CHAPTER 3

SAFE ASSETS: FINANCIAL SYSTEM CORNERSTONE?

Summary

The financial crisis and the heightened concerns about sovereign debt sustainability in many advanced economies have reinforced the notion that no asset can be viewed as truly safe. Recent rating downgrades of sovereigns previously considered to be virtually riskless have reaffirmed that even highly rated assets are subject to risks. The notion of absolute safety—implicit in credit rating agencies' highest ratings and embedded in prudential regulations and institutional investor mandates—can create a false sense of security, and it did prior to the crisis.

In this context, the chapter examines the various roles of safe assets; the effects of different regulatory, policy, and market distortions; and potential future pressure points that these distortions may create. Safe assets have varied functions in global financial markets, including as a reliable store of value, collateral in repurchase and derivatives markets, key instruments in fulfilling prudential requirements, and pricing benchmarks. In the absence of market distortions, safety is priced efficiently, reflecting sustainable demand-supply dynamics. However, heightened uncertainty, regulatory reforms, and crisis-related responses by central banks are driving up demand. On the supply side, the number of sovereigns whose debt is considered safe has fallen, which could remove some $9 trillion from the supply of safe assets by 2016, or roughly 16 percent of the projected total. Private sector production of safe assets has also declined as poor securitization in the United States has tainted these securities, while some new regulations may impair the ease with which the private sector can produce safe assets.

Demand and supply imbalances in global markets for safe assets are not new. Prior to the crisis, global current account imbalances encouraged safe asset purchases by official reserve managers and some sovereign wealth funds. Now, attention has focused on safe assets' capacity to meet new prudential requirements, increased collateral needs for over-the-counter (OTC) derivatives transactions or their transfer to centralized counterparties, and the increasing use of such assets in central bank operations. The shrinking set of assets perceived as safe, now limited to mostly high-quality sovereign debt, coupled with growing demand, can have negative implications for global financial stability. It will increase the price of safety and compel investors to move down the safety scale as they scramble to obtain scarce assets. Safe asset scarcity could lead to more short-term volatility jumps, herding behavior, and runs on sovereign debt.

To mitigate the risk to financial stability from a potentially bumpy, uneven path to a new price for safety, policy responses should allow for flexibility and be implemented gradually enough to avert sudden changes in what are defined as safe and less-safe assets. In general, policymakers need to strike a balance between the desire to ensure the soundness of financial institutions and the costs associated with a potentially too-rapid acquisition of safe assets to meet this goal. Specifically, careful design of some prudential rules could help increase the differentiation in the safety characteristics of eligible safe assets and would thus decrease the likelihood of cliff effects or runs on individual types of assets. On the supply side, desirable policies include improving fiscal fundamentals in countries subject to concerns about their debt sustainability, encouraging the private production of safe assets—such as well-conceived and regulated covered bond structures and placing securitization on a sounder footing—and building up the capacity of emerging economies to issue their own safe assets. These efforts can help to remove some of the impediments that may inhibit safe asset markets from moving to a new price for "safety."

In the future, there will be rising demand for safe assets, but fewer of them will be available, increasing the price for safety in global markets. In principle, investors evaluate all assets based on their intrinsic characteristics. In the absence of market distortions, asset prices tend to reflect their underlying features, including safety. However, factors external to asset markets—including the required use of specific assets in prudential regulations, collateral practices, and central bank operations—may preclude markets from pricing assets efficiently, distorting the price of safety. Before the onset of the global financial crisis, regulations, macroeconomic policies, and market practices had encouraged the underpricing of safety. Some safety features are more accurately reflected now, but upcoming regulatory and market reforms and central bank crisis management strategies, combined with continued uncertainty and a shrinking supply of assets considered safe, will increase the price of safety beyond what would be the case without such distortions.

The magnitude of the rise in the price of safety is highly uncertain given the broad-based roles of safe assets in global markets and regulations. Safe assets are used as a reliable store of value and aid capital preservation in portfolio construction. They are a key source of liquid, stable collateral in private and central bank repurchase (repo) agreements and in derivatives markets, acting as the "lubricant" or substitute of trust in financial transactions. As key components of prudential regulations, safe assets provide banks with a mechanism for enhancing their capital and liquidity buffers. As benchmarks, safe assets support the pricing of other riskier assets. Finally, safe assets have been a critical component of monetary policy operations. These widely varying roles of safe assets and the differential price effects across markets make it difficult to gauge the overall price of safety.

Assessing future supply-demand imbalances in safe asset markets is also made more complicated by the difference in emphasis that various groups of market participants place on specific safety attributes. From the perspective of conservative investors, for example, safe assets act as a store of value or type of insurance during financial distress. For official reserve managers and stabilization-oriented sovereign wealth funds, the ability to meet short-term contingent liabilities justifies a focus on the low market risk and high liquidity aspects of safety. From the perspective of longer-term investors—such as pension funds and insurance companies—safe assets are those that hold their value over longer horizons. Banks, collectively the largest holder of safe assets, demand safe assets for asset-liability management, for collateral, and for fulfilling their primary dealer and market-making responsibilities.

However, it is clear that market distortions pose increasing challenges to the ability of safe assets to fulfill all their various roles in financial markets. Even before the crisis, the rapid accumulation of foreign reserves and financial market underdevelopment in many emerging economies accounted for supply-demand imbalances in safe asset markets.[1] For banks, the common application of zero percent regulatory risk weights on debt issued by their own sovereigns, irrespective of risks, created perceptions of safety detached from underlying economic risks and contributed to the buildup of demand for such securities.[2] During the crisis, supply-demand imbalances and safe asset market distortions became even more obvious. Large-scale valuation losses on assets perceived as safe, first on AAA-rated tranches of mortgage-backed securities during the crisis, and more recently on some Organization for Economic Cooperation and Development (OECD) government debt, reduced the supply of relatively safe assets. Meanwhile, heightened uncertainty, regulatory reforms—such as new prudential and collateral requirements—and the extraordinary postcrisis responses of central banks in the advanced economies, have been driving up demand for certain categories of safe assets. Hence, safe asset demand is expanding at the same time that the universe of what is considered safe is shrinking.

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[1]See Caballero (2010); and Caballero and Krishnamurthy (2009).

[2]For euro area banks, zero percent risk weights can be applied to the debt issued by any euro area sovereign.

The tightening market for safe assets can have considerable implications for global financial stability, including an uneven or disruptive pricing process for safety. As investors scramble to attain scarce safe assets, they may be compelled to move down the safety scale, prompting the average investor to settle for assets that embed higher risks. In an extended period of low interest rates and heightened financial market uncertainty, changes in investors' risk assessment of the safety features of assets could lead to more frequent short-term spikes in volatility and the potential for a buildup of asset bubbles. Although regulatory reforms to make institutions safer are clearly needed, insufficient differentiation across eligible assets to satisfy some regulatory requirements could precipitate unintended cliff effects—sudden drops in the prices—when some safe assets become unsafe and no longer satisfy various regulatory criteria. Moreover, the burden of mispriced safety across types of investors may be uneven. For instance, prudential requirements could lead to stronger pressures in the markets for shorter-maturity safe assets, with greater impact on investors with higher potential allocations at shorter maturities, such as banks.

This chapter examines potential pressure points and distortions in the markets for safe assets and identifies how best to address them.[3] The shortage of safe assets has raised widespread concern in recent months, but no comprehensive, integrated view of the global demand and supply pressures has emerged as of yet. This chapter provides such a view. It first outlines the changes in investor perceptions as a result of the crisis and then identifies key demand and supply pressures. The chapter then outlines the resulting financial stability risks and concludes with potential policy implications.

The Safe Asset Universe

Characteristics of Safe Assets

It is important to recognize that there is no risk-free asset offering absolute safety. In theory, safe assets provide identical real payoffs in each state of the world.[4] True absolutely safe assets are a desirable part of a portfolio from an investor's perspective, as they provide full protection from credit, market, inflation, currency, and idiosyncratic risks; and they are highly liquid, permitting investors to liquidate positions easily.

However, in practice, all assets are subject to risks which, in an ideal world, should be reflected accurately in asset prices. The notion of absolute safety—implicit, for example, in credit rating agencies' highest ratings and embedded in prudential regulations and institutional investor mandates—can lead to an erroneously high level of perceived safety.[5] In turn, such inaccurate perceptions can expose regulated financial institutions and markets to higher credit and concentration risks. The onset of the global financial crisis revealed considerable underpricing of safety linked to over-reliance on credit ratings, adverse incentives from prudential regulations and private sector practices. The fact that even highly rated assets are not without risks was reaffirmed during the global financial crisis by losses on AAA-rated tranches of mortgage-backed securities and, more recently, by rating downgrades of sovereigns previously considered virtually riskless.

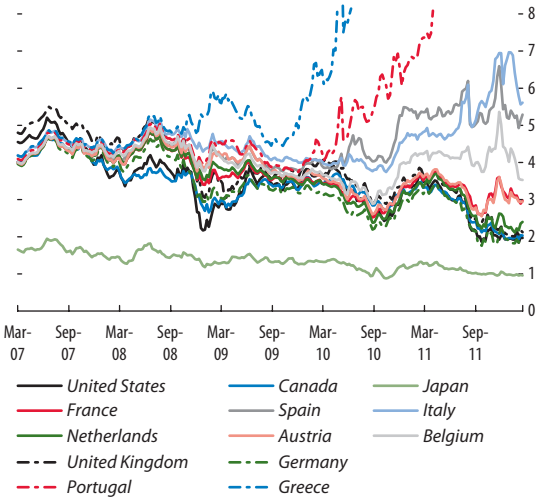
The global financial crisis appropriately prompted greater differentiation in the pricing of asset safety, with safety increasingly viewed in relative terms. Relative safety explains the considerable substitution away from other riskier asset classes into the debt of economies with perceived stronger fundamentals in recent months, including U.S. Treasuries (despite Standard & Poor's 2011 downgrade), German bunds, and Japanese government bonds. Investors' flight to relative safety has accounted for an increasing differentiation in the sovereign debt universe. Yields on some government bonds that ceased to be

[3]This chapter focuses on structural issues related to safe asset markets. Some short-term issues are discussed in Chapter 2.

[4]Theoretically, safe assets can be viewed as equivalent to a portfolio of Arrow-Debreu securities. An Arrow- Debreu security has an identical payoff in a particular state of the world across time, and a zero payoff in all other states. If an investor constructs a portfolio that includes an Arrow-Debreu security for each state of the world (assuming that financial markets are complete and investors are able to do so), he or she would effectively hold a safe asset.

[5]See IMF (2010b) for a more extensive discussion of ratings and their role in the crisis. The chapter recommends decoupling credit ratings from regulatory rules to avoid the buildup of inaccurate perceptions identified above.

Figure 3.1. Ten-Year Government Bond Yields in Selected Advanced Economies
(In percent)



Source: Bloomberg L.P.
Note: Yields greater than 8 percent are deliberately excluded to clarify developments in the low-yield range.

perceived as safe have spiked in the aftermath of the crisis, while yields on bonds viewed as safe havens irrespective of credit rating (such as those of the United States, Japan, and Germany, for example) have declined to historical lows (Figure 3.1).

A historical overview of sovereign debt ratings suggests that shifts in relative safety have precedents. Despite the limitations in the information content of sovereign debt ratings, the long time span of S&P ratings provides useful insights about the evolution of asset safety (Table 3.1):

- The current degree of differentiation across sovereigns in the OECD is more pronounced than in previous periods, with historically low ratings in southern Europe, Iceland, and Ireland, and downgrades in countries that had maintained AAA ratings since S&P reinstated sovereign ratings in the mid-1970s—Austria, France, and the United States.
- Sovereign ratings in Greece, Iceland, Ireland, Italy, Portugal, and Spain followed a sharp downward correction after an increase in the 1990s.
- OECD government debt was predominantly rated AAA during the 1990s.
- The share of unrated OECD sovereigns was high until the mid-1980s, in part reflecting low defaults and high perceptions of safety in the 1960s and the 1970s.[6]

The first three points suggest that during some periods, such as periods of calm, ratings did not sufficiently capture the credit quality of assets with varied underlying fundamentals.

In practice, relative asset safety can be seen by considering a continuum of asset characteristics. Safe assets meet the criteria of: (1) low credit and market risks, (2) high market liquidity, (3) limited inflation risks, (4) low exchange rate risks, and (5) limited idiosyncratic risks. The first criterion, low credit and market risks, is pivotal to asset safety, as a lower level of these risks tends to be linked with higher liquidity. However, high market liquidity depends on a wider array of factors, including ease and certainty of valuation, low correlation with risky assets, an active and sizable market, and low market correlation, among others.[7] Importantly, different investors place a different emphasis on each of these criteria. For example, investors with long-term liabilities—such as pension funds and insurance companies—place limited emphasis on market liquidity and thus consider less liquid, longer maturity assets as safe. If their potential payoffs are linked to inflation and no inflation indexed securities are available, pension funds emphasize the real capital preservation aspect of safe assets. Global reserve managers consider all of these aspects, in view of the high share of credit instruments denominated in foreign currencies and their need to maintain ready liquidity. Finally, demand for some noncredit instruments, such as gold, is largely driven by perceptions of its store of value, with less regard to its market risk.

Changes in Safe Asset Perceptions

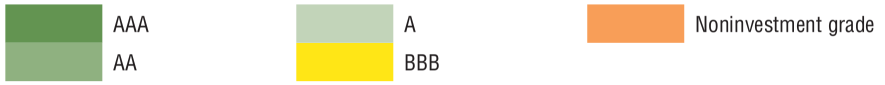
The global financial crisis was preceded by considerable overrating, and hence mispricing, of safety. In retrospect, high credit ratings were applied too often, both for private and sovereign issuers, and they did not sufficiently differentiate across assets with different underlying qualities.

[6]See also Gaillard (2011).

[7]For a more detailed discussion of the safety criteria for assets underlying liquidity risk management, see BCBS (2010a), pp. 5–6.

Table 3.1. Historical Overview of S&P Sovereign Debt Ratings of Selected OECD Countries, 1970–January 2012

Country	Year of First Rating	1970	1975	1980	1985	1990	1995	2000	2005	2010	2011	2012 (End-January)
Austria	1975	NR	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AA+
Belgium	1988	NR	NR	NR	NR	AA+	AA+	AA+	AA+	AA+	AA	AA
Canada	1949	AAA	AAA	AAA	AAA	AAA	AA+	AA+	AAA	AAA	AAA	AAA
Denmark	1981	NR	NR	NR	AA+	AA	AA+	AA+	AAA	AAA	AAA	AAA
Finland	1972	NR	AAA	AAA	AAA	AAA	AA-	AA+	AAA	AAA	AAA	AAA
France	1975	NR	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AA+
Germany	1983	NR	NR	NR	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA
Greece	1988	NR	NR	NR	NR	BBB-	BBB-	A-	A	BB+	CC	CC
Iceland	1989	NR	NR	NR	NR	A	A	A+	AA-	BBB-	BBB-	BBB-
Ireland	1988	NR	NR	NR	NR	AA-	AA	AA+	AAA	A	BBB+	BBB+
Italy	1988	NR	NR	NR	NR	AA+	AA	AA	AA-	A+	A	BBB+
Japan	1959	NR[1]	AAA	AAA	AAA	AAA	AAA	AAA	AA-	AA	AA-	AA-
Luxembourg	1994	NR	NR	NR	NR	NR	AAA	AAA	AAA	AAA	AAA	AAA
Netherlands	1988	NR	NR	NR	NR	AAA	AAA	AAA	AAA	AAA	AAA	AAA
Norway	1958	NR[1]	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA
Portugal	1988	NR	NR	NR	NR	A	AA-	AA	AA-	A-	BBB-	BB
Spain	1988	NR	NR	NR	NR	AA	AA	AA+	AAA	AA	AA-	A
Sweden	1977	NR	NR	AAA	AAA	AAA	AA+	AA+	AAA	AAA	AAA	AAA
Switzerland	1988	NR	NR	NR	NR	AAA	AAA	AAA	AAA	AAA	AAA	AAA
Turkey	1992	NR	NR	NR	NR	NR	B+	B+	BB-	BB	BB	BB
United Kingdom	1978	NR	NR	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA
United States	1941	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AA+	AA+



Sources: Standard & Poor's; and IMF staff estimates.

Note: The Organization for Economic Cooperation and Development (OECD) was established in 1961. Countries selected constituted the OECD membership in 1970. Ratings shown are S&P's long-term foreign currency ratings. NR = not rated.

[1]Sovereign rating suspended; see Bhatia (2002).

Table 3.2. Long-Term Senior Sovereign Debt Ratings and Implied Probabilities of Default

Interpretation of Rating	S&P Rating	Average Implied Five-Year Probability of Default *(in percent)* 2007	2011
Highest quality	AAA	0.108	1.266
High quality	AA+ AA AA-	0.110	2.423
Strong payment capacity	A+ A A-	0.213	2.684
Adequate payment capacity	BBB+ BBB BBB-	0.734	6.050
Likely to fulfill obligations, ongoing uncertainty	BB+ BB BB-	2.795	4.240
High-risk obligations	B+ B B-	4.041	18.410

Sources: Standard & Poor's; and IMF staff estimates.

Note: For each country, the implied probabilities of default are estimated from its observed CDS spreads. The probabilities of default shown here are averages for countries whose ratings fall within specific S&P rating ranges.

- AAA-rated securitizations were found to embed much higher default risks than warranted by their high ratings. For example, as of August 2009, 63 percent of AAA-rated straight private-label residential mortgage-backed securities issued from 2005 to 2007 had been downgraded, and 52 percent were downgraded to BB or lower.[8]
- Five-year probabilities of default associated with AAA-rated sovereign debt were about 0.1 percent in 2007, suggesting virtually no credit risk, but markets' implied default rates had risen to more than 1 percent by 2011 (Table 3.2). The large difference between the implied default probabilities within each rating bucket across the two periods suggests that the default probabilities do not increase consistently with the decline in ratings, reaffirming ratings should not be relied upon as the sole quantitative measure of safety.[9]
- Haircuts on the highest rated securitized instruments in the U.S. private bilateral repo market increased sharply from near-zero precrisis levels to more than 30 percent for certain instruments (see Gorton, 2009).
- In the euro area, the years following the creation of the monetary union were characterized by almost perfect convergence of government bond yields. As evidenced by greater risk differentiation since 2010, this development was arguably not justified on the basis of fiscal fundamentals of different euro area member states.

Empirical analyses confirm the mispricing of risk prior to the crisis. Returns show a high degree of homogeneity across assets of different quality within each asset class (Figure 3.2). Asset classes were grouped closely into asset pools with limited differentiation in terms of safety. These pools included: (1) U.S. debt (sovereign, agency, and corporate); (2) Japanese debt (sovereign and corporate); (3) European debt (sovereign and corporate), including EU covered bonds and highly collateralized bonds issued by German banks (Pfandbriefe); (4) emerging market sovereign debt; and (5) a more dispersed set including equity market indices, commodities, and currencies. The very tight clustering of euro area sovereign debt shown in Figure 3.2 confirms that, indeed, prior to the crisis, there was little price differentiation across assets of varied quality.[10] Moreover, sovereign debt instruments of advanced economies were found to have highly homogeneous exposures to aggregate risk factors.[11] This suggests that market prices did not embed information sufficient to differentiate the underlying risks of countries with weaker fundamentals.[12]

After the crisis, the differentiation in the perceived safety of various asset classes increased

[8]See IMF (2009a) for a detailed discussion of securitization and credit ratings flaws.

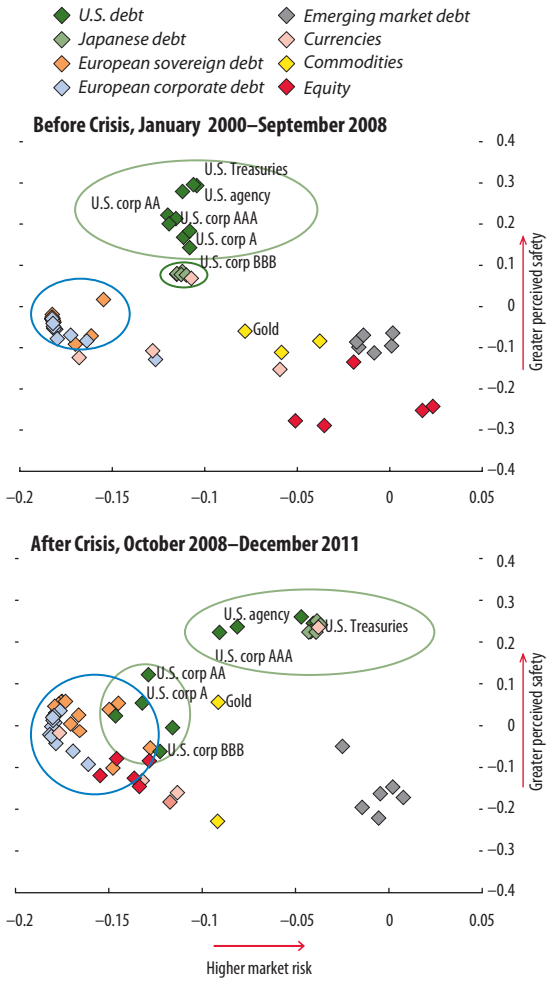
[9]The implied volatility of default falls from 6.050 to 4.240 between the BBB and BB rating groups and rises again for the B groupings, showing the large volatility across ratings.

[10]See Annex 3.1 for details.

[11]These factors include (1) the excess return on the global market portfolio as a measure of perceived market risk of an asset or a portfolio, (2) the VIX as a measure of market uncertainty, (3) the term spread as a measure of rollover or reinvestment risk, (4) a measure of market liquidity based on bid-ask spreads, (5) credit spreads between AAA and BBB corporate bonds, (6) innovations to the London interbank offered rate (LIBOR), and (7) a measure of future global inflation risk.

[12]The only noticeable difference was in exposures to the market factors, with U.S. debt appearing markedly safer than European debt.

Figure 3.2. Asset Exposures to Common Risk Factors before and after Global Crisis



Sources: Bloomberg L.P.; and IMF staff estimates.

Note: Based on principal component analysis of the assets' excess returns. Figure plots the factor loading, showing the influence of the excess return of a single asset on the common risk factors. The first principal component is positively correlated with global liquidity (measured by the M2 money supply of the G4 economies) and with market risk, which is proxied by the excess return on a global market portfolio. The second component is positively correlated with safety, which, as expected, shows a negative correlation with the VIX and thus has limited sensitivity to volatile market conditions. Axis arrows show direction of higher market risk and greater perceived safety.

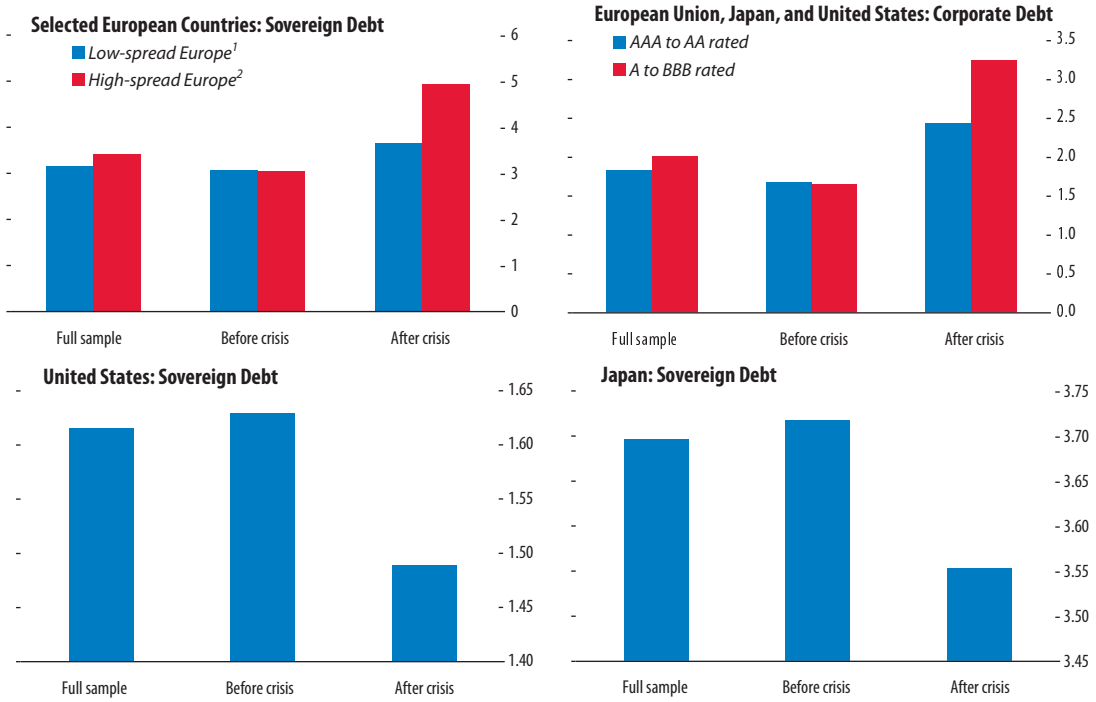
markedly.[13] The analysis suggests that investors have become more discerning in their assessment of safety. The results show increasing signs of greater differentiation in the perception of safety across European assets and a clear decoupling of highly rated U.S. debt—including sovereign, agency, and AAA-rated corporate securities—from lower-rated corporate instruments (Figure 3.2). AAA-rated U.S. corporate debt has become clustered with U.S. sovereign debt, and lower-rated U.S. debt with European entities. Altogether, sovereign debt and highly rated corporate debt in Japan and the United States have become more tightly clustered in a pattern suggesting that investors perceive assets in both countries as safer than those in Europe. Heightened uncertainty also bolstered the perceived safety of gold. Markets also appear to have put higher trust in the safety of the Japanese yen, whose differentiation from other currencies has increased markedly. Overall, perceptions of the relative safety of various currencies have remained tightly linked to the perceived safety of their respective countries' or regions' debt instruments, perhaps suggesting exposures to common risk factors. Detailed analysis (not shown) of the risk factors that affect safe asset returns indicates that the crisis has exacerbated differences in exposures to such factors across asset classes. For example, differences in inflation risk exposures across the portfolios became significant only after the crisis.

The evolution of the volatility of debt returns also confirms that the differentiation between safer and riskier debt instruments increased considerably as a result of the crisis. For example, before the crisis, this volatility—at roughly 3 percent—was almost identical across Europe. However, afterward, the volatility in peripheral euro area countries outstripped that in the rest of Europe by more than 1 percent a month, a nontrivial difference (Figure 3.3).[14] Importantly, U.S. and Japanese debt became less volatile after the crisis, suggesting an investor perception of increased safety.

[13]These patterns are confirmed by the statistical techniques of principal component analysis and hierarchical clustering.

[14]Excess returns represent the difference between the monthly returns on a given portfolio and the return on the one-month U.S. Treasury bill. Volatility is calculated as the standard deviation of monthly excess returns in the sample.

Figure 3.3. Volatility of Excess Returns in Debt Instruments before and after Crisis
(In percent)



Sources: Bloomberg L.P.; and IMF staff estimates.
Note: "Before crisis" refers to the period until December 2007; "after crisis" from January 2008 to October 2011. For Europe, threshold between the low- and high-spread countries is at 350 basis points.
[1]Austria, Denmark, Finland, France, Germany, Luxembourg, Netherlands, Norway, and United Kingdom.
[2]Portugal, Ireland, Italy, and Spain. Greece and Slovenia are excluded due to the lack of data.

Roles of Safe Assets for Various Participants

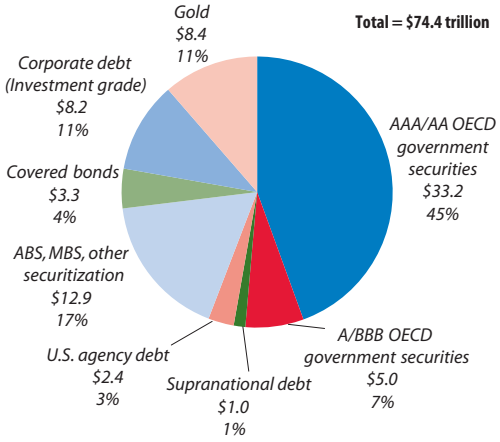
The Universe of Potentially Safe Assets

While many assets have some attributes of safety, the global universe of what most investors view as potentially safe assets is dominated by sovereign debt. As of end-2011, AAA-rated and AA-rated OECD government securities accounted for $33 trillion or 45 percent of the total supply of potentially safe assets (Figure 3.4). Although asset safety should not be viewed as being directly linked to credit ratings, they are used here as a rough indication of market perception. Securitized instruments—including mortgage-backed and other asset-backed securities and covered bonds—still play an important role as potentially safe assets, accounting for 17 percent of the global aggregate, followed by corporate debt (11 percent), and gold (11 percent). The markets for supranational debt and covered bonds are limited, collectively accounting for roughly 6 percent.

Overview of the Uses of Safe Assets

Safe assets have several broad-based roles in international financial markets. Their characteristics—including their steady income streams and ability to preserve portfolio values—are key considerations in investors' portfolio decisions. Safe assets serve as high-quality collateral critical to many transactions, including those in private repo, central bank repo, and OTC derivatives. They are integral to prudential regulations, influencing, at least in part, the amount of safe assets on banks' balance sheets. Safe assets are widely embedded in portfolio mandates and often act as performance benchmarks. Yields on government bonds are reference rates for the pricing, hedging, and valuation of risky assets. Finally, safe assets—at least in the case of advanced economies—have been a part of central banks' liquidity operations in response to the crisis.

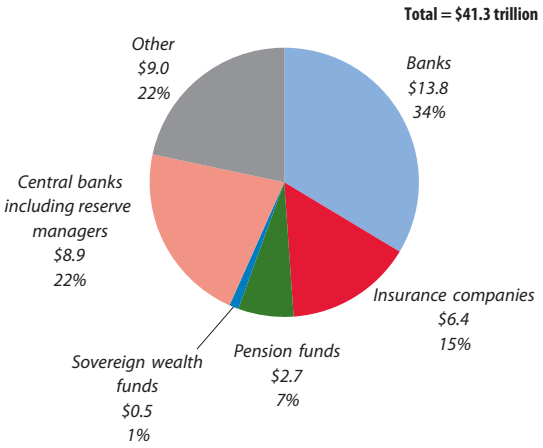
Figure 3.4. Outstanding Amounts of Marketable Potentially Safe Assets
(In trillions of U.S. dollars and percent of total)



Sources: Bank for International Settlements; Dealogic; the European Covered Bond Council (ECBC); SIFMA (the Securities Industry and Financial Markets Association); Standard & Poor's, World Gold Council; and IMF staff estimates.

