FIXED INCOME

CREDIT RISK AND MORTGAGE SECURITISATION

FIXED INCOME

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1. Credit risk*

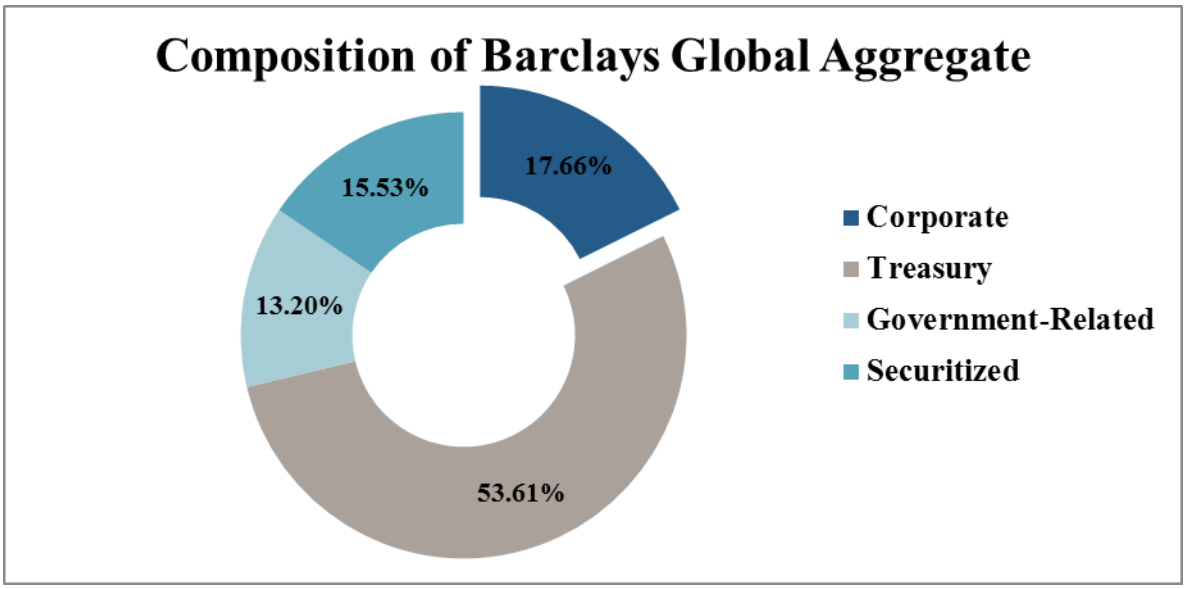
Credit risk reflects the likelihood that the security's issuer will default on payments of interest and/or principal. If the issuing firm is experiencing financial difficulties, it may not be able to honour the bond indenture and may default on a coupon (or principal) payment. To protect against such an occurrence, it is essential for the bond investor to know the issuer's future financial and business prospects.

As the default on Greece government bonds showed in 2012 even government bonds of OECD countries may not be deemed as default risk free. However defaults are more common in the corporate space and this section therefore is focussed on corporate bonds.

1.1 Relevance of the corporate bond market*

A good way to show the relevance of corporate bonds is their weight in broad based benchmarks. For example Barclays Global Aggregate Index provides a good overview of investment grade bonds globally.

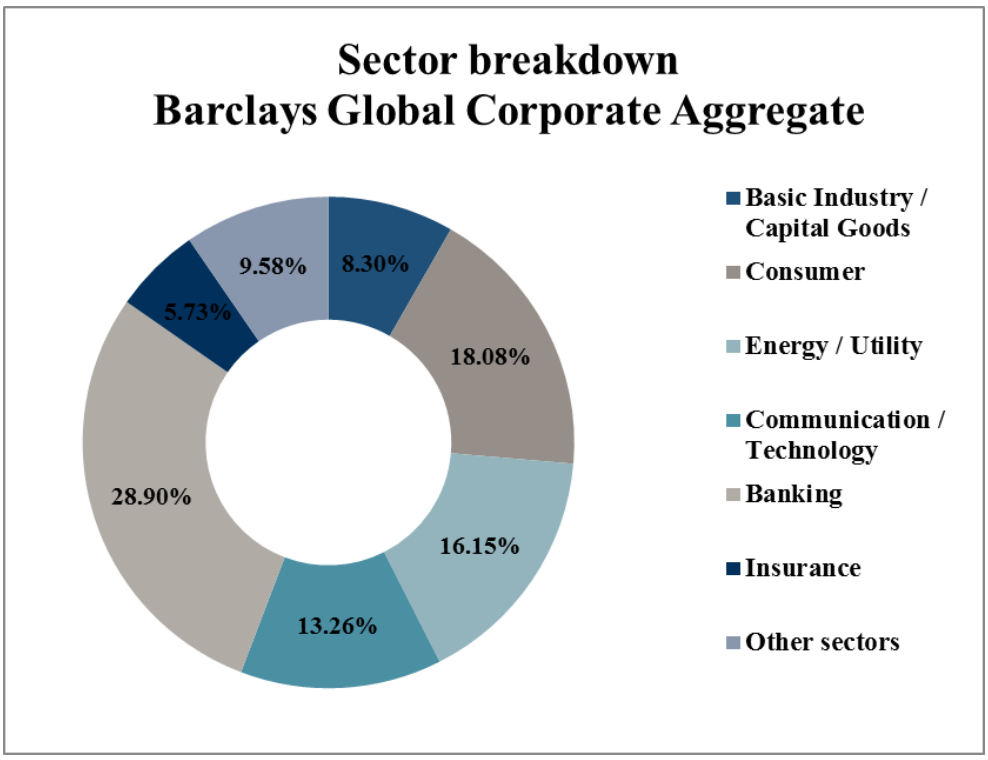
As of February 27, 2015, Barclays Global Aggregate Index showed a market capitalization of USD 43'252 bn and the following composition:



Source: Barclays Bank PLC, Data as of 27.02.2015

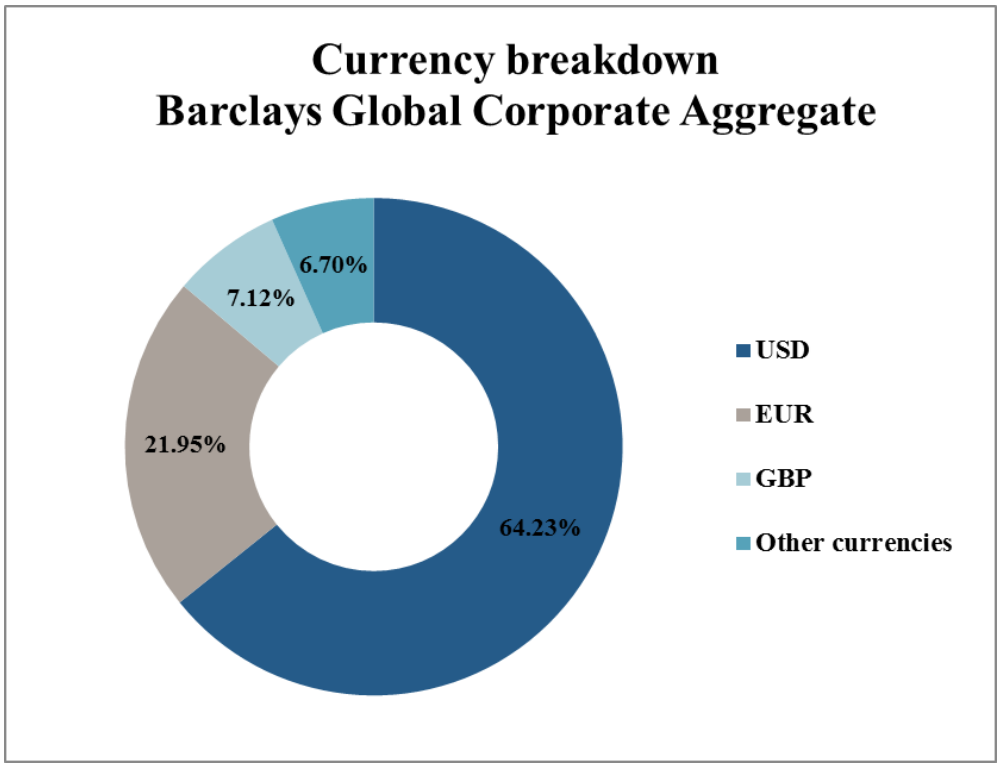
Overall the relevance of corporate bonds is even bigger than the counted USD 7'638 bn, as there are various requirements to be fulfilled in order to be included in the index. As many corporate bonds don't have an investment grade rating or an issue size of above EUR/USD 300 m they are not considered in these numbers. Another index rule is that bonds with a maturity of less than one year get also excluded. As this is valid for both government and corporate bonds this shouldn't change the picture much.

The exclusion of high yield bonds, however, is certainly the biggest factor which is responsible for underestimating the relevance of corporate bonds. According to Barclays Global High Yield Corporate Index the market value of corporate bonds with a subinvestment grade rating added up to USD 1'940 bn as of February 27, 2015. This equals to about a quarter of investment grade corporate bonds. Although there is more and more interest for alternatives in the actual low yield environment, many investors are still restricted from investments in high yield bonds, why the following charts only focus on investment grade corporate bonds.

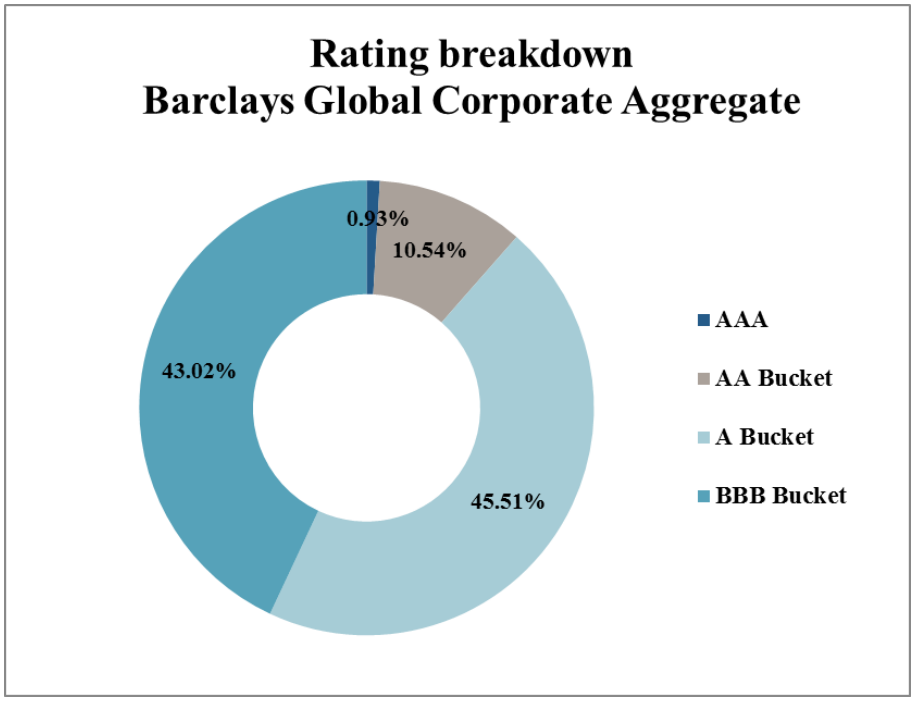


Source: Barclays Bank PLC, Data as of 27.02.2015

A closer look at the Barclays Global Corporate Aggregate shows that issuers out of the banking, consumer and energy/utility sectors have the largest weights. The banking sector weight can be explained with its the heavy reliance on external financing. In respect of currencies USD is the currency of choice for the majority of issuers as the United States have the most developed corporate bond market. As the ratings migrated down in the last years the vast majority of issuers have their rating now in the single A- or BBB-range.



Source: Barclays Bank PLC, Data as of 27.02.2015



Source: Barclays Bank PLC, Data as of 27.02.2015

Comparing todays corporate bond market with that one of 10 years ago shows the dramatic changes the market went through. The corporate bond market doubled its size, halved its yield, doubled its spread, lowered the average rating by one notch and increased its duration by one year.

	Barclays Global Corporate Aggregate		
	as of 28.02.2005	**as of 27.02.2015**	**Difference**
Number of Issues	4'786	9'014	4'228
Market Value in bn USD	3'726	7'638	3'912
Average Rating Moody's	A1/A2 (6.644)	A3/Baa1 (8.006)	-1.362
Average Rating S&P	A/A- (7.019)	A/A- (7.881)	-0.861
Yield to Worst	4.05%	2.39%	-1.67%
OAS (Option adj. Spread) in bps	55.4	113.5	58.1
Duration to Worst	5.41	6.38	0.97

Source: Barclays Bank PLC, Data as of 27.02.2015

1.2 Fundamental credit analysis*

Since the actual payment on due time of a corporate bond is more or less uncertain, it is important to know the **factors affecting credit risk**, in order to measure it and to try to manage it. The ability to repay debt is ultimately linked to the borrower's ability to generate **adequate cash flows**, the economic and financial current and prospective conditions of the firm are thus of primary interest and concern for bond's investors. Thus it is important to be aware of the fundamental factors which influence credit risk.

Usually credit investors shape their judgment about the firm's ability to repay its debt both on economic and industry wide considerations and on firm specific considerations.

*1.2.1 Industry considerations**

As far as economic and industry wide considerations are concerned, the main factors which have to be taken into account are:

- Economic cyclicality: the more an industry is cyclical the higher is the credit risk of firms operating in that industry, because cyclicality means variability of returns and this increases the likelihood of default;
- Growth prospects: the better the growth prospects of an industry, the lower the credit risk of companies operating within it;
- Research and development expenses: are in large part sunk costs that can be recouped only if the firm is viable. Different industries have different incidence of R&D expenses;
- Competition: the higher the competition in an industry the lower and more volatile the profit margins of the firms in it, and thus the cash flows that can be employed to service the debt;

- Sources of supply: shortages in supply can be very harmful to the smooth conduct of operations by the issuer, to its profitability and thus to its ability to repay debt;
- Degree of regulation: the regulation of a particular industry tends to limit competition and thus to level the profitability of the subjects in that industry. Although regulation has a positive impact on the stability of cashflows, changes of the regulatory environment could have severe adverse effects and need to be monitored closely;
- Labor: the degree of unionization of an industry affects the profitability of firms operating in that industry and thus their ability to repay debt.

*1.2.2 Ratio analysis**

The financial resources needed to service the debt issued can come from three sources: cash flow from operations; liquidation of some asset; another source of financing. In the long run, however, the ability to repay debt comes essentially from **cash flows from operations**. Consequently, bondholders need to know something about the cash flows that the issuer is likely to generate. The main source of information relies on the analysis of balance sheet and income statement accounts and is synthesized in the analysis of **financial ratios** that relate different items of income statement and balance sheet.

