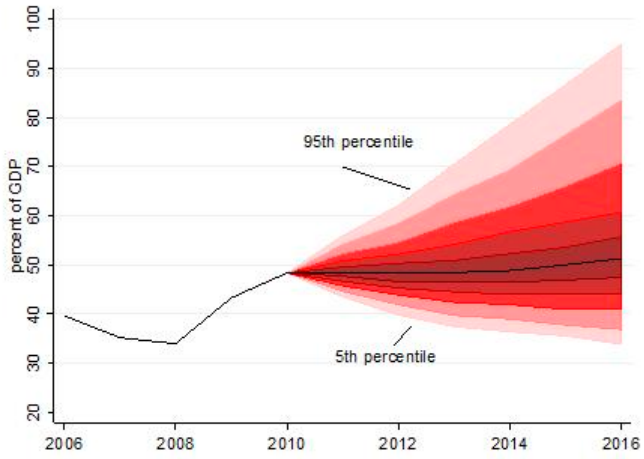
A risk-based approach to debt sustainability involves first an estimation of a fiscal reaction function, followed by an unrestricted VAR model to derive the stochastic path of the general government debt. Shocks to the key macroeconomic variables are random draws from the

[14] Some rating agencies consider the financing costs to revenues as one measure of default risk. If financing costs increase beyond a certain threshold, governments may become less able or less willing to service their debt.

[15] For more details see Alper, Debrun and Shabunina (2012).

joint normal distribution with zero-mean and the variance-covariance matrix of the unrestricted VAR estimates. The same VAR is used to generate macroeconomic projections consistent with each series of shocks and the underlying economic dynamics. A key output from these simulations is a series of probability distributions of public debt depicted in "fan charts" of debt dynamics (Figure 1, see Appendix E for more details). They indicate for each year the likelihood of deviations from the planned debt trajectory.

Figure 1. Illustrative Stochastic Debt Projections



Source: IMF staff estimates.

To assess risks to medium-term public debt dynamics, two indicators are used measuring "good" and "bad" outcomes. The "good" outcome is defined as the medium-term stabilization of the public debt ratio. The indicator measures the probability that the five-year-ahead model-based projected debt ratio will not be greater than the maximum median debt level observed during the seven years prior. This indicator, however, is mute to the level of the debt ratio at which the stabilization takes place and it does not fully account for the tail risks. Therefore, we supplement it with a "bad" outcome ("tail event") indicator that is measured as the model-based projected five-year-ahead debt ratio corresponding to the 90th percentile value. The country can reach this debt level only if a large share of adverse shocks materializes and the parameters of the fiscal response function do not change.

III. An Illustrative Application of the Methods, Tools, and Indicators

This section illustrates how the methods described above can be used to gauge fiscal vulnerabilities and risks. Key indicators are provided for selected advanced economies, with a view to demonstrating the various dimensions of fiscal challenges that most economies face. For illustrative purposes this section focuses on five countries—Germany, Greece, Japan, the United Kingdom, and the United States—but includes data also for other selected advanced economies to provide a basis for comparison. The objective is not to give an up-to-date or comprehensive assessment of fiscal vulnerabilities but rather an illustration on the type of information that these indicators and tools can offer for the analysis of fiscal challenges. Data for macroeconomic variables draw on the September 2011 *Fiscal Monitor* and the *World Economic Outlook*.