Note: Data for government and corporate debt are as of 2011:Q2; supranational debt, covered bonds, and gold, as of end-2010; and U.S. agency debt and securitization, as of 2011:Q3. ABS = asset-backed securities; MBS = mortgage-backed securities; OECD = Organization for Economic Cooperation and Development.

Figure 3.5. Holdings of Government Securities Worldwide, by Investor Type, End-2010
(In trillions of U.S. dollars and percent of outstanding sovereign debt)



Sources: Bank for International Settlements (BIS); Bankscope; Organization for Economic Cooperation and Development; and IMF staff estimates.

Note: Banks include commercial, investment, and development banks; data for pension funds include only direct holdings; SWF holdings are an IMF staff estimate; reserve manager holdings are an IMF staff estimate based on a representative allocation of total official reserves to government securities and own government bond holdings by the Federal Reserve, Bank of England, and Bank of Japan. "Other" is estimated as a remainder based on BIS data on total outstanding government securities worldwide.

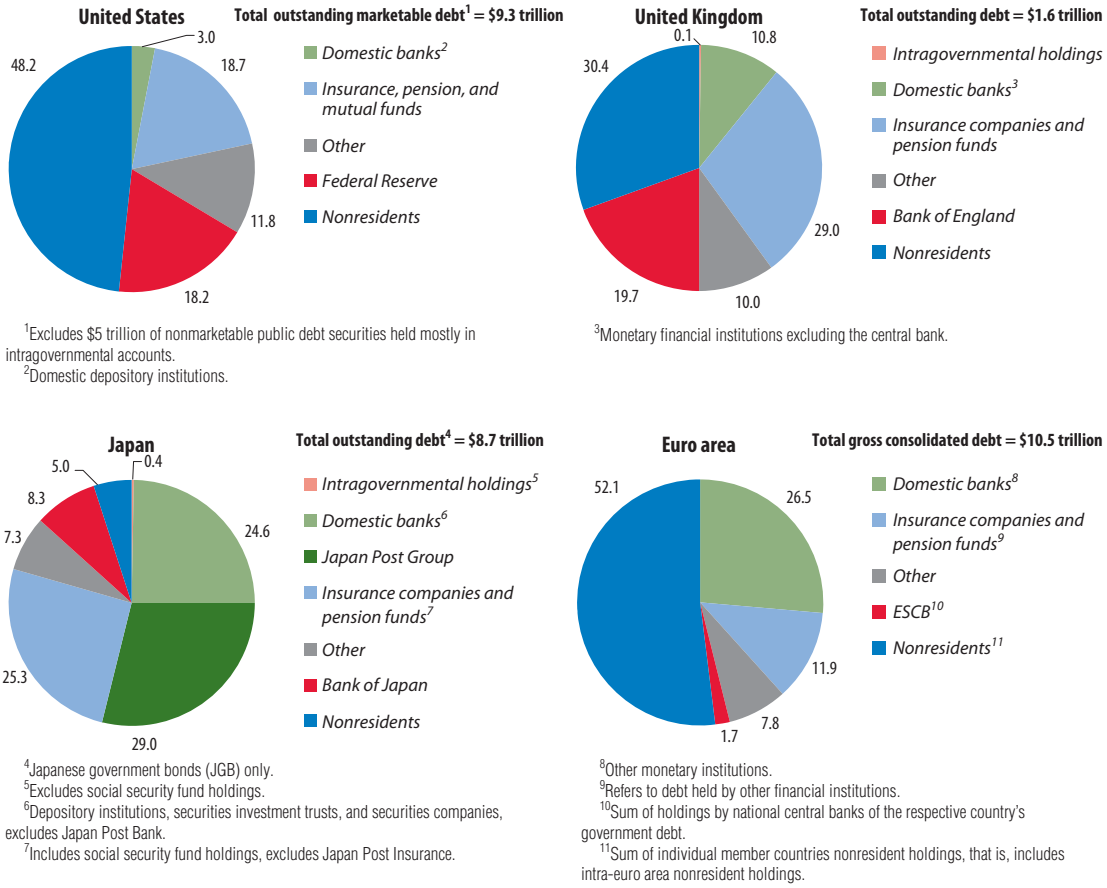
Each of these safe asset functions has a different degree of relevance for various types of investors.[15] For example, banks—which collectively account for the largest share of safe asset holdings—demand safe assets for several purposes (Figure 3.5): (1) managing their inherent maturity mismatches, (2) fulfilling their primary dealer and market-making functions, (3) obtaining preferential regulatory treatment through their sovereign debt holdings, and (4) using collateral for repo and derivatives transactions. Safe assets are critical to the conservative, value preservation policies of global reserve managers, and their need for ready liquidity. Value preservation is also a high priority for some types of sovereign wealth funds—particularly stabilization funds—whose fiscal stabilization role is similar to that of reserve managers. The demand for safe assets by insurance companies and pension funds—long-term safe asset investors—is largely driven by their need to bridge intrinsic asset-liability mismatches and preserve market value to meet long-term liabilities. Safe assets for nonfinancial corporations and individual investors largely take the form of sovereign debt, although the size of such holdings is limited.[16]

The extent of investor demand varies considerably across countries and has also changed as a result of the global financial crisis. In the United States, foreign investors have dominated the market for

[15]The classification and collection of data on holdings of government securities by investor type are yet to be standardized. At present, there is no comprehensive centralized database on government securities holdings. The issue is addressed by an ongoing initiative of the IMF, Bank for International Settlements, European Central Bank, and others to close existing data gaps.

[16]This chapter does not discuss in detail the demand for safe assets by individual investors and nonfinancial corporations. Their holdings of government securities are limited and typically unleveraged, unlike those of other investors, and are unlikely to pose considerable risks to global financial stability. Even in the United States, where they play a more prominent role relative to most other countries, households and nonfinancial corporations hold less than 11 percent of domestic government debt. In the euro area, their holdings, on average, account for less than 8 percent of total government debt (Lojsch, Rodríguez Vives, and Slavík, 2011). Customer bank deposits are considerably more sizable, amounting to roughly $40 trillion globally at end-2010. Their relevance for global financial stability, however, is related to tail-risk events—such as potential bank runs—that are beyond the scope of this chapter. In many countries, such deposits are covered by deposit insurance schemes that—within the covered maximum—provide a degree of safety to individual and corporate investors.

Figure 3.6. Sovereign Debt Holdings, by Type and Location of Investor
(In percent of total, June 2011 or latest available)



[1]Excludes $5 trillion of nonmarketable public debt securities held mostly in intragovernmental accounts.
[2]Domestic depository institutions.
[3]Monetary financial institutions excluding the central bank.
[4]Japanese government bonds (JGB) only.
[5]Excludes social security fund holdings.
[6]Depository institutions, securities investment trusts, and securities companies, excludes Japan Post Bank.
[7]Includes social security fund holdings, excludes Japan Post Insurance.
[8]Other monetary institutions.
[9]Refers to debt held by other financial institutions.
[10]Sum of holdings by national central banks of the respective country's government debt.
[11]Sum of individual member countries nonresident holdings, that is, includes intra-euro area nonresident holdings.

Source: IMF staff estimates based on Andritzky (forthcoming).
Note: The classification and collection of holdings data of government securities by investor type are yet to be standardized.

U.S. Treasuries in view of its large size and depth and its high perceived degree of safety. However, postcrisis monetary stabilization efforts increased the prominence of the Federal Reserve as a holder of government debt. In Europe and Japan, domestic banks have played an important role as sovereign debt investors, in each case accounting for about 25 percent of outstanding sovereign debt (Figure 3.6). In the United Kingdom, insurance companies and pension funds have been traditional holders of government securities, although the Bank of England and foreign investors assumed a more prominent role after the global financial crisis.

To assess emerging demand pressures in safe asset markets, the following subsections review the principal uses of safe assets by the largest market participants. The discussion in subsequent sections then turns to the ability of safe asset supply to keep up with potential demand, and the implications for financial stability of a further rise in safe asset supply-demand imbalances.

Use in Portfolio Construction

Probably the most basic use of safe assets is as a source of steady income and capital preservation in portfolio construction. The importance of this function varies considerably across investor types, based on their investment strategies and horizons.

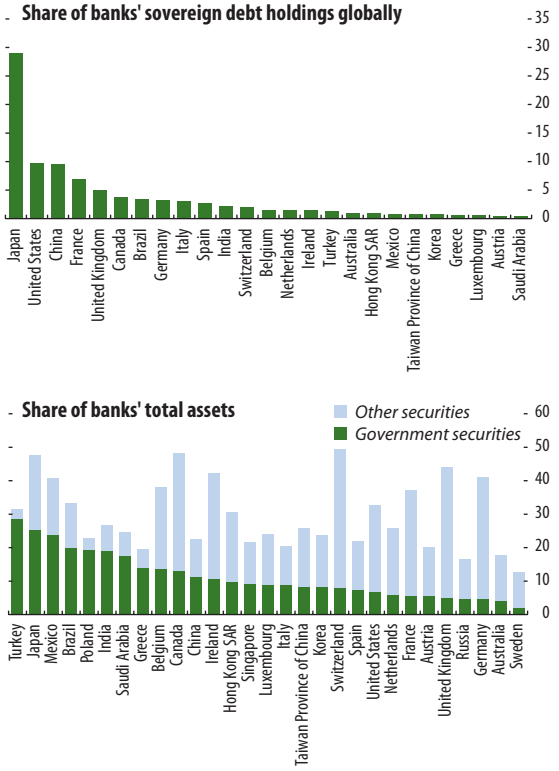
Banks

Banks have intrinsic incentives to hold safe assets to manage liquidity and solvency risks. Safe assets—particularly short-term government securities—play a key role in banks' day-to-day asset-liability management. Banks' inherent maturity mismatches justify their holding some assets with high market liquidity and stable returns. Shorter-term safe assets permit banks to curb unwanted maturity mismatches and manage their short-term funding needs. At times of stress, banks can also temporarily increase safe asset allocations to: (1) raise capital ratios via exchange for riskier assets, (2) access secured funding markets, or (3) counterbalance trading book losses to stabilize income.[17]

Banks' role in safe asset demand is particularly important, given that they are the largest holders of safe assets in the form of government securities. Their role is particularly pronounced in China, France, Japan, and the United States, where banks jointly account for about 55 percent of the roughly $14.8 trillion in sovereign debt held by banks globally (Figure 3.7, top panel). In some countries such holdings account for a considerable share of banking sector assets, as high as roughly 30 percent in Turkey, and more than 20 percent in Brazil, Mexico, and Japan (Figure 3.7, bottom panel).[18] Overall, sovereign debt plays a considerably more important role in the asset allocation of emerging market banks than of banks in advanced economies, which—with the exception of Japan—have higher allocations in riskier assets.

Banks' demand for government bonds is also linked to their symbiotic relationship with their respective governments. Some banks act as primary dealers and market makers for government bonds and support secondary market liquidity for such bonds through active trading. For example, 46 of the 71 banks that were part of the 2011 EU capital exercise are primary dealers of domestic government bills or bonds.[19] Primary dealer arrangements are also common in Canada, Japan, the United States, and other advanced economies, though their requirements and obligations vary considerably across countries.

Figure 3.7. Banks' Holdings of Sovereign Debt, by Selected Country, End-September 2011
(In percent)



Sources: Bankscope; and IMF staff estimates.
Note: Data are as of end-September 2011 or latest available. Estimates only reflect data for banks—mostly larger banks—with information in Bankscope.

Official Reserve Managers

Official reserve managers use safe assets in portfolio allocation, placing priority on safety, liquidity, and returns, in that order. Reserve managers put a premium on short-term safety in order to meet short-term contingent liabilities linked to balance of

[17]In some cases, banks hold cash at their respective central bank, which also serves as a store of value.

[18]However, banks' practice of excessive buying of sovereign debt is generally discouraged in less developed financial systems, in part to provide banks with incentives to enhance their intermediation role via lending to nonfinancial corporations and households.

[19]Based on Association for Financial Markets in Europe (2011); websites of national debt management offices or ministries of finance; and IMF staff calculations. Banks that are members of the Bund Issuance Auction Group or the Gilt-Edged Market Makers were considered primary dealers for Germany and the United Kingdom, respectively.

payments requirements and other financial stability considerations. Thus, from a reserve manager's perspective, liquidity and low credit and market risks are key aspects of asset safety, as assets need to be readily available for sale, without incurring valuation losses.

The upsurge in reserve manager demand for safe assets in the past decade has been linked to the considerable accumulation of global foreign exchange reserves. Official reserves increased from $2.2 trillion at end-2001 to $10.8 trillion at end-October 2011, with China's reserve holdings alone rising more than 15-fold from $0.2 trillion to $3.3 trillion. This rapid growth is in part linked to precautionary saving motives and higher risk aversion in the wake of the Asian crisis in the late 1990s.

Safe asset investments by reserve managers take the form of government and other securities, deposits at other central banks and international institutions, and gold. The securities portfolio (64 percent of total reserves) mostly consists of government securities, estimated at approximately $7 trillion as of end-October 2011.[20] Bank deposits, which had increased steadily as a share of reserves, declined considerably with the onset of the crisis as their perceived safety changed. Reserve managers withdrew roughly $0.5 trillion of deposits and other investments from the banking sector in a flight to safety during the global financial crisis (Figure 3.8).[21] Since the crisis, reserve managers have reversed their long-term position as net sellers of gold, and have turned into net buyers.[22] At end-October 2011, the official sector accounted for 22 percent of the global holdings of physical gold.[23]

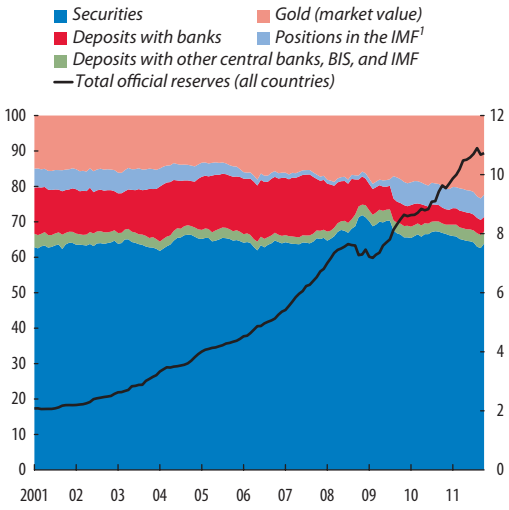
[20]IMF staff estimate derived from total global official reserve holdings (IMF, International Financial Statistics data); the share of securities in total official reserve holdings for countries subscribing to the IMF's Special Data Dissemination Standard (SDDS); and the share of U.S. Treasury securities in foreign official holdings of U.S. Treasury and corporate securities (TIC data), assuming that these shares are representative of global reserve portfolio allocations.

[21]See Pihlman and van der Hoorn (2010). Note that the jump in IMF positions in 2009 (Figure 3.8) was not related to asset allocation decisions by reserve managers but to the allocations of special drawing rights (SDR) provided by the IMF.

[22]Aggregated gold holdings (by fine ounce) of reserve managers reporting to the IMF SDDS increased in 2009, 2010, and the first 10 months of 2011. This may be partly related to the IMF's use of central banks' selling quotas to liquidate some of its own holdings.

[23]Based on data from the World Gold Council.

Figure 3.8. Official Reserve Accumulation, by Instrument
(Components in percent, left scale; total in trillions of U.S. dollars, right scale)



Source: IMF Composition of Official Foreign Exchange Reserves.
Note: BIS = Bank for International Settlements.
[1]Positions in the IMF comprise reserve tranche positions and SDR holdings.

Reserve managers' demand for sovereign debt is likely to persist, if not grow, in the medium term. Global official reserves are projected to rise by 11.3 percent in 2012 and by 61 percent by end-2016, indicating higher potential demands for sovereign debt, even if their relative share in reserve managers' portfolio contracts.[24] Some large reserve managers are already diversifying away from government securities, as their accumulated reserves have exceeded balance of payments and monetary policy needs.

Sovereign Wealth Funds (SWF)

The pattern of SWF safe asset allocations is highly heterogeneous. Safe asset demand by SWFs varies based on each fund's type, objectives, and investment horizons. Only a few types make extensive use of safe assets.

Stabilization funds typically have conservative asset allocations focused heavily on high-quality sovereign assets. Their investment horizons and liquidity objectives are close to those of global reserve managers, in view of their role in countercyclical fiscal policies. Hence, stabilization funds have low risk-return pro-

[24]Reserve projections are based on the *World Economic Outlook*.

files and tend to invest mostly in fixed-income assets, particularly shorter-term sovereign instruments.

Pension reserve funds, *reserve investment corporations*, *and saving funds* have a very limited demand for safe assets. They tend to have longer investment horizons justified by their specific mandates and objectives: (1) they expect fund outflows far in the future (pension reserve funds), or (2) their mandate is to reduce reserve holding costs (reserve investment corporations), or (3) their express objective is to transfer wealth across generations (saving funds).

Current SWF holdings of sovereign debt are estimated to be at $500 billion to $600 billion, accounting for roughly 18 to 21 percent of SWFs' total assets. See Box 3.1 for the methodology behind this estimate. This is less than one-tenth of the amount of sovereign debt held by official reserve managers.

The potential for SWFs to exert pressure on sovereign debt demand is ambiguous. Several countries are currently setting up new stabilization funds, which invest heavily in sovereign debt. Existing SWFs, particularly in emerging economies, are also likely to continue to grow if relatively high commodity prices and current account surpluses persist, potentially raising sovereign debt demand. However, SWFs with long-term investment horizons have been increasing the share of real estate and alternative investments in their portfolios—a trend likely to continue. Also, many SWFs with dual objectives (for example, stabilization and saving) increasingly emphasize their saving mandates, resulting in higher allocations in riskier asset classes.

Insurance Companies and Pension Funds

Insurance companies and pension funds complement their risky asset holdings with safe asset allocations, mainly to match liabilities. At end-2010, insurance companies held approximately $6.4 trillion in government bonds, and pension funds held about $2.7 trillion.[25] Life insurance companies that offer mostly products with guaranteed returns place a higher priority on value preservation and thus maintain conservative portfolios with high allocations to long-term high-quality debt. Pension fund demand for safe assets is related to the nature of their liabilities and their risk tolerance.[26] Asset allocations at many pension funds are dominated by sovereign debt holdings. Across OECD countries, bonds—a large share of which are sovereign—accounted for 50 percent of aggregate pension fund assets at end-2010.

The low-interest-rate environment in advanced economies since late 2008 may marginally curb pension funds' demand for safe assets. A protracted period of low interest rates would put pressure on pension funds to shift to riskier assets as the present value of future payable benefits increases—an increase that is even greater if longevity risk is properly accounted for.[27] Under such conditions, pension funds may embark on a search for yield by shifting asset allocation to riskier assets. However, such a shift is likely to be gradual, given that pension funds tend to change their strategic asset allocations only slowly.[28]

The Role of Safe Assets as Collateral

Safe assets play a critical role as a source of high-quality, liquid collateral in a wide range of financial transactions. Their use as collateral spans private and central bank repo markets and OTC derivatives markets.

Private bilateral and tri-party repo markets depend heavily on safe assets as collateral.[29] While, in principle, any type of asset could be used as collateral in private repos, liquid assets with high credit quality are the preferred type of collateral and are associated with lower secured funding costs than other assets. The bilateral repo market is structured around global dealer banks that, in part, reuse the received collateral to meet demand by other financial institutions and

[25]Based on OECD data and IMF staff estimates. Holdings by pension funds do not account for indirect holdings of government bonds via mutual funds.

[26]For example, pension funds with inflation-linked liabilities tend to focus on real returns.

[27]See Chapter 4 for a discussion of the increase in pension fund liabilities due to longevity risk; also see IMF (2011b).

[28]See IMF (2011b).

[29]Tri-party repos are repurchase agreements in which a third party—a custodian bank or a clearinghouse—provides intermediation of transactions, including collateral allocation, collateral substitution, and marking to market. In the United States, the two key tri-party agents are Bank of New York Mellon (BNY Mellon) and JPMorgan Chase. In Europe, the tri-party repo market is dominated by Euroclear, Clearstream, BNY Mellon, and JPMorgan Chase (Singh, 2011).

Box 3.1. The Size of Sovereign Wealth Funds and Their Role in Safe Asset Demand

The amount of assets held by all sovereign wealth funds is estimated here to be about $2.8 trillion. However, these funds' investments in safe assets vary significantly by type of fund.

Due to the lack of a generally agreed definition of a sovereign wealth fund (SWF), estimates of their sizes vary considerably. Upper-end estimates—such as the often-cited $4.7 trillion from the Sovereign Wealth Funds Institute—double count by including central bank assets already captured in official reserves. Estimates here use the definition of SWF in the Santiago Principles, based on publicly available data for 30 SWFs meeting the definition, and explicitly excluding central banks and state-owned enterprises.[1] More than 70 percent of SWFs in the sample provide information on the size and allocation of their assets. Estimates for the rest are based on consensus estimates of size, and within-sample weighted averages for SWFs of the same type for approximations of asset allocations. SWFs that follow several objectives—including those of Azerbaijan, Norway, and Trinidad and Tobago—were categorized by prevailing operational objective based on judgment. In this fashion, the aggregate size of SWF assets is estimated here at $2.8 trillion.

SWFs' preferences for safe assets vary, depending on their mandates and objectives (see Figure 3.1.1):

Stabilization funds are set up to insulate government budgets and economies from commodity price volatility and external shocks. They are largely fixed-income investors and allocate an average of 69 percent of their assets to government securities.[2]

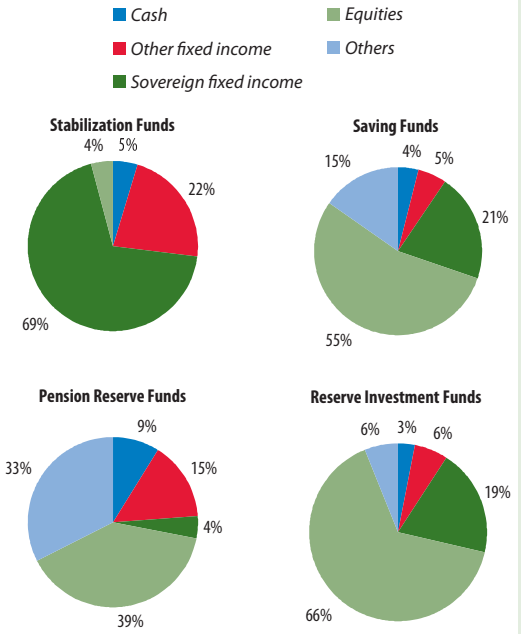
Pension reserve funds are established to meet future pension liabilities on the governments' balance sheets and have very long investment horizons. Therefore, they hold very small portfolio shares in sovereign securities, averaging about 4 percent.[3]

Note: Prepared by Abdullah Al-Hassan, Jukka Pihlman, and Tao Sun.

[1]See International Working Group of Sovereign Wealth Funds (2008).

[2]*Stabilization funds* are those in Azerbaijan, Bahrain, Botswana, Chile, Kiribati, Mexico, Oman, Russia, Timor-Leste, and Trinidad and Tobago. *Pension reserve funds*: Australia, Chile, Ireland, and New Zealand. *Reserve investment corporations*: China, Korea, and Singapore. *Saving funds*: Abu Dhabi, Alberta (Canada), Alaska (United States), Bahrain, Brunei, Kazakhstan, Kuwait, Malaysia, Norway, Qatar, Russia, and Singapore.

Figure 3.1.1. Asset Allocations at Sovereign Wealth Funds, by Type of Fund, End-2010[1]



Source: IMF staff estimates based on annual reports and other information from SWFs.

[1]Or latest available.

Reserve investment corporations that invest a portion of foreign reserves to reduce reserve holding costs pursue higher returns through high allocations to equities and alternative investments—for example, up to 50 percent in South Korea and 75 percent in the Government of Singapore Investment Corporation (GIC)—and have a fairly limited need for liquidity. The share of sovereign securities in their portfolios is, on average, about 19 percent.

Saving funds, which are mandated to share cross-generational wealth or manage strategic government investment portfolios, allocate high portfolio shares to equities and other investment instruments—40 percent (e.g., Libya Investment Authority) and higher (e.g., Singapore's Temasek). Their sovereign debt allocations are limited to an average of 21 percent.

[3]The only exception is the Pension Reserve Fund in Chile, which moved toward a riskier allocation in 2011.

play a key role in liquidity provision. The key collateral providers—and, thus, the ultimate demanders of safe assets for collateral purposes—include hedge funds, broker-dealers, and banks, among others.[30]

In the United States and Europe, collateral in private repo markets is dominated by sovereign debt securities. With a total size of approximately $1.7 trillion, the tri-party repo market is an important source of funding for U.S. financial institutions.[31] In the United States, U.S. Treasury and agency securities—traditionally viewed as safe assets—collectively accounted for 83 percent of collateral in the U.S. tri-party repo market at end-September 2011.[32] In Europe, sovereign debt accounted for 79 percent of EU-originated collateral in the repo market at end-2011.[33] Tri-party repos account for only about 11 percent of repo transactions in Europe, where they relied on more diversified collateral, comprising government securities (45 percent), and another 41 percent in corporate bonds, covered bonds, and equity.

The potential impact of private repo collateral on safe asset demand depends on various factors. For example, if ongoing strains in unsecured interbank funding markets in Europe persist, the importance of collateralized funding in European banks' funding structures may increase, leading to stronger near-term demand for safe assets (see Chapter 2). However, the prospect of further bank deleveraging may, in part, mitigate further upward demand pressures stemming from the banking sector if that process entails a reduction in the assets held on their balance sheets.

Central bank collateral policies are another factor that affects banks' incentives to hold safe assets to meet funding needs. Safe assets in the form of government securities are a principal form of collateral in central bank repo operations in many countries. Their prevailing role is linked in part to the historically lower volatility and greater liquidity of government securities, particularly in times of stress. It is also related to the intrinsic comfort of central banks that the probability of a sovereign default is (usually) low and that they take a highly senior position, reducing losses in the case of an outside counterparty default that is using sovereign collateral. However, during periods of severe market stress, central banks could (and did in the latest crisis) expand eligible collateral criteria to address market illiquidity (Annex 3.2).[34]

The potential move of standardized OTC derivatives contracts to central counterparties (CCPs) may spur demand for high-quality collateral. OTC derivative transactions are highly dependent on the use of collateral, with 80 percent of these including collateral agreements. In 2010, approximately 80 percent of collateral backing OTC derivatives transactions was in cash and an additional 17 percent was in government securities.[35] The shift of a considerable number of OTC derivatives transactions to CCPs under proposed changes to OTC derivatives regulation will elevate collateral demand by between $100 billion and $200 billion for initial margin and guarantee funds, though some of this will offset current needs in the OTC market (see Box 3.2). The resulting lower ability to rehypothecate, or reuse, the collateral in additional repo contracts when it remains within a CCP's default fund may intensify financial institutions' need for collateral to meet desired aggregate funding volumes.[36] Indeed, one CCP has already decided that high-grade corporate bonds will be accepted as initial margin for swap trades as a result of a shortage of high-quality assets.

Use in Prudential Regulations

Banks' high demand for safe assets was influenced in the past by the accommodative treatment of government bonds in prudential regulations, the most prominent of which are the following:[37]

[30]See also Copeland, Martin, and Walker (2010).

[31]The information on U.S. repo markets is from the Federal Reserve Bank of New York (www.newyorkfed.org/tripartyrepo/margin_data.html).

[32]Agency securities include mortgage-backed securities.

[33]Mostly in the form of British, French, and German sovereign securities. See ICMA (2012).

[34]Also see Cheun, von Köppen-Mertes, and Weller (2009), for example.

[35]See ISDA (2011).

[36]See Singh (2011).

[37]Large exposure limits may influence bank demand for government debt when such holdings are treated differently from other assets. In many economies, domestic and other zero percent risk-weighted government bonds are explicitly exempt from limits on large exposures. This treatment may give rise to the risk that banks accumulate very large positions vis-à-vis individual

Box 3.2. The Impact of Changes in the OTC Derivatives Market on the Demand for Safe Assets

Moving a critical mass of OTC derivatives to central counterparties (CCPs) is expected to entail higher upfront initial margin and contributions to guarantee funds that reside at the CCP. This would result in increased demand for collateral.

In response to the global financial crisis, authorities in many jurisdictions are encouraging greater use of CCPs for OTC derivatives transactions.[1] In particular, the G20 has agreed that by end-2012 all standardized OTC derivatives should be centrally cleared so as to lower counterparty credit risk through multilateral netting. The global nature of OTC derivatives markets has also highlighted the need for international coordination to establish minimum cross-border risk management standards and avert regulatory arbitrage in cases where CCPs compete with each other.

The expected changes in OTC market infrastructure will likely increase demand for safe assets via higher demand for collateral.[2] While a shift toward central clearing of standardized OTC contracts will eliminate some of the need for bilateral collateralization, the move of a critical mass of OTC derivatives to CCPs is expected to increase the demand for collateral. The higher demand would arise from an upfront initial margin that typically is not posted on bilateral interdealer trades, and from contributions to guarantee funds at the CCP, with the size of contributions depending on the amount of cleared contracts.[3]

The direct incremental initial margin and the guarantee fund contributions are expected to amount to between $100 billion and $200 billion.[4] The higher estimate would be associated with effective incentives to boost counterparty participation—via a mandated wholesale move for dealers or through the assignment of higher capital charges. Moreover, a proliferation of CCPs without mutual recognition may raise total CCP collateral requirements even further. The lower estimate is associated with exemptions of certain types of OTC derivative counterparties (such as sovereigns and "hedgers") or types of contracts (such as foreign exchange derivatives) from the central clearing mandate. More importantly, restrictions on the market reuse (rehypothecation) of collateral posted with CCPs may lower the effective supply of collateral in the market and hence increase the liquidity risk premium (Singh, 2011).[5] For current CCP requirements, see Annex 3.3.

Note: Prepared by Hanan Morsy.

[1]See IMF (2010a) for a more detailed discussion of these issues.

[2]Collateral requirements are based on a party's likelihood of default, the risk—market, credit, operational, and counterparty—of the derivative transaction being collateralized, its tenor, and liquidity. In OTC derivatives markets, collateral is posted as a form of down payment against potential losses in the event of counterparty default.