Financial ratios are usually organized into categories: **common size ratios; profitability ratios; liquidity ratios; solvency (financial leverage) ratios; turnover ratios**.

a) **Common size ratios** express the relevant items of the balance sheet account as a percentage of total asset and relevant income statement account as a percentage of total revenue.

b) **Profitability ratios** express the firm's profitability compared to some investment base or to net sales and so measure the overall efficiency of the firm. The most common profitability ratios are:

$$\textbf{ROE (Return on Equity)} = \frac{\text{Net income}}{\text{Net worth}};$$

which is a summary measure of profitability;

$$\textbf{ROA (Return on Assets)} = \frac{\text{EBIT}}{\text{Total assets}};$$

which expresses the efficiency with which the management employs the total capital;

$$\textbf{Profit margin} = \frac{\text{Net income}}{\text{Net sales}};$$

which measures the profit per dollar of net sales. Its complement to 1 (1 – profit margin) gives the expenses incurred in order to generate 1 dollar of revenues.

c) **Liquidity ratios** underline the firm's ability to meet its short term liabilities. Two main ratios are used:

$$\textbf{Current ratio} = \frac{\text{Current asset}}{\text{Current liability}};$$

which shows the extent to which the claims of short term creditors are covered by assets readily convertible into cash;

$$\textbf{Quick ratio} = \frac{\text{Current assets - inventory}}{\text{Current liability}};$$

in this case only already liquid assets are compared with current liabilities so that the effect of inventory valuation is purged.

d) **Solvency (financial leverage) ratios** underline the degree with which the creditors are financing the firm. From the bondholder point of view, the amount of equity invested in the firm represents a buffer against the decline in value of total assets. The most common ratios are:

$$\textbf{Debt ratio (Leverage)} = \frac{\text{Total debt}}{\text{Total assets}};$$

it represents the portion of assets financed by creditors. The higher the leverage the higher the risk of the firm since its net earnings are more volatile.

$$\textbf{Net debt to EBITDA ratio} = \frac{\text{Net Debt}}{\text{EBITDA}};$$

is a dynamic measure of leverage and shows the company's debt repayment ability.

$$\textbf{Free operating cash flow to debt ratio} = \frac{\text{FOCF}}{\text{Debt}};$$

is a more conservative approach to show a company's debt repayment ability as it takes interests and taxes paid, capital expenditures and changes in working capital into consideration.

$$\textbf{Interest Coverage ratio} = \frac{\text{Earnings before Tax and Interest (EBIT)}}{\text{Interest expenses}};$$

which measures the degree by which the EBIT is absorbed by interest expenses; the lower the ratio, the higher the credit risk.

$$\textbf{Fixed-charge Coverage ratio} = \frac{\text{EBIT} + \text{lease payments}}{\text{Interest} + \text{lease expenses}};$$

which measures the degree by which the EBIT is absorbed by interest expenses and contractual commitments under leasing agreements.

e) **Activity ratios** (also called turnover ratios) measure the intensity with which the main assets are used to reach a given production. Three widely used activity ratios are: the average collection period; the fixed-asset turnover and the inventory turnover ratio.

$$\textbf{Average collection period} = \frac{\text{Receivable}}{\text{Sales per day}};$$

which indicates the average time the firm has to wait to collect after making a sale; it measures the quality of the commercial credit extended by the firm and the effectiveness of its collections

$$\textbf{Fixed asset turnover} = \frac{\text{Sales}}{\text{Fixed assets}};$$

which measures the sales relative to fixed assets. A low value indicates a below-capacity operations (slack of productive capacity) a high value may mean underinvestment in plant and equipment.

$$\textbf{Inventory turnover ratio} = \frac{\text{Cost of sales}}{\text{Average inventory}};$$

it shows the effectiveness of inventory management and gives the number of times in a year that the firms rolls over the whole inventory. Too high a level means a less than optimal inventory level (and risk of lost sales because of insufficient stock); too low a level may mean poor inventory and production management or even obsolete products.

A useful technique to summarize the main factors affecting the ROE (the main index, showing the ultimate source of income for the firm and so its capacity to refund debt) is given by the so called **Du Pont System** as follows

$$\textbf{ROE} = \frac{\text{Net income}}{\text{Pre-tax profits}} \cdot \frac{\text{Pre-tax profits}}{\text{EBIT}} \cdot \frac{\text{EBIT}}{\text{Sales}} \cdot \frac{\text{Sales}}{\text{Assets}} \cdot \frac{\text{Assets}}{\text{Equity}}$$

where the first term gives the so called tax-burden ratio (the average tax rate paid by the firm); the second gives the incidence of interest payments of the firm (the lower the interest paid, the higher the ratio); the third is the profit margin (also called ROS – Return on Sales); the fourth is the asset turnover ratio and the last is a measure of leverage.

1.3 Credit rating and rating agencies*

The relative credit-risks of long-term bonds are assessed by various independent financial services firms which are known as the rating agencies. The three major rating agencies are Moody's Investors Service (Moody's), Standard & Poor's Corporation (S&P) and Fitch. (There are numerous other local or sector specific ratings agencies, such as Japan Credit Rating Agency in Japan or A.M. Best for insurance companies.) Their analysts analyse the various financial data such as fundamentals of the company, industry data and the macro-economic data to determine the possibility of the default in interest and/or principal payments.

Beside the fundamental factors of an issuer the assumed support plays also an important role for the agency's credit rating. Support can vary from issuer to issuer and can be either intragroup or governmental support. Intragroup support is often designed as an explicit guarantee from stronger group entities to weaker ones. Governmental support can vary from a very strong support like explicit guarantees for governmental financing agencies to an assumed implicit support for privately owned systemic banks. An issuer receives usually the rating of the stronger guarantor if the support is designed as unconditional and irrevocable guarantee. In the past there was nearly the same outcome for implicit support which led for example to an alignment between government and bank ratings in 2006. While there was substantial support for banks during the financial crisis, the willingness to support banks suffered strongly thereafter. New regulations (Basel III) and new laws which facilitate bail-in of bondholders (e.g. European Bank Recovery and Resolution Directive (BRRD)) resulted in a strong reduction of assumptions for governmental support in the rating agency's methodologies. The impact on ratings could be mitigated by banks by increasing their capital base and shrinking their balance sheet in order to become fundamentally stronger.

Finally, based on these analyses, rating agencies assign a **rating** to the issuer which is published in various publications available to investors. Typically ratings are paid by the issuer.

The following table provides the brief definitions of Standard & Poor's and Moody's long-term ratings.

S & P	Definition	Moody's corresponding rating
Investment-grade bonds		
AAA	Highest rating assigned by S&P. The obligor's capacity to meet its financial commitment on the obligation is EXTREMELY STRONG.	**Aaa**
AA+ **AA** **AA-**	Differs from the highest rated obligations only in small degree. The obligor's capacity to meet its financial commitment on the obligation is VERY STRONG.	**Aa1** **Aa2** **Aa3**
A+ **A** **A-**	Somewhat more susceptible to the adverse effects of changes in circumstances and economic conditions than obligations in higher rated categories. However, the obligor's capacity to meet its financial commitment on the obligation is still STRONG.	**A1** **A2** **A3**
BBB+ **BBB** **BBB-**	ADEQUATE protection parameters. However, adverse economic conditions or changing circumstances are more likely to lead to a weakened capacity of the obligor to meet its financial commitment on the obligation.	**Baa1** **Baa2** **Baa3**
Speculative / Low Creditworthiness		
BB+ **BB** **BB-**	LESS VULNERABLE to nonpayment than other speculative issues. However it faces major ongoing uncertainties or exposure to adverse business, financial or economic conditions which could lead to the obligor's inadequate capacity to meet its financial commitment on the obligation.	**Ba1** **Ba2** **Ba3**
B+ **B** **B-**	MORE VULNERABLE to nonpayment than obligations rated "BB", but the obligor currently has the capacity to meet its financial commitment on the obligation. Adverse business, financial or economic conditions will likely impair the obligor's capacity or willingness to meet its financial commitment on the obligation.	**B1** **B2** **B3**
CCC+ **CCC** **CCC-**	CURRENTLY VULNERABLE to nonpayment, and is dependent upon favorable business, financial, and economic conditions for the obligor to meet its financial commitment on the obligation. In the event of adverse business, financial or economic conditions, the obligor is not likely to have the capacity to meet its financial commitment on the obligation.	**Caa1** **Caa2** **Caa3**
Predominantly speculative / Substantial risk or in default		
CC	Highly vulnerable to nonpayment. The "CC" rating is used when a default has not yet occurred, but S&P expects default to be a virtual certainty, regardless of the anticipated time to default.	**Ca**
C	Highly vulnerable to nonpayment and the obligation is expected to have lower relative seniority or lower ultimate recovery compared to obligations that are rated higher.	**C**
D	In default or in breach of an imputed promise. For non-hybrid capital instruments, the "D" rating category is used when payments on an obligation are not made on the date due, unless S&P believes that such payments will be made within 5 business days in the absence of a stated grace period or within the earlier of the stated grace period or 30 calender days. The "D" rating also will be used upon the filing of a bankruptcy petition or the taking of similar action and where default on an obligation is a virtual certainty (e.g. due to automatic stay provision). An obligation's rating is lowered to "D" if it is subject to a distressed exchange offer.	

Standard & Poor's and Moody's ratings[1]

These ratings are used by market participants as a factor in the valuation of securities because of their independent and unbiased nature and because they directly reflect the probability of default. The following table shows the cumulative mortality losses (in %) by original Standard & Poor's rating, covering default and issues from 1981 to 2013.

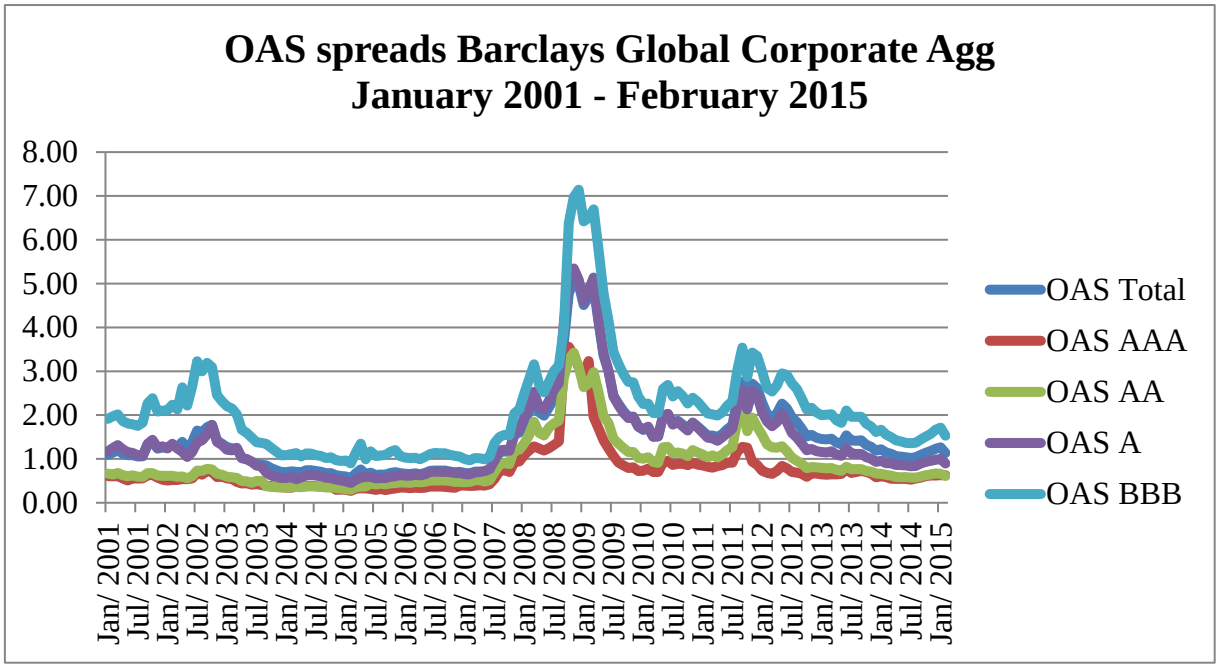
[1] Source: Bloomberg, Standard & Poor's Corporation.

Original rating	Years after issuance									
	1	2	3	4	5	6	7	8	9	10
AAA	0.00	0.03	0.13	0.24	0.35	0.47	0.53	0.62	0.68	0.74
AA	0.02	0.07	0.13	0.24	0.36	0.47	0.58	0.67	0.75	0.84
A	0.07	0.17	0.28	0.43	0.6	0.78	1	1.19	1.38	1.59
BBB	0.21	0.6	1.02	1.53	2.06	2.56	3.01	3.45	3.89	4.33
BB	0.8	2.46	4.41	6.29	8.01	9.64	11.03	12.26	13.4	14.39
B	4.11	9.27	13.61	16.99	19.55	21.61	23.29	24.65	25.82	26.97
CCC/C	26.87	36.05	41.23	44.27	46.75	47.77	48.85	49.67	50.64	51.35

Percentage of Global Corporate Average Cumulative Default Rates (1981-2013)[2]

Most investors view bonds rated Aaa-Baa as “investment” quality, with rating Ba-B designating “speculative”, “high yield”, or “junk” bonds. A rating of Caa-C is assigned to an extremely risky bond that may have already defaulted and be moving towards bankruptcy.

Many organisations are not allowed to invest in bonds with ratings lower than a certain category. For example, many pension funds don’t allow to invest in bonds which are rated lower than investment-grade. Bond ratings have a direct influence on the borrowing costs of the issuer. This can be shown by charting credit spreads for different rating buckets. As the chart below shows, credit spreads are quite dynamic over an credit cycle. To invest successfully in corporate bonds, investors need to be aware of this dynamic, as returns can vary significantly depending on the point in time when they get exposure. Although corporates with an excellent rating of AAA and AA were also affected by the financial crisis in 2008/2009 the biggest impact could be perceived with the lower rated BBB bonds whose option adjusted spreads (OAS) increased from 1% before the crisis up to 7% at the peak of the crisis.



Source: Barclays Bank PLC, Data as of 27.02.2015

[2] Source: S&P 2013 Annual Global Corporate Default Study and Rating Transitions

1.4 Curves and Credit*

Corporate bonds are issued and trade at a higher yield than the relevant benchmark. The spread between the two yields compensates the bondholder for number of factors, including lower liquidity, possible lower repo eligibility and so on. But by far the largest risk compensated is the credit risk.

Traditionally yield spreads of corporate bonds have been measured against a benchmark of government bonds on the grounds that these are considered to be default risk free and have a higher liquidity. In recent years, the swap curve has taken on the role of an alternative benchmark, and in many cases is becoming the comparison curve of choice. There are a number of reasons for that:

1) In the Eurozone, it is not immediately obvious what the liquid government benchmark might be.

2) In the US, Treasury bonds have a favourable tax status at state level.

3) Banks risk capital requirements for holding corporate bonds is greater than for holding government bonds.

The benchmark choice is highly relevant, because although government and swap yield curves do remain relatively stable to one another, the spread between them is by no means constant. In general however, and particularly in academic research, the trend is towards measuring bond credit spreads against the relevant swap curve.

Finally there are credit curves themselves, which plot the yields of similar credit bonds, or even of bonds of the same issuer. Often there are usually not enough bond issues outstanding from the same issuer to be able to fit a sensible curve to the data: a term structure model is more typically used.

*1.4.1 The Additional Dimensions of Credit**

There are at least four key variables which must be discovered or, at worst intelligently estimated, for any meaningful or comparable measure of expected return to be calculated on a credit bond. These are:

1) Credit Migration. The return on a bond can be estimated as a statistic applicable to the life of the bond, but it may well also be estimated for a holding period. Whilst default is an ever-present possibility throughout the life of the bond, until final repayment, the possibility that the credit rating (or market estimation thereof) will change during any holding period is equally important to estimate. This point is particularly important for fund managers, whose performance will typically be assessed continously.

The other three dimensions are:

2) Default risk: the risk that there will be a failure to pay interest or principal on the bond, OR that there will be an equivalent failure on another bond issued by the same borrower.