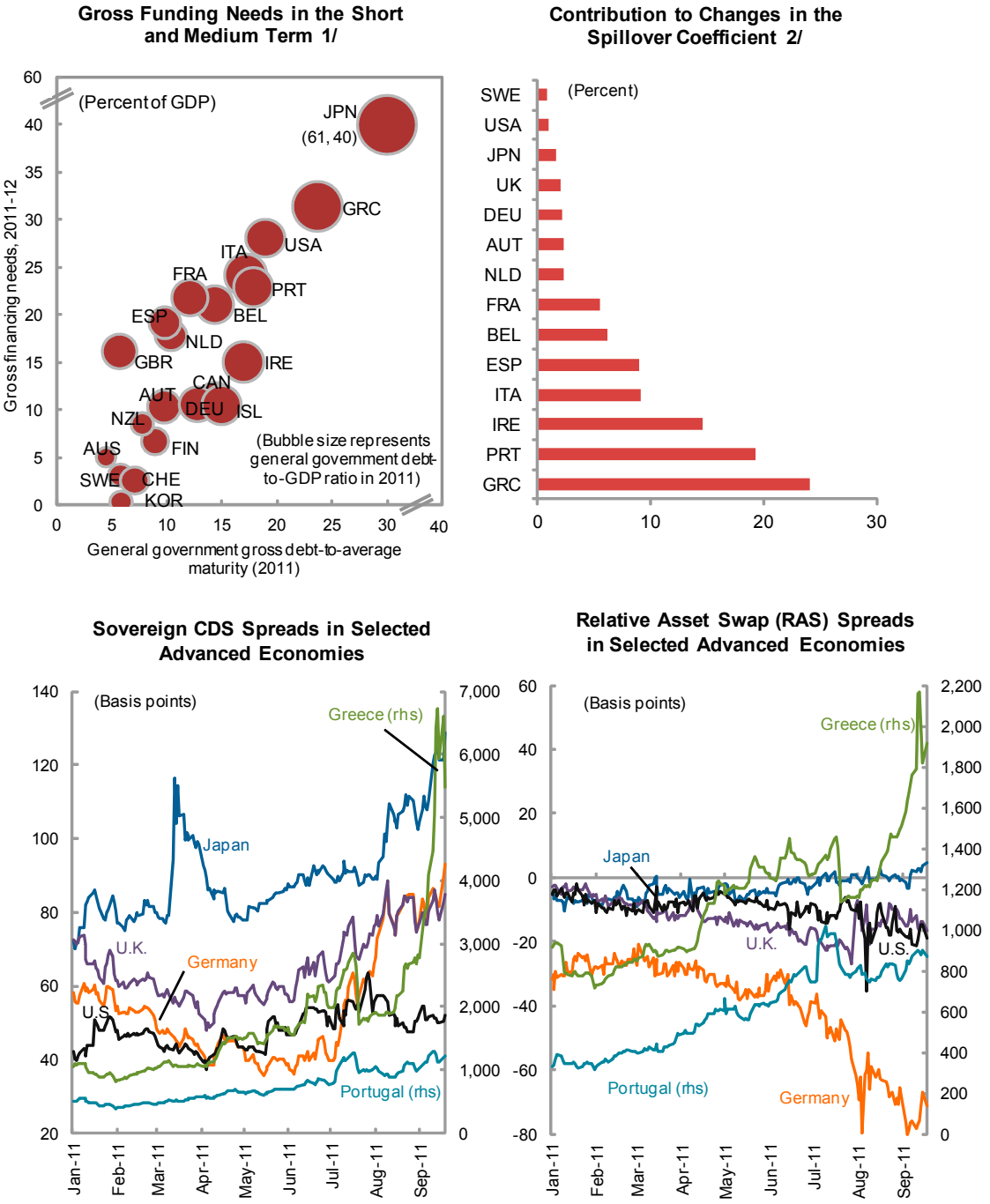
A. Gross Funding Needs, Market Perceptions, and Susceptibility to Spillovers

A range of advanced economies faces high rollover and financing needs (Figure 2, first panel). For Japan, the financing needs in the remainder of 2011 and 2012 are by far the highest and exceeded 60 percent of GDP by the time of the data cut-off, followed by Greece and the United States (about 30 percent of GDP). For Japan, this reflects its large fiscal deficit and debt stock as well as the relatively short maturity profile of its debt. In Figure 2, it is thus positioned in the far right hand corner, followed by Greece and the United States, with the size of the bubble indicating their relatively high debt levels. For Japan and the United States, mitigating factors for these vulnerabilities have been low yields which reflect in part structural factors, such as a stable investor base. However, market access at low rates cannot be taken for granted and the impact of interest rates increases on debt dynamics can be powerful in the medium run (see third panel in Figure 3).

The examples of gross funding indicators for Germany and the United Kingdom show that relying on a single measure could give an incomplete picture. In particular, both countries have roughly the same debt ratio in 2011 but fare differently across the two indicators on short and medium-term gross funding needs. Germany, due to its low projected deficit, has much smaller gross funding needs than the United Kingdom in 2011-12. But, the United Kingdom has the longest average debt maturity among advanced economies and thus needs to annually roll over a much smaller portion over the medium term than does Germany (the United Kingdom's ratio of debt to maturity is about half of that for Germany). These indicators show that even for countries with strong fiscal fundamentals there are trade-offs that need to be carefully considered as part of the debt management strategy.

Markets' perceptions of default risks is highest for 'peripheral' euro area economies but with strong country differentiations. CDS and RAS spreads for Greece, depicted in the third panel in Figure 2, have surged while they have stabilized in Portugal and come down sharply in Ireland (not shown in the figure) since July 2011. While this in part reflected markets' increased differentiation of the economies' growth, reform, and fiscal outlooks, in other episodes sovereign spreads have moved closely together reflecting global and financial developments as well as policy uncertainties. RAS spreads have, until early September 2011, continued to be negative for several advanced economies, such as Germany, the United Kingdom, and the United States. This can be attributed in part to the downward trend in sovereign yields and somewhat less for the fixed interest rate arm of interest rate swap contracts. It indicates that for these countries (e.g., Germany) markets assessed government paper to be less risky than flows of funds exchanged between big commercial banks. The divergence of RAS and CDS spreads for some of countries tends to reflect the relative illiquidity of derivatives markets as well as, for some countries, flight-to-quality effects, both of which distort the no-arbitrage relationship across the cash and derivatives markets.

Figure 2. Indicators of Fiscal Vulnerabilities and Risks —Funding Needs and Market Perceptions



Sources: Bloomberg, L.P.; Datastream; IMF *World Economic Outlook*; and IMF staff estimates. Data are from September 2011.

1/ For Greece, the gross funding need shown here does not include any assumption on a debt exchange.

