NBIM memo

On fixed-income investments

March 2011

This memo contains the theoretical and empirical background and underpinning for Norges Bank's advice on the Fund's fixed-income investment strategy. The respective chapters contain independent, standalone sections.

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Chapter 1

Forward-looking analysis

Sovereign risk

Government debt has increased sharply in most developed countries in the wake of the financial crisis. The increased debt burden comes on top of an expected surge in debt due to demographics. Sharpened by the European peripheral debt crisis, this has led to increased focus on the risk associated with investing in government debt. This section reviews measures of this risk and discusses possible implications for investment returns.

Main findings

- A continuation of current policies in most developed countries is unsustainable. This is mainly due to today's high debt-to-GDP ratio and an ageing population incurring costs in the future.

- In order to bring the debt-to-GDP ratio onto a sustainable path, governments need to change policies, default on debt or expropriate assets. The mix of the options a government chooses will have implications for investment returns.

- Empirical evidence shows that governments historically have both defaulted on debt and expropriated assets, but usually opt to change fiscal policies.

- Constructing measures that predict when governments will choose the default-on-debt option is challenging. In developed economies, validating such a measure empirically would in any case be difficult since defaults are almost non-existent.[1] As a group, developed economies are, however, in a new situation: the debt-to-GDP ratio is higher than ever previously observed and significant policy changes are needed to make policies sustainable (IMF 2010a).

- Some indicators, albeit noisy, do indicate that the default risk on government debt in developed economies has increased, and it should be noted that even a small increase

[1] The last defaults in the industrial world were Japan and Germany in the immediate aftermath of World War II (Reinhart and Rogoff 2008).

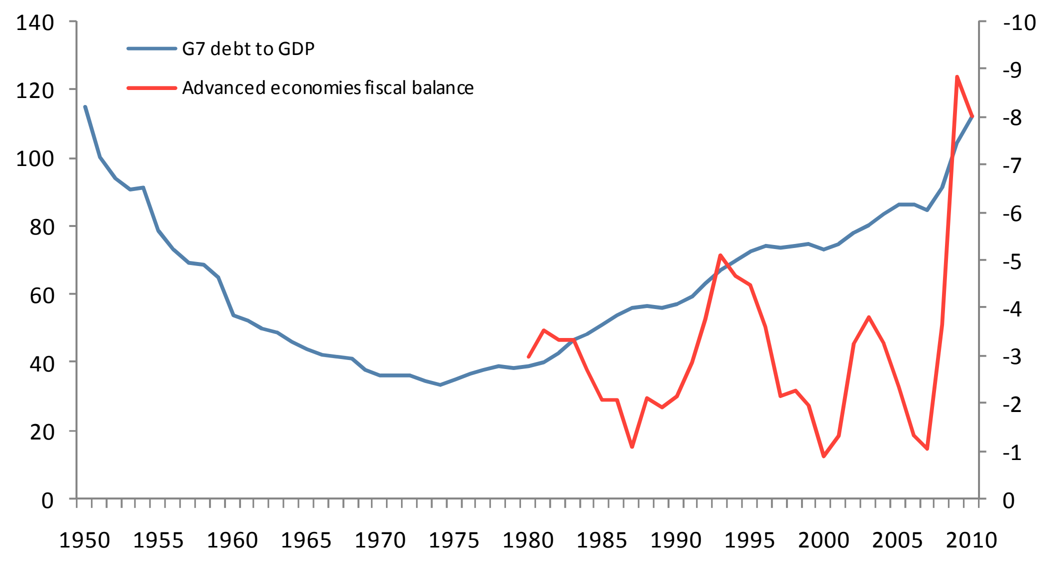
in this default probability can change the way investors construct portfolios and price risk: the premise that a risk-free investment exists, which is an important building block in portfolio theory and management, may no longer be valid (Damodaran 2010).

- Even if we still judge the risk of outright defaults on government debt in the developed economies as fairly small, the high and increasing debt levels may imply a weak real return outlook in developed countries.[2]

Is a continuation of current policies unsustainable?

The chart below is based on IMF data and shows developments in G7 debt-to-GDP and fiscal balance in advanced economies on the left- and right-hand scales respectively. Debt is approaching levels not registered since the early 1950s when these countries were recovering from World War II. Record-high fiscal deficits suggest that the debt-to-GDP ratio will rise further over the next few years. This development has fuelled discussions of whether a continuation of current policies is sustainable.

Figure 1: G7 debt-to-GDP and fiscal balance in advanced economies



Source: IMF

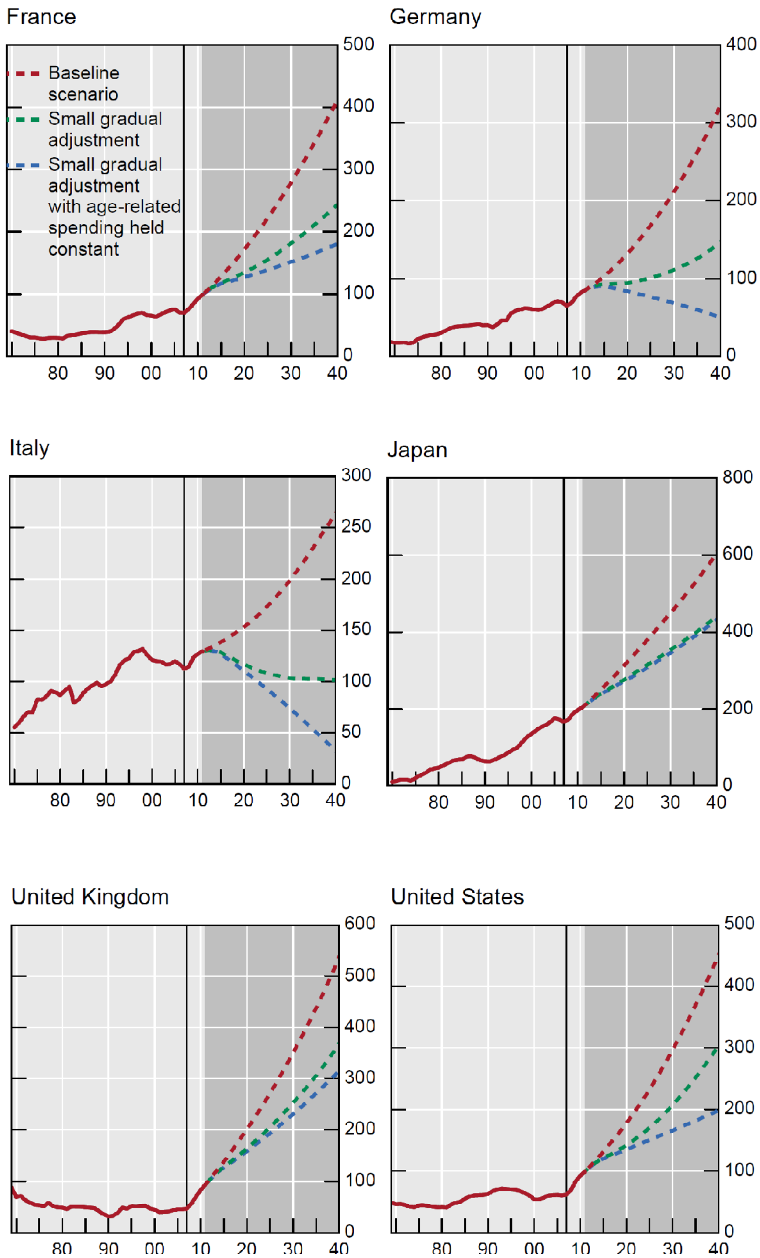
[2] Reinhart and Rogoff (2010) find that a high debt-to-GDP ratio is associated with low real economic growth.

It is difficult to determine whether a continuation of current policies is unsustainable, not least since it involves assessing uncertain future tax revenues and expenditures. In a recent paper from the BIS, Cecchetti, Mohanty and Zampolli (2010) project the path of the debt-to-GDP ratio in several major developed countries for the coming 30 years. In the baseline case, they assume that government revenues and non-age-related primary spending remain a constant share of GDP at the 2011 level as projected by the OECD. They then use the Congressional Budget Office and European Commission projections for age-related spending to generate a path for total primary government spending (total spending excluding the interest bill on outstanding debt).

They make two further assumptions: the real interest rate on government debt is assumed to be at its 1998-2007 average, and potential real GDP growth is set equal to recent OECD estimates. They then compute the primary surplus and debt as a percentage of GDP over the coming 30 years (the red line in Figure 2). Note that, for most of the countries, debt as a share of GDP will roughly triple from today's historically high levels, and the path does not show any sign of flattening out, leading the authors to conclude that a continuation of current policies is unsustainable. This is not a controversial conclusion: see also IMF (2010a), European Commission (2009) and de Mello and Padoan (2010).

The BIS paper also computes debt-to-GDP under two new policies. First, it is assumed that the primary surplus as a share of GDP improves by 1 percentage point each year for the next five years (the green line in Figure 2), and then, in addition, age-related spending relative to GDP is kept constant at the projected 2011 level (the blue line in Figure 2). Even after these significant changes, the authors find policies to be unsustainable in some countries.

Figure 2: Debt-to-GDP projections



Source: Cecchetti, Mohanty and Zampolli (2010)

The government's budget constraint

This subsection defines theoretically what it means for a continuation of current policies to be unsustainable and explores the options available to government for bringing policies onto a sustainable path.

The simplified budget constraint facing a government can be written as

$$G_t + (A_t - A_{t-1}) + i_{Bt}B_{t-1} = T_t + i_{At}A_{t-1} + (B_t - B_{t-1}) + (M_t - M_{t-1}) \qquad (1)$$

where G_t is government expenditures, A_t the government's assets, i_{Bt} the interest rate on the government's (nominal, local currency[3]) debt, B_t, and M_t is the outstanding money stock, all in period *t.* The budget constraint simply says that, for every period, the government's expenditures and investments (increase in assets) and the interest bill must be financed by its tax revenues, interest/dividends on its assets, debt issuance and/or an increase in the money stock.

Even without discussing the government's preferences, we can make a few observations from this problem. First, the amount of debt a government issues in one period depends on many variables, of which several may be associated with uncertainty: G_t, T_t and i_{At}. Furthermore, there are alternatives to issuing debt to cover any shortfall of revenues to expenditures – disinvestments or printing money.

In most developed countries, the money stock is under the control of an independent central bank. For the time being we will ignore the possibility of increasing the money stock. We will, however, return to this later given the current conduct of unconventional monetary policy. We also assume that $i_{Bt} = i_{At} = i$ – the interest rates on debt and investments are equal to a constant. Given these assumptions, we can sum the intertemporal budget constraint (1) over all periods to get

$$\sum_{t=0}^{\infty} \frac{1}{(1+i)^t} (G_t - T_t) = (A_0 - B_0) \qquad (2)$$

[3] We do not discuss in length the distinction between debt issued in foreign and local currency. Note, however, that throughout history we find examples of countries that have defaulted on both local and foreign currency debt simultaneously, local currency debt only and foreign currency debt only, though the last of these takes place most frequently (see Damodaran 2010 for more details).

which simply says that in any initial period 0, the net present value of current and future government expenditures over tax revenues has to be equal to initial net wealth – the difference between the government's assets and debt in period 0.

A continuation of current policies implying present and future expenditures, G_t^*, and taxes, T_t^*, is unsustainable if

$$\sum_{t=0}^{\infty} \frac{1}{(1+i)^t} (G_t^* - T_t^*) > (A_0 - B_0) \tag{3}$$

The government can then change policies by cutting expenditures, spending less than G_t^*, and/or collecting more taxes than T_t^*, e.g. by increasing the tax rates. Another possibility is to default on the debt, reducing B_0, and/or to increase its assets, A_0, e.g. through expropriation. The key point is that some measures will be taken (at some point) to restore equality in (3). Which measure will be taken may vary across both countries and governments.

Assessing whether a country is in a situation described by (3) is a challenging task. First, it involves making projections of government expenditures and tax revenues under a continuation of current policies. Second, it involves valuing the government's assets, many of which may not be traded in a marketplace. In addition, since governments may differ in their response to such a situation, assessing the probability that a government will choose to default on its debt is not straightforward. Consequently the credit rating agencies use a range of factors in their assessments of this probability (IMF 2010b), including the state of the government's finances.[4]

For a long-term investor, observing a situation described by (3) should raise some concerns since current investments may be hurt: investments in government bonds may lose value if the government chooses to default on its debt; foreign direct investments may be targeted if the government chooses expropriation as the solution. Even if the government opts for a change of policies, investments may be affected: for example, increasing corporate tax rates may be bad for equity investments in general and reducing government expenditures may involve cutting subsidies and consequently lower the equity value of companies relying heavily on such support.

[4] Damodaran (2010) concludes that all of the ratings agencies seem to have, on average, delivered the goods in terms of measuring default risk.

Debt levels are often the starting point when considering a government's finances. To enable comparisons across time and countries, debt is usually measured as a share of GDP.[5] We can write debt, the primary surplus (the difference between tax revenues and government expenditures), the money stock and the interest bill as a share of nominal GDP in period *t* as

$$b_t \equiv \frac{B_t}{Y_t},\ \ p_t \equiv \frac{P_t}{Y_t} \equiv \frac{T_t - G_t}{Y_t},\ \ m_t \equiv \frac{M_t}{Y_t}\ \ \ l_t \equiv \frac{iB_{t-1}}{Y_t}$$

Nominal GDP grows at a rate δ_t

$$Y_t = Y_{t-1}(1+\delta_t) = Y_{t-1}(1+\pi_t)(1+g_t),$$

where π_t is inflation and g_t is real GDP growth, all in period *t*.

If we now return to (1) and simplify it by ignoring the government's assets, A_t, debt to nominal GDP can be written as

$$b_t = -p_t + l_t + \frac{1}{1+\delta_t} b_{t-1} - (\, m_t - m_{t-1}) - \frac{\delta_t}{1+\delta_t} m_{t-1} \qquad (4)$$

If we assume that the money stock and nominal GDP grow at the same rate, which is a simplified version of Friedman's quantity theory of money (Friedman 2008), then $m_t = m_{t-1} = m^*$ – a constant – and (4) simplifies to

$$b_t = -p_t + l_t + \frac{1}{1+\delta_t} b_{t-1} - \frac{\delta_t}{1+\delta_t} m^* \qquad (5)$$

We find that the higher the nominal growth in the economy, δ_t, the easier the "debt burden", all else equal. Debt as a share of GDP becomes smaller the higher the nominal GDP growth rate, through two channels. The obvious one is that the denominator grows faster. The other is due to higher returns on seigniorage$\frac{\delta_t}{1+\delta_t} m^*$. The stronger the nominal GDP growth, the more money will be in circulation, money on which the government does not pay any interest. Consequently the government can print more money instead of issuing more debt to cover some of its expenditures.

Higher nominal growth through higher real growth has few disadvantages, but the government can also consider letting inflation rise to ease the debt burden. This may hurt real growth (Barro 1996) and it may be in conflict with stated monetary policy targets such as

[5] The resources available to service the debt are not GDP, but rather tax revenues or the potential tax revenues both of which are only a fraction of GDP. This fraction may also vary across time and countries.

inflation targeting. Consequently the degree of independence of the central bank and the targets of the central bank may be factors determining how governments choose to service their debt.

The real interest rate the government pays on outstanding fixed-rate nominal bonds would also be lower with higher inflation, easing the real burden further. This is a temporary effect, though, since one would expect the nominal interest rate on new issuances of debt to rise with the increase in the inflation rate. Should governments follow the route of letting inflation rise, investments in real government bonds or other real assets should be preferred over investments in nominal government bonds.

From (5), ignoring seignorage altogether, $m^* = 0$, it also follows that for debt-to-GDP to be stable when the primary budget is balanced, $b_t = b^*$ and $p_t = 0$, the nominal growth rate has to be equal to the nominal interest rate on the outstanding debt, $\delta_t = i$. Another section of this enclosure, entitled "Yields and prospective real returns in fixed income", illustrates the effects on debt-to-GDP of the time-varying difference between the nominal growth rate and the nominal interest rate, and discusses a government's ability to achieve low real rates.

Empirical evidence of defaults and expropriation

We have argued that a continuation of current policies in several developed countries is deemed unsustainable, and we have discussed in theory what governments in such countries can do. The focus in this subsection is on what the empirical evidence says about what governments in similar situations have chosen. Should we expect governments to default on their debt or expropriate assets instead of changing policies sufficiently?

To start, defaults and expropriations are rare in developed economies. The latest defaults in the developed world were Japan and Germany in the immediate aftermath of World War II (Reinhart and Rogoff 2008). Back then, government debt as a share of GDP was above 100 percent, as now, in several countries. What is new about the current situation is that total government debt as a share of GDP in the OECD countries is expected to reach 100 percent of GDP for the first time. For the G7, the debt-to-GDP ratio is roughly back at the elevated level after World War II (see Figure 1). The fact that several countries have high indebtedness simultaneously makes policy changes cutting expenditures and increasing tax revenues more costly (IMF 2010c).

If we look at a broader sample than only the developed countries, we do find both defaults and expropriation of foreign direct investments. These two combined are called sovereign theft in Tomz and Wright (2010), who define default and expropriation as follows:

Default
A default occurred whenever a country failed to pay interest or repay principal within the allowable grace period. We also regarded a country as having defaulted if, in the case of sovereign bonds, it made an exchange offer that contained terms "less favorable than the original issue".

Expropriation
(1) Nationalization, defined as action by a government to take ownership of a foreign firm;

(2) Coerced sale, in which the government threatens or takes actions that induce foreigners to sell part or all of their direct investments to the government or to domestic citizens;

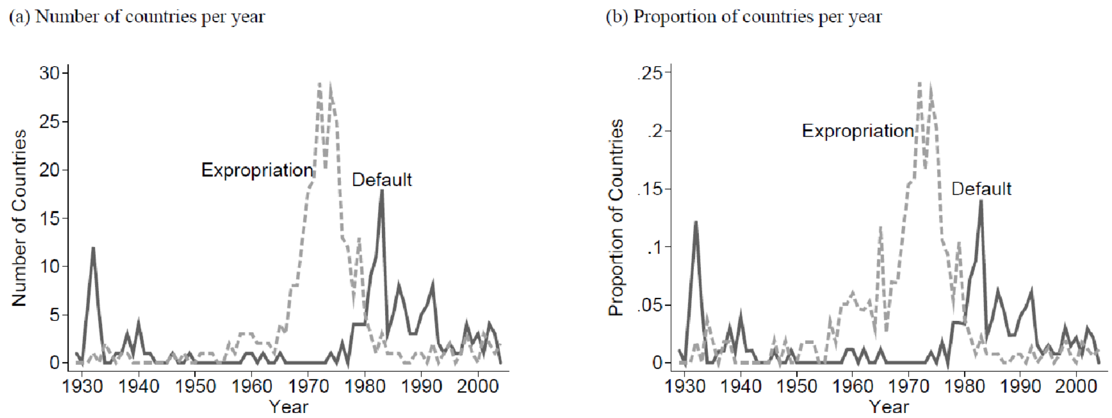
(3) Intervention or requisition, in which the government takes control of foreign direct investments without proclaiming itself the rightful owner; or

(4) Renegotiation, in which the government compels direct investors to accept substantial changes in a contract or a concession.

Tomz and Wright construct a data set covering more than 150 countries from 1929 to 2004. They find that expropriation was widespread in the 1970s, where such acts were taking place in almost 30 of the countries, or nearly 25 percent of the sample, at their peak (see Figure 3). Defaults on debt were more prevalent in the 1980s, with a peak of almost 20 countries, or 15 percent of the sample. Combined, some form of sovereign theft took place globally almost every year over the sample period (1929-2004).

Looking closer at individual countries, Tomz and Wright find that countries tend to either both expropriate and default (but not necessarily at the same time) or take part in no sovereign theft whatsoever.

Figure 3: Sovereign theft in history



Source: Tomz and Wright (2010)

How often have *defaults* been chosen as a solution when a continuation of current policies is deemed unsustainable? One approach is to assume that a sovereign bond spread above 1,000 basis points signals that a continuation of current policies at a given point in time is unsustainable, since market prices then assign a non-negligible probability to default as the chosen option for the government. A recent IMF Staff Position Note (Cottarelli, Forni, Gottschalk and Mauro 2010) finds incidents of emerging economy sovereign bond spreads above 1,000 basis points and investigates how many of these incidents were followed by a default. They find that only seven out of 36 incidents ended with a default. This indicates that governments usually do not default when a continuation of current policies is unsustainable. This even applies to governments of countries with a history of default.

When do countries default on sovereign debt?

Is there any way of predicting when a default will take place? Cottarelli, Forni, Gottschalk and Mauro (2010) conclude when looking at default episodes in all emerging economies since 1976 that:

The economies that defaulted in recent decades did so primarily as a result of high debt *servicing costs, often in the context of major external shocks.*

They also compare the characteristics of those episodes with the characteristics of today's situation in selected developed countries. Their findings are summarised in the table below:

Table 1: Decomposition of debt dynamics, advanced economies and default episodes (percent of GDP)

		Primary Balance (1)	Nominal Interest Bill (2)	Capital Loss due to Nominal Devaluation (3)	Inflation Correction (4)	Total (Real Interest Bill) (5)=(2)+(3)+(4)	Real Growth Contribution (6)	Debt/GDP
Advanced Economies (Averages for 2009 - 2010)	France	-5.9	2.5	...	-0.4	2.1	0.2	80.8
	Greece	-5.5	5.3	...	-2.1	3.3	2.2	106.9
	Ireland	-10	2.4	...	1.3	3.8	2.2	71.7
	Italy	-0.8	4.6	...	-2	2.7	2.3	117.2
	Japan	-8.7	2.9	...	2.8	5.7	3.3	222.4
	Netherlands	-3.6	2.4	...	-0.3	2.1	0.8	61.9
	Portugal	-6.1	3.1	...	-0.7	2.4	0.8	81.9
	Spain	-9.4	2.1	...	0	2.1	0.9	61.1
	United Kingdom	-9	2.6	...	-1.2	1.3	0.9	73.2
	United States	-10	2.7	...	-0.7	2	-0.4	87.9
	Median	-7.4	2.6	...	-0.6	2.3	0.9	81.3
Emerging Economies (Averages for the two years prior to default)	Argentina (2002)	-0.5	4.4	0	0	4.4	1.2	44
	Ecuador (1999)	0.6	4.3	0	-1.3	3	-1.6	65.1
	Indonesia (1999)	0.3	2	31.6	-10.5	23.1	1.9	35
	Jamaica (2010)	0.9	9.4	7.6	-10.4	6.6	2	104.5
	Mexico (1982)	-4.5	3.8	0.1	-4.1	-0.2	-1.7	21.4
	Moldova (2002)	4.5	5.3	6.8	-14.6	-2.6	-3.7	93.9
	Pakistan (1999)	-0.2	5.7	4.6	-6.9	3.4	-1.3	74.4
	Russia (1998)	-9.9	5	3.7	-10.1	-1.4	0.5	44.2
	Ukraine (1998)	-2.1	2.1	2.9	-4	1	0.8	30.6
	Uruguay (2003)	-1.3	3	15.4	-4	14.3	2.9	49.7
	Median	-0.4	4.3	4.1	-5.5	3.2	0.7	46.9

Source: Cottarelli, Forni, Gottschalk and Mauro (2010)

Notes: The default episodes (the year of default is reported in parenthesis next to the country name in the first column) include all emerging economies defaulting since 1976 for which there are available data to compute the decomposition.

Three variables are highlighted in the table: the primary balance, the nominal interest bill and the debt ratio. These can be related to three time-varying right-hand-side variables in equation (5).

The authors' conclusion is that it is mainly the nominal interest rate bill, l_t, that stands out as high in the default episodes (lower half of the table above). However, it matters greatly whether the nominal interest rate bill is high due to a high debt-to-GDP ratio or a high nominal interest rate. For a long-term investor, the latter case is less alarming since compensation for the given default risk is higher.[6] Second, the primary surplus, p_t, tends to be close to zero. Inspecting the table reveals considerable heterogeneity, however. Lastly, the debt-to-GDP level, b_{t-1}, does not seem to be a good predictor of default.

Comparing the default episodes with the situation of today in industrial countries (upper half of the table above), neither the primary surplus nor the nominal interest rate bill have the "typical" default value. Debt-to-GDP is high, but the evidence from the default episodes suggests that this says little about the probability of default.

As Cottarelli, Forni, Gottschalk and Mauro (2010) state, defaults take place *"often in the context of major external shocks"*. Shocks are hard to predict[7], and even if one could, this would not suffice to predict defaults accurately. To quote Tomz and Wright (2007):

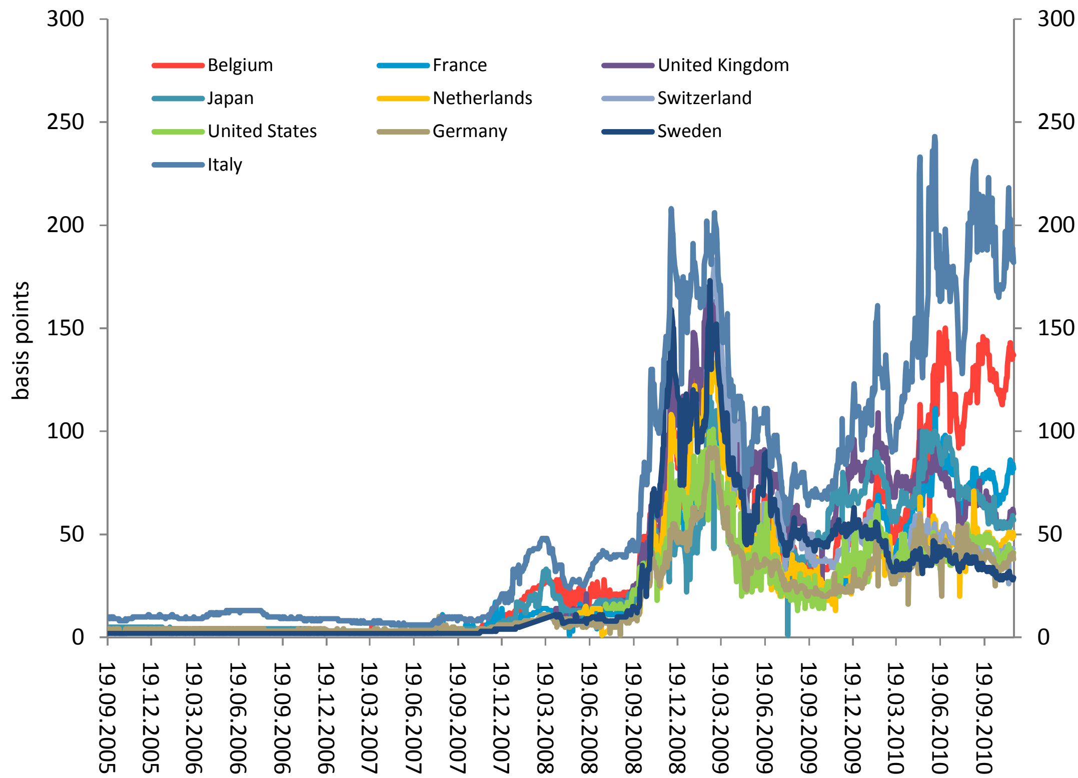
Throughout history, countries have indeed defaulted during bad times, but they have also maintained debt service in the face of severe adverse shocks, and they have defaulted when domestic economic conditions were highly favorable. This pattern is puzzling, not only because it seems inconsistent with the conventional wisdom that countries default in response to adverse economic conditions, but also because it stands at odds with prominent models in which default provides costly insurance against economic adversity.

Another approach to assessing the probability of defaults is to use the market of credit default swaps (CDSs) for sovereigns where investors try to put a price on the default risk and trade at that price. This approach has its limitations since it does not say anything about why the default risk is at a given level. Additionally, exposure to counterparty and liquidity risk in this market can cause changes in CDS prices that have nothing to do with changes in default risk. One of the conclusions in Damodaran (2010), however, is that *"the evidence, at least as of now, is that changes in CDS prices provide information, albeit noisy, of changes in default risk"*. Figure 4 shows that CDS prices for several developed economies have increased

[6] This is related to the findings in Damodaran (2010), who argues that the interest rate spread (the difference between the interest rate on debt issued in foreign currency (e.g. USD) and assumed risk free debt issued in the same currency (e.g. US Treasuries) is correlated with the default risk.
[7] See Hatchondo, Martinez and Sapriza (2007) for a survey of different types of shocks that can lead to a sovereign default.

considerably, indicating that the discounted default probability has increased.[8]

Figure 4: Five-year credit default swap prices



Source: Bloomberg, November 18, 2010

What if nothing is risk-free?

The presence of (a non-negligible) default risk in developed economies' government bonds may have far-reaching consequences. Damodaran (2010) argues that only government bonds have the potential of being a risk-free investment, and if they now all have a perceived

[8] In general, to compute the default probability associated with a given CDS spread, the calculation requires an iterative numerical procedure. In the case of a flat CDS curve, however, the default probability to a time measured in years from the valuation date equals approximately 1-e^(-S * t/(1-R)), where S is the flat CDS spread and R is the recovery rate. Setting t=5 and R=40 percent, a CDS spread of 1.8 percent (Italy) and 0.6 percent (UK and Japan) gives default probabilities of 13.9 percent and 4.9 percent respectively.

positive default probability, a risk-free investment no longer exists. Many of the results from portfolio theory and management, which use a risk-free investment as a building block, would no longer be valid. Damodaran argues that this may have consequences for investor behavior and result in less diversified portfolios and higher risk premiums.

Less diversified portfolios:

Without a riskless asset available for adjusting risk, investors have to tailor portfolios to their specific risk needs. In practical terms, this would require investors who want to bear more (less) risk holding stocks in the riskiest (safest) sectors and avoiding safe (risky) companies… Both groups will give up some diversification when they do so, resulting in less efficient risk bearing overall.

Higher risk premiums:

Building on the theme of less efficient risk bearing, the absence of a riskless investment will make risky investment seem even riskier to all investors. … Investors may invest less in risky assets, demand higher risk premiums (and pay lower prices) and be quicker to flee these assets in the face of danger. … As a consequence, we can expect to see lower prices for all risky assets, higher volatility in prices in these markets and abrupt, painful market corrections.

Sovereign debt, economic growth and inflation

A high debt-to-GDP ratio may have wider consequences than possibly increasing the default risk as discussed in the previous sections. Reinhart and Rogoff (2010) find that a high debt-to-GDP ratio is associated with low real economic growth, and hence potentially a low real return on investments. Some of their findings are summarised in the tables below taken from their paper.

The first thing to note is that a debt-to-GDP level above 90 percent is associated with significantly lower real growth than lower debt levels. The second is that this finding is remarkably stable. It holds both looking at advanced and emerging economies separately, and looking at only a post-World War II sample for both these groups. It does not hold for every single country, though, but high-growth high-debt observations in the advanced economies are clustered in the years following World War II.

Inflation is not found to increase significantly with the debt-to-GDP level in advanced economies as a group. It is the case in the US, though, and in the group of emerging economies. This lends some support to the conclusion that advanced economies do not have a history of increasing inflation to ease the debt burden.

Note that these results do not say anything about causality. This is just an empirical regularity. Whether it is the high debt-to-GDP ratio that leads to low growth or another factor leading to both, a high debt-to-GDP ratio may signal low real growth and a low real return going forward.[9] With the group of developed countries having a debt-to-GDP ratio of around 100 percent, this may have implications for regional asset allocation. We could also interpret the findings as an indication that it is challenging to enhance real growth to ease the debt burden.

[9] This is exactly what market prices currently indicate. As discussed in the section "Yields and prospective real returns in fixed income", current real yields are close to historical lows.

Table 2: Real GDP growth as the level of government debt varies: selected advanced economies 1790-2009 (annual percentage change)

		Central (Federal) government debt/ GDP			
Country	**Period**	**Below 30 percent**	**30 to 60 percent**	**60 to 90 percent**	**90 percent and above**
Australia	1902-2009	3.1	4.1	2.3	4.6
Austria	1880-2009	4.3	3	2.3	n.a.
Belgium	1835-2009	3	2.6	2.1	3.3
Canada	1925-2009	2	4.5	3	2.2
Denmark	1880-2009	3.1	1.7	2.4	n.a.
Finland	1913-2009	3.2	3	4.3	1.9
France	1880-2009	4.9	2.7	2.8	2.3
Germany	1880-2009	3.6	0.9	n.a.	n.a.
Greece	1884-2009	4	0.3	4.8	2.5
Ireland	1949-2009	4.4	4.5	4	2.4
Italy	1880-2009	5.4	4.9	1.9	0.7
Japan	1885-2009	4.9	3.7	3.9	0.7
Netherlands	1880-2009	4	2.8	2.4	2
New Zealand	1932-2009	2.5	2.9	3.9	3.6
Norway	1880-2009	2.9	4.4	n.a.	n.a.
Portugal	1851-2009	4.8	2.5	1.4	n.a.
Spain	1850-2009	1.6	3.3	1.3	2.2
Sweden	1880-2009	2.9	2.9	2.7	n.a.
United Kingdom	1830-2009	2.5	2.2	2.1	1.8
United States	1790-2009	4	3.4	3.3	-1.8
Average		3.7	3	3.4	1.7
Median		3.9	3.1	2.8	1.9
Number of observations = 2,317		866	654	445	352

Source: Reinhart and Rogoff (2010)

Notes: An n.a. denotes no observations were recorded for that particular debt range. There are missing observations, most notably during the World War I and II years; further details are provided in the data appendices to Reinhart and Rogoff (2009) and are available from the authors. Sources: There are many sources, among the more prominent are: International Monetary Fund, World Economic Outlook, OECD, World Bank, Global Development Finance. Extensive other sources are cited in Reinhart and Rogoff (2009).

Table 3: Real GDP growth as the level of government debt varies: selected emerging market economies 1900-2009 (annual percentage change)

Central (Federal) government debt/ GDP

Country	Period	Below 30 percent	30 to 60 percent	60 to 90 percent	90 percent and above
Argentina	1900-2009	4.3	2.7	3.6	0.5
Bolivia	1950-2009	0.7	5.2	3.7	3.9
Brazil	1980-2009	3.2	2.3	2.6	2.3
Chile	1900-2009	4	1	7.5	-4.5
Colombia	1923-2009	4.3	3	n.a.	n.a.
Costa Rica	1950-2009	6.9	5	3.4	3
Ecuador	1939-2009	5.3	5	3.2.	1.5
El Salvador	1939-2009	3.6	2.6	n.a.	n.a.
Ghana	1952-2009	n.a.	4.6	4.7	1.9
India	1950-2009	4.2.	4.9	n.a.	n.a.
Indonesia	1972-2009	6.6	6.3	-0.1	3.1
Kenya	1963-2009	6.3	4.2	2.3	1.2
Malaysia	1955-2009	2	6.2	6.9	5.5
Mexico	1917-2009	4.1	3.4	1.2.	-0.7
Nigeria	1990-2009	5.4	10.6	11.2	2.6.
Peru	1917-2009	4.3	2.9	2.7	n.a.
Philippines	1950-2009	5	3.8	5.1	n.a.
Singapore	1969-2009	n.a.	9.5	8.2	4.0.
South Africa	1950-2009	2	3.5	n.a.	n.a.
Sri Lanka	1950-2009	3.3	3.7	4.2	5
Thailand	1950-2009	6.1	6.6	n.a.	n.a.
Turkey	1933-2009	5.4	3.7	3.2	-6.4
Uruguay	1935-2009	2.1	3.1	3.2	0
Venezuela	1921-2009	6.5	4.1	3.2	-6.5
Average		4.3	4.1	4.2	1
Median		4.5	4.4	4.5	2.9
Number of observations = 1397		686	450	148	113

Source: Reinhart and Rogoff (2010)

Notes: An n.a. denotes no observations were recorded for that particular debt range. There are missing observations, most notably during the World War I and II years; further details are provided in the data appendices to Reinhart and Rogoff (2009) and are available from the authors. Sources: There are many sources, among the more prominent are: International Monetary Fund, World Economic Outlook, OECD, World Bank, Global Development Finance. Extensive other sources are cited in Reinhart and Rogoff (2009).

Table 4: Inflation as the level of debt varies: summary (annual percentage change)

Measure	Period	Below 30 percent	30 to 60 percent	60 to 90 percent	90 percent and above
		Advanced economies			
Average	1946-2009	6.4	6.3	6.4	5.1
Median	1946-2009	5.2	3.7	3.5	3.9
		Emerging Markets			
Average	1946-2009	64.8	39.4	105.9	119.6
Median	1946-2009	6	7.5	11.7	16.5
		Total (public plus private) Gross External Debt/GDP			
Average	1970-2009	10.3	17	37.1	23.4
Median	1970-2009	10.9	12.1	13.2	16.6

Source: Reinhart and Rogoff (2010)

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Yields and prospective real returns in fixed income

In this section, we discuss the potential long-term real return implications of current yield levels in developed economies' government bond markets.

Treasury yields in the major economies are at or very close to their historical lows. Forward-looking measures of real yields based on inflation-indexed bonds or on surveys of long-term inflation expectations are depressed.

From a strategic point of view, we must consider the longer-term implications of increased public indebtedness and unconventional monetary measures, such as quantitative easing, on our return expectations. Against this background, we conduct various decompositions of nominal yields into their real, inflation and risk premia components to assess the compensation that we can expect to receive for holding bonds over a five- to ten-year horizon.

Main findings

- Forward-looking yield measures indicate that real hold-to-maturity returns on developed market government bonds could be very low compared to recent history and low relative to long-term averages.

- Decompositions of current nominal bond yields into a real yield, inflation expectation and risk premia component suggest that risk compensation for holding bonds is thin.

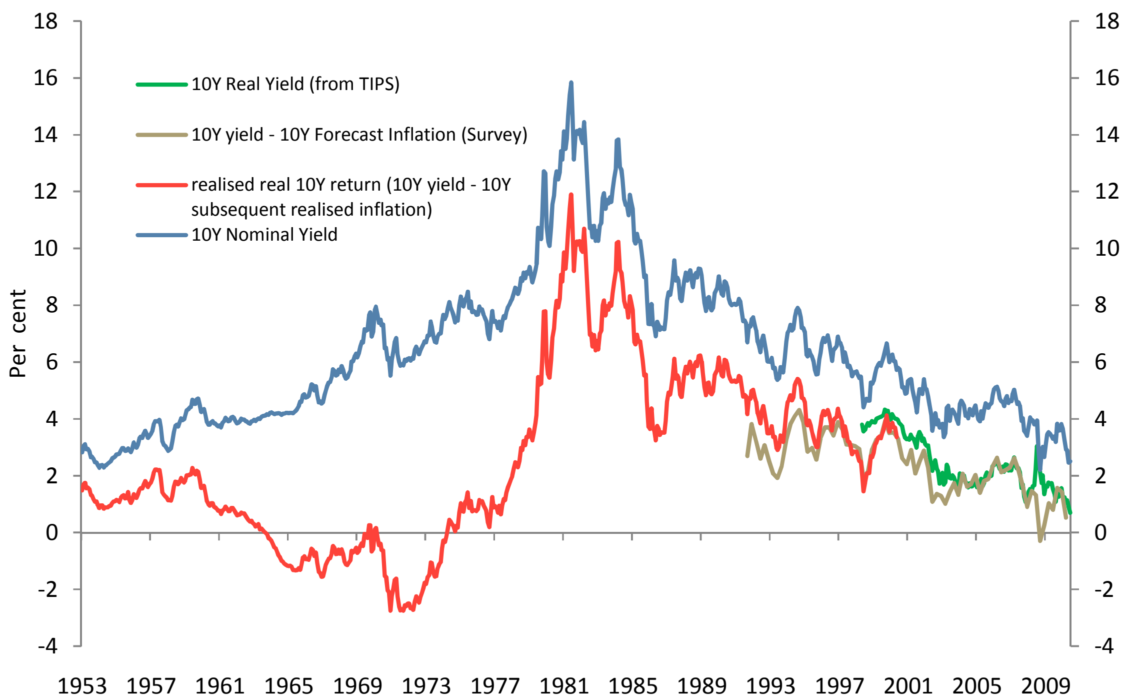
- Government debt dynamics and the high level of under-utilised resources in the developed economies could create an incentive for policymakers to attempt to keep real interest rates as low as possible to relieve the burden on the leveraged public and private sectors. This would reduce prospective returns.

- A significant risk for bondholders in markets where real yields are kept artificially low is that other investors withdraw from those markets and a disorderly currency depreciation ensues during which real yields are driven significantly higher.

Real yield and return in a historical context

The evolution of nominal government bond yields in the largest advanced economies after World War II can broadly be divided into two distinct regimes: a secular rise in long-term interest rates before the early 1980s and a sustained decline since then. As the leading debt market in the world, the development of the US Treasury market can be seen as representative of these trends. In Figure 1, the secular rise and subsequent fall of nominal ten-year US government bond yields is clearly visible.