3) Recovery rates: measure the likely absolute return in the event of default. They are the obverse of Loss Given Default (LGD) i.e. Recovery rate =1-LGD.

4) Bankruptcy procedures: even if the recovery rate is certain, the timing of that recovery has a crucial effect on the calculable expected return of a credit bond. In practice this dimension of credit is left to specialists and is not a notable feature of credit in the regular bond market.

It should be noted that whereas the factors listed above are essential features of any serious attempt to value credit, in practice market participants are likely to fall back on observed CDS prices in order to value credit instruments. Therefore rather than constructing a term structure or using some other model to ascertain the underlying theoretical value of the credit risk as implied by the factors mentioned, credit yield spreads are derived from the prices of those instruments which specifically reflect the credit risk. The construction of CDS prices however may itself be heavily influenced by issues of supply and demand, and cannot necessarily be always expected to reflect underlying economic value. Of course any significant drift away from the range of theoretically correct prices will be arbitraged out between the two markets, it does not follow that this establishes more than the range of reasonably correct valuation. That the focus of analysis is a range rather than a spuriously precise figure is reflected in the fact that both market and academic practice frequently assumes for the sake of simplicity that, for example, recovery rates are a standard 40% irrespective of the facts underlying a specific case. In fact a closer look at recovery rates indicates that they may vary widely, but in practice a rule of thumb is used.

Furthermore, in the specific case of a bond in the event of default, normal market participants will almost invariably accept the price quoted by the small number of specialists who focus on defaulted bonds. These specialists concentrate a sophisticated knowledge of bankruptcy law and procedures (which may differ very significantly between jurisdictions) on the recovery process. Since doing so is not a trivial task, and requires specialised and up to date expertise, it is generally considered to be beyond the capabilities of most participants. Added to this required expertise is the fact that most investors will prefer to sell a bond in default to the experts than continue to hold a very volatile asset. The result of this situation is that most participants concentrate on credit migration risk, in the hope that they will never be in the situation of owning a bond in default. As a result, if they do end up with such a position, they will generally accept the best bid offered by the specialist experts. Indeed the practice is so standard that a common approach in calibrating models that value bonds in default is to compare model projections with the prices observed in the market for relevant bonds one month after the event of default[3].

*1.4.1.1 Credit Migration**

The usual measure of credit migration is known as a transition matrix. Based on the empirical evidence of a given credit agency's rating on a given bond being changed within a given period, a transition matrix measures the probability that a bond with a given rating at the start of the given period will have the same or a different rating at the end of the period. The tables below are examples of credit migration transition matrices:

[3] See also Altman, Brody, Resti and Sironi (2003) where the recovery rate is taken to be the price of the bond after default.

Global Average One-Year Transition Rates 1981 to 2013

From/to	AAA	AA	A	BBB	BB	B	CCC/C	D	NR
AAA	87.10%	8.88%	0.53%	0.05%	0.08%	0.03%	0.05%	0.00%	3.27%
AA	0.55%	86.39%	8.26%	0.56%	0.06%	0.07%	0.02%	0.02%	4.07%
A	0.03%	1.87%	87.33%	5.48%	0.35%	0.14%	0.02%	0.07%	4.70%
BBB	0.01%	0.12%	3.59%	85.22%	3.82%	0.59%	0.13%	0.21%	6.31%
BB	0.02%	0.04%	0.15%	5.20%	76.28%	7.09%	0.69%	0.80%	9.74%
B	0.00%	0.03%	0.11%	0.22%	5.48%	73.89%	4.46%	4.11%	11.70%
CCC/C	0.00%	0.00%	0.15%	0.23%	0.69%	13.49%	43.81%	26.87%	14.76%

Source: Standard & Poor's 2013 Annual Global Corporate Default Study and Rating Transitions

The matrix above shows the average annual transition rates from one rating category to another, with both upgrades and downgrades, over an extended period. For example, according to these figures, if you were holding an "A" rated bond today, on average, you would have a close to 2% chance that it would have been upgraded to "AA" by this time next year. The chances that it would be further upgraded to "AAA" within another year would (on average) be 1.87% x 0.55% = 0.01%. It is important to realise that these are averages, and that the fluctuations can be quite large from year to year. For example the table below covers the year 2013:

Global One-Year Transition Rates in 2013

From/to	AAA	AA	A	BBB	BB	B	CCC/C	D	NR
AAA	90.48%	9.52%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
AA	0.00%	94.08%	2.49%	0.00%	0.00%	0.00%	0.00%	0.00%	3.43%
A	0.00%	1.17%	91.91%	3.58%	0.08%	0.08%	0.00%	0.00%	3.19%
BBB	0.00%	0.06%	3.79%	89.76%	2.37%	0.12%	0.00%	0.00%	3.91%
BB	0.00%	0.00%	0.00%	5.10%	82.00%	4.64%	0.00%	0.09%	8.16%
B	0.00%	0.00%	0.00%	0.18%	5.65%	77.96%	4.36%	1.60%	10.25%
CCC/C	0.00%	0.00%	0.00%	0.00%	0.00%	10.13%	46.20%	23.42%	20.25%

Source: Standard & Poor's 2013 Annual Global Corporate Default Study and Rating Transitions

It is apparent for example that more issuers kept their rating in 2013 versus the multi-year average. Another difference which can be observed, shows that it was more difficult for coporates to improve their ratings to an AA or AAA-level.

Of course these matrices capture data ex-post facto, but one would assume that markets might be able to anticipate imminent ratings changes, and that this anticipation would be made evident in relative credit spread changes. Thus the movements of the spread changes of a bond relative to similarly rated bonds would be expected to reflect anticipated changes in the ratings from agencies (or perhaps more precisely, would reflect the change in creditworthiness that will subsequently be confirmed by the ratings agencies). A number of studies tend to confirm that this is the case, and whilst the role of ratings agencies in guiding overall credit decisions remains paramount, day-to-day estimation of the likelihood of a change in rating has turned to other methodologies[4].

[4] Kou and Varotto(2004), Hull, Predescu and White (2004-2).

*1.4.1.2 Default risk**

Financial default is the failure to pay interest or principal on a debt. In the context of bonds, the concept is taken further in that most bonds include in their issuing circular details a cross default clause, which in effect states that ANY default on ANY of the issuer's bonds issued in the past or future will constitute a default on this particular bond. This means in effect that a default on one interest payment is a default on all of the issuer's debt (whether in the form of bonds or not: cross default clauses most often include all of the issuer's debt, whether in loan or bond form).

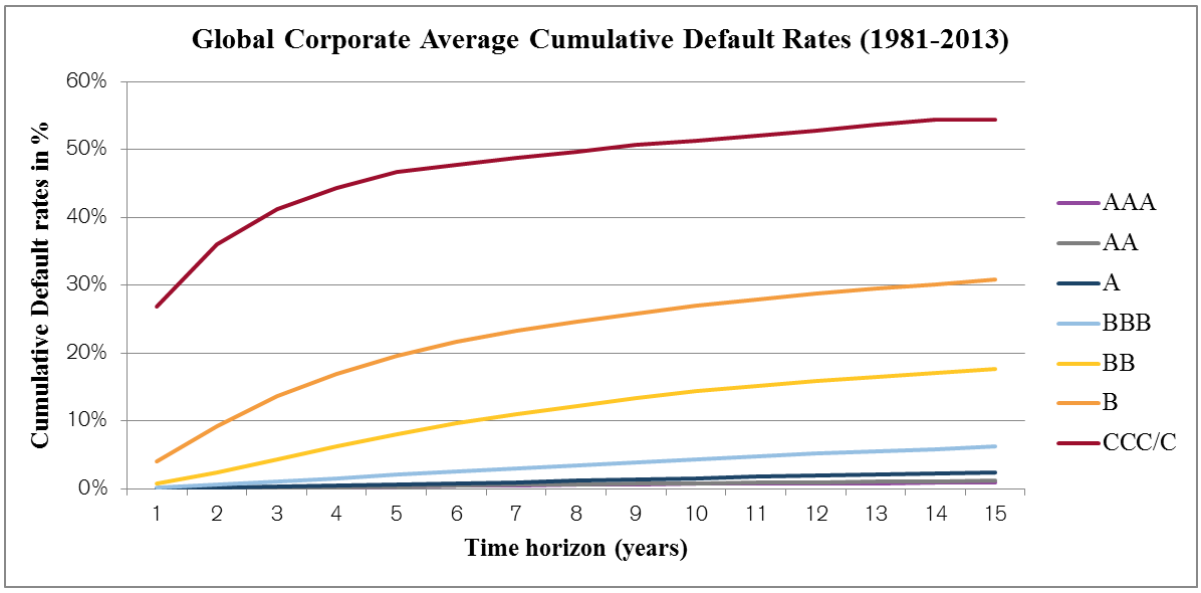
Default is a very specific phenomenon, and it has proved well-nigh impossible to abstract a set of indicators which are persistent and predictive factors in future defaults. This does not mean that there are some models that can guide the way: an example is the so-called Altman Z-scores. It is arguable of course that if such a model existed with enough predictive power, its net result would be to feed back into the corporations whose bankruptcy it was predicting, thus altering those corporations' behaviour, and hopefully rendering the predictions false! As a result much of the work on defaults and their effects on returns focuses on the statistical analysis of empirically observed default rates. This does not mean to say that default risk cannot be evaluated for specific borrowers: there are both quantitative and qualitative tools for applying credit research to the calculation of default risk for individual issuers.

Global Corporate Average Cumulative Default Rates (1981-2013)

	Time horizon (years)														
Rating	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
AAA	0.00%	0.03%	0.13%	0.24%	0.35%	0.47%	0.53%	0.62%	0.68%	0.74%	0.77%	0.81%	0.84%	0.91%	0.99%
AA	0.02%	0.07%	0.13%	0.24%	0.36%	0.47%	0.58%	0.67%	0.75%	0.84%	0.93%	1.00%	1.08%	1.16%	1.24%
A	0.07%	0.17%	0.28%	0.43%	0.60%	0.78%	1.00%	1.19%	1.38%	1.59%	1.78%	1.95%	2.11%	2.27%	2.45%
BBB	0.21%	0.60%	1.02%	1.53%	2.06%	2.56%	3.01%	3.45%	3.89%	4.33%	4.80%	5.18%	5.53%	5.90%	6.27%
BB	0.80%	2.46%	4.41%	6.29%	8.01%	9.64%	11.03%	12.26%	13.40%	14.39%	15.21%	15.92%	16.52%	17.05%	17.64%
B	4.11%	9.27%	13.61%	16.99%	19.55%	21.61%	23.29%	24.65%	25.82%	26.97%	27.95%	28.76%	29.48%	30.15%	30.81%
CCC/C	26.87%	36.05%	41.23%	44.27%	46.75%	47.77%	48.85%	49.67%	50.64%	51.35%	51.99%	52.76%	53.67%	54.40%	54.40%
Investment grade	0.11%	0.30%	0.52%	0.79%	1.07%	1.35%	1.61%	1.86%	2.10%	2.35%	2.59%	2.79%	2.98%	3.17%	3.37%
Speculative grade	4.02%	7.86%	11.19%	13.86%	16.03%	17.82%	19.33%	20.60%	21.74%	22.78%	23.66%	24.42%	25.09%	25.69%	26.28%
All rated	1.53%	3.02%	4.33%	5.43%	6.35%	7.14%	7.82%	8.39%	8.92%	9.42%	9.85%	10.21%	10.54%	10.84%	11.14%

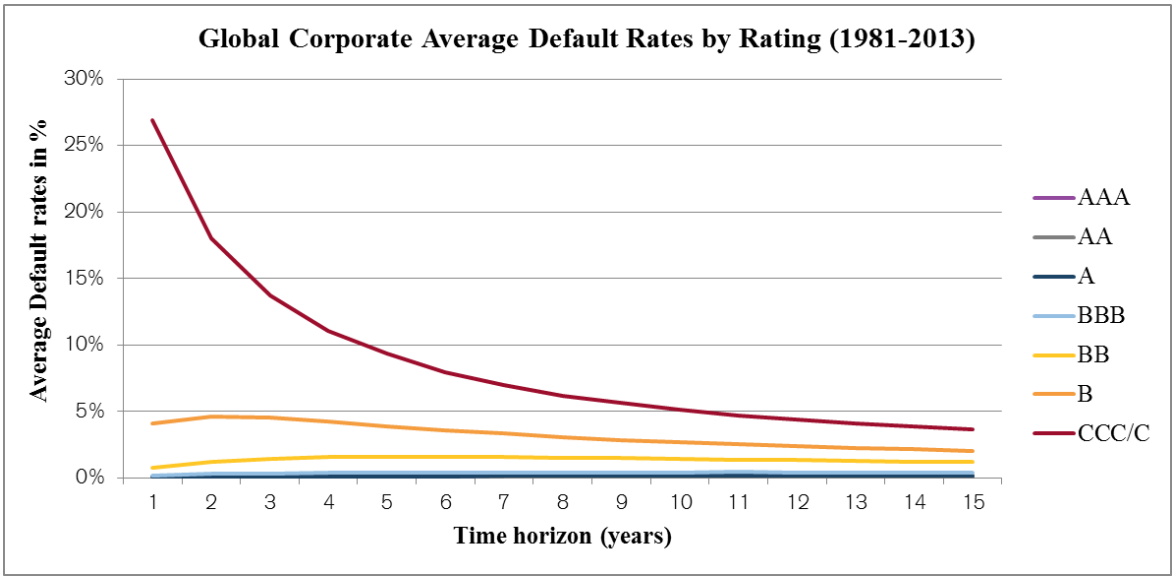
Source: Standard & Poor's 2013 Annual Global Corporate Default Study and Rating Transitions

The table above shows the data for the graphs of cumulative default curves plotted below. There is a clear correlation between credit quality and default remoteness: the higher the rating the lower the probability of default, and vice versa. Over each time span, lower ratings correspond to higher default rates.



Source: Standard & Poor's 2013 Annual Global Corporate Default Study and Rating Transitions

Note that the observed annualized expected default probability (now) in any of the ratings categories is simply the first difference of the cumulative rates given here. Alternatively an average can be taken over the fifteen years, so that, for example, the annualized expected default probability for an AAA bond based on the data above is 0.99/15=0.07%. Plotting the annualized expected default probability gives an important insight into credit valuation, as can be seen from the chart below:



Source: Standard & Poor's 2013 Annual Global Corporate Default Study and Rating Transitions

Without anticipating too much the section on curve shapes and credit, we will simply note here that the general shape of the curves corresponding to each category (if not the absolute level of the curves) correspond closely 1) to predicted results from, for example, Merton (1974), among many, and 2) to the results obtained by various researchers fitting term structures to observed credit yield spreads. The implication is (among others) to confirm what one might assume: that the observed default probability has an important effect on the level of credit spreads.

Techniques, such as those developed by Moodys KMV, have been developed to extract meaningful default probabilities (or in the case of Moodys KMV "EDF" or expected default frequency) from many different types of data. Calculating EDF for example depends on the basic concept that the value of a firm's equity is what remains when all obligations (debts etc) have been paid, based essentially on Merton (1974). Therefore the creditworthiness of a corporation can be implied by its equity price movement. Extracting the signal from the data is not a trivial task, but the result is a reasonable leading indicator of default. Changes in the EDF can be mapped reasonably well onto agency ratings, so that changes in the EDF can anticipate changes in ratings too[5].