[3]Under current market practices, dealers typically do not post independent amounts—equivalent to initial margins in clearinghouses—to each other, and do not ask for collateral from some types of customers, namely most sovereign and quasi-sovereign entities and some corporate clients. However, some regulators intend to impose costs for trades that are not moved to CCPs.

[4]Based on the methodology used in IMF (2010a).

[5]See Singh (2011) for a more detailed discussion.

- *Capital requirements,* via widespread application of zero credit risk weights for own sovereign debt (see Box 3.3);[38] and
- *Liquidity requirements,* via the favorable treatment of government bonds in the determination of existing liquidity-based prudential regulations in some countries.

sovereigns that are treated as safe by regulation but may actually be risky.

[38]Under Basel II, risk weights on the most highly rated (equivalent of AA– or higher) sovereign debt exposures are set at zero under the standardized approach, and at a minimum positive value based on banks' own models under the internal ratings-based (IRB) approach. Under the standardized approach, at national discretion where the exposure is denominated and funded in the domestic currency, banks may apply a preferential treatment to domestic sovereign exposures. Where a sovereign asset class is perceived to be immaterial in size and risk profile, Basel II permits supervisors to allow the continued use of the standardized approach for that asset class by banks that are using the IRB approach for the rest of their portfolio. The Capital Requirements Directive (CRD) permits banks using the standardized approach to apply a zero risk weight to all sovereign exposures within the EU, and banks using the IRB approach may adopt the standardized approach for sovereign exposures, subject to supervisory approval and where the number of material counterparties is limited.

Box 3.3. Regulatory Risk Weighting of Banks' Government Debt Holdings: Potential Bias in Capital Adequacy Ratios

The potential removal of the zero percent risk weighting of banks' domestic sovereign debt holdings has implications for their solvency ratios. Many banks use zero percent risk weighting for sovereign debt, accounting for an upward bias in banks' capital adequacy ratios.[1] *The analysis estimates risk weights implied by the default rates embedded in sovereign credit default swap spreads, with spreads prior to the global crisis adjusted to reflect medium-term sovereign fiscal positions.*

To estimate the impact of a potential elimination of zero percent risk weighting for own local currency sovereign debt, precrisis risk weights on bank sovereign debt holdings are adjusted to reflect countries' medium-term fiscal fundamentals. Potential changes in banks' capital adequacy are assumed to be driven by risk weights based on default rates implied by sovereign credit default swap (CDS) spreads. CDS spreads do not only measure sovereign credit risk, because they depend on global and financial factors, and could be extremely volatile at times of market stress.[2] However, they are more forward-looking in nature and can capture increased fiscal risks better than many other market indicators.[3] When adjusted for fiscal fundamentals, they can provide a more realistic view of the sovereign risk bias in banks' capital adequacy ratios. However, given potential weaknesses in using CDS spreads, the exercise is repeated using bond yields and similar results are obtained during a period of compressed spreads.[4]

CDS spreads observed before the global crisis are adjusted to "true" risk fundamentals based on medium-term sovereign fiscal positions.[5] The magnitude of the precrisis bias in capital adequacy ratios depends on the share of sovereign debt holdings in total bank assets (the exposure at default—EAD), the evolution of sovereign debt probability of default (PD), and the recovery rate (or 1 minus LGD—loss given default).[6] The estimations are carried out using global bank-by-bank data, and are based on the conservative assumption that all sovereign debt is risk weighted at zero.[7] EAD varies considerably across regions. Historically, the share of bank sovereign debt holdings in total assets has been considerably smaller in the euro area, the United

Note: Prepared by Srobona Mitra and Christian Schmieder.

[1]Sovereign risk is partially captured and controlled by the Basel II framework. Under the standardized approach used by most banks, zero percent risk weights apply to all sovereigns rated AA– and above. Under the internal ratings-based approach, banks are expected to apply a minimum probability of default (floor) of 3 basis points. Banks could deviate from this floor and apply lower risk weighting—even at zero percent—subject to supervisory discretion. The credit quality of sovereign debt held for trading purposes or for sale on banks' balance sheets also affects capitalization via their profit and loss accounts. In addition, interest rate risk in the banking book related to sovereign exposures is captured by Pillar 2 of Basel II, with supervisors expected to require additional capital for this risk. Moreover, the introduction of a non-risk-weighted leverage ratio under Basel III will complement risk-weighted capital adequacy requirements.

[2]See Alper, Forni, and Gerard (2012) and Schaechter and others (2012).

[3]Previous research shows that CDS spreads are more forward-looking than bond spreads, despite issues with liquidity in the CDS market (Chan Lau, 2003). Alper, Forni, and Gerard (2012) show that CDS spreads can better capture increased fiscal risks compared to relative asset swap (RAS) spreads, for example.

[4]For a more detailed discussion of various methodologies and other sovereign risk considerations in the context of risk weighting, see European Parliament (2010). For methodologies used in rating agency analysis, see Standard & Poor's (2011) and Fitch Ratings (2011), for example.

[5]Adjustments of the precrisis sovereign CDS spreads (2002–07) are carried out on the basis of the following equation: $AdjCDS_t = CDS_t + 459.33 \times FII$, where FII is the IMF's Fiscal Indicators Index, a continuous 0–1 index of fiscal fundamentals derived from 12 indicators of near- and medium-term fiscal risk (IMF, 2011c). The estimation is carried out using annual panel data for 2008–11, regressing CDS spreads on FII, a constant, and past CDS spreads, taking into account period fixed effects. The goal is to capture the relationship between fiscal fundamentals and more differentiated CDS in the wake of the crisis, and apply it to the precrisis period. The adjusted CDS spreads imply higher probabilities of default (PDs) in the calculation of the risk weights of banks' sovereign debt holdings based on Basel's internal ratings-based (IRB) model. The adjusted capital adequacy ratios for a region are asset-weighted averages for the bank-by-bank ratios in that region. The capital adequacy ratio for 2010 is IRB-adjusted to reflect PDs from observed CDS spreads.

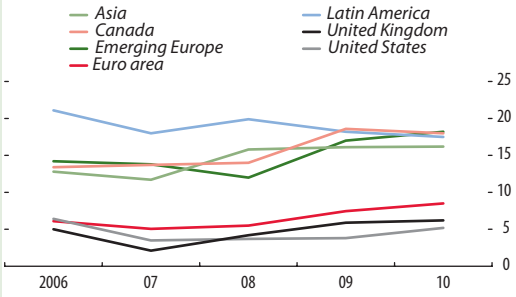
[6]The LGD is assumed to be a constant of 45 percent, a standard assumption in the literature. It is identical to the LGD used for senior unsecured debt in the Basel II foundation IRB approach.

[7]For simplicity, it is assumed that all government debt holdings are domestic and risk weighted at zero percent—a conservative assumption that overestimates the bias. For the euro area, this definition would include exposure to other euro area sovereigns. In countries with flexible exchange rates and in situations in which banks hold their own sovereign debt in domestic currency, sovereign debt may be considered safer.

Box 3.3 *(continued)*

Figure 3.3.1. Share of Banks' Assets Allocated to Government Debt

(In percent, held-to-maturity, average of banks weighted by equity)



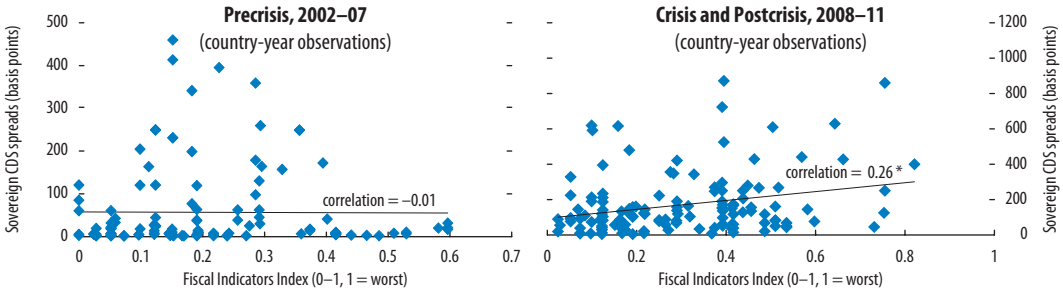
Sources: Bankscope; and IMF staff estimates.

Kingdom, and the United States than in other regions, notably emerging markets (Figure 3.3.1).

CDS spreads did not reflect adequately countries' fiscal fundamentals before the crisis, even though their differentiating power improved considerably afterward (Figure 3.3.2). As a result, the 2007 PD levels adjusted for fiscal fundamentals were considerably higher than those derived from actual CDS spreads. The differential between the two was particularly high for Europe, indicating weaker fiscal paths in some parts of Europe.

The estimated magnitude of capital adequacy bias was high for some regions. The 2007 bias is linked to a mixture of zero percent risk weighting and nondifferentiation of underlying fiscal risks in CDS spreads (Figure 3.3.3). Using internal ratings-based (IRB) risk weights

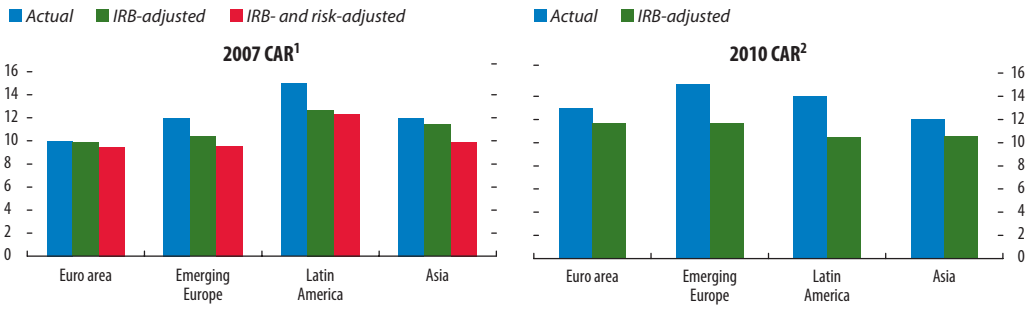
Figure 3.3.2. Sovereign CDS Speads and Fiscal Fundamentals—Precrisis, Crisis, and Postcrisis



Sources: Bloomberg L.P.; IMF (2011c); and IMF staff estimates.
*Significant at 5 percent level.

Figure 3.3.3. Capital Adequacy Ratios—Actual, IRB-Adjusted, and IRB- and Risk-Adjusted, 2007 and 2010

(In percent)



Sources: Bankscope; and IMF staff estimates.
Note: Data for each region are the median for all reporting banks. CAR = capital adequacy ratio; IRB = internal ratings-based.
[1]Actual = reported CAR; IRB-adjusted = CAR based on IRB risk weights for government security holdings, rather than zero, using observed CDS spreads in 2007 to extract estimates of probabilities of default (PDs); IRB- and risk-adjusted = IRB risk weights, using adjusted CDS spreads to extract estimates of PDs (adjusted CDS spreads = observed CDS spreads + 459.33 x IMF Fiscal Indicators Index).
[2]IRB-adjusted = CAR based on the observed sovereign CDS spreads and the associated PDs in 2010.

Box 3.3 *(continued)*

and PDs based on actual CDS spreads, the capital adequacy ratios are considerably lower for emerging markets. Adjusting further for risk differentiation (based on the observed differentiation seen during 2008–11), the capital adequacy ratios are even lower. The bias is low in advanced economies in view of their relatively low EADs. At end-2007, the difference between the observed capital adequacy ratio and the "IRB- and risk-adjusted" capital adequacy ratio ranged from 0.5 to 2 percentage points across the countries in Europe. In emerging economies, adjustments were in the range of 2 to 3 percentage points, given those banks' more sizable domestic sovereign exposures and higher CDS spreads due to worse medium-term fiscal fundamentals. In Canada, Japan, the United Kingdom, and the United States, downward revisions of the capital adequacy ratios were relatively low, in the 0.2 to 1.5 percentage point range. The bias was even higher for some regions in 2010 because of worse fiscal fundamentals and higher EADs.

Even now, the favorable capital treatment does not adequately reflect underlying economic risks and may lead to higher bank allocations to sovereign debt than warranted by more accurate risk-return considerations.[39] The current preferential treatment of sovereign exposures is based partly on national supervisors' practice of applying zero risk weighting on sovereign debt within the same currency area. Many countries' supervisors apply the zero percent risk weight to their own sovereign debt. The European Union Capital Requirements Directive applies preferential treatment to debt issued by cross-border euro area sovereigns despite the fact that the countries have given up independent monetary policy and that their fiscal fundamentals vary widely. Setting the risk weights at levels reflecting actual underlying risks and medium-term fiscal fundamentals would eliminate this bias. More generally, underestimation of government debt-related risks in bank portfolios can account for an upward bias in capital adequacy ratios.[40] The magnitude of potential capital adequacy bias could be high (see Figure 3.7 and Box 3.3).

Bank demand for government debt is likely to expand in the future. The advent of new regulations may force banks to hold even more safe assets. For example, on the liquidity side, unless banks alter their liability structure to moderate their liquidity needs, the requirements of the new Basel III Liquidity Coverage Ratio (LCR) alone could further increase the demand for safe assets by some $2 trillion to $4 trillion worldwide (see Box 3.4). An increase in the risk weights of riskier sovereigns could also spur stronger demand for the safest sovereign assets (see Box 3.3). In addition, business uncertainty is likely to put upward pressures on such demand.

The upcoming introduction of the LCR could influence how maturity risks associated with sovereign safe asset holdings are distributed within banks. Under Basel III, maturity restrictions on qualifying liquid assets are lifted, and assets—including government securities—with different terms to maturity are eligible to meet the LCR.[41] Government securities are a substantial component of the liquid assets required under Basel III; however, they are not the only qualifying liquid assets.

The upcoming implementation of the Solvency II regulations, although not yet finalized, may stimulate stronger demand by European insurance companies for certain assets. Under the current proposal for Solvency II, insurance companies would, for instance, not be required to hold regulatory capital against exposures to government bonds issued by member states of the European Economic Area, or government guarantees backed by multilateral development banks, regardless of the credit ratings or risk premiums of such instruments.[42] Solvency II may also boost the demand for highly rated safe assets because it links insurance companies' capital requirements to the credit ratings of their asset holdings.

[39]Basel I alloted zero percent risk weights to all OECD countries. Following the Asian crisis in the 1990s, Basel II provided greater risk-weight differentiation for sovereign debt.

[40]Capital adequacy ratios are measured as the ratios of regulatory capital to risk-weighted assets.

[41]See Hannoun (2011).

[42]Solvency II is expected to be fully implemented in 2014.

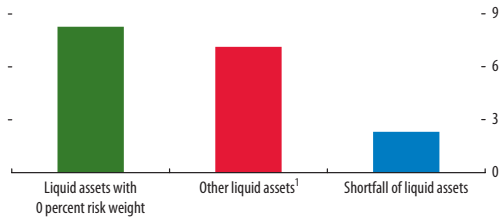
Box 3.4. Impact of the Basel III Liquidity Coverage Ratio on the Demand for Safe Assets

Unless they change their funding profiles, banks may need to increase their government debt holdings to ensure that they meet the liquidity requirements of the new Liquidity Coverage Ratio (LCR).

The introduction of the LCR under Basel III could be an important regulatory driver of bank demand for safe assets.[1] The liquidity buffer held by banks to fulfill the LCR requirement includes two types of liquid assets, both of which are supposed to have high credit quality and low market risk, traits presumed to translate into high market liquidity (Table 3.4.1): Level 1 assets are meant to exhibit characteristics akin to the safest assets; those in Level 2 are subject to a haircut and a limit on their quantity in the overall liquidity requirement. The LCR excludes lower-quality assets (below Levels 1 and 2) because in times of severe market stress, banks are either unable to sell them or are forced to accept considerable fire-sale haircuts.[2]

LCR requirements could have a sizable impact on the global demand for safe assets. To fulfill the Basel III LCR requirements by end-2009, large G20 banks would have required approximately $2.2 trillion in additional liquid assets, at least partly in the form of sovereign debt assets, according to the 2010 Quantitative Impact Study (QIS) of the Basel Committee on Banking Supervision (BCBS, 2010b) (Figure 3.4.1). An extrapolation for smaller G20 banks and non-G20 banks—not included in the QIS sample—shows that the potential need for qualifying liquid assets globally is in the range of $2 trillion to $4 trillion, equivalent to 15 percent to 30 percent of banks' total current sovereign debt holdings.[3] The combined sample approximately

Figure 3.4.1. Large G20 Banks: Available Liquid Assets and Expected Shortfall to Meet the Liquidity Coverage Ratio, End-2009
(In trillions of U.S. dollars)



Sources: The Quantitative Impact Study (QIS) (BCBS, 2010b); Bankscope; and IMF staff estimates.

Note: In its initial and follow-up data collection, the QIS covered 249 banks, which are from 23 of the Basel Committee's 27 member countries and cover most of the G20 countries. The value for liquid assets required to meet the Basel III liquidity coverage ratio was inferred from the QIS report, and the shortfall is as given in that report. A report with the European subset of the QIS data is CEBS (2010).

Note: Prepared by Maximilian Fandl and Christian Schmieder.

[1]See BCBS (2010a). To meet the LCR, banks need to maintain sufficient liquid assets to cover net cash flows over 30 days without external funding. Calibration of the LCR is subject to revision until end-2014.

[2]See BCBS (2010a) for exceptions for countries with insufficient amounts of assets at Levels 1 and 2.

[3]Estimates based on the latest QIS and relevant bank data; a more precise estimate would require an update of the QIS. The extrapolation for smaller G20 banks and non-G20 banks assumes that the proportions of assets to net outflows (the LCR ratios) are identical to those of the large G20 banks in the 2010 QIS. The estimate of required liquid assets is presented as a share of total sovereign debt holdings only to provide a sense of the relative magnitude of the potential liquid asset needs. Certainly, the liquid assets to meet the LCR may take the form of non-sovereign eligible assets.

Table 3.4.1. Liquid Assets Eligible for the Liquidity Coverage Ratio

Type of Asset	Haircut (in percent)	Description
Level 1	0	Cash and central banks reserves (to the extent they can be drawn down in times of stress) Zero percent risk-weighted marketable securities or sovereign guarantees (including subsovereigns and public sector), central banks, and certain multilateral institutions Nonzero percent risk-weighted, domestic currency debt securities issued by sovereigns or central banks Nonzero percent risk-weighted, foreign currency debt securities issued by sovereigns or central banks to the extent that holding such debt matches the currency needs of the bank's operations in that jurisdiction
Level 2	15	20 percent risk-weighted marketable securities or guarantees by sovereigns (including subsovereigns and public sector), central banks, and certain multilateral institutions Covered bonds with high ratings (AAA to AA–) Plain-vanilla corporate bonds by nonfinancial corporations with high ratings (AAA to AA-)

Source: Bank for International Settlements.

Box 3.4 *(continued)*

doubles the total assets and hence the required liquid assets, based on the assumption that the balance sheet structure of smaller G20 banks and non-G20 banks is identical to the QIS banks. However, banks have three more years to adapt their funding profiles to meet the LCR, at which time their needs for safe assets could be lower. A more continuous calibration of the qualifying liquid assets—including eligibility and haircuts—could ameliorate pressures on the markets for safe assets. It is worth noting that the estimates here cannot account for the cross-country variation in amounts demanded by individual institutions and potentially supplied by issuers of the required assets.

The Role of Central Bank Demand for Safe Assets

Some advanced economies' central banks have influenced the markets for safe assets via massive purchases of government securities (Figure 3.9).[43] Notably, the Federal Reserve and the Bank of England have resorted to such purchases in the wake of the crisis to boost system-wide liquidity and stimulate economic activity by lowering long-term interest rates. These policies have contributed to a substantial decline in the long-term yields on government securities. They have also been successful in compressing yields and improving market liquidity in certain non-government securities—including corporate bonds—thus enhancing this aspect of their perceived safety.[44]

- In the *United States*, the pace of the Federal Reserve's asset purchases accelerated markedly under QE2 (the second stage of the so-called quantitative easing program), even though the share of such purchases in overall holdings has not increased drastically compared with precrisis levels. During QE2, the Federal Reserve became the principal buyer of U.S. Treasury securities in the secondary market, while such purchases in other sectors—particularly the foreign official sector—slowed down.
- In the *United Kingdom*, the Bank of England increased its gilt holdings considerably—both in absolute terms and in terms of market share—in the two years since its first gilt purchase under the Asset Purchase Program in March 2009. As intended, the Bank of England increased its share in aggregate gilt holdings, while the shares of pension funds, insurance companies, and other financial institutions declined.

These large-scale purchase programs have turned the Federal Reserve and the Bank of England into large holders of long-term government securities, with some risks for safe asset markets. The longer-term purchases have resulted in a marked increase in the maturities of both central banks' government securities holdings. At end-January 2012, about 40 percent of the Bank of England's holdings consisted of securities with remaining maturities of 10 to 25 years (Figure 3.10).[45] In the United States, the share of longer-term securities in the Federal Reserve's portfolio increased to roughly 30 percent after the introduction of the Maturity Extension Program—also known as "Operation Twist."[46] The sizable presence of central banks in the long-term government securities markets may limit the room for further policy maneuver, and may constrain central bank flexibility in smoothly unwinding current monetary policies.[47] This can lead to a loss of asset safety in

[43]The Bank of Japan has been an active buyer of government debt since the introduction of quantitative easing in Japan in 2001 (terminated in 2006), and continues to be under its current Asset Purchase Program.

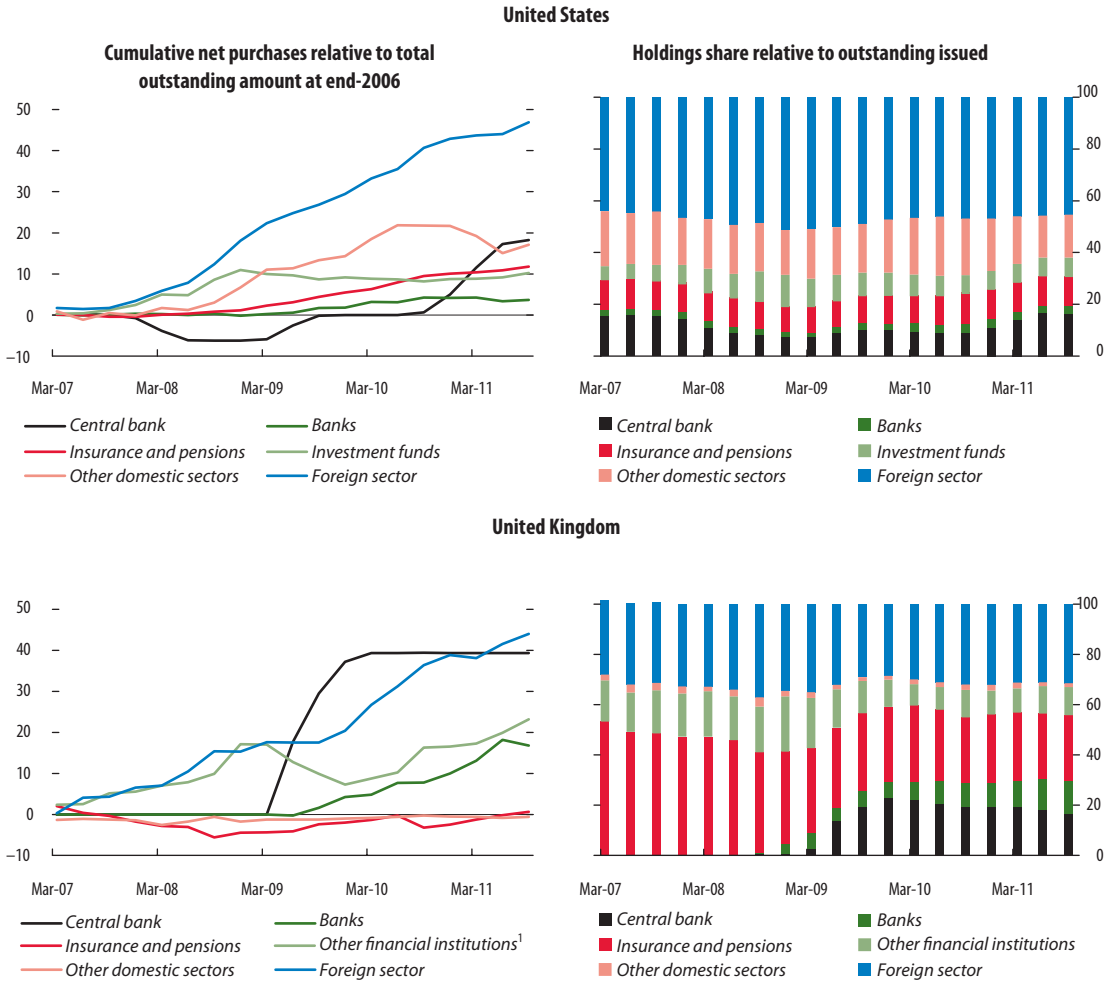
[44]See Yellen (2011); and Joyce, Tong, and Woods (2011). See IMF (2012) for a discussion of the role that central bank purchases of sovereign debt play in relieving the financial markets from absorbing large issuances. To the extent that central banks also supply central bank money (safe asset), reserve balances held by banks could increase, resulting in a change in composition of safe assets, rather than a decline (see the section below on "Central Bank Supply").

[45]Bank of England purchases are restricted to nominal gilts, with maturity initially capped at 25 years. However, the maturity restriction was subsequently relaxed as the purchase program expanded.

[46]Operation Twist was introduced to exert a downward pressure on long-term interest rates and support more accommodative broad financial conditions (Board of Governors of the Federal Reserve System, 2011).

[47]See Board of Governors of the Federal Reserve System (2011); and Fisher (2010).

Figure 3.9. Government Securities Purchases and Holdings by Sectors
(In percent)



Sources: Bank of England; national flow of funds data; and IMF staff estimates.
[1]For the U.K., includes financial institutions other than investment funds.

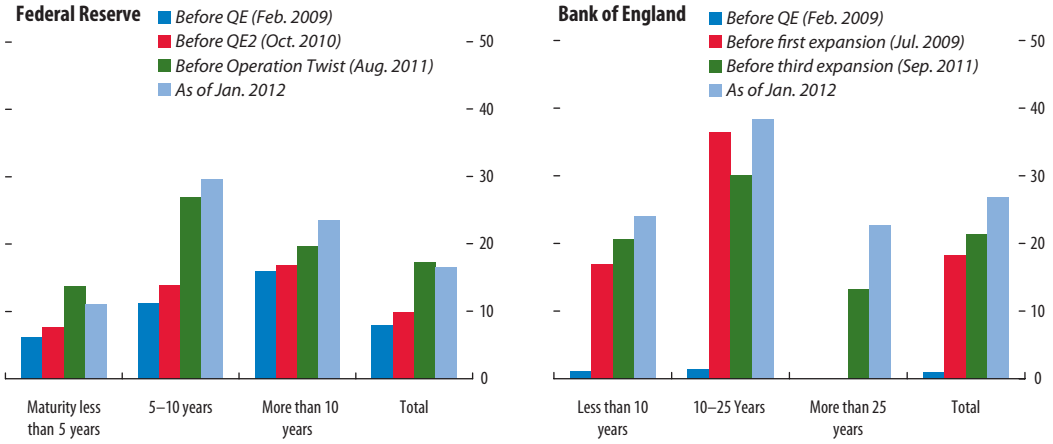
real terms and to higher currency risks. Large-scale asset purchases can also have an adverse effect on the political incentives to improve fiscal discipline because the back stop of central bank purchases keeps interest rates and thus funding costs low.

Use as Benchmark Securities

Safe assets play an important role as benchmarks both to judge relative performance and to assign prices to other assets. They serve: (1) as an integral part of the mandates of some pension, mutual, and sovereign debt funds globally, and as fund performance benchmarks (for example, market-neutral hedge fund strategies that attempt to be risk free); (2) as reference rates for the pricing, hedging, and valuation of a broad number of risky assets; and (3) as indicators of monetary and financial conditions (for example, an inverted government bond yield curve may signal an incipient economic contraction).

The integration of safe assets in the mandates of various funds suggests that potential shifts away from downgraded sovereign debt can lead to upward demand pressures on AAA-rated securities. Anecdotal evidence suggests that the most conservative global funds and mandates are now moving to AAA-rated

Figure 3.10. U.S. and U.K. Central Bank Holdings of Government Securities, by Remaining Maturity
(In percent of total amount outstanding)



Sources: Bank of England; Federal Reserve; U.K. Debt Management Office; U.S. Department of the Treasury; and IMF staff estimates.
Note: End of month figures. Government securities for the Bank of England exclude treasury bills, indexed bonds, and undated bonds. QE = quantitative easing.

bond indices. For example, some euro government bond fund mandates and benchmarks are increasingly reallocating to AAA-rated sovereign debt. This process could accelerate if debt sustainability concerns widen and sovereign downgrades persist. A reversal of the mandate changes could potentially span years: credit and risk committees of reserve managers, insurance companies, and pension funds would need to be persuaded that the risk-return trade-offs on downgraded entities were sufficiently stable and well performing before the committees readmit them to the benchmark.

Safe assets—via the government yield curve—are also a traditional benchmark in the pricing and valuation of risky assets in financial markets. The benchmark role of the government yield curve is linked to the historically high market liquidity and perceived safety of government securities. Fixed-income securities are often priced at a spread to a government debt instrument of the same maturity. Because of their perceived safety, sovereign yields have also been typically used as risk-free rate proxies in asset valuations. Moreover, the benchmark role of government securities is critical for local market development in emerging economies. The establishment of a liquid government bond yield curve is viewed as a precondition for the development of other market segments—including derivatives and corporate bond markets—typically priced off the government yield curve.

A potential deterioration in their status as the safest assets raises questions about the future role of government securities as benchmarks in the pricing and evaluation of riskier assets. For example, there was speculation that Standard & Poor's downgrade of U.S. sovereign debt from AAA to AA+ in 2011 would lead to a potential loss of the benchmark status of U.S. Treasuries with highly detrimental consequences. Theoretically, complete removal of U.S. sovereign debt would alter portfolio choices rather substantially (see Box 3.5), but to date, the downgrade has had little discernible effect on the status of the U.S. Treasuries as benchmark securities.