2/ The "spillover coefficient" is a vulnerability index that takes into account the distress dependence of each country to all the other countries in the sample. The chart shows the contribution of each country to changes in the spillover coefficient measure for all other countries in the sample (see Section II .A and Appendix B for methodological details).

Using sovereign CDS spreads to assess spillover risks indicates that countries representing the "largest source of contagion" in the sample are Greece, Portugal and Ireland (based on CDS data as of end-August 2011 (Figure 2, second panel). The spillover coefficient for these countries has almost doubled since March 2011. Germany, Japan, and the United States, on the other hand, together with several other advanced economies, appear to be the most resilient to sovereign risk contagion, according to the spillover coefficient.

B. Medium- and Long-Run Pressures and Susceptibility to Shocks

Most advanced economies need to sustain substantial fiscal efforts over the medium term in order to reverse current debt trajectories. Greece, Japan, and the United States would need to reach and maintain a cyclically-adjusted primary surplus of more than 7 percent of GDP to achieve a debt-to-GDP ratio of 60 percent of GDP by 2030 (Figure 3, panel 1, indicator I_1). Even for Germany and the United Kingdom, efforts will be sizeable in light of the debt legacy that the crisis has left and the additional medium-term pressure from age-related costs.

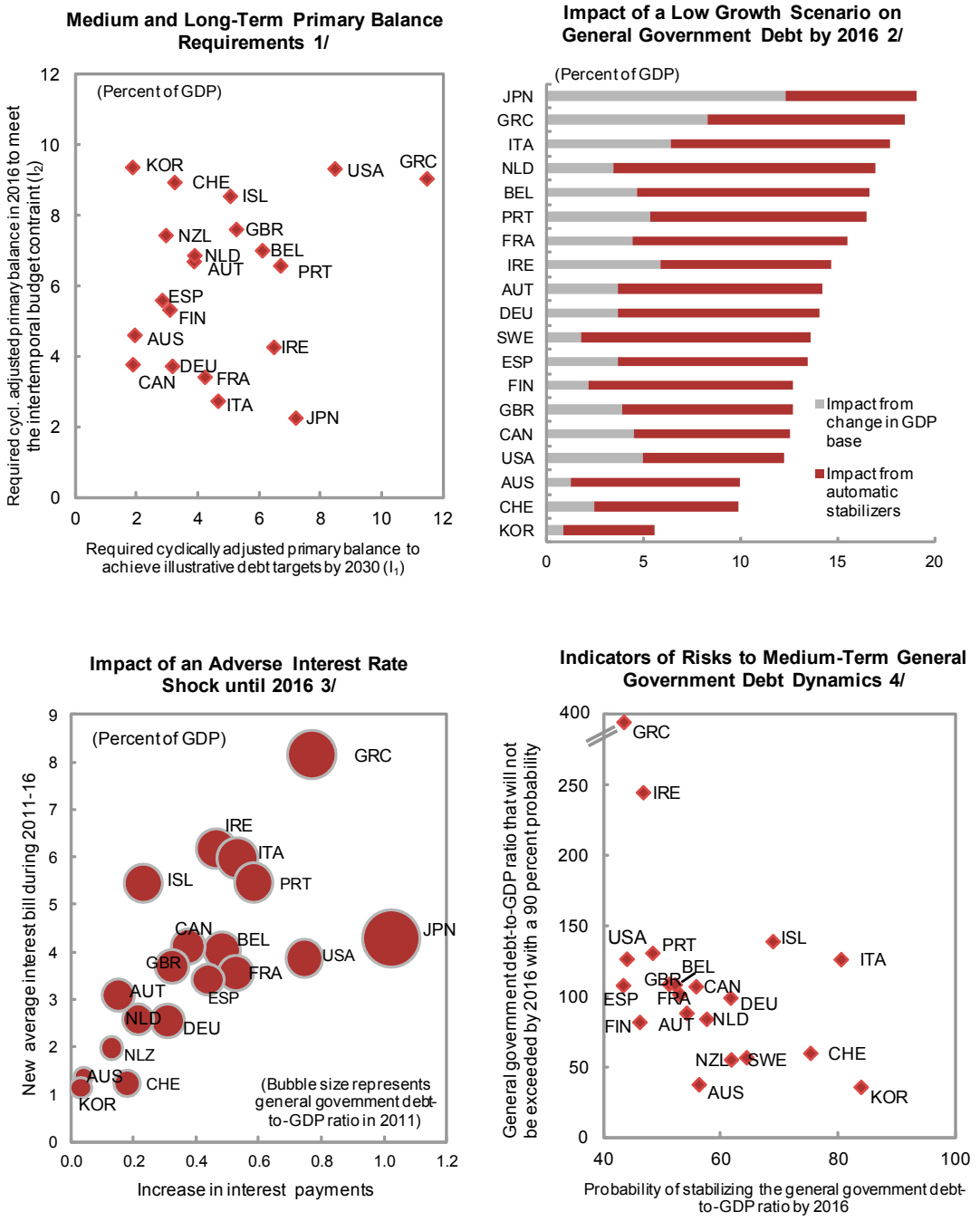
Sources of the medium-term spending pressures differ. For instance, for the United States and the United Kingdom both the initial debt level and the age-related costs are important contributing factors, whereas for Japan and Greece the required balance is explained mainly by the high debt levels. This is also the reason why the United Kingdom needs a higher primary surplus in the very long run (indicator I_2) than Japan. It reflects for the United Kingdom a projected substantial increase of age-related spending of more than 9½ percent of GDP over the next four decades compared to a projected increase of about 2 percent of GDP for Japan.