*1.4.1.3 Recovery Rates**

In the event of a default, the recovery rate is, as its name implies, the proportion of what is owed that is eventually repaid. The table below may deal only with defaults in the US, but it does illustrate the wide range of recovery rates, even when averaged out by industry: the highest average recovery rate is just over 75%, and the lowest is just below 30%. Overall the average recovery rate for bonds from nonfinancial corporates was 38%.

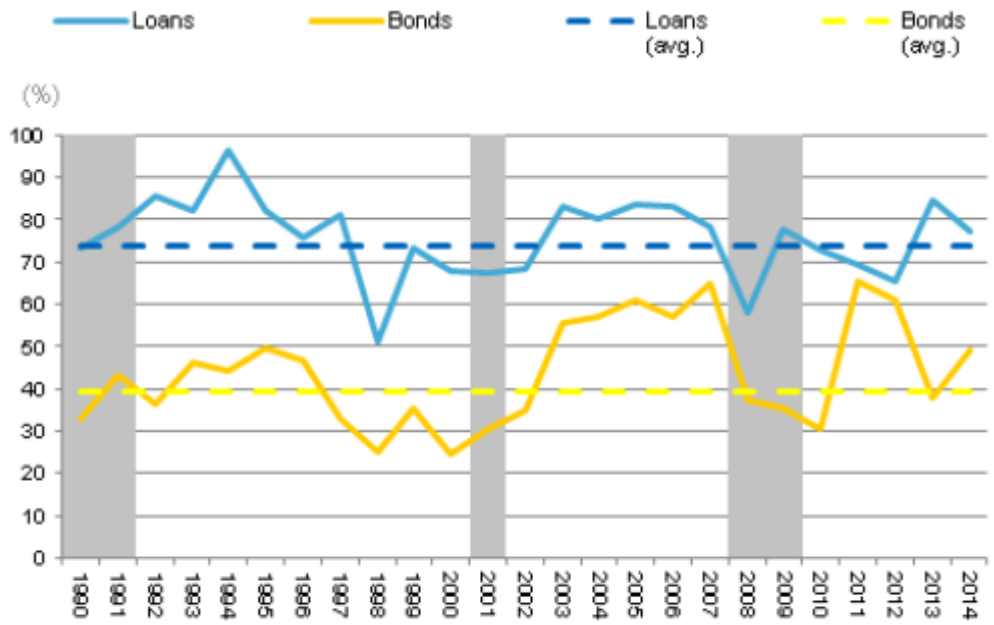
Average Recovery Rates by Nonfinancial Sector (1987-2014)

Sector	Average Bonds	Count
Aerospace and defense	29.3%	30
Automotive	33.0%	135
Capital goods	36.3%	125
Chemicals, packaging	40.2%	86
Consumer products	39.5%	178
Forest products and building materials	43.3%	101
Health care	34.6%	98
High technology	34.6%	112
Homebuilders/real estate	29.8%	62
Media and entertainment	37.8%	268
Metals, mining, and steel	36.9%	76
Oil and gas	37.8%	136
Retail/restaurants	31.7%	318
Telecommunications	29.5%	408
Transportation	45.4%	151
Utilities	75.2%	155
Total	**38.0%**	**2439**

Source: Standard & Poor's Recovery Study (U.S.): Recoveries remain elevated in the post-recession period for most debt types, December 2014

[5] Denzler, Dacorogna, Müller and McNeil (2005)

Recovery rates differs not only between sectors but also at what stage of a business cycle they occur. As the chart below shows recovery rates are trending lower during recessions. This can be explained that during recessions potential buyers of assets have less available liquidity during this periods what hold prices down. This can also be seen on the recovery rates on bank loans which shows a similar pattern, although on a higher level, as bank loans usually are better secured with some type of collateral.



Tallied for the year of default. Includes only bank debt and bonds that defaulted. Shaded areas are periods of recession as defined by the National Bureau of Economic Research. Sources: Standard & Poor's CreditPro® and Standard & Poor's Global Fixed Income Research.

Source: Standard & Poor's Recovery Study (U.S.): Recoveries remain elevated in the post-recession period for most debt types, December 2014

Recovery rates are even more idiosyncratic than default risk. How much is actually recovered and to whom it is paid (since there are usually a number of classes of creditor, often including the taxman) is often well-nigh impossible to predict. In addition it is inextricably linked to the local bankruptcy procedure, and often to the prevailing political climate. However, in practice the unknown and unpredictable is disregarded and a pragmatic approach is taken to estimating recovery rates: it is even the case that a generic recovery rate is usually used[6]. Not surprisingly, in those circumstances, the recovery rate is generally assumed to be 40%.

Loss Given Default (LGD) also known as Loss In the Event of Default (LIED), or default severity is simply 1- the Recovery Rate. The annualized expected loss rate is equal to the annualized default probability multiplied by the loss given default (LGD).

[6] Hull, Predescu and White (2004-1).

*1.4.1.4 Bankruptcy processes**

It may be possible to ascertain a reasonably accurate recovery rate parametrically, but that is only half of the problem: in order to be used meaningfully to calculate the expected returns from investment in the bonds of a corporation, the time-value of that recovery rate crucially depends on the bankruptcy process. The determination of what creditors may recover during bankruptcy proceedings is a complex process that typically involves substantial negotiation and litigation. A World Bank study[7] from the year 2014 examines under the title "Resolving Insolvency" amongst other also the time needed between the company's default until the payment of the recovery amount. The differences between the countries are huge, with the average duration of bankruptcy proceedings ranging from 0.4 years in Ireland up to 8.0 years in Mauretania. According to World Bank data the regional averages are smaller ranging from 2.3 years for Europe & Central Asia to 3.1 years for Sub-Saharan Africa as well as Middle-East & North Africa. However, if only OECD high income economies are taking into consideration an average of 1.7 years is shown. Depending on the complexity of a default, it can takes easily several years until a bankruptcy case is finalized. For example the default of Swissair from the year 2001 is still ongoing. However, as explained in greater detail above, in practice, by the time a defaulted bond is the subject of the bankruptcy procedure, it usually owned by specialists in the matter.

*1.4.2 Term Structure of Credit**

There are essentially two different types of model currently used to model credit risk and its term structure. There is the structural approach such as Merton (1974), which uses the value of the corporation as an explanatory variable, and there are reduced-form (or intensity) models such as those of Fons (1994), Jarrow-Turnbull (1995), Jarrow-Lando-Turnbull (1997), and Duffie-Singleton (1999). Unlike structural models these treat default as an unpredictable event. It is impossible to examine all of the models available in the market, let alone in the academic literature, and the following is merely a cursory inspection of some salient features.

Systems eventually derived from Merton (1974) include the KMV model (which is now part of Moody's KMV), and which determines the Expected Default Frequency (EDF) of an issuer from the value of the corporation. It uses the basic concept that since the equity value (of a publicly quoted company) is known and easy to determine, the rest of the company's valuation must equal the valuation of its debt. From that insight, and incorporating the further concept that the equity can be seen as being a call option on the company's value, we can imagine the probability of default as being precisely equal to the probability of the equity holder's call option expiring out-of-the-money at any given time in the future (and especially at the time debt must be repaid). The so-called distance to default is a measure of how many standard deviation that call option is in the money, and the lower that number, the higher the EDF.

Reduced-form models can be derived from mortality models of default. As their name implies, these use an analogy to actuarial mortality tables to measure the historical experience of bond default (as in the tables above in the section on "Default Risk"). As explained in that section, the annualized probability now of default in year *y* is the simply the difference between the cumulative default rate for year *y* minus that for year *y-1*. We calculate the conditional probability of default between time *y-1* and time *y*, and from there go further to calculate the expected instantaneous rate of default. This is also called the Hazard Rate, or the

[7] World Bank Group, Resolving insolvency, www.doingbusiness.org/data/exploretopics/resolving-insolvency

Default Intensity. Calibrating the hazard rate to observed yield and spread levels leads to a term-structure model, and risk-neutral probabilities can also be derived.

*1.4.2.1 Credit Default Swaps (CDS)**

Credit Default Swaps (CDS) are a form of derivatives (and will be featured in the "Derivative" module). In the most common type —a single-name credit default swap— two counterparties agree to exchange a stream of periodic payments for an agreement to pay a notional amount if a specified third party, the reference entity, defaults on a bond or loan. The reference entity is usually a company or sovereign government. Viewed as an option, a CDS is a contingent put option in which the underlying security to the put is a bond (issued by the reference entity), and the contingency is an event of default. As with most options, there is an exercise period, an exercise price (which is almost always par or 100%), and a premium paid. The key difference between a CDS and the put described is that instead of there being one single up-front payment (the premium of an option), the CDS is a swap, and there is therefore a regular premium paid annually up to the final exercise date. This payment can be interpreted as a yield spread capturing the difference between a risk-free yield and the yield on the reference entity's bond or loan (presupposed that there is a Credit Support Annex in place which reduces counterparty risk significantly by providing collateral). A CDS is designed to transfer credit exposure between the two parties, and is often used as an insurance policy (the buyer of the put is said to buy "protection") or to hedge exposures to corporate bonds. The CDS market has been growing at an extremely fast rate, and there are now CDS curves mapping CDS prices against maturity constructed.

It is from CDS curves that the market increasingly derives the correct spread for a given borrower in a given maturity. Indeed, recent research finds that the CDS market leads the bond market: i.e. that credit events are reflected in changes of CDS prices before they filter through into the bond market. In principle the credit risk of a bond is encapsulated in a CDS, which implies that the spread against a credit-risk free benchmark should be the same as the price of the CDS. If it differed significantly then there would (in principle) be a clear arbitrage[8]. For example if the credit spread of a 5 year bond from an issuer is higher than his CDS for the same term, an investor could buy the bond and buy protection with a CDS. The result would be an artificial risk free asset, which yields more than a correspondent benchmark bond (without considering transaction costs). This will certainly work in theory, in practice there are transaction costs and some counterparty risk to be kept into consideration.

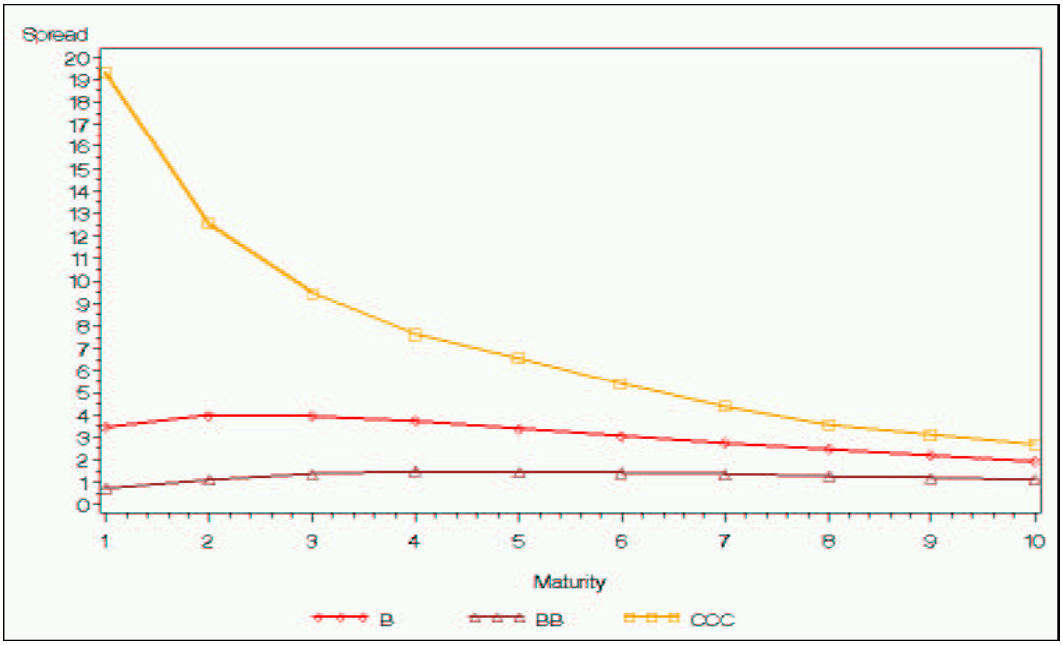
It should be noted that not all CDS assume that there will be a physical delivery of the bonds protected in the event of default: as often outstanding CDS predominate the underlying debt cash settlement contracts are increasingly used, leading to the vexed question of how to determine the cash settlement in question. ISDA (the International Swaps and Derivatives Association) has developed rules for an auction process which facilitates the clearing between the different parties when a credit event occurs.

[8] There are numerous reasons why arbitrage would not be simple (see for example Hull, Predescu and White (2004-2) pp 10-11).

*1.4.3 Curve Shapes and Credit Quality**

While it is generally the case that higher quality credit curves (whether defined as spreads or taken from CDS prices) tend to be upward sloping, there is some debate as to whether the credit term structure for riskier issuers is upward or downward sloping. There is much evidence for humpbacked curves in lower quality credit term structures[9], but it is questioned whether this shape is the result of bias in the selection of observed yields in the studies that come to that conclusion: in particular Helwege and Turner (1998) highlight the fact that in the realm of speculative-grade credits, there is quite a range of creditworthiness, within which only the better credits will even be able to issue longer-term bonds: since these are by definition the "safest" credits in the speculative environment, they will issue at smaller spreads than riskier (but still speculative-grade) issuers. The result would be that the yields for longer speculative-grade bond maturities will be biased lower by the greater preponderance of "better" credits in the longer end. The humpbacked or downward sloping credit curve for particularly poor credits is explained by the "crisis at maturity" hypothesis[10], and it also corresponds with the observed annualized default probabilities as mentioned above. The "crisis at maturity" hypothesis argues that speculative-grade companies with low credit quality, in the original context those with a high leverage-ratio, may face severe problems of refinancing as their short term debt matures. In consequence the risk of not being able to meet the obligations and thus the probability of default in the short term is quite high. Once those companies have overcome their problems and survived a certain period of time without a default, they face a lower risk in the long run. For currently large and solid companies, the outlook in the short term is very stable with a low risk of default, whereas the forecast of credit quality over longer periods is less certain. As a result, while higher quality credit curves tend to be positive, speculative-grade credit curves can be sharply inverted[11].

Calculated Bond Spreads for February 11th 2004



Source: Trück, Laub and Rachev (2004) p. 18

9 Sarig and Warga (1989)

10 Johnson (1967)

11 Trück, Laub and Rachev (2004)

However overall it seems that less-risky bonds typically have positive credit yield curves[12], and very risky bonds have inverted curves.

Finally, some research shows that the slopes of credit spread yield curves can be used to predict future credit levels[13], with steep credit spread curves leading to future increases in credit spread levels[14].

[12] Helwege and Turner (1998) and Bohn (1989)

[13] Krishnan, Ritchken and Thomson (2005)

[14] Bedendo, Cathcart and El-Jahel (2004)

2. Mortgage-backed securities*

2.1 Introduction to the Mortgage-Backed Bond Market*

Mortgage-backed bonds involve creating pools of mortgages as collateral for investors. There are two main categories based on the type of collateral used:

- residential mortgage-backed bonds (RMBS): backed by residential mortgages; and
- commercial mortgage-backed bonds (CMBS): backed by commercial mortgages.

The total volume of RMBS is very substantial, especially in the United States where they account for roughly one third of the Barclays US Aggregate Bond Index. The total volume of US RMBS in circulation is impressive. It currently (2015) stands at approximately 70 per cent of the total figure for US treasury bonds, although in 2006 the figure was nearly two hundred per cent.