Figure 1: Nominal and real yields in the US Treasury market



Source: NBIM calculations, Bloomberg, Factset, Federal Reserve

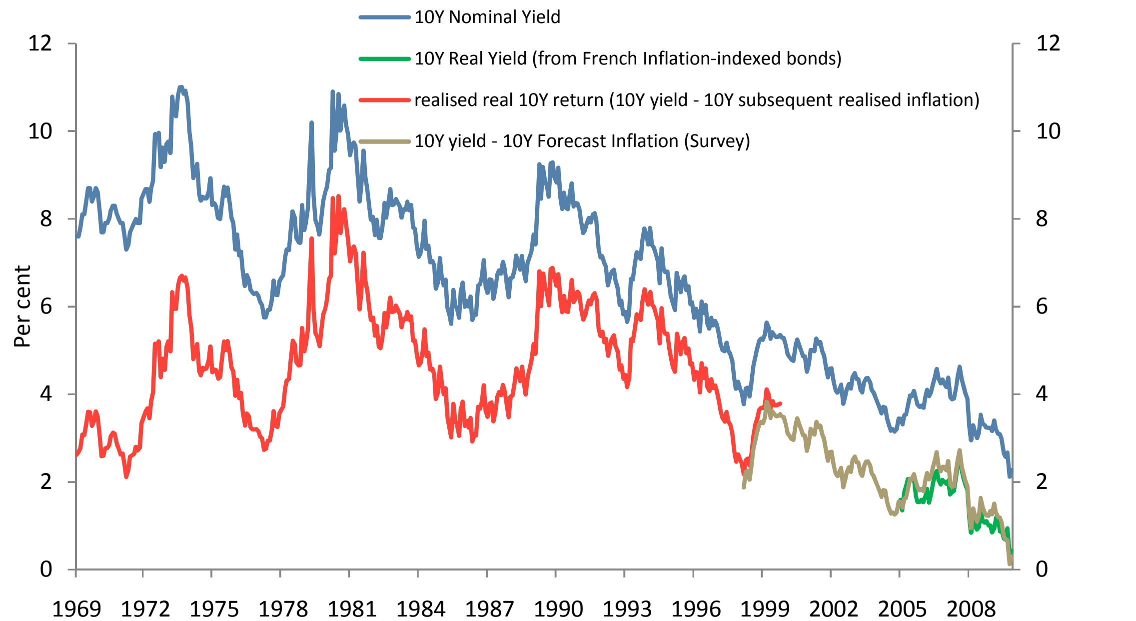
The real yield, i.e. the return from buying and holding these securities to maturity adjusted for the erosion of purchasing power through inflation, is shown both as an ex-post (realised real return) and as a forward-looking measure. To calculate the real realised return, we subtract the average annual inflation over the subsequent ten years from the nominal ten-year yield. The time series of ex-post real return stops in September 2000, since taking it further would require knowledge of future inflation rates. However, we also show two forward-looking measures of real yields that can be compared to realised real returns. The first one is obtained by subtracting a survey measure of ten-year annual inflation (the Philadelphia Fed's Survey of Professional Forecasters) from nominal yields. The other is the real yield from inflation-protected ten-year Treasury securities (TIPSs). Barring default by the US government, the latter allows us to know with certainty what the real realised return will be if we hold the bond until maturity.

We observe that both measures of ex-ante real yields are currently well below 1 percent, with the inflation-indexed yield at 0.7 percent and the survey-based real yield at 0.2 percent. They are also at or very near their lows compared to the relatively short history that is available.

Realised real returns from holding nominal ten-year bonds went through two very distinct regimes over the last 60 years, very similar to nominal yields. Before mid-1978, ex-post ten-year real returns never exceeded 2½ percent and were even negative for most ten-year periods starting between the mid-1960s and the mid-1970s. In this first regime, nominal yields and subsequent real returns diverged as the market had not discounted the rising inflation of the 1970s.

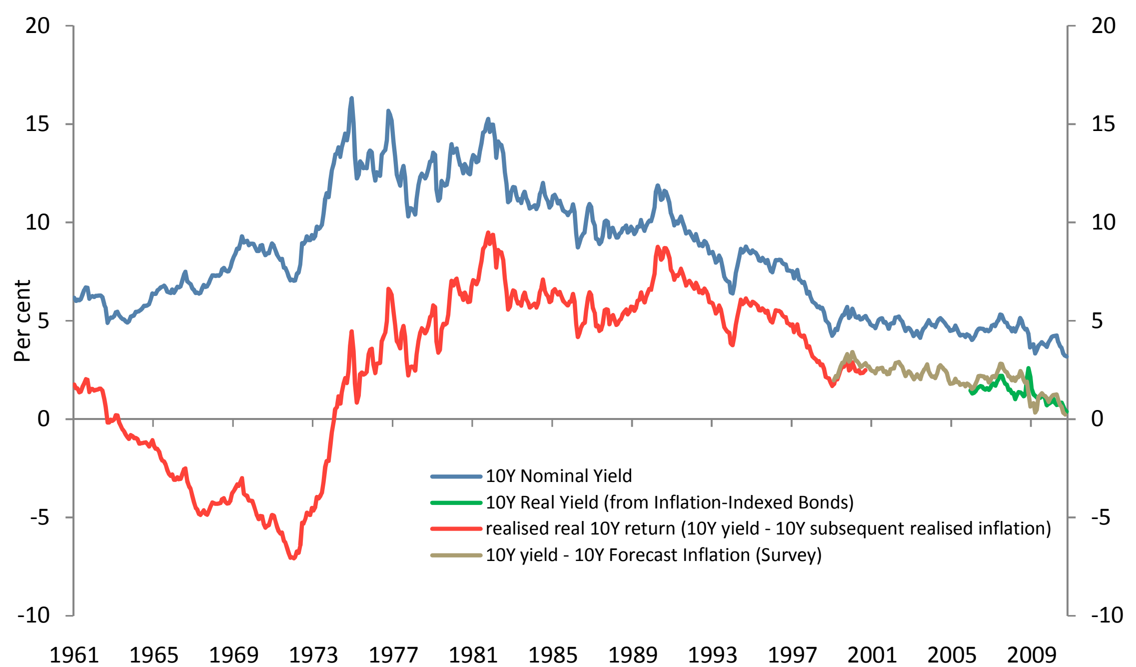
As nominal yields rose above 8 percent in the late 1970s, subsequent buy-and-hold real returns improved markedly, reaching levels above 5 percent for a few years and staying above 2½ percent for most periods through to 2000 when the series stops. This second regime is characterised by a positive correlation of nominal yields and real returns. Where realised real return and the survey-based ex-ante measure of real yield overlap, it is noteworthy that the forward-looking yield measure underestimated actual real returns by 1½ percent at most during the early 1990s, but tracked actual returns remarkably well from the mid-1990s through to 2000. The inflationary outcome was therefore largely in line with expectations priced in the market in this second regime.

Figure 2: Nominal and real yields in the German government bond market



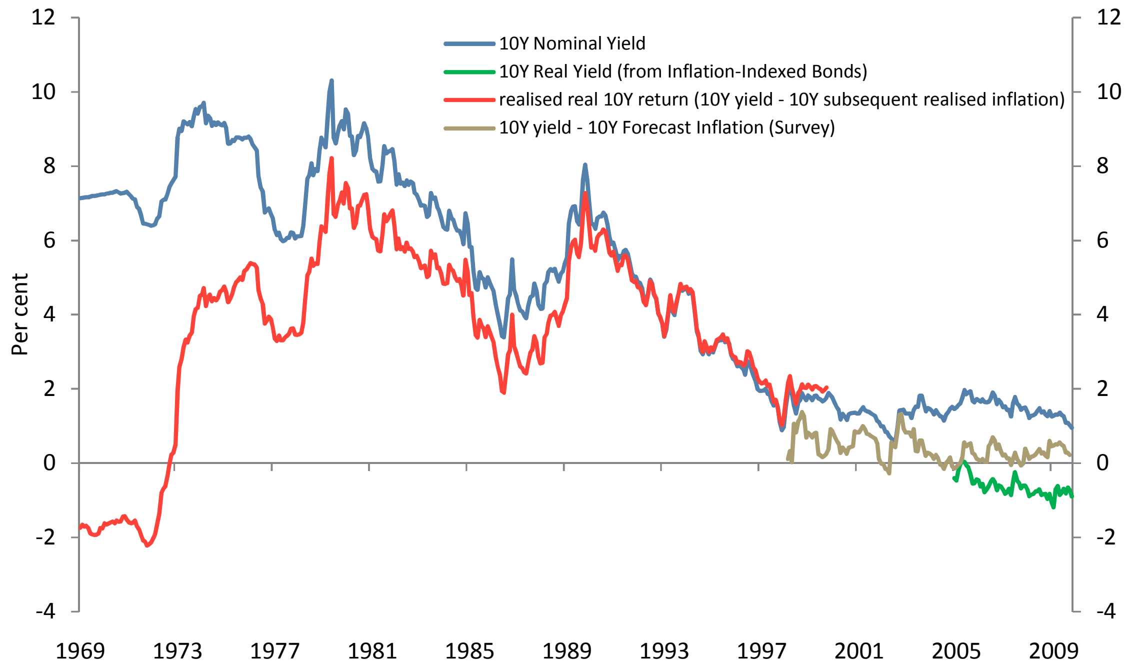
Source: NBIM calculations, Bloomberg, Factset, Federal Reserve, ECB

Figure 3: Nominal and real yields in the UK gilt market



Source: NBIM calculations, Bloomberg, Factset, Federal Reserve, Consensus Economics

Figure 4: Nominal and real yields in the Japanese government bond market



Source: NBIM calculations, Bloomberg, Factset, Federal Reserve, Consensus Economics

Figures 2 to 4 are the equivalents to Figure 1 for the German, UK and Japanese government bond markets respectively. Developments in the German and UK fixed-income markets are broadly in line with the US case. Real realised returns were strongly correlated with nominal yields from the late 1970s onwards. Furthermore, expectations of real returns were fairly close to the outcome during the 1990s. In Japan, however, the ex-post real returns on government bonds significantly exceeded the ex-ante measures in the brief period of overlap, indicating that market participants were surprised by the onset and persistence of deflation.

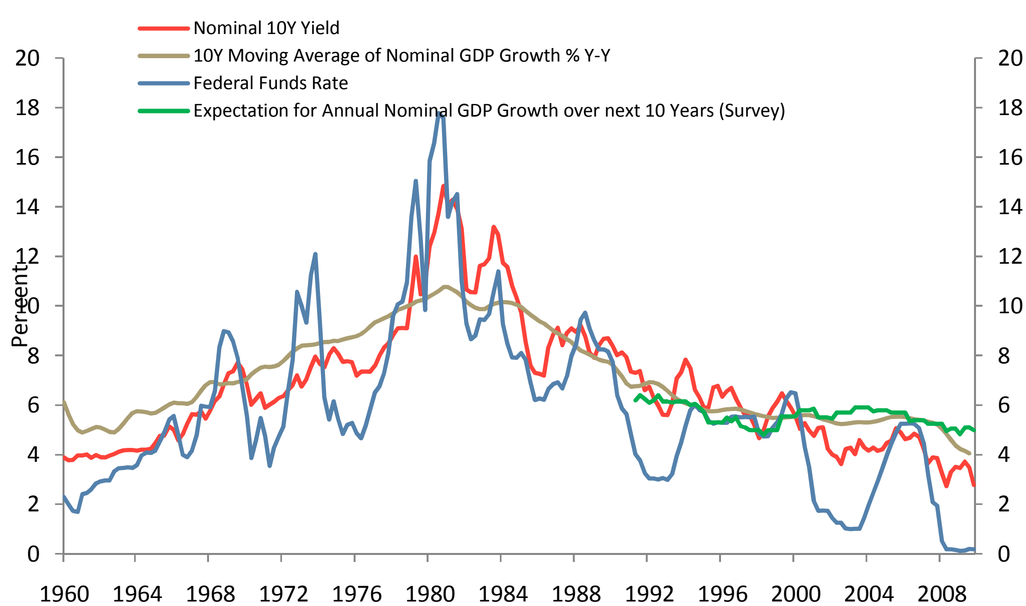
Investing in ten-year TIPSs will yield a certain (ignoring default risk), but historically very low, real return, currently well below 1 percent. Ex-ante measures of the real return from investing in nominal ten-year securities are in the vicinity of the TIPS yield, but obviously subject to uncertainty with regard to the inflation outcome. The low level of nominal and expected real yields seems to leave little room for upward surprises to the rate of inflation or negative shocks to sovereign creditworthiness. In other words, the risk premium for holding long-term bonds appears to be relatively thin – a question we discuss further in the next section.

Decomposing yields into real, inflation and risk premia components

While breaking down nominal yields into a real and break-even inflation component using TIPSs provides valuable insights, the break-even element not only reflects the inflation expectations of market participants, but will also incorporate premia for inflation volatility, liquidity and other risks.

One approach to explaining government bond yields over time is to use macroeconomic variables such as GDP and inflation as explanatory variables in order to decompose bond yields. This framework is related to models of the "term premium", which try to account for the excess return of longer-maturity bonds over Treasury bills that results from yields of the former being higher than would be justified by the expected path of future short-term interest rates.[1]

Figure 5: Nominal US ten-year yields, Federal Funds rate and nominal GDP growth



Source: NBIM calculations, Factset, Federal Reserve

[1] The term premium is the subject of a separate section.

These two approaches are ultimately linked because macroeconomic fundamentals and short-term interest rates move together in the long run, as shown in Figure 5, which plots nominal ten-year Treasury yields against the Federal Funds rate and the ten-year moving average of year-over-year nominal US GDP growth. The co-movement of nominal interest rates and nominal economic growth is evidence of a long-run equilibrium relationship between the macroeconomy and financial market prices.

In this section, we present a model based on macroeconomic fundamentals in order to link the outlook for real returns of government bonds to long-term projections of economic variables. The model was developed by economists at Morgan Stanley[2] and is a regression of the ten-year nominal yield of US Treasuries against three variables:

- The real Fed Funds rate, where past core inflation is used to deflate the nominal policy rate. The measure can be thought of as a proxy of real economic activity as the central bank is expected to follow a so-called Taylor rule and react to GDP deviating from its potential by adjusting the real short-term rate

- Expectations for 12-month ahead CPI inflation as measured by the Philadelphia Fed Survey of Professional Forecasters

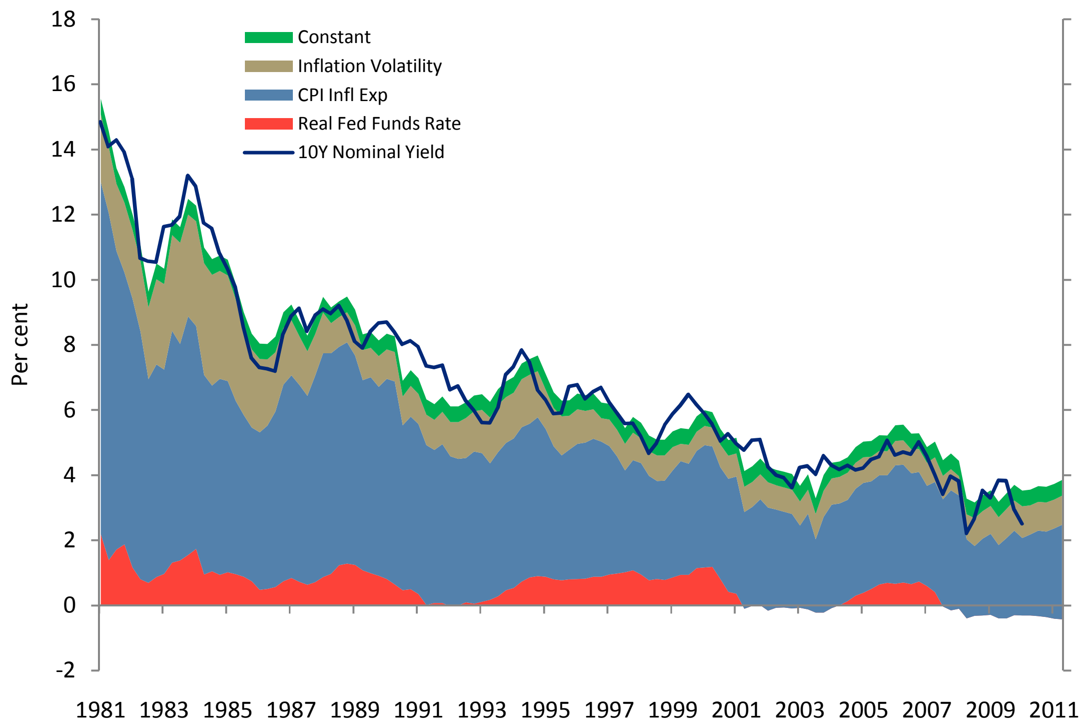
- Inflation volatility as measured by the trailing five-year standard deviation of quarterly changes in core prices

The output from the model is shown in Figure 6, where the coloured areas are the contributions from each of the variables (i.e. their regression coefficient multiplied by the variable's value) to the fair-value yield[3], and the blue line represents the actual nominal ten-year Treasury yield. The first observation worth making is that the inflation expectation component contributes most to explaining the variation in the nominal yield. The compression in the fair-value yield can therefore largely be attributed to a trend decline of the survey measure of inflation expectations. The second most important variable is the volatility of

[2] See Fels and Pradhan (2006). Other investment banks that we have surveyed, for example Kapadia (2010), maintain comparable models that currently yield similar conclusions.
[3] We have obtained forecasts of the fair-value yield through to the end of 2011 by plugging the Fed's forecasts of growth and inflation into the model, as well as assuming that inflation volatility and the policy rate will stay at their current levels.

inflation, which has also fallen over the period under consideration. Maybe surprisingly, the real Fed Funds rate as a proxy for economic activity has played a lesser role in explaining the variation in fair-value yields, currently deducting about half a percentage point from the equilibrium yield.

Figure 6: Nominal US ten-year yields and contributions to fair-value yield



Source: NBIM calculations, Morgan Stanley

Market interest rates have been below fair values for most of the time since 2004. The predicted model yield based on forecast GDP and inflation shows a slightly rising trend into 2011 while staying below the 4 percent mark. All things considered, fair-value models commonly employed by practitioners appear to imply that a substantial part of the yield compression during the last three decades can be ascribed to the fall in inflation expectations and past *volatility* of inflation, the latter of which we could interpret as a decline in the inflation risk premium.[4] The "real" component as proxied by the real policy rate currently

[4] The gradual reduction of inflation risk compensation could well be justified by the increased credibility of central banks and the inflation outcomes actually delivered over the last thirty years, while the threat of deflation

subtracts from the yield, which is consistent with the negative real yields observed from some maturities of the TIPS market.

These observations generally point to risk premia embedded in nominal long-term bond yields being relatively thin. This reflects an expectation that policy rates will remain low and that inflation and growth are muted for now. Recent declines in inflation volatility cannot be guaranteed to persist, however, as sovereign indebtedness and unconventional central bank policies make the outlook for inflation more uncertain than before.

Real yields and debt dynamics

In the aftermath of the financial crisis, a widespread belief has emerged that the indebtedness of the state and the household sectors in many developed economies will seriously constrain the ability of these countries to grow vigorously. This belief is supported by the analysis of Reinhart and Rogoff (2010) based on a large historical cross-country dataset. Most developed-country central banks seem to have subscribed to the view that low nominal and real interest rates across the entire maturity spectrum are needed to underpin the nascent, tepid recovery. What is more, government deficits and debt-to-GDP have ballooned in many advanced nations following the large-scale state interventions during the financial crisis of 2007-2009. Keeping real interest rates low is therefore not only necessary to support the economic expansion, but has nearly become an imperative for keeping debt-to-GDP on a sustainable path given the historically high debt-to-GDP ratios in many industrialised nations.

The crucial role of the real interest rate paid on outstanding debt, and in particular whether that rate is above or below the real rate of economic growth, follows from the arithmetic of the long-term government budget constraint. Under some simplifying assumptions, this arithmetic can be summarised in the following statement: When the primary (i.e. non-interest) government budget is in balance, the debt-to-GDP ratio can be stabilised and fiscal policy is therefore sustainable *if the real growth rate of the economy is equal to or greater than the real interest rate on outstanding debt* (or equivalently nominal growth is at least as high as the nominal interest rate).

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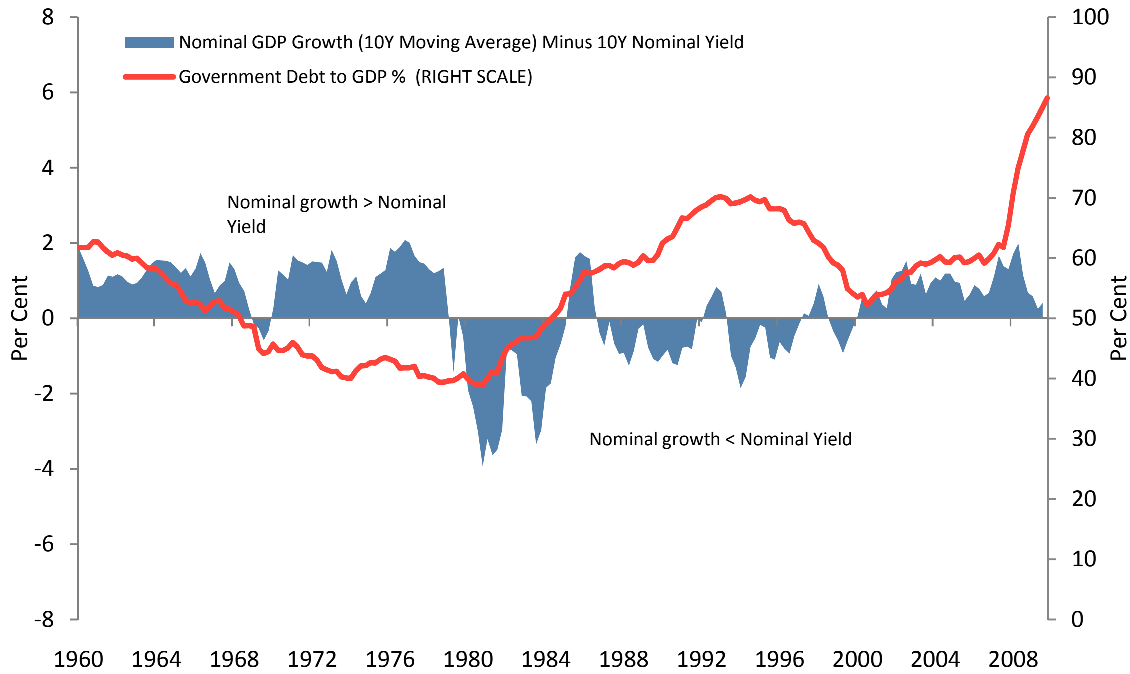
may compress this risk premium even further. On the other hand, embedded inflation risk compensation should account for the massively increased *incentive* for countries to create surprise inflation so as to reduce the real value of outstanding government and private debt.

Figure 7: US debt-to-GDP and nominal GDP growth minus nominal ten-year yield



Source: NBIM calculations, Factset

Using the US example once again, we can see these dynamics at play in Figure 7, which depicts the aforementioned difference between nominal growth and nominal interest rate alongside the public debt-to-GDP ratio. In the 1960s and the 1970s, nominal economic growth largely exceeded the ten-year bond yield, which coincided with a gradual reduction in the debt-to-GDP ratio, as fiscal arithmetic would suggest. From about 1980 until 2000, the relationship between growth and yields reversed, with growth now mostly being below interest rates. As expected, the debt-to-GDP ratio rose through most of this period until the mid-1990s when the large primary surpluses of the Clinton administration brought about a temporary reduction in the debt ratio. In the 2000s, yields fell below the rate of nominal economic growth once again, but this favourable shift in the yield-growth relationship was more than offset by a massive widening in the primary public deficit (not shown in the figure).

In order to stabilise or even reduce debt–to-GDP from these elevated levels, policymakers are likely to try to keep bond yields below the rate of growth. This applies not only to the US, but also to other highly indebted developed nations.

Possible implications for bond investors

In a situation where the sovereign debt dynamics of several G7 countries are on an unsustainable path, the policy option of imposing losses on bondholders is a risk that cannot be easily dismissed. This may be a more likely outcome than the remote possibility of an outright default.

One way of imposing such real losses is to keep nominal yields lower than what their market-determined value would be. Quantitative easing, as practised by the US Federal Reserve, the Bank of Japan and the Bank of England, could have that effect as it is conducted through purchases of government securities.

Such bond acquisitions by monetary authorities may have had a significant impact on yields. The Bank of England (Joyce et al., 2010) estimates that the round of quantitative easing that was decided on in March 2009 and involved purchasing about 200 billion pounds worth of UK gilts (about 14 percent of nominal GDP) lowered gilt yields by about 100 basis points. In addition to taking on the entire supply of government bonds in the 2009/2010 fiscal year, the Bank of England made new issuance cheaper for the UK Treasury by shifting the gilt curve downward in nominal terms.

The asset purchase programmes in the US, Japan and the euro zone have not been as large as in the UK (relative to GDP), but the policies of quantitative easing are continuing. It is worth noting that such programmes can last a very long time. During World War II and afterwards until 1951, the US Treasury and the Federal Reserve had an agreement to keep the yield on the longest-term marketable securities at 2½ percent.

Another way of lowering real interest rates is to create surprise inflation. The large gap between actual and potential output in developed economies and evidence of a dysfunctional monetary transmission mechanism (i.e. the large amount of excess reserves that commercial banks hold with central banks) are impediments to a significantly higher rate of inflation in the short term. Notwithstanding these headwinds to faster inflation, quantitative easing is clearly aimed at lifting inflation rates to more “normal” levels. Current yield levels appear to provide insufficient protection against an overshooting of inflation, caused either by policymakers failing to correctly anticipate the inflationary effects of unconventional policies as the monetary transmission mechanism regains traction, or by intention.

An intentionally higher rate of price increases could be justified by the theory of "price-level targeting", as recently advocated by reputable economist Michael Woodford (2010) as well as Fed presidents Charles Evans and William Dudley. Price-level targeting recommends that central banks should aim for a temporarily faster rate of inflation than long-term targets to "make up" for any past downward deviations from the inflation goal.

Other plausible ways of keeping real interest rates low involve regulatory measures that coerce the private sector into buying more government debt than it voluntarily would. Pension funds and insurance companies are often subject to solvency requirements that can compel them to buy long-dated fixed-income securities when their assets have a lower duration than their liabilities. In that case, a fall in discount rates raises, all other things being equal, the actuarial value of liabilities more than that of assets, widening the funding gap and weakening the solvency position. Such regulations are already in place in many developed economies, but policymakers could increase the pressure on private sector agents to purchase government debt by tightening solvency requirements. Under existing regulations, lowering discount rates across all maturities through quantitative easing could be seen as a further step to compel institutional investors to acquire bonds at uneconomic prices.

A caveat is in order at this point. Even if most G7 central banks and governments did have the intention of keeping a lid on real interest rates, and have various means of working towards that aim, they may not succeed. Some governments depend on capital inflows to fund shortfalls in public budgets. Foreign investors, such as sovereign holders of developed market government debt, are less subject to regulations that compel them to keep holding these securities. If foreign investors lose confidence in a market, they may divest their holdings too hastily, driving down bond prices and the debtor's currency. The greatest risk for bondholders in markets where real yields are kept artificially low is that other investors withdraw from these markets, leading to a disorderly currency depreciation during which real yields are driven significantly higher.

According to US Treasury statistics, China held more than 850 billion US dollars of Treasury notes as of August 2010 and foreign investors are thought to own about half of the marketable US government debt outstanding. Statements coming from the central bank of China on the impact of quantitative easing clearly convey these concerns (People's Bank of China, 2009):

"...an unconventional monetary policy featuring quantitative easing is potentially risky and could have far-reaching implications for international financial markets and the global

economy. First, it might increase the risks of future global inflation. [...] Second, it increases the possibility of major exchange rate fluctuations. [...]The third influence is on the bond markets of the major economies."

While it is clearly not in the foreign creditors' interest to spark an accelerated depreciation of the debtor currency and a disorderly rise in real interest rates, the risks of such a scenario appear to be increasing with the unconventional policies pursued by developed-country policymakers.

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Chapter 2

Risk premia

On risk premium variation

This section provides a brief introduction to modern financial economics and theories of discount factor variation.

Main findings

- During the last four decades, financial research has moved from striving to understand how new information about future payoffs is incorporated into market prices to striving to account for how and why the discount factor of these payoffs varies over time and across assets. This has profound practical implications. Multiple dimensions of risk with time-varying discount factors potentially open up a more demanding portfolio theory.

- The average investor must by necessity hold the market portfolio, but the market portfolio is not necessarily optimal for all investors. Thorough understanding of how own liabilities, own non-traded risks, and careful identification of comparative advantages and disadvantages relative to other investors, might give reasons to pursue dynamic portfolio strategies that differ from those of both the marginal and the average investor.

- These strategies might include departures from mean-variance trade-offs, such as engaging in trading strategies which aim at exploiting known premiums in cross-section and time series, e.g. employing value-weighted rebalancing rules.

- The analytical framework used by modern financial economics is also shared with modern applied fiscal theory, which, among other things, gives a transparent rationale for the Norwegian government's fiscal spending rule ("handlingsreglen").

The central tenet of modern finance

The central tenet of modern finance is that prices are equal to expected discounted payoffs, formally

$$p_t^i = E_t\left(m_{t,t+1} x_{t+1}^i\right),$$

where E_t denotes the expectation conditional on information available at time t, $m_{t,t+1}$ is a (stochastic) discount factor, and $x_{t+1}^i$is a random payoff of a traded asset i. m_{t+1} is stochastic or random since it is not known with certainty at time t. Payoff x_{t+1}^i might, for example, be the sum of the next period's dividend and price: $x_{t+1}^i = d_{t+1}^i + p_{t+1}^i$. In a world where the discount factor for asset i does not vary over time, the pricing formula can be expressed via the standard present value formula, $p_t^i = \frac{E_t(x_{t+1})}{R^i}$, where R^i represents a constant discount factor.

Using the definitions of covariance and the real risk-free rate at time t, the expected risk premium (the expected return in excess of the risk-free rate) for asset i can be written as follows (see appendix for derivation):

$$E_t\left(R_t^{ei}\right) = -R_t^f cov_t\left(m_{t,t+1}, R_t^i\right).$$

The more negative the covariance, the poorer the insurance properties of the asset, the lower and more "discounted" the price, and the higher the expected return. For newcomers to asset pricing theory, this might be surprising. The variance of the return R_t^i is per se irrelevant and does not measure risk or the risk premium. Only the covariance of the return with the stochastic discount factor $m_{t,t+1}$ matters for the expected risk premium.

Efficiency and asset pricing "anomalies" and "puzzles"

Historically, financial research focused on the expectations operator $E_t(\cdot)$ and strived to understand how market prices incorporate information as it becomes available. The introductory textbook view of asset pricing and portfolio theory is simple. There is one source of systematic risk, the market index. Investors understand this and choose a desired portfolio consisting of a combination of an approximately risk-free interest-bearing asset and the market index. Within this analytical framework, active management means uncovering inefficiently priced assets, or “chasing alpha”.

The research agenda associated with this simple, stylised portfolio model was to “test market efficiency”. Researchers found that new information is quickly incorporated into market prices. Tentative conclusions, such as that “chasing alpha” might, on average, be an unprofitable activity, are partially based on these findings.

Despite new information about future payoffs being efficiently and almost immediately processed by markets, studies show that expected returns vary more over time and across assets than can be accounted for by traditional models where the variation of discount rates is constant. In these models, changes in future expected payoffs are calibrated to match the statistical properties of observed time series. These observations gave rise to a large number of apparent “puzzles” and “anomalies”, such as the “term spread puzzle” and the “credit spread puzzle”.

One set of empirical regularities in financial markets is that returns on stocks, long-term government bonds and corporate bonds have, on average, been higher than returns on short-term government bonds. The “equity premium puzzle” describes the failure of models with constant variation of the discount factor to account for the observed excess return of equities over short-term government bonds.

Cross-sectional factors in stocks, such as value, small-cap, momentum, accruals and issuance, are well-documented, as is the way that low current stock valuations relative to fundamentals (for example, dividend yield, earnings growth and price/earnings to growth) tend to be followed by high subsequent returns. Another well-documented set of empirical regularities is that returns on certain long-short strategies have had a predictable component: the returns on currency carry trades are predictable based on interest rate differentials. Various strategies involving a definition of “liquidity provision” have some of the same properties. Analyses of hedge fund strategies have highlighted other possibilities, including index puts and other option strategies, which seem to offer predictable premiums.

Discount factor dynamics – a unifying theme of modern financial economics

Based on persuasive empirical documentation of time-varying expected returns, the focus for modern financial research has therefore moved to further documenting how, and accounting for why, the stochastic discount factor m varies as much as it does over time. This is one of the unifying themes of modern asset pricing theory. In the introduction to a recent paper, John Cochrane (December 2010) summarises:

> Prices should equal expected discounted value. In 1970, Gene Fama argued that *the expected part*, "testing market efficiency," provided the framework for organizing finance research... Finance research today is really all about *the discounted part*: *How* risk premia vary over time and across assets, *why* they do so, and *how* to apply this understanding. "Efficiency" isn't wrong; it just doesn't describe the focus of what we do. When we see information, it is quickly incorporated into market prices. When we see anomalies – and we see many – informational frictions aren't an interesting alternative. Anomalous discount rate variation is.

A starting point for any portfolio strategy that includes deviations from the market portfolio must be to account for how these seemingly "puzzling" empirical regularities can be sustained over time. If any mass of investors systematically try to exploit these empirical regularities, the regularities will vanish. To believe that these factors have "behavioural" explanations and are caused by "irrationality" seems an untenable position.

Asset pricing and the real economy

In some way, the discount factor between the two periods t and $t+1$ (m_{t+1}) must be related to the marginal investor and to the ratio of the marginal utility of wealth between these two consecutive periods

$$m_{t,t+1} = \frac{V_W(t+1)}{V_W(t)}.$$

Loosely speaking, the marginal value of wealth answers the question "how much better off would you be if I give you one additional unit of wealth (one krone, say)?" The discount factor is high at times and in states where investors strongly want more wealth – and would be willing to give up a lot of wealth at other dates or in other states to get it.

Understanding the dynamics of the marginal value of wealth is intimately linked to modern dynamic macroeconomics. The centrepieces of macroeconomics are the equation of marginal rates of substitution to marginal rates of transformation (loosely speaking, that the marginal time value of wealth is equal to the marginal product of capital), and the allocation of consumption and investment across time and states of nature. The same mechanisms that ensure that these equilibrium conditions hold are the same mechanisms that ensure market clearing in asset markets.

Formally, this ratio is the first-order condition of the hypothetical marginal investor who has maximised the net present value of current and future welfare V

$$V(W_t, z_t) = E_t \sum_{i=0}^{\infty} \theta^i u(c_{t+i})$$

given a period-by-period budget constraint and an optimal, time-consistent decision rule (or policy function) h

$$c_t = h(W_t, z_t)$$

where W_t is wealth at time t, z_t is other state variables at time t, θ is a time-discount factor, c is whatever is the source of welfare ("consumption"), and the function $u(\cdot)$ is the transformation of the source of welfare ("consumption") into a measure of welfare.[1]

The Norwegian government's fiscal spending rule (*handlingsreglen*) can be accounted for as the decision rule or policy function resulting from a similar, simple, transparent optimisation

[1] The mathematical representation of the net present value of future welfare for the hypothetical marginal investor is similar to the expression of the price of an asset as a function of future cash flow. If payoff x_{t+1}^i is the sum of the next period's cash flow and price, $x_{t+1}^i = d_{t+1}^i + p_{t+1}^i$, substituting forward and using the law of iterated expectations, the price can be expressed as the expected sum of discounted cash flows

$$p_t^i = E_t \sum_{\tau=1}^{\infty} m_{t,t+\tau} d_{t+\tau}^i$$

where $m_{t,t+\tau} = \prod_{j=1}^{\tau} m_{t+j-1,t+j}$.

problem. It is just one of very many examples of how modern asset pricing and portfolio theory provide the same analytical tools and ways to frame the questions as modern dynamic macroeconomics, including analysis of long-run fiscal policy.

In the remainder of this section, we will very briefly survey some scientific contributions that have attempted to account for time and cross-sectional variation in discount factors. These contributions fall into at least three broad categories: (i) model economies that explicitly take into account non-tradable risks, (ii) model economies that explicitly model market frictions, and (iii) model economies where markets are complete and frictionless, but where structural parameters, such as preference parameters, are calibrated such that they capture underlying incompletenesses and frictions. Finally, we will suggest one possible framework for thinking systematically about the potential dynamic implications of having preferences that differ from those of the marginal investor in a framework where discount factor volatility matches that of the data.

Model economies with incomplete markets and non-tradable risk

In order to account for cross-sectional variation and time-varying volatility of market discount factors, researchers have worked with models that explore the connection between asset market valuations and investors' risks associated with their non-market, non-tradable wealth. The central object of investigation is the effect of market incompleteness and non-tradable risk on market pricing. For individuals, these risks might include the net present value of the return on human capital; for corporations, the net present value of business capital; and for countries, the net present value of future output or tax revenues.

These models can also be used as analytical frameworks to identify how and why an individual investor's effective risk preferences, and hence also portfolio composition, differ from those of the implicit marginal investor.

Fama and French's (1996) suggested explanation for the value premium belongs to this category. For investors whose value of future human capital is highly correlated with the fortunes of value firms, investing in these firms provides poor insurance. These investors would therefore require a higher expected return for investing in these companies than in companies whose fortunes are less correlated with the value of their human capital. If there are enough investors in this category, that might be sufficient to account for the observed excess return on value firms.

The key premise of this line of research is that traded assets do not span the space of risk that investors care about. One implication of these contributions is that assets that are highly correlated with non-traded risk tend to have higher excess returns (be discounted by a higher factor) than assets that are less correlated with non-traded risk. Another implication is that all investors do not share the same portfolio. Instead investors will adapt their portfolios to hedge their non-tradable outside risk.

On average, the financial wealth of individuals is smaller than other non-tradable wealth components, such as the net present value of future labour income. To maximise the risk-adjusted net present value of total wealth, individuals could be expected to use their financial wealth partially to offset specific risks associated with their non-tradable wealth components. The "equity home bias puzzle", defined by, among others, French and Poterba (1991) and Tesar and Werner (1995), is a statement about the apparent failure of individuals to do this; instead of hedging country-specific risk by shorting assets of the home country and countries that are highly correlated to it, and going long in assets from countries that are less correlated with the home country, individuals in most countries seem to have a sub-optimal home bias in their financial assets.

Model economies with frictions

Another strategy to account for time and cross-sectional variation in discount factors, and to identify own comparative advantages, has been to explicitly identify and test frictions that might contribute to the observed time and cross-sectional variation. One possible categorisation of models with explicit frictions is: 1) segmented markets, 2) institutional finance or intermediated markets, and 3) liquidity premiums.

In a segmented market, some investors participate in some markets, and other investors participate in other markets. This means that the basic first-order condition

$$p_t^i = E_t\left(m_{t+1}^j x_{t+1}^i\right),$$

holds only for investors j who are matched to security i. Risks are then shared only between investors in a specific group, not across groups. This feature limits risk-bearing activity and therefore leads to the emergence of premia that are not related to aggregate risks. Thus, one basic consequence of "segmented markets" is that risks are not shared across market participants as they are in the standard model.

One example might be how a general borrowing constraint affects different age groups differently. Constantinides, Donaldson and Mehra (2002) argue that the equity premium can partially be put down to the fact that young households are borrowing-constrained and so equity risk is not shared among age groups.

The literature on "intermediated markets" or "institutional finance" applies to a different, vertical, separation of investor from payoff. Investors use delegated managers to handle their assets. Then, frictions or principal/agent problems in the delegated management relationship spill over into market prices for the assets.

A long tradition in asset pricing recognises that some assets have higher or lower discount rates in compensation for greater or lesser "liquidity". Defining "liquidity", modelling it and understanding it deeply are still, however, open questions. Recently, both theoretical and empirical work have emphasised liquidity as a systemic factor, not just an individual-security characteristic. Times when all assets become illiquid are high marginal utility events, so assets that pay off well in times of aggregate illiquidity should offer lower expected returns.

Frictionless, complete-markets model economies

When modelling markets as frictionless, we gain transparency and tractability. We can then exploit consumer/investor first-order conditions to tie the discount factor to changes in the marginal utility of wealth. Since Mehra and Prescott (1985), Hansen and Jagannathan (1991) and others showed that the standard model with additive separable preferences could not account for observed risk premia (like the equity premium), many approaches have been undertaken to provide preference-based (or production-based) theories consistent with observed asset pricing facts. Surveys of the literature can, for example, be found in Cochrane (2001), and a list of "exotic preferences" generated by the ensuing research can be found in Backus, Routledge and Zin (2004).

Preferences play several important roles in financial economics. They provide, in principle, an unchanging feature of the model in which decision-makers can be confronted with a wide range of different asset classes, environments and institutions.

While there are many routes, those seeking to "reverse-engineer" preferences from key asset pricing facts have mainly followed two approaches. The first involves habit formation or "catching up with the Joneses" (see, for example, Campbell and Cochrane 1999). The second approach seeks to relax the classic assumption that welfare can be separated and added up across time and over states of nature (see Epstein and Zin 1989).

In dynamic, stochastic settings, individuals have preferences over time, preferences towards risk, and combinations of the two. Partially due to analytical convenience, the most common preference specification in macroeconomics and financial economics has been the additive expected structure

$$V = \sum_{i=t}^{\infty} \theta^{i-t} \sum_{\forall s} \pi(s^t) u(c_{t,s})$$

where θ is the time-discount factor, $\pi(s^t)$ is the probability of history s^t, and u is a period/state welfare function.

Additive separability is, however, a very strong and restrictive assumption for preferences over time and states of nature. In addition, for reasonable parameters, the associated stochastic discount factor is almost constant. As proven by, among others, the many "puzzles" and "anomalies" surveyed earlier in this section, its mean, standard deviation and time-variation of volatility are such that it cannot account for the basic asset pricing facts.

Building on work by, among others, Kreps and Porteus (1978) and Johnsen and Donaldson (1985), Epstein and Zin (1989) derived a recursive preference specification that satisfies the fundamental axioms for choice, is analytically tractable, and is not restricted by the assumption of additive separability. Epstein and Zin (1991) pioneered employing utility specifications that are non-separable across time and across states in the asset pricing literature. It has since gained a dominant status and is often referred to as the standard preference specification of modern asset pricing.

Epstein and Zin propose a recursive formulation of utility that abandons the strong assumption of additive separability across time and states of the world. In their specification, the time aggregator is

$$U_t = \left[(1-\beta)c_t^{\rho} + \beta\mu(U_{t+1})^{\rho}\right]^{\frac{1}{\rho}}$$

where $\mu(\cdot)$ is the risk aggregator function, often also referred to as the certainty-equivalent function. $\mu(U_{t+1})$ is a future welfare from the next period and onwards, measured in terms of current welfare (or consumption). The time aggregator returns the weighted sum of current welfare and welfare from the next period and onwards. The lower ρ is, the more individuals would prefer current welfare and the certainty equivalent of future welfare to move together.