In the absence of viable alternatives, it is unlikely that major government securities markets would lose their benchmark role. The role of an alternative benchmark in asset pricing and valuation is often played by the swap curve, even if it is not based on instruments that are considered mostly risk free. For example, the swap curve is the principal asset pricing benchmark in the euro area, given that there are no common sovereign debt instruments and no homogeneous euro area sovereign yield curve.[48] Swap curves—based primarily on "plain vanilla" interest rate

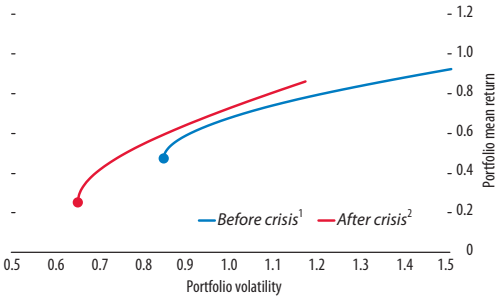
[48]The yield curve of the German bund may be regarded as an alternative benchmark. Also, the ECB publishes two euro area bond yield curves on a daily basis, one for all euro area countries and the other only for AAA-rated government bonds, but none of them is used as often as the swap curve in the euro area.

Box 3.5. The Impact of a Further Loss of Sovereign Debt Safety Illustrated in a Mean-Variance Framework

The impact of a hypothetical loss of sovereign debt safety can be assessed through its effect on portfolio choices in a typical mean-variance framework. The model estimates a mean-variance efficient frontier of returns of portfolios constructed from a set of base assets.[1] Even though the method assumes stable relationships among asset correlations across the experiments conducted below, it can help to illustrate the potential impact of the crisis and of a hypothetical elimination of safe assets on portfolio choices.

Contrary to intuition, the volatility of the optimal portfolios decreased after the crisis, thus raising the potential safety of bond portfolios for short-term investors.[2] The monthly volatility of the minimum variance portfolio decreased to 0.65 percent post-crisis from 0.85 percent in the period before 2008 (Figure 3.5.1). This result was driven by the sharp decline in the correlations across many of these assets after the global crisis, which allowed investors to reduce fluctuations in their portfolios despite stronger volatility in individual asset returns. This does not contradict the sharp increase of correlations across asset classes driven by the initial panic selling immediately after the failure of Lehman Brothers. More specifically, the crisis produced a decoupling of the returns of various sovereign bonds, giving investors the opportunity to better exploit the power of diversification and to construct portfolios whose ultimate volatility is much smaller. This highlights the importance of viewing asset safety from a portfolio perspective. For the minimum variance portfolio considered here, the crisis

Figure 3.5.1. Efficient Frontier, before and after Crisis
(In percent)



Sources: Bloomberg L.P.; and IMF staff estimates.
[1]January 1997 through December 2007.
[2]January 2008 through October 2011.

increased the role of U.S. sovereign debt—and of French, Spanish, and Finnish sovereign bonds—in the safest portfolio, and conversely reduced the importance of Pfandbriefe and Dutch, German, and Italian sovereign bonds.[3]

A hypothetical deterioration of highly rated sovereign debt would likely have considerable repercussions for the ability of investors to protect themselves from risks. Potential sovereign debt problems are modeled via the estimation of an efficient frontier that excludes the debt of key countries, such as France, Germany, the United States, and peripheral euro area countries. The exclusion of U.S. debt would make investors less capable of shielding their portfolios from risks, as shown by the sharp inward contraction in the efficient frontier (Figure 3.5.2). The special role of U.S. debt in safe portfolios is even more discernible when one compares the considerable impact of a deterioration of U.S. debt markets to the negligible impact of potential

Note: Prepared by Tiago Severo.

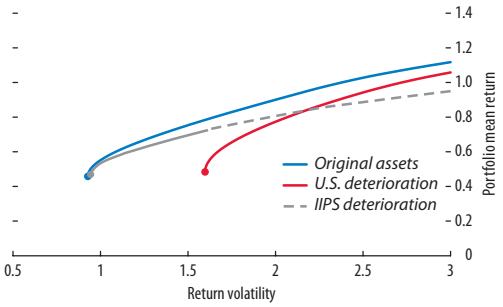
[1]The efficient frontier is the curve of minimum return volatilities for any given level of expected returns of portfolios constructed from base assets. The base assets consist of 14 sovereign debt instruments issued by major advanced economies, a highly collateralized bond issued by German banks (the Pfandbriefe), five broad stock indexes, and a short-term asset represented by the three-month Treasury bill. The efficient frontier is constructed from portfolios of the base assets to minimize the return volatility for any given level of expected returns. The expected returns on the assets and their variance-covariance matrix are estimated on the basis of a sample of monthly returns between January 1997 and October 2011.

[2]The precrisis period covers the beginning of 1997 to the end of 2007; the crisis period covers the period from January 2008 through October 2011.

[3]The basic intuition for explaining the increased role for Spanish bonds after the crisis is that they became less correlated with the sovereign bonds of core advanced economies, particularly Finland, the Netherlands, the United Kingdom, and the United States. Given that the sovereign bonds of these core countries gained importance in the minimum variance portfolio, the appeal of Spanish bonds also increased. Moreover, Spanish bonds are highly correlated with Italian bonds. Thus, during the crisis, the optimal portfolio had large short positions in Italian bonds, offset by long positions in Spanish bonds. Conversely, German bonds became less important because of their high correlation with U.S. bonds.

Box 3.5 *(continued)*

Figure 3.5.2. Debt Deterioration and the Efficient Frontier
(In percent)



Sources: Bloomberg L.P.; and IMF staff estimates.
Note: IIPS = Ireland, Italy, Portugal, and Spain.

problems in other markets (Figure 3.5.2, line for Ireland, Italy, Portugal, and Spain). This interpretation assumes that the correlation structure remains intact and that investors are predominantly making buy/sell decisions on the basis of risk and return rather than for liquidity or other reasons.

swaps—incorporate market perceptions of average bank credit risk and interest rate expectations and thus embed explicitly some credit risk. In view of this risk, the swap curve is typically above the Treasury yield curve, with swap spreads widening with market volatility and higher counterparty credit risks. However, at times of heightened sovereign risks, the swap curve is linked to the Treasury yield curve, in view of the linkages between sovereign and banking risks. Overall, in the absence of viable alternatives, markets will likely continue to use government yield curves or swap curves as benchmarks, even if they are not perceived to be based on truly risk-free assets.

The Supply of Safe Assets

From the preceding discussion, it is clear that the demand for safe assets is subject to considerable upward pressures. This section examines whether supply is likely to satisfy such demands. It analyzes, in turn, the role of sovereign issuers, the private sector, central banks, and emerging markets (Table 3.3).

Sovereign Supply

Traditionally, the issuance of sovereign debt by the advanced economies has been a key source of safe assets in global financial markets. Before the crisis, the safety of these instruments was underpinned by two features: the rarity of sovereign default, and the strength of advanced economies' political institutions, including government taxing power.

However, the recent considerable deterioration of some advanced economies' fiscal profiles has reduced the supply of sovereign debt perceived as safe. The sharp increase in advanced economies' public indebtedness after the global financial crisis, combined with low tax revenues and high current and future public expenditures, has raised concerns about the sustainability of their debt. Such concerns have been augmented by government difficulties—including the political gridlock in the United States and Europe—that have impaired the ability of advanced economies to devise credible adjustment strategies that properly balance short-term concerns about economic activity with long-term fiscal consolidation. Thus, while 68 percent of advanced economies carried a AAA-rating at end-2007, the proportion dropped to 52 percent by end-January 2012 (Figure 3.11, left panel).[49] This amounts to

[49]As discussed previously, ratings are subject to considerable deficiencies and should be viewed only as a loose indication of credit quality. They are used here given their extensive use by investors and ready availability over time; as earlier GFSR analysis showed, asset safety should not be viewed as being directly linked to credit ratings. See IMF (2010b) for a more extensive discussion of ratings and their role.

Table 3.3. Demand and Supply Factors and their Anticipated Impact on Safe Asset Markets

Source of Demand	Investor Type	Important Short- to Medium-Term Factors	Expected Impact on Demand
Stable store of value in a portfolio management context	Reserve managers	Importance of safety considerations in strategic asset allocation and rising overall reserves, partly mitigated by increasing diversification and reallocation to sovereign wealth funds	↑
	Insurance companies and pension funds	Demand related to overall investment policy, but low-interest-rate environment may limit safe asset allocation by putting pressure on profitability	→
	Nonbank financial institutions	Flight to safety due to the European sovereign debt crisis (temporary effect related to the market turmoil)	↑
High-quality collateral for financial transactions	Banks and other financial institutions	Gradual shift of over-the-counter derivatives to central counterparties	↑
		Limits on the reuse of collateral and decreasing velocity of collateral	↑
		Increasing importance of secured funding sources for financial institutions with more differentiation in terms of applied haircuts in repo transactions[1]	→
Cornerstone in prudential regulations	Banks	Introduction of the liquidity coverage ratio (Basel III) (temporary effect)	↑
		Higher risk weights for riskier or downgraded sovereign debt	[2]
	Insurance companies	Treatment of sovereign debt and covered bonds under Solvency II	↑
Part of crisis-related liquidity provision	Central banks	Crisis-related monetary easing	↑
Benchmark for other assets	Banks and other financial institutions	Shift in the structure of demand toward assets that are perceived as relatively safer (e.g., U.S., U.K., Germany)	[3]

Source of Supply	Important Short- to Medium-Term Factors	Expected Impact on Supply
Sovereign issuers	Considerable deterioration of fiscal profiles in some advanced economies	↓
Private sector	Reduced effectiveness of traditional hedging instruments	↓
Central banks	Crisis-induced extension of liquidity provision	↑
Emerging markets	Restricted ability to generate safe assets (financial development, legal institutions, etc.) and lower degree of financial depth than advanced economies	→

Source: IMF staff.

Note: → indicates no impact; ↑ indicates an increase; ↓ indicates a decrease.

[1]Temporary effect due to disruptions of funding markets but possibly a more structural trend in the future.

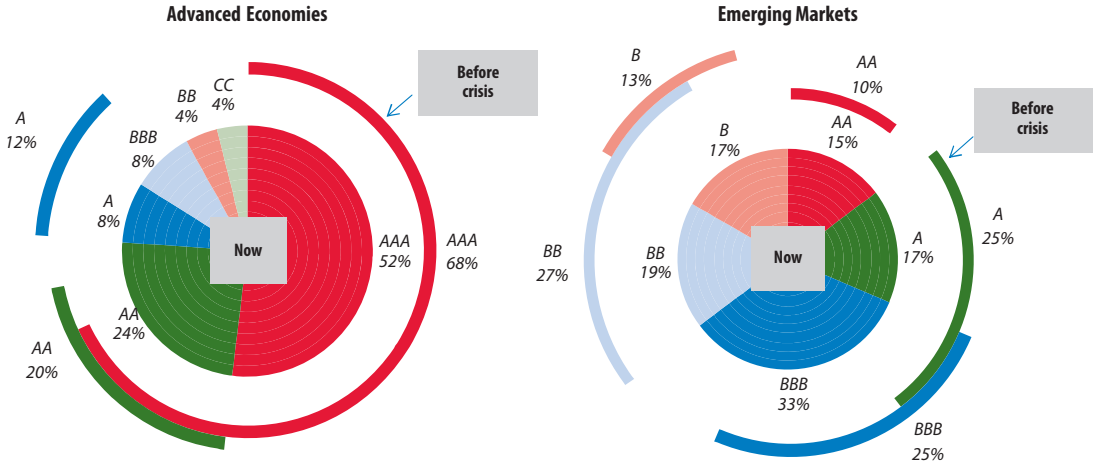
[2]Possibly less demand for riskier or downgraded sovereign debt and higher demand for relatively safer or higher-rated sovereign debt as substitute.

[3]Overall impact will depend on evolution of perceptions of safety for benchmark assets.

approximately $15 trillion of sovereign debt globally as of end-June 2011.

The experience of advanced economies shows that safety is a special characteristic of assets that can be lost very rapidly if market perception of soundness deteriorates. As the recent crisis in southern Europe suggests, once a country's ability or willingness to service its debt starts to be questioned by investors, they begin to move their holdings to other assets that are thought to be safer. Hence, deterioration in fiscal conditions has an important endogenous effect on the supply of safe financial instruments.

Figure 3.11. Distribution of Selected Advanced and Emerging Market Economies, by Sovereign Debt Rating
(In percent of total)



Source: IMF staff estimates based on S&P ratings of 25 advanced economies and 48 emerging market economies.

The considerable deterioration in the perceived safety of sovereign debt raises doubts about the ability of sovereigns to act as suppliers of safe assets, a role that they are best positioned to serve. The critical importance of advanced economies' sovereign debt is related to two factors: the very large stocks of these securities and their ability to readily meet the collateral and regulatory requirements faced by various investors. Regarding its formidable size, the aggregate general government gross debt of advanced economies amounted to over $47 trillion at end-2011, on average accounting for roughly 69 percent of each country's output (Figure 3.12). IMF projections suggest that the total outstanding government debt of this group of countries will rise to roughly $58 trillion by 2016, an increase of 38 percent in five years.[50] Unlike securitized instruments or covered bonds produced by the private sector, sovereign debt can generate safety that is intrinsic rather than synthetically created by combining the payoffs of risky instruments.

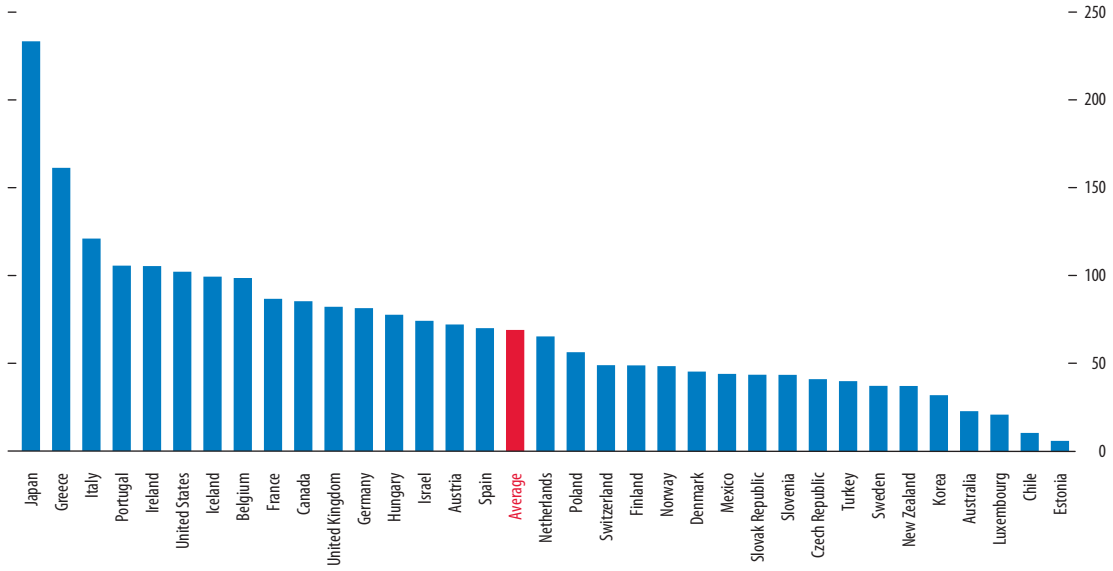
Both the lack of political will to reshape fiscal policies at times of rising concern over debt sustainability and an overly rapid reduction of fiscal deficits limit governments' capacity to produce assets with low credit risk. When large primary deficits—in line with those observed in 2010—persist over extended periods, it is difficult to return public sector fundamentals to sound levels. This suggests that unsustainable fiscal policies that are not reversed in a timely manner impair long-term asset safety. Conversely, up-front austerity measures could impair the sustainability of a country's public debt, especially if accompanied by rapid private sector deleveraging and a contraction in GDP. Thus, the pace of improvement of fiscal fundamentals needs to account for the impact on economic growth and take into consideration country-specific circumstances.

The fiscal deterioration in advanced economies can have considerable consequences. If levels of recent credit default swap (CDS) spreads on sovereign debt are used as the criterion for excluding certain countries as suppliers of safe assets, current and projected supply would drop significantly.[51] Using spreads above 350 basis points at end-2011 as the cutoff would exclude Greece, Hungary, Ireland, Italy, Portugal, Slovenia, and Spain, and the projected 2012 supply of safe assets would

[50]Outstanding government debt is measured in current prices. Projections of total outstanding debt are based on the *World Economic Outlook*.

[51]The exclusion of certain countries' assets is justified by investors' decisions to underweight or to exclude underperforming bonds, even where existing benchmarks are retained. See Chapter 2 for a discussion in the context of the recent removal of Portuguese bonds from the Citigroup World Government Bond Index.

Figure 3.12. OECD Countries: General Government Gross Debt Relative to GDP, End-2011
(In percent)



Source: IMF, World Economic Outlook database.

drop by $4.6 trillion (Figure 3.13).[52] This contraction would increase to $8.1 trillion, or approximately 16.4 percent of the 2012 total supply of advanced economy debt, if countries with five-year CDS spreads above 200 basis points at end-2011—including Belgium, France, Iceland, Poland, the Slovak Republic, and Turkey—are also excluded. Projections of advanced economy public indebtedness indicate that the exclusion of all 13 countries from the sample will reduce the supply of safe public debt by more than $9 trillion by 2016, or about 16 percent of the 2016 projected total.[53]

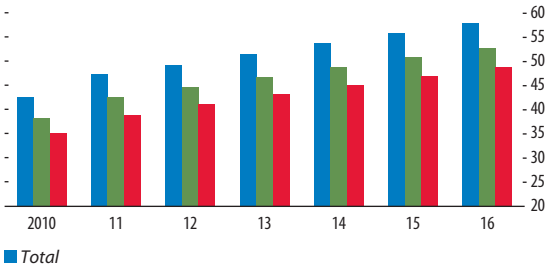
Private Sector Supply

The production of safe assets by the private sector largely collapsed with the onset of the global crisis. Total private sector securitization issuance declined from more

[52]The spreads are the prices paid for five years of protection (via CDS contracts) against default of the debt, with the price expressed in basis points of the nominal amount insured.

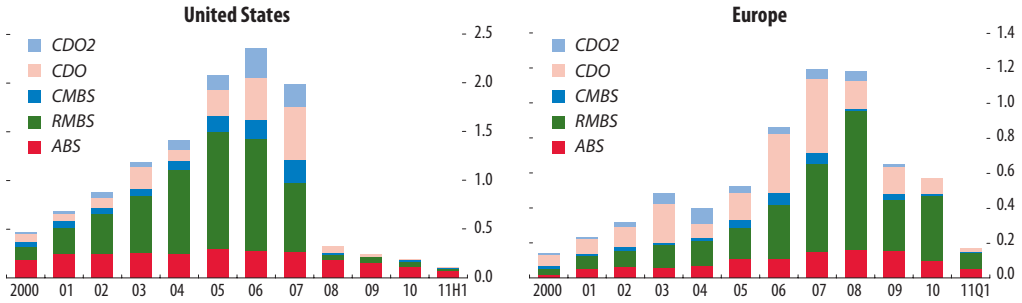
[53]The numbers are based on extrapolations rather than forecasts; realization of the latter depends critically on the developments in the Greek and euro area crisis discussions and other factors.

Figure 3.13. OECD Countries: General Government Gross Debt, 2010–16
(In trillions of U.S. dollars)



Sources: Bloomberg L.P.; and IMF, World Economic Outlook database.
Note: For 2012–16, the data are projections.
[1]Greece, Hungary, Ireland, Italy, Portugal, Slovenia, and Spain.
[2]Belgium, France, Greece, Hungary, Iceland, Ireland, Italy, Poland, Portugal, Slovak Republic, Slovenia, Spain, and Turkey.

Figure 3.14. Private-Label Term Securitization Issuance
(In trillions of U.S. dollars)



Sources: Association for Financial Markets in Europe; Board of Governors of the Federal Reserve System; Fitch Ratings; Inside Mortgage Finance; JP Morgan Chase & Co.; Merrill Lynch; and IMF staff estimates.
Note: ABS = asset-backed security; CDO = collateralized debt obligation; CDO2 = CDO-squared and CDOs backed by ABS and MBS; MBS = mortgage-backed security; RMBS = residential MBS; CMBS = commercial MBS.

than $3 trillion in the United States and Europe in 2007 to less than $750 billion in 2010 (Figure 3.14). The extraordinary volume of precrisis issuance was driven by the perception that the instruments were nearly risk-free while offering yields above those of the safest sovereigns. By construction, the high risk levels inherent to the lowest-rated (equity) tranches of the structured securities were expected to be offset by the near risk-free senior AAA-rated tranches. In reality, as the global financial crisis showed, the losses in the underlying portfolios were sufficiently large to threaten the solvency of even senior AAA-rated tranches. Moreover, the lack of information on the quality of the underlying assets made estimations of true asset value difficult and hence sensitive to sudden bad news. As a result, investors are still generally unwilling to invest much in these types of assets.

The ability of private issuers to generate safe assets depends critically on the inherent credit risk of issued instruments. These risks are determined not only by the issuers' default risk but also by the structure of such instruments. An interesting case in this regard is that of covered bonds, or German-style Pfandbriefe. Covered bonds are similar to traditional securitized instruments in being typically structured to ensure higher perceived safety than warranted by issuers' own credit profiles.[54] However, two critical aspects differentiate covered bonds from typical securitizations: the unobstructed access they provide to asset pools in case of an issuer default and, perhaps most importantly, the ongoing substitutability of asset pools that underlie these bonds. The latter feature ensures that the quality of asset pools is kept high at all times, as issuers are required to substitute or add collateral in case of credit quality deterioration (thus ensuring overcollateralization).

Aside from securitization, there are other, more conventional strategies that allow investors to effectively manufacture safe assets from combinations of risky payoffs. For example, investors who want to purchase a safe debt instrument may buy risky debt from a corporation or a sovereign and combine it with a CDS on the reference entity. As long as counterparty risk in the CDS market is small, the payoff of this portfolio will resemble that of safe debt from the perspective of credit risk.

However, policies implemented during the recent turmoil may have reduced the effectiveness of traditional hedging instruments. For example, the authorities' desire to avert a trigger on CDS payments and the imposition of voluntary losses on private investor holdings of Greek sovereign debt until recently impaired the integrity of this hedging mechanism. Similarly, prohibitions imposed by some advanced economy governments on short sales of sovereign debt constrain investors' hedging strategies and thus their ability to create synthetically safe assets. Some investors have responded to these measures by resorting to alternative strategies that mimic the hedging properties of the disallowed hedging mechanisms. For example, the earlier decision to avoid the trigger of the CDS on Greek sovereign debt may have induced investors to short bonds issued by other euro area countries to obtain sovereign risk protection.

[54]See Packer, Stever, and Upper (2007).

Box 3.6. Conventional Monetary Policy and Its Demand for Safe Assets under Normal Conditions

On the supply side, central banks can augment banking system reserve balances, primarily via open market operations. From the perspective of a bank, such reserve balances can be viewed as safe assets because they: (1) are most liquid (can be used for immediate settlements), (2) carry no market risk (nominal values remain constant), and (3) do not embed credit risk (at least in nominal terms, given central banks' ability to issue fiat money).[1] Central banks also supply banknotes—a medium of exchange without market and credit risks in the present context—to the general public.[2]

On the demand side, central banks conduct collateralized lending—including securities repo transactions—and outright securities purchases to provide the most liquid assets to the financial system (Table 3.6.1). Central banks generally do not engage in unsecured lending so as to protect themselves (and ultimately, to protect taxpayers should central banks need to be recapitalized) against financial losses related to counterparty defaults. In this context, eligible collateral for open market operations and standing facilities also tends to be restricted to high-quality securities. However, the types and range of such collateral vary considerably across central banks, in view of country-specific factors such as banking and financial market structures, number and diversity of counterparties, and statutory requirements.[3]

Similarly, eligible securities for outright purchases are generally limited to domestic government securities and, to a lesser extent, securities issued by central banks (Table 3.6.2). Because many countries have deep markets for government securities, such purchases are often used by central banks as a tool for injecting liquidity into the financial system while minimizing interference in domestic capital allocation and credit risk.

Table 3.6.1. Proportion of Central Banks Using Selected Tools for Open Market Operations, 2010
(In percent)

Outright purchase of securities	56.3
Securities repo	79.6
Collateralized lending	65.0

Source: IMF Information Systems for Instruments of Monetary Policy (2010).

Note: Results are for 103 central banks. Many central banks use more than one of the tools shown.

Table 3.6.2. Proportion of Central Banks Purchasing Selected Securities for Open Market Operations, 2010
(In percent)

Government securities	70.7
Central bank liabilities	43.1
Other	15.5

Source: IMF Information Systems for Instruments of Monetary Policy (2010).

Note: Results are for 58 central banks that conduct outright purchases of securities for open market operations. Many central banks purchase more than one of the types shown.

Note: Prepared by Ken Chikada.

[1] This in turn implies that central bank money is susceptible to inflation risk and thus is not entirely risk free.

[2] Central banks could also issue central bank bills or offer term deposits to financial institutions. Such instruments could be considered safe assets in a broader context, as they have zero credit risk and generally low market risk, given their short-term maturities. Also, they are typically used to absorb excess liquidity in the system and thus are tools for maturity and liquidity transformation within the central banks' liabilities.

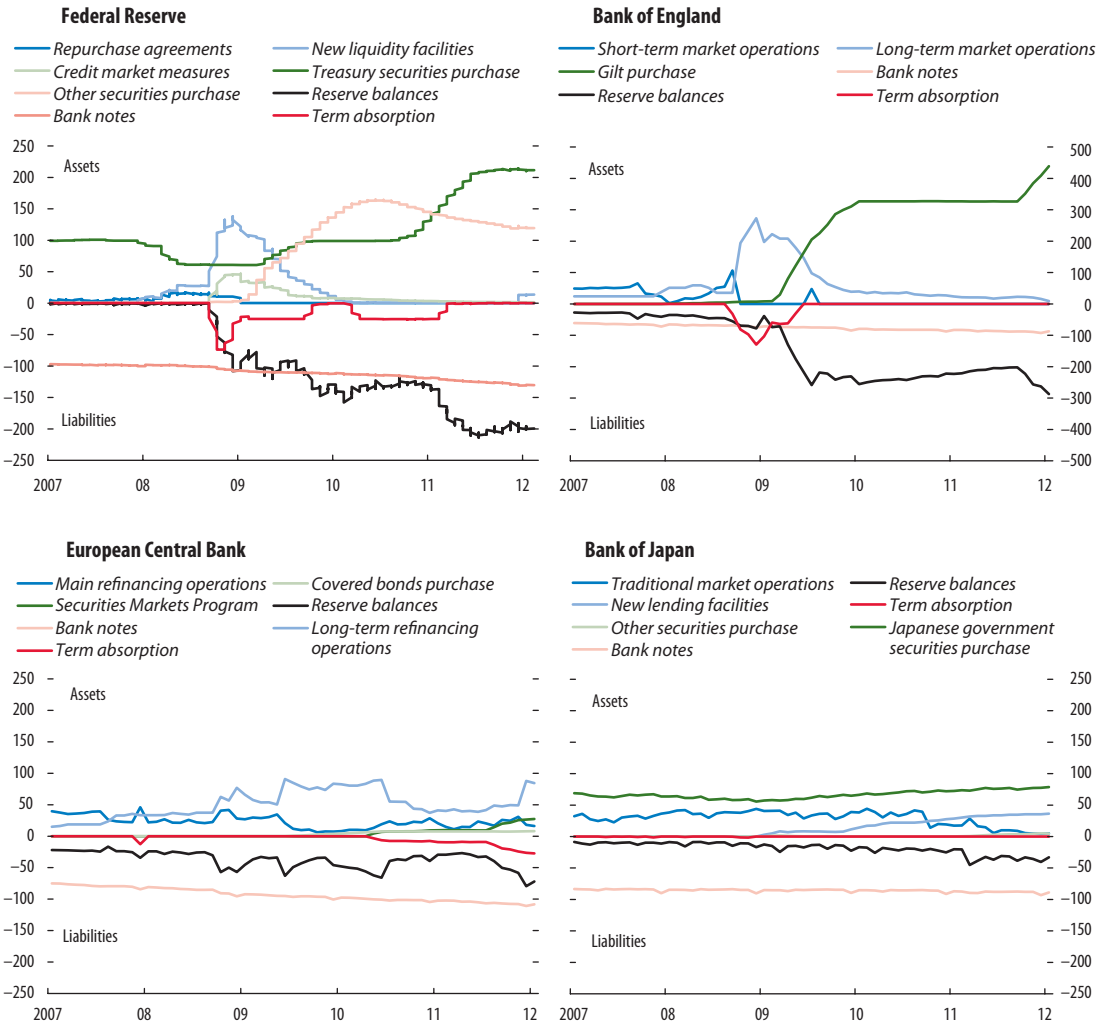
[3] See Chailloux, Gray, and McCaughrin (2008); and Cheun, von Köppen-Mertes, and Weller (2009) for more details on the collateral frameworks.

Central Bank Supply

In response to the global financial crisis, major central banks undertook the role of providing safer assets. In normal times, central banks enlarge or reduce the supply of central bank money in the system through exchanges of high-quality securities with longer maturities and less liquidity; thus they in effect conduct maturity and liquidity transformation within the safe asset universe (see Box 3.6).[55] In contrast, during the crisis, central banks could and actually did act as a backstop by temporarily exchanging riskier assets with safer ones (central bank money), in part via an expansion of eligible collateral types, with more frequent open market operations to a broader range of counterparties and at

[55] Liquidity here refers to closeness to cash.

Figure 3.15. Selected Advanced Economies: Changes in Central Bank Assets and Liabilities since the Global Crisis
(In percent relative to monetary base at end-2006)



Sources: Bloomberg L.P.; central banks; Haver Analytics; and IMF staff estimates.

Note: Monetary base here is defined as bank notes in circulation plus reserve balances (including excess reserves and overnight deposit facilities). Term absorptions consist of term deposits, reverse repo transactions, central bank bills (for the Bank of Japan), and U.S. Treasury Supplementary Financing Account (for the Federal Reserve). New liquidity facilities and new lending facilities include measures that were already terminated. New liquidity facilities of the Federal Reserve include U.S. dollar liquidity swap arrangements with central banks. Credit market measures of the Federal Reserve consist of facilities such as the Commercial Paper Funding Facility, Asset-Backed Commercial Paper Money Market Mutual Fund Liquidity Facility, and Term Asset-Backed Securities Loan Facility.

longer maturities. They also made direct or indirect purchases of securities that had lost liquidity—a key characteristic of safety—in specific market segments, including commercial paper, corporate bonds, and asset-backed securities (Figure 3.15).[56] While valuable as a crisis management tool, this process clearly has limits, as central banks assume the credit risk of the securities taken onto their balance sheets.