In terms of volume, CMBS are less significant and make up just 2 per cent of the Barclays US Aggregate Index. It should be noted that a substantial proportion of CMBS are issued as floating-rate instruments. They are therefore not included in traditional bond indices.

We also distinguish between private securitisation and agency securitisation. In the first of these, securitisation provides all of the bond's collateral – both the assets used as collateral and any other collateral (e.g. insurance benefits from private insurers). For this reason, a separate credit check has to be performed for every transaction.

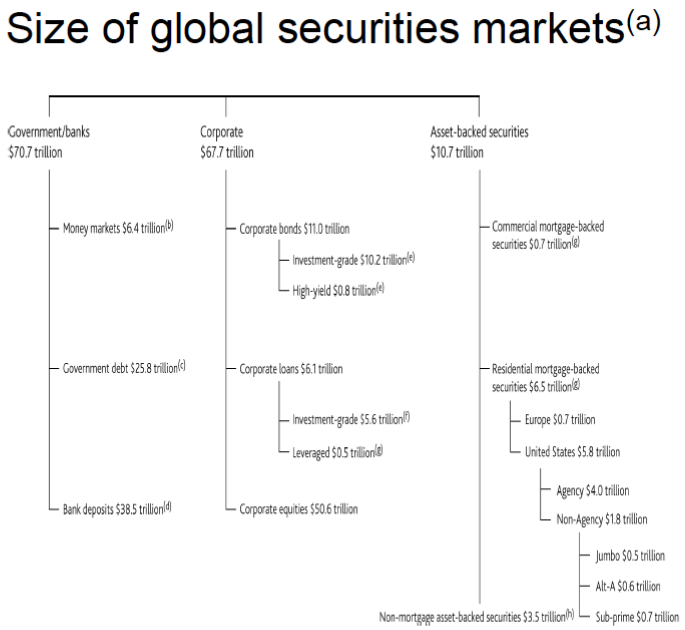
By contrast, in the case of agency securitisation, credit default guarantees are provided by a variety of state-sponsored agencies. In most cases, the agencies assume all the credit default risks. The credit risk with this type of securitisation is therefore insignificant, the only remaining credit risk being that of insolvency of the agency that provides the guarantee. Accordingly, from the investor's perspective, there is no need for a specific credit check. Only the creditworthiness of the agency is relevant.

The following overview clearly illustrates the relative sizes of individual bond segments (at the end of 2006, i.e. before the financial crisis). With regard to mortgage-backed bonds, it shows the dominance (in terms of volume) of residential mortgages, the US market and agency securitisation. In the non-agency (private) securitisation segment, cases of Alt-A (supposedly good-quality mortgage holders albeit with poor documentation) and sub-prime securitisation (lower-quality mortgagees) have practically 'died out' in the absence of new issues. Both these segments were hit badly by credit defaults during the crisis and caused balance sheet problems at banks such as UBS. Jumbo securitisation, based on collateral in the form of larger, good-quality mortgages, is still a feature of the market.

As at 2015, the total volume of agency securitisation has grown to USD 7.12 trillion. By comparison, the volume of non-agency RMBS has shrunk to USD 0.94 trillion – because hardly anything new has been issued[15].

[15] Source: SIFMA (Securities Industry and Financial Markets Association), first quarter 2015

Size of global securities markets[16]



Sources: BIS, Board of Governors of the Federal Reserve, European Securitisation Forum, Eurostat, Fitch Ratings Ltd, McKinsey Global Institute, ONS, Securities Industry and Financial Markets Association, Standard and Poor's, World Federation of Exchanges and Bank calculations.

(a) All data are global at end-2006 unless stated.

2.2 Types of Mortgages*

A mortgage is a loan secured by the pledge of specified real estate property. If the borrower fails to make the predetermined series of payments, the lender is entitled to seize the property in question and to sell it to satisfy his claims.

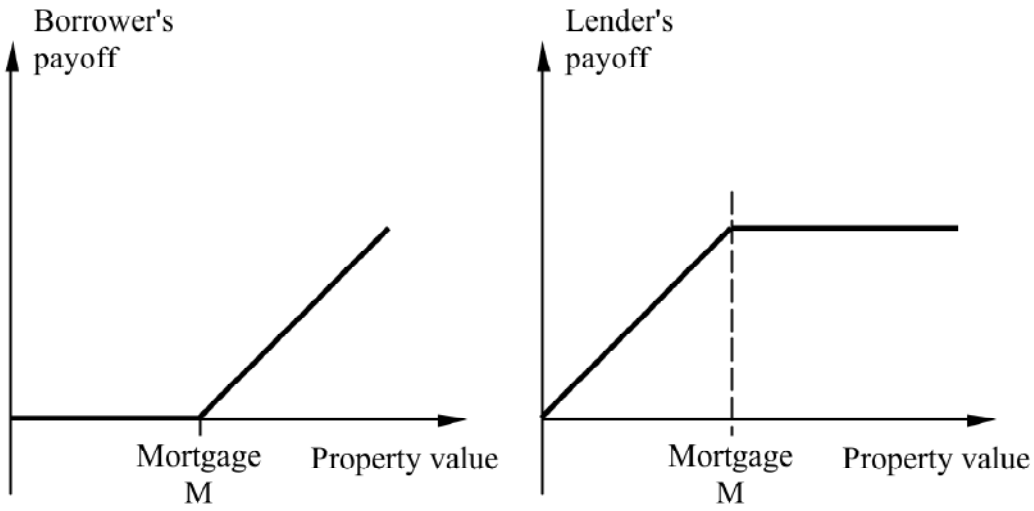


Figure 2-1: A stylised payoff structure of a mortgage upon termination. M indicates the mortgage balance including interest.

[16] Source: Bank of England, Financial Stability Report, October 2007 | Issue No. 22

Depending on the state of the world at maturity, the lender will receive the whole or part of the contractual principal and interest.

Let us determine the fair price of the simplest mortgage one can think of: a **fixed-rate, default-free, perfectly liquid mortgage**, without amortisation. To justify the absence of default risk, one may think of it as being insured by a government agency . The price of such an instrument is obtained by discounting its future cash flows with the risk free rate of corresponding maturity, just like a bond.

In principle, a risk-free mortgage can be valued by means of a straightforward present value computation:

$$P_0 = \sum_{t=1}^{T} \frac{CF_t}{(1+R_t)^t}$$

where:

P_0	Present value of the mortgage
CF_t	Cash flow at time t
R_t	Spot rate for time t years
T	Maturity

In reality investing in mortgages is exposed to the risk that the borrower will default. One important factor is the loan to value (LTV), i.e. the ratio of the amount of the loan to the market value of the property. The higher this ratio (the less equity the borrower has in the property) the higher the probability of default. Moreover, if during the life of the mortgage home prices decline and/or equity is reduced through additional mortgages (second mortgages or home equity credit), default risk increases. In the case of default, the lender does not receive any interest; moreover, before he recovers part of the lent amount (which might have declined because of downturn in property value and lack of maintenance) he faces an opportunity loss on funds that could be reinvested and he incurs insurance and legal expenses.

In many cases, it is not only the property that may be used to repay the loan; the mortgagee may also be liable to make repayments out of personal assets and income. This makes the process of valuation even more complex and variable in practice.

The US mortgage market comes closest to the scenario illustrated at the beginning of this section. In effect, the liability of many US mortgagees is limited to the property in question. Depending on the source used, between ten and fifteen US states allow only non-recourse loans (i.e. liability is limited to the property), and in nearly all the remaining states it is very often not worthwhile instigating legal proceedings for recovery of the loan through claims on other assets[17]. For this reason, the term frequently used in cases of mortgage insolvency is ‘handing over the keys’.

[17] Ron Harris and Asher Meir, 2012 Non-recourse mortgages – a fresh start, Available at: http://works.bepress.com/ron_harris/41

It is interesting to note the historical context behind these specific laws[18]. Many of the legislative changes that created this effective or notional non-recourse regime date back to the wave of regulation that followed the Great Depression and the associated real estate crash. The aim of this regulation was to protect mortgage holders while creating incentives for the banking system only to grant solid loans. The expectation was that a more cautious approach to lending would result as the banks would be exposed to a greater risk in the case of non-recourse mortgages that prevented them from recovering the loan through claims on other assets. In the wake of the recent financial crisis, there is a now a lively debate as to whether these regulations helped trigger the mortgage crisis or mitigated its impact on the economy. We can be certain that legislators at the time did not anticipate the subsequent development of an international securitisation market – a good example, no doubt, of the unintended consequences of regulation.

In the vast majority of countries and jurisdictions, however, the liability of the borrower is much more widely interpreted.

The mortgage contracts differ in the timing and the amount of the cash flows. Just like for bond analysis, one can calculate for a mortgage loan its **yield** (i.e. its internal rate of return IRR), its **duration** and its **convexity**. These will characterise the mortgage in terms of its sensitivity to interest rate risk.

*2.2.1 Fixed Rate Level-Payment**

Fixed-rate level-payment mortgages are the standard form of mortgage in the United States.

Up to the year 2003, i.e. before the last phase of the real estate boom in the United States, fixed-rate level-payment mortgages accounted for roughly 75 per cent of all the country's mortgages. During the subsequent boom years, variable-rate mortgages became increasingly popular and made up around 50 per cent of all new mortgages in 2005 and 2006. Throughout this period, variable-rate mortgages offered the benefit of even lower interest rates. Most were privately financed – without assistance from US mortgage agencies. Furthermore, many variable-rate mortgages were of lower quality (Alt-A or sub-prime). Today, in the wake of the real estate crisis, over 90 per cent of all mortgages are again based on fixed-rate level-payment terms, and nearly all are guaranteed by US mortgage agencies.

The characteristics of a fixed rate level-payment mortgage are the following:

- fixed coupon interest rate;
- constant periodic payments (annuity);
- maturity typically 20 to 30 years;
- option on partial or full prepayment on the part of the borrower with exercise price at par;
- no termination option for the lender.

[18] Changing the Rules: State Mortgage Foreclosure Moratoria During the Great Depression, David C. Wheelock, Federal Reserve Bank of St. Louis *Review*, November/December 2008

The assumption underlying the 20-30 year term with 100 per cent amortisation is that a property should be fully depreciated over this period. This reflects the predominant US reality of low land values and construction materials that are not designed to last for ever[19].
In this type of mortgage, all cash flows are the same. However, as time passes, the portion of the periodic payment applied to interest declines and the portion applied to reducing the mortgage balance increases. The initial formula simplifies to

$$P_0 = \sum_{t=1}^{T} \frac{A}{(1+R_t)^t}$$

where:

P_0	Present value of the mortgage
A	Constant annuity
R_t	Spot rate for t periods
T	Maturity

The annuity is a function of the periodic coupon interest rate c. With the same notation as above, one finds for the initial mortgage balance MB_0:

$$MB_0 = \frac{A}{c} \cdot \left(1 - \frac{1}{(1+c)^T}\right)$$

or solving for A:

$$A = MB_0 \cdot \frac{c}{1 - \frac{1}{(1+c)^T}}$$

Example:
We calculate the present value, the duration and the convexity of a default-free 6-year fixed-interest, amortisable, level-payment mortgage loan with a coupon of 6%.
The annuity of the loan will be:

$$A = 100 \cdot \frac{0.06}{1 - \frac{1}{(1+0.06)^6}} \cong 20.336$$

[19] In 2000, the median age of US residential property was around 30 years. This has now risen (2015) to 38 years. Source: DB research, Thorsten Slok, 2015

Using this annuity to value the mortgage, one finds the following values:

Year	Spot Rates R_t	Beginning Mortgage Balance [1]	Interest [2]=c·[1]	Principal Repayment [3]=[4]-[2]	Annuity [4]	Discounted Cashflows $[4]/(1+R_t)^t$
1	5.15%	100	6.000	14.336	20.336	19.340
2	5.38%	85.664	5.140	15.196	20.336	18.313
3	5.52%	70.467	4.228	16.108	20.336	17.309
4	5.64%	54.359	3.262	17.075	20.336	16.329
5	5.68%	37.284	2.237	18.099	20.336	15.428
6	5.71%	19.185	1.151	19.185	20.336	14.574
YTM	5.593%				**PV**	**101.293**
					Duration	**3.342**
					Convexity	**15.61**

Table 2-1: Cash flows, present value, duration and convexity of a fixed-interest, amortisable, level-payment mortgage loan with a coupon of 6%

A parallel shift of +1% in the spot rate curve, i.e. 5.15% becomes 6.15%, 5.38% becomes 6.38%, etc, reduces the present value of the mortgage to 98.17. Using the duration and the convexity to calculate the change, one finds:

$$\frac{\Delta P_0}{101.29} \cong -\frac{3.342}{1+0.05593}\cdot 0.01+\frac{1}{2}\cdot 15.61\cdot (0.01)^2 \cong -0.03087 = -3.087\%\ ,$$

which leads to $\Delta P_0 \cong -0.03087 \cdot 101.29 \cong -3.126$ and hence to a new value approximately equal to 98.17.

These calculations are a gross simplification, however, as they do not take account of the borrower's option to prematurely redeem the loan at par. This introduces optionality into the cash flows along the same lines as callable bonds. This optionality has an impact on valuations (price and yield) and on risk indicators (duration and convexity). This will be examined in more detail later in this document.

*2.2.2 Adjustable Rate Mortgage (ARM)**

*2.2.2.1 Fundamentals**

The adjustable rate mortgage is a floating-rate mortgage whose coupon is reset periodically in accordance with some chosen reference rate. In some cases the reference rate is a market rate, for example based on Treasuries. These mortgages provide an alternative method of financing through which lender and borrowers share the interest rate risk.

The pricing of an ARM is quite straightforward. Intuitively, it seems that the price of such a mortgage should not change much with movements in the interest rate, since the coupon adjusts automatically. In fact, the price of such an instrument is always equal to its face value M. This is the same case as a floating rate bond.

Thus, if the period of revision of an ARM is very short, say one day, the value of the mortgage will always stay at its face value no matter what the maturity, if there is a maturity at all. On the other hand, if the coupon rate is reset every three months, the mortgage price will only equal its nominal value on the reset date. Between reset dates, the value may vary according to the interest rate for the time span until the next reset date.

Some ARMs are tied to calculated rates based on the cost of funds for thrifts (i.e. on the average interest cost of their liabilities), hence they do not accurately reflect any market interest rate.

*2.2.2.2 The Case of the Swiss Variable Rate Mortgage**

It has been shown previously that the valuation of a perfect adjustable-rate mortgage is a trivial matter as its price is simply the mortgage balance outstanding. Yet, the Swiss version of the ARM is of a more cumbersome kind.

First, the Swiss variable rate mortgage (SVRM) does not carry a coupon rate, which is automatically tied to a specific market interest rate. Instead the bank has the right to change the coupon rate at any time with a three-month or so notice. Moreover, both parties have the right to terminate the contract, again typically with a three-month notice. One could expect that in a competitive environment such a contract specification would lead to coupon rate patterns matching very closely the behaviour of market rates. In fact, one observes that coupon rates vary in the same direction as market rates, but the extent to which they vary is dampened. It is commonly argued that the main reason why banks do not choose to adjust their rates to market conditions is political pressure. Since rent ceilings were tied to SVRM mortgage rates (up to 2008), every coupon adjustment was subject to a heavy popular scrutiny. During high interest rate phases, banks are expected not to raise their coupons rates as fast as market rates would require. In order to break even, when interest rates are decreasing, banks do not lower their rates by the same amount. It is not quite obvious how to go about pricing this particular type of mortgage. One possibility is to treat it like an ARM whose coupon rate adjusts only partially to interest rate movements.