The susceptibility of medium-term debt dynamics to adverse growth and interest rate shocks varies strongly with structural country differences.

- The impact on lower-than-expected real GDP growth hinges on trend growth, the size of the pre-shock stock of public debt, and the size of the automatic stabilizers. As the second panel in Figure 3 shows, trend growth matters particularly for countries with projected low average growth rates, such as Japan. The second factor, the initial stock of debt, also plays a key role for Japan and Greece. The third factor matters more for many European countries, including Germany and the United Kingdom, where the size of automatic stabilizers is bigger. Comparing the impact of a one percentage point reduction in real GDP growth over the next six years, the impact is largest for Japan and Greece. The impact on the debt path of the United States is mitigated somewhat by its relatively strong trend growth and smaller automatic stabilizers.

- The impact of a permanent increase in interest rates on average financing costs during 2011-16 (I_1) is largest in Japan, Greece, and the United States (Figure 3, third panel), ranging between 1 and ¾ percent of GDP for these three countries. This reflects their high gross financing needs. Looking at the second interest rate shock indicator, which measures the new total average interest rate bill corresponding to the higher interest

Figure 3. Indicators of Fiscal Vulnerabilities and Risks —Focusing on the Medium and Long Run



Sources: Bloomberg L.P.; IMF World Economic Outlook; and IMF staff estimates. Data are from September 2011.

1/ I_1 indicates the required primary balance that needs to be maintained from 2020-30 to reduce the debt ratio to illustrative targets by 2030 (in most cases gross debt-to-GDP ratio of 60 percent, or to stabilize at the end-2012 if below 60 percent; net debt targets for Australia, Canada, Japan (80 percent) and New Zealand. See Section II.B and Appendix C for methodological details.
2/ Assumes a one percentage point lower real GDP growth in 2011-16 than in the WEO baseline projection.
3/ Cumulative increase in interest bill starting in 2011. Shock assumes that the interest rate on new issuances is 100 basis points higher than in the baseline.
4/ Based on probabilitiy distributions resulting from random shocks to key macroeconomic variables and fiscal response functions based on historical data (see Section II.B and Appendix E for methodological details).

rate (I_2), countries such as Ireland, Italy, and Portugal indicate greater vulnerability relative to the first indicator given their already high financing costs in the baseline.

- Most economies that are highly vulnerable to growth shocks are also exposed to interest rate shocks. One country where the impact of both shocks differs is the United States. It is vulnerable to an interest rate shock due to its large gross financing needs but is relatively less exposed to a growth shock given its relatively small size of automatic stabilizers and more robust trend growth.

Finally, when applying stochastic simulations to analyze risks to medium-term debt dynamics, they point to trajectories being most unfavorable in Japan, Greece, and the United States (Figure 3, fourth panel). All three have a less than fifty percent probability to stabilize their debt ratio by end-2016. For the United States, however, the debt level that it will not exceed with a 90 percent probability is substantially lower than for the other two countries. For Germany and the United Kingdom, the simulations predict a greater than 50 percent probability to stabilize debt ratios over the next five years based on random shocks and past fiscal behavior.

C. Bringing the Indicators Together

The illustrative application of the indicators and tools highlights the complexity and interconnectedness of different dimensions of vulnerabilities and related policy options. While for a few countries fiscal vulnerabilities appear large on all fronts, for most others vulnerabilities are concentrated in particular areas. Expanding the existing strengths can be one way of mitigating vulnerabilities in other dimensions. For the countries shown here, this includes, for example, ensuring strong trend growth in the United States to support debt dynamics, containing the relatively small age-related spending pressure from entitlements in Japan to manage this source of medium and long-term pressure, and maintaining a long average maturity of debt in the United Kingdom to keep funding needs in check. However, such policies would need to be combined with forceful measures that address fiscal weaknesses in other areas. The use of a set of indicators and tools, as well as a comparison of countries against their peers can be a useful way of identifying and communicating key areas of concern as well as policy requirements and options.[16]

IV. Conclusions and Ways Forward

The crisis has heightened fiscal vulnerabilities and risks in many advanced economies but the levels, types, and origins differ across countries, as captured by the various indicators

[16] To summarize the relative vulnerabilities of countries across the various indicators and tools, one can consider ranking them or assigning "warning flags", for example for "low", "medium", and "high" risk depending on their relative position to other countries. This approach is followed in the joint FSB-IMF Early Warning Exercise which prepares vulnerability ratings for each sector, including the fiscal sector (for more details, see IMF, 2012).

covered here. This paper presents a range of indicators and analytical tools to monitor fiscal developments with a view to capturing these differences and identifying the various dimensions of fiscal challenges. While these tools are far from comprehensive, they cover pressures that can be exerted in the short run from financing needs and markets as well as medium and long-term pressures on debt dynamics and potential shocks that can aggravate the baseline scenario. With data available for a large set of advanced economies with little time lag, the methods also allow a systematic comparison of countries against their peers along many fronts. Such positioning can provide a useful backdrop for policymakers. It allows drawing lessons from "comparators" and is often used by market analysts in their assessment of fiscal developments.