[56]This process is still under way in the euro area. For a more general discussion and assessment of unconventional monetary policies, see Borio and Disyatat (2009); and IMF (2009b), for example. In contrast to a central bank's traditional role as the lender of last resort, Tucker (2009) refers to this new role as the market maker of last resort.

As a result of these crisis-driven operations, the increase in central bank reserve balances was quite pronounced, particularly for the Federal Reserve, the Bank of England, and the European Central Bank. Spikes in central bank liabilities were initially facilitated by newly established liquidity facilities and longer-term open market operations that replaced traditional short-term market operations.[57]

- In the *United States*—where capital markets play a considerable role in corporate and household financing—direct nongovernment securities purchases and indirect purchases via credit market measures accounted for most of the marginal increase in Federal Reserve assets.
- In *Japan*, the increase in reserve balances and central bank assets was less pronounced, given that the Japanese financial system was less affected by the global financial crisis.
- In *Europe,* market stress prompted the ECB to resume covered bond purchases, broaden the criteria for collateral eligibility and, most recently, initiate the provision of longer-term liquidity (at a maturity of 36 months) to support bank lending and liquidity in the euro area market.[58] The ECB also launched the Securities Markets Program (SMP) to ease stress in the markets for peripheral euro area sovereign bonds, playing a role akin to a market maker of last resort. It also reabsorbed SMP-provided liquidity via weekly operations. From the banks' perspective, the two operations jointly amounted to an exchange of assets (bonds) with lost safety features for safe assets (term deposits offered by the central bank). The ECB's three-year longer-term refinancing operations have provided large amounts of liquidity to euro area banks, part of which could be used to purchase safer securities.

[57]Initially, the ample liquidity was partly offset by liquidity absorption operations to control policy interest rates. However, as the policy interest rates were subsequently cut closer to zero, use of absorption tools generally declined.

[58]Also, in November 2011, major central banks enhanced their capacity to provide dollar-based liquidity support to the global financial system by lowering the pricing on the existing temporary U.S. dollar liquidity swap arrangements.

Supply by Emerging Market Economies

The high demand for safe assets produced by advanced economies has been, in part, supported by the inability of emerging market issuers to contribute to the global supply of safe assets. Many emerging markets are still in the process of developing well-functioning financial systems, which are characterized by sound legal institutions and adequate property rights. The absence of market infrastructures on par with those of advanced economies means that governments, corporations, and individuals will continue to have difficulties pledging future cash flows associated with the issuance of local currency debt securities. Such limitations curb the supply of assets in local capital markets and limit the development of liquid financial markets, forcing some to seek assets outside their country, with attendant currency risks. Though shrinking, the disparity in the degree of financial depth between emerging markets and advanced economies is still considerable. At end-2009, emerging markets accounted for approximately 40 percent of global GDP (Kose and Prasad, 2010), but their contribution to financial depth was less than 20 percent of that of advanced economies (Table 3.4).

Financial Stability Implications

Considerable upward pressures on the demand for safe assets at a time of declining supply entails sizable risks for global financial stability. The unmet demand drives up the price of safety, with the safest assets affected first.[59] In their search for safety, investors that are unable to pay the higher prices are likely to settle for assets that embed higher risks than desired. These risks would also affect markets more broadly. For example, if prime collateral became too expensive, funding markets would need to accept lower-quality collateral and absorb risks that, depending on how far this process goes, may impinge on the trust that underpins effec-

[59]Quantification of demand pressures and forthcoming safe asset supply is difficult, given uncertainties in the economic and financial environment. Therefore, it is impossible to predict how demand pressures will translate into demand for specific assets (such as U.S. Treasuries) and how much of the projected supply will be considered safe.

Table 3.4. Top Five Financially Deep Worldwide Economies, as Share of Own GDP and of Global Financial Depth, 1989 and 2009

In Percent of Own GDP				In Percentage Contribution to Global Financial Depth			
1989		2009		1989		2009	
				World	**100**	**World**	**6.71**
Advanced economies				**Advanced economies**	**92.58**	**Advanced economies**	**82.03**
Japan	7.25	Ireland	21.61	United States	32.45	United States	29.28
Switzerland	6.48	United Kingdom	12.64	Japan	28.26	Japan	13.12
Belgium	5.45	Switzerland	11.48	United Kingdom	5.69	United Kingdom	7.73
United Kingdom	5.03	Netherlands	10.63	Germany	5.33	Germany	6.04
United States	4.51	Japan	9.31	France	4.53	France	5.40
Emerging markets				**Emerging markets**	**7.42**	**Emerging markets**	**17.97**
Lebanon	8.94	Hong Kong SAR	26.67	Brazil	1.94	China	7.13
Hong Kong SAR	7.44	Singapore	10.47	China	0.93	Brazil	1.63
Malaysia	4.92	Lebanon	7.44	Hong Kong SAR	0.67	Hong Kong SAR	1.56
Singapore	4.76	South Africa	6.47	Republic of Korea	0.66	Republic of Korea	1.15
South Africa	3.96	Malaysia	6.30	India	0.54	India	1.14

Source: Goyal and others (2011) based on data from the Bank for International Settlements, the World Bank, and an updated dataset of "external wealth of nations" constructed in Lane and Milesi-Ferretti (2007) for 50 economies, half advanced and half emerging, that collectively account for more than 90 percent of global GDP.

Note: Summing all assets and liabilities (held against residents and nonresidents) as a share of GDP gives a measure of the weight of total financial claims and counterclaims of an economy—both at home and abroad. Domestic claims are defined as the total of domestic financial liabilities, including broad money, resident claims on the banks, domestic securities, and stock market capitalization. The table also shows financial depth, as a share of global depth (right columns; each country's contribution is weighted by its GDP).

tive market functioning. Such frictions in funding markets can reduce the ability of financial institutions—including investment banks, asset managers, and hedge funds—to secure funding or onlend excess funds. This process was discernible in 2008 after the collapse of Lehman Brothers: because only short-term Treasuries continued to be widely accepted in repo operations, investors bid up their price to the point that their nominal yields turned negative.

Demand-supply imbalances in safe asset markets could also lead to more short-term volatility jumps, herding, and cliff effects. In an environment of persistent low interest rates and heightened financial market uncertainty, excess demand in the markets for safe assets can raise the frequency of short-term volatility spikes and potentially lead to asset bubbles. Rapid changes in investor perceptions of safety and insufficient differentiation in the risk categorization of assets, either in terms of creditworthiness or liquidity, could lead to cliff effects, in which deterioration in market conditions and a downgrade could lead to an automatic reclassification of assets to a lower category and a sudden price drop of those assets. Tying up high-quality collateral in CCP guarantee funds and initial margin to improve CCP solvency profiles may reduce liquidity in OTC derivative markets and, more generally, in repo markets; as a result, various shocks could lead to price spikes and shortages of high-grade collateral.[60]

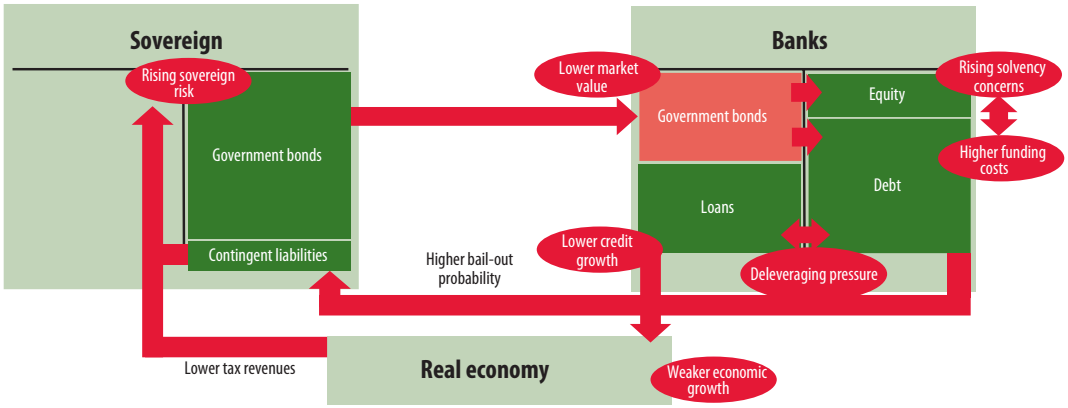
Banks are also exposed to unintended risks related to the preferential regulatory treatment of sovereign debt. The common use of zero percent risk weighting on banks' holdings of their own sovereigns' debt, and the extension of this practice to holdings of other sovereign debt within a monetary union, leads to harmful effects on bank resilience and intermediation. It encourages more leverage on safe assets and potential overinvestment in higher-risk sovereigns with favorable risk-return characteristics, leading to possible undercapitalization of banks in times of stress.

Banks' sizable sovereign exposures, in part related to regulatory incentives, can act as a contagion channel between sovereigns and the banking sector with knock-on effects to the economy. Sovereign risks can have a negative spillover to banks via valuation losses on sovereign debt holdings and, thus, a drop in collateral values. This risk could lead to exclusion of sovereign securities from collateral pools and may impair banks' ability to obtain secured funding (Figure 3.16).[61] Mounting sovereign risks may also

[60]Collateral posted in CCP guarantee funds and for initial margin cannot be rehypothecated, unlike in repo markets, and hence reduces collateral available for other uses.

[61]See Committee on the Global Financial System (2011); and IMF (2011a) for a detailed discussion of the transmission chan-

Figure 3.16. Government Bond Holdings and Risk Spillovers between Sovereign and Banks



depress the value of explicit and implicit government guarantees and thus elevate the credit and liquidity risks—particularly funding costs—of banks benefiting from such guarantees. In reverse, banking sector stress can create higher contingent liabilities for the sovereign sector or the need for outright government support. If risk weights suddenly increase, banks may be prompted to deleverage by curbing new lending, leading to a dampening effect on economic growth, and to secondary effects on sovereigns via weaker tax revenues. Ultimately, this could exacerbate negative feedback loops between sovereigns and the banking sector, as has been observed in parts of Europe in recent months (see Chapter 2).

A crucial mitigating factor that may have tempered the immediate concerns arising from a shortage of safe assets has been the provision of abundant liquidity by central banks. Although these measures will allow banks to continue to fund themselves in the short term and hold onto assets of all risk profiles, they will not remove the underlying tension in the markets for safe assets, as described here.

Key Conclusions and Policy Implications

Flexibility in policy design and implementation is warranted to ensure a smooth adjustment to the upcoming supply and demand pressures on the markets for safe assets. Investors' cost of safety will inevitably rise, but an adjustment process that is too abrupt or too volatile may compromise financial stability. Stronger demand for certain assets deemed the safest will put upward pressure on their prices, while assets suddenly viewed as less safe may be subject to downward pressures. Arguably, the cost of safety was distorted before the crisis, but the demands arising from regulatory reforms and ongoing central bank policies suggest potentially substantial pressure on certain safer asset classes. Policymakers should be cognizant of the effects of existing and upcoming policies on spurring demand for safe assets.

Ultimately, efforts to ensure that fine distinctions across safe assets are reflected in regulation or policy responses could help alleviate discontinuities or cliff effects in their usage and pricing.

- As shown in Box 3.3, the common application of a zero percent risk weight on holdings of debt issued by a bank's own sovereign, irrespective of its risk, tends to inflate bank capital adequacy levels. This creates a perception of safety detached from underlying economic risks and leads to an inflated demand for such safer assets. Hence, for banks, sovereign debt should ultimately carry assigned risk weights that more accurately reflect

nels. As discussed in IMF (2011a), even in cases where heightened sovereign risk is not reflected on banks' financial statements—for example, via banking book sovereign exposures and valuations at amortized costs—creditor perceptions of balance sheet weakness and heightened bank credit risk can increase bank vulnerability since credit risk is assessed in economic rather than accounting terms.

the relative credit risk of the issuing sovereign.[62] While a discussion of changes in risk weights for sovereign debt should be initiated, any alteration will need to be examined carefully in advance since establishing risk weights is particularly difficult in the context of sovereign debt. Measures such as CDS spreads are likely to be too volatile to be practically implementable; however, there is a range of other methods for estimating sovereign risk that could be considered.[63] Any change to risk weights should be introduced gradually and reviewed periodically to avoid market disruptions. It should be noted that the introduction of a non-risk-weighted leverage ratio under Basel III will complement risk-weighted capital adequacy requirements.

- The new liquidity coverage ratio in Basel III would require banks to hold more liquid assets to better address short-term funding pressures. The qualifying highly liquid assets mostly consist of the safest assets; as Box 3.4 shows, banks could require some $2 trillion to $4 trillion of such assets to meet the new ratio unless they adjust their funding profiles. It will be important to ensure that, when the regulation is formally implemented at end-2014, haircuts for liquid assets of different quality can be reviewed at appropriate intervals and reflect the differential risks across the eligible assets. Basel III's observation period for the ratio would allow the Basel Committee to revisit the calibration of haircuts to avoid sudden changes. Attention to the implementation of Solvency II for EU insurance companies is also warranted, as similar incentives to hold certain safe assets are also present.
- The use of safe assets as collateral for CCP default funds—in the context of the anticipated move of OTC contracts to CCPs—is another area where demand pressures can be alleviated by some flexibility in the definition of acceptable safe assets. By ensuring that CCP oversight allows for a broad range of collateral (with appropriate risk-based haircuts and minimum criteria for inclusion) alongside other risk management practices, undue pressures on certain types of safe assets can be avoided without compromising the soundness of the CCP.

Supply-side measures could stem upward price pressure on highly demanded safe assets.

- The issuance of government securities is not meant to be the sole means of satisfying the demand for safe assets. Nonetheless, countries that experience fiscal difficulties and face questions about their credit quality would obviously benefit from a strong and credible commitment to medium-term fiscal adjustment, not least because it could curb the downward migration in their credit ratings and could help them regain their debts' safe asset status.[64] Strategies to lower debt levels, improve debt management, and put in place better fiscal infrastructures are generally welcome, as they improve governments' creditworthiness, lower borrowing costs, and enhance economic growth prospects. However, in times of financial stress, these features also help support financial stability by reducing the chance of widespread fire-sales and avoiding rapid declines in the quality of collateral.
- The production of safe assets by the private sector is an important source of supply and should not be unnecessarily impeded. The private market can synthetically create safe assets via combinations of existing intrinsically risky instruments and hedging strategies. To ensure that such products fulfill their safety role, there is a need to introduce: (1) intensive supervision, (2) better incentives for issuers (aligning issuer's compensation with the longer-term performance of the created securities), (3) a robust legal framework, and (4) improved public disclosure to ensure that securitized products are well understood and market participants have the resources and information to price and manage the risks. Well-conceived and regulated

[62]Banks are already permitted to use their own models and apply nonzero risk weights to sovereign debt. Even without using their own models, banks are also permitted to hold more capital against sovereign risk.

[63]For a more detailed discussion of various methodologies and other sovereign risk considerations in the context of risk weighting, see European Parliament (2010). For methodologies used in rating agency analysis, see Standard & Poor's (2011) and Fitch Ratings (2011), for example.

[64]See IMF (2012) regarding the benefits for financial stability of addressing long-term fiscal challenges.

covered bond structures of mortgages (with overcollateralization and the ability to replace impaired loans) are one good example. Sound securitization can also play a role.[65] In contrast, short sale restrictions and hurdles to the use of CDS contracts inhibit the creation of synthetic safe assets. Importantly, the creation of such assets needs to be monitored closely to avert negative experiences similar to the sharp decline in the quality of structured credit products—perceived as safe in view of their AAA ratings—during the financial crisis.

- In emerging markets, prudent fiscal policies together with ongoing improvement in domestic financial infrastructure—including legal certainty, clearing and settlement systems, and transparent and regular issuance procedures—will support further deepening of local sovereign bond markets. Over the longer run, these improvements will facilitate the use of such securities as safe assets both within their domestic context and possibly in global markets.
- It has been suggested that the issuance of bonds that would rely on the ability and willingness of a group of countries to jointly and severally honor their payment obligations could be a source of safe asset production. By sharing creditworthiness, these securities would diminish the chance of sharp increases in borrowing costs due to country-specific events. However, such securities would be considered safe only to the extent that the framework within which they were issued ensured the fiscal sustainability of all the countries backing them. Moreover, while such assets could augment the quantity of safe assets available to investors (in terms of credit risk and market liquidity), sovereigns whose creditworthiness was higher than the pooled credit quality underlying the new bond would face higher borrowing costs.

[65]See IMF (2009a) for a discussion of what constitutes "safe" securitization.

One clear policy response to the crisis has been to make financial institutions more resilient, in part by encouraging them to hold safer assets. This additional policy step, in the context of a shrinking supply, will drive up the price of safety. By itself, this is an appropriate outcome, but the key will be to ensure that prices are allowed to adjust smoothly. In particular, regulatory reforms should be formulated so that the fine distinctions across the relative safety of various instruments and strategies are discernible to all institutions requiring safe assets. Moreover, regulations and market practices should be designed flexibly and phased in gradually according to an internationally agreed schedule, to avoid situations that could harm financial stability.

The provision of abundant liquidity by central banks, especially if in exchange for less liquid collateral, affords crucial temporary relief from some of the strains arising from a shortage of safe assets. Although such measures ensure stability of the financial system in the short term and represent an appropriate crisis management response, they will not provide the lasting answer to the problem of a demand-supply imbalance in safe assets. In sum, maintaining flexible and efficient markets in light of the changing supply and demand conditions for safe assets will help to guarantee a smooth adjustment process and thereby a safer, more stable financial system.

Annex 3.1. Exposures to Common Risk Factors

This exercise analyzes the information contained in the time series and the cross-section of asset returns to identify common factors across a broad set of potentially safe assets. A key objective of the analysis is to gauge how the global financial crisis may have affected commonalities and risk factor exposures across various assets and thus infer the changes in the relative riskiness of these assets. The analysis uses the excess returns of various assets relative to the return on the one-month U.S. Treasury bill, as a safe short-term instrument, to control for the variability in interest rate levels over time.

Methodology

Principal Component Analysis (PCA)

A key aspect of analyzing large sets of asset returns is that their behavior may, in reality, be related to a handful of common patterns. Intuitively, sets of different assets may behave similarly because of the effect of underlying unobservable factors. Statistical methods can assist when the nature of such factors cannot be determined reasonably a priori. PCA is a useful technique in this regard, as it reduces a set of asset returns to a smaller set of uncorrelated variables (principal components) that can capture most of the variability in the original data. Thus, PCA can help identify patterns in data and highlight their similarities and differences. It uses an orthogonal transformation to construct the principal components. The first principal component has as high a variance as possible (that is, accounts for as much of the variability in the data as possible). Each succeeding component in turn has the highest variance possible under the constraint that it be orthogonal to (uncorrelated with) the preceding components. The higher the degree of comovement in the original series, the fewer the number of principal components needed to explain a large portion of the variance of the original series.

Clustering Analysis

To understand the nature of the commonalities in asset returns, cluster analysis is used to identify the structure in the assets' correlation matrix before and after the crisis. The cluster analysis uses an algorithm to sort asset returns into groups in which the members of each group are as similar as possible. At the same time, the groups are formed to be as dissimilar from one another as possible. In effect, the cluster analysis creates groupings in a way that maximizes the average correlations between asset returns in the same group and minimizes such correlations across different groups. The cluster analysis uses Ward's method, which forms clusters so as to minimize the total within-cluster variance. Each step finds the pair of clusters that leads to a minimum increase in total within-cluster variance after merging that pair with the others. This increase is a weighted squared distance between cluster centers.

Data

An initial set of 127 global assets were examined as the broadest set from which investors could choose, spanning asset classes for sovereign and quasi-sovereign bonds, corporate bonds, commodity indices, currencies, and equity indices. Overall, the data cover the period between February 1977 and October 2011, although data availability varies across assets.[65] A narrower representative set of 56 assets across the various classes was used in the analysis to maintain a fully balanced sample, as is required by both techniques. Using monthly asset dollar returns, the excess total return for each asset (in dollars) was computed relative to the return on the one-month U.S. Treasury bill.

Empirical Results

The PCA identifies a few common factors that explain the patterns of correlations between excess monthly asset returns. A significant amount of commonality in the variation of monthly asset returns is captured by the first principal component, which accounts for half of the variation. Furthermore, the first two principal components collectively explain two-thirds of the variance in the asset returns. The first principal component is highly correlated with global liquidity, measured by the money supply (M2) of the G4 economies, and with the excess return on

Note: Prepared by Hanan Morsy.

[65]For most assets, the data start in the 1990s.

the global market portfolio.[66] This suggests that the first principal component is associated with different measures of market risk. The second principal component captures perception of safety, reflected by a high negative correlation with market volatility measured by the VIX index. The second principal component is also significantly related to liquidity and credit spreads, suggesting that it proxies for safety. Other econometric methods were used to check the robustness of the results, including factor model regressions.

The hierarchical clustering broadly confirms the results of the principal component analysis. Prior to the crisis, asset classes were grouped closely into asset pools, corresponding to (1) U.S. debt (sovereign, agency, and corporate); (2) Japanese debt (sovereign and corporate); (3) European sovereign and corporate debt, including highly collateralized bonds issued by German banks (Pfandbriefe) and EU covered bonds; (4) emerging market sovereign debt; and (5) equity market indices, commodities, and currencies. The tight clustering of euro area sovereign debt shows little pricing differentiation across assets of different credit quality.

Postcrisis, AAA-rated corporate securities appear to have decoupled from lower-rated instruments, clustering with U.S. sovereign debt, while corporate debt rated AA and below clustered with European entities. Gold clustered with lower-rated U.S. corporate debt, separated from other commodities. Japanese and U.S. sovereign and highly rated corporate debt have become more tightly clustered, suggesting that investor perceptions of asset safety for both countries differed markedly from those for Europe. All of the above suggests that investors became more discerning in terms of safety.

[66]Monetary policies created an environment of low interest rates, prompted a search for yield, and lowered funding costs for leveraged investors, thereby creating a push factor on asset prices across the globe and inducing prices to move in tandem.

The use of excess market portfolio returns—computed as the difference between the average returns for all assets in the sample and the return on the one-month U.S. Treasury bill—is motivated by the capital asset pricing model. Assets with large exposures to the market tend to be perceived by investors as risky since they typically perform poorly when markets are down. Data for the return on the one-month U.S. Treasury bill were downloaded from the website of Kenneth French (http://mba.tuck.dartmouth.edu/pages/faculty/ken.french).

Annex 3.2. Central Bank Securities Policies since 2007

Table 3.5. Central Bank Changes in Policies on Collateral and Purchases of Nongovernmental Securities since 2007

	Federal Reserve	European Central Bank	Bank of England	Bank of Japan	Bank of Canada	Swiss National Bank
Collateral policies						
Broadening of type of securities eligible for collateral or repo	X[1]	X	X	X	X[2]	X
Easing in credit rating requirements		X		X	X[2]	
Easing in securities lending facilities	X[3]		X	X		
Nongovernment securities purchases[4]						
Commercial papers[5]	(X)[6]		X	X[7]		
Asset-backed securities	(X)[6]	X[8]				
Corporate bonds			X	X[7]		X[9]
Other securities	X[10]			X[11]		

Sources: respective central banks.

Note: The table does not cover all the measures taken by the central banks.

[1]By introducing new lending facilities accepting broader types of collateral. All the new facilities were either closed or expired.

[2]By introducing new lending facilities. All the new facilities were terminated or discontinued by April 2010.

[3]Term Securities Lending Facility. Closed in February 2010.

[4]Excludes securities purchased under resale agreements.

[5]Includes asset-backed commercial paper.

[6]By providing funding directly to borrowers and investors in the markets. The new facilities were either closed or discontinued.

[7]Purchases were terminated in December 2009 but resumed under the Asset Purchase Program established in October 2010.

[8]Covered bonds. Purchases were terminated in June 2010 but resumed in October 2011.

[9]Discontinued in December 2009.

[10]Direct obligations of, and mortgage-backed securities issued by, housing-related government-sponsored enterprises.

[11]Equity held by financial institutions (conducted as prudential policy and terminated in April 2010). Exchange-traded funds and real estate investment trusts purchased under the Asset Purchase Program established in October 2010.

Annex 3.3. Collateral Requirements of Central Counterparties for Over-the-Counter Derivatives

Central counterparty (CCP)-related collateral requirements mostly take the form of cash and government securities (Table 3.6). Initial margin—deposits from all transaction parties that act as buffers against potential losses to the CCPs following default of a clearing member—usually takes the form of cash and marketable securities issued by selected sovereigns and their agencies. To mitigate risk, various haircuts are applied to marketable bonds depending on their riskiness. The recent European sovereign debt crisis has had implications for CCPs, in terms of both the deterioration of collateral quality and the increase in the risks of counterparties directly linked to sovereign governments. Collateral eligibility rules for guarantee (or default) funds—comprised of clearing member deposits that act as additional buffers against potential losses under a range of stress scenarios—are usually stricter than those for initial margin, and only cash and marketable securities issued by selected sovereigns are acceptable.

The potential increase in the demand for qualified collateral—given the incremental initial margin and default fund requirements associated with moving all standardized over-the-counter derivatives to CCPs—may account for shortages in the supply of cash and government bonds. Large banks that are also clearing members may offer collateral transformation services to their customers to turn less liquid assets into CCP-acceptable ones through repos and swaps. This could potentially exacerbate liquidity pressures for CCPs during market downturns, when clearing members would need to provide liquid funds for their clients at a time when they themselves are being subjected to a liquidity freeze.

Table 3.6. Collateral Requirements of the Big Three CCPs Handling OTC Derivatives

<table>
<tr><th>Chicago Mercantile Exchange</th><th>Intercontinental Exchange (ICE) Clear</th><th>LCH.Clearnet Swapclear</th></tr>
<tr><td>Guarantee fund:
U.S. dollars, marketable U.S. Treasury securities, selected U.S. agency securities, and selected money market funds.</td><td rowspan="2">Guarantee fund and initial margin:
The U.S. operation (ICE Clear Credit) accepts cash of selected countries and marketable U.S. Treasury securities.

The U.K. operation (ICE Clear Europe) accepts cash of selected countries, and marketable securities issued by selected governments.</td><td>Default fund:
Cash in British pounds only.</td></tr>
<tr><td>Performance bond:
Cash of selected countries, marketable U.S. Treasury securities, selected U.S. government agency securities and agency mortgage-backed securities, selected foreign government bonds, stocks selected from the Standard & Poor's 500 index, selected money market mutual funds, and gold.[1]</td><td>Initial margin:
Cash of selected currencies and securities issued or guaranteed by selected governments and selected government agencies.[2]</td></tr>
<tr><td>Variation margin: Cash</td><td>Variation margin: Cash</td><td>Variation margin: Cash</td></tr>
</table>

Source: IMF staff discussions with CCPs.

Note: CCP = central counterparty; OTC = over the counter.

[1]For OTC interest rate swaps (but not for credit default swaps), the Interest Earning Facility 4 (IEF4) program allows participants to pledge corporate bonds into a tri-party account to meet the performance bond requirements.

[2]LCH.Clearnet also accepts performance bonds as initial margin.

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CHAPTER 4

THE FINANCIAL IMPACT OF LONGEVITY RISK

Summary

As populations age in the decades ahead, the elderly will consume a growing share of resources. It is recognized that this will strain public and private balance sheets, and governments and private pension providers have been preparing for the financial consequences of aging. However, these preparations are based on baseline population forecasts that in the past have consistently underestimated how long people live.

Unexpected longevity beyond those baseline forecasts, while clearly beneficial for individuals and society as a whole, is a financial risk for governments and defined-benefit pension providers, who will have to pay out more in social security benefits and pensions than expected. It may also be a financial risk to individuals, who could run out of retirement resources themselves. These risks build slowly over time, but if not addressed soon could have large negative effects on already weakened private and public sector balance sheets, making them more vulnerable to other shocks and potentially affecting financial stability.

Few governments or pension providers adequately recognize longevity risk. Where they do, they find it is large. This chapter shows that if individuals live three years longer than expected—in line with underestimations in the past—the already large costs of aging could increase by another 50 percent, representing an additional cost of 50 percent of 2010 GDP in advanced economies and 25 percent of 2010 GDP in emerging economies. In an example, the chapter shows that for private pension plans in the United States, such an increase in longevity could add some 9 percent to their pension liabilities. Because the stock of pension liabilities is large, corporate pension sponsors would have to make many multiples of typical annual pension contributions to match these extra liabilities.

Addressing longevity risk requires a three-pronged approach. First, governments should acknowledge the significant longevity risk they face through defined-benefit plans for their employees and through old-age social security schemes. Second, risk should be appropriately shared between individuals, pension plan sponsors, and the government. An essential reform measure would allow retirement ages to increase along with expected longevity. This could be mandated by government, but individuals could also be encouraged to delay retirement voluntarily. Better education about longevity and its financial impact would help make the consequences clearer. Allowing flexibility for pension providers is also important: where it is not feasible to increase contributions or retirement ages, benefits may have to decrease. Risk transfers in capital markets from pension plans to those that are better able to manage the risk are a third approach. The chapter highlights a number of instruments in this growing market, and potential measures to improve its functioning.

Better recognition and mitigation of longevity risk should be undertaken now. Measures will take years to bear fruit and effectively addressing this issue will become more difficult if remedial action is delayed. Attention to population aging and the additional risk of longevity is part of the set of reforms needed to rebuild confidence in the viability of private and public sector balance sheets.

The economic and fiscal effects of an aging society have been extensively studied and are generally recognized by policymakers, but the financial consequences associated with the risk that people live longer than expected—longevity risk—has received less attention.[1] Unanticipated increases in the average human life span can result from misjudging the continuing upward trend in life expectancy, introducing small forecasting errors that compound over time to become potentially significant. This has happened in the past. There is also risk of a sudden large increase in longevity as a result of, for example, an unanticipated medical breakthrough. Although longevity advancements increase the productive life span and welfare of millions of individuals, they also represent potential costs when they reach retirement.

More attention to this issue is warranted now from the financial viewpoint; since longevity risk exposure is large, it adds to the already massive costs of aging populations expected in the decades ahead, fiscal balance sheets of many of the affected countries are weak, and effective mitigation measures will take years to bear fruit. The large costs of aging are being recognized, including a belated catch-up to the currently *expected* increases in average human life spans. The costs of longevity risk—*unexpected* increases in life spans—are not well appreciated, but are of similar magnitude. This chapter presents estimates that suggest that if everyone lives three years longer than now expected—the average underestimation of longevity in the past—the present discounted value of the additional living expenses of everyone during those additional years of life amounts to between 25 and 50 percent of 2010 GDP. On a global scale, that increase amounts to tens of trillions of U.S. dollars, boosting the already recognized costs of aging substantially.