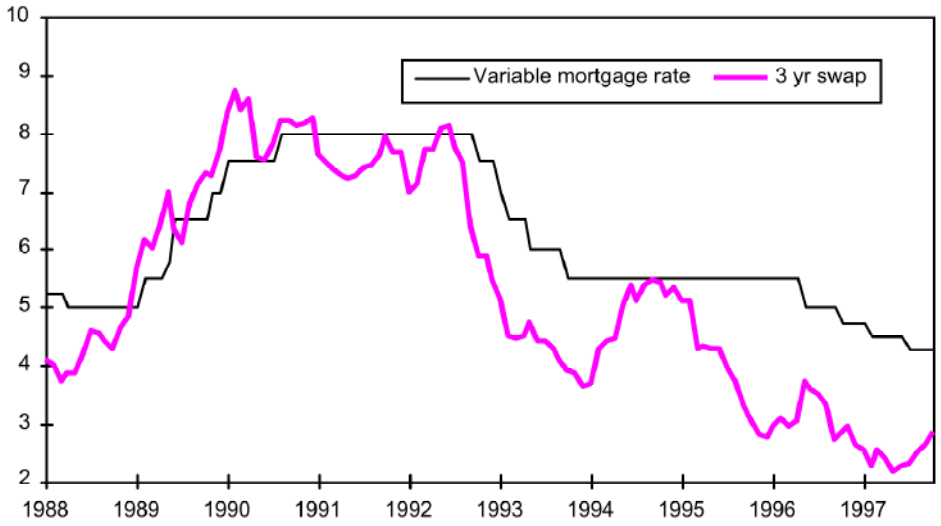


Figure 2-2: Swap rates and rates on existing VRMs

One striking feature of this instrument is that its price is not necessary equal to the face value, like the perfect floating mortgage. Whether the mortgage is valued above or below a hundred depends on the interest rate process. What is known for sure is that dampening or enhancing the floating feature of an ARM does not have a symmetric effect on the mortgage value. The fact that coupon rates do not adjust completely implies that the mortgage's price will fluctuate along with interest rate movements, increasing with low rates and decreasing with high rates.

As mentioned previously, the SVRM entails a bilateral termination right. Empirically, borrowers seem to make use of their call option quite regularly. They typically choose to prepay in low interest rate environments, since this allows them to refinance their property with a low coupon fixed rate mortgage. Yet this behaviour is not symmetric. Banks do not tend to exercise their put option even when it is deep in the money. Although the reasons for this behavioural pattern are not very obvious, the following explanation may provide a tentative answer. If a bank were to call back all its SVRMs in order to take advantage of high interest rates by offering new SVRMs at current market conditions, it would place the borrower in the same economic situation as if it had simply raised its coupon rate in step with market rates. Thus, it seems plausible that the same vaguely defined political pressure would work to prevent such behaviour.

Variable-rate mortgages are now much less significant as a proportion of overall mortgage volumes. The market has moved towards fixed-term mortgages (without the option to redeem the loan at par that characterise US mortgages) or Libor mortgages (variable rates based directly on Libor).

2.3 Mortgage Securitisation*

In this section, we address the issue of mortgage securitisation by presenting the meaning of securitisation, how it works and by illustrating its application to mortgage refinancing via Mortgage-Backed Securities. We will also examine the role of the US mortgage agencies and the MBS market in the financial crisis of 2008.

*2.3.1 Introduction to Securitisation**

The process of **securitisation** involves the packaging of usually homogenous but illiquid and non-marketable assets into a pool, and selling new securities which represent a claim on the assets in the pool or on the cash flows generated from them.

These new securities thereby become much more readily transferable than they would have been otherwise. In fact, they can now be transferred without the involvement of third parties other than the seller and the purchaser. Thus, debt claims, in particular, may now pass from hand to hand without any involvement of the debtor, but only by pure consent between the seller and the purchaser. The invention of securities is a great economic achievement of mankind. It has enormously increased the liquidity and mobility of all sorts of claims. The debtor, or the physical object of the claim, may be perfectly immobile, but the security renders the claim highly mobile and marketable. In particular, securitisation has rendered the benefits of risk diversification available to virtually everybody. In principle, every asset can be securitised. As evidenced by the diversity of, for instance, Danish mortgages and mortgage bonds, every type of mortgage can be securitised. In financial circles, "securitisation" has come to mean much more than just securitisation, viz.

- **The pooling** of a large number of primary asset-backed personal debt contracts (of varying sizes, but similar design) in a **special purpose vehicle** (SPV) or in a fully-fledged **financial intermediary**.

- **The repackaging of the pool of claims:**
  - The issuance of a large number of small standardised **shares** of all the cash flows from the pool by a pure pass-through vehicle which has no obligation towards the security holders other than the provision of a financial service (securitisation American pass-through style),

  or

  - the issuance of a large number of small standardised **debt claims** on the intermediary, i.e. mortgage bank (securitisation German, Danish, Swiss *Pfandbrief* style, US mortgage bonds).

- **Possible credit enhancements:**
  - An external credit enhancement can be represented by a third party guarantee that provide for first loss protection against losses to a specified level, for example 8%.
  - An internal credit enhancement can be realized through excess servicing spread accounts (a proportion of the interests paid by the mortgagors is allocated into a separate reserve account to cover potential losses), by introducing senior/subordinated structures, and through reserve funds.

- **Securitisation proper** of the small standardised debt claims, i.e. embodiment of the standardised claims on a piece of paper (or a computer entry).

In the United States, securitisation was viewed as a solution to a double problem:

1) the **maturity mismatch** of loans and deposits in savings and loan institutions. In the 1980s, when interest rates started to rise dramatically, many institutions ran into financial problems as they had financed long-term mortgages with short-term deposits.

2) the recurring shortage **of deposits** in savings and loan institutions due to interest rate regulations.

Both these problems had arisen because of the extremely ill-conceived US financial legislation emerging in and after the "New Deal" of the thirties that had made the US financial system unfit to adequately cope with the high and volatile inflation of the seventies and early eighties. The shortage of deposits gave rise to periodic spells of disintermediation, which created financing problems, particularly for individual would-be homeowners and small businesses. Large companies were less affected because they have direct access to the capital market via their own securities.

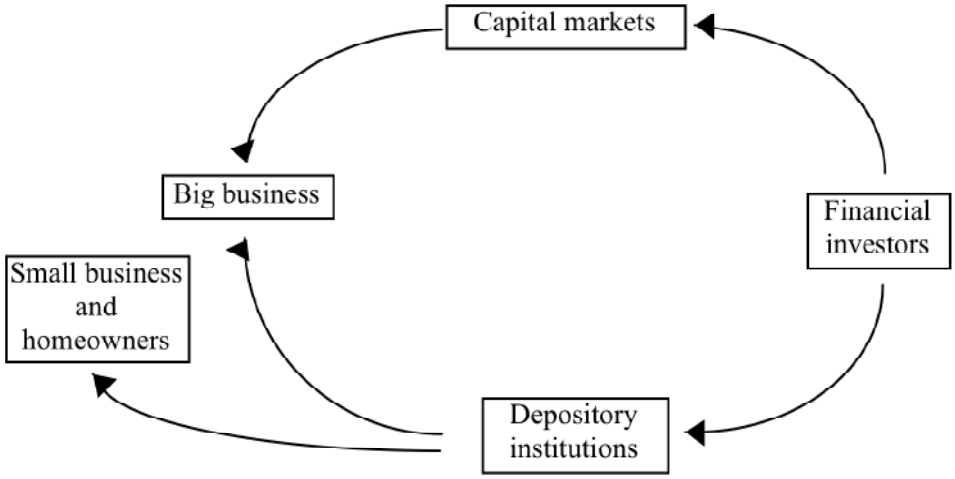


Figure 2-3: Disintermediation and mortgage credit availability problem at high interest rates under Regulation Q

In Switzerland, mortgage securitisation started with the launch in May 1998 of the first MBS named "Tell" for Total Equity and Liability Leverage by the former Swiss Bank Corporation (now UBS). The experience can be looked at as a pioneer deal for Swiss MBS. Many legal (e.g. bank secrecy law) and a few cultural barriers have reduced the attractiveness of MBS in Switzerland. However, the financial and economic appeal for MBS used to be high as, depending on the regulation, it could free more than 90% of the regulatory capital and transfer risk instead of pooling it. However, after the major financial crisis of 2008-2009, where these instruments played an important role, regulators and in particular Basel III are reviewing the situation. Following the imposition of stricter capital adequacy requirements, Swiss banks in particular are now securitising a greater proportion of their mortgages, although they often do so through the US or EUR bond market.

Alongside other European countries such as Denmark and Germany, Switzerland has a very successful tradition of mortgage securitisation schemes dating back to the nineteenth century (the Swiss *Pfandbrief* or *lettre de gage*, i.e. a type of covered bond). *Pfandbriefe* do not follow the traditional method of securitisation, however. The primary liability is that of the issuing *Pfandbrief* bank for its bonds – as in the case of conventional corporate bonds. It is only in the event of bankruptcy that the mortgage pool linked to the bonds appears as the second form of collateral. Due to the fixed maturity of the mortgages behind typical *Pfandbriefe* and the virtual absence of prepayment, or other options, the valuation of such German standard mortgages is rather straightforward. Consequently, the valuation of the mortgage bonds, which are used to refinance such mortgages in a practically maturity-matching fashion, amounts to a pretty straightforward application of well-known fixed-income analysis.

On the other hand, standard American mortgages and standard Danish mortgages – fixed-rate level-payment mortgages –, which have many similarities, require more intricate analysis. In the following, we will, therefore, focus on the American situation, which is the most developed in MBS matters.

*2.3.1.1 What are Mortgage-Backed Securities[20]**

Mortgage-Backed Securities are debt and related securities whose commitment to repay investors is backed by:

- the value of the pool of mortgages and
- the credit support from a third party to the transaction.

The investor's risk is linked to the mortgages, which back the MBS he invests in. It is not the issuer's general revenue that remains the primary source of interest payments and repayment of principal of the MBS, but the cash flow generated by the pool of mortgages. Frequently, features are built into MBS structures to enhance, either by means of internal structure or with the help of outside parties, the credit quality of the underlying mortgages.

MBS are issued by the special purpose vehicles, which have no purpose other than to hold a specific pool of mortgages and issue securities against these mortgages. The motivation for the mortgage lender to issue MBS is multiple:

- Financing technique:
  - diversification of funding sources for mortgage bank (off-balance sheet);
  - increase financial flexibility;
  - access to new investor base.

- Balance sheet management technique:
  - management of liquidity and duration (assets & liabilities);
  - improvement of financial ratios (ROE, liquidity, etc) and profitability.

- Equity capital management technique:
  - free-up capital for more profitable businesses;
  - cost effective form of funding (WACC, credit arbitrage).

- Risk management technique:
  - management of credit, market, liquidity and refinancing risks;
  - securitisation encourages best practice in commercial lending (ISO 9000).

- Positive side effects:
  - additional management information; regular publication of large quantities of information relating to the performance of the underlying asset pools.

[20] See the excellent book of Frank Fabozzi, “Bond Markets: Analysis and Strategies”, Prentice-Hall, chap.10-12, and www.swx.com, “Asset-Backed Securities”.

For the investors, MBS are also appealing:

- Better yields due to securitisation premium: compared to similar grade (e.g. Aaa) corporate bonds, MBS and ABS pay a higher yield.
- Rating: They offer high ratings. This can be very important for certain groups of investors; especially and in all cases where regulation stipulates or favours higher ratings.
- Liquidity: In the USA, MBS were homogeneous products involving very large deals in a very liquid secondary market before the 2008-2009 financial crisis; after the crisis, liquidity was very constrained for some time. The markets for agency securitisation have now returned to normal operation. By contrast, private MBS securitisation is now less common. In Europe, MBS are still more of a buy and hold market.
- Risk characteristics: Supposedly good diversification because the risk is spread over a large pool of debtors; however, the 2008-2009 financial crisis proved this assumption wrong in the US.

Before the 2008-2009 financial crisis, MBS and ABS generally provided much better ratings than their corporate equivalent securities. Table 2-2 presents an overview of the different proportion of ratings for MBS & ABS and for corporate bonds.

	Aaa	Aa	A	BBB
MBS & ABS	72%	7%	11%	6%
Corporate	5%	16%	38%	20%

Table 2-2: Rating dispersion (1995-1997)[21]

MBS and ABS still attract much better ratings than corporate bonds. Although now extremely rare in the case of corporate bonds, over 80 per cent of securitised debt instruments have a AAA rating – despite a significant tightening of securitisation ratings by the agencies since the financial crisis.

	Aaa	Aa	A	BBB
MBS & ABS	87%	5%	6%	2%
Corporate	2%	13%	44%	41%

Table 2-3: Rating dispersion (2015)[22]

[21] Hans-Peter Bär, Securitisation in Switzerland: A new trend, Proceedings of the MGI Conference on ABS in Switzerland, Geneva, 1999

[22] Source: Credit Suisse, Barclays Multiverse Index, 31 March 2015

*2.3.2 The Building Blocks of a Pass-Through Security**

To grasp the essence of the US securitisation mode, one has to recall the historical purpose of the move towards mortgage securitisation. The goal of the process initiated in the late sixties was to solve the mismatch problems and to make the US mortgage financing system safe from macroeconomic turbulences without sacrificing and credit rationing the consumer-friendly US standard fixed-rate level-payment mortgage. Recall that critical ingredients of this mortgage design are:

1. fixed coupon interest rate;
2. constant annuity payments;
3. fixed maturity, typically 30 years;
4. Option on partial or full prepayment on the part of the borrower with exercise price at par, no termination option for the lender.

Since, ultimately, the intermediary can sell only the cash flows embodied in his asset portfolio, this mortgage design requires a relatively complex long-term refinancing instrument. It should be a very long-term, fixed rate and callable refinancing vehicle. This could be achieved by a combination of a variety of different instruments. Securitisation of the entire package is an alternative. Instead of a complex on-balance sheet refinancing tool, the financial investor is offered exactly the cash flows that mortgage borrowers choose to make.

*2.3.2.1 The Securitisation Structure for MBS**

The structure required for the securitisation of mortgages is presented schematically in Figure 2-4. When the debtor signs the mortgage with his bank, it is not known yet, whether the mortgage bank will sell the mortgage to the SPV at a later point in time in order to securitise it into a MBS. In Switzerland, due to the bank secrecy law, this cannot be done without the debtor's agreement. This is the reason why, after the TELL deal by the Swiss Bank Corporation in 1998, the large Swiss commercial banks have started to include a clause usually printed in bold in the mortgage contract, which allows them to "pass" the mortgage to a third party, i.e. the special purpose vehicle (SPV).