However, more work needs to be done to systematically capture additional aspects of fiscal vulnerabilities. This includes, for example, the investor base, the currency denomination of debt, and the level of contingent liabilities. Judgment is ultimately needed in putting the different pieces of information together for a vulnerability analysis. An indicator-based approach alone cannot fully account for vulnerabilities having potentially different relevance across countries. For example, the rather low maturity of debt in Japan is currently mitigated by the stable and overwhelmingly domestic investor base. Another warning against a simple mechanical use of the tools is that some variables react with a lag or tend to overreact. This applies in particular to market perceptions of default risk that have in the past frequently responded very late in differentiating countries' individual fiscal vulnerabilities and subsequently overshot in responses. Consequently, the tools to assess fiscal vulnerabilities and risks should be continuously monitored for their usefulness and expanded or adjusted as needed.

APPENDIX: TECHNICAL ASPECTS OF THE VULNERABILITY AND RISK ASSESSMENT TOOLS

This appendix provides further technical details to the indicators and methods described in the paper for analyzing fiscal vulnerabilities and risks. The main motivation and ideas of the tools can be found in the main text.[17]

A. Data Sources

Data for the vulnerability indicators and the analytical tools are drawn from a range of sources. Historical annual macroeconomic data and projections are based on the *World Economic Outlook*; quarterly non-fuel price commodity price index, long-term bond yield and Treasury bill data are from the IMF *International Financial Statistics;* and quarterly real effective interest rate data from the IMF *Information Notice System*. Data for maturing government debt, the debt structure, and average debt maturity data are from Bloomberg L.P.. Data for five-year sovereign CDS spreads are provided by CMA (Markit), while yields on benchmark bond—used with a constant ten-year maturity—and interest swap rates are taken from Datastream. Projections of increases in health care and pension spending are from the September 2011 *Fiscal Monitor* and the IMF Policy Paper (2010b) "Macro-Fiscal Implications of Health Care Reform in Advanced and Emerging Economies." Elasticities of expenditure and revenues to the output gap are taken from Girouard and André (2005) for OECD member states and European Commission (2005) for non-OECD Member states.

B. Distress Dependence Among Sovereigns

To assess the dynamics of distress dependence among sovereigns the following linkages are estimated, using the sovereign CDS spreads as inputs (see Caceres et al., 2010). The probability of sovereign distress in country A given a default by country B—P(A/B)—is obtained in three steps:

- The marginal probabilities of default for countries A and B, P(A) and P(B) respectively, are extracted from the individual CDS spreads for those countries.

- The joint probability of default of A and B, P(A,B), is obtained using the CIMDO methodology developed by Segoviano (2006). This is a non-parametric methodology, based on the Kullback (1959) cross-entropy approach, which estimates the joint probability of default without imposing a (pre-determined) distributional form while at the same time constraining to characterize the data. That is, the individual probabilities of default obtained from integrating the CIMDO joint probability of default must match the observed probabilities of default (extracted from the CDS spreads).

[17] For a summary guide on key fiscal formulas related to debt dynamics see Escolano (2010).

- Finally, the conditional probability of default P(A/B) is obtained by using Bayes' law:

  P(A/B) = P(A,B) / P(B), and similarly for P(B/A).

A vulnerability index is constructed that takes into account the distress dependence of each economy to all the others in the sample. This allows ranking economies along a single measure of inter-linkages risk; and this ranking enters the overall index of fiscal risk. This distress dependence measure—the "Spillover Coefficient" (SC) —was used and developed in Caceres et al. (2010). For each country Ai, the SC measure is computed using the formula:

$$SC(Ai) = \sum P(Ai/Aj) \cdot P(Aj) \qquad \text{for all } j \neq i$$

which is the weighted sum of the probability of distress of country Ai given each of the other countries in the sample (weighted by the probability of default of each of these countries).

The last step analyzes which economies represent the largest "source of contagion" to the others. That entails calculating the contribution of each country to changes in the spillover coefficient measure for all other countries in the sample. For this purpose, we analyze the developments in the spillover coefficient (SC) variable over time.