Threats to financial stability from longevity risk derive from at least two major sources. One is the threats to fiscal sustainability as a result of large longevity exposures of governments, which, if realized, could push up debt-to-GDP ratios more than 50 percentage points in some countries. A second factor is possible threats to the solvency of private financial and corporate institutions exposed to longevity risk; for example, corporate pension plans in the United States could see their liabilities rise by some 9 percent, a shortfall that would require many multiples of typical yearly contributions to address.

Longevity risk threatens to undermine fiscal sustainability in the coming years and decades, complicating the longer-term consolidation efforts in response to the current fiscal difficulties.[2] Much of the risk borne by governments (that is, current and future taxpayers) is through public pension plans, social security schemes, and the threat that private pension plans and individuals will have insufficient resources to provide for unexpectedly lengthy retirements. Most private pension systems in the advanced economies are currently underfunded and longevity risk alongside low interest rates further threatens their financial health.

A three-pronged approach should be taken to address longevity risk, with measures implemented as soon as feasible to avoid a need for much larger adjustments later. Measures to be taken include: (i) acknowledging government exposure to longevity risk and implementing measures to ensure that it does not threaten medium- and long-term fiscal sustainability; (ii) risk sharing between governments, private pension providers, and individuals, partly through increased individual financial buffers for retirement, pension system reform, and sustainable old-age safety nets; and (iii) transferring longevity risk in capital markets to those that can better bear it. An important part of reform will be to link retirement ages to advances in longevity. If undertaken now, these mitigation measures can be implemented in a gradual and sustainable way. Delays would increase risks to financial and fiscal stability, potentially requiring much larger and disruptive measures in the future.

Note: This chapter was written by S. Erik Oppers (team leader), Ken Chikada, Frank Eich, Patrick Imam, John Kiff, Michael Kisser, Mauricio Soto, and Tao Sun. Research support was provided by Yoon Sook Kim.

[1]See, for example, IMF (2011a).

[2]See IMF (2012).

Box 4.1. The Evolution of Life Expectancy in the Twentieth and Twenty-First Centuries

Most gains in life expectancy at birth are attributable to improvements in infant mortality, but they have also occurred in life expectancy at older ages, the variable most important for longevity risk.

Life expectancy at birth has increased greatly in the past 100 years. In the 1750s, estimated life expectancy at birth was below 40 years in northern and western Europe. Life expectancy at birth rose steadily after that and has seen a near linear increase since about 1900, reaching about 80 years by 2010 in the best performing areas (the Nordic countries, New Zealand, and Japan). More generally, life expectancy at birth has been increasing in all regions of the world, rising from a global average of 48 years in 1950 to 60 years in 1980 and close to 70 years by 2010. The increases over the past decades have been particularly marked in countries classified by the United Nations as less developed and least developed (see Figure 4.1.1).

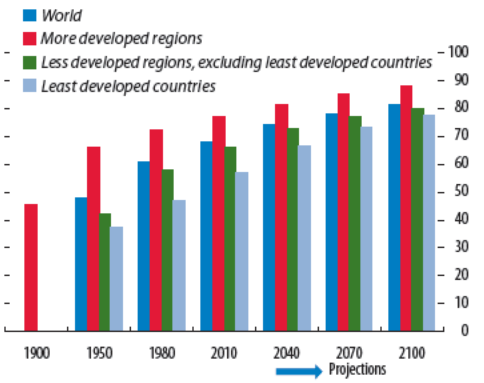
The large increase in life expectancy at birth is mainly attributable to a decline in infant mortality rates. In the period 1950–70, more than 70 percent of the increase in life expectancy at birth in Canada and the United States was due to improvements in mortality at ages below 65 years. In the other advanced economies about 85 percent of the increase was due to improvement at younger ages.

What matters for longevity risk, however, are developments in life expectancy at older ages, which has also improved significantly over the past 100 years. Life expectancy at age 60 in advanced economies in Europe, for example, rose from 15 years in 1910 to 24 years in 2010, and is expected to improve further. This raises the question of how far life expectancy can be extended and whether there is a maximum life span for humans (Siegel, 2005).

These effects can be visualized in so-called life curves, which track (and project) the proportion of a population that remains alive at various ages (see Figure 4.1.2, in which the year labels represent the year of birth). If people died evenly across age groups, the curve would be closer to a downward-sloping diagonal line. With a high rate of infant mortality, the curve drops steeply near age zero, as in the curve for 1851.

If all people died at the same age, the curve would be a rectangle, with 100 percent of the population being alive before that age, and 0 percent

Figure 4.1.1. Life Expectancy at Birth
(In years)



Sources: Kinsella and He (2009); United Nations (2011); and IMF staff estimates.
Note: The regional groupings reflect the UN classification.

Note: Prepared by Frank Eich, John Kiff, and Mauricio Soto.

The chapter proceeds as follows. After defining and quantifying longevity risk, the chapter investigates its impact, who is exposed to it, and how it affects their liabilities, including in the current low-interest-rate environment. The chapter then describes the market for longevity risk transfer, identifying impediments, and looks forward with measures that could promote its development. It concludes with potential policy implications.

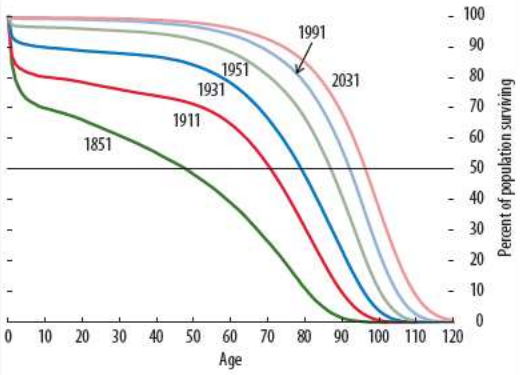
Longevity Risk

Longevity risk is the risk that actual life spans of individuals or of whole populations will exceed expectations.[3] As described in Box 4.1, people have been

[3]This chapter focuses on *aggregate* longevity risk, the risk that people on average live longer than expected. Individuals face an individual or "idiosyncratic" longevity risk that may cause them to outlive their financial resources, sometimes referred to as "retirement ruin" (Milevsky, 2006).

Box 4.1 *(continued)*

Figure 4.1.2. Life Curves for the United Kingdom, by Year of Birth, 1851–2031



Source: Office of National Statistics.
Note: Proportion of persons born in a given year surviving to successive ages. For example, of people born in 1851, 50 percent survived to about age 47.

after that age. Developments in longevity that have made the life curve more rectangular over time have been dubbed the "rectangularization" of the life curve.

Using various methodologies detailed in Box 4.2, most current forecasts assume that increases in life expectancy, including those at older ages, will slow down in the future. As noted in the main text, that assumption is arguable. Nonetheless, the United Nations projects that by 2050 life expectancy at age 60 will increase to an average of 26 years in advanced economies and about 22 years in developing economies—an improvement of about 1 month per year. These expected increases are slightly below the increases experienced in the past for the United States and Canada but substantially below those in the rest of the world (see Table 4.1.1).

Table 4.1.1. Longevity Trends, 1970–2050
(In years)

	Observed			Projected	
	1970–2010	Increase per year	Standard deviation	2010–50	Increase per year
Change in life expectancy at birth					
United States and Canada	8.2	0.20	0.14	4.3	0.11
Advanced Europe	8.6	0.21	0.13	4.7	0.12
Emerging Europe	1.1	0.03	0.36	6.8	0.17
Australia and New Zealand	10.8	0.27	0.27	4.9	0.12
Japan	10.8	0.27	0.23	4.6	0.11
Change in life expectancy at age 60					
United States and Canada	4.9	0.12	0.11	3.1	0.08
Advanced Europe	5.7	0.14	0.13	3.7	0.09
Emerging Europe	0.6	0.02	0.18	3.8	0.09
Australia and New Zealand	7.2	0.18	0.23	3.7	0.09
Japan	7.7	0.19	0.19	3.7	0.09

Sources: Human Mortality Database as of December 13, 2011; and IMF staff estimates.

living longer lives for at least a century now, and this has obvious benefits. But governments, private companies, and individuals all potentially face financial risks if people on average live longer than expected. In particular, defined-benefit pension plans, insurance companies that offer life annuities, and governments that sponsor old-age social security systems would have to pay benefits longer than anticipated, increasing the present discounted value of their liabilities.

The main source of longevity risk is therefore the discrepancy between expected and actual life spans, which has been large and one-sided: forecasters, regardless of the techniques they use, have consistently underestimated how long people will live (Box 4.2). These forecast errors have been systematic over time and across populations. A study by the U.K. Office for National Statistics (Shaw, 2007) has evaluated the forecast errors made in

Box 4.2. Forecasting Longevity

Longevity forecasts can be made using various methods. Forecasting models can be broadly categorized into (i) methods that attempt to understand and use the underlying drivers of mortality and (ii) extrapolative methods, which use only historical trends to forecast future developments.

So-called process-based methods and econometric models seek an understanding of the underlying factors driving death rates. These methods use biomedical assumptions to forecast death rates from various causes, leading to longevity rates of "cohorts" (people in a particular demographic section of the population born in a particular year or period). Econometric methods principally model longevity as a function of general economic, environmental, and epidemiological factors. A difficulty with both approaches is that they require a model for the relationship between underlying factors and longevity. Also, if they are used to make forecasts of longevity, forecasts need to be available for any underlying factors used in the model.[1]

Extrapolative approaches do not attempt to identify the drivers of death rates but use only information contained in historical data to forecast future mortality rates. Such models could assume that historical trends continue into the future, either exactly or in some "smoothed" form, or could try to derive a more sophisticated model from historical trends (possibly disaggregated by cohort) that could then be used for a forecast. Methods can be deterministic—meaning that they directly calculate future changes from past trends—or stochastic, meaning that they apply random changes from a probability distribution derived from past developments to generate future changes.

When Lee and Carter (1992) showed that their extrapolative model explained 93 percent of the variation in mortality data in the United States, it became the standard model for the longevity forecast literature and the preferred forecasting methodology for the U.S. Census Bureau and the Social Security Administration. Employing time-series analysis, the model estimates an underlying "mortality index" using variations in mortality data across different age groups over time. The index can then be used to forecast future longevity.[2]

A drawback with the extrapolative approach, including that of Lee and Carter, is that it looks only at the past and does not use available information (or assumptions) about possible future developments that affect longevity, such as medical breakthroughs or changes in behavior. Although the Lee-Carter model has been successfully applied to Canada, France, Japan, Sweden, and the United States, it has not been as successful in some other countries. For example, it has trouble explaining developments in the United Kingdom because of cohort effects that depend on the year in which a group of individuals was born. Forecasters in the United Kingdom now generally use another extrapolative method (Currie, Durban, and Eilers, 2004). Other studies have explicitly included cohort effects.[3]

Note: Prepared by John Kiff and Michael Kisser.

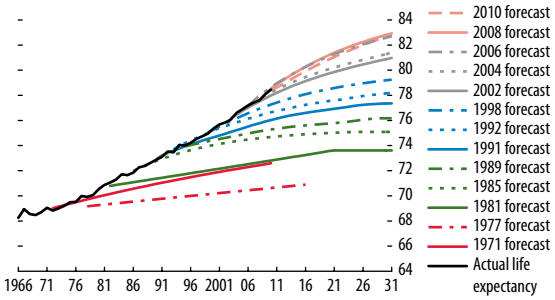
[1]For a detailed discussion of these issues, see for example Continuous Mortality Investigation (2004).

[2]Specifically, the model assumes that $\ln[m(x, t)] = a(x, t) + b(x)k(t) + \varepsilon(x, t)$ where $m(x, t)$ denotes the death rate at age x and time t. The death rate is a direct function of the individual's age through $a(x)$. It also depends on $k(t)$, which represents falling mortality rates (that is, improvements in longevity) over time. How much mortality falls at a given point in time also depends on the individual's age, through $b(x)$. ε is a random term.

[3]A detailed comparison of different stochastic mortality models can be found in Cairns and others (2009).

the United Kingdom over the past decades (Figure 4.1). It showed that future estimates of longevity were consistently too low in each successive forecast, and errors were generally large. In fact, underestimation is widespread across countries: 20-year forecasts of longevity made in recent decades in Australia, Canada, Japan, New Zealand, and the United States have been too low by an average of 3 years (Bongaarts and Bulatao, 2000). The systematic errors appear to arise from the assumption that currently observed rates of longevity improvement would slow down in the future. In reality,

Figure 4.1. United Kingdom: Projected Life Expectancy at Birth, for Males, 1966–2031
(In years)



Source: Office of National Statistics.

they have not slowed down, partly because medical advances, such as better treatments for cancer and HIV-AIDS, have continued to raise life expectancy (Box 4.3).

Life expectancy at birth is most often used to discuss longevity, although the measure most relevant for longevity risk is life expectancy at pensionable age. The latter has increased less in the past, but the rectangularization of the life curve (see Box 4.1) implies that more of the increases in life expectancy in the future will be due to increases at older ages. Still, higher longevity at younger ages is clearly *not* a risk. Longer healthy and productive lives (before retirement) add to incomes, retirement savings, and tax revenues. This matters particularly in countries with currently low life expectancy, where longer life spans generally are economically beneficial.

Appropriate longevity assumptions should use the most recent longevity data and allow for future increases in longevity. Even when pension providers use updated data, they do not always allow for reasonable further future increases in longevity from its current level. In fact, longevity at age 60 in the advanced economies has increased in every decade over the past half century by an average of one to two years (see Table 4.1.1 in Box 4.1). Typical assumptions for pension liability valuations in some countries suggest that longevity assumptions may not adequately account for future developments in longevity. Although valuations typically incorporate some future increases that exceed current life expectancy tables, those increases are still much smaller in a number of countries than those that have occurred in the past (Table 4.1). This is partly because regulatory frameworks—while mandating the use of the most recent actual longevity data—often do not require that *future* expected improvements in longevity are included in calculations of pension liabilities.

The substantial costs of aging already faced by society provide a useful starting point to assess the magnitude of longevity risk. The most common measure of aging is the old-age dependency ratio—the ratio of the population 65 and older to the population 15 to 64. Over the period 2010–50 old-age dependency ratios are expected to increase from 24 to 48 percent in advanced economies and from 13 to 33 percent in emerging economies. These numbers are subject to considerable uncertainty, not only regarding longevity, but also with respect to developments in fertility. United Nations populations

Table 4.1. Pension Estimates and Population Estimates of Male Life Expectancy at Age 65 in Selected Advanced Economies
(In years)

Country	(1) Typical Assumption for Pension Liability Valuation[1]	(2) Population Life Expectancy[2]	Difference: (1)–(2)	(3) Observed Improvements since 1990[3]
Australia	19.9	18.7	1.2	3.5
Austria	20.8	17.0	3.8	3.4
Canada	19.4	18.2	1.2	2.6
Germany	19.0	16.9	2.1	3.3
Ireland	21.0	16.7	4.3	3.8
Japan	18.8	18.6	0.2	2.7
United Kingdom	21.2	17.2	4.0	3.9
United States	18.4	17.5	0.9	2.4

Sources: Sithole, Haberman, and Verrall (forthcoming); Human Mortality Database as of February 22, 2012.

[1]Takes into account some future improvement in longevity.

[2]Does not take into account future improvement in longevity.

[3]Difference beween the latest population life expectancy at age 65 and that in 1990 (taken from the Human Mortality Database).

Box 4.3. An Example of a Longevity Shock

The advent of antiretroviral drugs for people with HIV infection in the mid-1990s created a positive longevity shock for patients but undid the financial expectations of existing investors in viatical settlements.

The AIDS epidemic emerged in the early 1980s and drove down the life expectancy of patients infected with HIV. During the early years of the epidemic, patients with HIV whose infection had progressed to AIDS were considered terminally ill, with a life expectancy measured in months.

Often without other sources of income, patients with AIDS turned to the value embedded in their life insurance policies for financial resources in a transaction known as a viatical settlement. If their life insurance policies permitted it, terminally ill patients could obtain a significant proportion of the face value of their policy as an immediate cash payment by selling the policy to a third party. The size of the cash payment depended principally on the life expectancy of the policy owner.

A number of viatical settlement companies emerged during the 1980s. Although settlement terms varied widely, some sense of the financial provisions can be gleaned from government regulations that were introduced in the 1990s to protect those selling their life insurance. For example, in the United States, Virginia regulations stipulate minimum payout percentages to be received by the seller that range from 80 percent of face value for those with a life expectancy of less than 6 months to 60 percent of face value for those with a life expectancy of up to 24 months. For 25 months or more, the payout could be less, as only the cash surrender value was required (Virginia Registrar of Regulations, 2003).

In the mid-1990s, HAART (highly active antiretroviral therapy) drugs became available and sharply improved the outlook for those infected with HIV. Whereas the median survival time after infection with HIV without treatment is about 11 years, the survival time at age 20 with treatment is estimated to be close to 50 years.[1] For those patients who progress to AIDS, the improvement in life expectancy with treatment is even more dramatic. The median survival time after diagnosis with AIDS without treatment is 6 to 19 months (Zwahlen and Egger, 2006). With treatment, many individuals recover from AIDS to a state of latent HIV infection, with survival rates similar to other HIV-infected individuals.

The introduction of these life-saving anti-HIV medications led to a large positive longevity shock for those living with HIV. Viatical settlements disappeared quickly as life expectancies rose. Investors in viatical settlements saw a significant realization of longevity risk, with associated losses, as they were required to continue to pay premiums for much longer than expected and were faced with delayed payouts. Data on such losses are not available, but a crude estimate can be made from the minimum percentage payouts in the Virginia regulations: if life expectancy rose from less than 6 months (80 percent payout) to more than 24 months (60 percent payout or less), the loss to investors could be 20 percent or more.

Note: Prepared by S. Erik Oppers.

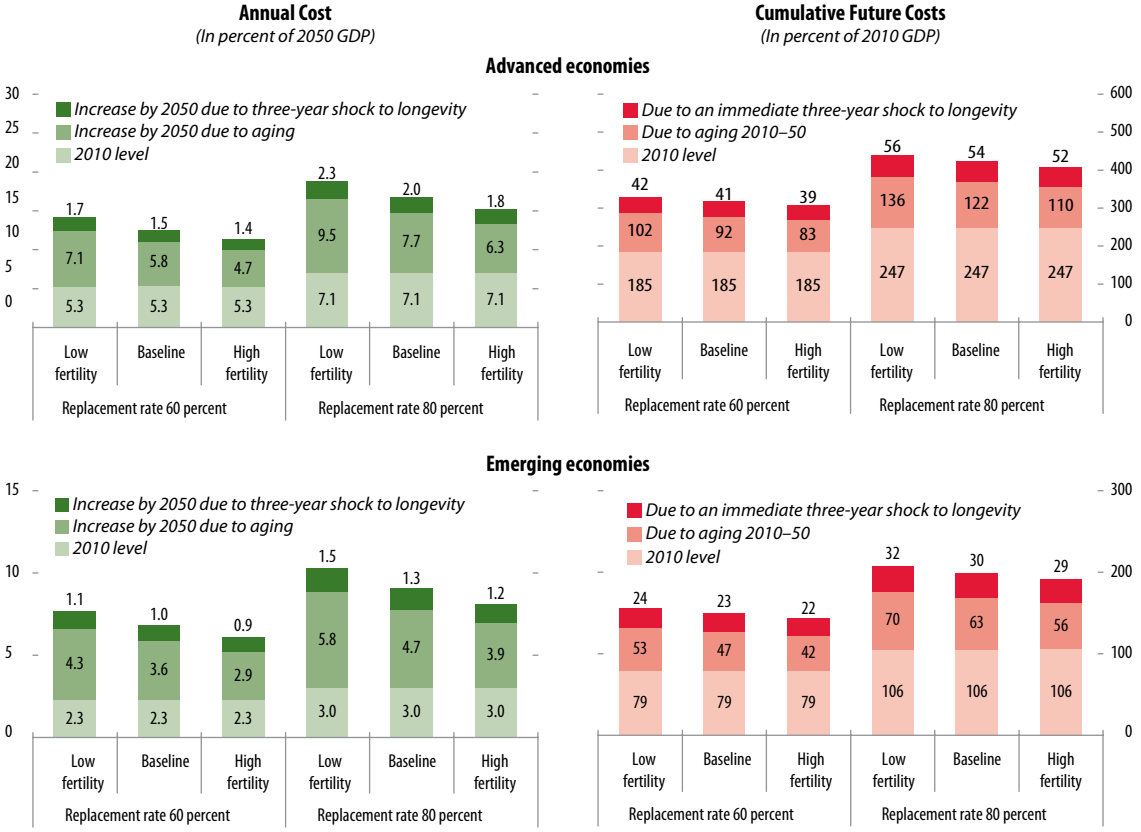
[1]UNAIDS Reference Group for Estimates, Modeling and Projections (2006); and Antiretroviral Therapy Cohort Collaboration (2008).

forecasts therefore have a baseline, and low and high fertility variants.[4] A way to measure the associated financial burden of an aging society is to estimate the cost of providing all individuals aged 65 and older with an average income necessary to keep their standard of living at its preretirement level. That income, measured as a percentage of the average preretirement income, is called the "replacement rate." A reasonable replacement rate may differ across countries, but the literature generally puts it in the range of 60 to 80 percent.[5]

[4]The United Nations projects that life expectancy at age 65 will increase by two years over the period 2010–50.

[5]The 60 to 80 percent range for replacement rates reflects the fact that retirees often need lower gross incomes to maintain their preretirement standards of living: retirees do not pay payroll taxes and pensions generally have preferential income tax treatment. In addition, retirees do not need to save for retirement and do not incur work-related expenses such as transportation. On the other hand, medical expenses may be higher. Several studies suggest that the actual replacement rates are within this range for the advanced economies (OECD, 2009, 2011; Borella and Fornero, 2009; Palmer, 2008; and Disney and Johnson, 2001).

Figure 4.2. Increases in Costs of Maintaining Retirement Living Standards due to Aging and to Longevity Shock



Sources: United Nations; and IMF staff estimates.

Note: The left panels correspond to spending levels in 2050—a flow measure—expressed as share of 2050 GDP. The right panels represent the present discounted value of all future spending—a stock measure—expressed as a share of 2010 GDP. This calculation uses a discount rate of 1 percent, which is equivalent to assuming a differential between the interest rate and rate of growth of 1 percentage point. The replacement rate is the percentage of preretirement income needed to maintain standard of living during retirement.

Under the demographic trends expected by the United Nations, and with a 60 percent replacement rate, the aggregate expenses of the elderly will roughly double over the period 2010–50. In the baseline population forecast and with a 60 percent replacement rate, the annual cost rises from 5.3 percent to 11.1 percent of GDP in advanced economies and from 2.3 percent to 5.9 percent of GDP in emerging economies (Figure 4.2). Taken over the full period, the cumulative cost of this increase because of aging in this scenario is about 100 percent of 2010 GDP for the advanced economies and about half that amount in emerging economies. The numbers reflect pension costs only and do not account for likely increases in health and long-term care costs, which will further increase the burden of aging. Much of the costs of aging will need to be funded through existing retirement systems, and various reforms have been put in motion to deal with these cost pressures (see IMF, 2011a).

A longevity shock of three years would add nearly half to these cumulative costs of aging by 2050. A three-year shock approximates the average underestimation of longevity in the past.[6] Using the same calculation as in the previous paragraph, in the

[6]Bongaarts and Bulatao (2000) found underestimations of life expectancy at birth, not life expectancy at pensionable age. However, other evidence supports at least a three-year underestimation for life expectancy at older ages as well: in the Netherlands, for example, life expectancy at 65 rose from 14 years in 1971 to 18 years in 2010. In the United States, life expectancy at 63 rose from 15 years in 1971 to 19 years in 2007.

baseline aging scenario the additional cost of providing all individuals of age 65 with a 60 to 80 percent replacement rate for those additional three years adds about 1.5 to 2.0 percentage points of GDP to the *annual* cost of aging in advanced economies in 2050, and 1.0 to 1.3 percentage points of GDP in emerging economies. These annual increments imply a cumulative cost of about 50 percent of 2010 GDP for the advanced economies and about 25 percent of 2010 GDP for the emerging markets—in each case adding nearly half to the cost of aging.[7]

There is uncertainty around these estimates, but the effects are of similar magnitude in different aging scenarios. In the U.N. high fertility variant (which leads to slower aging of the population as a whole), the cumulative effect of a longevity shock in advanced economies is still in the range of 39 to 52 percent of GDP, depending on the replacement rate. For emerging economies, the range is between 22 and 29 percent.

The Impact of Longevity Risk

Although longevity risk develops and reveals itself slowly over time, if left unaddressed it can affect financial stability by building up significant vulnerabilities in public and private balance sheets. On a macroeconomic level, the effects of a longevity shock on the economy and markets are similar to the effects of aging—they propagate through the size and composition of the labor force, public finances, corporate balance sheets, private saving and investment, and potential growth (Box 4.4). While the effects of longevity risk perhaps act too slowly to cause sharp movements in asset prices, if unaddressed they add to balance sheet vulnerabilities, affecting fiscal sustainability and the solvency of private financial and corporate institutions. This in turn makes institutions and markets more prone to the negative effects of other shocks.

The Effect of Longevity Risk on Fiscal Sustainability

Governments in particular bear a significant amount of longevity risk. Their longevity exposure is threefold: (i) through public pension plans, (ii) through social security schemes, and (iii) as the "holder of last resort" of longevity risk of individuals and financial institutions. An unexpected increase in longevity would increase spending in public schemes, which typically provide benefits for life. If individuals run out of resources in retirement they will need to depend on social security schemes to provide minimum standards of living. There may also be an expectation that governments will step in if financial institutions or corporations face solvency threats from longevity exposure. In addition, private pensions in some countries are backed by guarantee funds (including in Japan, Sweden, the United Kingdom, and the United States), but these may be underfunded (as in the United States), representing an additional contingent liability for the government.

The longevity risk faced by governments adds strain to public balance sheets, which have already seriously deteriorated under the stress of the financial crisis (see Chapter 2). To the extent that governments are not acknowledging longevity risk (and few in fact do), fiscal balance sheets become more vulnerable. If not adequately addressed soon, it could potentially further threaten fiscal sustainability.

The framework that was used earlier to calculate the overall potential cost of longevity risk can be used country by country to estimate its effect on fiscal sustainability. Table 4.2 summarizes the impact of aging and a longevity shock on the fiscal position for a number of advanced and emerging market economies.

[7]The large addition to the cost of aging because of the longevity shock can be seen intuitively as follows. The total cost of aging is the result of two factors: first, lower fertility rates (two-thirds of the effect) and, second, an increase in life expectancy at the age of retirement (one-third of the effect). Longevity at the age of retirement, the second factor, increases by nearly two years in the U.N. baseline, so that an additional shock of three years should have an impact of (3 years/2 years) × 1/3 which equals ½. Because changes in fertility take a long time to work themselves through the age structure, they are unlikely to have a large impact on the financial implications of aging over the next few decades. For example, if fertility rates were to immediately increase by 0.5 children per woman across all regions, the old-age dependency ratio in 2030 would remain virtually unchanged. In contrast, an increase in life expectancy at age 60 of one year would increase old-age dependency ratios substantially. Migration can alter the demographic structure quickly. Immigration of young adults and children from "younger" nations could offset to some extent the aging of populations in advanced economies.

Box 4.4. The Impact of Aging on the Macro Economy and on Financial Stability

This box summarizes the literature on the impact of aging on the macro economy and on financial stability.

The Macro Economy

The macroeconomic effects of aging can be summarized with the help of the national accounts identity and the Cobb-Douglas production function.

Note: Prepared by Patrick Imam and Tao Sun.

The national account framework shows the relation between aggregate production, income, domestic demand, and the external accounts through the following equations:

$$GDP = (C_{\text{private}} + I_{\text{private}}) + (C_{\text{public}} + I_{\text{public}}) + X - M \quad (1)$$

$$GNDI = C_{\text{private}} + C_{\text{public}} + S_{\text{private}} + S_{\text{public}} \quad (2)$$

4.4.1. Impact of Aging on the Macro Economy

Framework	Variable	Impact	Channels
National account framework	Consumption	Changing consumption pattern toward nontradables	• Different consumption patterns for the elderly (see Eghbal, 2007, for a case study of Italy) tend to shift demand toward services and lead to an increase in the price of nontradables compared with tradables, causing an increase in the real exchange rate.
	Investment	Reducing investment return	• If the aging population is also declining, this may lead additionally to falling rates of return on public investment. If governments do not plan for a declining population, existing public capital (e.g., schools, public infrastructure) may become underutilized to the extent that their use differs among generations.
	Savings	Reducing private and public saving	• According to the life-cycle hypothesis, older people will tend to liquidate existing savings. • Assuming no migration or fertility rise, with fewer active individuals, governments pay out more in health care and pension benefits and collect less tax revenue, leading to deteriorating fiscal conditions. • Rising fiscal deficits (negative public saving) could put the fiscal outlook on an unsustainable trajectory.
	Current account	Reducing current account balance	• The net effect of falling private and public saving on the current account depends on the relative changes in saving and investment. It is expected that the effect will apply to both current account surplus and deficit countries (see Lee and Mason, 2010). • The shrinking current account balance in some major countries, such as China and Japan, may contribute to the adjustment of global imbalances to the benefit of global financial stability.
	GDP	Reducing growth rates	• Skirbekk (2004) finds that skills that are key inputs to innovation—problem solving, learning, and speed—tend to degenerate with age, leading to a population that is less creative and entrepreneurial, thereby reducing growth rates. • Empirically, the IMF (2004) finds that per capita GDP growth is positively correlated with changes in the relative size of the working age population and negatively correlated with changes in the share of the elderly.
Cobb–Douglas production function			• Empirical evidence from OECD countries shows that the complementary role of young and old workers means an optimum mix that exists may be damaged by having too many old workers (Feyrer, 2007).
	Capital	Reducing real interest rates	• Aging is likely to translate into a gradual rise in the ratio of capital to labor and some concomitant decline in longer-term real interest rates (Visco, 2005). The flattened yield curve would reduce the effectiveness of monetary policy transmission and could impact institutions such as banks or pension funds that rely on a steep curve for their business model. This effect may be counterbalanced by decreasing saving, which may drive up interest rates.
	Labor	Affecting labor supply and returns	• An aging population will tend to shrink the labor force, which could lead to a lack of both unskilled and skilled workers. Countervailing factors, however, such as working longer (by raising the pension eligibility age for instance) or encouraging migration, could counteract the shrinking labor supply effect. • The higher capital-to-labor ratio would tend to lower expected returns on investment. Similarly, the same countervailing factors, such as working longer and immigration, may help buffer the decline in returns on investment.
	Productivity	Reducing productivity growth	• The elderly demand more services than the rest of the population (van Groezen, Meijdam, and Verbon, 2005), which tends to shift consumption toward services and away from durables. Given generally lower productivity growth in the service sector, this will tend to reduce productivity growth in the overall economy.