The long-run welfare risk aggregator $\left(\mu(U_{t+1})\right)$, or certainty-equivalent function, is a similar functional form. The smaller (more negative) the parameter α is, the more individuals dislike variation in future welfare

$$\mu(U_{t+1}) = [E_t({U_{t+1}}^{\alpha})]^{\frac{1}{\alpha}}$$

Without going into details in this section, the difference between the parameters $\alpha - \rho$ is a measure of individual preference for early resolution of uncertainty. Very loosely speaking, it is a matter of how impatient individuals are to learn what the future will look like.

If $\rho = \alpha$, the specification reduces to a model where utility is additively separable across time and states. Models with non-time-separable utilities (habits, durables) also distinguish risk aversion and intertemporal substitution, but not in such a simple way.

If $\rho \neq \alpha$, we see a second term: expected returns will depend on covariances with changes in the utility index, capturing news about the investor's future prospects, as well as on covariances with consumption growth.

The associated stochastic discount factor is

$$m_{t+1} = \beta \left(\frac{c_{t+1}}{c_t}\right)^{\rho-1} \left(\frac{U_{t+1}}{\mu(U_{t+1})}\right)^{\alpha-\rho}$$

Work by Bansal and Yaron (2004), Hansen, Heaton and Li (2008) and many others indicates that many of the asset price "anomalies" can be accounted for in model economies where uncertainty is time-varying and decision-makers have this class of recursive preferences. In calibrations with this set of preferences, most of the time-varying volatility in the discount factor comes from the second part of the expression, $\left(\frac{U_{t+1}}{\mu(U_{t+1})}\right)^{\alpha-\rho}$, which is the ratio of future welfare (broadly defined) to the certainty-equivalent of future welfare. In other words, fluctuations in the long-run growth prospects of the economy and time-varying level of uncertainty associated with long-run growth (consumption or output volatility) drive changes in the stochastic discount factor, in other words the market price of risk.

This preference specification is also a necessary condition for several successful attempts to account for the cross-sectional differences in mean returns across assets. Bansal, Dittmar and Lundblad (2005) show that the systematic risks across firms should be related to the systematic long-run risks in firms' cash flows that investors receive. Firms whose expected cash flow (earnings) growth rates move with the economy are more exposed to long-run risks and hence should carry higher risk compensation. The authors show that a high book-to-market portfolio (i.e. a value portfolio) has a larger sensitivity to long-run risks than a low book-to-market portfolio (i.e. a growth portfolio). Hence, the high mean return of value firms can be attributed to this risk exposure.

This preference specification in environments with time-varying uncertainty has also been employed to address a rich array of other asset market issues. A few examples: Kiku (2006) can account for the shortcomings of the capital asset pricing model (CAPM) and consumption CAPM (C-CAPM) in accounting for the cross-sectional differences in mean returns. Eraker (2006) and Piazzesi and Schneider (2005) consider the implications of the marginal investor's sensitivity to growth-rate risks for the risk premia on US Treasury bonds and can account for some of the average premium puzzles in the term structure literature. Chen, Collin-Dufresne and Goldstein (2009) and Chen (2010) show that they can use this framework to account for the credit spread and leverage puzzles of the corporate sector.

Deviations from standard additive-separable preferences seem also to be necessary to analyse how "fat tails" and other deviations from normality are priced.[2] Backus, Chernov and Martin (2009) use information about the volatility of higher-order moments implied by equity index options to derive information about deviations from normality and implications for market preference parameters.

Heterogeneity in sensitivity to long-run risk and higher-order moments (such as "fat tails") is also a natural point of departure for portfolio heterogeneity, both on average in cross section and dynamically over time (rebalancing). As stated earlier in this section, in frictionless environments, preference heterogeneity is not necessarily literally "preference" heterogeneity. It might also be a reduced-form representation of other forms of heterogeneity, such as differences on the liability side, different regulations or differences in how investors are affected by the same regulations.

Backus, Routledge and Zin (2009) have made some progress in analysing risk-sharing and asset allocations with heterogeneous recursive preferences. Their working paper shows how the dynamics of output growth not only reflect standard mean-variance tradeoffs, but also tradeoffs involving the timing of the resolution of uncertainty. This framework would also be very suitable for analysing the dynamic portfolio allocation of an investor with different risk sensitivities to those implied by the "marginal investor". In particular, this framework is suited to studying dynamic reallocation as uncertainty (and the market price of risk) changes.

Concluding remarks

In recent decades, research into asset pricing has increasingly focused on documenting and accounting for cross-sectional and time variation in discount factors. This change has been prompted by persistent empirical regularities: the well-known "puzzles" and "anomalies" can almost all be traced back to discount factor variation rather than problems of information incorporation.

[2] Deviations from normality are moments like skewness and excess kurtosis. Martin (2010) extends the Epstein-Zin asset pricing model to incorporate information about the higher-order moments – equivalently cumulants – of consumption growth. He argues that the importance of higher-order moments might be a double-edged sword: parameters that govern higher-order moments (or cumulants) are critically important for asset pricing, but extremely hard to calibrate.

Academic research is just about to understand the implications of the view of the world that there are multiple dimensions of risk with shifting premiums. This might have a profound impact on strategies for the management of large, long-term funds such as the Government Pension Fund Global.

Even though it is clear that investors with different risk sensitivities and different exposures to non-tradable risks should hold different portfolios, these insights should be applied with caution. The complement of any asset management strategy that aims at systematically exploiting discount factor variation must be a convincing theory for why it is optimal for the average investor to hold the market portfolio, given preferences, risks and price dynamics. For example, a statement about own comparatively higher-than-average risk-bearing capabilities must be coupled with convincing arguments for why the majority of other investors have lower risk-bearing capabilities.

A large and growing body of academic literature has documented how several of the observed premiums (including the credit and term premiums) can be accounted for by exposure to changes in uncertainty associated with long-run growth prospects. The source of what is represented by differences in risk preferences might be differences in non-tradable risk or how the investor is affected by market frictions. This should not only be postulated, but also documented. A starting point for gaining further understanding of the existing rebalancing rule, as well as formulating new strategies to systematically exploit time-varying market discount factors, may be to study dynamic portfolio problems for investors with risk preferences that differ from those of the implicit marginal investor.

Deviations from the market portfolio might not only be based on differences in regulation and risk-bearing capabilities. This is also by itself a as well as reason to deviate from the market portfolio. Modern macroeconomics has an analytical framework that is similar to and complements that of modern asset pricing and portfolio theory. Investment strategies for the Government Pension Fund Global could potentially be structured in order to partially hedge the non-tradable macroeconomic risk facing the owners of the fund.

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Appendix

We have

$$p_t^i = E_t(m_{t+1}x_{t+1}^i).$$

Using the definition of covariance

$$p_t^i = E_t(m_{t+1})E_t(x_{t+1}^i) + cov_t(m_{t+1}, x_{t+1}^i),$$

gross returns are defined as the ratio of payoffs to price, $R_t^i = \frac{x_{t+1}^i}{p_t^i}$, hence

$$E_t\left(m_{t+1}\frac{x_{t+1}^i}{p_t^i}\right) = E_t(m_{t+1}R_t^i) = 1.$$

Using the definition of covariance and the real risk-free rate at time t, $R_t^f = \frac{1}{E_t(m_{t+1})}$,

$$\frac{E_t(R_t^i)}{R_t^f} + cov_t(m_{t+1}, R_t^i) = 1.$$

If expected excess returns are defined as $E_t(R_t^{ei}) \equiv E_t(R_t^i) - R_t^f$, then

$$E_t(R_t^{ei}) = -R_t^f cov_t(m_{t+1}, R_t^i).$$

The expected risk premium or "expected excess return" is determined by the covariance with the discount factor.

The term premium

In this section, we review the theory and empirical evidence of the term premium. The term premium is the excess return that an investor obtains in equilibrium from committing to hold a long-term bond instead of a series of shorter-term bonds.

Main findings

- Most of the empirical research has focused on the post World War II period and the US Treasury market, and finds that the term premium is positive on average.

- The presence of excess returns on long-maturity bonds over Treasury bills contradicts the expectations hypothesis of the term structure, but the literature is inconclusive with regard to the economic rationale for the term premium.

- Most academic contributions to the term premium literature (for example, Campbell and Shiller 1991) point to a time-varying term risk premium, and an investor would have to adopt a dynamic approach towards duration exposure in order to best capture this premium.

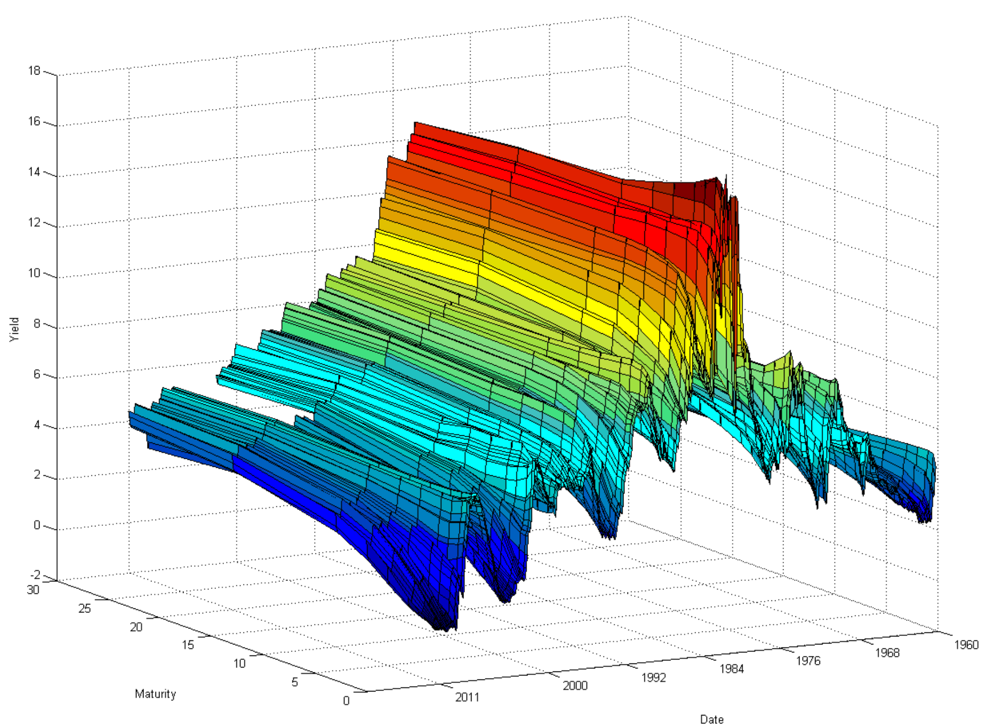
- Historical approaches to explaining the term premium, such as the liquidity preference and the market segmentation theory, have been followed by a rich empirical literature that can be classified as influenced by financial theory (affine term structure models) or by macroeconomic theory (reduced-form models). While the finance-orientated research identifies uncertainty about the evolution of the short-term interest rate as the primary driver of the term premium, the macro-finance approach emphasises uncertainty about the macroeconomy, i.e. growth and inflation.

- The macro-finance models combine the approaches of macroeconomic literature with the no-arbitrage models from financial literature and tentatively give credence to the notion that a positive term premium is compensation for risk with regard to the evolution of policy interest rates, which in turn is driven by uncertainty about underlying macroeconomic factors.

Theories of the term structure of interest rates

The term structure of interest rates describes the relationship between bond yields and their maturities. The yield curve plots the term structure, and two basic patterns of yields emerge when looking at historical curves (see Figure 1): (1) on average the yield curve is upward sloping, and (2) there is substantial volatility in yields across all maturities.

Figure 1: Term structure in the US Treasury market over time



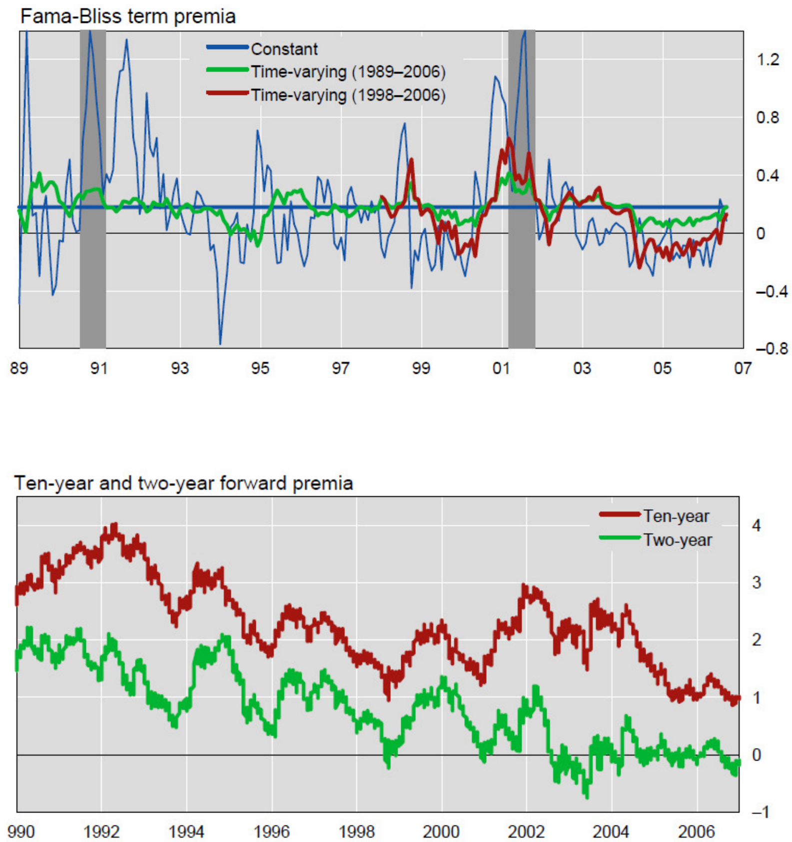
Source: NBIM calculations, Federal Reserve Bank of St. Louis

The expectations hypothesis developed by Irving Fisher (see Fisher 1930 and Lutz 1940) is one of the oldest and most widely known theories of the term structure of interest rates. The expectations hypothesis argues that investments in different maturities will generate the same expected return over a given investment horizon, and thus default-free bonds of all maturities are perfect substitutes.[1] This hypothesis does not take into account that future interest rates are uncertain and thus fails to take into account the compensation an investor requires for taking on interest rate risk. A term premium will arise whenever there is a deviation from the expectations hypothesis. The latter also ignores that the real return on nominal bonds is subject to the risk of unexpected inflation, and that uncertainty tends to increase with longer time horizons.

The expectations hypothesis finds little support in empirical studies (for example, Roll 1970, Sargent 1979, Hansen and Sargent 1981, and Campbell and Shiller 1991). In particular, several studies show that a strategy where the investor sells fixed-income securities with a short maturity and invests in securities with a long maturity when this interest rate spread is wide will earn an excess return over time. The return achieved by an investor using such a strategy can be viewed as reaping a term premium. Fama and Bliss (1987) use data from the period 1965-1985 and find a non-zero and time-varying term premium. While they estimate this premium to be almost as large as 6 per cent (close to mid-1980s) during periods of strong business activity, they also find that the premium can turn negative when the business environment turns sour (1973-1974 and 1979-1982). Kim and Orphanides (2007) estimate the Fama and Bliss (1987) regression on a short-term data sample of the futures curve from 1989 to 2007. The authors find an average short-term premium of 0.18 percent. However, this volatile measure of the term premium behaves very differently if the sample period starts a decade later in 1998 (see graph above). Moreover, Kim and Orphanides employ an affine term structure model that incorporates forecast three-month T-bill rates and find (mostly) positive and time-varying term premia for both short and long horizons.

[1] Note that while the expectations hypothesis focuses on expected returns, empirical literature such as Fama (1984), Fama (1990) and Fama and Bliss (1987) use term premium to refer to realized, rather than expected, excess returns on long-term bonds.

Figure 2: Top panel: Fama-Bliss term premia in the US Treasury market (units in %)
Bottom panel: Blue Chip Financial Forecasts term premia (units in %)



Source: Kim and Orphanides (2007)

Similarly, Campbell and Shiller (1991) argue that the expectations hypothesis holds reasonably well in a data sample for 1952-1978, while being strongly rejected for the period 1952-1987. The authors suggest that the deviation from the expectations hypothesis could arise from a time-varying risk premium. Cochrane and Piazzesi (2005) confirm these findings on an updated data sample by pointing out that the difference between forward rates and current spot rates does not forecast a change in the spot rate from this year to the next. Moreover, the estimates obtained by, among others, Kim and Orphanides (2007) and Cochrane and Piazzesi (2005) show that the term premium varies significantly across the term structure and an investor would have to adopt a dynamic approach towards duration exposure in order to best capture this premium.

The question is then: how can we account for this excess return? In particular, what manifestation of risk are investors being compensated for holding? In empirical studies of asset pricing, the term premium is usually viewed as a systematic risk factor (Fama and French 1989 and 1993). The source of this systematic risk factor is still not fully accounted for in academic finance (Campbell, Lo and MacKinlay 1997).

Two of the most cited fundamental theories of the term structure are the liquidity preference hypothesis (Hicks 1946) and the market segmentation hypothesis (Culbertson 1957). While the expectations hypothesis states that the forward rate equals the expected future spot rate, these two theories assume that forward rates can be decomposed into expectations of future short-term interest rates and interest rate risk premia. Moreover, an average of these forward rates is what makes up long-term interest rates. Long-term interest rates also depend on expectations of future short-term interest rates and interest rate risk premia. For this reason, movements in long-term rates can be attributed to movements in either expectations of short-term rates, risk premia or both. The observation that a significant part of long-term interest rates is made up of a time-varying and stochastic risk premium finds support in academic research. The open question that remains, however, is what determines the level and variation of the term premium over time and time-to-maturity.

Models of the term structure of interest rates

Broadly, the literature trying to account for the level and variation of the term premium can be classified into two complementary approaches: the affine structural-model approach and the reduced-form approach.

- Affine structural-model approach: This approach, in which the yield curve (and the price of risk) is driven by a set of latent – unobservable – factors, stems from the financial literature and in particular the concept of no-arbitrage. A strict interpretation of the no-arbitrage condition excludes the possibility of achieving a risk-free future profit with a zero net investment.[2] Any existing arbitrage opportunities would be eliminated by instant price adjustments resulting from efficient market activity within this framework.

[2] Defined as a portfolio of long and short investments with a net value of zero.

- Reduced-form approach and macro-finance models: This approach stems from the empirical macroeconomic literature and takes the form of factor models based on macroeconomic variables. These reduced-form models provide a way to identify and interpret the underlying drivers behind the unobserved factors from the affine structural models. More recent models, the so-called macro-finance models, combine the approaches of the macroeconomic literature with the no-arbitrage models from the financial literature.

Affine term structure models

Affine term structure models have been defined in a number of different ways. Piazzesi (2010) has written an overview of the class of affine term structure models and defines these models as no-arbitrage models in which bond yields are affine functions – a constant plus a linear function – of some set of (risk) factors. Within a structural framework, these models offer a simple way of interpreting factors that affect the term structure and their impact across different maturities. However, financial literature generally does not specify these factors in detail, and they are therefore treated as latent – unobservable – variables. Duffie and Kan (1996) argue in favour of explaining yields with latent factors. They cannot observe a given variable X directly, but rather infer X by looking at its effect on yields. Most models with latent variables aim at giving the variables intuitive labels. In general, these factors are typically categorized as “level”, “slope” or “curvature” depending on the nature of their impact on the yield curve. This approach presents a framework for understanding term structure dynamics. However, it does not offer any insight into what determines the interest level itself, and cannot be used as a tool for forecasting.

In their most basic form, affine term structure models allow short-term interest rates to be the sole determinant of the whole term structure. Vasicek (1977), which is one of the earliest affine term structure models, is such a one-factor model. The Vasicek model is based on a statistical approach where short-term rates are independent of macroeconomic determinants and thus determined only by their own past movements. This implies that expectations of future rates are formed purely on the basis of currently observed interest rates. The only source of risk within this framework is the potential deviation of short-term interest rates from their expected levels.[3]

The basic one-factor approach implies that long-term interest rates are given as the average of expected short-term rates and a time-varying and maturity-dependent risk premium. The magnitude of this risk premium depends on both the variation in the short-term interest rate and the "market price of risk".[4] Moreover, this approach can be described by a linear one-factor relationship, where long-term interest rates are determined by the one-month interest rate. Thus, for a given maturity, the slope can be interpreted as the sensitivity of long-term rates to changes in one-month rates. This sensitivity will differ across maturities and be determined by, among others, the dynamics and volatility of short-term interest rate as well as the market price of risk.

The linear relationship between short- and long-term rates forces interest rates to be perfectly correlated across all maturities. This is a strong assumption with dubious empirical support even though interest rates of different maturities do co-vary to some extent. The fact that rates are not perfectly correlated tells us that short-term rates cannot be the sole determinant of the joint dynamics of interest rates across maturities. A perhaps more important limitation of the Vasicek model is that it allows negative interest rates with near-constant volatility.

In order to overcome these limitations, Cox-Ingersoll and Ross (1985) and Longstaff and Schwarz (1992) extend the Vasicek model to two-factor models that are characterised by time-varying and level-dependent volatility. Duffie and Kan (1996) suggested a multifactor affine term structure model which has been further investigated by, among others, Dai and Singleton (2000) and Duffee (2002). Multifactor models describe yield dynamics by imposing strict linear conditions, which ensures tractability. However, whether or not these models can capture empirical observations is an open question.

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[3] As an illustration: the price an investor receives in one month for selling a two-month bond depends solely on the prevailing interest rate one month from now. The risk lies in the fact that this interest rate is unknown at present. Thus, many term structure models, including Vasicek (1977), assume that the fundamental source of uncertainty in the economy is the short rate.

[4] The market price of risk can be seen as a representation of the risk aversion of the marginal investor and, ultimately, the premium investors on the margin require as compensation for taking an additional unit of risk, including that associated with holding a long-term bond. The no-arbitrage condition implies that there is no expected excess return on any asset after properly adjusting for risk. It further implies that different returns at different maturities are a result of different risks associated with these maturities. Moreover, Campbell, Lo and MacKinlay (1997) define the market price of interest rate risk as the ratio of the expected bond excess return to the standard deviation of the bond excess return.

A strand of research by, among others, Wachter (2006) and Buraschi and Jiltsov (2007) extends from the multifactor affine term structure models of Duffee (2002) and allows time-varying risk aversion to affect the shape of the term structure while retaining the affine structure. A study by Campbell, Sunderam and Viceira (2010) builds on these models even though they to a great extent depart from the affine framework in order to introduce time-varying covariance into their model. The authors find that the term premium is partly determined by the covariance between bond and equity returns. The authors include a covariance factor in their model and argue that investors will require a positive (negative) term premium for holding bonds whenever this covariance is positive (negative). Their logic states that bond risk is low whenever returns on bonds and equities move in opposite directions, as in the early 2000s. Investors treat bonds as a hedge against equity risk in these scenarios, while the opposite will be the case when bond and equity returns tend to co-move, as in the early 1980s.

A study by Swanson, Rudebusch and Sack (2007) reviews several approaches to measuring the term premium and comes out in favour of the methodology put forward by Kim and Wright (2005). Kim and Wright employ an affine three-factor model based on the work by Duffie and Kan (1996) and Duffee (2002). In their model, interest rates and the term premium are determined by three latent factors that are linear functions of observed bond yields. The model estimates expected future short-term interest rates and defines the term premium as the forward rate less the model-implied expected future short-term rate.

Traditional reduced-form macroeconomic models

The purely statistical reduced-form models take the form of factor models based on macroeconomic variables, and are usually specified as a regression of interest rates on various macroeconomic variables. These macroeconomic variables include inflation, GDP (level and growth), government debt and other economic indicators, and can be translated into risks such as risk of real economic activity variability and risk of inflation variability. The approach aims to examine the extent to which macro variables can explain movements in both short-term and long-term interest rates.

The foundations for recent developments in reduced-form models were laid down by a comprehensive strand of literature during the 1960s, 1970s and 1980s. Patinkin (1965) estimates a model where government debt, the monetary base and an income factor together have significant explanatory power over interest rates. Sargent (1969) estimates several regressions in order to examine the impact of various macro variables on interest rates. In particular, the author argues that money supply, gross national product and anticipated inflation have an effect on nominal interest rates. On the other hand, Yohe and Karnosky (1969) find that anticipated inflation is the only systematic influence that can account for most of the movements in interest rates. Feldstein and Eckstein (1970) run a series of regressions and conclude that long-term interest rates are mainly determined by four variables: liquidity, inflation, government debt and expected interest rate changes. Hambor and Weintraub (1974) argue that government debt, base money, risk aversion as well as industrial production and general economic activity have a significant impact on the term structure of interest rates. Cornell (1983) studies the effects of money supply innovations and concludes that these innovations can account for movements across all interest rate maturities. Urich and Wachtel (1984) examine the effects of inflation and money supply announcements on interest rates. In particular, they claim that both these announcements and the actual changes in money supply have an immediate effect on interest rates.

In contrast to the affine structural models, these purely statistical reduced-form models are unable to impose the no-arbitrage condition. However, the models prove useful in identifying the sensitivity of interest rates across maturities to changes in the different macro risk factors and provide a way to identify and interpret the underlying drivers behind the unobserved factors from the affine structural models.

New macro-finance models

More recent literature has come a long way in combining the affine term structure models with the approaches of macroeconomics in order to account for the co-movements of the market prices of risks and the real returns on nominal assets. In particular, Ang and Piazzesi (2003) argue that macro variables can account for 85 percent of the variation in US yields over time. Lildholdt, Panigirtzoglou and Peacock (2007) confirm this result for the UK, and claim that inflation and the GDP gap drive short-term yields, while long-term inflation drives long-term yields. On the other hand, among others, Jorion and Mishkin (1991), Estrella and Hardouvelis (1991) and Estrella and Mishkin (1998) argue that inverted (downward-sloping) yield curves predict recessions (with only one exception since the mid-1960s).

These combined models replace the latent (unobserved) variables with actual macroeconomic variables while retaining the fundamental structure of the affine multifactor models. The macroeconomic variables include inflation rate, GDP growth, exchange rates, government debt, unemployment and other economic indicators, and can be translated into risks such as inflation variability and real economic activity variability. These models, just like the models with latent factors, offer a way to determine the sensitivity of interest rates across maturities to changes in the different risk factors.[5]

The relationship between various macro variables and the yield curve has been studied within a no-arbitrage framework by Ang, Piazzesi and Wei (2006), Wu (2006), Dewachter and Lyrio (2002), Kozicki and Tinsley (2001), Diebold, Rudebusch and Aruoba (2003), Evans and Marshall (2007) and Piazzesi (2001). Ang and Piazzesi (2003) and Hördahl, Tristani and Vestin (2003) model the term structure on a set of macro variables, but allow for a residual component that remains unexplained. This latent component is not necessarily the same as one of the latent factors from the financial literature. The authors argue that macro variables can account for most of the variability in short- to medium-term yields, but do not find evidence of the same macro-sensitivity in longer term yields. Evans and Marshall (2007) employ the same framework but allow for interest rate smoothing – i.e. current yields are dependent on historical yields – and argue that macro variables have a strong effect on both short- and long-term yields. Cochrane and Piazzesi (2002) isolate monetary policy shocks (changes in the Federal Funds target rate) by investigating daily data for long-term yields, and claim that fiscal shocks have a significant impact on yields. This is in contrast to Evans and Marshall (2007), who argue that fiscal policy shocks play a negligible role in determining interest rate variability.

Gallmeyer, Hollifield, Palomino and Zin (2007) link the dynamics of the term structure to macroeconomic variables by explicitly combining a monetary policy process, which is specified as a Taylor rule (Taylor 1993), and an endogenous inflation process. In this

[5] As in the latent variable model, the market price of risk determines the compensation an investor receives for being exposed to these risks.

framework, shocks to real growth are transmitted through the central bank policy rule and the inflation process to determine the shape of the yield curve and its evolution over time. The authors argue that these macroeconomic shocks can account for a large part of the time variation in yields, and in particular the (on average) upward-sloping yield curve. The correlation between the inflation process and the market price of risk tells us that the term premium will be affected by the volatility of short-term interest rates and investors’ sensitivity to this volatility.

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Realised term premium

In this section, we supplement the review of the academic literature on the term premium with our own analysis of the "realised" or "ex-post" term premium.

Main findings

- Our analysis of the ex-post term premium is in line with findings from academic literature and, more specifically, there are indications of a significant structural break in the term premium in the US Treasury market around the late 1970s. Before this break-point, evidence of a positive premium is weak, whereas longer-term bonds persistently outperformed short-term debt in the three decades that followed.

- The decision about whether to have a constant exposure to the term premium hinges on whether the time variation in that premium is small (in which case it is advisable) or whether the swings in the ex-ante premium are large and a more dynamic approach would be desirable. Our empirical analysis is supportive of the latter.

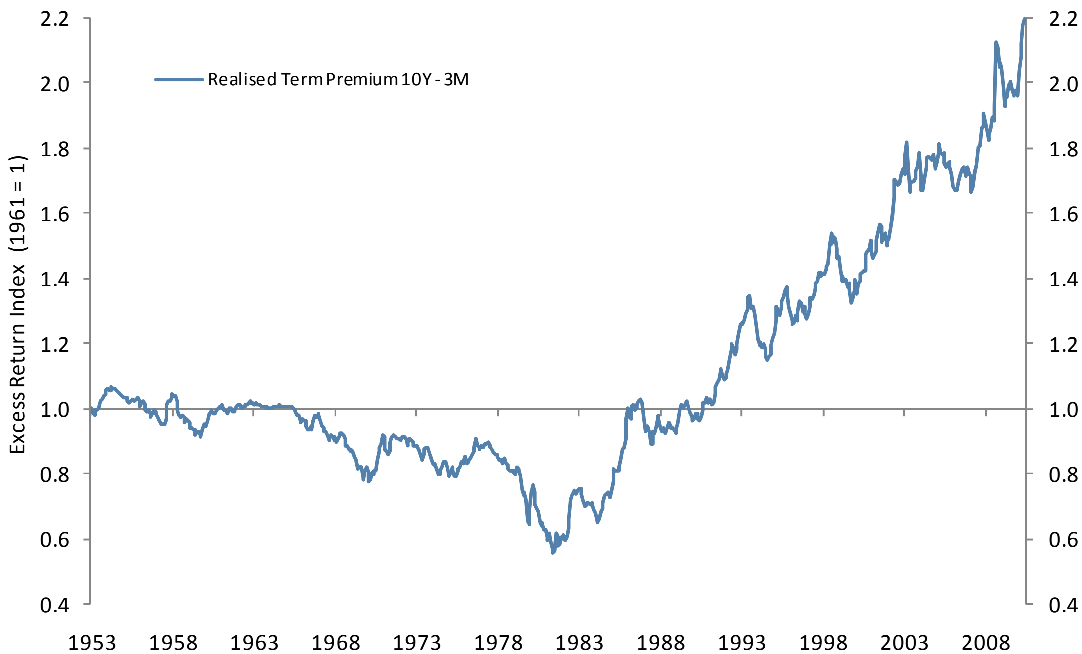
Analysis of the ex-post term premium

The realised term premium is defined in this analysis as the return from buying ten-year Treasury bonds at the beginning of a month and selling an equal dollar amount of three-month Treasury bills (T-bills). At the end of the month, that trade is closed and re-opened with the most current ten-year and three-month securities. We employ two approximations of that ex-post term premium based on monthly data, which are shown as excess return index series in Figures 1 and 2. The first one uses constant-maturity ten-year Treasury yield data from the Federal Reserve database, but ignores the effects of rolling down the curve during the one-month holding period.[1] As the roll-down effect usually contributes positively to the total return from investing in a longer-term Treasury, this approximation tends to underestimate the

[1] Roll-down refers to the fact that a ten-year note becomes a note with nine years and 11 months residual maturity after the one-month holding period. Since the yield curve is usually upward sloping, it has a slightly lower yield than a ten-year security.

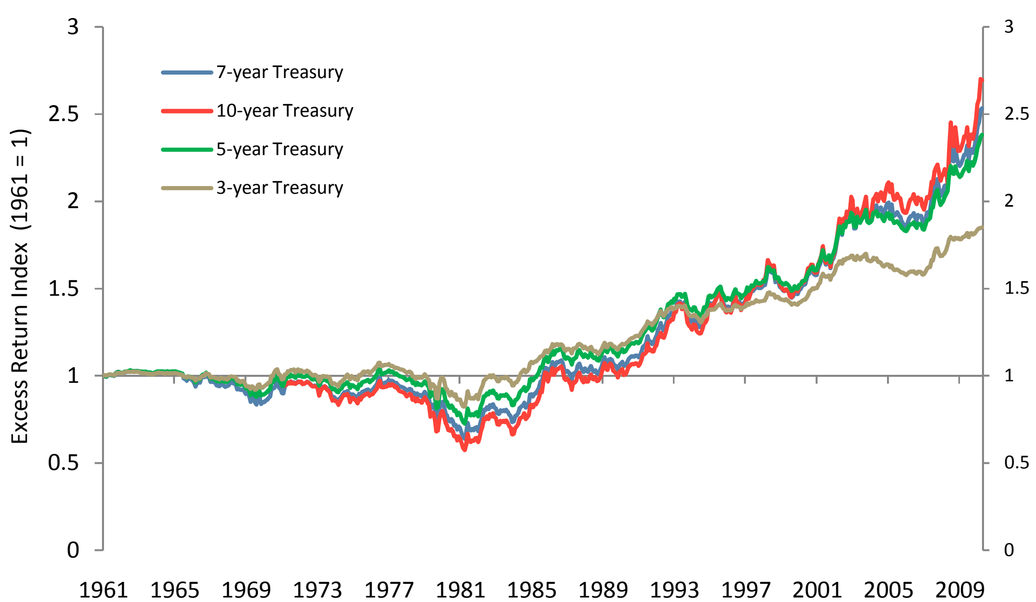
term premium, especially when the yield curve is very steep around the ten-year maturity point.

Figure 1: Realised term premium from ten-year US Treasuries over three-month T-bills without roll-down effect



Source: NBIM calculations, Gurkaynak et al (2006)

Figure 2: Realised term premium from Treasuries over three-month T-bills with roll-down effect



Source: NBIM calculations, Gurkaynak et al (2006)

However, this approximation allows us to calculate the realised term premium starting in 1953. The second method employs complete yield curve data from Gurkaynak et al (2006), which enable us to estimate the excess return on three-, five-, seven- and ten-year bonds *with* the monthly roll-down effect, but at the expense of a somewhat shorter history.

The results of this exercise are quite striking. For both measures, we can observe two very distinct regimes for the realised term premium. Before around 1980, the excess return series is largely flat and even turns significantly negative in the late 1970s, whereas persistent positive excess returns of longer-term bonds over T-bills can be recorded throughout the three decades that follow. In the 1950s and 1960s, realised inflation may have evolved largely in line with market expectations, before the 1970s brought episodes of unanticipated erosion of real purchasing power, resulting in rising bond yields and mark-to-market losses on long-term Treasuries.

Having lost the trust of the bond market by the late 1970s, governments were only able to sell bonds with a significant embedded risk premium over the path of expected short-term interest rates, while the early 1980s saw key central banks adopt a strong anti-inflationary stance. Both factors may have paved the way for the sustained excess returns of ten-year Treasuries over T-bills between the early 1980s and the present. Our own preliminary analysis is somewhat similar to the results from Campbell and Shiller (1991), which argued that the expectations hypothesis held during the 1951-1978 period (in which our ex-post term premium measure largely moves sideways), but not if the 1979-1987 period is included.

Benchmark duration

For an investor aiming to harvest the term premium, the choice of exposure along the yield curve, and in particular portfolio duration, is important. Most investors choose a market-value-weighted fixed-income benchmark with relatively narrow bands for duration. Market weights accurately reflect the investment opportunities and the relative liquidity of the maturity segments in fixed-income markets. However, market-weighted benchmarks expose investors to fluctuations in average market duration over time. Another option is to find a maturity profile with a constant duration so as to insulate the investor from potential conflicts of interest with the issuers.

Table 1: Sharpe ratios of Treasury maturities over three-month T-bills (common sample 1971-2009)

Maturity	Excess return	St Dev	Sharpe Ratio	Skew
3-year	1.6%	4.3%	0.36	0.66
5-year	2.3%	5.3%	0.43	0.04
7-year	2.6%	6.5%	0.39	0.07
10-year	2.7%	8.3%	0.33	0.16

Source: NBIM calculations

The benchmark duration could then be chosen such that it optimises the trade-off between three considerations: (1) investability and liquidity of the benchmark, (2) the term premium that can be expected to be earned, and (3) the additional volatility incurred from maximising the term premium, which may impede on the usefulness of the high-quality debt portfolio for rebalancing purposes. Using the historical excess return of various maturities over three-month T-bills (i.e. the realised term premia) and their associated Sharpe ratios is a first approach to the above question.

In terms of cumulative excess returns, we show in Table 1 that the longest maturities had the highest term premia over the full period, and the shortest maturities the lowest. In terms of the Sharpe ratio, i.e. when trading off the term premium with its standard deviation, the five-year maturity bucket fared best with a Sharpe ratio of 0.43, and the ten-year bucket the worst with a ratio of 0.33. If an investor without explicit liabilities were to choose a constant benchmark duration, this may argue in favour of an average maturity of five years (or duration of roughly 4¾ years at current Treasury yield levels), but the differences in Sharpe ratio are too small and sample-dependent for this to be a firm recommendation.

When taking into account the high indebtedness of developed nations and the currently low term premia (see also our analysis of the level of yields and sovereign risk in the other sections of this enclosure), it may be plausible to expect governments to issue more long-term debt going forward. This can also be seen as an argument in favour of a constant duration that is *shorter* than the market-determined one, currently 5.7 years for the Barclays Capital Aggregate Global Index. An investor who decides to stay with the market-weight duration should monitor the behaviour of issuers and its impact on index duration regularly and allow for large deviations of portfolio duration from the benchmark or an eventual switch to a constant duration.

Liability-driven investment

A recent development to influence the shape of the yield curve – and so the realised term premium – in many developed countries is a change in the behaviour of institutional investors that has been termed “asset-liability matching” or “liability-driven investment” (LDI). Such behaviour, where investors focus on their own liabilities rather than follow the return-versus-volatility mindset of the Markowitz-Sharpe paradigm, may be consistent with the “market segmentation” theory of the yield curve discussed in our literature review of the term premium (see separate section). Since only long-dated bonds are suitable for matching the long-term liabilities of certain institutional investors, these segments of the market may be bid up in price beyond what would be consistent with their return expectations (Bank of England 2006). Regulatory changes, in particular the move to mark-to-market accounting of pension fund assets *and* liabilities and closer scrutiny of the funding status of pension funds and insurance companies, are partly responsible for this drive towards LDI. Anecdotal and econometric evidence reported in BIS (2007) suggests that the impact of liability-driven investment on the yield curve has been substantial in the countries that were early implementers of regulatory change, such as the UK and Canada, but more limited in the US and Continental Europe.

It is likely that regulatory pressure towards LDI will persist (or even intensify) and continue to have an impact on the yield curve in the future unless the supply response of governments and other issuers of long-dated fixed-income securities fully matches the additional demand. This means that, in the transition towards full matching of liabilities, long-term bonds suitable for liability hedging may be better protected against a sharp sell-off and mark-to-market losses than they would have been in the absence of regulation. For a long-term investor without explicit liabilities, however, the additional demand from pension funds and other constrained investors will depress hold-to-maturity yields and the expected term premium, arguably making the very long end of the yield curve less attractive.

Conclusion

In conclusion, there are indications that the sign and the magnitude of the term premium are strongly dependent on the time period, and that there are long periods when the premium can be zero or negative. Extrapolating the strong excess returns of longer-maturity government bonds over cash during the last three decades into the future could be overly optimistic and requires some conviction in the continued emphasis of central banks on price stability against a backdrop of rising government and private indebtedness in the developed countries. Having a constant exposure to the term premium, for example by having a high fixed allocation to long-duration nominal fixed-income securities, is therefore not recommendable.

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The credit premium

In this section, we review the theory and empirical evidence of the credit premium. The credit premium is the excess return that an investor obtains for holding bonds issued by entities other than governments. A natural starting point for this objective is to discuss the so-called "credit spread puzzle" and different attempts to resolve it.

Main findings

- The spread of BBB-rated (three- to five-year maturity) corporate bonds over Treasuries (the credit spread) averaged 170 basis points p.a. during the period 1997-2003, while the total loss from default for the same bonds averaged 20 basis points p.a. for the same period. Clearly, the credit spread has historically compensated for more than the expected loss from default.

- The credit spread puzzle refers to the observation that structural models such as the one proposed by Merton (1974) have failed to explain the high excess returns received by corporate bondholders historically. Key assumptions of the structural models from which the puzzle arose were time-invariant default probabilities and recovery rates. The puzzle suggests either that the static assumptions of the Merton model may be too restraining or that components other than default and recovery risk affect the credit spreads.

- Broadly, the academic literature can be classified into approaches based on reduced-form models and approaches based on structural models.

- Reduced-form models have attempted through statistical analysis to identify factors, including non-default-related factors, that can account for the observed credit spreads, such as liquidity, tax, equity volatility and interest rate structure.

- Structural models combine economic theory, measurements and identification to quantitatively account for observed credit spreads.

- Recent structural models argue that credit spreads can be accounted for by extending the standard models along the same dimensions that have previously been used to account for the equity premium puzzle. These structural models incorporate time-varying reward-to-volatility ratios and can capture both the level and time-variation of historical spreads. This strand of literature suggests that credit spreads are not primarily driven by credit-specific idiosyncratic risk, but rather by the same common systematic risk factors that drive other security prices like equity.

- The academic literature finds that there is a positive and time-varying credit premium. This premium is typically seen as compensation for two main types of risk: default risk and recovery risk. The former refers to the risk of an issuer defaulting, while the latter is the risk of receiving less than the promised payment if the issuer defaults.