C. Medium- and Long-Term Adjustment Needs to Ensure Fiscal Sustainability

For the calculation of the first indicator (I_1), which shows the cyclically-adjusted primary balance needed to be achieved by 2020 and maintained until 2030 so as to reach a given debt ratio by 2030, we indentify two time horizons: T_1 (10 years in this case) during which the primary balance is adjusted gradually by a factor equal to α and T_2 (also 10 years) during which the primary balance is kept constant at the level projected at the end of the T_1 period. The derivation of the adjustment factor α is as follows:

$$\alpha = \frac{-B_T + \lambda^T B_0 - \left(\frac{1-\lambda^T}{1-\lambda}\right)\pi_0 - \sum_{\tau=1}^{T}(\gamma(\tau) - \psi(\tau))\lambda^{T-\tau}}{\sum_{\tau=1}^{T} f(\tau)\lambda^{T-\tau}}$$

where

$$f(t) \equiv \begin{cases} \forall t \leq T_1 & t \\ \forall \tau > T_1 & T_1 \end{cases}$$

$$\forall t \quad \pi_t = \pi_0 + \alpha f(t) + \gamma(t)$$

π_t is the primary balance in period t, $\gamma(.)$ is the cyclical component of the primary balance as projected in the WEO and $\psi(.)$ is the change in age-related expenditures relative to 2016 and $\lambda = 1 + r$, where r is the growth-adjusted interest rate. B_T is the target level of the debt/GDP ratio, B_0 is the GDP ratio of public debt at t_0, the starting date of the adjustment.

To decompose the contributions of different factors to the required primary balance in 2020, we first rewrite the equation above to link the present value of primary surpluses that the country needs to run (left hand side) to finance the debt gap ($-B_T + \lambda^T B_0$) and the combination of the cyclical component of primary balance and age-related costs ($-\sum_{\tau=1}^{T}(\gamma(\tau)-\psi(\tau))\lambda^{T-\tau}$) on the right hand side.

$$\alpha\left(\sum_{\tau=1}^{T} f(\tau)\lambda^{T-\tau}\right)+\left(\frac{1-\lambda^T}{1-\lambda}\right)\pi_0 = -B_T + \lambda^T B_0 - \sum_{\tau=1}^{T}\gamma(\tau)\lambda^{T-\tau}$$

Manipulating this expression, one can write the required primary balance in 2020 ($\pi_0 + T_1\alpha$) in terms of four key components that reflect:

1. The size of debt at the beginning and at the end of the adjustment period (B_0 and B_T) (the first term in the equation below);
2. The size of the age-related costs during 2013-30 (the second term)
3. The level of the cyclically-adjusted primary balance at the beginning of the adjustment period (the third term)
4. The projected path of the cyclical component of the primary balance (the last term)

Thus, the above equation can be rewritten as follows:

$$\pi_0 + \alpha T_1 = \left(\frac{T_1}{\sum_{\tau=1}^{T} f(\tau)\lambda^{T-\tau}}\right)(-B_T + \lambda^T B_0) + \left(\frac{T_1}{\sum_{\tau=1}^{T} f(\tau)\lambda^{T-\tau}}\right)\sum_{\tau=1}^{T}\psi(\tau)\lambda^{T-\tau}$$
$$-\left(\frac{T_1\left(\frac{1-\lambda^T}{1-\lambda}\right)}{\sum_{\tau=1}^{T} f(\tau)\lambda^{T-\tau}}-1\right)\pi_0 - \left(\frac{T_1}{\sum_{\tau=1}^{T} f(\tau)\lambda^{T-\tau}}\right)\sum_{\tau=1}^{T}\gamma(\tau)\lambda^{T-\tau}$$

Note, that the adjustment path and in particular the value of T_1 affects the required primary balance. A higher value suggests a slower adjustment and hence a higher required primary balance in 2020. The initial primary balance also plays a role in determining the required primary balance in 2020 because it affects the adjustment path. The coefficient associated with it is positive, which suggests that a higher initial balance implies a lower required primary balance in 2020. The reason for this is that the initial primary balance only matters due to its effect on the adjustment path.[18] A higher starting balance implies that the primary

[18] Another way to see this is to consider a scenario where the adjustment is immediate, or in other words, the primary balance is kept at the same level during 2013-30. In this scenario, the initial primary balance (primary balance in 2012) does not matter for the required primary balance that needs to be maintained during 2013-30.

balance will be higher during 2013-20, lowering the primary balance that needs to be maintained during 2020-30. The indicator I_1 then is defined as the level of the cyclically-adjusted primary balance between 2010 and 2030 needed to reach the debt target.

To calculate the second indicator (I_2) —which shows the implied primary balance in 2016 that is consistent with stabilizing the debt level in the very long run, in order to satisfy the inter-temporal budget constraint—we use the formula for the sustainability indicator S2, developed by the European Commission:

$$S_{2,t_0} = rD_{t_0-1} - r\sum_{s=t_0}^{\infty}\frac{PB_s}{(1+r)^{s-t_0+1}}$$

where PB_t is the primary balance-to-GDP ratio and has three components: the cyclically adjusted primary balance, increase in aging related costs after 2016 and the cyclical component of the primary balance. The S2 indicator shows the required adjustment that is applied to the baseline primary balance every year in the future to satisfy the inter-temporal budget constraint. By using the available WEO projections, the calculation takes already into account the adjustment governments plan to undertake up to 2016. The S2 indicator can be decomposed into four components:

1. Effect of the level of initial debt (the first term in the equation above);
2. The projected path of the increase in aging related costs;
3. The projected path of cyclically adjusted primary balance using the baseline assumptions as discussed before; and
4. The projected path of the cyclical component of the primary balance.