Box 4.4 *(continued)*

where:

GDP = gross domestic product
C = consumption expenditures
I = gross domestic investment
X = exports of goods and services
M = imports of goods and services
$GNDI$ = gross national disposable income
S = gross national savings
$(S - I) = CA$ = current account balance

The impact of aging on each of the components of the national income identity is summarized in Table 4.4.1.

The effect of aging on GDP can be further investigated by considering the Cobb-Douglas production function, which describes the relationship of the aggregate output of the economy to the use of inputs, as follows:

$$Q = AL^{\alpha}K^{\beta} \qquad (3)$$

where:

Q = total production (the value of all goods produced in a year)
L = labor input
K = capital input
A = total factor productivity

Exponents α and β are the output elasticities of labor and capital, respectively, which are viewed as constants determined by available technology at a point in time.

Thus, changes in GDP as a result of aging can be explained by changes in the labor supply, in the capital stock, and in productivity, as summarized in Table 4.4.1.

Financial Stability

The impact of aging on financial stability occurs largely through changes in the allocation of assets and liabilities among individuals and institutions. These effects are summarized in Table 4.4.2.

Table 4.4.2. Impact of Aging on Financial Stability

Balance Sheet Items	Impact	Channels
Assets	Reallocation of saving from riskier to safe assets may lead to potential mispricing of risk	• The rising demand for safe assets by the elderly (including through their pension funds) may lead to safe asset shortages and an overpricing of safe assets. At the same time, since risky assets such as equities are increasingly shunned, there is a possibility of an underpricing of riskier assets (Caballero, 2006). • These effects may be counterbalanced by defined-benefit funds with funding gaps in the current low-interest-rate environment, which may invest in risky assets to enhance expected returns. Underpricing may also be mitigated by international investors' buying the cheaper risky assets.
	Running down assets may result in negative wealth effects	• Evidence is increasingly emerging that asset prices fall with advancing population aging (Poterba, 2004). For instance, an aging population, by requiring less housing, puts downward pressure on house prices (Takáts, 2010). The same principle applies to equity prices, although because equities are internationally tradable, they are somewhat less susceptible to supply/demand changes driven by aging (Brooks, 2006). • Negative wealth effects could have deflationary consequences (as suggested by Japan's experience), which could lead to a negative price spiral that further depresses economic activity.
Liabilities	Changing borrowing habits may alter banks' business model	• The business model of banks is closely related to the life-cycle behavior of consumers. In their early years, consumers are net borrowers from banks, to pay for education and housing. Over their life time, consumers pay back their debt to banks. Therefore, in a consumer's later years, banks will increasingly be used for payment/transaction purposes, and less for maturity transformation. With fewer young borrowers, traditional lending activities would decline, and banks would have to enter new activities and act more like nonbanks. If not well managed (including through supervision), this transition could pose risks to financial stability. • With saving increasingly being channeled to capital markets via pension funds, the similarity of investment approaches may lead to herding, which, combined with procyclicality in the markets, could raise volatility and threaten financial stability.
	Individuals, governments, and pension providers face longevity risk	• Aging societies face heightened longevity risk—the risk of living longer than expected. Currently, there is a lack of instruments to hedge this risk. Those exposed—defined-benefit pension plan sponsors (i.e., corporations and governments), social security systems (i.e., governments), and individuals themselves—could face financial difficulties in the event of a realization of this risk. In the case of corporations, such difficulties could lead to potentially large changes in stock prices. Extreme longevity risk is likely to be borne by the sovereign, and a realization of this risk can lead to a substantial deterioration of the fiscal accounts and possible debt sustainability issues.

Table 4.2. Longevity Risk and Fiscal Challenges in Selected Countries
(In percent of 2010 nominal GDP)

Country	(1) Household Total Financial Assets (2010)[1]	(2) Present Discounted Values of Needed Retirement Income	(3) General Government Gross Debt (2010)	(4) Gap: (1) – (2)	(5) Increase in Present Discounted Values Given Three-Year Increase in Longevity
United States	339	272 to 363	94	67 to –24	40 to 53
Japan	309	499 to 665	220	–190 to –356	65 to 87
United Kingdom	296	293 to 391	76	3 to –95	44 to 59
Canada	268	295 to 393	84	–27 to –125	42 to 56
Italy	234	242 to 322	119	–8 to –88	34 to 45
France	197	295 to 393	82	–97 to –196	40 to 54
Australia	190	263 to 350	21	–73 to –161	36 to 49
Germany	189	375 to 500	84	–186 to –311	55 to 74
Korea	186	267 to 357	33	–81 to –170	39 to 52
China	178	197 to 263	34	–19 to –85	34 to 45
Spain	165	277 to 370	60	–112 to –205	39 to 52
Hungary	108	190 to 254	80	–82 to –146	34 to 45
Czech Republic	89	216 to 289	39	–127 to –200	36 to 48
Poland	88	160 to 213	55	–72 to –125	27 to 35
Lithuania	80	189 to 252	39	–109 to –172	34 to 45

Sources: National flow of funds accounts; national accounts; IMF (2011c); and IMF staff estimates.

Note: Range of values in columns (2), (4), and (5) cover, at the low end, a replacement rate of 60 percent of preretirement income and, at the high end, an 80 percent replacement rate for retirees aged 65 or older to maintain preretirement standard of living during the 2010–50 period.

[1]For China, 2009.

- In many countries, the private sector does not appear to have sufficient financial assets to deal with aging-related costs, let alone with longevity risk. In most countries, the estimated present discounted value of required retirement income under current U.N. longevity assumptions for 2010–50 [Table 4.2, column (2)] exceeds household total financial assets [column (1)].[8] Gaps vary among countries, partly because of differing aging trends; they may also reflect individuals counting to varying degrees on income from social security schemes and on net housing wealth (which are excluded from the table because of data limitations).
- In Japan and Germany, for instance, the gaps between financial assets and potential liabilities are equivalent to between about 2 and 3½ times their respective GDPs in 2010, assuming again a range of replacement rates of 60 to 80 percent of the average wage. Although some of the gaps in the table would be covered by social security, housing equity, and further asset accumulation by households, it is unlikely that current household wealth is sufficient to provide for the necessary retirement income in many countries.
- The potential effects of longevity risk on government liabilities are substantial in many countries. With the private sector ill-prepared for even the expected effects of aging, it is not unreasonable to suppose that the financial burden of an unexpected increase in longevity will ultimately fall on the public sector. Implied increases in potential public liabilities from a three-year extension of average lifetimes are generally between one-third and one-half of 2010 GDP, with larger effects in Germany (two-thirds of 2010 GDP) and Japan (three-fourths of 2010 GDP) [Table 4.2, column (5)].
- The contingent liabilities from longevity risk could add to already-stretched debt-to-GDP ratios in a number of countries. For instance, if the risk of an extra three years of longevity were indeed to fall on the government, debt-to-GDP ratios could rise to about 150 percent in Germany and the United States and to 300 percent in Japan [Table 4.2, sum of columns (3) and (5)].

[8]Column (1) of Table 4.2 includes the claims on defined-benefit pension plans, balances of defined-contribution plans, claims on insurance reserves, and other financial assets. In a defined-contribution plan, an employee contributes a set amount to a retirement plan. These amounts, often complemented by employer's contributions, are then invested. The amount available at retirement depends only on contributions and cumulated rates of return; there is no promise of a particular payment upon retirement.

The Effect of Longevity Risk on Private Institutions

The rising awareness of longevity risk is starting to affect the corporate sponsors of retirement plans. For corporations that offer defined-benefit schemes, unexpected increases in longevity assumptions (sometimes forced by improved accounting rules) hurt firms' profits, affect their balance sheet, and—ultimately—their stock price.[9] Institutional investors and credit rating agencies are increasingly scrutinizing longevity risks in defined-benefit schemes, and forcing companies to increase reserves. In addition, merger and acquisition activities are increasingly complicated by risks in defined-benefit schemes, including longevity risk (Pensions Institute, 2005).

Longevity risk is also affecting financial institutions. For life insurance companies, longevity risk may lead to losses on their existing annuity contracts, potentially leading to regulatory increases in reserves for such contracts. For insurance companies with important annuity business (as is the case for many in France, Japan, and the United Kingdom) large and continuous longevity increases have a potentially substantial financial impact. Without the benefits of diversified business lines, stand-alone annuity providers, such as those in the United Kingdom, run even greater risks of insolvency. For pension funds, longevity risk can add significantly to underfunding (see example below). To the extent that insurance companies and pension funds are interconnected with other financial institutions (including, importantly, banks), the financial consequences of a longevity shock could propagate through the financial system. Longevity risk may also have an upside, however, depending on the specific exposure of financial institutions. For example, to the extent that life insurance companies have written more life policies than annuities, they benefit when their policyholders live longer, since that leads to longer premium payments and delayed payouts. This is why life insurance companies are a "natural buyer" of longevity risk (see "Longevity Risk in the Low-Interest-Rate Environment" below).

[9]Recent acknowledgment of unrealized losses of banks has caused large declines in their share prices. A similar event could occur for corporations with pension liabilities.

An Example: The Impact of Longevity Risk on U.S. Defined-Benefit Plans

This example uses detailed data from the U.S. Department of Labor (DOL) to estimate the longevity risk faced by defined-benefit pension plans in the United States.[10] Actuarial and financial information on large U.S. pension funds are contained in filings of the DOL's Form 5500 between 1995 and 2007 (the most current year available). Important statistics from this form for evaluating longevity risk are total liabilities, number of plan participants, and the actuarial assumptions used.

The Form 5500 data suggest that the use of outdated mortality tables has been a common practice (Table 4.3).[11] Until recently, a majority of plans used the Group Annuity Mortality table of 1983, and many still did by the end of the sample period, implying a lag of almost a quarter-century in their mortality assumptions. Throughout the sample, only a few plans used the latest available table.[12] This exposes many pension providers to substantial longevity risk. Indeed, a study by Dushi, Friedberg, and Webb (2010) compared the present value of pension liabilities as reported by the plan sponsor (using its own longevity assumptions) with the liabilities that result from using longevity forecasts by the Lee-Carter model.[13] The study argued that the use of outdated mortality tables is causing pension liabilities to be understated by some 12 percent for a typical male participant in a defined-benefit pension plan.[14]

[10]For a complete treatment of this example, see Kisser and others (forthcoming).

[11]Actuaries typically use mortality statistics to compute liabilities. Mortality is of course the complement of longevity, and therefore conceptually equivalent.

[12]For some pension funds, information on the underlying mortality table is not available as the corresponding tables are classified as "other" with no further information given. Anecdotal evidence suggests that some funds may have switched to another recently proposed table (the RP-2000 mortality table), but this evidence cannot be used in the analysis. Nonetheless, assuming that plans that do not report a mortality table use the most recent one changes the results of the analysis only marginally.

[13]For a description of the Lee-Carter model, see Box 4.2.

[14]Similarly, Antolin (2007) computes the impact on a hypothetical pension plan of an unexpected improvement in life expectancy and finds that the present value of pension liabilities increases between 8.2 percent and 10.4 percent.

Table 4.3. Mortality Tables Used by Reporting Pension Plans
(In percent)

Year	1951 GAM	1971 IAM	1984 UP	1983 IAM	1983 GAM	1994 UP	2007 Mortality Table	Other	Hybrid	None
1995	1	0	7	1	48	6	0	3	22	0
1996	0	0	6	0	57	1	0	6	19	0
1997	0	0	4	0	62	1	0	6	17	0
1998	0	0	4	0	66	1	0	6	15	0
1999	0	0	3	0	67	1	0	7	14	3
2000	0	0	3	0	68	2	0	7	13	2
2001	0	0	2	0	69	2	0	8	12	2
2002	0	0	2	0	69	2	0	10	11	3
2003	0	0	2	0	66	3	0	13	11	3
2004	0	0	1	0	63	3	0	17	10	3
2005	0	0	1	0	49	3	0	31	10	3
2006	0	0	1	0	28	3	0	55	8	3
2007	0	0	1	0	16	2	12	57	6	4

Sources: U.S. Department of Labor; and IMF staff estimates.

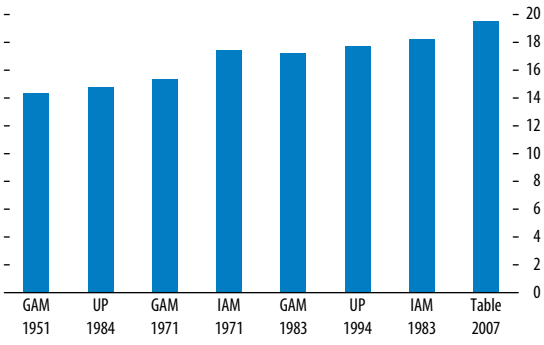
Note: GAM = Group Annuity Mortality table; IAM = Individual Annuity Mortality table; UP = Unisex Pension table. "Other" includes undefined mortality tables. "Hybrid" means that the standard mortality tables have been modified by the pension fund. "None" means that no mortality table has been used.

Each mortality table implies different life expectancies of retirees, and the impact of longevity increases can be inferred across funds and from instances when plans shift to the use of an updated table. The difference in implied life expectancy of 63-year-old males (the average retirement age in the sample) between the most dated and the most current mortality table is 5.2 years (Figure 4.3). For the substantial fraction of plans previously employing the 1983 Group Annuity Mortality table, a switch to the 2007 table (as required since 2008) implies an increase in longevity of 2.1 years.

Because the Form 5500 data show which table is used each year by each plan, the increase in the longevity assumptions is known when a plan switches to an updated table. Hence, controlling for other changes over time, a regression method can be used to disentangle increases in liabilities due to differences in discount rates, benefit payments, and the number of plan participants (Annex 4.1). The results imply that U.S. pension funds face a longevity risk that would see their total liabilities increase by about 3 percent for each additional year that their retirees live beyond the age of 63, implying a 9 percent increase for a three-year longevity shock.

The estimated shock is considerable, since it affects a large stock of liabilities; multiples of sponsors' typical yearly contributions would be necessary to increase assets commensurately. For example, a longevity adjustment in the Nether-

Figure 4.3. Life Expectancy at Age 63, by Year of Mortality Table
(In years)



Sources: For GAM 1951, SOA (1983); for UP 1984, Jackson and Fellers (1976); for GAM 1971, Greenlee and Keh (1971); for IAM 1971, Cherry (1971); for GAM 1983, SOA (1983); for UP 1994, SOA (1995); for IAM 1983, SOA (1981); for Table 2007, *Federal Register* (2007).

Note: GAM = Group Annuity Mortality table; IAM = Individual Annuity Mortality table; UP = Unisex Pension table.

lands in 2010 led to an increase in liabilities of the pension sector of about 7 percent (or 8 percent of GDP). This increase in liabilities could not be matched by an increase in assets through employer and employee contributions; other measures to cover the shortfall are now being considered, including foregoing indexation of pensions and possible lowering of nominal pensions—measures allowable under Dutch law, but not typically available in most countries (Box 4.5).

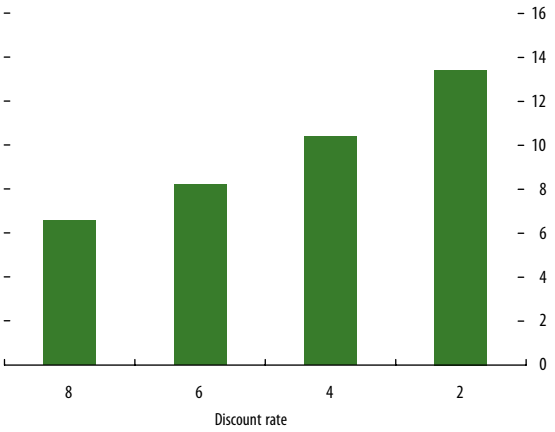
Longevity Risk in the Low-Interest-Rate Environment

Pension plans, providers of annuities, and other providers of retirement income face larger increases in liabilities because currently low interest rates exacerbate the financial impact of longevity risk. Longevity risk pertains to events in the future, so its financial consequences must be discounted. The lower the discount rate, the higher the present discounted value of the cost of longevity risk events.[15] A stress test framework for defined-benefit pension plans developed by Impavido (2011) indicates how the impact of longevity risk is dependent on interest rates.

The magnitude of the effects of longevity changes on pension liabilities differs depending on the age structure of a pension plan, on the actuarial assumptions used, and on how shocks are applied. Therefore, the calculations in this section should be viewed as an illustrative example that is based on the following specific assumptions:[16]

- To simulate longevity shocks, "extension factors" are applied to all age-specific mortality rates in the original mortality table in Impavido (2011), so that average life expectancy would be increased by three years.
- Retirement benefits in the model are single-life inflation-indexed annuities, based on a final-salary formula with an accrual rate of 1 percent.[17] The exercise assumes an inflation rate of 1 percent, annual real salary increases for active employees of 1 percent, and an annual inflation correction for retirees receiving an annuity.
- The calculations assume that all pension plan members enter the plan at age 20 and retire at age 60.

Figure 4.4. Increase in Actuarial Liabilities from Three-Year Increase in Longevity, by Discount Rate
(In percent)



Source: IMF staff estimates.
Note: Actuarial liabilities are projected benefit obligations of a model pension plan.

The calculations confirm that lower discount rates have significant effects on the size of longevity risk (Figure 4.4). With a discount rate of 6 percent, a three-year extension in average life expectancy increases liabilities by 8 percent in this example; with a discount rate of 2 percent, the same three-year shock increases liabilities by almost 14 percent.

Low interest rates therefore affect pension plans in two ways: by increasing their liabilities and by exposing them to higher longevity risk. In some countries liabilities of defined-benefit pension plans already exceed assets (leaving their funding ratios below 1), partly because of declining or low discount rates, which increase the present discounted value of liabilities.[18] The same discount effect applies to longevity risk, exacerbating the underfunding problem. In a sample of advanced economies, a three-

[15]For accounting purposes, the discount rate used in calculating pension liabilities is typically the yield on long-term high-quality domestic corporate bonds; for prudential regulation purposes, it is often the long-term government bond yield, which is currently around historical lows.

[16]For more information on technical details and assumptions, see Impavido (2011).

[17]Single-life refers to an annuity that does not include survivor benefits.

[18]See IMF (2011b) for the possible effects of protracted low interest rates on pension plans.

Box 4.5. Pension Reform in the Netherlands: Proactively Dealing with Longevity Risk

A recent agreement on pension reform in the Netherlands explicitly factors in longevity risk. The flexibility permitted by this agreement is exemplary, providing potential guidance to other countries facing similar longevity issues.

The Netherlands has a mandatory pension scheme for all employees based on the premise of full prefunding. Dutch pension funds have accumulated a large pool of assets, amounting to about 130 percent of GDP (OECD, 2011). Still, liabilities exceed assets, with the funding ratio falling below 100 percent recently. Several developments have contributed to this fall, including declines in asset prices since the start of the financial crisis, falling interest rates, and increases in life expectancy.

Longevity risk has contributed to the decline in funding ratios. In 2005, a new Financial Assessment Framework was introduced, later codified in the new Pension Act of 2007, mandating that pension funds not only use the latest mortality tables to calculate liabilities (which had been the practice), but also take into account the latest forecasts of future increases in longevity (which had previously not been included). This change had the effect of increasing aggregate liabilities of Dutch pension funds by some 5 to 6 percent. An update of future longevity assumptions in 2010 further increased liabilities by 7 percent, or €50 billion (8 percent of 2011 GDP; Stichting van de Arbeid, 2011). These large longevity shocks led to significant declines in funding ratios.

These developments prompted a discussion on pension reform in the Dutch Labor Foundation, a consultative body consisting of trade unions and employers' associations. In 2010, a Pension Accord was reached, recommending the following elements for reform:

- *Contribution stabilization.* The Accord recognized that a maximum limit had been reached on contribution rates by employers and employees. Contribution adjustments could no longer be part of the mechanism used to absorb changes in life expectancy or financial market shocks.
- *Marked-to-market assets and liabilities.* While the assets of Dutch pension funds have traditionally been marked-to-market, the liabilities had been discounted at the risk-free interest rate. A discussion is now ongoing about replacing this with the expected long-term return, allowing future liabilities to be discounted at a market-based rate. More realistic valuations will allow better management of the risks.
- *No unconditional nominal commitments.* Future pension benefits are explicitly conditional on the investment performance of the pension fund. Financial market shocks will be offset by reductions in benefits (for pensioners) or accrual rates (for active participants) aimed at returning the funding ratio to 100 percent over a 10-year period.
- *Adjustments for changes in longevity.* Pensions will be adjusted to relate the number of expected benefit years to the number of accrual (working) years, thus linking the effective retirement age to expected developments in longevity. In practice, the retirement age for private pensions will rise with that for the public old-age pension, to 66 in 2020, with further adjustments every 5 years in line with projected longevity.

The reform elements from the Pension Accord have been transmitted to the government as recommendations, to be codified and implemented in the period ahead. It is expected that these reforms will result in a pension system that is more robust to financial market and longevity shocks.

Note: Prepared by S. Erik Oppers.

year longevity shock could further reduce funding ratios by between 6 and 10 percent (Table 4.4). Moreover, low interest rates also lower the return on the fixed-income assets in the portfolio, making it more difficult for plans to earn their way out of the underfunding problems.

Mitigating Longevity Risk

Like any other risk faced by economic agents—such as interest rate or exchange rate risk—longevity risk should be recognized and addressed. On a global scale, *reducing* longevity risk would require reversing

Table 4.4. Corporate Pension Funding Ratios and Discount Rate Assumptions for Selected Countries
(In percent)

	Funding Ratio			Discount Rate	
	2006	2010	With Three-Year Longevity Shock[1]	2006	2010
Japan	70	62	55	2.0	1.5
United Kingdom	87	95	88	5.1	5.4
Netherlands	89	97	90	4.6	5.1
United States	89	85	79	5.8	5.4
Ireland	90	95	89	4.7	5.2
Canada	92	91	84	5.1	5.2
Switzerland	99	87	77	2.7	2.6

Sources: Towers Watson (2011); Watson Wyatt (2007); and IMF staff estimates.

Note: The funding ratios in this table are ratios of the current market value of plan assets to the plans' projected benefit obligations, which are based on a survey of accounting assumptions for corporate defined-benefit plans. Regulatory calculation requirements may differ from accounting assumptions, and funding ratios in this table may therefore differ from ones reported by regulators.

[1]Calculations assume projected benefit obligations increase by parameters derived from the model used in Figure 4.4. The discount rate for this calculation was 2 percent for Japan and Switzerland, and 6 percent for the others. Possible effects of a longevity shock on the plans' assets are not taken into account.

the current bias toward underestimating longevity. Given the uncertainties inherent in forecasting, however, it is likely that longevity risk will remain. To effectively deal with longevity risk, three types of approaches are required: (i) addressing government longevity exposure; (ii) risk sharing between governments, pension providers, and individuals (including across generations), coupled with an improved ability of individuals to self-insure against their individual longevity risk and attention to the sustainability of the old-age safety net; and (iii) market-based transfer of longevity risk to those that are better able to bear it.

One of the most effective offsets to longevity risk is individuals' human capital, their labor or entrepreneurial income. By linking the retirement age to expected future developments in longevity, longer working lives can offset longer life spans, essentially keeping the number of years in retirement (and thus financial retirement needs) fairly constant. Increases in the retirement age can be mandated by the government for its own retirement or old-age payments, reducing the liabilities of the government (and of private pension providers if they use the government retirement age as a benchmark). People have also been working longer spontaneously—without government intervention—as individuals choose to work longer in response to living longer healthy lives and when they realize they might live longer than previously expected. Additional years spent working can increase financial buffers of individuals, helping further to offset their individual longevity risk. The extra labor income would also generate additional tax revenue, offsetting some of the public sector's costs.

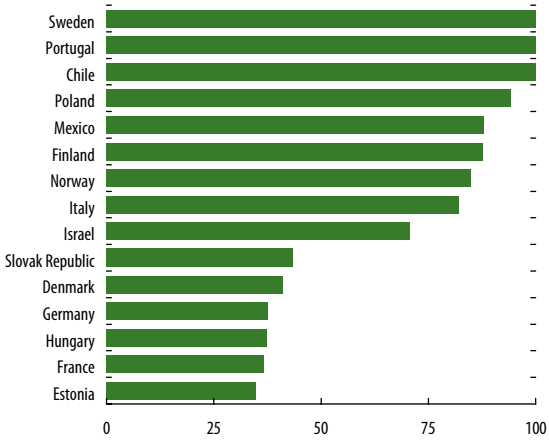
Addressing the Longevity Exposure of the Public Sector

Addressing the substantial longevity risk of the public sector will first require measuring the extent of its exposure. As in the case of the private sector, determining future contingent liabilities demands realistic estimates of future life spans for individuals covered by public pension plans and old-age social security schemes. In addition, it would be important to assess the extent of the contingent liability that governments hold because of possible insufficient retirement resources in the private sector.

The longevity risk could be partly quantified with a variety of longevity scenarios, possibly derived from the range of assumptions that are typically used in population forecasts. Such an analysis could effectively "stress test" the public finances regarding their exposure to longevity risk and their resilience to various shocks and outcomes. The exercise would be akin to the stress tests used by private financial institutions to determine their exposure and resilience to various types of financial and macroeconomic risks that affect their liquidity and solvency.

Mitigation of the identified risk would likely require a combination of policies. These could include

Figure 4.5. Index of Share of Pension Entitlements Linked to Life Expectancy in Selected Countries
(In percent)



Source: OECD (2011).
Note: Index includes links to life expectancy through defined-contribution plans.

risk sharing with individuals (see the section below) by adjusting the terms of pension plans and social security schemes (including reducing benefits, increasing contributions rates, and raising the statutory retirement age), and reducing debt in anticipation of potential longevity pressures. The main considerations for these adjustments are the sustainability of the public debt, the ability of public schemes to alleviate old-age poverty, the consequences for intergenerational equity, and transfers across income groups. Finally, like private holders of longevity risk, governments could also use the possibility of selling the risk in the capital markets (see the section on "Market-Based Transfer of Longevity Risk" below).

Only a few governments so far have taken steps to limit their exposure to longevity risk (Figure 4.5). Some countries have adjusted pension formulas to relate improvements in life expectancy to benefits (Finland, Germany, Japan, and Portugal) or to the retirement age (Denmark, France, and Italy), transferring some of the longevity risk to individuals. Some governments have instituted defined-contribution plans (Chile and Sweden). Governments could also consider increasing contribution rates to social security schemes.[19] Although such transfers could be an effective way to share the burden of aging and longevity risk, any measures need to be carefully designed to avoid overwhelming the retirement resources of individuals, in which case the risk would return to the government as the holder of last resort.

Risk Sharing across Sectors

Longevity risk is too large to be managed by any one sector of society. The solution therefore demands better risk sharing between the private business sector, the public sector, and the household sector (individuals). Much of the risk is now borne by pension providers and governments. Risk sharing could be promoted by having pension plans share longevity burdens with retirees through raising the retirement age, and increasing financial buffers for individuals to allow "self-insurance" against longevity risk.

More flexibility in the design of retirement income schemes would allow more effective burden sharing between pension providers and retirees, increasing the system's resilience to longevity shocks. Providers of pension income are already taking measures to shift some longevity risk to individuals, but national regulations differ as to the flexibility that plan sponsors have in this respect. Private and public pension providers should optimally have a variety of ways to cope with financial shortfalls as a result of unexpected increases in longevity and share the associated financial burden, including increasing the retirement age, increasing pension premiums, and reducing pensions, measures that are currently being discussed in the Netherlands.[20] Where flexibility is lacking (such as in the United Kingdom), plan sponsors are closing down defined-benefit plans and

[19]This is an option for countries that still have room for raising payroll contribution rates. In countries where the tax wedge—income and payroll taxes as a share of labor earnings—is already near or above 50 percent of total labor costs, raising contribution rates could have adverse labor market effects. Another option is to equalize the taxation of pensions and other forms of income—many advanced economies tax pensions at a lower rate, even though there is little justification for taxing pensions differently than other forms of income. Where increasing revenues is desirable, alternative revenue sources such as consumption taxes could also be considered, particularly to finance the redistributive components of pension systems.

[20]For annuities, rather than adjusting the pensionable age, Richter and Weber (2009) and Denuit, Haberman, and Renshaw (2011) discuss contracts that link payouts to longevity.

switching to defined-contribution schemes. Insurance companies are also taking longevity risk into account by charging higher premiums for annuities.

As pension providers shed aggregate longevity risk, individuals are increasingly exposed to their own individual longevity risk; to cope, individuals should delay their retirement and increase their financial buffers. Effective burden sharing requires increasing individual financial buffers for retirement, for example by mandating additional retirement savings or encouraging saving through tax policy. In order for these buffers to be available for retirement, financial stability and prudent investment strategies (with appropriate shares of "safe" assets—see Chapter 3) are key to avoid a situation where turmoil in financial markets would deplete buffers intended for retirement (as occurred recently in some countries that rely heavily on defined-contribution schemes, including the United States).

These buffers could then be used for self-insurance of households against longevity shocks without recourse to government resources, resulting in better burden sharing between households and the public sector. For instance, to avoid running out of resources before the end of life, households could be required to use a minimum portion of their retirement savings to buy an annuity contract, which guarantees a specific recurring payment until death. However, this annuitization should be well designed and well regulated to ensure consumers fully understand these contracts and to avoid the undue concentration of this risk among annuity sellers.

Few households purchase annuities, partly because annuities are not priced at actuarially fair levels for general populations (Dushi and Webb, 2006). Unattractive pricing is partly due to administrative costs and profit margins. In addition, those who expect to live longer than average are more apt to purchase annuity contracts—a form of adverse selection. Annuity companies take this selection bias into account in their pricing, which makes these products unattractive for the general public. To get around this problem, some governments have made annuitization compulsory—for example, the United Kingdom until recently, and Singapore in 2013 (Fong, Mitchell, and Koh, 2011). As an alternative, Piggott, Valdez, and Detzel (2005) have proposed that groups of retirees pool and self-annuitize to reduce adverse selection costs. Another option for elderly homeowners is to increase retirement income by consuming their home equity via reverse mortgages.[21]

Better education about retirement finances and about the concept of longevity risk are important if individuals are to increase their financial buffers for retirement and self-insure against longevity risk. Retirement finance is a complex subject, and although it is related to decisions about medical care and housing, it is often considered in isolation instead of holistically. Most households are probably unaware of the magnitude of the individual (idiosyncratic) longevity risk to which they are exposed, which make it less likely that they will be willing or able to self-insure against longevity risk. Improved education on these issues should therefore be part of a comprehensive plan of governments to address longevity risk.