The credit spread puzzle

Normally corporate bonds trade at a higher rate than government bonds. This is what is referred to as the credit spread, which is typically seen as compensation for two main types of risk: default risk and recovery risk. The former refers to the risk of an issuer defaulting, while the latter is the risk of receiving less than the promised payment if the issuer defaults. The spread of BBB-rated (three- to five-year maturity) corporate bonds over Treasuries averaged 170 basis points p.a. during the period 1997-2003, while the total loss from default for the same bonds averaged 20 basis points p.a. for the same period. This illustration, which is given by Amato and Remolona (2003), shows the existence of a significant credit spread which has historically compensated for more than the expected loss from default.

The term “credit spread puzzle” can be traced back to the work done by Huang and Huang (2003). They estimated credit spreads using a range of different traditional structural models and historical company data on leverage, default and recovery. The authors compared the results with historical spreads and found consistent evidence of underestimation in the models. The term “credit spread puzzle” was thus coined. The reason for this puzzle must either be misspecification in the traditional structural models or that additional factors drive the empirically observed credit spreads.

Attempts by academics to explain the historical credit spread have employed different analytical tools. Broadly, this academic literature can be classified into two approaches:

- The reduced-form approach is based on statistical analysis aiming at explaining the spread by suggesting possible explanatory factors in a factor model regression.

- The structural-model approach combines economic theory, measurements and identification to quantitatively account for observed credit spreads.

Findings from reduced-form models

Credit risk models and the desire to resolve the credit spread puzzle have been a frequent theme in empirical research. While credit and recovery risk are considered the principal factors in accounting for credit spreads, several non-default-related factors have been suggested as possible components of the credit spread. One such non-default-related factor is liquidity. This effect reflects the fact that corporate bonds are less actively traded than Treasuries, and thus corporate bond investors are dealing with relatively wider bid-ask spreads for which they are compensated with a liquidity premium.

Houweling, Mentink and Vorst (2005) use a sample of 999 investment-grade bonds in a reduced-form setup and conclude that liquidity risk accounts for a significant portion of credit spreads and that this liquidity premium is time-varying. However, as liquidity effects cannot account for the entire spread, this still leaves a portion of the variation in credit spreads unexplained. A factor representing tax effects is another plausible factor to account for the residual spread. The tax effect comes from the fact that corporate and government bonds are taxed differently in the United States. In particular, government bonds are taxed at a lower rate and thus corporate bond investors require compensation for this disadvantage.

Elton, Gruber, Agrawal and Mann (2001) investigate the explanatory power of the tax factor together with the Fama-French risk factors[1] in a reduced-form regression. The authors conclude that the spread can be explained by the loss from expected defaults, taxes and a systematic risk factor. The size and significance of the tax effect has been debated and Grinblatt (2001) argues that tax-exempt investors like pension funds or international investors would arbitrage away the tax effect.

A study by Driessen (2005) investigates the combined explanatory power of tax and liquidity effects through a regression on a sample of 104 US corporate bonds, and concludes that these factors account for more than half of observed credit spreads. Still, the remainder of the spread continues to be unaccounted for.

A study by Collin-Dufresne, Goldstein and Martin (2001) challenges the view that factors such as default, recovery and liquidity drive credit spreads. The authors employ a reduced-form framework and estimate a regression in order to assess the significance of these factors. Their results suggest that a single market-wide component has been the driving force behind historical spreads. This component is not identified but the authors argue that "monthly credit spread changes are principally driven by local supply/demand shocks that are independent of both credit-risk factors and standard proxies for liquidity." (Collin-Dufresne, Goldstein and Martin, 2001, p. 1).

On the other hand, Boss and Scheicher (2002) claim that interest rate dynamics, liquidity and volatility in stock and debt markets can account for observed credit spreads. They find these results by running an ordinary-least-squares regression on a sample of European market data. The authors confirm their findings from the European markets with similar results from the same analysis carried out on US market data.[2] Much like the study by Collin-Dufresne, Goldstein and Martin (2001), Boss and Scheicher (2002) find a sizeable and unobserved market-wide component.

Campbell and Taksler (2004) is another study that finds that equity volatility can help explain the magnitude and time-variation of historical credit spreads. They employ monthly corporate bond data for the period 1995-1999 within a reduced-form framework. The authors sample

[1] The Fama-French factors are a set of risk factors identified by Fama and French (1993) to help explain asset returns. Five factors are identified: three equity factors and two bond factors. According to Fama and French (1993), the three equity factors can be decomposed into "an overall market factor and factors related to firm size and book-to-market equity", while the bond factors are "related to maturity and default risks".

[2] The majority of the literature has focused on the US markets for investment-grade and high-yield debt, while less emphasis has been put on the European credit markets. Still, similar results have been found for both the EU and US debt markets, and in particular Boss and Scheicher (2002) and Jong and Driessen (2006) confirm their findings from the EU debt market with similar results from the US markets.

the variation of high-frequency stock returns and find that this can account for both short-term movements and long-term trends in credit spreads on investment-grade bonds.

Hibbert, Pavlova, Dandapani and Barber (2009) use a sample of investment-grade and high-yield bonds to examine changes in credit spreads in the US corporate bond market. The authors specify a regression on daily data and argue that systematic bond and equity market factors as well as idiosyncratic equity market factors drive daily variations in credit spreads. In particular the authors find a positive relationship between equity volatility and changes in the credit spread of investment-grade bonds. This relationship is even stronger for high-yield bonds. The authors argue further that decreasing company returns and increasing stock volatility translate into an increase in credit spreads that is larger than what is captured by the traditional credit models. Moreover, the authors find that there exists "an almost contemporaneous inverse relationship between changes in the bond yield spread and the stock return of the issuing firm" (Hibbert, Pavlova, Dandapani and Barber, 2009, p. 1). This has important implications for risk management and asset allocation decisions.

Findings from structural models

The first version of the structural credit risk model, often referred to as the Merton model or asset-value model, was put forward by Merton (1974), who applied the option-pricing theory developed by Black and Scholes (1973) to the modelling of a firm's value. Structural models price debt and equity as contingent claims on firm value and use the evolution of these structural variables to determine the point of default.

Structural models offer an economically intuitive framework for credit risk pricing and have been widely used to analyze corporate bond spreads. Within the framework of the structural model, Huang and Huang (2003) find that credit risk accounts for a smaller portion of the credit spread for investment-grade than for non-investment-grade bonds.

Delianedis and Geske (2001) estimate a structural model in order to assess the spreads for a sample of US corporate bonds for the period 1991-1998. Factors such as default and recovery risk have little explanatory power, while a sizeable unidentified residual together with tax and liquidity effects can account for the majority of credit spreads in their model. The authors make the observation that residual spreads are larger and more volatile for lower-rated corporate bonds. Finally, Delianedis and Geske analyse the characteristics of their residual, and find that this is mainly driven by systematic market risk factors such as equity risk. Amato and Remolona (2003) also find a sizeable portion of credit spreads that cannot be explained within their framework. They claim that this residual should be interpreted as compensation for the risk of unexpected losses which are difficult to diversify away due to significantly negative skewness.

Tang and Yan (2006) study a structural model that incorporates macroeconomic dynamics. Within this framework, consistent asset prices result from an equilibrium that jointly determines the market price of risk and the risk-free rate. The findings of Tang and Yan (2006) suggest that macro factors can account for most of the level and variation in credit spreads over time. The authors conclude that they have managed to find the factors that can account for the sizeable unidentified residual observed by, among others, Collin-Dufresne, Goldstein and Martin (2001).

Chen, Collin-Dufresne and Goldstein (2009) further break the credit spread puzzle into two puzzles: the credit spread level puzzle and the credit spread time-variation puzzle. This refers to the observation that structural models not only fail to generate the average level, but also the volatility, in particular the high degree of default clustering that occurs during recessions.

Recent structural models, like Chen, Collin-Dufresne and Goldstein (2009), argue that credit spreads can be accounted for by extending the standard models, such as the Merton model, along the same dimensions that have previously been used to account for the equity premium puzzle. This is a particularly interesting and relevant question since it might shed some light on the issue of whether credit risk and equity risk are two distinctly different risk factors or whether they are rather two different manifestations of the same fundamental risk factor.

The equity premium puzzle[3] is another well-known puzzle in financial economics which has received much attention during the last couple of decades. Since the puzzle was first stated by Mehra and Prescott (1985), a lot of progress has been made in exploring the puzzle and indentifying the dimensions along which structural models must be extended in order to resolve it.

[3] The equity premium puzzle is based on comparison of time series for aggregate consumption and equity returns. In order to reconcile these two series and account for why individuals on the margin will be indifferent between their observed consumption process and a consumption process with higher growth and higher variance resulting in a higher equity share, their aversion to consumption fluctuations must be implausibly high.

One critical assumption in the Merton framework is the assumption of constant reward-to-volatility ratios[4]. As noted by Mehra and Prescott, the equity premium puzzle refers to the difficulty of reconciling the smooth, low-growth consumption series with the more volatile, high-growth equity series, and not the equity premium as such. Thus, the equity premium puzzle results from the fact that the standard model gives, via the consumption series, a constant and (too) low reward-to-volatility ratio (Hansen and Jagannathan, 1991).

Hansen and Jagannathan developed a measure to evaluate whether an asset-pricing model can account for observed financial time series. A necessary requirement for passing this measure is that a model-generated reward-to-volatility ratio is greater than a certain lower bound defined by movements of observed time series. The Hansen and Jagannathan bound gives an alternative representation of the equity premium puzzle. It highlights the fact that the standard model from which the equity premium puzzle was defined gives an almost constant and (too) low reward-to-volatility ratio. Hence, in order to account for observed asset-price movement, including the equity premium puzzle, the model's market prices of risks (discount factor) must be highly volatile. The Hansen and Jagannathan bound evaluates whether a model meets this requirement, or, more specifically, whether the reward-to-volatility ratios generated by the model are large and volatile enough. Two widely cited papers on resolving the equity premium puzzle are Campbell and Cochrane (1999) and Bansal and Yaron (2004). Both methods are based on raising the reward-to-volatility ratio of market prices of risks, satisfying the Hansen-Jagannathan bound.

Employing the same extensions, Chen, Collin-Dufresne and Goldstein (2009) explore to what extent these structural models can also account for the credit spread premium. Their paper is motivated by the fact that at the core of both the equity premium puzzle and the credit spread puzzle are the stochastic properties of the reward-to-volatility ratio. Their logic states that if structural models incorporate strongly time-varying reward-to-volatility ratios (risk premium per unit of risk), and take into account the greater likelihood of default during recessions, they can capture both the level and time-variation of historical spreads.

[4] The reward-to-volatility ratio, also called the Sharpe ratio, is a measure of a risk premium relative to an actual degree of risk, where risk is represented by the standard deviation of the asset return.

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Decomposing credit spreads

In another section, we have shown that investors historically have been compensated for adding credit risk to their portfolios. We have also shown that the compensation from investing in corporate bonds has varied significantly over time and been driven by different factors. In this section, we take a closer look at two different approaches to how the historical credit spread of various corporate bonds can be decomposed into various components and how these components have varied over time.

Main findings

- For an investor with no immediate liquidity needs, investment in corporate bonds may be one of many possible ways to access the liquidity premium.

- Both approaches to decomposing credit spreads discussed below show that compensation for adding liquidity risk through investment in corporate bonds has varied significantly over time. This implies that a dynamic approach to investing in corporate bonds, i.e. increasing exposure to the asset class when compensation for adding liquidity risk is historically high and decreasing it when it is low, may yield a better return-to-risk trade-off than a constant weight.

Structural approach

Webber and Churm (2007) at the Bank of England apply an extension of the so-called structural approach to credit risk pioneered by Merton (1974) to decompose spreads into credit-related and non-credit-related factors. In simplified terms, the structural approach uses the market value and volatility of a firm’s equity to infer the probability of corporate default. This default probability determines the credit-related compensation, which then can be further broken down into compensation for *expected* default loss on the one hand and compensation for the *uncertainty* about default losses (i.e. unexpected losses) on the other.

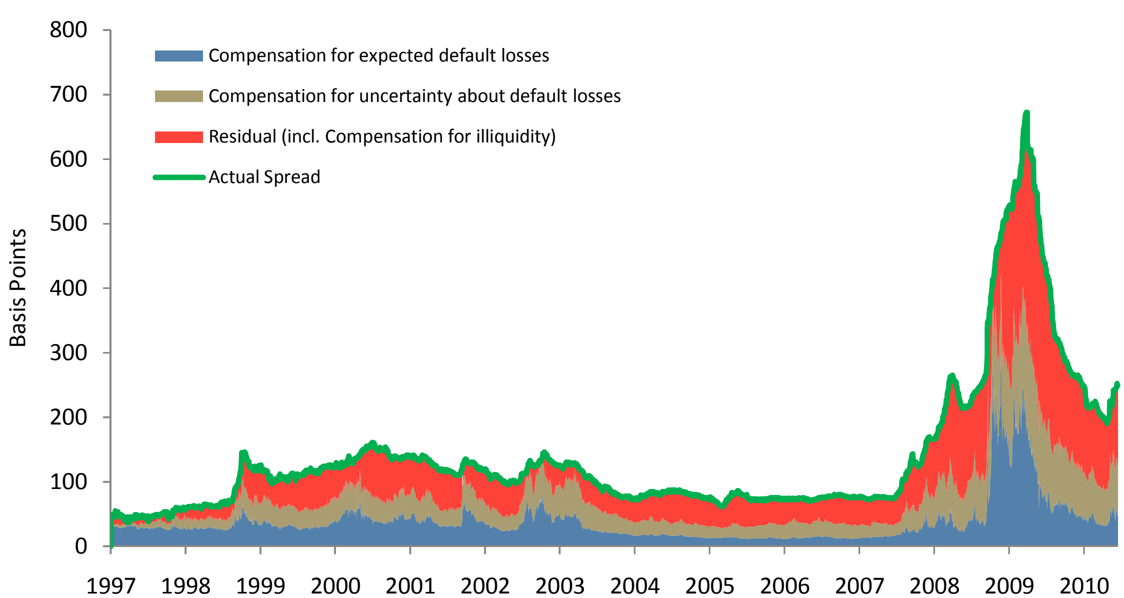
In addition, corporate bond spreads may also contain compensation for a number of non-credit factors, including illiquidity. In Webber and Churm's framework, the non-credit component is simply the difference between the observed spread and the sum of the credit-related components. Note that in this approach the compensation for taking on liquidity risk associated with investments will be part of the residual and not estimated directly.

In the upper panel of

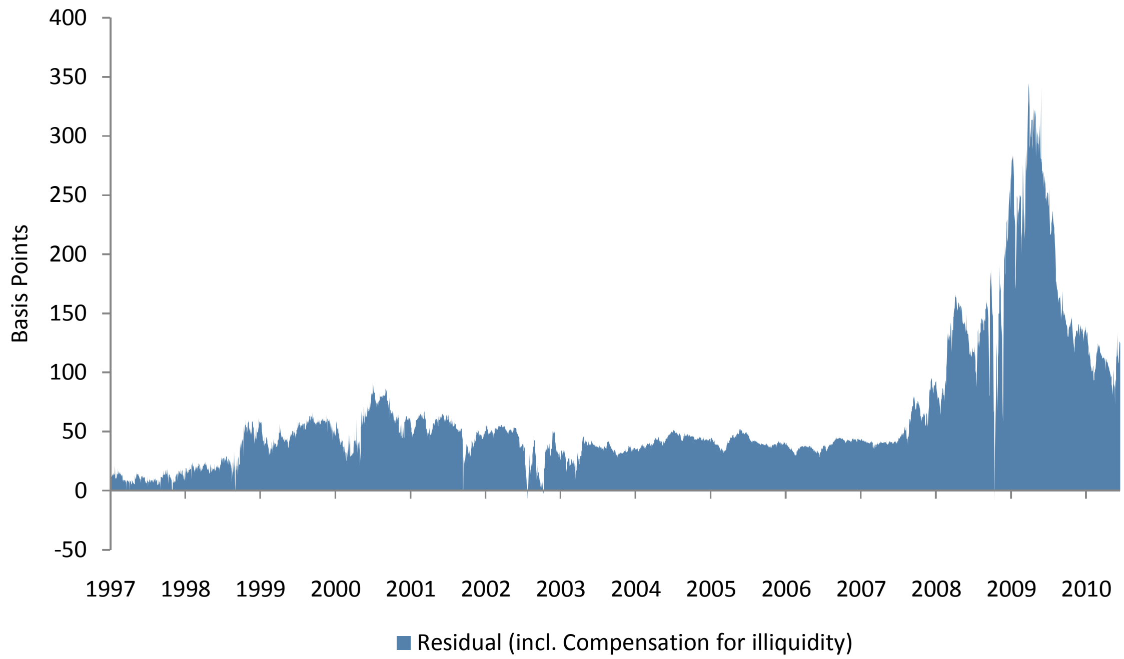
Figure 1, we show their decomposition of the spread over government bonds of the Sterling Corporate Bond Index as supplied by Bank of America Merrill Lynch into the three aforementioned components: (1) expected loss compensation, (2) loss uncertainty compensation, and (3) the residual, which can be assumed to contain compensation for illiquidity.

The lower panel of the figure depicts the residual only. Having been well below 100 basis points between 1997 and mid-2007, the non-credit related component rose sharply during the financial crisis and reached a peak of over 300 basis points in the spring of 2009 before moving back towards 100 basis points more recently. While the credit-related components also increased during the crisis, it is the large time variation in the residual that is of particular interest for a long-term investor.

Figure 1: Decomposition of sterling-denominated investment-grade corporate bond spreads



Source: Bank of England



Source: Bank of England

Direct liquidity cost approach

Another approach is to try to decompose the credit spread based on prices in the derivative markets and transaction costs.

In its report *Decomposing Credit Spreads*[1], Barclays Capital splits a bond's spread over government bonds with the same maturity into compensation for expected liquidity cost, expected losses from defaults and a market-wide risk premium. Expected losses from defaults are measured using a bond's credit default swap (CDS). The bond's expected liquidity cost is measured using the bond's liquidity cost score (LCS). The liquidity cost score measures the cost (in basis points) of immediately executing a roundtrip transaction for a standard institutional trade.

Using a monthly cross-sectional regression, Barclays Capital takes the OAS (option adjusted spread) for a number of bonds and regresses them on their CDS and LCS values, as well as a

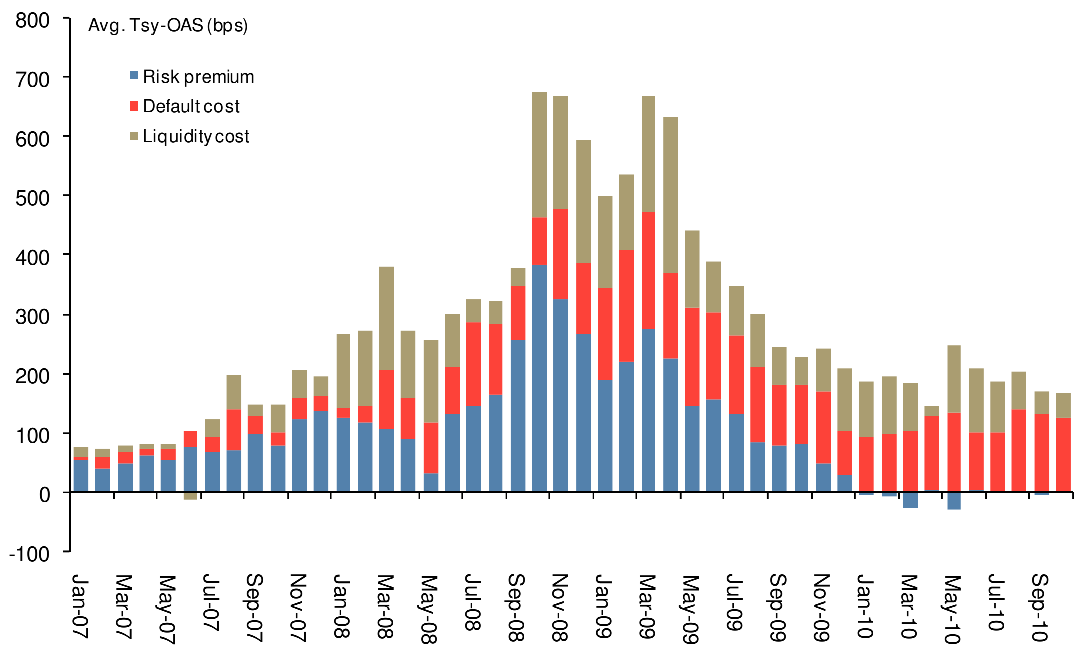
[1] Phelps and Dastidar, Decomposing Credit Spreads, Barclays Capital Quantitative Portfolio Strategy, 8 July 2010

constant term to represent the market-wide risk premium (see Equation 1). This premium is common to all bonds.

$$OAS_{it} = \alpha_t + \beta_t CDS_{it} + \gamma_t LCS_{it} + \eta_{it} \tag{1}$$

The estimated regression coefficients in each month can be used to derive contributions to the OAS spread that are due to liquidity cost, default cost and the market-wide risk premium respectively (see Figure 2).

Figure 2: Decomposition of credit spreads



Source: Barclays Capital

We see from the chart that in November 2008, for example, the average OAS for the approximately 100 or so investment-grade bonds in this sample was 6.7 percent, of which 1.9 percentage points can be attributed to liquidity and 1.5 percentage points to default costs as measured by the CDS. The residual of 3.25 percentage points is attributed to an overall market risk premium unrelated to factors specific to individual bonds.

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Chapter 3

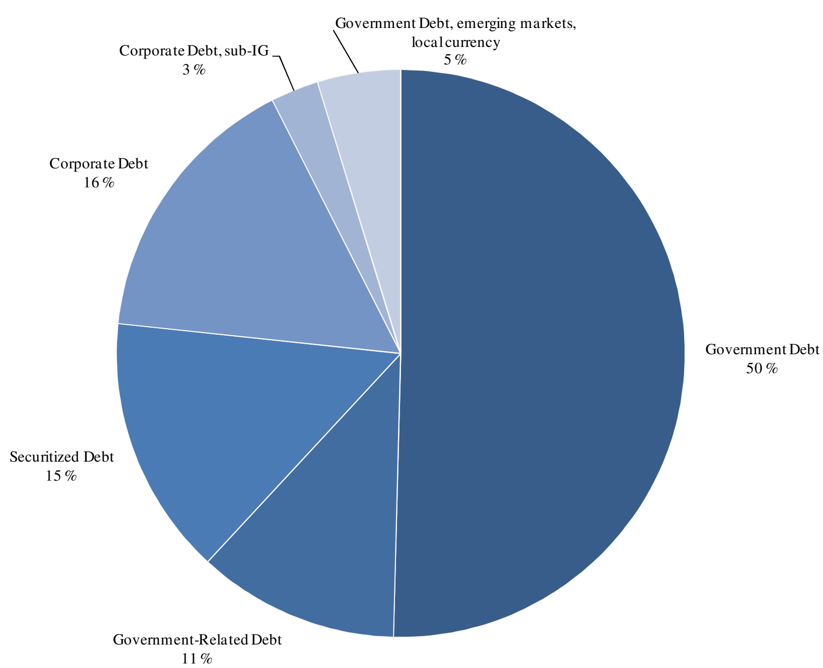
The fixed-income market

Investment opportunities in fixed income

This section presents the investment opportunities for a global fixed-income investor. The market for nominal bond investments makes up approximately 40,000 billion dollars based on numbers from Barclays and Bloomberg. The distribution between major segments is shown in the figure below. A more detailed overview can be found at the end of this section. Note that the figure and projections of market size do not include private placements, bank loans or derivatives.

The dominant segment is government bonds in developed markets, which makes up about half the market. Close to 95 percent of this segment are issued in the JPY, USD, Euro and GBP, while other developed markets make up the remaining 5 percent. Emerging market government bonds issued in local currencies make up about 5 percent of the market for nominal bonds as shown in the figure below.

Figure 1: Investment opportunities in nominal bonds (as of September 2010)

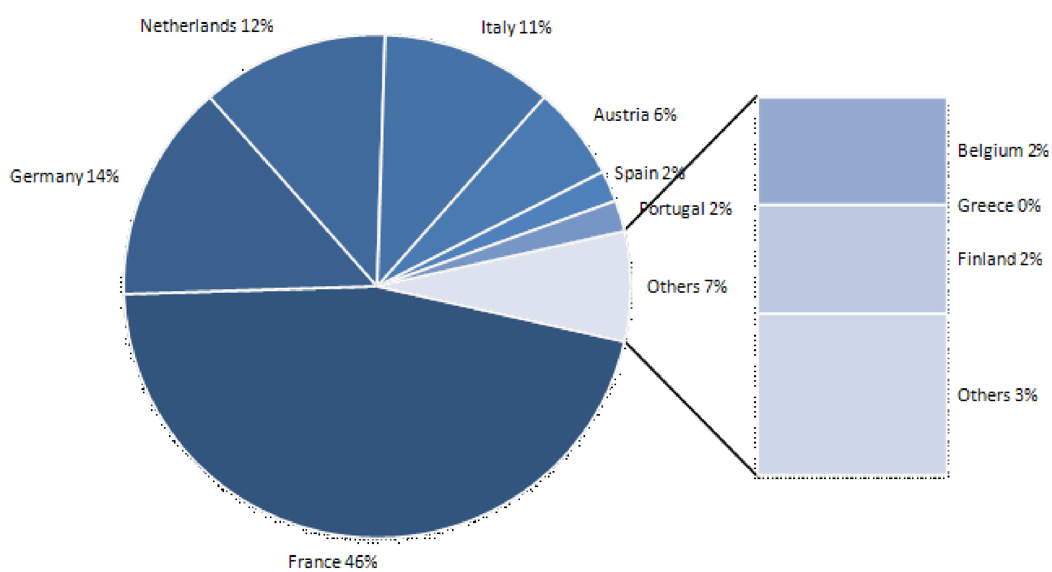


Source: Barclays Capital and Bloomberg

The government-related segment includes bonds issued by multilateral organisations, local authorities, companies/institutions in which governments have a dominant ownership share and government bonds issued in foreign currencies. Government-related bonds are issued by a wide range of institutions, ranging from the World Bank (IBRD) to Electricité de France (EDF).

The US market is the largest, most liquid and well-functioning market for corporate bonds. The European market for corporate bonds is growing. However, as shown in figure 2, there are significant differences between the various euro member states. The size of the corporate bond market in respective countries does not reflect the country's relative size of GDP. The market for corporate bonds with higher credit risk ("high-yield bonds") constitutes a relatively small fraction of the overall market and is dominated by bonds issued in USD.

Figure 2: Total euro zone corporate bond market



Source: GaveKal

Securitised debt makes up a significant part of the investment opportunities within the fixed-income market and is about the same size as the market for corporate bonds. Such bonds are mainly issued by financial institutions and with a pool of underlying loans as collateral. In the

United States the market for securitised debt is almost equal in size to that of government bonds. The market for securitised debt is large in several European countries, but still relatively small compared to the market for government bonds in the respective countries. The European market for securitised debt consists almost exclusively of so-called covered bonds.

Emerging market government bonds issued in local currencies make up about 5 percent of the market. This market has emerged as a new and growing segment over the past few years. Table 1 displays a more detailed composition of this particular market segment as of September 2010.

Table 1: Barclays Capital emerging markets local currency government universal index

Currency	USD billion
China	444.0
India	359.2
Korea	319.9
Brazil	118.1
Poland	102.8
Mexico	92.9
Malaysia	77.5
South Africa	58.3
Thailand	55.2
Turkey	52.3
Russia	49.4
Indonesia	40.8
Czech Republic	39.5
Israel	35.2
Colombia	35
Hungary	29.8
Egypt	21
Philippines	20.3
Peru	7.5
Chile	3.9
Croatia	3.5
Argentina	0.4
TOTAL	**1,966**

Source: Barclays Capital

Table 2 gives a more detailed overview of the opportunities available in the developed markets. This table also includes index-linked bonds. Note that these numbers do not represent the total size of the investment universe, but rather market-cap of different segments within the benchmark.

Table 2: Size of debt markets, billions of US dollars, nominal (September 2010)

Type of rates	Type of debt	CCY		Fixed Cpn >1y	Floating Cpn	Sub 1y	Sub-IG	Sum
Real rates	Government debt	USD		495	-	31	-	526
		EUR		320	-	38	21	378
		JPY		63	-	-	-	63
		GBP		219	-	7	-	226
		CAD		28	-	-	-	28
		SEK		24	-	-	-	24
		DKK		-	-	-	-	-
		CHF		-	-	-	-	-
		AUD		10	-	-	-	10
		NZD		1	-	-	-	1
		SGD		-	-	-	-	-
			SUM	1,159	-	76	21	1,256
	Non-government debt	USD		-	-	-	-	-
		EUR		14	-	3	-	17
		JPY		-	-	-	-	-
		GBP		44	-	-	-	44
			SUM	57	-	3	-	61
Nominal rates	Government debt	USD		4,845	-	614	162	5,621
		EUR		4,835	230	511	396	5,972
		JPY		5,802	590	954	4	7,350
		GBP		1,122	-	51	0	1,173
		CAD		308	-	29	-	337
		SEK		67	-	8	-	75
		DKK		93	-	7	-	99
		CHF		84	-	8	1	93
		AUD		103	-	10	-	113
		NZD		27	-	-	-	27
		SGD		44	-	9	-	53
			SUM	17,330	820	2,200	563	20,914
	Government-related debt	USD		1,841	300	371	5	2,517
		EUR		1,249	51	62	1	1,363
		JPY		677	4	5	-	686
		GBP		190	2	2	-	194
			SUM	3,957	357	441	5	4,760
	Securitised debt	USD	AGENCY MBS	4,547				
			COVERED	40				
			OTHER (ABS/CMBS)	346				
			Grand Total	4,933			79	5,012
		EUR	AGENCY MBS	-				
			COVERED	1,049				
			OTHER (ABS/CMBS)	14				
			Grand Total	1,063				1,063
		JPY	AGENCY MBS	-				
			COVERED	5				
			OTHER (ABS/CMBS)	2				
			Grand Total	7				7
		GBP	AGENCY MBS	-				
			COVERED	5				
			OTHER (ABS/CMBS)	52				
			Grand Total	57				57
			SUM	6,060				6,139
	Corporate debt	USD		2,803	252	204	891	4,150
		EUR		1,539	595	253	195	2,582
		JPY		353	90	15	-	459
		GBP		385	61	30	44	520
			SUM	5,080	998	502	1,130	7,710
Sum				**33,644**	**2,175**	**3,223**	**1,720**	**40,841**

Source: Barclays Capital and Bloomberg

Corporate bonds

In this section, we investigate the role corporate bonds play in a diversified portfolio. Our analysis is primarily focused on investment-grade corporate bonds. The role of high-yield bonds is briefly discussed towards the end of the section.

Main findings

- We find that investors have historically been compensated for investing in corporate bonds even when the return series are adjusted for losses in the case of default. Our findings are in line with what the academic literature describes as the credit-spread puzzle.

- The spread between five-year US Treasuries and BBB corporate bonds averaged 2.03 percent in the period between April 1953 and July 2010. The spread has fluctuated significantly over time, with variations within an interval of approx. 0-7 percent.

- The introduction of corporate bonds into a portfolio with a fixed 60 percent allocation to equities has historically added to returns, increased risk as measured by standard deviation, and improved the portfolio Sharpe ratio somewhat at the cost of an increased skew.

- Corporate bonds have added value in a portfolio context as measured by the Sharpe ratio when introduced during stages of expansion, and reduced value when introduced during periods of contraction.

- The returns on credit spreads have been positively correlated to the returns in the equity market, albeit the correlation has not been constant over time. Credit spreads tend to widen in periods with sharp declines in stock markets. During periods with rapidly rising stock markets, the relationship between credit spreads and the stock market is less clear, suggesting one-sided tail dependency.

- Credit spreads tend to widen when interest rates decline. The relationship is however not linear.

- Government bonds seem to be an effective hedge in periods with sharp declines in the stock markets, as interest rates tend to decline when stock markets fall sharply. The relationship between bond yields and stock markets in strong bull markets is less clear.

- We find that the introduction of high-yield bonds into a diversified portfolio with a fixed allocation to equities changes the portfolio characteristics. The only period where an allocation to high yield seems to have added value and improved overall portfolio characteristics has been during periods of early expansion. This warrants an opportunistic approach to high-yield investments.

- Our Monte Carlo simulations support the main conclusions from our empirical study on the role of corporate bonds in a portfolio with a fixed allocation to equities. The simulations are, however, not able to capture the trending characteristics of interest rates.

- We find both that the standard deviation of returns on government bonds historically has been highly dependent on the level of interest rates, and that the relationship between the rate level and standard deviation appears to have been linear. An investor should be cautious when interpreting a low standard deviation around the absolute rate level as a signal of low risk. An alternative approach could be to measure the standard deviation of percentage changes in the rate level.

- The ratio of credit spread to the level of yield on government bonds affects the portfolio characteristics of a corporate bond. As the ratio increases (typically at low levels of Treasury yields), credit spread volatility dominates. Moreover, corporate bonds will have more favourable portfolio characteristics when this ratio is at high levels.

Investment-grade bonds

Our data sample

In order to assess the role of corporate bonds in a diversified portfolio, it is essential to use a data sample that spans several business and credit cycles. The US market is the most mature market for non-government bonds and the only market where we can obtain consistent, high-quality data for a sufficiently long period. Our analysis is based on three monthly time series from the Federal Reserve Economic Data (FRED) database of the Federal Reserve Bank of St. Louis for the period 01.04.1953 to 01.07.2010:

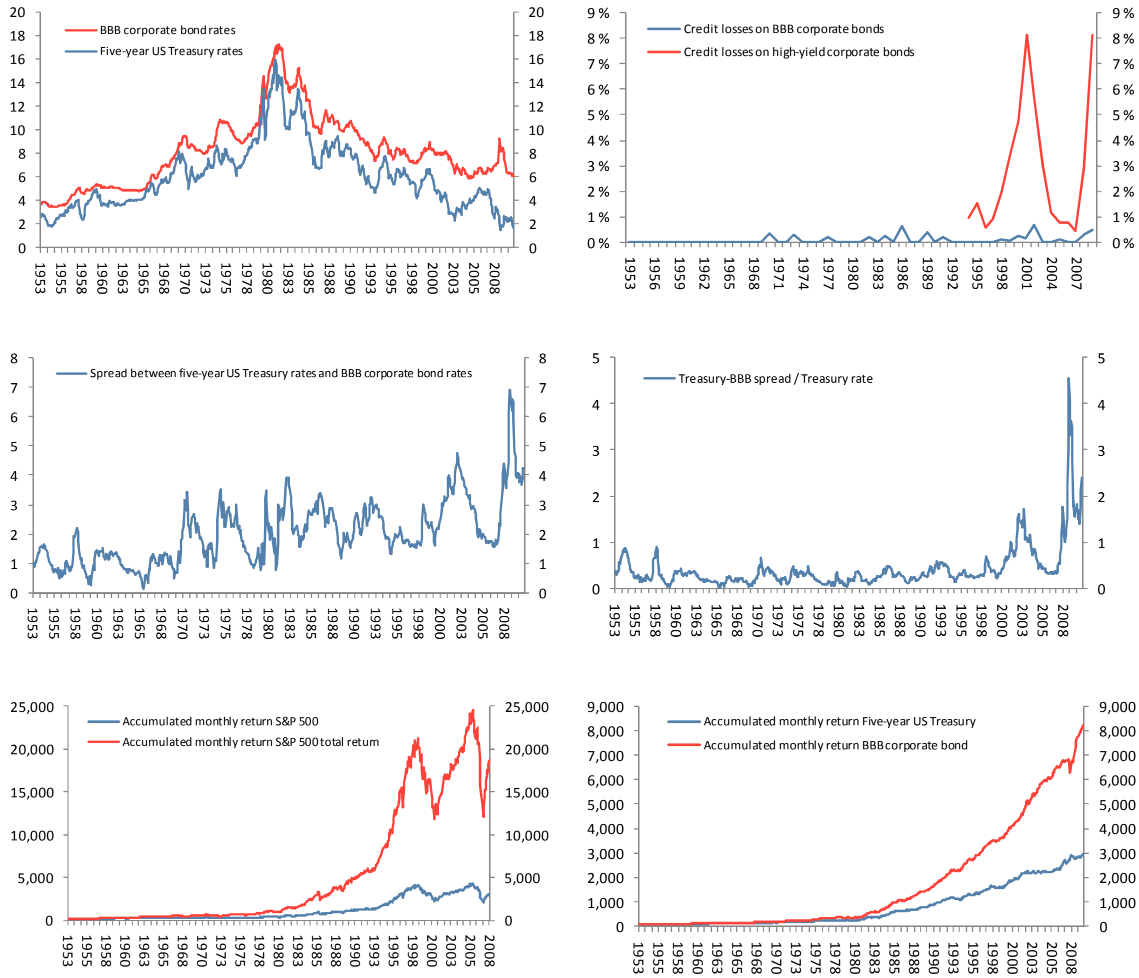
- Five-year US Treasury rates
- BBB corporate bond rates
- S&P 500 stock index
- 3-month US Treasury rates

These time series are publicly available at http://research.stlouisfed.org/fred2/.

We have also used times series from Bloomberg and Moody’s in order to capture losses in the case of default and dividend payments on the S&P 500.

Our approach has certain limitations in that we exclusively use data from the US and focus on BBB-rated bonds, which are more risky than our benchmark.

Figure 1: Graphical representation of raw data



Source: NBIM calculations, Bloomberg, Federal Reserve Bank of St. Louis, Moody's

Calculations of historical returns

Our raw data have been transformed into return series. As the raw data are in the form of rate levels, the data have to be transformed into time series of returns. The monthly returns for government bonds and credit spread are calculated according to the following two formulas:

$$Return_{gov,t} = -\left[\frac{rate\ level_t - \ rate\ level_{t-1}}{rate\ level_{t-1}} \times duration\ \times rate\ level_{BP}\right] + \left[\frac{rate\ level_{BP}}{12}\right]$$

$$Return_{cred,t} = return_{gov,t} - \left[\frac{spread\ level_t - \ spread\ level_{t-1}}{spread\ level_{t-1}} \times duration\ \times spread\ level\ _{BP}\right] + \left[\frac{spread\ level_{BP}}{12}\right] - \ credit\ loss_t$$

Where:

$Return_{gov,t}$ is the total return for five-year Treasuries during month 't'

$rate\ level_t$ is the Treasury rate level recorded for month 't'

$rate\ level_{t-1}$ is the Treasury rate level recorded for month 't-1'

$rate\ level_{BP}$ is the Treasury rate level for the "base period"*

$Return_{cred,t}$ is the total return for BBB-rated corporate bonds during month 't'

$spread\ level_t$ is the BBB corporate bond to Treasury spread recorded for month 't'

$spread\ level_{t-1}$ is the BBB corporate bond to Treasury spread recorded for month 't-1'

$spread\ level\ _{BP}$ is the BBB corporate bond to Treasury spread for the base period*

$duration$ is the duration for both Treasuries and BBB corporate bonds, which is set to 5

$credit\ loss_t$ is the credit loss on BBB corporate bonds incurred during month 't'

* For the purposes of historical data analysis, this is identical with $rate\ level_{t-1}$. For the Monte Carlo simulations, we use different assumptions for the base period rate level, and these levels are drawn on a twelve-month basis.

Both these return calculations take into account duration and carry, represented by the two brackets in both formulas respectively. Duration is a measure of the price sensitivity of a bond to interest rate movements.[1] Carry represents the return an investor makes from just holding the position, regardless of changes in market rates.

The monthly S&P 500 returns are given by the following formula:

$$return_{equity,t} = \frac{index\ level_t - \ index\ level_{t-1}}{index\ level_{t-1}} + dividend_t$$

Where:

$return_{equity,t}$ is the total return on the S&P 500 index during month 't'

$index\ level_t$ is the index level of the S&P 500 recorded for month 't'

$index\ level_{t-1}$ is the index level of the S&P 500 recorded for month 't-1'

$dividend_t$ is the dividend for the S&P 500 index recorded for month 't'

By calculating our own return series, we obtain a constant duration for the bond portfolios. Further, the return data for BBB bonds have been adjusted for losses in the case of default in this particular segment of the bond market, and the S&P data have been adjusted to include dividends.

In the table below, we have listed the annualised mean, standard deviation, Sharpe ratio and skew for the return on the S&P 500 (equity), the credit spread[2] and Treasuries (five-year US Treasury debt) over the full sample as well as during various stages of the business cycle[3] and

[1] Numerically described by the following relationship: % Price Change = -1 * Duration * Yield Change

[2] We define the credit spread as the difference in yield between the BBB corporate bonds and five-year US Treasuries used in this analysis. The total return on corporate bonds will equal the sum of Treasury and Credit.

[3] To analyse performance during various stages of the business cycle, we have divided the sample into "early expansion", "mature expansion" and "recession", based on the National Bureau of Economic Research (NBER) classification scheme. The full classification scheme is publicly available at http://www.nber.org/cycles/cyclesmain.

two distinct interest rate regimes. 1982 marks a shift in what had until then been a market with upward-trending interest rates. While rising interest rates provided a tailwind for bond returns up until 1982, returns have faced a headwind from the downward trend in interest rates ever since. Our sample has therefore been split into two sub-samples. As shown in the chart, investors have historically been compensated for investments in corporate bonds.