The indicator I_2 is the implied primary balance in 2016 that is consistent with the S2 indicator and is calculated as the sum of the baseline primary balance in 2016 plus the required adjustment (S2). The reason for using I_2 as opposed to the S2 indicator is the fact that S2 indicator can understate the fiscal risks for countries that already have a significant fiscal adjustment in the baseline since this reduces the degree of further needed adjustment. However, as in the I_1 indicator, a more valid measure of fiscal effort is the level of the required primary balance that needs to be maintained for debt sustainability.

The calculations for indicators I_1 and I_2 require making several assumptions on macroeconomic variables. In the illustrations in Section III, the growth-adjusted interest rate r is assumed to be equal to 0 up to 2015 and 1 percent thereafter, broadly in line with the WEO projections for advanced economies, and in line with the standard illustrative scenario in the *Fiscal Monitor*. The primary balance projections for the current year and the next five years are those of the latest WEO, while thereafter until 2050 the primary balance is calculated by adding the flow of age-related expenditure (in percent of GDP) to the last year

of the WEO projections for the primary balance. From 2050 onwards, the primary balance-to-GDP ratio is assumed to remain constant at the 2050 level.

The results for the I_1 and I_2 indicators are not fully comparable, as they assume different paths of adjustment and reflect debt sustainability pressures based on different time horizons. The calculation of the I_1 indicator includes the adjustment required until 2020 to achieve the cyclically adjusted balance consistent with a particular debt target, whereas the adjustment underlying the I_2 indicator is based on longer-term expenditure pressures and is applied on top of the primary balance path that is assumed in the baseline.

D. Vulnerabilities to Adverse Growth and Interest Rate Shocks

A low growth scenario

Two debt paths are compared for each country. The baseline scenario based on the current WEO projection and a low growth scenario, in which the real GDP growth is by one percentage point lower, in the current year and the next five years, than in the baseline. The shock affects the deficit and debt-to-GDP ratios through higher automatic stabilizers and the change in the GDP base as it is assumed that potential GDP is not impacted by the shock and that governments do not take any corrective discretionary action to smooth its impact.

In the low growth scenario, the public debt-to-GDP ratio d_t is calculated using a standard debt dynamic equation:

$$d_t = d_{t-1}(1+r_t) - pb_t$$

Where pb_t is the primary balance and r_t is the growth adjusted interest rate.[19] In turn the primary balance is calculated as follows:

$$pb_t = pb_t^{WEO} + (\eta_R - \eta_G)\Delta og_t$$

Where pb^{WEO} is the primary balance-to-GDP ratio of the baseline scenario; η_R and η_G are semi-elasticities of revenues and expenditures to changes in the output gap and Δog_t is the change in the output gap between the baseline and the low growth scenario. The interest rate is derived by dividing the amount of interest payments by the stock of debt observed at the end of the preceding year.

[19] The growth adjusted interest rate is defined as $r = \frac{i-\gamma}{1+\gamma}$, where i is the nominal interest rate and γ is the growth rate of nominal GDP.

An interest rate shock scenario

The size of gross financing needs and the structure of new debt issuance determine the effect that changes in interest rates have on the budget balance and the medium-term debt path. The impact of the shock is computed as:

$$\tilde{c}_{i,t} = nf_t \times \tilde{i}_t$$

Where $\tilde{c}_{i,t}$ is the difference in net financing costs relative to the baseline, nf_t is the accumulated amount of debt in percent of GDP that has been financed since the beginning of the shock and $\tilde{i}_t$ is the deviation in interest rate relative to the baseline (i.e. the interest rate shock). As debt is rolled over and new deficits are financed, more and more debt is subjected to the higher interest rate. One can calculate the total impact over time by keeping track of the amount of debt that becomes subject to the higher interest rates, using data on the gross financing needs and the structure of issuance. The gross financing needs is defined as the rollover of existing debt plus the budget deficit. The rollover needs is estimated using the maturity structure of outstanding marketable debt at end-2010 (t-1). It is practical to apply this maturity structure on the outstanding total gross debt at the end of 2010 to calculate rollover needs for the current year (t) and the next five years (t+5). The rollover needs are also affected by the structure of gross issuances during this time as some of the debt that is financed during this period is projected to be rolled-over during t+1 to t+5. The maturity structure of gross issuance is also based on the maturity structure of debt at end-2010.

To estimate the impact on the debt path, the baseline budget balance path is adjusted for the higher interest payment. At the same time it is assumed that remuneration of financial assets held by the general government changes by the same amount as the interest rate for new borrowing. Moreover, an average maturity of financial assets of five years is assumed for all countries as country-specific data are sparse.

E. Stochastic Simulations: Medium-Term Risks to Public Debt Trajectories

The risk-based approach to debt sustainability methodology involves the following steps.