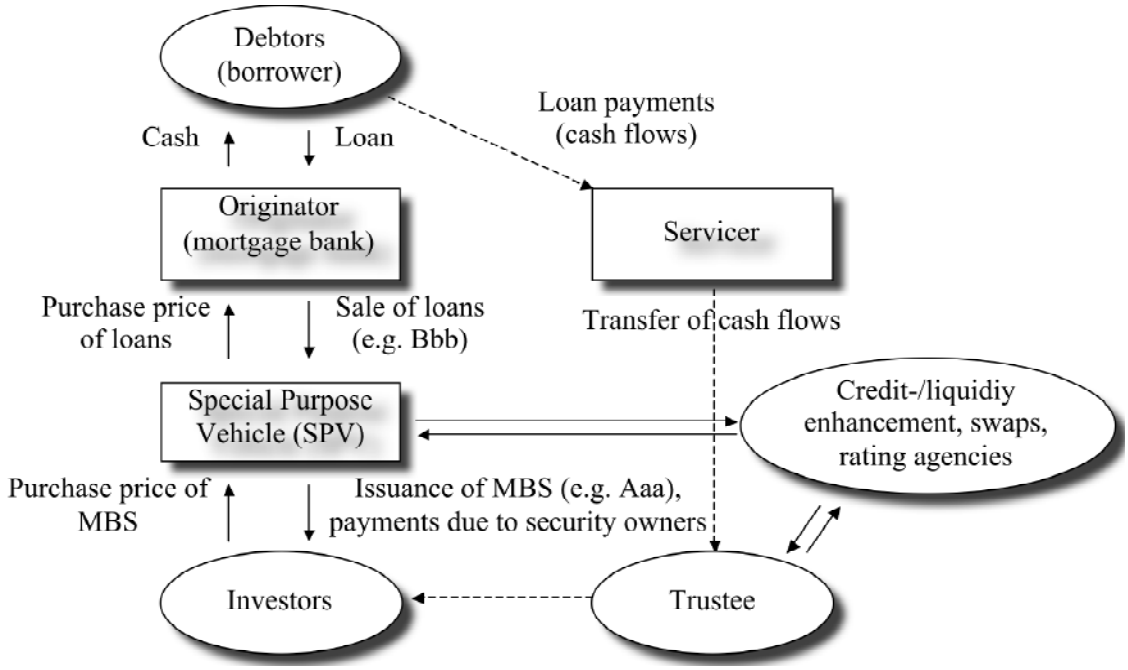


Figure 2-4: Schematic working structure for the securitisation of mortgages

After selling the mortgage to the SPV, the mortgage bank often remains the servicer of the mortgage on behalf of the SPV, so that the client contact does not necessarily need to be "passed", along with the mortgage, to another advisor. The servicer receives a fee from the SPV for his services. The SPV then issues MBS, which are generally structured in various tranches:

- the senior (priority) debt, typically rated Aaa, corresponding to approximately 95% of the pool value;
- the junior (subordinated) debt made of one or more tranches, rated Aa, A, ... corresponding to approximately 5% of the pool value;
- the reserve account, generally guaranteed by the originator, corresponding to less than 1% of the pool value.

This is done to enhance the credit risk of the senior debt to an Aaa rating in order to pay lower yields on the MBS.

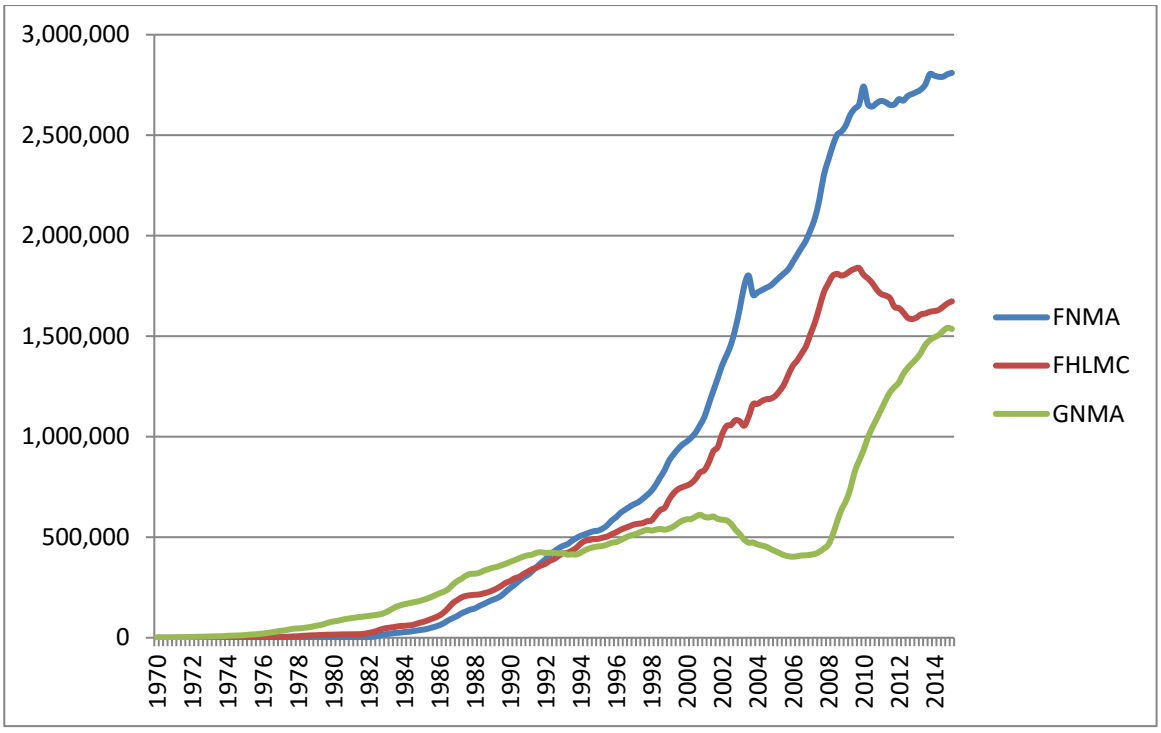
The servicer receives the cash flows from the mortgage borrower, i.e. the interest and the amortisation, depending on the contract, and transfers them to a trustee. Here, various interest rate derivatives can be used to reduce credit and liquidity risk such as, for instance, interest rate swaps. The trustee will finally pay his due to the investor in the form of coupon and principal.

*2.3.2.2 US Mortgage Agencies**

In the case of agency securitisation, a further intermediary is brought in between the originator and the SPV. The originator sells the mortgages to the agencies. The agencies provide a guarantee to cover the credit default risk for those mortgages. In the event of default, the agency pays the outstanding amount to the SPV.

The US mortgage agencies were set up following the Great Depression. Their mission reflects government policy. They exist to facilitate lending and therefore make property ownership more affordable to more people. They were established as stock corporations under private law. On account of their role in implementing policy and their size and importance within the real estate market (and hence for the economy as a whole), it was always assumed that the agencies were themselves backed implicitly by the US government. Accordingly, their bonds were always graded AAA by the rating agencies.

Before the financial crisis, the three biggest mortgage agencies were the Government National Mortgage Association (GNMA; known as Ginnie Mae), the Federal National Mortgage Association (FNMA; known as Fannie Mae) and the Federal Home Loan Mortgage Corporation (FHLM; known as Freddie Mac). As the largest of these, Fannie Mae guarantees mortgages with a total value of approximately USD 2,700 billion. In addition to the big three, there are various state-sponsored agencies that provide guarantees for certain mortgages (e.g. Federal Housing Administration and Banks, Veterans Administration, Rural Housing Service). The principle is similar to that of the three traditional housing agencies, which are examined in further detail below.



[23]

Figure 2-5: MBS issues guaranteed by the mortgage agencies

In the case of agency MBS, the agency provides a guarantee covering all credit defaults risks. In the event of bankruptcy, the MBS SPV will receive the nominal value of the mortgage from the agency. From the investor's point of view, bankruptcy is therefore equivalent to any other form of early redemption.

[23] Source: SIFMA (Securities Industry and Financial Markets Association), 2015

Historically, the mortgage financing role of the agencies was always directed at the middle classes. Reflecting this policy, an upper limit (reviewed annually by the Federal Housing Finance Agency) was always set on the financing of mortgages through the agencies. At present, the limit for single family homes is USD 730,000 (1980: USD 94,000, 2000: USD 253,000, 2006: USD 417,000)[24]. The idea behind the limit was to support lending for homes in the lower half of the US property market, and until the real estate crash the limit was tied to median US house prices. In order to meet all the agencies' requirements, 'conforming' mortgages also had to fulfil strict standards in terms of debtor quality and documentation. Only conforming mortgages are securitised by the agencies.

All relatively large mortgages that are properly documented and of good quality are treated as jumbo mortgages and are securitised through the private market. Following the real estate crash in 2007, however, the private lending market for mortgages came to a standstill due to a lack of investor interest. In order to rectify this 'credit crunch', a decision was taken by policymakers to massively increase the upper limit for conforming mortgages. In some cases, exceptions were approved even to the new higher limits[25].

At the end of the day, an agency mortgage is simply a hidden state subsidy for mortgages. Implicit state backing facilitates cheaper refinancing, while exemption from banking industry legislation represents a massive saving with regard to the amount of capital used/required (section 2.3.3.6). Historically, conforming mortgages were on average around 20-30 bp p.a. cheaper than jumbo mortgages financed through the private market. During the financial crisis, this subsidy rose intermittently to over 2 per cent p.a.

In terms of regulatory policy, the fact that the agencies' market share has now risen to over 90 per cent of all US mortgages due to the increased upper limits for conforming mortgages is highly controversial. In effect, lending in the residential property market has been almost completely nationalised – not exactly what you would expect in a country regarded as a model of free market economics.

*2.3.2.3 Cash Flows from a Portfolio of US Standard Mortgages**

A portfolio of US standard mortgages generates a characteristic uncertain cash flow. The period cash flow consists of three components:

1. the interest due on outstanding principal;
2. the regular amortisation due on outstanding principal;
3. the prepayment of principal at par due to either
   - ordinary prepayment or
   - default of borrower (if the payment is guaranteed by an agency or an insurer).

Note that if the mortgage is not insured and guaranteed – private MBS - , or if the insurance or guarantor cannot meet his obligations, the above total can be diminished by losses from default and insolvency.

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[24] Source: Fannie Mae

[25] Up to a point, this large-scale political intervention in the securitisation and lending system is a counterpart to state intervention in the banks in typical banking/lending systems (as witnessed during the financial crisis in Europe). Whether securitisation or banking, in the event of a systemic crisis both will suffer when they reach their 'genetically' predetermined breaking point (refinancing in the case of securitisation markets; capital and liquidity in the case of banking markets). On past evidence, at least, it appears that we are unable to deal with severe market crises without state intervention.

This is the cash flow pattern that the mortgage intermediary can sell to its shareholders and depositors. Thus, either the intermediary issues some liability that duplicates this cash flow structure, or, if it wants to shelter its depositors from the undesirable effects of the cash flow pattern generated by this mortgage design, it needs large amounts of both equity capital and precautionary cash.

The financial investor is entitled to a proportional share in all the cash flows coming from the mortgage borrowers, be they coupon, contractual amortisation, or prepayment.

*2.3.3 The Role of MBS, Agencies and CDOs in the 2008-2009 Financial Crisis**

Much has been written on the causes of this major financial crisis. Academics, finance professionals, politicians and many others have provided numerous explanations about the root causes of this disaster. Among the many causes, two sets of events played a central role: the boom and subsequent bust of the US real estate market and changes in the US banking business model, allowed by regulatory changes that led to excesses in disintermediation.

*2.3.3.1 The Boom and Bust of the US Real Estate Market**

In nominal terms, the price of the typical US house increased by 170% between 1997 and 2006, or almost 12% per annum on average. Relative to income, the ratio of median house price to median income was around 3 during the 1980s and 1990s, but increased to 4 in 2004 and 4.6 in 2006.

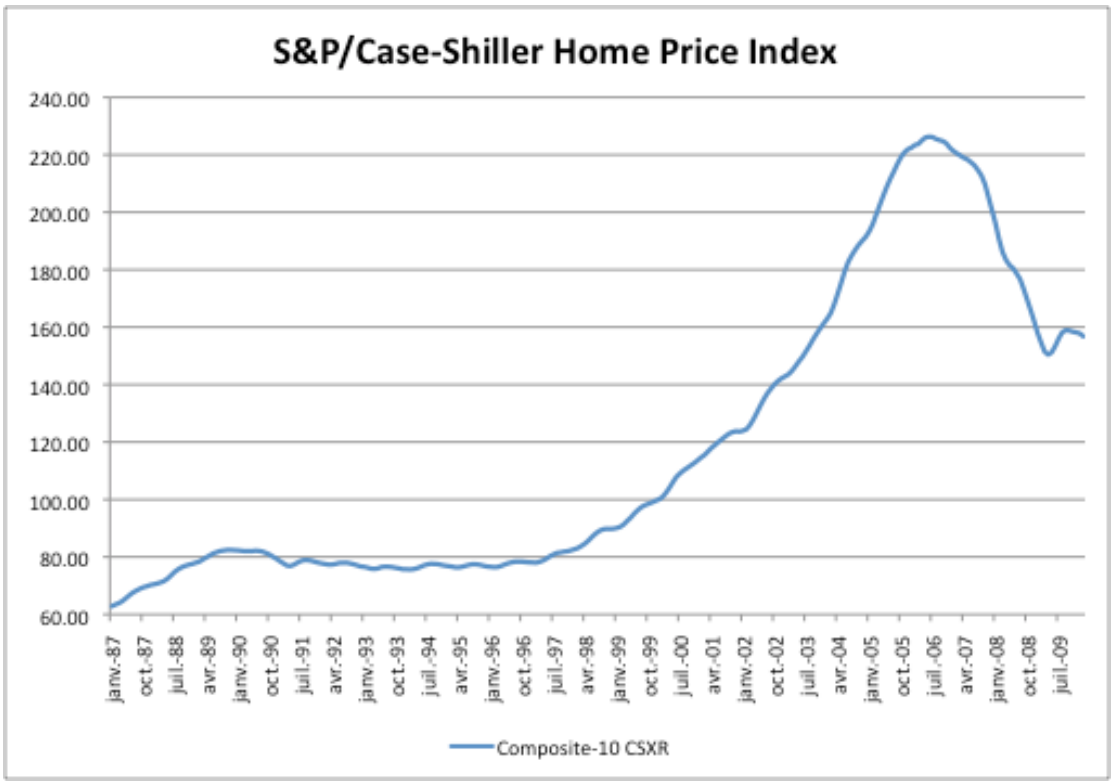

Figure 2-6: S&P/Case-Shiller Home Price Index

What were the reasons for this housing boom? The unusually low interest policy conducted by the Fed between 2002 and 2005 was certainly a factor, as highlighted by Taylor[26] (author of the "Taylor rule" to determine the optimal interest policy). During most of this period, the Fed policy was too easy and the Fed funds were about 2% lower than predicted by the "Taylor rule" that worked well since the early 1980s.

*2.3.3.2 US Banks' Business Model Changes**

In 2004, several regulatory changes[27] allowed banks to accelerate off-balance sheet mortgage securitisation into Special Purpose Vehicles (SPVs)[28] in order to increase balance sheet and revenues. These changes included the relaxation of leverage limits for investment banks from 15:1 up to 40:1 in some cases. Also, the publication of the Basel II accord lowered the capital weight given to high-quality mortgage from 50% in Basel I to 35% in the simplified Basel II and even 15% to 20% for banks using internal ratings, based on their own risk model. This accord also opened an arbitrage opportunity to increase off-balance sheet activities before the actual implementation of Basel II.

These changes and others created an opportunity for banks to expand their securitisation business model and paved the way to significant growth in their balance sheet… and profitability.

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[26] The Financial Crisis and the Policy Responses: An Empirical Analysis of What Went Wrong, John B. Taylor, NBER Working Paper No. 14631

[27] For more details, refer to "The Current Financial Crisis: Causes and Policy Issues", OECD 2008.

[28] Also called Asset-Backed Commercial Paper (or ABCP) conduits.