Table 1: Historical risk and return data (annualised data)[4]

	1954 - 2010			1954 - 1982			1982 - 2010		
	Equity	Treasury	Credit	Equity	Treasury	Credit	Equity	Treasury	Credit
	Full sample			Full sample			Full sample		
Mean	11.79 %	6.32 %	1.76 %	11.07 %	3.73 %	1.24 %	12.50 %	8.98 %	2.29 %
St. Dev.	14.76 %	5.80 %	4.16 %	14.02 %	5.98 %	4.36 %	15.48 %	5.52 %	3.94 %
Skew	-0.43	0.86	-0.99	-0.05	1.25	-0.98	-0.72	0.48	-0.99
Sharpe Ratio	0.43	0.20	0.42	0.40	-0.23	0.28	0.46	0.70	0.58
	Early expansion			Early expansion			Early expansion		
Mean	16.91 %	6.15 %	3.92 %	18.87 %	2.84 %	3.97 %	15.13 %	9.31 %	3.86 %
St. Dev.	12.49 %	4.95 %	3.18 %	12.52 %	3.97 %	3.23 %	12.49 %	5.59 %	3.15 %
Skew	-0.02	0.14	0.29	0.16	-0.29	0.39	-0.19	0.05	0.19
Sharpe Ratio	0.97	0.37	1.23	1.15	-0.24	1.23	0.81	0.82	1.23
	Mature expansion			Mature expansion			Mature expansion		
Mean	10.04 %	3.49 %	5.38 %	5.22 %	0.30 %	2.29 %	14.89 %	6.64 %	8.43 %
St. Dev.	14.40 %	4.82 %	3.07 %	12.79 %	4.91 %	2.72 %	15.75 %	4.58 %	3.17 %
Skew	-0.77	-0.77	-0.60	-0.32	-1.53	-2.39	-1.08	0.12	0.15
Sharpe Ratio	0.28	-0.45	1.75	-0.06	-1.08	0.84	0.57	0.24	2.66
	Recession			Recession			Recession		
Mean	3.26 %	14.69 %	-3.94 %	7.73 %	14.06 %	-6.34 %	-2.54 %	15.56 %	-0.59 %
St. Dev.	20.15 %	8.94 %	7.16 %	18.78 %	9.93 %	6.88 %	21.99 %	7.49 %	7.48 %
Skew	-0.10	1.24	-0.67	0.09	1.35	-0.69	-0.20	0.89	-0.75
Sharpe Ratio	-0.11	1.00	-0.55	0.07	0.76	-0.92	-0.33	1.45	-0.08

Source: NBIM calculations, Bloomberg, Federal Reserve Bank of St. Louis, Moody's

Asset class correlations and tail dependency

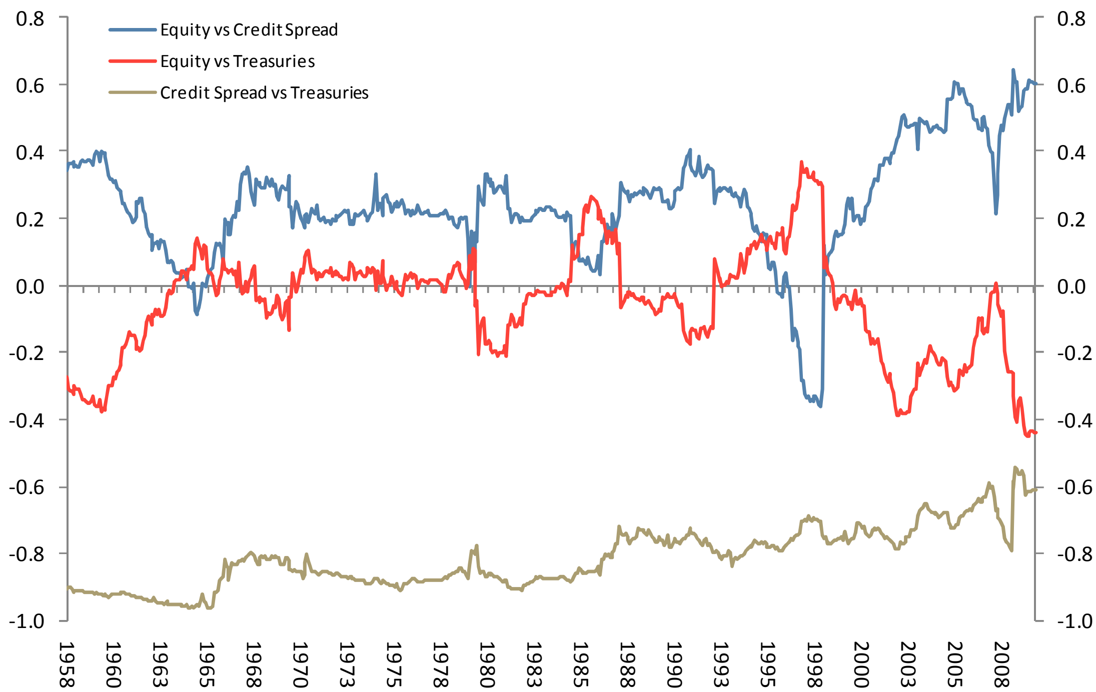
Below, we take a closer look at some key characteristics of the data in our sample in order to identify possible properties that are not well captured by our analysis above of historical average returns and standard deviations of the respective time series.

Uncorrelated assets can be expected to improve the overall risk/return profile of the portfolio through diversification. We have studied the rolling five-year monthly correlation between

[4] Note that the table above displays the total return for the S&P 500 and five-year Treasuries, while the credit column displays the return on the credit spread as such (rather than the total return on BBB corporate bonds). Thus, while the Sharpe ratio for the two total return series is calculated as excess return (using three-month Treasuries) over standard deviation, the Sharpe ratio for the spread is calculated as the return on the credit spread over standard deviation.

return series for equities and Treasuries, equities and the credit spread, and Treasuries and the credit spread in Figure 2 below.

Figure 2: Rolling five-year correlations (monthly data)



Source: NBIM calculations, Bloomberg, Federal Reserve Bank of St. Louis, Moody's

We find that the credit spread has been positively correlated to the return on equities throughout most of the sample, albeit with significant variations over time. The correlation between Treasuries and the credit spread is negative, as credit spreads tend to widen when interest rates decline.

Tail dependency is another cross-asset class property that is of interest. It describes the probability that one asset class will experience an extreme monthly return (a tail event) given that another asset class has registered a similarly extreme outcome. In particular, investors are wary of two asset classes simultaneously experiencing negative tail returns.

In order to identify possible tail dependency, we have also examined the relationship between percentage changes in government bond yields and credit spreads during periods with sharp movements in stock market returns, defined as a +/- 10 percent move on a monthly basis. The results of our analysis are summarised in Table 2 below.

Table 2: Historical equity returns and yield changes from whenever the S&P 500 has moved more than 10 percent in absolute value in one month

S&P500 down 10% or more in a month			
Date	S&P500 monthly change	Treasury yield monthly change	Credit spread monthly change
Nov 1973	-11.09 %	-1.73 %	12.00 %
Sep 1974	-11.52 %	-4.78 %	38.67 %
Oct 1987	-21.54 %	-8.04 %	13.39 %
Aug 1998	-14.44 %	-12.33 %	32.09 %
Sep 2002	-10.86 %	0.34 %	7.17 %
Oct 2008	-16.79 %	-16.12 %	12.52 %
Feb 2009	-10.61 %	-2.67 %	6.28 %

S&P500 up 10% or more in a month			
Date	S&P500 monthly change	Treasury yield monthly change	Credit spread monthly change
Nov 1962	10.16 %	-1.11 %	0.00 %
Oct 1974	16.81 %	-3.64 %	16.33 %
Jan 1975	12.72 %	-4.05 %	4.12 %
Jan 1976	12.17 %	-0.13 %	-5.42 %
Nov 1980	10.65 %	3.27 %	4.42 %
Aug 1982	12.14 %	-5.77 %	1.81 %
Oct 1982	11.51 %	-3.89 %	-0.25 %
Aug 1984	11.04 %	-1.18 %	-6.67 %
Jan 1987	13.47 %	2.26 %	-7.14 %
Dec 1991	11.42 %	0.81 %	-5.86 %

Source: NBIM calculations, Bloomberg, Federal Reserve Bank of St. Louis, Moody's

We find that government bonds seem to be an effective hedge in a typical bear market when stock markets fall significantly as rates tend to decline. Perhaps more surprisingly we also find that interest rates declined in seven of the ten months where the S&P 500 rose more than 10 percent. The declines in interest rates during bull markets were, however, significantly smaller than registered during months with sharp falls in the equity market.

Furthermore, our analysis shows that credit spreads widened in all months where the S&P 500 declined more than 10 percent, while the pattern appears less clear in bull markets. Credit spreads widened in four of these months and narrowed in five months. One possible conclusion is that there seems to be evidence of strong tail dependence between equity returns and the credit spread, but only during periods with declining stock markets.

Historical portfolio backtest

Here, we analyse how portfolios with different combinations of our three assets have performed historically in order to identify the role of corporate bonds in a total portfolio context. We keep our allocation to equities fixed at 60 percent and study how the average annual return and standard deviation of a portfolio changes when Treasuries are gradually replaced with corporate bonds. As previously done, we have split the sample into two different interest rate regimes and looked at performance during various stages of the business cycle.

Our analysis of the performance of the same five portfolios over different stages of the business cycle shows a somewhat more varied picture. Historically credit has added value in a portfolio context as measured by return per unit of risk when introduced during stages of expansion, and reduced value when introduced during periods of contraction. Hence, the Sharpe ratio increases when the share of credit in the portfolio is raised during expansions, and decreases with rising a credit share during contractions.

Table 3: Historical risk and return on different portfolios over the whole data sample (1954-2010) (annualised data)

	Full Sample			SUBSAMPLE: 1954 - 1982			SUBSAMPLE: 1982 - 2010		
Portfolio	Mean	St Dev	Skew	Mean	St Dev	Skew	Mean	St Dev	Skew
60% Equity 40% Treasury	9.56 %	9.01 %	-0.16	8.06 %	8.60 %	0.17	11.05 %	9.40 %	-0.43
60% Equity / 10% Credit / 30% Treasury	9.75 %	9.05 %	-0.21	8.19 %	8.59 %	0.11	11.29 %	9.48 %	-0.47
60% Equity / 20% Credit / 20% Treasury	9.94 %	9.12 %	-0.26	8.32 %	8.60 %	0.06	11.54 %	9.58 %	-0.51
60% Equity / 30% Credit / 10% Treasury	10.13 %	9.20 %	-0.31	8.45 %	8.64 %	0.00	11.79 %	9.70 %	-0.55
60% Equity 40% Credit	10.32 %	9.29 %	-0.36	8.58 %	8.70 %	-0.06	12.05 %	9.83 %	-0.60

Source: NBIM calculations, Bloomberg, Federal Reserve Bank of St. Louis, Moody's

Table 4: Historical risk and return on different portfolios across different stages of the business cycle (annualised data)

	Early expansion			Mature expansion			Contraction		
Portfolio	Mean	St Dev	Skew	Mean	St Dev	Skew	Mean	St Dev	Skew
60% Equity 40% Treasury	12.45 %	7.77 %	0.01	7.35 %	8.59 %	-0.46	7.62 %	12.43 %	0.13
60% Equity / 10% Credit / 30% Treasury	12.87 %	7.77 %	0.01	7.55 %	8.63 %	-0.49	7.20 %	12.54 %	0.06
60% Equity / 20% Credit / 20% Treasury	13.30 %	7.78 %	0.01	7.74 %	8.68 %	-0.53	6.78 %	12.68 %	-0.01
60% Equity / 30% Credit / 10% Treasury	13.73 %	7.81 %	0.02	7.94 %	8.74 %	-0.55	6.36 %	12.86 %	-0.08
60% Equity 40% Credit	14.17 %	7.85 %	0.02	8.14 %	8.82 %	-0.58	5.94 %	13.08 %	-0.15

Source: NBIM calculations, Bloomberg, Federal Reserve Bank of St. Louis, Moody's

Table 5: Sharpe Ratio table

Sharpe Ratio Analysis	Full sample	Early expansion	Mature expansion	Contraction	Subsample 1954 - 1982	Subsample 1982 - 2010
Portfolio						
60% Equity 40% Treasury	0.47	1.02	0.18	0.15	0.32	0.62
60% Equity / 10% Credit / 30% Treasury	0.49	1.07	0.20	0.12	0.33	0.64
60% Equity / 20% Credit / 20% Treasury	0.50	1.12	0.22	0.09	0.34	0.65
60% Equity / 30% Credit / 10% Treasury	0.52	1.17	0.24	0.06	0.36	0.67
60% Equity 40% Credit	0.53	1.22	0.26	0.02	0.37	0.69

Source: NBIM calculations, Bloomberg, Federal Reserve Bank of St. Louis, Moody's

Portfolio Monte Carlo simulations

In this section we aim to briefly describe the distribution of the return series for the same set of portfolios investigated earlier. As the historical portfolio backtests are based on a finite data sample, we wish to enhance the distribution analysis with a larger data set, created by employing a Monte Carlo simulation method. The Monte Carlo simulations are based on repeated random draws from the empirical distribution of our raw data and allow us to characterise the entire distribution of portfolio returns with more confidence.[5] Moreover, this method enables us to create a robust data sample free of any significant sample-specific data characteristics from the raw data and describe the portfolios in a more general setting. One example of such a characteristic is the natural drift in our raw data for bond rates. This drift is taken out in order to avoid the effect of the trending in bond rates over the sample period.

Table 6: Mean, standard deviation and percentiles of different portfolio compositions with stochastic rate levels (average annual returns)

Portfolio	min	1	2.5	5	95	97.5	99	max	median	mean	stdev	Sharpe
60% Equity 40% Treasury	-26.9 %	-12.2 %	-8.9 %	-6.2 %	25.8 %	29.4 %	33.6 %	63.6 %	9.1 %	9.4 %	9.8 %	0.45
60% Equity / 10% Credit / 30% Treasury	-26.8 %	-12.4 %	-9.0 %	-6.2 %	26.1 %	29.8 %	34.1 %	63.3 %	9.3 %	9.6 %	9.9 %	0.47
60% Equity / 20% Credit / 20% Treasury	-26.8 %	-12.9 %	-9.0 %	-6.3 %	26.6 %	30.3 %	34.6 %	63.0 %	9.6 %	9.8 %	10.0 %	0.48
60% Equity / 30% Credit / 10% Treasury	-32.2 %	-13.3 %	-9.3 %	-6.5 %	27.2 %	31.0 %	35.2 %	62.7 %	9.8 %	10.1 %	10.3 %	0.49
60% Equity 40% Credit	-39.5 %	-13.6 %	-9.7 %	-6.7 %	27.9 %	31.6 %	36.0 %	62.3 %	10.1 %	10.3 %	10.5 %	0.50

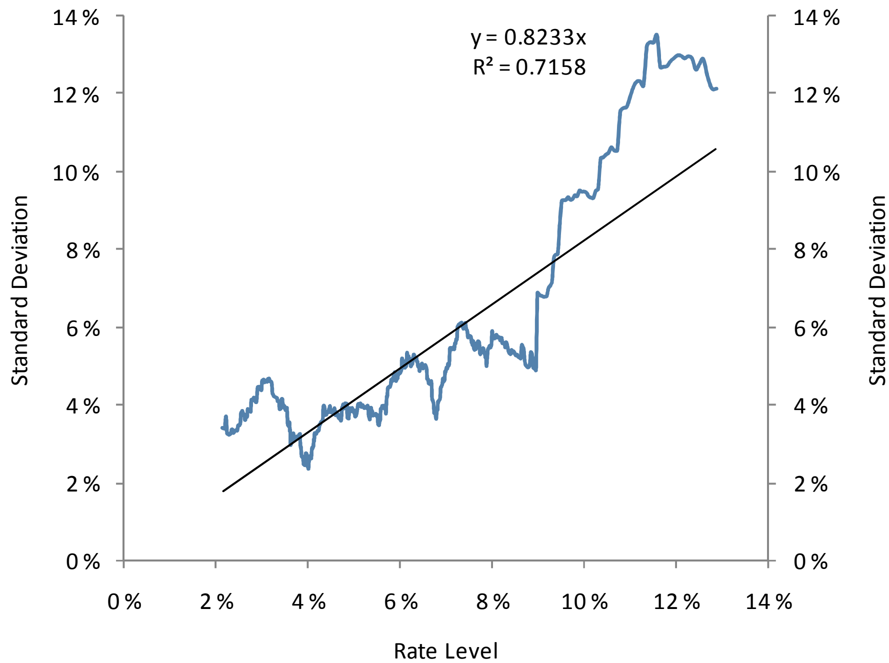
Source: NBIM calculations, Bloomberg, Federal Reserve Bank of St. Louis, Moody's

The ratio of spread to interest rate level and its impact on the portfolio characteristics of corporate bonds

In Table 1, the risk associated with investment in bonds was measured in terms of the standard deviation of the average annualised monthly return. A closer examination of our data sample shows that the standard deviation is highly dependent on the level of interest rates. The historical relationship between standard deviation of government bonds and rate level is illustrated in the chart below. There seems to be a strong linear relationship between these two variables as high levels of interest rates are associated with high standard deviations. However, we believe that investors should be cautious about interpreting a low standard deviation around the absolute rate level as a signal of low risk. An alternative approach could be to measure the standard deviation of percentage changes in the level of rates.

5 By following this approach, we are implicitly assuming that consecutive monthly returns are independent of each other, and thus the simulation will not capture any mean reversion effects and trends that span several months. Time dependencies within each month are however captured. We have also carried out a simulation with annual intervals in an effort to capture trends more accurately. The results are mainly consistent with those of the monthly simulations. However, these results are less robust as the sample size shrinks significantly when using yearly data intervals.

Figure 3: Relationship between rate level and standard deviation

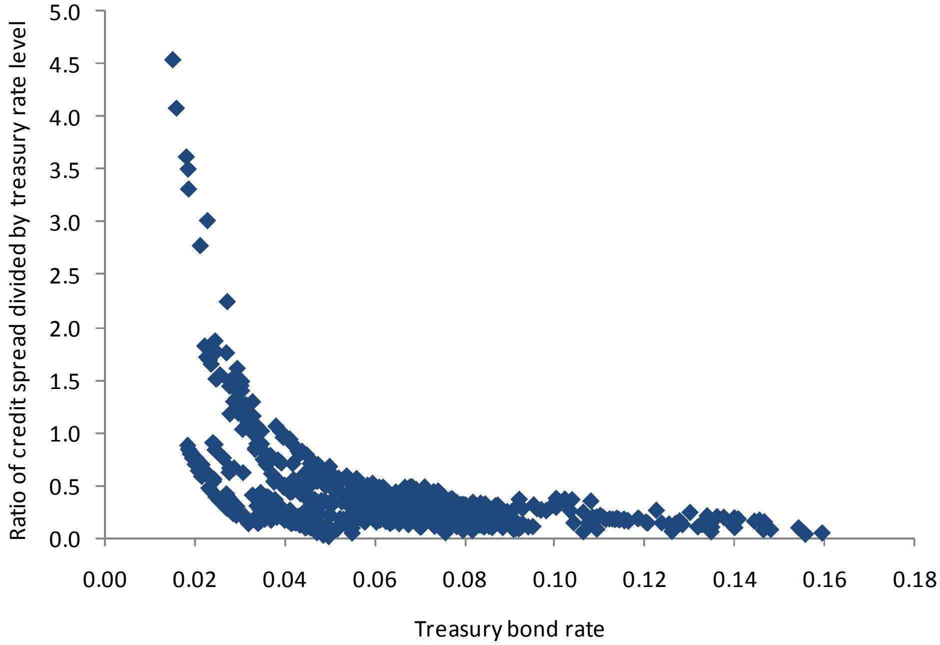


Source: NBIM calculations, Federal Reserve Bank of St. Louis

Corporate bond volatility, defined as the standard deviation of the return on an investment in corporate bonds, depends on both government bond volatility and credit spread volatility. Our empirical study of developments in credit spreads and government bond yields shows that these tend to move in opposite directions.

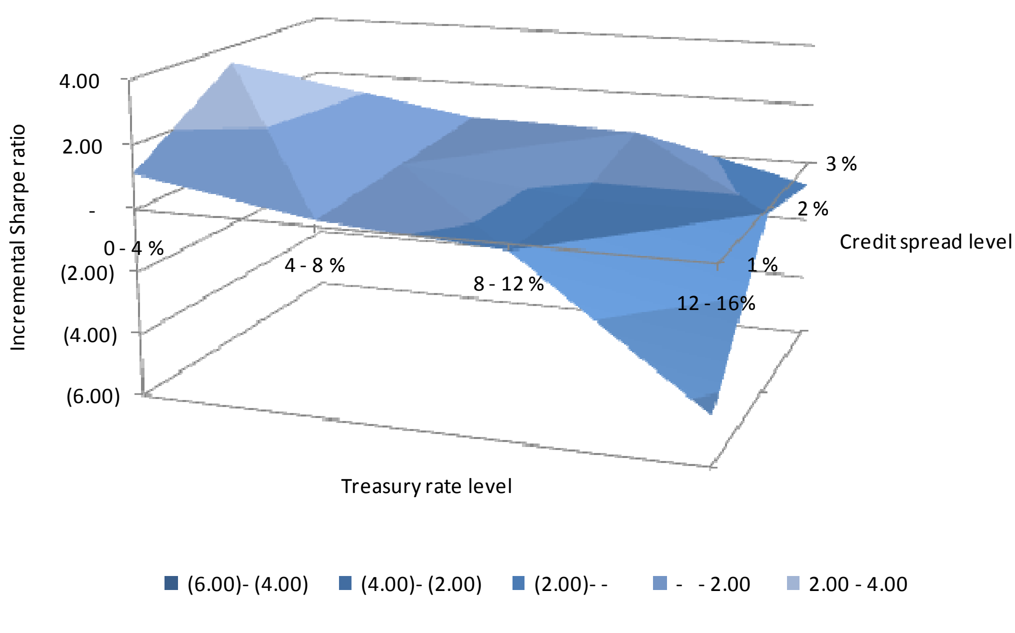
Figure 4 shows the relationship between the Treasury rate and the ratio of the credit spread to interest rate level. The graph confirms that the ratio of spread to interest rate is typically large when interest rates are at low levels. As the ratio of credit spread to the level of Treasury yields increases, credit spread volatility dominates. These characteristics are confirmed in Figure 5, which plots the incremental Sharpe ratio effect of shifting from a 100 percent Treasury portfolio to a 60/40 percent equity-credit portfolio under different interest rate regimes. This graph effectively shows that corporate bonds will have more favourable portfolio characteristics when credit spreads are relatively large compared to interest rate levels.

Figure 4: The relationship between the Treasury rate and the ratio of spread to interest rate level



Source: NBIM calculations, Federal Reserve Bank of St. Louis

Figure 5: Incremental Sharpe ratio for portfolio shift in different rate regimes



Source: NBIM calculations, Federal Reserve Bank of St. Louis

High yield

In the previous sections, we have studied the role of investment-grade bonds in a diversified portfolio. A growing segment in the corporate bond market is bonds issued by companies with lower credit ratings, the so-called high-yield market. Below, we take a closer look at the role these types of bonds play in a diversified portfolio. We have used the same raw data for equities and US Treasuries as in our previous calculations, including dividends on the S&P 500. Data returns are adjusted for losses in the case of default. The high-yield market is less mature than the market for investment-grade bonds. Our data sample therefore spans a shorter period, from January 1994 to July 2010.

In the table below, we have calculated the annualised average return, standard deviation, skew and Sharpe ratio for our three time series over the entire sample as well as during different stages of the business cycle. We find that high-yield bonds have been the worst-performing asset class in terms of both returns and Sharpe ratio during the full sample period.

Table 8: Historical risk and return across different stages of the business cycle (annualised data)

	Equity	Treasury	High Yield
	Full sample		
Mean	8.74 %	6.03 %	4.97 %
St. Dev.	15.53 %	4.54 %	14.01 %
Skew	-0.76	-0.15	-0.61
Sharpe Ratio	0.32	0.53	0.10
	Early expansion		
Mean	12.78 %	4.72 %	13.83 %
St. Dev.	12.91 %	4.84 %	11.80 %
Skew	-0.68	-0.45	-0.04
Sharpe Ratio	0.95	0.75	1.19
	Mature expansion		
Mean	13.53 %	7.10 %	1.44 %
St. Dev.	14.26 %	4.06 %	8.56 %
Skew	-0.65	0.20	-1.03
Sharpe Ratio	1.00	1.68	0.22
	Recession		
Mean	-16.12 %	5.48 %	-3.64 %
St. Dev.	23.20 %	5.48 %	28.48 %
Skew	-0.22	0.01	-0.27
Sharpe Ratio	-0.73	0.81	-0.12

Source: NBIM calculations, Bloomberg, Federal Reserve Bank of St. Louis, Moody's

Next, we will assess how high-yield bonds have performed in a portfolio context. The results of our portfolio analysis follow in Tables 9 and 10. We study five different portfolios. The starting point for our analysis is a portfolio consisting of a 60 percent allocation to equities and a 40 percent allocation to five-year US Treasuries. We keep the allocation to equities fixed and study the impact of a gradual increase in the allocation to high-yield bonds.

Table 9: Historical risk and return on different portfolios across different stages of the business cycle (annualised data)

	Full Sample			Early expansion			Mature expansion			Contraction		
Portfolio	Mean	St Dev	Skew	Mean	St Dev	Skew	Mean	St Dev	Skew	Mean	St Dev	Skew
60% Equity 40% Treasury	7.60 %	9.13 %	-0.59	9.35 %	8.08 %	-0.47	10.80 %	8.37 %	-0.36	-7.74 %	12.48 %	-0.31
60% Equity / 10% High Yield / 30% Treasury	8.10 %	9.91 %	-0.73	10.72 %	8.61 %	-0.51	10.92 %	8.81 %	-0.49	-8.08 %	14.56 %	-0.37
60% Equity / 20% High Yield / 20% Treasury	8.59 %	10.82 %	-0.85	12.11 %	9.26 %	-0.54	11.05 %	9.31 %	-0.61	-8.42 %	16.85 %	-0.41
60% Equity / 30% High Yield / 10% Treasury	9.09 %	11.83 %	-0.94	13.52 %	10.01 %	-0.55	11.18 %	9.85 %	-0.71	-8.77 %	19.27 %	-0.43
60% Equity 40% High Yield	9.58 %	12.90 %	-1.00	14.94 %	10.83 %	-0.54	11.30 %	10.44 %	-0.80	-9.11 %	21.78 %	-0.45

Source: NBIM calculations, Bloomberg, Federal Reserve Bank of St. Louis, Moody's

Table 10: Sharpe Ratio table[6]

Sharpe Ratio Analysis	Full sample	Early expansion	Mature expansion	Contraction
Portfolio				
60% Equity 40% Treasury	0.43	1.06	1.31	-0.70
60% Equity / 10% High Yield / 30% Treasury	0.45	1.18	1.26	-0.63
60% Equity / 20% High Yield / 20% Treasury	0.45	1.26	1.21	-0.56
60% Equity / 30% High Yield / 10% Treasury	0.46	1.32	1.16	-0.51
60% Equity 40% High Yield	0.45	1.36	1.11	-0.46

Source: NBIM calculations, Bloomberg, Federal Reserve Bank of St. Louis, Moody's

[6] Note that there is no established consensus on how to treat Sharpe ratios in scenarios where excess returns are negative.

We find that the introduction of high-yield bonds into a diversified portfolio with a fixed allocation to equities changes the portfolio characteristics. The only time when an allocation to high yield seems to have added value and improved portfolio characteristics, as measured by the Sharpe ratio, has been during periods where the economy has been in a state of early expansion. Hence, raising the portfolio share of high-yield corporate bonds improves the Sharpe ratio during early expansions, but has an unfavourable effect on the Sharpe ratio during mature expansions and contractions. In a portfolio context, high-yield bonds can be expected to behave more like equities than interest rate instruments, especially in a situation where the ratio between the credit spread and the yield on government bonds is high.

The table below shows the results of a Monte Carlo simulation with methodology identical to that used in the section on investment-grade bonds. We draw from the empirical distribution of our raw data in order to characterise the entire distribution of portfolio returns with more confidence. Returns are calculated using the same approach as presented earlier. The simulations support our finding above that the introduction of high-yield bonds into a diversified portfolio with a fixed allocation to equities can be expected to add to return, but at the cost of a significant increase in portfolio risk as measured by standard deviation.

Table 11: Mean, standard deviation and percentiles of different portfolio compositions with stochastic rate levels (annualised data)

Portfolio	min	1	2.5	5	95	97.5	99	max	median	mean	stdev	Sharpe
60% Equity 40% Treasury	-29.4 %	-14.7 %	-11.2 %	-8.3 %	23.4 %	26.9 %	30.7 %	50.9 %	7.3 %	7.4 %	9.7 %	0.40
60% Equity / 10% High Yield / 30% Treasury	-34.3 %	-16.1 %	-12.3 %	-9.2 %	24.8 %	28.4 %	32.3 %	57.0 %	7.6 %	7.7 %	10.4 %	0.40
60% Equity / 20% High Yield / 20% Treasury	-38.9 %	-18.0 %	-13.8 %	-10.3 %	26.5 %	30.5 %	34.9 %	74.2 %	7.9 %	7.9 %	11.2 %	0.39
60% Equity / 30% High Yield / 10% Treasury	-43.4 %	-19.9 %	-15.4 %	-11.4 %	28.3 %	32.7 %	37.9 %	92.9 %	8.1 %	8.2 %	12.2 %	0.38
60% Equity 40% High Yield	-47.6 %	-22.4 %	-17.3 %	-12.8 %	30.4 %	35.2 %	41.7 %	113.3 %	8.3 %	8.5 %	13.3 %	0.37

Source: NBIM calculations, Bloomberg, Federal Reserve Bank of St. Louis, Moody's

Government bonds

In this section, we investigate the role government bonds play in a diversified portfolio. Our analysis is primarily focused on US government bonds. We look more closely at how government bonds historically have behaved relative to other asset classes, such as equities and corporate bonds. Finally, we characterise government bond liquidity as measured by the bid-ask spread and compare this to other segments of the fixed-income market and show how liquidity can differ between different sovereigns.

Main findings

- Returns on government bonds over time have been negatively correlated to returns in the equity market, albeit the correlation has not been constant over time.

- Government bonds seem to be an effective hedge in periods with sharp declines in stock markets, as interest rates decline when stock markets fall sharply. The relationship between bond yields and stock markets in strong bull markets is less clear.

- We find the same diversifying effect during periods of stress in other government bond markets. We also find that correlations between government bond markets tend to increase during recession periods.

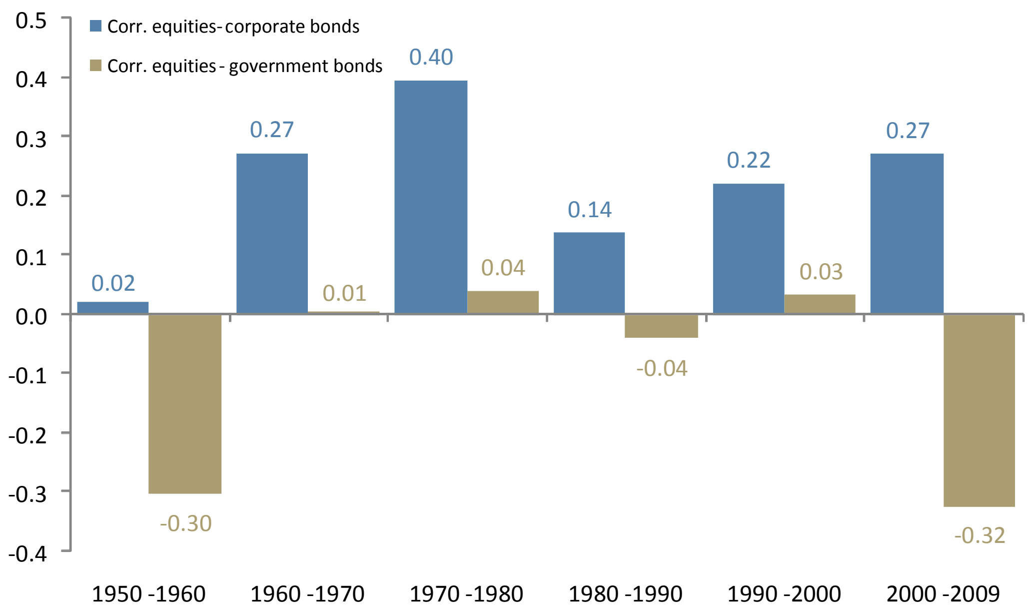
- Government bonds can be considered very liquid compared to other fixed-income segments. This can be seen by looking at the bid-ask spread, which has been relatively stable and low over our entire sample period.

- We also find that liquidity can evaporate during periods with rising sovereign risks.

Historical asset class correlations

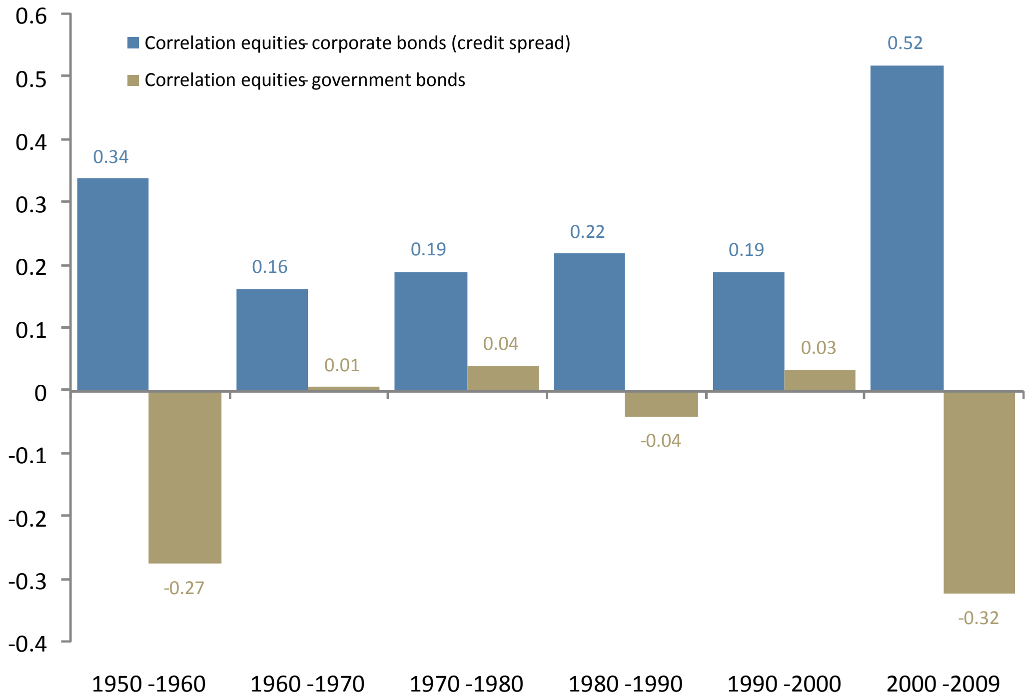
Uncorrelated assets can be expected to improve the overall risk/return profile of the portfolio through diversification. We have studied the correlation between return series for equities and government bonds and for equities and corporate bonds over the last six decades in Figure 1 below. First of all, the numbers show that these correlations vary over time, while being mostly negative between equities and government bonds and the opposite between equities and corporate bonds. The data (figure 3) seem to suggest that high-quality government bonds should be expected to have a stabilising effect on the returns of a diversified portfolio.

Figure 1: Ten-year correlations between equities and government bonds and between equities and corporate bonds



Source: NBIM calculations, Bloomberg, Federal Reserve Bank of St. Louis, Moody's

Figure 2: Ten-year correlations between equities and government bonds and between equities and corporate bonds (credit spreads)



Source: NBIM calculations, Bloomberg, Federal Reserve Bank of St. Louis, Moody's

The table below digs deeper into how correlations might vary over time and shows how the return on US government bonds has moved with the return on the S&P 500 since 1953. We find that government bonds seem to be an effective hedge in a strong bear market when stock markets fall significantly as rates tend to decline. Perhaps more surprisingly, we also find that interest rates declined in seven of the ten months where the S&P 500 rose more than 10 percent. The declines in interest rates during bull markets were, however, significantly smaller than registered during months with sharp falls in the equity market.

Figure 3: Historical return data during periods with significant moves in the S&P 500

S&P 500 up 10% or more in a month			
Date	S&P 500 monthly change	Treasury yield monthly change	Credit spread monthly change
Nov 1962	10.16 %	-1.11 %	0.00 %
Oct 1974	16.81 %	-3.64 %	16.33 %
Jan 1975	12.72 %	-4.05 %	4.12 %
Jan 1976	12.17 %	-0.13 %	-5.42 %
Nov 1980	10.65 %	3.27 %	4.42 %
Aug 1982	12.14 %	-5.77 %	1.81 %
Oct 1982	11.51 %	-3.89 %	-0.25 %
Aug 1984	11.04 %	-1.18 %	-6.67 %
Jan 1987	13.47 %	2.26 %	-7.14 %
Dec 1991	11.42 %	0.81 %	-5.86 %

S&P 500 down 10% or more in a month			
Date	S&P 500 monthly change	Treasury yield monthly change	Credit spread monthly change
Nov 1973	-11.09 %	-1.73 %	12.00 %
Sep 1974	-11.52 %	-4.78 %	38.67 %
Oct 1987	-21.54 %	-8.04 %	13.39 %
Aug 1998	-14.44 %	-12.33 %	32.09 %
Sep 2002	-10.86 %	0.34 %	7.17 %
Oct 2008	-16.79 %	-16.12 %	12.52 %
Feb 2009	-10.61 %	-2.67 %	6.28 %

Source: NBIM calculations, Bloomberg, Federal Reserve Bank of St. Louis

The analyses above are based on historical data from the US markets. Below, we look at the relationship between government bonds and equity markets in the US, Germany, Japan and the UK, albeit for a shorter time period (from 1987 to January 2011). We examine these markets across different equity market trends (bull, bear and neutral). The table below reports the average monthly return and Sharpe ratio on the four domestic government bond segments during bull, bear and neutral equity markets.[1] These results confirm the diversifying effect government bonds have had during times of financial stress.

Figure 4: Return statistics for four different government bond markets during bull, bear and neutral equity markets

	Full sample	Bull	Neutral	Bear	
US	0.58 %	0.55 %	0.48 %	0.76 %	*average monthly return*
	0.56	0.16	0.41	1.05	*Sharpe ratio*
Germany	0.50 %	0.27 %	0.47 %	0.82 %	*average monthly return*
	0.60	-0.23	0.50	1.42	*Sharpe ratio*
Japan	0.34 %	0.12 %	0.25 %	0.55 %	*average monthly return*
	0.68	0.32	0.61	1.01	*Sharpe ratio*
UK	0.67 %	0.65 %	0.65 %	0.70 %	*average monthly return*
	0.39	0.54	0.38	0.31	*Sharpe ratio*

Source: NBIM calculations, Bloomberg, Barclays Capital

[1] Equity market trends are defined by sorting the 271-month-long sample according to the six-month returns on the S&P 500, Nikkei 225, FTSE 100 and DAX. The top and bottom 30 percent of the list of months are then defined as bull and bear months respectively, whereas the remaining 40 percent are defined as neutral equity months.

Moreover, the table shows that the diversifying effect can be found across markets, as average monthly returns dominate the remaining sample period for all four government bond indices. A closer examination of the correlation coefficients across these four different government bond markets shows that government bonds tend to co-move even more strongly during periods of financial stress. The figure below quantifies this observation and we find that correlations increase across all markets during recession periods.

Figure 5: Correlations across different government bond markets

Full sample: 1987-2011

	US	Germany	Japan	UK
US	1.00			
Germany	0.66	1.00		
Japan	0.30	0.33	1.00	
UK	0.60	0.70	0.29	1.00

Recession sub-sample

	US	Germany	Japan	UK
US	1.00			
Germany	0.76	1.00		
Japan	0.39	0.36	1.00	
UK	0.80	0.73	0.49	1.00

Non-recession sub-sample

	US	Germany	Japan	UK
US	1.00			
Germany	0.64	1.00		
Japan	0.29	0.33	1.00	
UK	0.55	0.69	0.25	1.00

Source: NBIM calculations, Bloomberg, Barclays Capital

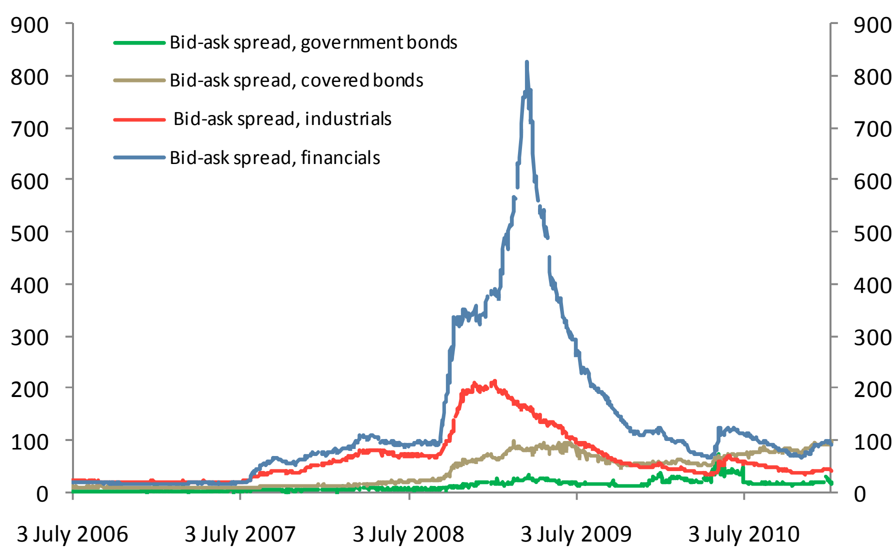
Liquidity

A liquid investment is an investment that can be traded quickly and with relatively low transaction costs, even during periods of significant financial distress. A typical measure of this liquidity is the spread between bid and ask prices – i.e. the difference between the prices at which investors are willing to buy and sell an asset – where a liquid investment will trade with a tight spread.

In Figure 6, we have compared the bid-ask spread of government bonds with other segments of the fixed-income market. This analysis uses data from the European markets alone due to data availability.

Figure 6 illustrates how the government bond component's bid-ask spread has been relatively low and stable compared to European corporate and covered bonds. This observation is based on daily quotes over the period 2006-2011.[2] Intuitively, this liquidity is also a result of the capital flow to government bonds when investors close more risky positions during periods of financial stress.