Fiscal reaction function. The first step is estimating a representative "fiscal reaction function" for the advanced economies. Using annual data for a panel of 33 advanced economies and a maximum of 21 years (1990-2010), the fiscal reaction function is estimated as[20]

[20] Estimates are obtained using a fixed effects regression specification. Except for the coefficient on the positive output gap, all coefficients are significant at the 5 percent level of significance using robust standard error estimates. Other than the fixed effects specification, limited information maximum likelihood as well as generalized method of moments with instruments for the output gap is also estimated. Based on various diagnostics, the fixed effects specification is chosen.

$$\widehat{pb}_{i,t} = \widehat{\propto}_i + 0.74pb_{i,t-1} - 0 \times ygap_{i,t}D_{it} + 0.58ygap_{i,t}(1 - D_{it}) + 0.04d_{i,t-1}$$

where pb_{it} is the ratio of the primary fiscal balance to GDP in country i and year t; $d_{i,t-1}$ is the gross general government debt to GDP ratio at the end of the previous year; $ygap_{i,t}$ is the current WEO estimated output gap; D_{it} are dummy variables that take the value 1 when the output gap is positive and zero otherwise; and $\widehat{\propto}_i$ are the country fixed effects.

The estimates for the primary balance-to-GDP ratio as the dependent variable suggests that while current fiscal policies were persistent (coefficient of lagged primary balance is 0.74), they were also sensitive to economic conditions (countercyclical with 0.58 percent of GDP increase in primary deficit for each 1 percentage point of output gap widening during recessions) but asymmetrical (there is no budget tightening during booms) and, more importantly, the policymakers attempted to take corrective fiscal actions to rising debt (0.04 percent of GDP), on average in advanced economies

Calibration exercise. In a second step, an unrestricted quarterly VAR model for the period 1990-2010 is estimated using real output growth, the natural logarithm of the real effective exchange rate, real long-term domestic bond yields and real long-term foreign bond yields.[21] Shocks to the key macroeconomic variable are random draws from the joint normal distribution with zero-mean and the variance-covariance matrix of the unrestricted VAR estimates.

Probability distribution calculation. Using (i) the coefficients of the estimated fiscal reaction function (common to all countries in the panel); (ii) the fiscal policy shock that is distributed normally with mean zero and country specific variance of the fiscal reaction function's residuals; (iii) the most recent WEO projections of debt, the primary balance, output gap and nominal output for each advanced economy; (iv) the estimated variance-covariance matrix of residuals for each country from the VAR, we construct explicit probability distributions for the evolution of the debt stock over t to t+5. While constructing the probability distributions, country-specific fixed effects are adjusted in order to anchor the primary balance projections to that of WEO projections for the period t to t+5. This adjustment might not be sufficient, however, to reconcile the median debt ratio projected by the model and the WEO forecasts over the medium term (see below).

Adjustments to projected growth-adjusted effective interest rates. The baseline model simulations discussed above use the steady-state interest rates and growth estimated by the VAR, while the medium-term interest and growth rate projections are likely to be different than the past in the aftermath of the financial crisis. The differences in historical and projected growth-adjusted effective interest rates are quite striking for several advanced

[21] The U.S. real long-term bond yield is used to proxy foreign rates for all countries excluding the U.S. and European Union economies (with the exception of Germany). For the latter economies German real rate is used.

economy, averaging -81 basis points and ranging up to 337 basis points. In many advanced economies, excluding those subject to fiscal distress, growth-adjusted effective interest rates are projected to fall in the medium term compared to historical averages. Given the uncertainty surrounding these projections, we adjust the growth-adjusted effective interest rates projection to bring them more in line with historical averages. Rather than making country-specific adjustments, we limit ourselves to three sizes of adjustment: (i) 130 basis points reduction (applies to 21 economies), (ii) 200 basis points increases (three economies), and (iii) 300 basis points increase (two economies).

Table A.1 compares the model-based median projections with that of the WEO baseline projections. For both of the most recent WEO vintages, the model based median debt ratios in 2016 are similar to the medium-term WEO debt projections. Exceptions are countries supported by EU/IMF programs, such as Greece and Ireland, for which debt projections may include financing operations that cannot be accounted for in the model-based approach.

Table A.1. Selected Advanced Economies' Model Based Debt Projection and WEO Baseline Projection in 2016

	Sept. 2011 WEO		Apr. 2011 WEO	
	Model 1/	WEO	Model 1/	WEO
Australia	24.8	20.2	24.1	20.6
Austria	72.1	72.9	69.5	69.8
Belgium	95.9	93.0	99.4	98.8
Czech Republic	45.9	46.3	47.9	47.6
Denmark	55.8	49.1	47.6	40.2
Finland	51.7	52.3	59.4	61.1
France	86.2	87.7	87.3	86.7
Germany	80.1	76.6	78.3	71.9
Greece	225.8	166.3	209.9	145.5
Ireland	131.7	114.3	141.2	121.5
Italy	103.4	112.9	118.0	118.0
Japan	261.3	253.3	264.9	250.5
Korea	14.1	22.2	10.6	19.8
Netherlands	63.7	64.4	64.9	64.4
Portugal	100.0	110.5	87.4	106.5
Spain	77.0	77.4	74.1	75.9
Sweden	35.0	19.3	39.6	22.8
Switzerland	45.9	46.3	47.2	45.7
United Kingdom	85.3	80.0	88.1	81.3
United States	106.0	115.4	108.8	111.9

Sources: WEO and IMF staff calculations.

1/ Model-based values refer to the median value of 1000 replications.

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