Market-Based Transfer of Longevity Risk

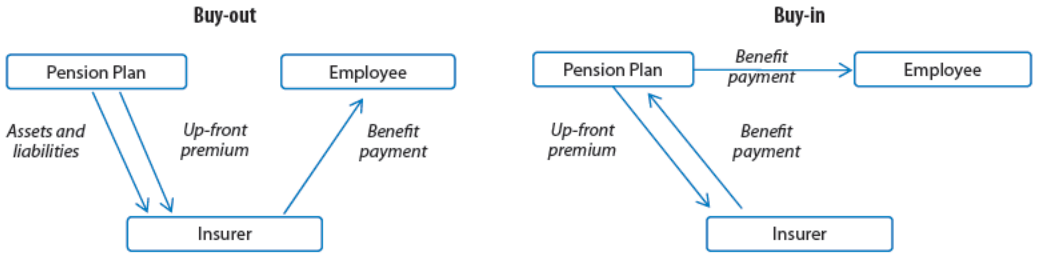
Further sharing of longevity risk could be achieved through market-based transfer of longevity risk to those better able to cope with its adverse financial consequences. In such a market, the "supply" of longevity risk would meet "demand" for that risk. That is, the risk would be transferred from those who hold it, including individuals, governments, and private providers of retirement income, to (re-)insurers, capital market participants, and private companies that might benefit from unexpected increases in longevity (providers of long-term care and health care, for example).[22] In theory, the price of longevity risk would adjust to a level at which the risk would be optimally spread through market transactions.[23]

[21]In a reverse mortgage the lender advances payments to the borrower. The loan continues to accrue interest and is settled using the proceeds from selling the property when the borrower dies.

[22]Reinsurers purchase (for a premium payment) blocks of insurance contracts from insurance companies looking to manage their risk exposures. Subject to any agreed-to conditions, the reinsurer then becomes responsible for paying any claims on the underlying insurance policies.

[23]Risk transfer would be beneficial to financial stability even for aggregate longevity risk. The benefit does not result from diversification—the aggregate risk cannot be diversified away—but from shifting the risk to those that are better able to handle its financial consequences.

Figure 4.6. Structure of Pension Buy-Out and Buy-In Transactions



Simply designed, over-the-counter (OTC) bilateral contracts and longevity bonds are the two principal instruments through which longevity risk can be transferred. The bilateral solutions include pension buy-outs and buy-ins, swaps, and other derivative contracts.[24]

Bilateral Contracts

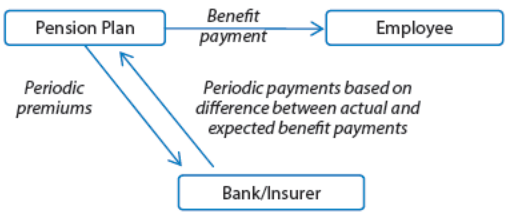
Buy-ins and buy-outs are simple transactions accomplishing risk transfer, but each has different implications for the sponsor. In a buy-out transaction all of the pension fund's assets and liabilities are transferred to an insurer for an up-front premium (Figure 4.6). The pension liabilities and their offsetting assets are removed from the pension fund sponsor's balance sheet and the insurer takes over full responsibility for making payments to pensioners. In a buy-in, the sponsor pays an up-front premium to the insurer, who then makes periodic payments to the pension fund sponsor equal to those made by the sponsor to its members. This "insurance policy" is held as an asset by the pension plan; the premium is the cost of the insurance policy that guarantees payments even if retirees live longer than expected.

In another type of bilateral transaction, the longevity swap, the pension fund obtains a similar protection from higher-than-expected pension payouts. The plan sponsor makes periodic fixed "premium" payments to the swap counterparty, which in turn makes periodic payments that are based on the difference between the actual and expected benefit payments (Figure 4.7). The sponsor maintains full responsibility for making benefit payments to its employees. An advantage of buy-ins and swaps is that they can be used to hedge the longevity risk associated with specific subsets of the underlying population. An advantage of swaps is that longevity risk can be isolated, whereas buy-in and buy-out transactions typically also transfer the investment risk of the assets. Longevity swaps can also be combined with other types of derivative contracts, such as inflation, interest rate, and total return swaps, to create so-called "synthetic" buy-ins that transfer all of the risks.

Longevity Bonds

The payout on a longevity bond would depend on an index that tracks the longevity experience of a given population (Figure 4.8). The periodic payment (or coupon) on a longevity bond would be proportional to the number of survivors in the population. Therefore, the issuer of the bond (an investment bank or insurance company) pays more to the owner of the bond (the pension fund sponsor) when longevity is higher. The owner of the bond could thus use the periodic payments from the bond to offset any higher-than-expected payments to retirees. Because investors can offset some of their longevity risk with this bond, the interest rate they demand for holding it may be lower than for regular bonds. One disadvantage is that, unlike a swap, the owner of the bond

Figure 4.7. Structure of Longevity Swap Transactions



[24]Longevity risk can also be transferred to capital markets via "life settlement" securitizations. A life settlement occurs when the owner of a life insurance policy sells the policy for an amount below the face value of the policy (i.e., the amount paid when the policyholder dies). The purchaser becomes responsible for making premium payments in return for collecting death benefits. Although life settlement volumes have been growing recently, they have not reached the point at which securitization becomes viable on a large scale. Life settlements are akin to viatical settlements (see Box 4.3).

Figure 4.8. Structure of Longevity Bond Transaction

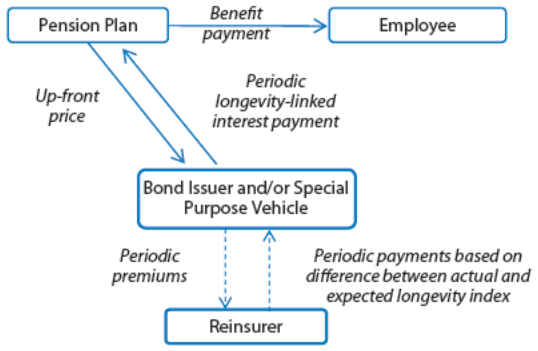
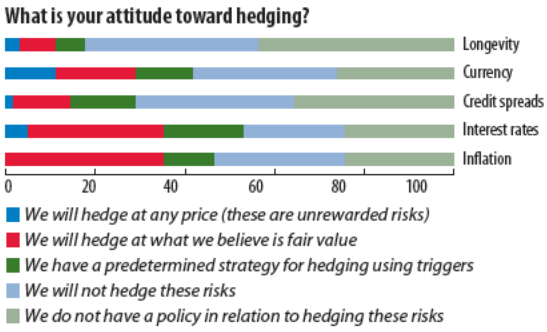
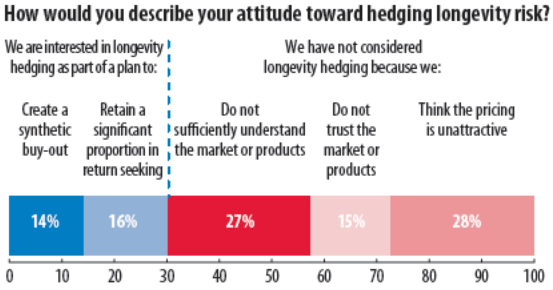


Figure 4.9. Attitudes of Pension Plan Sponsors toward Hedging Pension Risk, by Type of Risk
(In percent of respondents)



Source: Aon Hewitt (2011).

Figure 4.10. Attitudes of Potential Sellers of Longevity Risk toward Hedging
(In percent of respondents)



Source: Aon Hewitt (2011).

must make a large up-front payment to the issuer, resulting in counterparty risk exposure to the issuer. To date, there has been no successful longevity bond issuance, although there have been several false starts.

Challenges for the Risk Transfer Market

The use of capital market-based longevity risk management solutions has been growing, but their use remains small, with the notable exception of the swap, buy-in, and buy-out markets in the United Kingdom and the Netherlands (Box 4.6). Explanations for the slow growth include challenges on the sell and buy sides, as well as market infrastructure issues affecting both sides of the transaction.

For those that are "selling" (that is, trying to reduce) their longevity risk, a major reason for a limited market for longevity risk transfer is that only a few pension plan sponsors recognize longevity risk at all, and fewer still have plans to address it. Longevity risk is seen as less important to hedge than other financial risks (Figure 4.9). It is also considered to be dominated by the higher volatility of asset valuations and liability discount rates, which may mask the slower-moving effects of increases in life expectancy. In addition, many plan sponsors would have to first recognize and remedy existing underfunding before transferring their longevity risk, making risk transfer an "expensive" exercise. Also hindering the transfer market is a degree of moral hazard, in which pension providers may expect a government bailout if a significant longevity event threatens their financial viability.

Lack of familiarity with the market for longevity risk is another impediment. That lack of familiarity was shown in a recent survey (Aon Hewitt, 2011), which suggested that potential sellers of longevity risk (i) lacked an understanding of the market, (ii) lacked trust in longevity products, and (iii) considered pricing to be unattractive (Figure 4.10).

Another concern for sellers of longevity risk is basis risk. In this context, basis risk exists because the payout in a risk transfer deal is typically linked to an index that is based on the longevity experience of a sample population, whereas actual payouts depend on the actual pool of retirees of the pension provider.[25]

[25]Basis risk can be large, caused by differences in life expectancy at age 65 depending on gender, employment history, income, and geographic location. For example, for a higher-income female in

Box 4.6. Recent Activity in the Dutch and U.K. Buy-Out, Buy-In, and Longevity Swap Markets

This box provides an overview of recent activity in the longevity risk transfer market in the Netherlands and the United Kingdom.

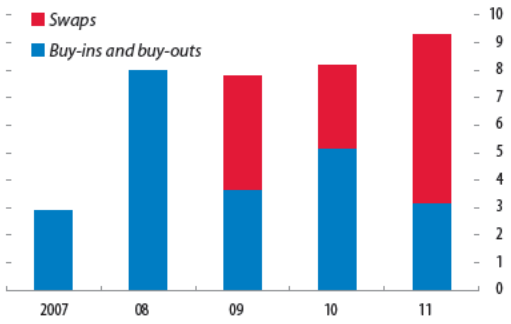
Transactions by defined-benefit pension funds in the United Kingdom to transfer their longevity risk averaged about £8 billion per year in the period 2008–10 and rose to about £9 billion in 2011 (see Figure 4.6.1). About half have been longevity swaps, with investment banks increasing their activity in this market starting in 2008 as buyers or intermediaries. Almost all of the largest transactions (greater than £1 billion) are swaps, with buy-outs being used primarily for smaller funds (less than £500 million). There have been a number of small transactions in the Netherlands over the last few years, and a €12 billion longevity swap between Aegon and Deutsche Bank in early 2012 (Steinglass and Wilson, 2012).

The different risk-transfer solutions are associated with particular types of counterparties (see Figure 4.6.2). U.K. insurers regulated by the Financial Services Authority are associated with all of the buy-in and buy-out activity, whereas almost all of the longevity swap transactions have been made by investment banks. In turn, insurers and banks have passed some of this risk to reinsurers via swap contracts. So far, none of the risk has been passed on to capital markets, although some longevity bond transactions may be in the works.

Despite numerous buy-out, buy-in and swap transactions (see Table 4.6.1 for the largest), to date no longevity bonds have been issued. The European Investment Bank tried to issue a longevity bond in 2004, but it was cancelled due to lack of interest on both the buy and sell sides (Biffis and Blake, 2009). The World Bank's attempt in 2010 also did not succeed (Zelenko, 2011). The experience with longevity bonds contrasts with the much more active market for "mortality" bonds, which transfer medium-term (three- to five-year) risk associated with catastrophic mortality events such as pandemics.

Note: Prepared by John Kiff.

Figure 4.6.1. U.K. Longevity Risk Transfers, by Type of Transfer
(In billions of pounds sterling)



Sources: Hymans Robertson; and IMF staff estimates.

Figure 4.6.2. Structure of Longevity Transfers by U.K. Defined-Benefit Pension Plans, by Type of Counterparty

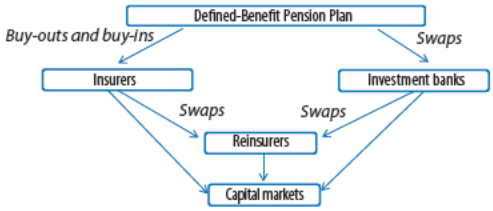


Table 4.6.1. Largest Longevity Risk Transfers by U.K. Pension Plans

Pension Plan	Provider	Deal Type	Value (In billions of pounds sterling)	Date
Rolls Royce	Deutsche Bank	Swap	3.0	November 2011
RSA Insurance	Rothesay Life[1]	Swap	1.9	July 2009
ITV	Credit Suisse	Swap	1.7	August 2011
British Airways	Rothesay Life[1]	Buy-in[2]	1.3	June 2010
British Airways	Rothesay Life[1]	Swap	1.3	December 2011
Babcock	Credit Suisse	Swap	1.2	July 2010
Thorne	Pension Corporation	Buy-out	1.1	December 2008
Turner & Newall	Legal & General	Buy-in	1.1	October 2011
Cable & Wireless	Prudential (U.K.)	Buy-in	1.0	September 2008
Pilkington	Legal & General	Swap	1.0	January 2012

Source: Hymans Robertson.
[1]An insurance subsidiary of Goldman Sachs.
[2]Synthetic buy-In (longevity swap plus asset swap).

The small size of the longevity risk market is due in part to a dearth of buyers of longevity risk relative to its potential sellers. Since global longevity risk is large and many individuals and institutions (including governments) are already exposed, there are few natural buyers for this risk.

Reinsurers and insurers exposed to life insurance risk are one class of natural buyers, as the acquisition of longevity risk may provide a partial hedge for their insurance exposure. This is because the two risks largely offset each other—life annuity liabilities increase when annuitants live longer, whereas life insurance liabilities decrease.[26] However, reinsurer capacity to take on longevity risk may already be approaching the limit (which market participants estimate at approximately $15 billion per year), so a broader investment base is needed to match the large potential seller volume. Other natural buyers might include those companies that would benefit from having people living longer, including firms in the health care, home-care, and pharmaceutical industries.[27] As this risk gets transferred to capital market participants outside the regulated perimeter, supervisors need to remain vigilant to ensure that final recipients understand the risks they take on and can manage them appropriately.

A relatively untapped pool of potential buyers of longevity risk consists of asset managers, sovereign wealth funds, and hedge funds. Asset managers and sovereign wealth funds may be encouraged by the fact that longevity risk is likely to be largely uncorrelated to the other risk factors in their portfolio.[28] However, hedge funds may be put off by the long duration of the contracts, which may make them inappropriate for most hedge fund's investment styles. A solution to the duration problem could be the Deutsche Börse's longevity swaps based on their XPect® family of longevity indices.[29] These swaps settle based on changes in expected life curves over shorter time periods.

Buyers of longevity risk may be discouraged by the illiquidity of instruments and by asymmetric information. Sellers of longevity risk would tend to seek customized hedge contracts to maximize the effectiveness of risk transfer, whereas many buyers of this risk would likely look for standardized instruments to maximize liquidity. This fundamental difference in perspective complicates the development of an active market. More standardized products would improve liquidity for buyers, but would also increase basis risk for sellers, because standardization will likely increase the demographic differences between the actual pool of retirees and the reference pool on which payments are based. In addition, the asymmetry of information in risk transfer deals disadvantages buyers, which can lead to mispricing in markets. For example, a pension fund may know more than risk buyers about the health of its retirees. Therefore, only those pension funds with the longest-living populations may want to hedge the risk.

Both buyers and sellers of longevity risk face counterparty risk. Longevity deals tend to be long-term contracts in which the counterparty may fail to honor its financial commitments over time. Such counterparty risk is usually addressed with collateralization, which can involve significant costs because it requires that the proceeds be invested in high-quality liquid securities that may be in short supply (see Chapter 3). This consideration favors derivative contracts, such as longevity swaps, which require the collateralization of only the net payments, which is

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the southeast of England life expectancy at 65 is approximately 22 years, whereas for a low-income male living in the north it is just under 13 years (Byrne and Harrison, 2005). Recent research has proposed index-based hedge methodologies to reduce such basis risk to acceptably low levels (Coughlan and others, 2011; and Li and Hardy, 2011).

[26]Cox and Lin (2007) and Dowd and others (2006) discuss the role that derivative contracts (mortality/survivor swaps) can play in such hedging. Mortality risk can be used in part to hedge longevity risk, but the risk reduction may be lower than expected because mortality risk contracts are short term in nature (typically one- to five-year maturity) with a large exceptional element (e.g., pandemic risk), while longevity risk is a longer-term risk (typically 20- to 80-year horizon) and reflects largely unanticipated changes in trend.

[27]There are fewer prospects for swapping risk between countries with different demographics. Developing and advanced economies have different levels of longevity, but they probably do not want to buy each other's longevity *risk*. What matters in trading longevity risk across countries is not the difference in longevity levels per se, but the degree to which they are correlated. It is likely that the correlations across countries are increasing, making such an investment unattractive.

[28]However, the value of instruments for transferring longevity risk is correlated with interest rate levels via their role in the present value discounting of future payouts, so the lack-of-correlation rationale may be weaker than expected.

[29]The monthly XPect® indices are based on data from Germany, the Netherlands, and the United Kingdom. They track a number of male and female cohorts defined by birth dates (1900–19, 1920–39, 1940–59, 1960–79, and 1980–99).

the difference between what each swap participant owes the other.[30]

Finally, both sides of the market are also affected by a lack of reliable and sufficiently detailed information about longevity developments. Life tables are not updated frequently and are only available for relatively aggregated groups in the population. Sophisticated longevity risk management and transfer would benefit from much more disaggregated demographic data (including, for example, by postal code and cause of death), which can reduce basis risk; indexes of such data would facilitate the design and trading of longevity risk transfer instruments. Index-based transactions may also lessen the problem of asymmetric information.

The Role of Government

Government may be able to facilitate the private sector in developing an efficient market for the transfer of longevity risk. A thriving market in longevity risk would transfer this risk to those that can better bear it, promoting financial stability, a clear public good. The government can promote this market through a number of measures, including:

- *Providing more detailed longevity data.* The lack of detailed longevity and related demographic data is a major constraint facing the longevity risk market. Governments are best placed to provide such data, perhaps through national statistics offices or government actuaries.[31] Essential data would include longevity information that is disaggregated by geographic area, as well as by gender, socioeconomic status, cause of death, and occupation. The government could also usefully track the emergence and evolution of new diseases, especially those afflicting the elderly (such as Alzheimer's disease), medical advances (such as new diagnostics and treatments, and genetic advances), and lifestyle changes (such as smoking and obesity rates).
- *Enhancing regulation and supervision.* Governments could provide tighter regulation to promote the recognition and mitigation of longevity risk, including through stricter funding requirements and enhanced accounting transparency for pension funds and insurance companies. Indeed, pension regulations requiring the mitigation of financial risks could be expanded to include longevity risk.
- *Improving the education of market participants.* Surveys suggest that market participants are generally unaware of longevity risk. There is a role for government to promote awareness of the importance of addressing longevity risk similarly to other financial risks. Pension supervisors are well placed to take on this task. In addition, in some countries, households are provided with periodic estimates of their pension resources to sensitize them to potential shortfalls.

Some market participants have suggested that there is also a role for the government in jumpstarting the market for longevity bonds, but it is not clear what market failure governments could correct. Government-issued bonds would provide benchmarks and liquidity to the market, and some say that once the market is established, the government could reduce its issuance and let the private sector take over (Blake, Boardman, and Cairns, 2010). However, unless tied to rising retirement ages, issuance of longevity bonds would expose governments to additional longevity risk. It is not clear that the advantages of jumpstarting the market outweigh the costs, although estimates of net gains are difficult to measure. Some liken the issuance of longevity bonds to that of inflation-indexed bonds that helped that market thrive.

Conclusions and Policy Considerations

Longevity risk is large and affects all of society. If everyone in 2050 lived just three years longer than now expected—in line with the average underestimation of longevity in the past—society would need extra resources equal to 1 to 2 percent of GDP per

[30]Biffis and others (2011) show that the cost of collateral to secure longevity swaps can be quite reasonable, especially when counterparty default risk and collateral rules are symmetric.

[31]The private sector also has a role in providing better data. The Life and Longevity Markets Association is a nonprofit group of several investment banks, insurers, and reinsurers interested in facilitating the structuring of longevity risk transfer deals. It is pushing for the development of a more standardized and liquid index-based longevity risk market. The group is setting up standardized term sheets and pricing methodologies for swap transactions and pushing for the production of detailed and frequently updated life tables. Efforts of individual companies (including Credit Suisse in 2006, Goldman Sachs in 2007, and JP Morgan in 2007) to develop indexes have been met with skepticism by market participants, who doubt the independence of their calculations.

year. If this longevity shock occurred today and society wanted to save to pay for these extra resources for the next 40 years (that is, fully fund these additional "pension liabilities"), advanced economies would have to set aside about 50 percent of 2010 GDP, and emerging economies would need about 25 percent of 2010 GDP—a sum totaling tens of trillions of dollars. As such, longevity risk potentially adds one-half to the vast costs of aging up to the year 2050—and aging costs themselves are not fully recognized in most long-term fiscal plans.

Private pension providers and governments are particularly exposed to longevity risk and this risk is greatly increased in the current low-interest-rate environment. In line with other estimates in the literature, the analysis in this chapter finds that the liabilities of U.S. pension plans would rise by 9 percent for a three-year increase in longevity. Governments may be even more exposed: many not only sponsor defined-benefit pension plans for their employees, but maintain extensive old-age social security systems covering most of the population. In addition, the government is likely liable for the "tail" of longevity risk: in the case of a longevity shock affecting the entire population, the private sector would likely be overwhelmed by the financial consequences. In that case, the losses are likely to be assumed by the government in some way, including through pension fund guarantee schemes that take on the pension liabilities of failing institutions and social security schemes that aim to prevent old age poverty.

Longevity risk is generally not well recognized, although this is slowly improving. Until recently, few pension plans or governments explicitly recognized the existence of longevity risk, and even fewer prepare for or mitigate it. Even if updated mortality tables were used, adequate provisions for future mortality improvements were often not being applied. Regulations tend not to emphasize longevity risk and supervisors may themselves not be fully aware of the extent of longevity risk faced by pension providers. Few governments have assessed the longevity risk present in public pension plans and social security systems. In the past few years, more pension plans and insurers have started to pay attention to longevity risk, especially in the United Kingdom and the Netherlands, and the market for risk transfer has developed some activity, although representing just a fraction of the existing risk.

Longevity risk affects financial stability by threatening fiscal sustainability and weakening private sector balance sheets, adding to existing vulnerabilities in the current environment. Although longevity risk is a slow-burning issue, it increases the vulnerability of the public and private sectors to various other shocks. The risk is therefore perhaps not immediate, but the longer these vulnerabilities are allowed to build up, the more likely it is that there will be large adjustments in the future.

Policy Recommendations

- Governments should acknowledge the existence of longevity risk in their balance sheets as contingent liabilities and ensure that it does not threaten the sustainability of the public finances. A credible and realistic plan to deal with longevity risk can help restore confidence in the long-term sustainability of the public finances. A first-best policy would be to link the eligibility age for public pensions to actual developments in longevity (thereby responding to longevity risk events as they materialize and holding constant the duration of retirement), preferably through automatic or formula-based periodic adjustments to avoid recurring public debate about the issue. In countries where higher taxation is unlikely to affect labor supply much, this policy could be complemented by increases in contribution rates. Reducing benefits, though perhaps most difficult politically, is a third way of coping with the issue.
- Given the magnitude of longevity risk, risk sharing between businesses, the government, and individuals will help alleviate pressures on any one sector. The government could promote risk sharing in several ways. It could increase the ability of pension providers to share shortfalls with plan participants. The government could promote increased financial buffers for individuals, for example by promoting retirement products that take account of possible future increases in longevity. Individuals could then share the burden of longevity risk by self-insuring against longevity risk to some extent. This would require better education on retirement finance

and improved awareness by individuals of longevity risk. Because individuals would turn to public resources if they run out of retirement resources, the government is a natural provider of such education and of regular updates on estimated personal retirement resources.

- Although the private sector will further develop market-based transfer mechanisms for longevity risk if it recognizes the benefits of doing so, the government has a potential role in supporting this market. Measures could include provision of better longevity data, better regulation and supervision, and education to promote awareness of longevity risk. Those governments that are able to limit their own longevity risk could consider issuing a limited quantity of longevity bonds to jumpstart the market.
- Full recognition and effective mitigation of longevity risk requires improvements in data availability and transparency. Public or private development of longevity indexes and more diverse population-specific mortality tables would facilitate assessment of longevity risk and its transfer. The credibility of these data would be enhanced if they were compiled by government statistical offices or independent industry associations acting at arm's length from the market.
- Regulation and supervision of institutions exposed to longevity risk should be improved. Insurance companies and defined-benefit pension plans should have to deal with longevity risk just as they must manage other financial risks, such as interest rate risk and inflation risk. Doing so would require at least an annual assessment using the most up-to-date mortality tables, conservative assumptions for future mortality improvements, and the use of appropriate discounting factors, all enforced by appropriately strengthened accounting rules. Recognition of underfunding by pension plans and their sponsors is key; they need realistic plans to achieve full funding over a reasonable period, because longevity risk can be transferred more easily once a plan is fully funded.

In sum, better recognition and mitigation of longevity risk should be undertaken now, including through risk sharing between individuals, pension providers, and the public sector, and through the development of a liquid longevity risk transfer market. Longevity risk is already on the doorstep and effectively addressing it will become more difficult the longer remedial action is delayed. Much of the apprehension surrounding fiscal sustainability relates to the apparent inability to address structural fiscal issues in the affected countries. Attention to population aging—and, *a fortiori,* the additional risk of longevity—is part of the set of reforms needed to rebuild confidence in the viability of sovereign balance sheets.

Annex 4.1. The Impact of Longevity Risk on U.S. Defined-Benefit Plans

This annex describes an empirical measure of the impact of longevity risk on defined-benefit pension plan liabilities. The analysis uses actuarial and financial data from U.S. corporate pension funds, which plan sponsors are required to submit annually to the U.S. Department of Labor on the department's Form 5500. The data used here cover the period 1995–2007.[32] As of 2007, the total amount of U.S. defined-benefit pension liabilities equaled approximately $2.2 trillion and covered more than 42 million plan participants.

When computing the present value of future pension obligations, corporations have to make and report several actuarial assumptions, including the discount rate they apply and the mortality tables underlying the computations of the expected length of future payout streams. The data show that there is a substantial level of variation in the use of mortality tables across funds and over time. This variation can be used in a regression analysis to estimate the impact of an additional year of life expectancy on the present value of pension liabilities.

Regression Specification

The regression specification is based on the idea that defined-benefit pensions can be modeled as an annuity; that is, a specified regular payment for the remainder of life. Following de Witt (1671) it is known that the present value of a pension liability (L) is given by

$$L = pb \sum_{i=1}^{T} \frac{(1 - s_i)}{(1 + r)^i} \tag{4.1}$$

where p is the number of plan participants, T is the assumed maximum life span, s_i denotes the survival probability over i periods, b is the promised amount of periodical payouts, and r denotes the discount rate.[33] Due to data limitations, we will proxy for the valuation equation by using

$$L \approx pb \left[\frac{(1 - (1 + r)^{-n}}{r} \right] \tag{4.2}$$

where n is the expected number of future payouts.[34] Rearranging terms and taking the logarithm, it follows that

$$\log(L) \approx \log(p) + \log(b) - \log(r) + \log[(1 + r)^n - 1] - n\log(1 + r) \tag{4.3}$$

Linearizing the two last terms of equation (4.3), we obtain

$$\log(L) = \alpha + \beta_1 \log(p) + \beta_2 \log(b) + \beta_3 \log(r) + \beta_4 n + \beta_5 \log(r)n + e \tag{4.4}$$

which can be estimated in a panel regression, accounting for plan-specific effects. The main interest is in the coefficient β_4, which is the effect of one additional year of life expectancy on the present value of pension liabilities.

Results

The impact of longevity assumptions on pension liabilities is estimated using the simple pension valuation model of equation (4.4) with the Form 5500 data and focusing on only those participants who are already receiving the "annuity," namely, retired plan participants. Table 4.5 summarizes the results.

Note: Prepared by Michael Kisser.

[32]The required level of detail differs depending on whether a plan is classified as small or large and on the type of plan (welfare plans, pension plans, common trusts, and so on). A plan is generally classified as large if it has more than 100 participants. The starting point for the coverage period was determined by the fact that information regarding the underlying mortality tables used in actuarial computations became available in 1995. The final year of the period, 2007, is the most recent for which Form 5500 data have been published.

[33]In reality, the promised periodic payment, b, would differ across employees. However, using the average payment across employees leads to a similar valuation.

[34]Note that the life expectancy is equal to the sum of the individual survival probabilities. The valuations presented in equations (4.1) and (4.2) will be exactly equal to each other when the discount rate, r, equals zero. If we assume that r is low (as in the current macroeconomic environment) then the approximation is reasonable.

Table 4.5. The Impact of Longevity Risk on Pension Liabilities

	Coefficient
log (discount rate)	–0.945***
log (participants)	0.914***
log (benefit)	0.519***
Longevity	0.03***
Observations	89552
R-squared	0.742

Source: IMF staff calculations.

Note: The initial estimation of equation (4.4) included the interaction term between longevity and log(discount rate), as specified. However, the high correlation between longevity, log(discount rate), and the interaction term rendered all three variables statistically insignificant in this specification. Subsequently, the interaction term was excluded; these results are reported in the table. *** p <0.001.

The regression explains 74 percent of the variation in (the logarithm of) pension liabilities and shows that an additional year of life expectancy at age 63 increases pension liabilities by approximately 3 percent.[35]

[35]A substantial number of pension plans do not specify the actuarial table used, which potentially biases the results. However, if all those plans are assumed to use the latest table (the strongest assumption possible), the results of the regression are substantially the same.

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