Figure 6: Bid-ask spreads across segments (basis points)

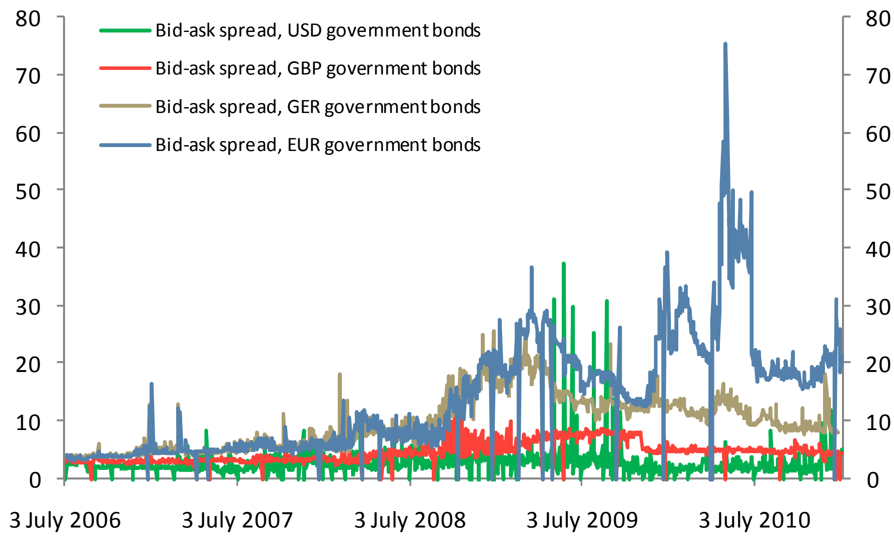


Source: iBoxx

In Figures 7 and 8, we compare bid-ask spreads across different sovereigns. The bid-ask spread of US government bonds has been more stable than that of the issuances in other currencies. The spike in the euro bid-ask spread came as a result of increased uncertainty about the creditworthiness of peripheral euro countries.

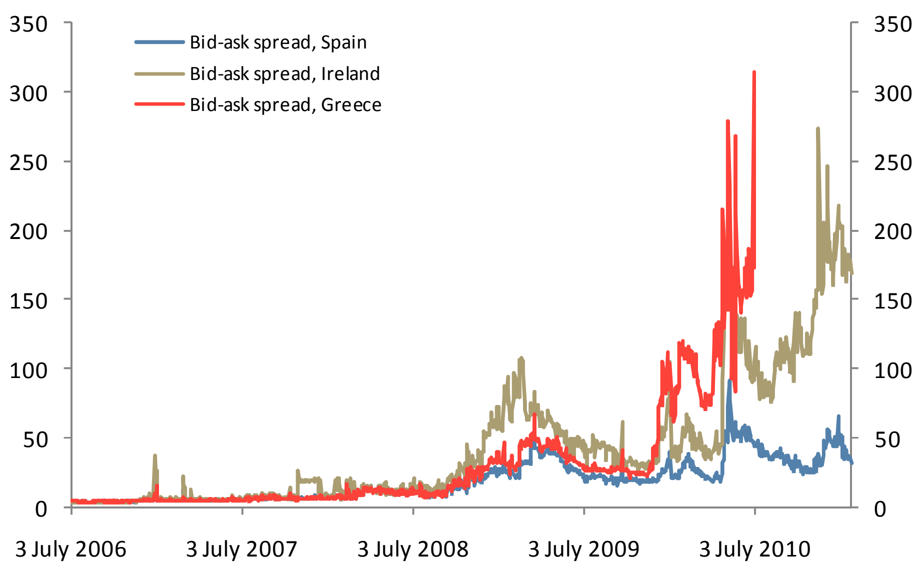
[2] It should be borne in mind that these are quotes and not actual trades.

Figure 7: Bid-ask spreads across different regions within the government bond segment (basis points)



Source: iBoxx

Figure 8: Bid-ask spreads across government bonds issued by selected euro countries (basis points)



Source: iBoxx

US mortgage-backed securities

The purpose of this section is to take a closer look at the role US mortgage-backed securities (MBSs) play in a diversified portfolio. These bonds fall into the bracket of securitised bonds in broad bond indices such as the Barclays Capital Global Aggregate. A securitised bond is a bond whose interest and payment are backed by the cash flow from a portfolio or pool of other assets. Mortgage pass-through securities (MBSs) are created when mortgages are pooled together and sold as undivided interests to investors. Usually, the mortgages in the pool have the same loan type and similar maturities and loan interest rates. In the US mortgage market a distinction can be drawn between agency and non-agency bonds.

Main findings

- An agency MBS is mortgage-backed security where principal and interest payments are guaranteed by a US government-sponsored agency. The agency MBS market is highly liquid and almost the same size as the US government bond market. These type of mortgage backed securities have historically played an important political role in the US as a vehicle for affordable home ownership financing.

- Although a highly liquid investment with currently negligible credit or downgrade risk, an agency MBS fails to deliver the desired diversification benefit when rates decline as borrowers exercise their option to prepay the mortgage.

- The credit risk of an agency MBS investment equals that of US Treasuries as long as the government guarantee remains in place. Uncertainty about this particular segment of the US fixed-income market is high, and medium- to long-term visibility is clouded.

- The inclusion of MBSs in a portfolio alters the portfolio characteristics. Duration will decline and the negative convexity will hurt performance in periods with declining interest rates.

- A fixed allocation to agency MBSs means that the investor will be selling options at all times, regardless of the price of volatility. As the price of volatility tends to vary over time, an opportunistic approach to agency MBSs may be more beneficial.

- Both model risk and political risk in this particular part of the fixed income market are high.

- An investment in a non-agency MBS differs from an agency investment and entails both credit risk and prepayment risk. The credit risk depends on the tranche in which investment is made, the underlying collateral, and the way the bond is structured. Prepayment risks are challenging to model, especially in the current environment, and are driven by factors other than prepayment for Agencies.

Agency MBSs

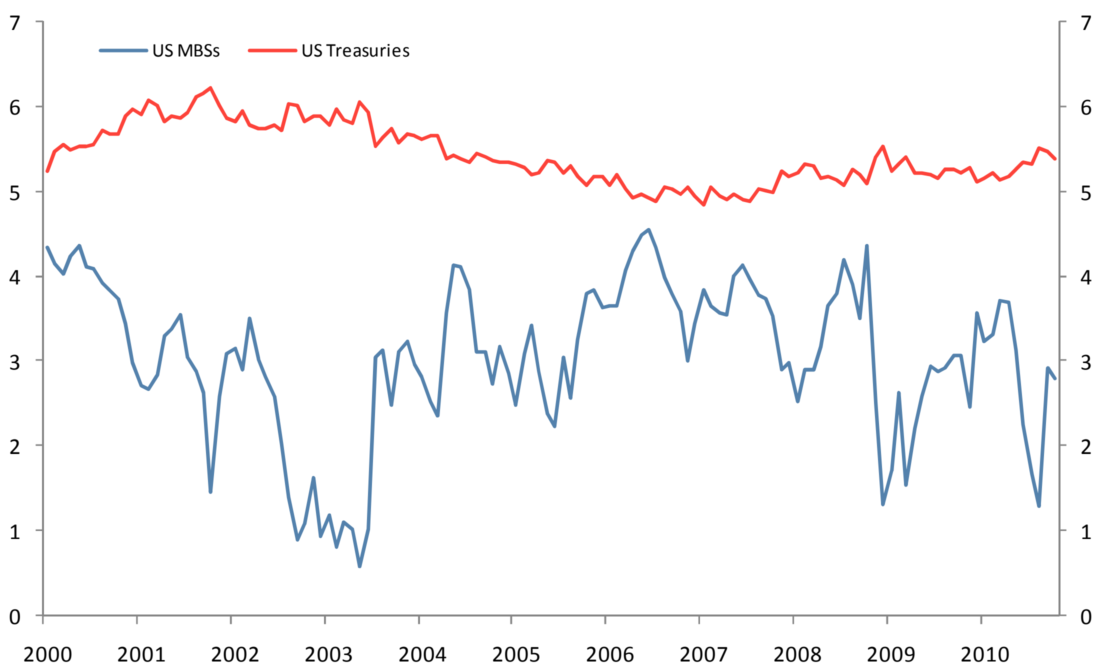
An agency MBS is mortgage-backed security where principal and interest payments are guaranteed by a US government-sponsored agency. The agency MBS market is highly liquid and almost the same size as the US government bond market.

What used to be an implicit government guarantee prior to the financial crisis became an explicit government guarantee when the US government put the government-sponsored institutions into conservatorship under the Federal Housing Finance Agency in September 2008. The conservatorship implies that the US government will provide capital as needed in order to cover losses on the underlying mortgages. As long as both principal and interest payments are guaranteed by the US government, an investment in an agency MBS entails the same credit risk as an investment in US Treasuries. The conservatorship represents a drain on public finances and has to be viewed as a temporary arrangement. We therefore view the medium- to long-term visibility in this particular segment of the fixed-income market as low, and the political risk as high.

The inclusion of MBSs in a diversified portfolio exposes the overall portfolio to an independent source of risk, prepayment risk, which originates in borrowers' right to pay off their mortgages early at par. Although agency MBSs are commonly issued with a 30-year maturity, the actual life of the security is likely to be significantly shorter as borrowers exercise their option to prepay at par.

An investment in an MBS is not an investment with a fixed income stream but an investment with an uncertain cash flow profile. The inclusion of agency MBSs in the benchmark for a fixed-income investor alters the portfolio characteristics of the overall portfolio. The duration is likely to decline, as the duration in the MBS segment, although uncertain and variable, will be lower than duration on average in a broad benchmark. The difference in duration alters the portfolio characteristics. Below, we compare duration in the US Treasury segment to the duration of the agency MBS segment in the Barclays Global Aggregate. The average duration of the MBS index was approximately 2.5 years compared to above 5 years in the Fund's overall fixed-income portfolio.

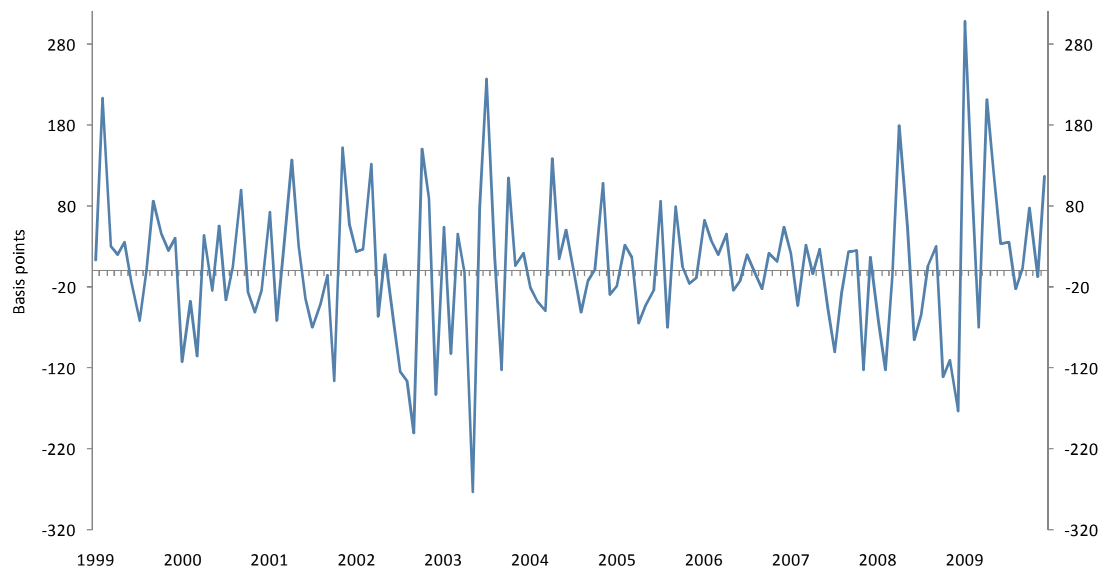
Figure 1: Duration of US Treasuries and MBSs in the Barclays Global Aggregate



Source: Barclays Capital

Below, we compare the difference in monthly returns on the MBS portfolio[1] with the US Treasury component of the Barclays Global Aggregate.[2] The US Treasury component represents in this respect the funding source for the MBS investments. A positive reading means that MBSs outperformed Treasuries. Of the 132 months we have examined, we find that MBSs outperformed Treasuries in 70 months and underperformed in 62 months. The two most extreme observations were a positive reading of 309 basis points and a negative reading of 273 basis points. Whether the reduction in duration following the inclusion of MBSs is attractive depends on the existence of a term premium in this particular part of the market.

Figure 2: Difference in return on US Treasury and MBS segments



Source: Barclays Capital

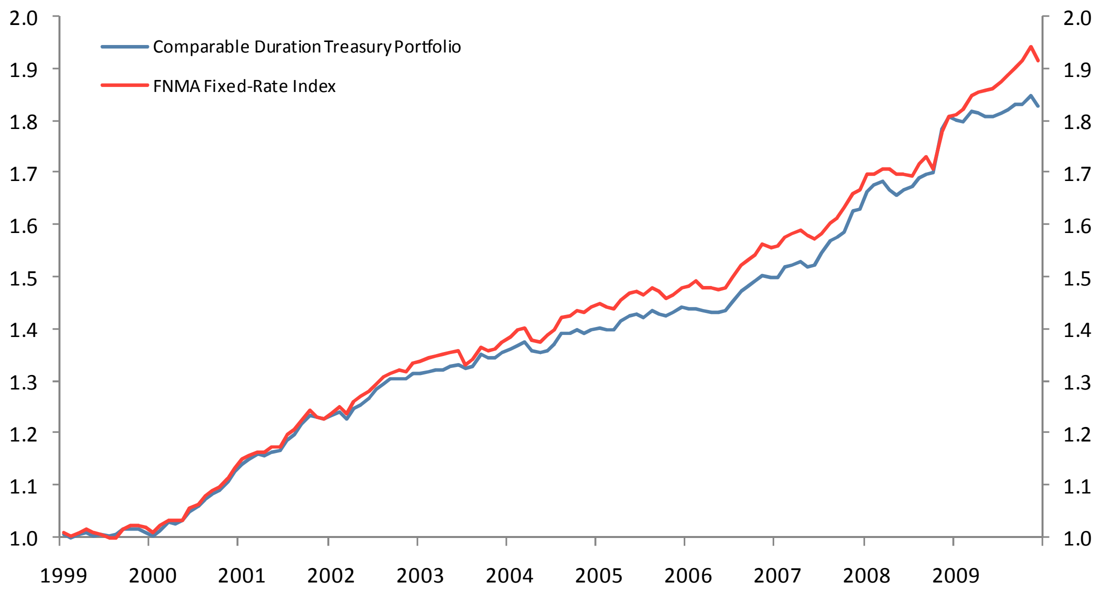
Whether an investment in an agency is attractive compared to a government bond investment with comparable duration depends on whether investors are sufficiently compensated for the embedded optionality in the instrument. In order to account for this optionality, we have to calculate the option adjusted spread (OAS). The OAS is driven by assumptions of the prepayment rate and the stochastically modelled path for interest rates. In general, the higher the OAS, the better we are compensated for the volatility we have sold. Note that the

[1] We have used the FNMA Fixed-Rate MBS Index. These securities are backed by pools of mortgages with interest rates that are fixed for the entire term of the mortgage.
[2] This is the basis for the current GPFG benchmark for fixed-income investments.

calculation of the OAS is highly dependent on the underlying assumptions. The same quoted price for an agency MBS can therefore be interpreted as either high or low depending on the model used. In the current macroeconomic environment model uncertainty is high and quoted OAS spreads tend to vary considerably depending on which model they are based.

One way to assess whether investors historically have been compensated for the optionality in an MBS is to compare the return on an MBS portfolio with the return on a comparable-duration portfolio consisting of US Treasuries. Our chart below is based on a model from Barclays Capital and contains data back to January 1999. During this period the MBS portfolio has yielded an average excess return of approximately 4 basis points each month compared to the constructed Treasury portfolio. Note that the composition of the comparable-duration Treasury portfolio will depend on the prepayment model, hence the calculated excess returns are also model-dependent.

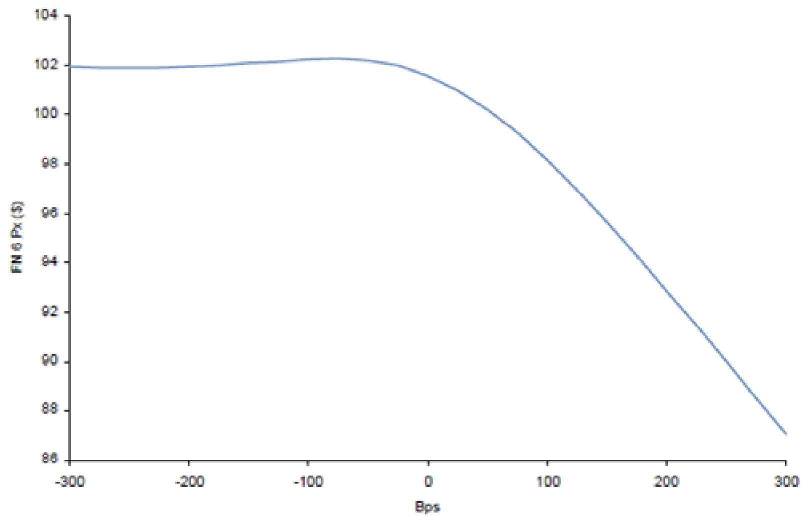
Figure 3: Return on FNMA Fixed-Rate Index and a comparable-duration Treasury portfolio



Source: Barclays Capital

The level of interest rates is the main driver for prepayment of agency MBSs. The option to prepay at par is more likely to be exercised when interest rates fall than during periods with unchanged or rising rates. The price of an MBS will therefore not rise as quickly as the price of a government bond during periods with falling interest rates. The price of the MBS might actually fall, as the likelihood for prepayment at par increases. Consequently, the shape of an MBS with respect to yield is negatively convex, see illustration below.

Figure 4: FNMA 6% (USD) vs shift in rates (basis points), as at July 2007



Source: Barclays Capital

The negative convexity of MBSs means that the investor is likely to see the duration decline when interest rates fall, all other factors equal. This property could hurt overall portfolio performance in periods with declining interest rates and should be taken into consideration in the design of an appropriate investment strategy for fixed income.

In the tables below, we compare the total return on US Treasuries[3] versus an FNMA fixed-rate index during periods with significant changes in the yield level of government bonds[4] from January 1999 to December 2009. We find that MBSs outperformed Treasuries in months where interest rates increased, and vice versa during periods with declining interest rates. This is in line with what we would intuitively expect given the negative convexity of MBSs.

[3] The US Treasury segment of the Barclays Global Aggregate.
[4] Percentage changes in the yield of five-year US Treasuries.

Figure 5: Total return on FNMA and US Treasuries in two different scenarios

Top 15 monthly changes in 5-yr Treasury rate				
Date	Change 5-year Treasury rate	FNMA total return	Treasury total return	Spread
Dec 01	10.58 %	-0.39	-0.97	0.58
Mar 02	10.23 %	-1.08	-2.41	1.33
Jul 03	26.43 %	-2.02	-4.39	2.37
Aug 03	17.42 %	0.77	0.59	0.17
Apr 04	21.51 %	-1.83	-3.22	1.38
May 04	13.57 %	-0.19	-0.34	0.15
Mar 05	10.61 %	-0.16	-0.33	0.16
Oct 05	7.98 %	-0.73	-0.78	0.06
Jun 07	7.71 %	-0.50	-0.04	-0.46
Apr 08	14.52 %	0.08	-1.72	1.80
May 08	10.92 %	-0.62	-1.17	0.54
Jun 08	10.79 %	-0.07	0.79	-0.85
Feb 09	16.88 %	0.56	-0.53	1.09
May 09	14.52 %	0.20	-1.01	1.21
Jun 09	27.23 %	0.12	-0.21	0.34

Bottom 15 monthly changes in 5-yr Treasury rate				
Date	Change 5-year Treasury rate	FNMA total return	Treasury total return	Spread
Dec 00	-9.30 %	1.67	1.91	-0.24
Sep 01	-9.85 %	1.54	1.59	-0.05
Jul 02	-9.07 %	1.13	2.37	-1.24
Aug 02	-13.65 %	0.80	2.16	-1.36
Sep 02	-10.64 %	0.69	2.70	-2.00
May 03	-13.99 %	0.15	2.88	-2.73
Jun 03	-9.92 %	0.17	-0.61	0.78
Mar 04	-9.12 %	0.44	0.94	-0.50
Aug 07	-9.22 %	1.29	1.57	-0.28
Nov 07	-12.62 %	1.84	3.07	-1.23
Jan 08	-14.61 %	1.89	2.54	-0.65
Mar 08	-10.79 %	0.63	0.69	-0.06
Nov 08	-16.12 %	4.20	5.31	-1.11
Dec 08	-33.62 %	1.66	3.39	-1.73
Jul 09	-9.23 %	0.78	0.42	0.36

Source: Barclays Capital

The portfolio characteristics of an agency MBS should be taken into account in the design of the investment strategy. A fixed allocation to this part of the interest rate market will reduce the overall duration of the portfolio and mean that the investor will be selling volatility/issuing options regardless of price. We know that the pricing of volatility varies over time and that volatility has a tendency to rise as rates go down and vice versa. This feature warrants an opportunistic approach to this particular segment of the fixed-income market. MBS investing entails significant operational costs due to the handling of cash flows. Index exposure to this segment can also be achieved by using to-be-announced (TBA) forwards[5] to replicate an agency MBS index the same way as equity exposure can be achieved by going long on equity futures/forwards. These types of instruments could be used as part of a more opportunistic approach towards this particular segment of the fixed-income market.

Non-agency MBSs and other asset-backed securities

MBSs issued by banks and financial companies not associated with a government agency represent another investment opportunity for a fixed-income investor. Investments of this type are often labelled non-agency MBSs. Another investment opportunity is securities issued against a pool of consumer and commercial loans. These types of investments are commonly referred to as asset-backed securities (ABSs). The common denominator for both non-agency MBSs and ABSs is that interest rate payments and principal are derived from and collateralised by a specific pool of underlying assets. These types of securities, hereafter referred to as non-agencies, have no credit guarantee other than the quality of the loans behind them, and any other structural credit protection provided by the terms of the bond deal to which they belong.

The size of the non-agency market is significant in absolute terms but small relative to the agency market (less than 10 percent). Liquidity in this part of the fixed-income market will vary over time. During periods with financial stress, liquidity could evaporate overnight.

The portfolio characteristics of non-agencies differ from those of agencies. Firstly, a non-agency investment entails credit risk. The amount of credit risk will differ depending on the tranche of the capital structure in which investment is made, the AAA or the equity tranche, the design of the structure such as the depth of the various tranches, as well as the underlying pool of assets. The credit risk comes on top of the prepayment risk. Prepayment behaviour in this segment differs from that of agency MBSs. Although interest rates remain an important driver, they are not necessarily the most important one. Under current market conditions, developments in house prices and various housing initiatives are important determinants of prepayment behaviour.

[5] A TBA is an OTC (over-the-counter) forward contract on an agency MBS.

Covered bonds

In this section, we describe the structural features of covered bonds, a type of collateralised fixed-income security that has a long history in Continental Europe. We then examine the risk and return characteristics of covered bonds, their outlook as an asset class after the financial crisis and their role in a diversified portfolio.

Main findings

- Covered bonds are debt instruments issued by financial institutions and secured by a pool of dedicated assets (mostly mortgages and public sector loans), known as cover pools. Investors have recourse against both the issuer and the pool of assets (dual recourse).

- In contrast to US mortgage-backed securities (MBSs), the issuers of covered bonds usually retain cover pool assets on their balance sheets, hence there is no capital relief for the issuer. In addition to satisfying regulatory requirements with regard to asset quality, maintaining exposure to cover assets is likely to give issuers a stronger incentive to apply prudent underwriting standards. Furthermore, issuers often actively manage the underlying cover pool by replacing non-performing assets, which can be of benefit to the investor. Finally, covered bonds are most often structured as bullet bonds and therefore not subject to prepayment risks, unlike US MBSs.

- Regulations governing eligible collateral and treatment of creditors in insolvency vary between European countries. Each investment in covered bonds should therefore be assessed in the light of the relevant jurisdiction’s covered bond legislation.

- Due to their structural features and quality of collateral, covered bonds often obtain AAA ratings from rating agencies, but usually are issued and trade at positive spreads to European sovereign debt with equivalent credit ratings. The relatively higher yield could largely be regarded as compensation for liquidity risk.

- During the recent financial crisis, it became evident that interbank market-making agreements that were designed to ensure liquidity in covered bonds could not always be maintained in the face of a systemic crisis.

- Over the past decade, the excess returns of euro covered bond indices over German government debt have been slightly negative, with the notable exception of the German Pfandbrief market. This result is influenced by the severe crisis at the end of the sample period. Against the respective home government bonds, the comparison is more favourable.

- Due to the involvement of European governments in supporting banks during the crisis, covered bond spreads have become more positively correlated with the respective sovereign yields. Because of their overcollateralisation and recourse to the issuing bank, some covered bonds may continue to be able to pay out all cash flows due even in the face of a credit event in the home sovereign's debt. However, they should not be considered an infallible hedge against sovereign risk.

- All in all, we believe that covered bonds issued in jurisdictions with strong covered bond legislation can to some extent be regarded as an alternative to investments in government debt in the same jurisdiction. However, the ability to trade covered bonds easily at all times is less certain than for sovereign debt, as the recent financial crisis has shown. Hence they are not suitable as part of a liquidity buffer portfolio.

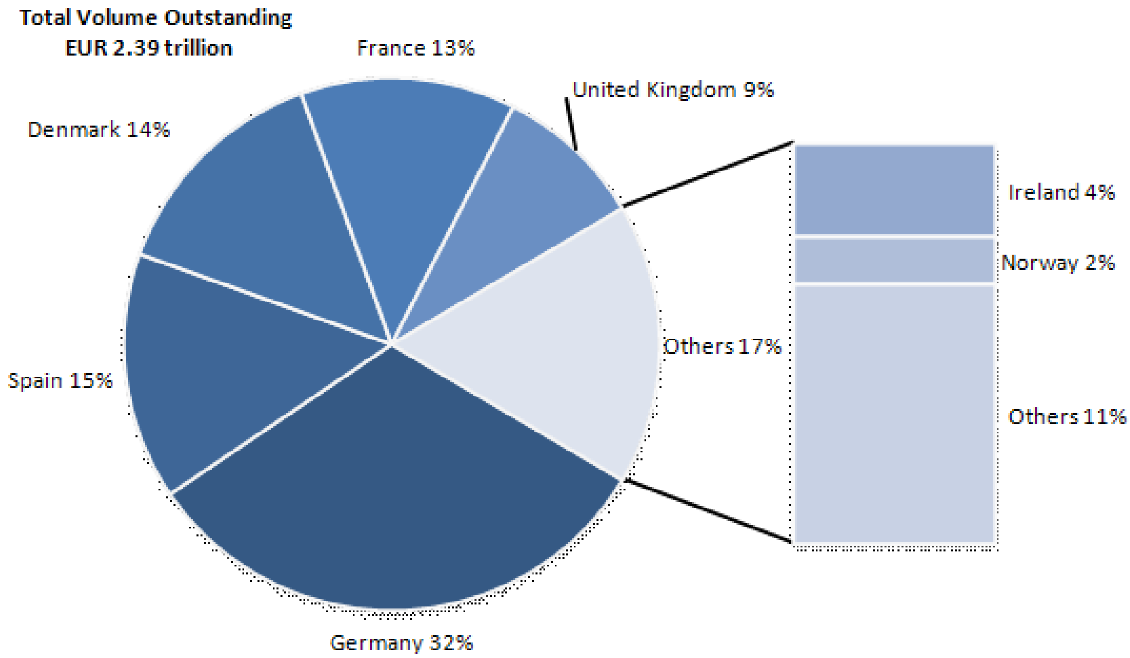
Definition and structural features

Covered bonds are debt instruments issued by financial institutions and secured by a pool of dedicated on-balance-sheet loans, known as cover pools. The most common types of assets securing covered bonds are residential and commercial mortgages, as well as public sector loans. Investors have recourse against both the issuer and the pool of loans (dual recourse). In the case of the issuer's insolvency, the assets in the cover pool are generally separated from the issuer's other assets solely for the benefit of the holders of the relevant securities. If the cover pool returns less than par in liquidation, investors retain an unsecured claim on the issuer ranking equally with other unsecured creditors. Issuers are usually also required to maintain a cover pool in excess of the notional value of the covered bond at all times ("overcollateralisation").

Dual recourse and overcollateralisation contribute to covered bonds attracting higher ratings than the unsecured senior bonds of the same financial institution issuer. In fact, most covered bonds have traditionally been issued with an AAA rating and normally trade at a small positive spread to government bonds. The yield pick-up over equally-rated government bonds could largely be interpreted as compensation for their liquidity risk.

The process of securitisation and the structure of covered bonds are dependent on the jurisdiction in which the securities are issued. In most European countries, the issuance of covered bonds is regulated by specific covered bond legislation ("law-based") whereas contractual arrangements apply in a few other jurisdictions ("contract-based"). Both types of framework set the rules for important features such as eligible assets, specific asset valuation rules, asset-liability management guidelines and transparency requirements. As the governing regulations vary between different member states in Europe, each investment in covered bonds should be assessed in the light of the relevant jurisdiction. Identifying the legal framework for issuer's bankruptcy is of particular importance. In some countries, general insolvency law applies, whereas other jurisdictions have a specific legal framework that supersedes general insolvency law.

Figure 1: Distribution of covered bonds outstanding in Europe as at 31 December 2009



Source: ECBC (2010)

Covered bonds were first developed in Germany and Denmark in the late 18th century and Continental Europe has the longest tradition in the asset class. This is reflected in the size of the covered bond markets as well. In descending order of total covered bond volume outstanding, the largest markets can be found in Germany, Spain, Denmark and France. The United Kingdom has also developed a sizeable (mostly euro-denominated) market in recent years, as shown in Figure 1. Over the past decade, covered bonds have become the largest segment of non-government bonds on Europe's capital markets, with a volume outstanding at the end of 2009 of EUR 2.39 trillion (ECBC, 2010).

This growth has been supported by the creation of benchmark covered bonds or so-called Jumbo Pfandbriefe ("Pfandbrief" being the German term for a covered bond) in the mid-1990s. Benchmark covered bonds are standardised securities with a certain minimum issue size, most often EUR 1 billion. The investment banks involved in bringing benchmark covered bonds to the market committed themselves to pre-defined market-making rules and to quoting two-way prices at all times. Due to the high credit quality and these efforts by issuers and market-makers to ensure liquidity, covered bonds were perceived by some investors to be very close substitutes for developed country sovereign debt prior to the 2007-2009 financial crisis. However, the market-making agreements could not be upheld during the crisis, curtailing secondary market liquidity in covered bonds, which may have brought about a re-evaluation of the asset class by important investor groups. On the other hand, policymakers and issuers in Europe have shown a strong interest in re-establishing the status of covered bonds as a surrogate for government debt due to their importance to bank funding and their structural advantages over MBSs.

Comparison with US MBSs

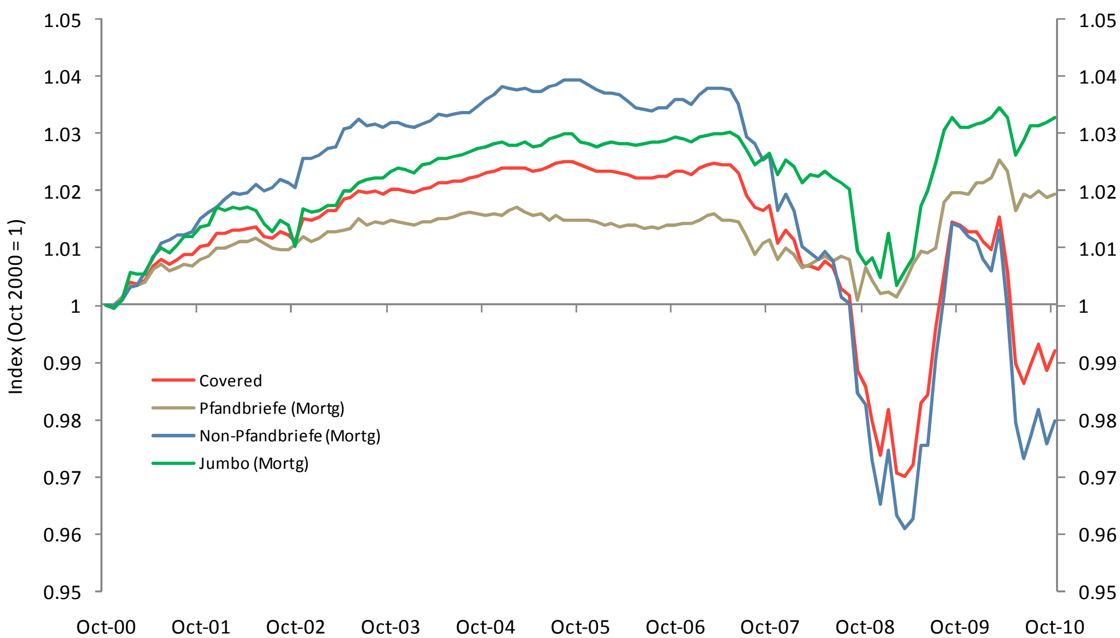
Covered bonds are similar to US MBSs in the sense that they are debt instruments secured against assets originated by a financial institution. In an MBS transaction, a bank removes the assets that are to be securitised – and the risks associated with them – from its balance sheet. In contrast, the issuers of covered bonds usually retain assets underlying the cover pool on their balance sheet, giving the issuing institutions a stronger incentive to apply prudent underwriting standards. Furthermore, in most jurisdictions issuers need to comply with asset coverage tests by the regulator which safeguard that the eligible collateral is of sufficient quality. Therefore, the collateral backing covered bonds is often managed dynamically as opposed to the static collateral pools backing MBSs. Policymakers in the US (Paulson, 2010) have suggested that covered bonds could be the way forward as long-term funding for banks due to their structural advantages over MBSs.

Covered bonds are most often structured as bullet bonds with a definite maturity date. The underlying assets themselves are of a fixed maturity, or cover pools are managed so that prepayments do not shorten the duration of the underlying assets. On the other hand, MBSs are subject to the risk that borrowers pay back their mortgages early as interest rates fall because they can refinance into a lower mortgage rate. The disadvantage for the bondholder is that the duration of MBSs falls when interest rates decline, often leading to an underperformance of MBSs versus equal-duration governments in those cases. Most covered bonds do not have this drawback.

Return and risks on covered bonds

Due to the higher yield of covered bonds over government bonds of equivalent maturity, we would expect them to generate positive excess returns over government debt in the majority of periods, but occasionally suffer episodes of underperformance when risk aversion and illiquidity rise, and when fears over banks' solvency surface. Using various components of the Barclays Capital euro covered bond index from October 2000 to October 2010, we find that the German Pfandbrief market meets that expectation, while the non-Pfandbrief segments of the index have generated negative excess returns over the sample period. Taken together, the broad covered bond index has underperformed government bonds by around 10 basis points per year.

Figure 2: Index of cumulative excess returns

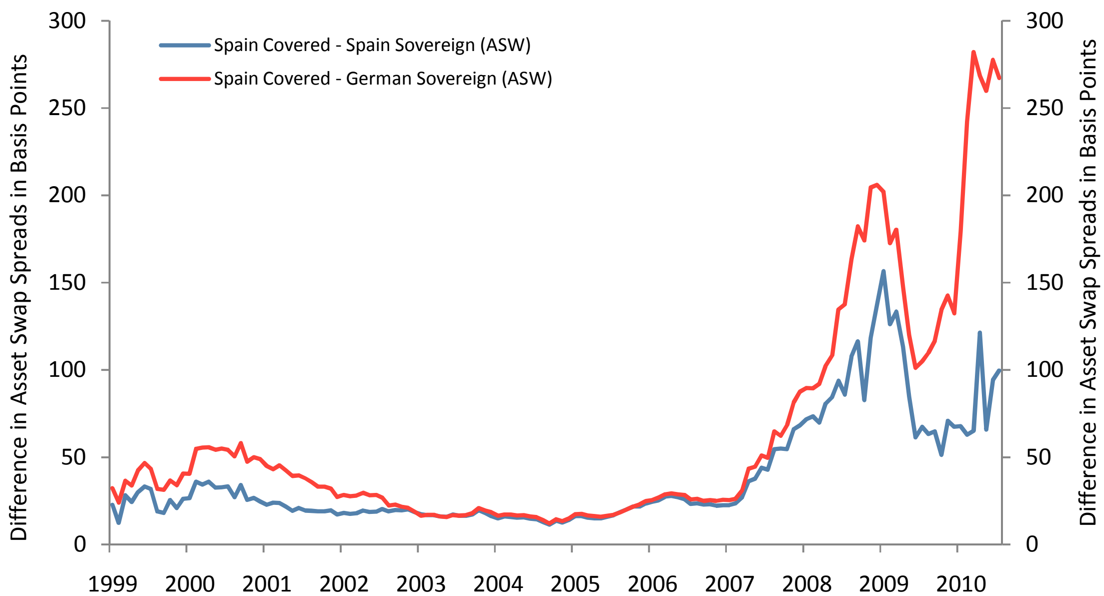


Source: Barclays Capital euro indices

As can be seen in Figure 2, all segments of the covered bond market accumulated fairly steady excess returns during the years 2000-2007, as would be expected. The crisis changed that dramatically and the non-Pfandbrief market has to this day not recovered from the severe drawdown. The German Pfandbrief and Jumbo Pfandbrief markets, on the other hand, suffered much shallower underperformance versus government debt, and recovery came more swiftly. In late 2009, both Pfandbrief indices had revisited the peaks in cumulative excess returns previously reached before the onset of the crisis in 2007. Over the 10-year period, Pfandbriefe and Jumbos produced accumulated returns that were around 20 and 30 basis points higher than for government debt respectively. Their excess returns were steadier than those of the broader market as well. While Pfandbriefe outperformed equivalent government debt in more than 60 percent of months, the covered bond index as a whole did so only in slightly more than 50 percent of periods.

It should be noted that these excess returns are calculated by the index provider against the benchmark government debt of the euro zone, i.e. usually German Bunds, which proved to be the European sovereign most in demand during the crisis. Calculated against the issuers' respective home government debt, the excess returns of covered bonds are more favourable.

Figure 3: Spread of Spanish covered bonds over Spanish and German sovereign debt

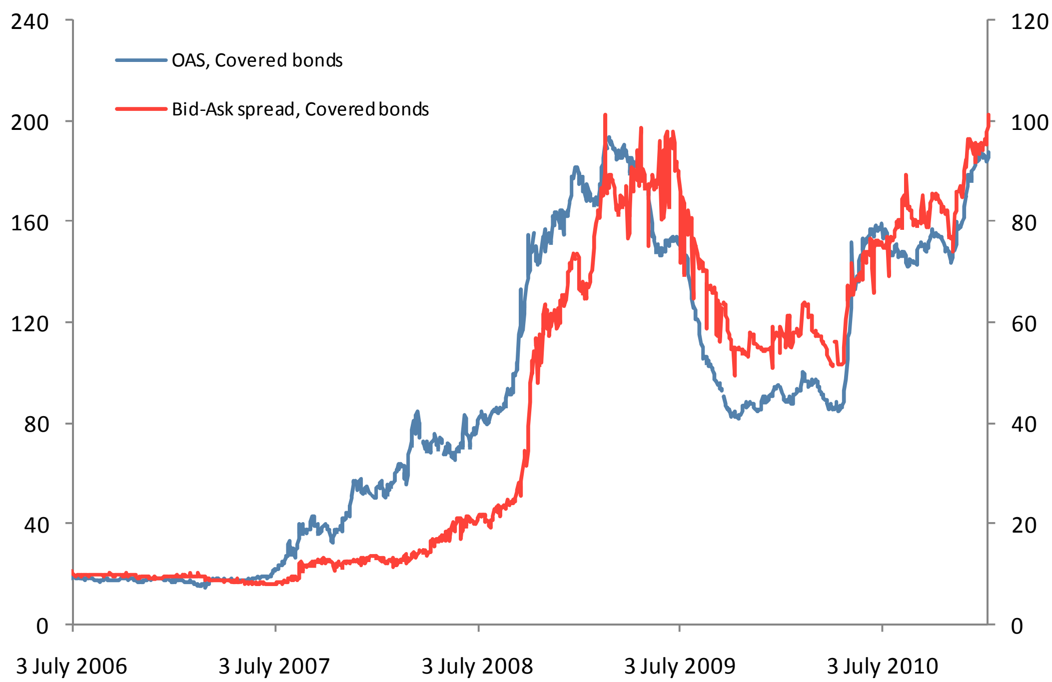


Source: Markit iBoxx

This can be seen by comparing the spread of Spanish covered bonds over their own sovereign debt with that of Spanish covered bonds over German government debt, as shown in Figure 3. Although the spreads of Spain's covered bonds over their home sovereign debt widened during the financial crisis, the rise is less striking than against German Bunds.

The financial crisis of 2007-2009 made investors more conscious of some risks of investing in covered bond markets for which there was less awareness previously. One was the trading liquidity of the asset class; another was the weaker-than-expected solvency position of banks globally and the (to a certain degree related) sovereign debt crisis in Europe. Liquidity, as measured by the Bid- Ask spread is illustrated in the figure below.

Figure 4: Bid-Ask and option adjusted spreads for covered bonds

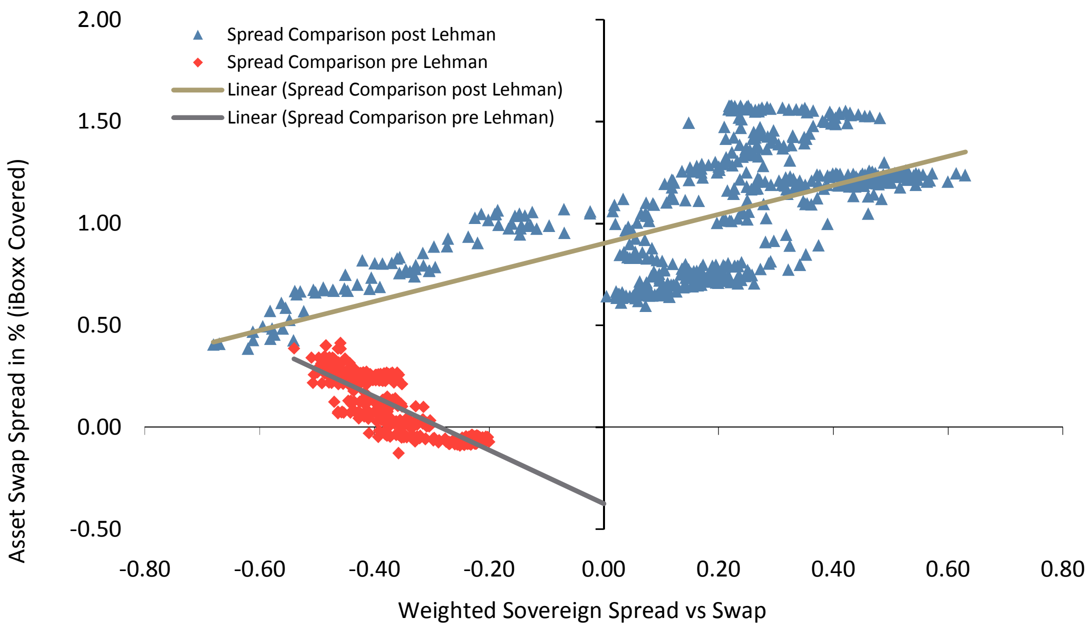


Source: iBoxx, NBIM

By late 2007, it became evident that the interbank market-making agreements that were designed to ensure liquidity in covered bonds could not be maintained in the face of a systemic crisis. In November 2007, market-making in the securities was suspended by the European Covered Bond Council, a group representing covered bond market makers and issuers, for nearly one week. Trading liquidity was again severely limited during the fall-out from the bankruptcy of Lehman Brothers in the autumn of 2008, but it has improved since then, albeit not returning to the pre-crisis levels. The worse-than-expected liquidity of covered bonds was one important contributing factor to their underperformance versus the safest government debt.

The freeze in wholesale lending markets in the wake of Lehman's collapse also affected primary market activity in covered bonds and marked the beginning of the longest period without benchmark covered bond issuance. The primary covered bond market remained effectively shut until the beginning of 2009. In order to prevent a complete freeze in bank funding, governments started guaranteeing bank bond issuance, which gave rise to the new class of government-guaranteed bank bonds (GGBs). In the aftermath of the crisis, these have become a relatively inexpensive source of long-term funds for banks, competing with covered bonds, but governments are keen to phase out the use of government guarantees amid a pick-up in covered bond issuance.

Figure 5: Correlation of covered bond spreads and sovereign spreads before and after Lehman



Source: Landesbank Baden-Württemberg (2010)

The second key factor affecting covered bonds negatively was the severity of the downturn in some national housing markets, which had a detrimental effect on bank solvency and ultimately sovereign solvency positions. Notwithstanding their overcollateralisation, covered bonds were negatively influenced by concerns over the viability of some issuer banks. When governments began supporting the financial sector and came to the rescue of the most seriously troubled institutions, covered bonds were impacted by worries over the ability of some of the smaller European nations with large banking sectors to provide an adequate backstop. This can be seen by inspecting the correlation of covered bond spreads with sovereign spreads (both relative to swaps), which has turned from negative in the period before the Lehman collapse to a significantly positive correlation (see Figure 5). Due to the involvement of European governments in supporting and bailing out banks, the outlook for bank debt including covered bonds has been perceived to be linked to the respective home country's sovereign debt.

The role of covered bonds in a diversified portfolio

Key policy institutions such as the European Central Bank (2010) have endorsed covered bonds, arguing that the structural advantages of covered bonds were validated during the financial crisis. This was underlined by the ECB's covered bond purchase programme in 2009, which was aimed at reviving market activity in this pivotal part of the capital markets. Another indication of the strategic importance of covered bonds is their preferential liquidity classification and more favourable haircut valuations for repo transactions with the ECB, compared to single-recourse instruments such as senior unsecured bank debt. Driven by this policy support, covered bonds are likely to remain an important funding tool for banks in the post-crisis financial market architecture.

What is more, credit quality as measured by average ratings has remained at the highest level for covered bonds (AAA/AA1 for the Barclays Capital euro covered bond index) while it has declined for the equivalent European sovereign index (AA1/AA2). In response to the crisis, covered bond issuers have been reported to increase the overcollateralisation in their cover pools (Landesbank Baden-Württemberg, 2010). Despite the divergence in credit quality, the correlation between the spreads of covered bonds and their respective home sovereign debt has become strongly positive in the aftermath of the Lehman bankruptcy. A sovereign credit event is likely to weigh on the covered bonds of the relevant country.

Due to their structural features and collateral, some covered bonds may be able to continue to pay out all cash flows due even in the face of the respective home sovereign's default or debt restructuring. However, covered bonds should not be considered an infallible hedge against the issuer's home country risk. The home country sovereign of a covered bond issuer ultimately has the power to tax and to enforce burden-sharing by private creditors. In the event of a sovereign credit event, a knock-on effect for holders of covered bonds issued by institutions of that country is more likely when the sovereign has spent a large amount of public resources on supporting the financial sector. However, covered bond holders should be better protected than senior unsecured and subordinated debt holders against such scenario due to their high ranking in the capital structure.

Summing up, an investment in a covered bond shares some of the portfolio characteristics of an investment in a government bond, but cannot be expected to be liquid at all times and has to be assessed in the context of the relevant jurisdiction. Markets with long history and a robust framework for the asset class, such as the German Pfandbrief market, have demonstrated that covered bonds can provide a yield pick-up over government debt at the expense of lower liquidity. Due to the recent involvement of the state in supporting and bailing out banks, the outlook for covered bonds has been linked to that of the relevant sovereign. Analysis of the underlying collateral of a covered bond, the issuer, the sovereign credit and the national political and regulatory framework are all important for successful investment in the asset class.

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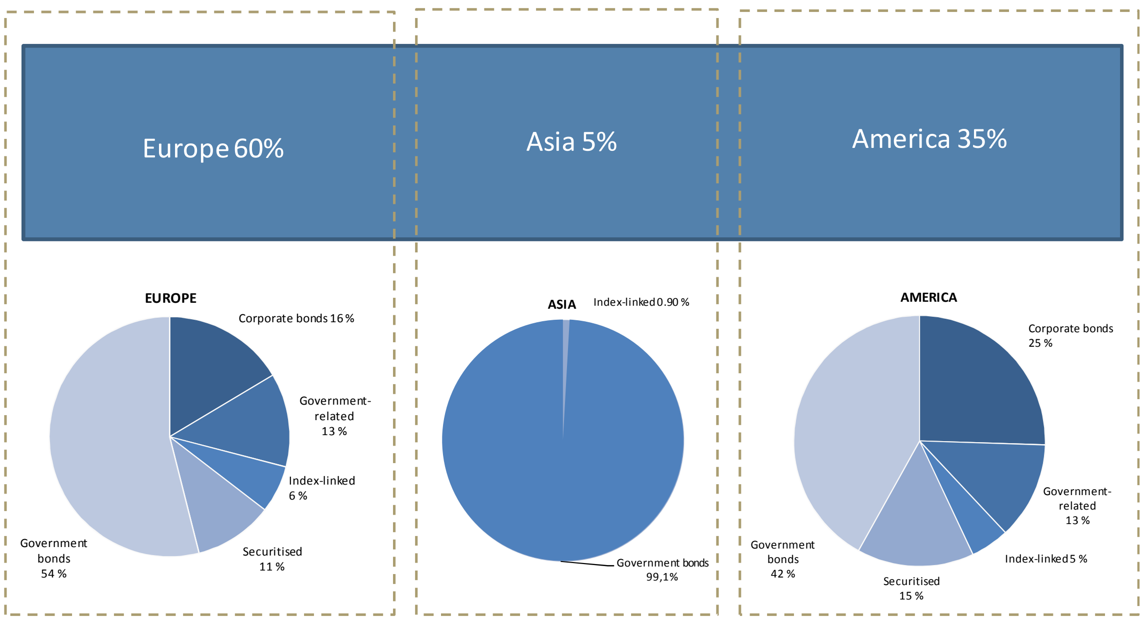
Chapter 4

Descriptive and empirical analysis

The Fund's strategic fixed-income index

The Fund’s strategic fixed-income index is based on sub-indices of *Barclays Capital Global Aggregate Index* and *Barclays Capital Global Inflation-Linked Index* . The Fund's startegic fixed-income index is made up of of three regional portfolios which are assigned fixed weights. The benchmark is market weighted within each of the three regions, with the exception of a re-weighting between different segments of the US market. The index for Switzerland amd Asia covers only government bonds.

Figure 1: Composition of the Fund's strategic fixed-income index, January 2011



Source: Barclays and NBIM

At the start-up of the Fund in 1996 the Fund was entirely invested in bonds according to the currency reserves allocation; 75 percent in 5 European countries, 18 percent in the United States and 7 percent in Japan. Since then, the benchmark for fixed-income investments has changed a number of times. The last major change took place in 2002 when corporate bonds and securitised debt were included. Changes to the Fund’s fixed-income index since the establishment of the Fund are summarised in the table below.

Year	Changes Made
1997	Effective from July 1st 1997, a new benchmark consisting of 10 currencies was established.
1998	New regulations for the management of the Fund were implemented in January 1998. Equity was introduced as a separate asset class. The Salomon Government Bond Index was kept as the benchmark for the fixed-income investments. The regional weights were set to 50 percent in Europe, 30 percent in the United States and 20 per cent in Asia/Oceania. The portfolio was GDP-weighted within these regions.
	The number of countries in the index for fixed-income investments was increased from 10 to 17. Portugal was later included, and the number of countries increased to 18.
1999	A technical adjustment of the currency composition took place when the ECU ceased to exist and the Euro was introduced.
2000	The GDP-weight calculation methodology moves from the existing practice of using average exchange rates to using GDP figures from IMF, measured in USD.
2001	Greece joins the Economic and Monetary Union and is included in the benchmark, effective from January 31st 2001.
2002	The regional weight for Asia/Oceania is decreased by 10 percentage points. This is offset by a 5 percentage point increase in the regional weights of Europe and USA each.
	The benchmark is extended to include corporate bonds and securitised debt in the United States, Europe (excluding Switzerland) and Asia/Oceania. The Salomon index is replaced with the Lehman Global Aggregate.
	The benchmark allocation to securitised debt (MBS/ABS) in the United States is set to 25 percent of a market weighted index. US government- and corporate bonds are weighted up in order to maintain a fixed allocation to USD.
	The benchmark allocation to Japan is set to 25 percent of market-cap of the Japanese bond market.
	Move from GDP-weights to market-cap weights within the three strategic regions.
2003	It was decided that the benchmark allocation to Asia would only consist of government bonds.
2005	Index-linked bonds are included in the benchmark. Adaptation to new sector classification in the Lehman Global Aggregate index.
2006	A further reduction of 5 percentage points in the regional Asia weight is met with a corresponding increase in the regional Europe weight.
2007	New weighting regime for US bonds. Agencies and MBS/ABS are assigned a weight of 50 percent of their respective market weight. Thus, the remaining sectors in USD are weighted upwards.

The dynamics of the Barclays Global Aggregate Bond Index

Main Findings

- Duration on the Barclays Global Aggregate Bond Index has trended upwards over the sample period.

- The relative share of BBB corporate bonds has increased to 29% from 24% within the BGA corporate segment.

- Monthly returns on US and European Treasuries can explain 89% of the monthly returns on the Barclays Global Aggregate Bond Index. Together, US, European, Japanese and British Treasuries can explain 96% of the monthly returns on the Barclays Global Aggregate Bond Index.

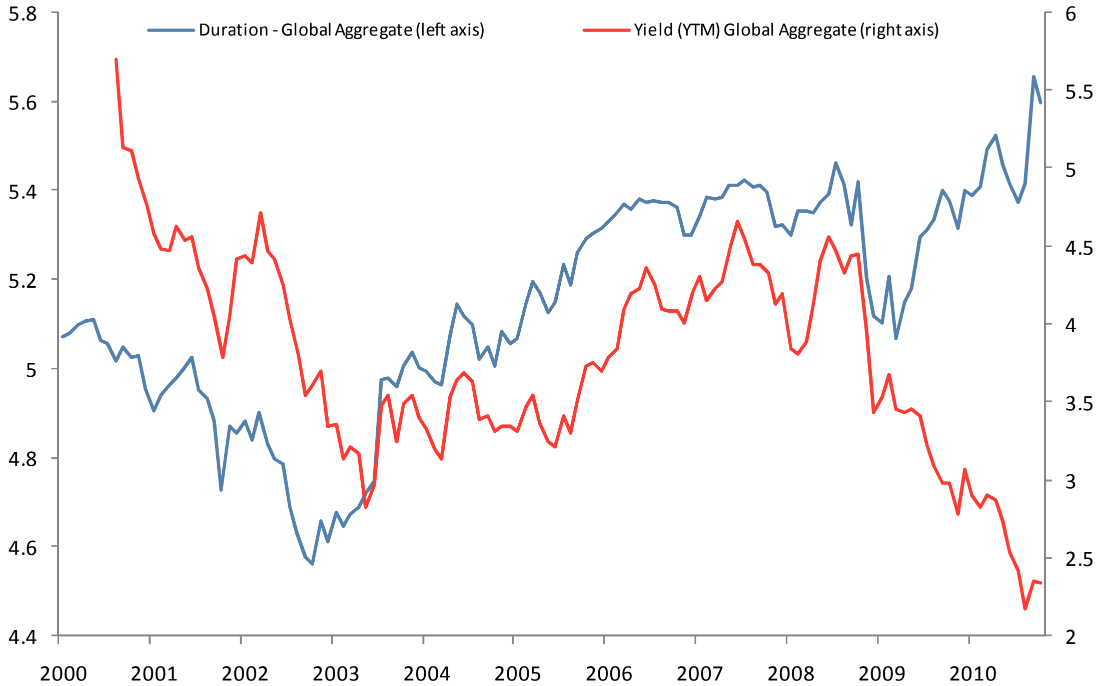
In this section, we look more closely at the dynamics of the Barclays Global Aggregate Bond Index.[1] These dynamics are extracted from a monthly data sample from the Barclays Capital Live database for the period 2000-2010.

By using a standardised fixed-income index as a benchmark, an investor must accept the index exposure to return drivers such as duration. The benchmark exposure will change as the index changes over time. As a result, the fixed-income benchmark will provide a target that is constantly moving.

As a motivating illustration for this analysis, consider the total Barclays Global Aggregate Index. One example of a key return driver for investments in this index is duration, as this provides a measure of the sensitivity of the index to movements in interest rates. The graph below looks back ten years and shows developments in duration up until November 2010.

[1] The Global Aggregate Index provides a broad-based measure of the global investment-grade fixed-rate debt markets.

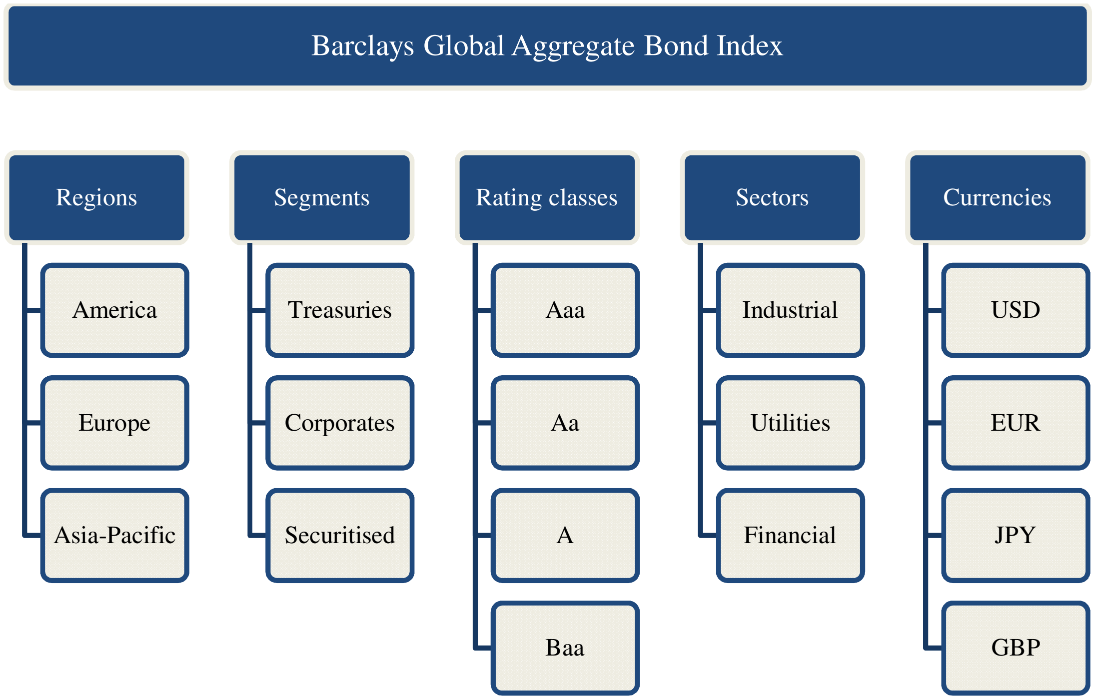
Figure 1: Barclays Global Aggregate duration



Source: Barclays Capital

As the above graph illustrates, exposure to key return drivers is not constant when investing in an index such as the Barclays Global Aggregate Bond Index. It is therefore interesting to see how these exposures have evolved over time in different sub-segments within the index. We break the index down into regions, segments, rating classes, sectors and currencies (see Figure 2) and look more closely at the dynamics within these breakdowns. In particular, we look at developments over time in terms of returns, duration and relative weighting.

Figure 2: Overview of index breakdown used in our analysis



Source: Barclays Capital

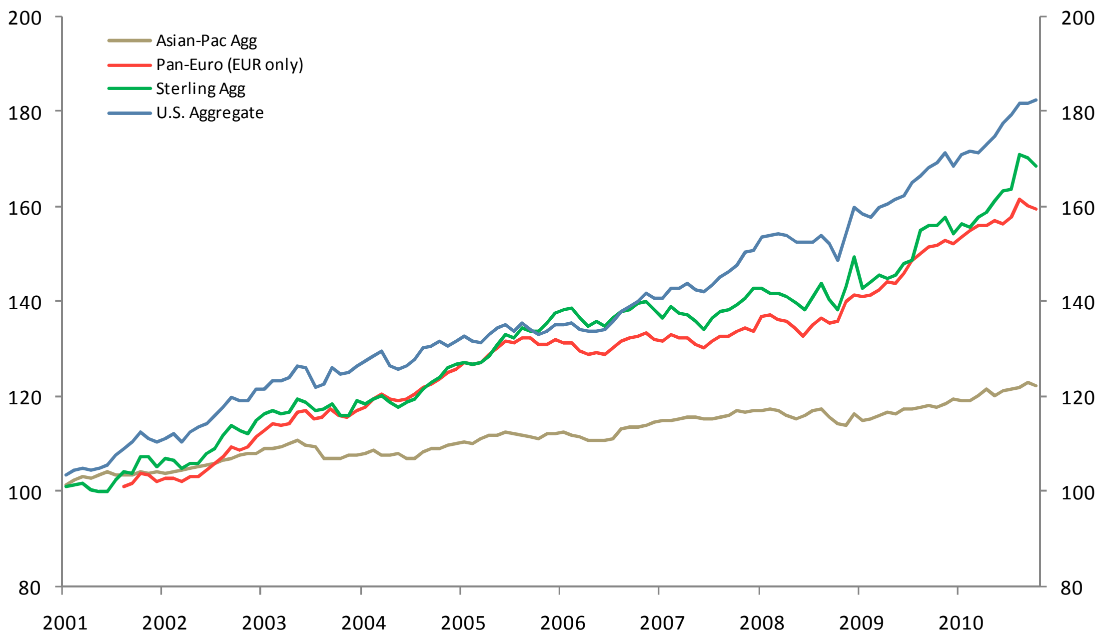
The Global Aggregate Index contains three major regional components:

- the US Aggregate (USD 300m)
- the Pan-European Aggregate (EUR 300m)
- the Asian- Pacific Aggregate Index (JPY 35bn)

Our region- and country-focused analysis will deviate somewhat from the above three major components as we wish to express returns net of currency effects. The Pan-European Aggregate index mainly includes bonds denominated in euro, but also bonds denominated in pounds sterling (GBP), the Swedish krona (SEK), the Danish krone (DKK), the Norwegian krone (NOK), the Czech koruna (CZK), the Hungarian forint (HUF), the Polish zloty (PLN), the Slovenian tolar (SIT) and the Slovakian koruna (SKK). Euro and pounds make up 95 percent of the index, and we thus separate out these two currencies, and use these as proxies for European exposure within the Aggregate index. The Asian-Pacific Aggregate mostly includes bonds denominated in JPY, and is consequently not decomposed into sub-currencies.

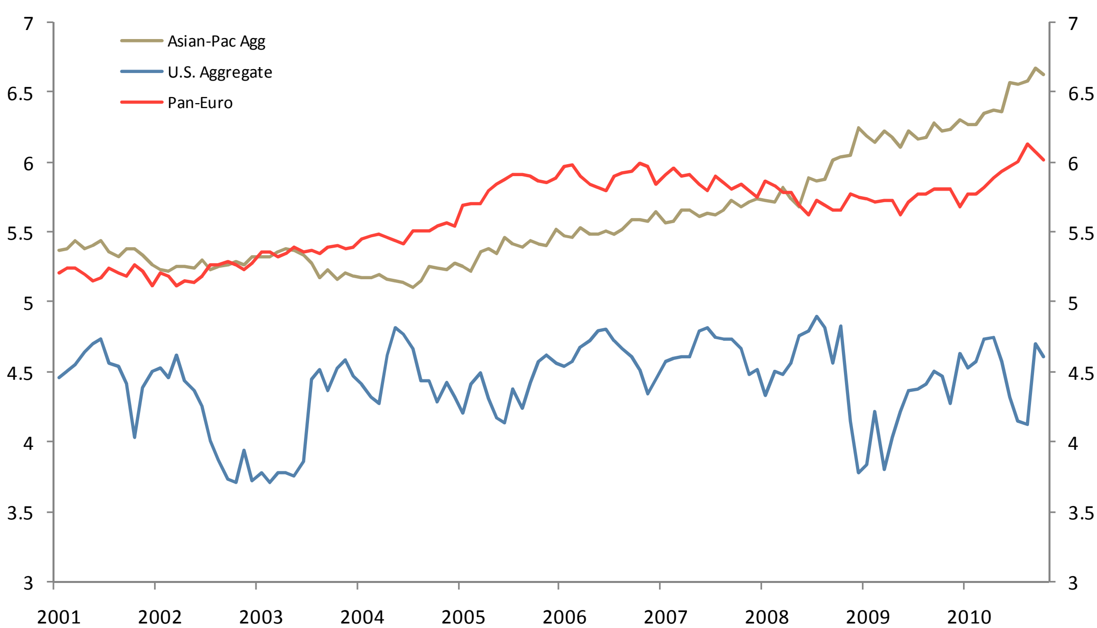
Regional dynamics

Figure 3: Historical returns by region



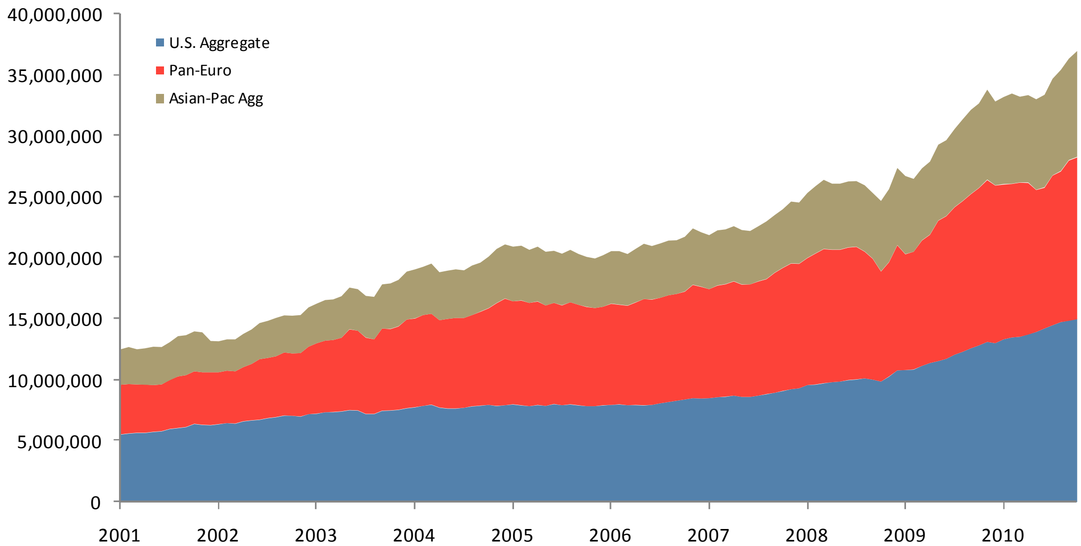
Source: NBIM calculations, Barclays Capital

Figure 4: Duration of regions



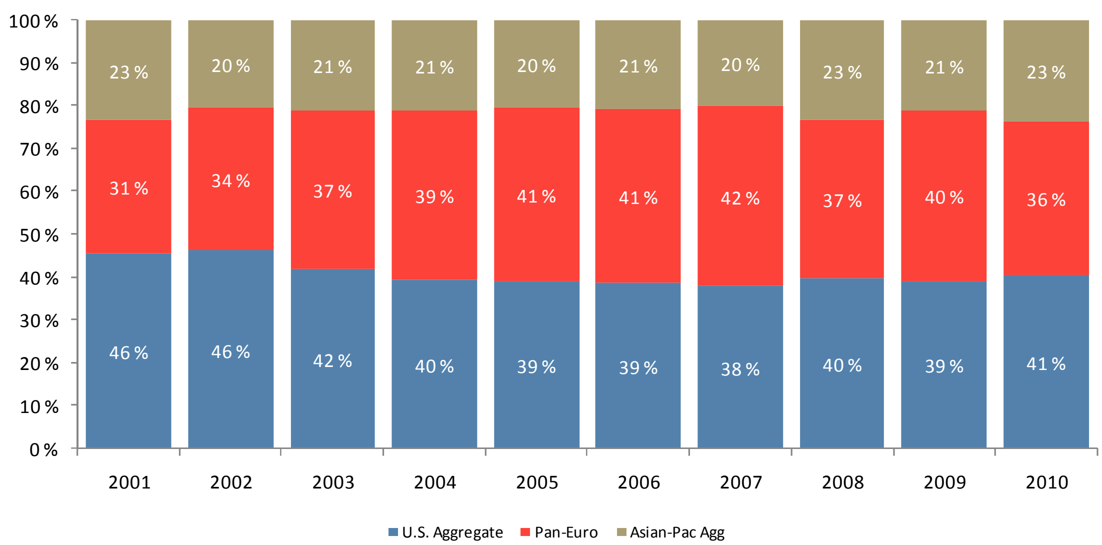
Source: Barclays Capital

Figure 5: Developments in region size (market value in US dollars)



Source: Barclays Capital

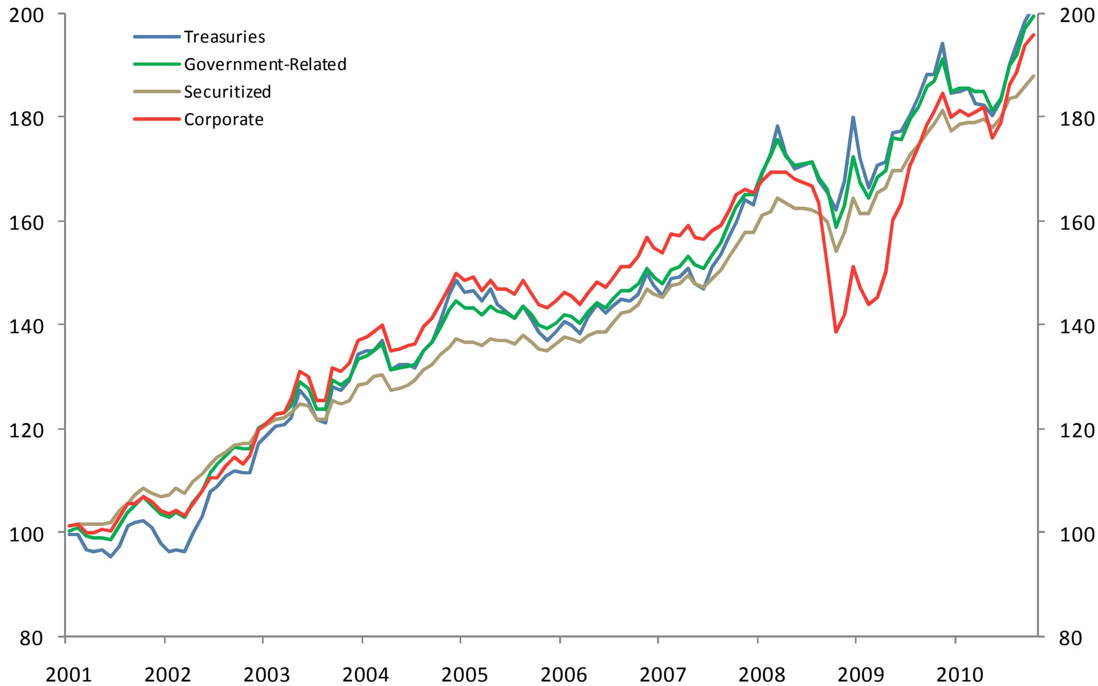
Figure 6: Historical composition by region (market value, percent)



Source: Barclays Capital

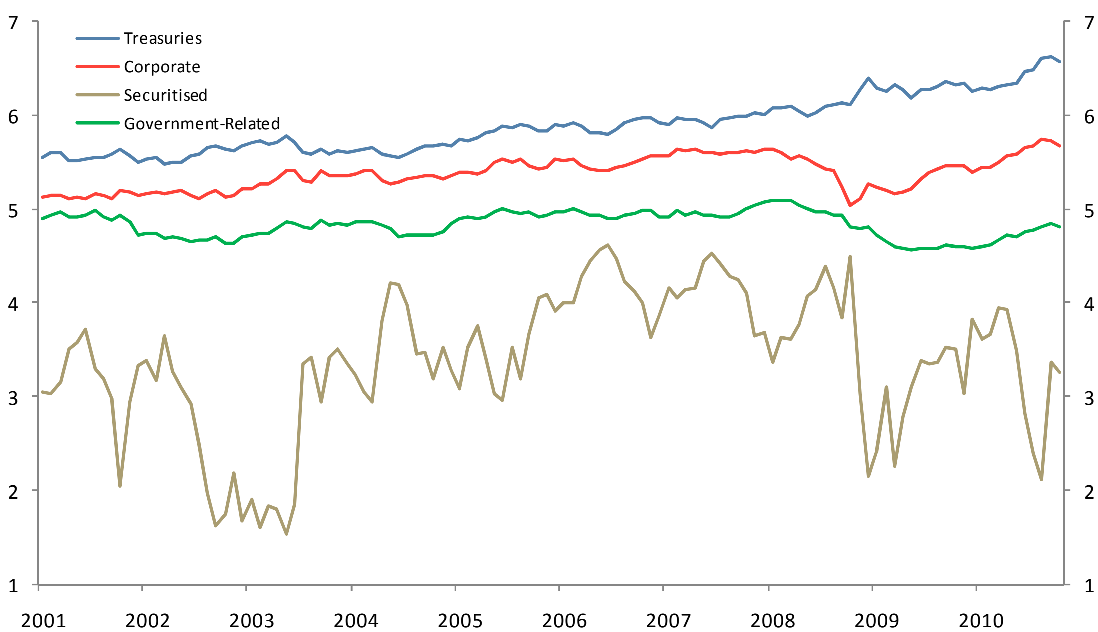
Segment dynamics

Figure 7: Historical returns by segment



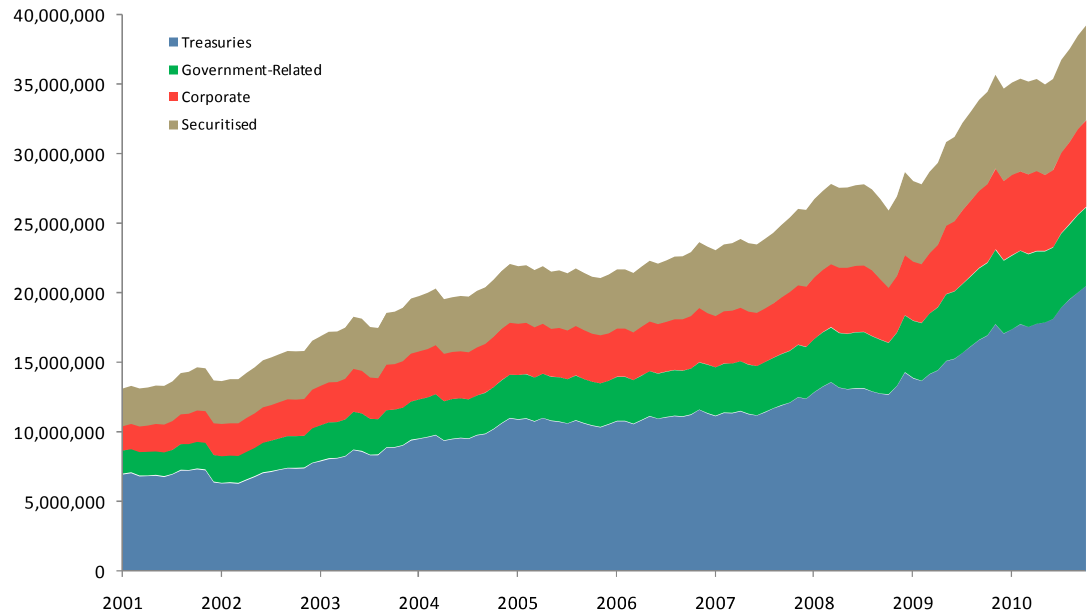
Source: NBIM calculations, Barclays Capital

Figure 8: Duration of segments



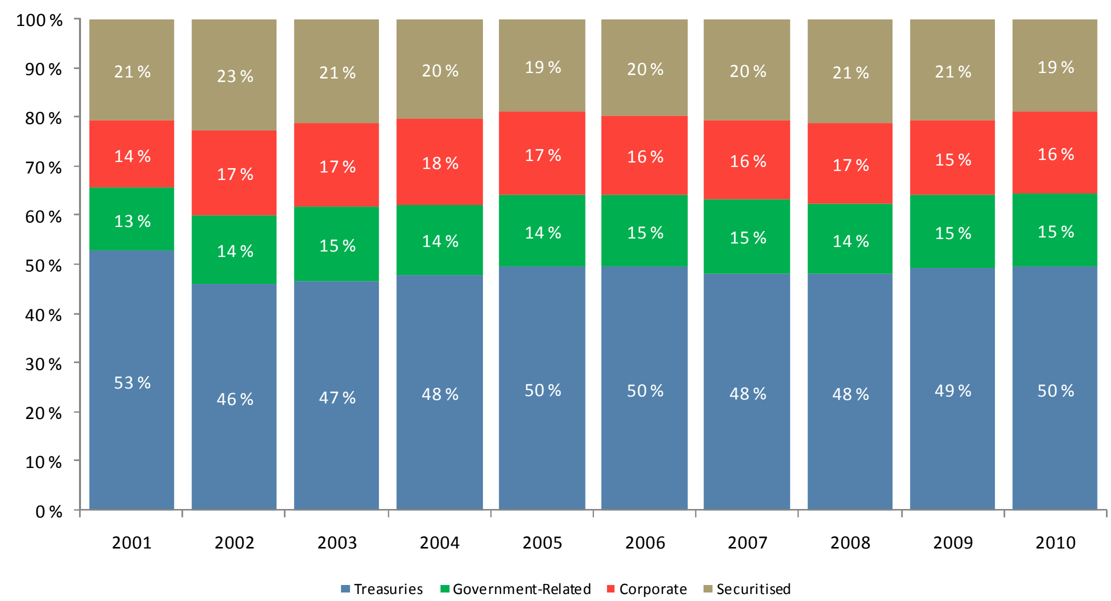
Source: Barclays Capital

Figure 9: Developments in segment size (market value in US dollars)



Source: Barclays Capital

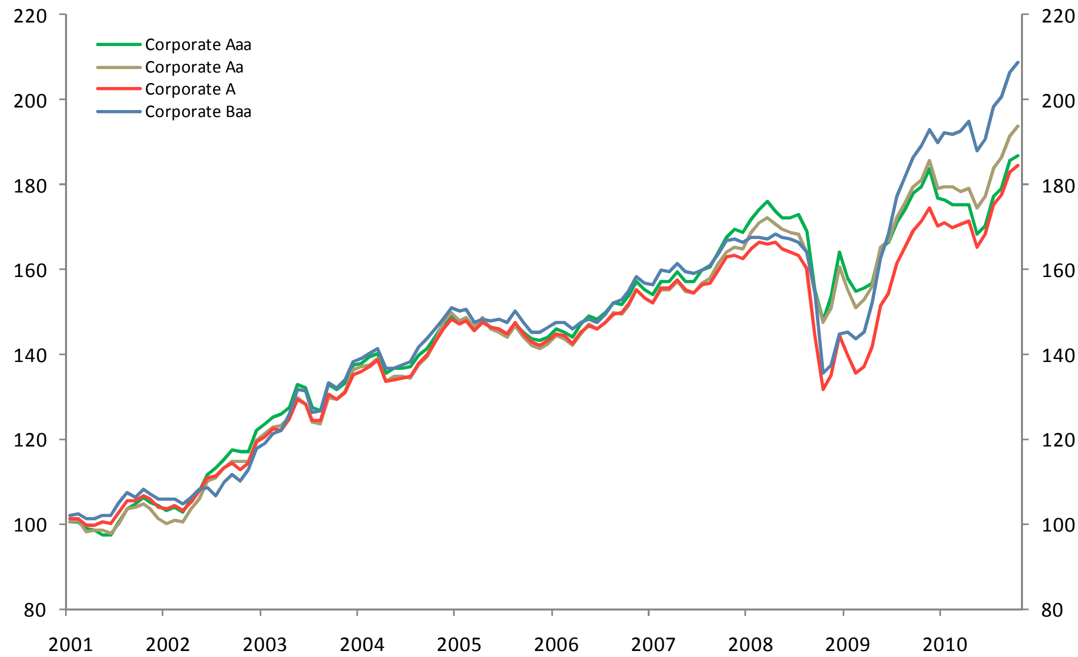
Figure 10: Historical composition by segment (market value, percent)



Source: Barclays Capital

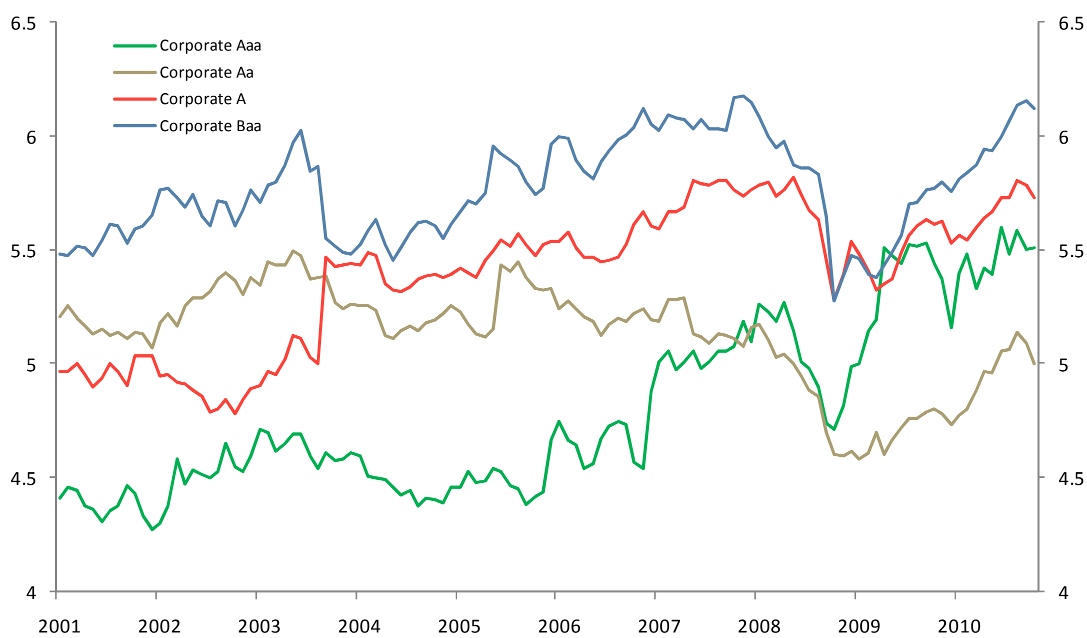
Rating class dynamics

Figure 11: Historical return on BGA corporate rating components



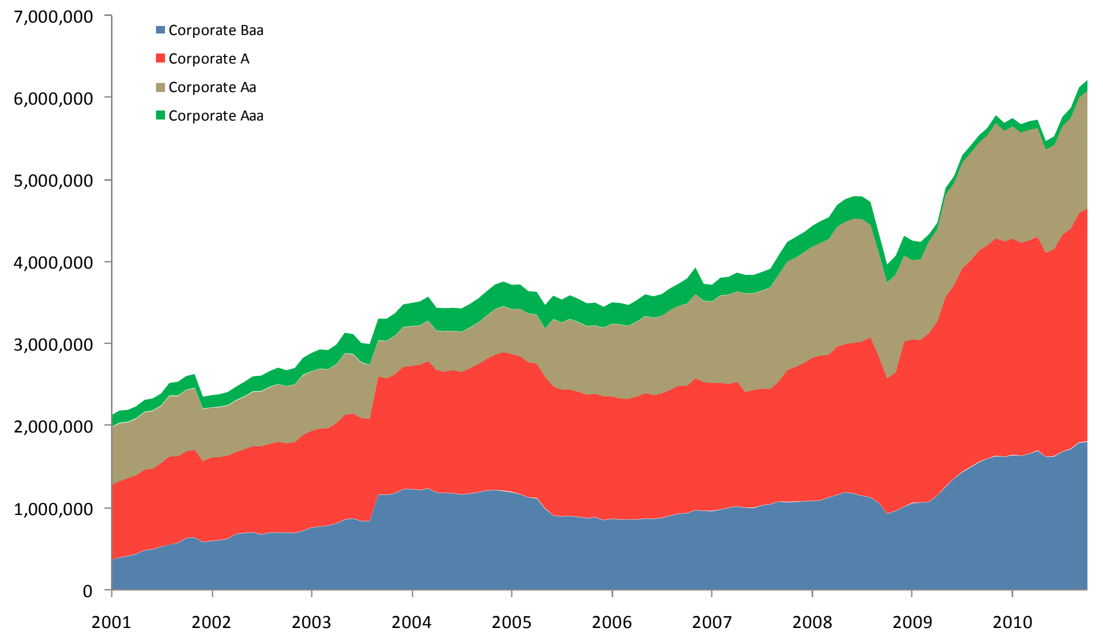
Source: NBIM calculations, Barclays Capital

Figure 12: Duration of BGA corporate rating components



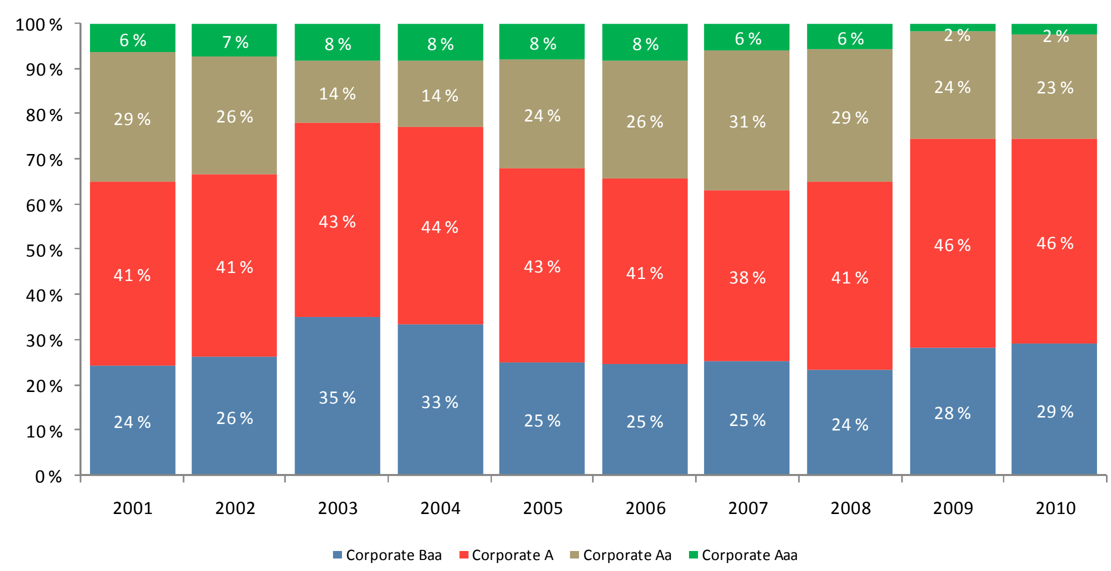
Source: Barclays Capital

Figure 13: Developments in BGA corporate rating class size (market value in US dollars)



Source: Barclays Capital

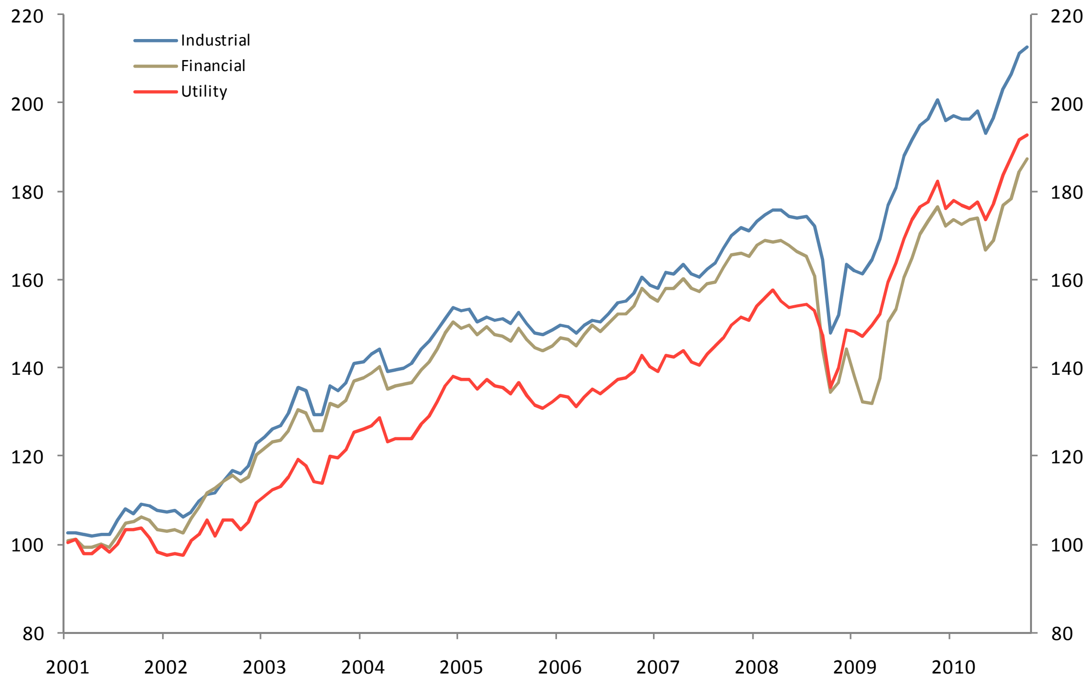
Figure 14: Historical composition by rating class within BGA corporate (market value, percent)



Source: Barclays Capital

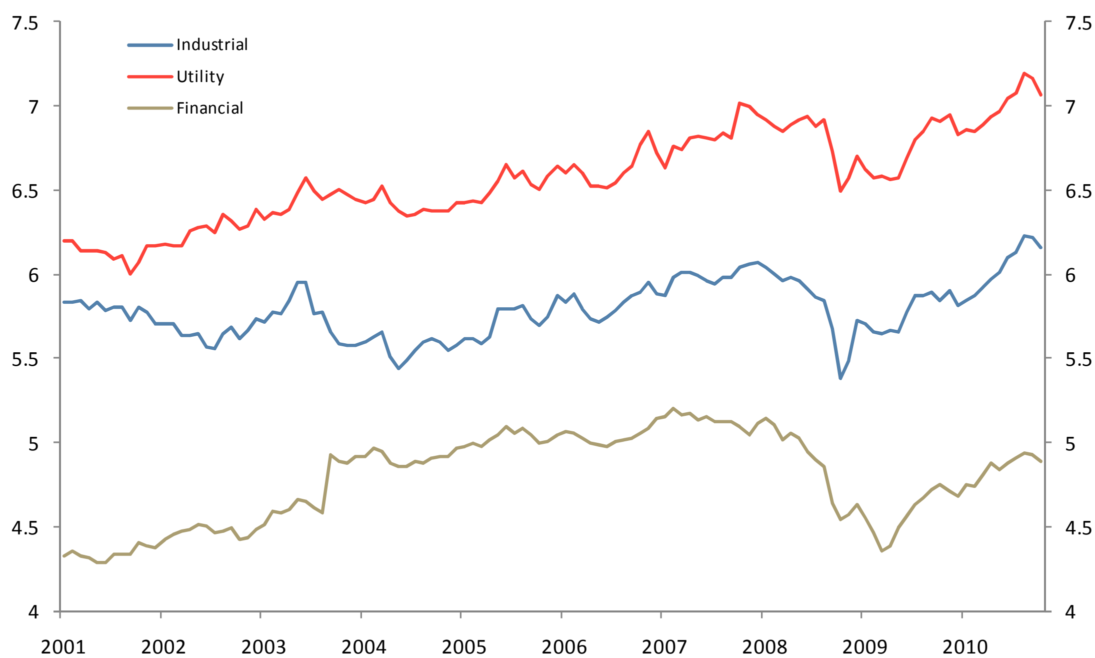
Sector dynamics

Figure 15: Historical return on three sectors



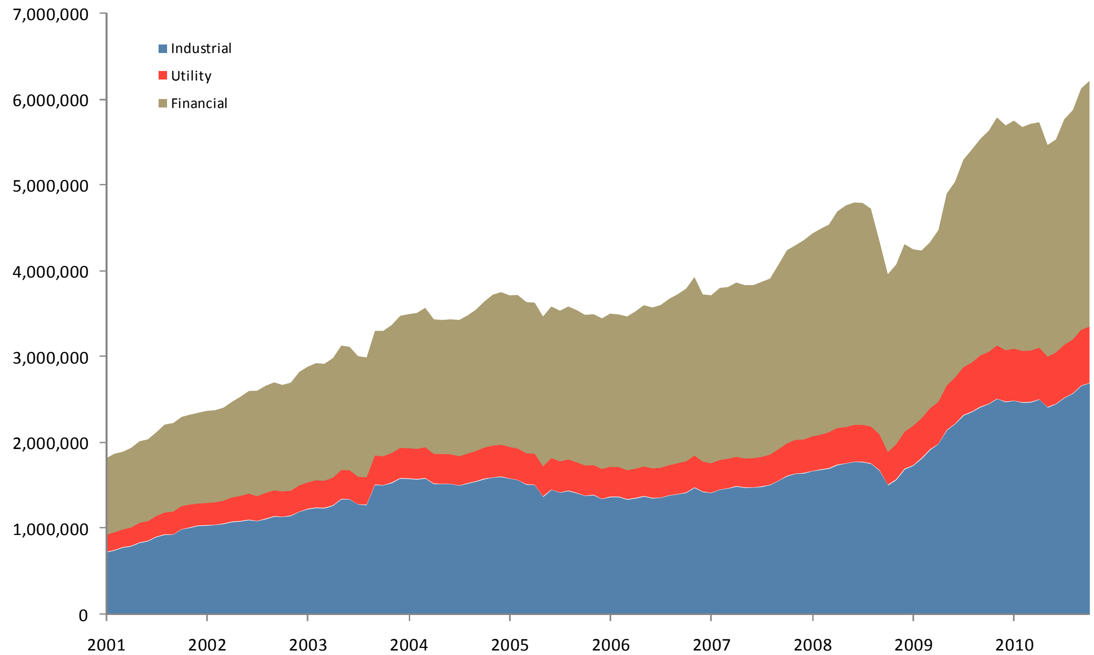
Source: NBIM calculations, Barclays Capital

Figure 16: Duration of three sectors



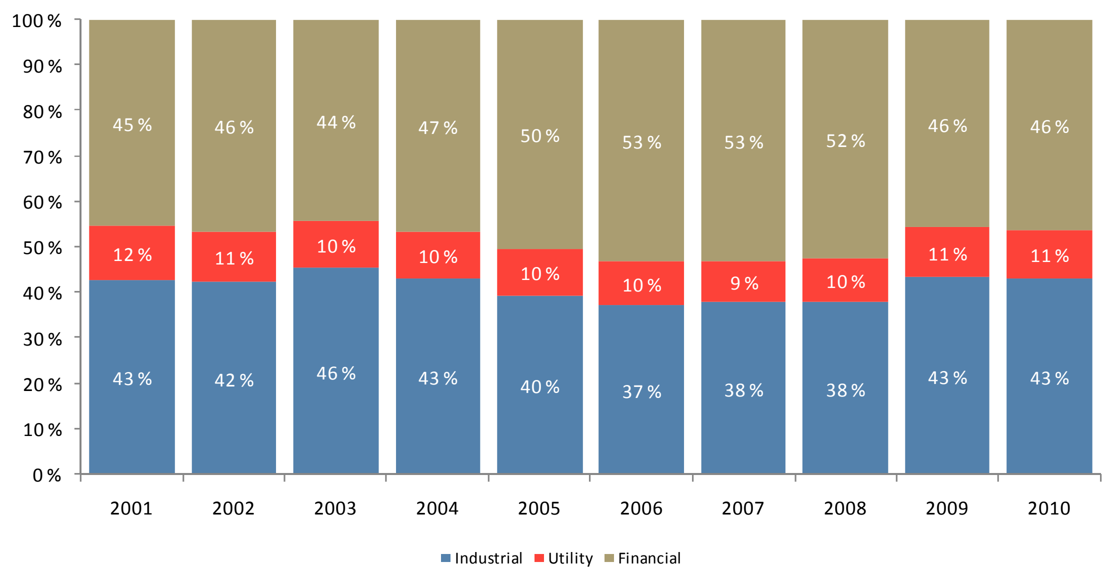
Source: Barclays Capital

Figure 17: Developments in sector size (market value in US dollars)



Source: Barclays Capital

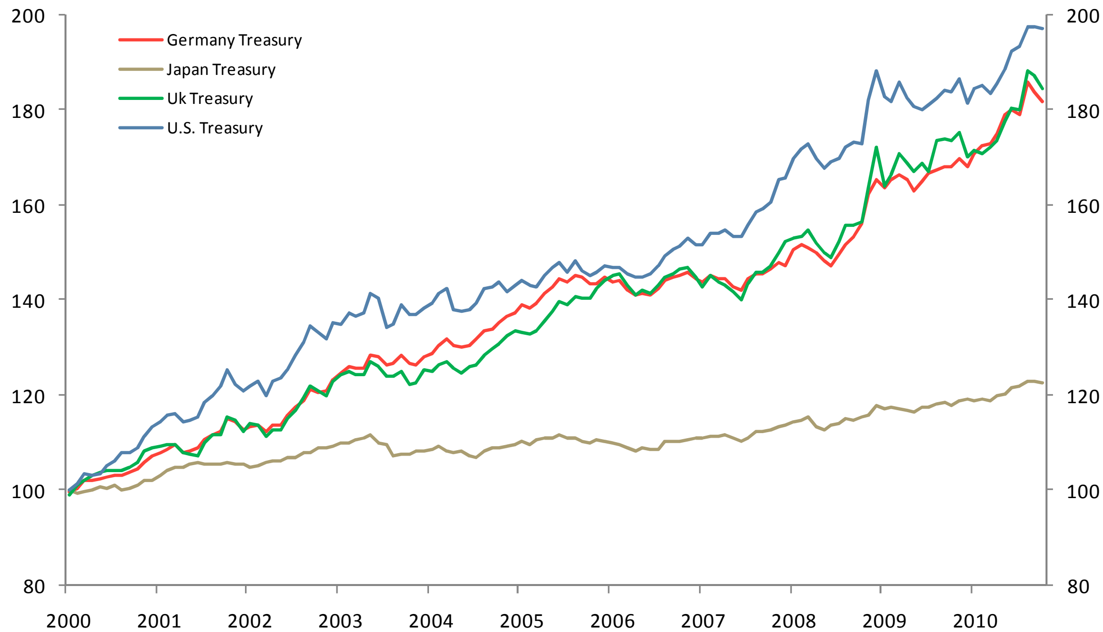
Figure 18: Historical composition by sector (market value, percent)



Source: Barclays Capital

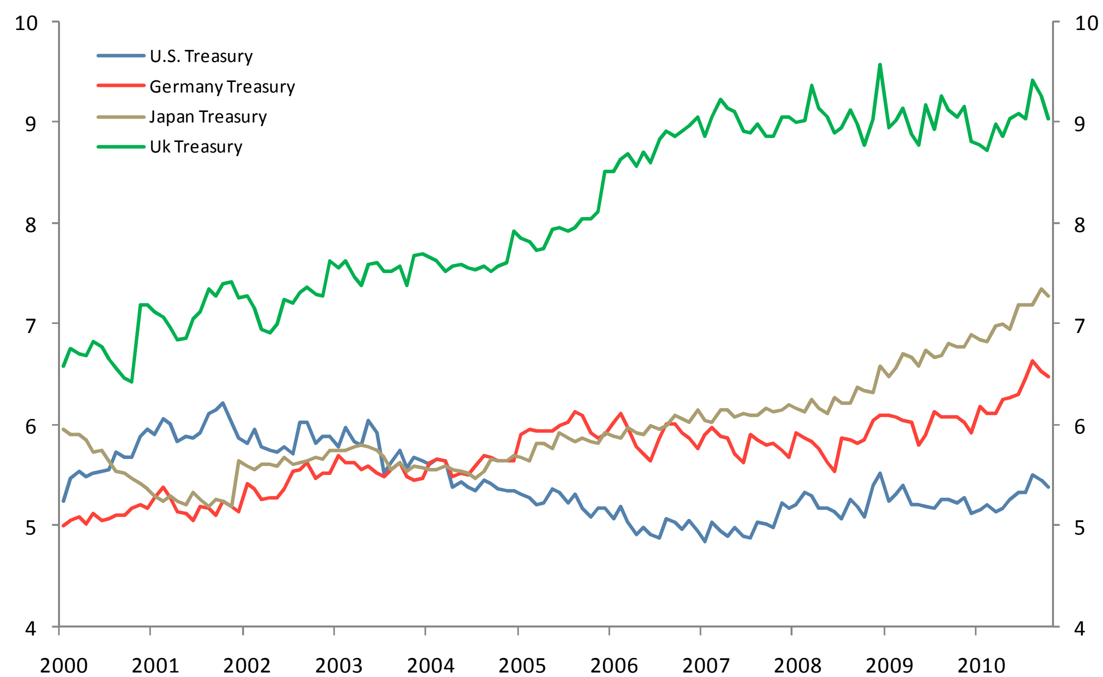
Dynamics on selected major currencies

Figure 19: Historical return on selected Treasuries



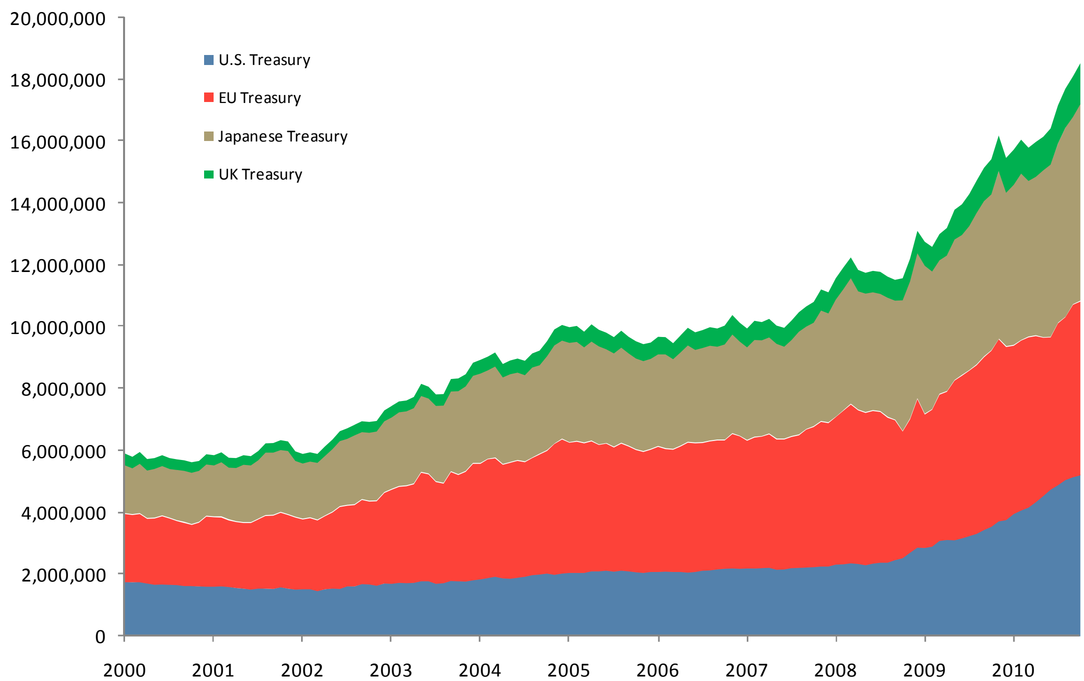
Source: NBIM calculations, Barclays Capital

Figure 20: Duration of selected Treasuries



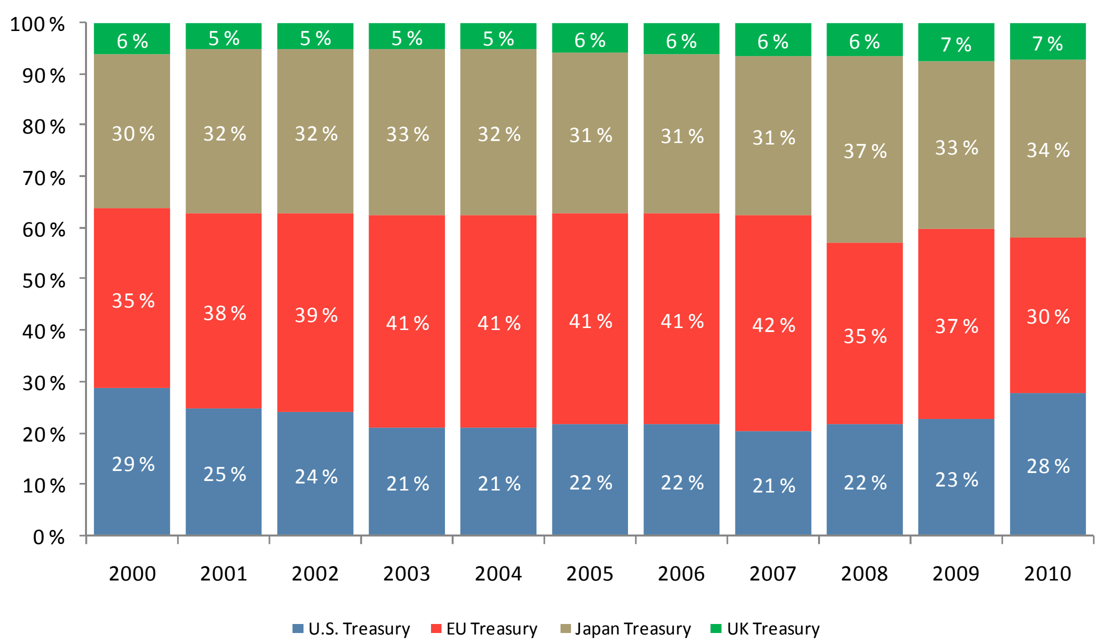
Source: Barclays Capital

Figure 21: Developments in size of selected Treasuries (market value in US dollars)



Source: Barclays Capital

Figure 22: Historical composition by selected Treasury (market value, percent)



Source: Barclays Capital

Regressions on Barclays Global Aggregate Bond Index

The returns on government bonds are a major determinant for the returns on aggregate fixed-income indices over time. We will now quantify this relationship within the Barclays Global Aggregate Bond Index.

First, we run an initial regression in order to assess the explanatory power of the returns on US and European Treasuries on the Barclays Global Aggregate Bond Index. All returns are expressed in hedged US dollar terms. The regression is specified as:

$$BGA_t = \alpha + \beta_1 US_{treasury_t} + \beta_2 EU_{treasury_t} + \varepsilon_t$$

Figure 23: Regression results

Regression Statistics	
Multiple R	0.945471238
R Square	0.893915862
Adjusted R Square	0.892271146
Standard Error	0.594804359
Observations	132

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	384.5777774	192.2888887	543.507954	1.4271E-63
Residual	129	45.6391971	0.353792226		
Total	131	430.2169745			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.072253783	0.055106097	1.311175837	0.192127488	-0.036774979	0.181282545	-0.036774979	0.181282545
US Treasury	0.336071894	0.04119973	8.157138183	2.64344E-13	0.25455722	0.417586569	0.25455722	0.417586569
EU Treasury	0.418254809	0.017049135	24.53231842	2.01358E-50	0.384522678	0.45198694	0.384522678	0.45198694

Source: NBIM calculations, Barclays Capital

Secondly, we add Japanese and UK Treasuries in order to assess the explanatory power of these four variables on the aggregate index. The regression is specified as:

$$BGA_t = \alpha + \beta_1 US_{treasury_t} + \beta_2 EU_{treasury_t} + \beta_3 UK_{treasury_t} + \beta_4 JAPAN_{treasury_t} + \varepsilon_t$$

Figure 24: Regression results

Multiple R	0.982432412
R Square	0.965173443
Adjusted R Square	0.964076544
Standard Error	0.343476619
Observations	132

	df	*SS*	*MS*	*F*	*Significance F*
Regression	4	415.2339987	103.8084997	879.9106142	1.60593E-91
Residual	127	14.98297582	0.117976188		
Total	131	430.2169745			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.091121629	0.03186062	2.860008042	0.004954314	0.028075213	0.154168045	0.028075213	0.154168045
US Treasury	0.208653365	0.025072851	8.321884418	1.16679E-13	0.159038719	0.258268011	0.159038719	0.258268011
EU Treasury	0.33489567	0.013676411	24.48710226	6.14862E-50	0.307832522	0.361958819	0.307832522	0.361958819
UK Treasury	0.085970687	0.015863965	5.419243333	2.89675E-07	0.054578764	0.117362611	0.054578764	0.117362611
Japan Treasury	0.175447637	0.011233637	15.61806117	2.40114E-31	0.153218296	0.197676978	0.153218296	0.197676978

Source: NBIM calculations, Barclays Capital

The two regressions show that most of the variation in the Barclays Capital Global Aggregate Index can be explained by a small number of underlying government bond indices. The adjusted R^2 with only the US and euro Treasury indices as explanatory variables, for example, is 0.89, implying that 89 percent of the monthly variation in the Barclays Capital Global Aggregate is determined by these two factors. Adding the Japanese and UK Treasury indices further increases the adjusted R^2 to 0.96.

Risk- and return properties of different benchmark designs

In this section we compare risk- and return properties of different benchmark designs. We try to isolate the impact of moving from a broad-based to a stylised narrower index from the impact of changes to the weighting regime.

First we look at the historical return properties of two different market weighted indexes. Then, we look at different weighting regimes. We compare the sector and currency composition of the proposed strategic benchmark to the Fund's current benchmark and market weights as of 31.12.2010. Finally we compare the historical risk- and return pattern of the proposed new benchmark to the current benchmark.

Main Findings

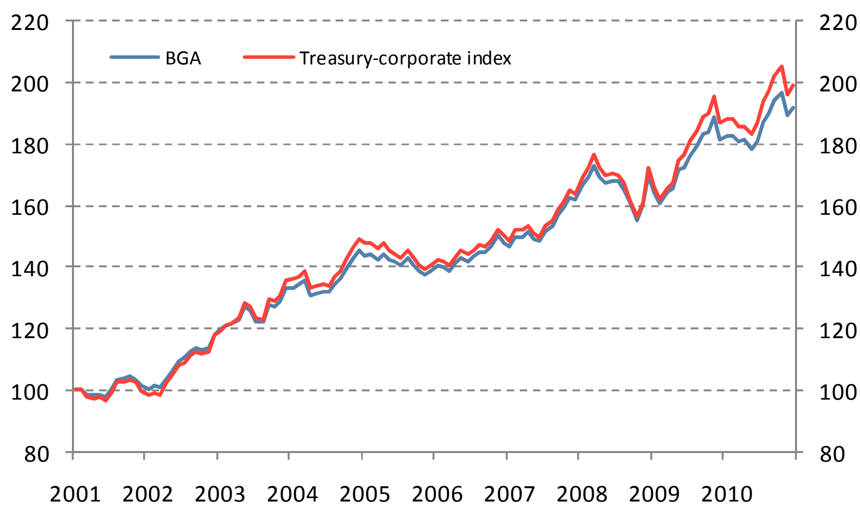
- A stylised version of the proposed strategic benchmark has shown better risk-return characteristics over a sample of daily data, going back to January 2006. Over this short time period the strategic benchmark had an annualised return of 6.25 percent with a standard deviation of 6.09 percent, while the Fund's current benchmark was 5.75 percent and 7.26 percent respectively.

Broad-based index versus a stylised narrower index

In the analysis below we have compared Barcalys Global Aggregate Index (BGA) to a narrower index made up of two of the four segments of BGA, namely Treasury and corporate. BGA is market weighted per definition, while the two sub-components of our narrower index have been assigned fixed weights of 70/30 respectively. Moreover, the narrower index is market weighted within each segment, which is made up of the four component currencies of BGA; EUR, JPY, GBP and USD. BGA consists of 23 currencies, but this difference in currency composition is not likely to have any significant impact on our findings. We have previously shown that returns on the BGA can be characterised by these four component currencies.

Our result is shown in Figure 1 below. Our calculations are based on monthly observations. We find that since 2001 the annualised return of the BGA and the narrower index has been 6.95 percent and 7.38 percent with a standard deviation of 6.33 and 7.11 percent respectively.

Figure 1: BGA and Treasury-corporate index performance over time



Annualised figures

	BGA	Treasury-Corporate index
Mean	6.95 %	7.38 %
St Dev	6.33 %	7.11 %

Source: NBIM calculations, Barclays Capital

Sector and currency composition of proposed strategic benchmark versus current benchmark

Figure 2 below show the sector composition of the proposed strategic benchmark versus the Fund's current benchmark as well as market weights as of end 2010.

We have also calculated the weighted duration, weighted yield to maturity and the weighted option adjusted spread. These stylised calculations are based on BGA segment numbers available through their POINT database and weighted according to respective weighting regimes. The proposed strategic benchmark had a higher duration, higher yield to maturity and a higher option adjusted spread as of 31.12.2010. However, this cannot be interpreted as a permanent feature only as a snapshot of the status as of end 2010.

Figure 2: Market weights and current and new benchmark weights across segments as of 31.12.2010

	Current benchmark weights	Market weights	New benchmark weights
CORPORATES	19.7 %	16.3 %	30.0 %
GOVERNMENT_RELATED	12.9 %	14.5 %	
SECURITIZED	12.4 %	17.9 %	
TREASURIES	55.0 %	51.3 %	70.0 %
Grand Total	***100.0 %***	***100.0 %***	***100.0 %***
Weighted duration	**5.76**	**5.65**	**5.84**
Weighted yield to maturity	**2.84**	**2.85**	**3.16**
Weighted OAS	**0.80**	**0.77**	**0.90**

Source: NBIM calculations, Barclays Capital

In Figure 3 we compare the currency composition of the proposed strategic benchmark to the current Fund benchmark as well as market weights. The currency composition is decomposed further into different segments in Figure 4. The proposed strategic benchmark entails a lower allocation to EUR and GBP and a higher allocation to USD and JPY. While the proposed allocation to USD is close to current market weights, the proposed allocation to JPY is significantly lower than market weights.

Figure 3: Market weights and current and new benchmark weights across currencies as of 31.12.2010

Total currency weights	Current benchmark weights	Market weights	New benchmark weights	Difference between current and new weights
AUD	0.4 %	1.1 %	2.0 %	1.6 %
CAD	2.2 %	2.7 %	3.5 %	1.3 %
CHF	0.5 %	0.8 %	1.3 %	0.8 %
DKK	0.8 %	0.4 %	0.6 %	-0.2 %
EUR	47.0 %	26.4 %	31.6 %	-15.5 %
GBP	9.5 %	5.3 %	6.7 %	-2.8 %
JPY	4.9 %	20.1 %	10.8 %	5.9 %
NZD	0.1 %	0.1 %	0.2 %	0.2 %
SEK	1.1 %	0.6 %	0.8 %	-0.2 %
SGD	0.2 %	0.1 %	0.3 %	0.2 %
USD	33.4 %	42.3 %	42.2 %	8.8 %
Sum	**100.0 %**	**100.0 %**	**100.0 %**	

Source: NBIM calculations, Barclays Capital

Figure 4: Market weights and current and new benchmark weights across currencies and segments

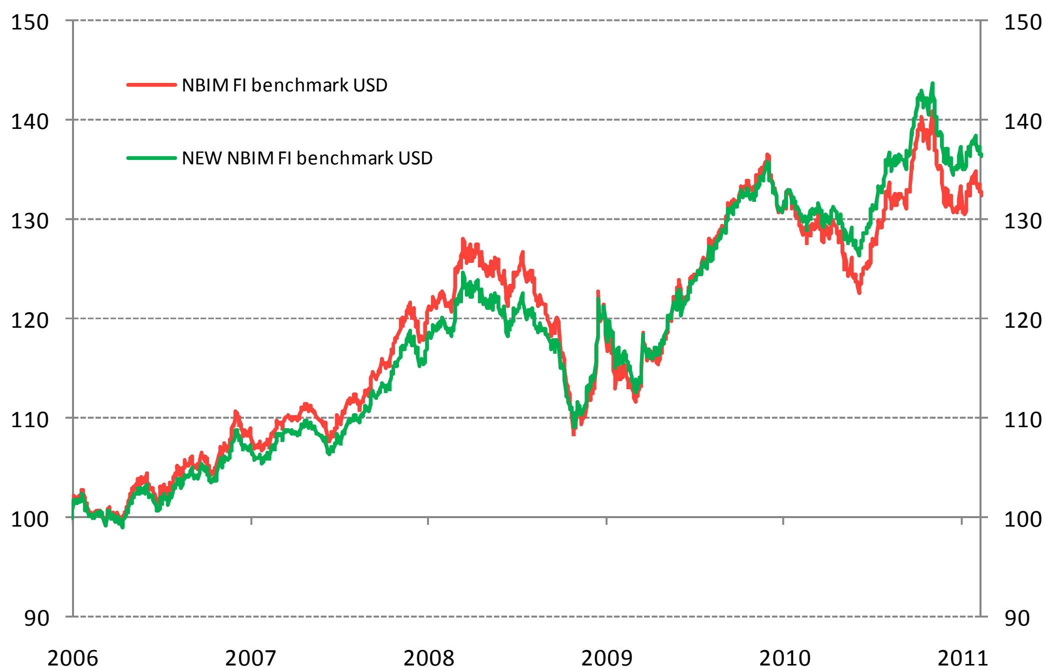
	GDP weights	Current benchmark weights		Market weights		New benchmark weights	
CORPORATES		**19.7 %**	% of segment	**16.3 %**	% of segment	**30.0 %**	% of segment
AUD				0.1 %	0.6 %	0.2 %	0.6 %
CAD		0.4 %	1.9 %	0.5 %	3.0 %	0.9 %	3.0 %
CHF				0.2 %	1.2 %	0.4 %	1.2 %
DKK		0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %
EUR		8.3 %	42.2 %	4.7 %	29.0 %	8.7 %	29.0 %
GBP		1.9 %	9.8 %	1.1 %	7.0 %	2.1 %	7.0 %
JPY				1.0 %	6.1 %	1.8 %	6.1 %
NZD				0.0 %	0.0 %	0.0 %	0.0 %
SGD				0.0 %	0.0 %	0.0 %	0.0 %
SEK				0.0 %	0.0 %	0.0 %	0.0 %
USD		9.1 %	46.1 %	8.6 %	52.9 %	15.9 %	52.9 %
GOVERNMENT_RELATED		**12.9 %**	% of segment	**14.5 %**	% of segment		
AUD				0.6 %	4.3 %		
CAD		1.0 %	8.0 %	1.2 %	8.6 %		
CHF				0.2 %	1.4 %		
DKK		0.0 %	0.0 %	0.0 %	0.0 %		
EUR		7.1 %	55.1 %	3.9 %	26.9 %		
GBP		1.0 %	7.8 %	0.5 %	3.5 %		
JPY				2.0 %	13.8 %		
NZD				0.0 %	0.1 %		
SEK		0.1 %	0.4 %	0.0 %	0.2 %		
USD		3.7 %	28.7 %	6.0 %	41.2 %		
SECURITIZED		**12.4 %**	% of segment	**17.9 %**	% of segment		
AUD				0.0 %	0.0 %		
CAD		0.0 %	0.0 %	0.0 %	0.0 %		
CHF				0.2 %	0.9 %		
DKK		0.3 %	2.4 %	0.2 %	0.9 %		
EUR		5.5 %	44.5 %	3.1 %	17.4 %		
JPY				0.0 %	0.1 %		
GBP		0.3 %	2.3 %	0.2 %	0.9 %		
SEK		0.6 %	4.9 %	0.4 %	2.1 %		
USD		5.7 %	45.9 %	13.9 %	77.6 %		
TREASURIES		**55.0 %**	% of segment	**51.3 %**	% of segment	**70.0 %**	% of segment
AUD	2.6 %	0.4 %	0.8 %	0.4 %	0.7 %	1.8 %	2.6 %
NZD	0.3 %	0.1 %	0.1 %	0.1 %	0.1 %	0.2 %	0.3 %
CAD	3.7 %	0.8 %	1.4 %	1.0 %	1.9 %	2.6 %	3.7 %
CHF	1.3 %	0.5 %	0.8 %	0.3 %	0.5 %	0.9 %	1.3 %
DKK	0.8 %	0.5 %	0.9 %	0.3 %	0.5 %	0.6 %	0.8 %
SEK	1.2 %	0.4 %	0.7 %	0.2 %	0.4 %	0.8 %	1.2 %
EUR	32.7 %	26.1 %	47.5 %	14.6 %	28.5 %	22.9 %	32.7 %
GBP	6.6 %	6.2 %	11.4 %	3.5 %	6.8 %	4.6 %	6.6 %
JPY	12.8 %	4.9 %	8.9 %	17.1 %	33.3 %	8.9 %	12.8 %
SGD	0.5 %	0.2 %	0.3 %	0.1 %	0.3 %	0.3 %	0.5 %
USD	37.6 %	14.9 %	27.1 %	13.8 %	26.9 %	26.3 %	37.6 %
OTHER							
Grand Total		**100.0 %**		**100.0 %**		**100.0 %**	

Source: NBIM calculations, Barclays Capital

Comparing current FI benchmark to proposed strategic benchmark

The graph below displays the daily performance of the Fund's current fixed income benchmark[1] and a stylised proxy of the proposed strategic benchmark. The stylised strategic benchmark is weighted 70/30 between Treasuries and corporate bonds, where the Treasury segment is GDP weighted and the corporate segment is market weighted. Our analysis is conducted on the basis on daily data and should be interpreted with caution. Note that this analysis is based on a significantly shorter data sample due to data availability. Over this short time period the strategic benchmark had an annualised return of 6.25 percent with a standard deviation of 6.09 percent. Corresponding figures for the Fund's current benchmark were 5.75 percent and 7.26 percent respectively.

Figure 5: Current and new fixed income benchmark performance over time



Annualised figures

	NBIM FI benchmark	NEW NBIM FI benchmark
Mean	5.75 %	6.25 %
St Dev	7.26 %	6.09 %

Source: NBIM calculations, Barclays Capital, NBIM

[1] All returns are measured in a common currency (USD)

Appendix – A note on Barclays Capitals GDP weighting methodology

Gross Domestic Product (GDP) Weighted Benchmark Bond Indices weight index-eligible countries by the size of their economies, rather than the total amount of outstanding debt and borrowing.

The underlying universe of securities of a GDP weighted benchmark is the same as that of a traditional market value weighted index. GDP weights have no impact on which securities are included in a benchmark, but rather how large a weight bonds issued in a certain currency have in the overall index. Therefore, each GDP weighted bond index will have the same number of securities as its market cap weighted equivalent, all other factors equal.

Barclays Capital GDP weighted indices use nominal GDP values (in USD, current prices) from IMF's World Economic Outlook (WEO) database each October to determine GDP weights. The International Monetary Fund (IMF) publishes its WEO database semi-annually in April and October; it includes actual, estimated, and forecast GDP levels by country.

Using GDP converted into USD enables comparisons to be made across different countries and currencies. A trailing 3-year weighted average of each country's nominal GDP is used, allowing GDP weights to reflect recently reported data while maintaining some historical perspective to make index weights more stable on a y/y basis.

GDP weights are recalculated annually and set as of January 1 of each year. GDP weighted bond indices rebalance back to the target GDP weight at the end of each month. This ensures that the index reflects the relative GDP weights at any point during the year, rather than allowing them to drift because of spot FX movements or the relative returns of the index components. Moreover, using a monthly reset to the target weight prevents a potentially large and concentrated index rebalancing that may be more difficult to execute if the GDP weights are allowed to drift.

Other major investors’ approach to fixed-income investments

This section gives a brief summary of how other large institutional investors have chosen to formulate its strategy for fixed-income investments.

ATP (Denmark)

ATP does not operate with a traditional benchmark but rather a risk budget, which are allocated between different risk classes. ATP distinguishes between allocation to credit and interest rate risk. The latter class is made up of Danish mortgage bonds and government bonds issued by OECD countries. The credit risk class includes all other types of bonds, such as corporate, high-yield, and emerging market debt. ATP has allocated 20 per cent of its risk budget to the interest rate and 10 percent to credit.

Canada Pension Plan Investment Board (CPPIB)

The Board of Directors has established a policy benchmark consisting of 35 percent liquid government bonds and 65 percent equities. This portfolio is expected to achieve the target return set for CPPIB at the lowest possible cost. CPPIB seeks to exploit the fund’s key characteristics through the operative management and create value beyond what a mechanical adjustment according to the policy portfolio would suggest. In practice this means that the fund's actual portfolio will differ quite a lot from the benchmark from time to time. All investments are “funded” by a combination of the two asset classes in the operative portfolio management. An investment in corporate bonds would for example be “funded” as a combination of equity- and interest rate risk.

Government of Singapore Investment Corporation (GIC)

Nominal bonds are expected to provide stable returns, liquidity and diversification of equity risk. In connection with their most recent investment strategy review, the GIC decided to remove corporate- and government-related bonds from the benchmark. GIC's benchmark currently consists of liquid government bonds of high credit quality (G5 currencies). This change reflects a desire that the benchmark to a greater extent should reflect the strategic role nominal bonds are expected to fulfil in the portfolio. The new benchmark is considered to be more defensive and less correlated with equity markets, particularly during periods of sharp declines in equity prices. In addition the benchmark can be expected to be more liquid during periods of financial stress.

APG (Netherlands)

In their fixed-income investments, APG distinguishes between nominal government bonds, index-linked bonds, money market instruments and credit bonds. The latter includes corporate bonds, high-yield, securitised debt and emerging market debt. This classification illustrates the fact that these different types of fixed-income instruments take on different roles in a portfolio. Each class is managed relative to a benchmark within a limit for relative volatility.