*2.3.3.3 Rapid Increase in MBS and CDO Issuance… but of Decreasing Quality**

Between 2002and 2007, the amount of MBS displayed explosive growth, increasing for agency MBS from about USD 4000 bn to over USD 5800 bn (+45%) and for private MBS from about USD 1200 bn to over USD 3600 bn (+200%), while other types of asset-backed securities did not display such growth. The CDO market on his side grew from USD 275 bn in 2000 to USD 4'700 bn in 2006. In the beginning, the banks' new business model worked well, as they were able to save capital, grow balance sheets and increase profitability.

However, over time, the new paradigm was pushed too far and, as more assets were required to meet investors' appetite for MBS, the quality of mortgages decreased. The decrease in quality was on-going from 2001 to 2007, but until 2006, increasing real estate prices masked it. This positively oriented real estate market allowed homeowners to refinance their mortgage easily, or even increase the value of their mortgage on the same house, thereby extracting cash from their home. On the other hand, banks and other lenders cared less about loan quality than in the traditional business model, because they passed most of the risks to investors through securitisation.

Homeownership was made possible even for households with little or no equity by the development of sub-prime mortgages. Sub-prime mortgages carry higher interest rates because of higher risk (poor credit score, high level of indebtedness, low equity, poor documentation, etc.). Most sub-prime mortgages carried very low "teaser" interest rates for 2 or 3 years and then reset at higher interest rates for the remainder of the 30 years. These are called adjustable rate mortgages or ARMs 2/28 or 3/27. Between 2001 and 2006, sub-prime mortgages displayed explosive growth from USD 57 bn to USD 375 bn in origination and increased their market share from 8% of to 20% of all mortgages. In their excesses, sub-prime mortgages and automated loan approvals allowed people with little or no equity, small or no income and little or no documentation to become homeowners, the so-called NINJA loans for "no income, no job, no assets".

When the house market soured, homeowners with negative equity and who, in certain states, had non-recourse loans[29] had little incentive to continue paying monthly debt service. Many stopped paying and some walked away with or without foreclosure.

*2.3.3.4 Credit Enhancement, Credit Insurance and Ratings Agencies**

A crucial ingredient of the mortgage securitisation business model was the rating attributed by rating agencies to private MBS and the various tranches of CDOs. In the end, it became clear that the 3 major rating agencies played a major role in the financial crisis by granting ratings that were, in retrospect, excessively optimistic.

At the height of the market, ratings of MBS and CDOs represented almost 50% of the revenues of rating agencies. A business model where the issuer pays to get rated can create a conflict of interest for rating agencies. They could be tempted to inflate ratings for fears of losing business to the competition. Issuers understood from rating agencies the conditions for a given emission or CDO tranche to get a given rating, say AAA. In order to secure the target rating, the bank would provide credit enhancement to the issuer or so-called mono-lines insurances companies would provide credit insurance. This allowed the creation of more AAA CDOs than there were actual underlying AAA assets.

[29] Mortgage without personal or business responsibility in addition to the value of the property.

In 2000, a new, simplified, mathematical formula[30] was developed to model default correlation. It allowed a much simpler pricing of CDOs and their various tranches, estimation of cumulative losses probabilities, first to default probabilities, etc. Instead of using historical data, this formula made use of market observations on the swap spreads and CDS markets. The simplicity and power of this formula secured its success and it quickly became a standard used by investment banks, ratings agencies and regulators alike.

In hindsight, the simplifications of the formula, in particular the assumption that the correlation of defaults between homeowners was small and constant appears heroic, but market participants endorsed it. Overall, a fundamental risk estimation error was made: taking a systematic risk for a specific one. While homeowners default is mostly specific (i.e. linked to the individual owner) when economic conditions are good, defaults can become systematic when an economic downturn affects the whole market. The model simply failed to factor-in the possibility of a synchronous, nation-wide real estate downturn!

*2.3.3.5 The Downturn in House Prices Triggers the Domino Effect**

As supply of homes exceeded demand and as speculators left the market, the downturn of the real estate market started in mid-2006. The downturn, coupled with the lower quality of many recent mortgages and the widespread use of ARMs that reset at higher interest rates, triggered a wave of defaults and foreclosure in 2007 and 2008.

It quickly became clear that a huge amount of MBS and CDOs were becoming worthless regardless of their credit rating, credit enhancement or credit insurance. Mono-lines were unable to meet their engagements: 15% to 20% of all of their guarantees were housing-related CDOs. The total losses on these guarantees exceeded their own capital (typically 8%-10% of all guarantees). The downturn resulted in huge losses to investors. Financial institutions also got hit, as many of these instruments were still on their balance sheet or parked off-balance sheet in SPVs that they owned. However, even though SPVs were off-balance sheet for regulatory purpose, the parent bank had often taken the engagement to provide liquidity and credit enhancements, meaning that investors had a put option to return the assets to banks if they suffered losses. As the cash-flow from mortgages into SPV declined, banks had to honour the credit lines that they had granted in “fair weather”. In addition, SPVs were often financed with short-term commercial paper, a market that dried up during the crisis, meaning that banks were suddenly forced to extend life-lines to their SPVs, jeopardizing their own survival, because SPVs were often much larger than their balance sheet. Even AAA-rated CDO tranches sitting on banks’ balance sheets – despite carrying a low capital charge - became troubled or “toxic”. Financial institutions had no other choice than off-loading or writing off these assets and raise equity as a matter of survival.

Finally, in late 2008, fears of huge losses that would jeopardise the survival of many of the largest US and international banks triggered a major confidence, financial and economic crisis that led central banks to provide huge amounts of liquidity at almost zero interest rates and required a massive government bail-out of the financial sector.

*2.3.3.6 Federal takeover of Fannie Mae and Freddie Mac**

The mortgage agencies were also hit hard by the crisis in the real estate market and finally had to be taken over by the state and placed in conservatorship in 2008.

[30] Li, David X. (2000). “on Default Correlation: A Copula Function Approach”. Journal of Fixed Income.

Overall, the mortgage agencies had very little to do with the property market excesses described above. All the mortgages granted by the agencies met established and quite conservative lending standards. The agencies only ever granted conforming mortgages and very few ARMs. So why did also the agencies have to be rescued by the state?

In order to answer this question, it is worth examining their balance sheets. The example given below is that of Fannie Mae.

Balance Sheets
(Dollars in millions)

	December 31, 2003
	(Dollars in millions, except share stated values)
Assets	
Mortgage portfolio:	
Mortgage-related securities:	
Total	**665'947**
Loans held-for-investment	**240'582**
Mortgage portfolio, net	**906'529**
Nonmortgage investments:	
Total	**59'493**
Other	**43'547**
Total assets	**$ 1'009'569**
Liabilities and Stockholders' Equity	
Liabilities:	
Debentures, notes and bonds, net:	
Total	**961'732**
Other	**25'464**
Total liabilities	**987'196**
Stockholders' Equity:	
Total stockholders' equity	**22'373**
Total liabilities and stockholders' equity	**$ 1'009'569**

[31]

As we can see, in 2003 Fannie Mae had MBS with a total value of around USD 1,009 billion on its books. In the main, these mortgages were securitised and guaranteed by Fannie Mae itself. These portfolios were financed through issues of agency bonds. These are conventional bonds guaranteed by Fannie Mae and given AAA ratings in view of their implicit state backing.

On the other side of the balance sheet, Fannie Mae's equity stood at USD 22 billion. At first sight, this would appear to be roughly 2 per cent.

According to Figure 2-5, in 2003 Fannie Mae was guaranteeing mortgages with a total value of around USD 1800 billion; however, although it had issued credit guarantees for this amount, they were not included in its official balance sheet. Instead, they were treated as off-balance-sheet liabilities. If we express Fannie Mae's equity of USD 22 billion as a proportion of its total guarantees of USD 1800 billion, the result is minuscule – just over 1 per cent.

[31] Source: Fannie Mae, annual report 2003

During the financial crisis, over 6 per cent of loans – even high-quality conforming mortgages – were affected by credit default. This ratio is not at all untypical for mortgage defaults during pronounced real estate market corrections. The level of mortgage default in the Swiss property market crisis of the 1990s was similar. The same is true of other real estate crises in Finland and Sweden (also in the 1990s). During the crisis, it quickly became clear that an equity ratio of 1 per cent is inadequate. Nor did this come as a surprise: previously low levels of capitalisation were the result of political decisions, and the agencies were even exempted from the Basel capital adequacy rules imposed on the banks.

Even now, the United States runs the mortgage agencies in nationalised form with no prescribed capital adequacy ratio. As yet, there is no political consensus for much-needed reform and privatisation of the US agencies, as this would result in higher borrowing costs for home owners while also forcing lenders to find billions of dollars in additional capital. These factors would reduce the volume of credit available. Consequently, efforts to reform this 'hot potato' have been put on hold. In the meantime, the country's mortgage lending market – and therefore a substantial part of the wider capital market – is almost entirely in state hands.

By contrast, a great deal of energy has been invested in measures to rectify shortcomings in the securitisation process. Some of the mortgages submitted by originators for securitisation by the agencies did not meet all the stipulated criteria; failings had also crept into the securitisation process in relation to the required documentation. While these shortcomings were only of marginal importance compared with the systemic problems described above, the legislative and political response led to record fines for the originators and banks involved.

*2.3.4 Analytical Properties of MBS**

The cash flow of a standard MBS, at any point in time, is the sum of three components.

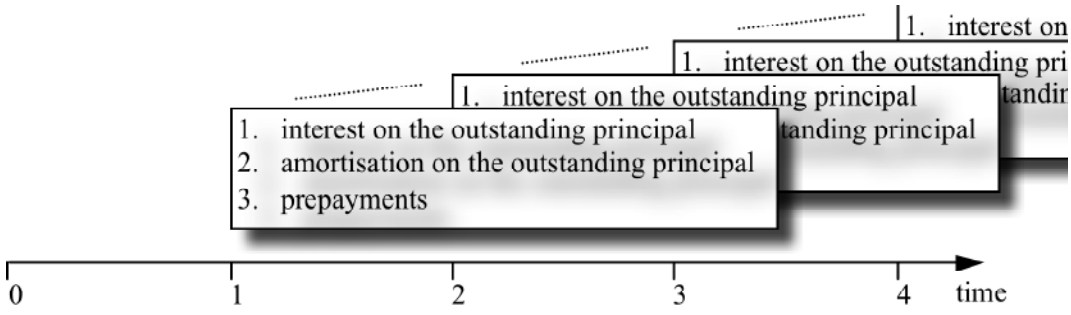

Figure 2-7: Cash flow components to the security holders of a pass-through MBS

*2.3.4.1 Analytical Properties of the Pass-Through MBS**

Were it not for the prepayment problem, bond valuation and pricing methodology could be equally well applied to MBS. It would even be easier, since MBS investors often bear no default risk (other than government default risk).

Prepayment affects the timing of the cash flows reaching the investor. In fact, due to the prepayment option, the investor never knows exactly what duration his security actually has. The problem is rather intricate since assumptions about prepayment behaviour affect the pricing of the coupon.

There are three broad causes of prepayment:

- mobility, i.e. human events such as death, sale, move, divorce, inheritance, etc.;
- refinancing, i.e. partial or full prepayment for portfolio reasons, mainly to take advantage of lower coupon rates on a new mortgage, but also to mobilise idle collateral by taking out a new, possibly larger mortgage;
- default-induced prepayments.

The three causes are related to different economic and non-economic variables:

Mobility prepayments are generated by social and natural processes that have no correlation with economic variables. They occur at a rate independent of the economic environment. They may be expected to occur at a reasonably constant rate over time. Their cumulated volume reflects time, i.e. seasoning.

Refinancing prepayments, on the other hand, are intimately related to the economic environment, particularly to interest rates. As market interest rates fall, there is an incentive to prepay and refinance to take advantage of lower coupon rates.

Default-induced prepayments, finally, are partially the result of purely personal events, partially of macroeconomic events. There is always some stream of bankruptcies. But generally, defaults on mortgages are likely to increase in times of falling real estate prices and of rising interest rates.

Thus, there are three basic variables that influence current prepayment flow:

- time, "seasoning";
- interest rate level;
- real estate prices.

Table 2-4 presents in some detail the three determinants for each category of prepayment. It has been observed that prepayments exhibit a typical pattern during the life of a mortgage pool:

1) In the early years, prepayment due to seasoning is low but rapidly increasing. This may be due to the fact that some people are rather strained by the monthly payments. As real wages rise, and inflation reduces the real burden, this effect vanishes.

2) Ceteris paribus, the prepayment rate subsequently stabilises at a steady level.

3) Interest rate declines accelerate the pace, and interest rate rises decelerate it.

4) So do real estate price declines and increases.

The cash flows of a mortgage loan consist of monthly mortgage payments representing interest, the scheduled repayment of principal, and any prepayments (see Table 2-4). As prepayments are difficult to predict accurately, the cash-flow of a pass-through are also uncertain.

Category of prepayments	Mobility prepayments	Refinancing prepayments	Default-induced prepayments (assuming mortgage insurance)
Time, "seasoning"	*Characteristic time pattern:* a) Initially small amounts b) Rising trend in early years c) Stabilisation after 30 or so months	*Characteristic time pattern:* a) Initially small amounts b) Rising trend during entire lifetime of issue (refinancing to take advantage of idle collateral)	*Characteristic time pattern (assuming normal growth and inflation):* a) High amounts in early years b) Falling trend during entire lifetime of issue (due to growth, inflation, and amortisation)
Market interest rates	No influence	Strong negative influence (refinancing to take advantage of lower market interest rates)	No definite influence
Real estate prices	Ambiguous	Ambiguous	Negative Influence

Table 2-4: Causes for and categories of prepayments

Determining the appropriate discount rate is also difficult. In the US market, even though the federal agency often guarantees to eliminate all **default risk**, there is still **prepayment risk** as all borrowers have the prepayment option.

*2.3.4.2 Prepayment Risk and Duration – Path Dependency**

The effect of rate-driven prepayments is best explained using an example.

Let us assume a newly issued MBS securitisation with an average interest rate for the underlying mortgages of 6 per cent and a term of 30 years.

What will happen to prepayments if rates remain unchanged at 6 per cent? Prepayments are influenced primarily by mobility and property prices and will therefore be relatively low. The anticipated duration will therefore be relatively long (e.g. approximately 12 years).

Interest rates now fall rapidly to 3 per cent. What happens to our mortgage pool? The number of prepayments will rise quickly because most borrowers will use the opportunity to take out a new mortgage at a lower rate. Durations will collapse (e.g. to one year and in extreme cases as low as 0 years if all mortgage holders choose to refinance). Some borrowers will not refinance, however: on the one hand, the new loan must be of sufficient quality (debtor and property), so some mortgages cannot be refinanced; on the other hand, there will be some borrowers who behave irrationally and choose not to take advantage of the opportunity to refinance.

Next, interest rates shoot up to 9 per cent. Interest rate-driven refinancing is no longer an attractive option, and the pool's duration will increase (e.g. to 15 years).

It is interesting to note what then happens if rates subsequently return to 3 per cent. The number of prepayments will again rise, albeit much less so than the last time rates were at 3 per cent. Why? All rate-sensitive borrowers in the securitisation pool will have exited the first time around, and the number of those able or wishing to refinance will be low, e.g. borrowers whose credit quality has since improved sufficiently to allow them to refinance. Durations will therefore decline, but to a much lesser extent than the first time (e.g. to 7 years).

This effect is referred to as the 'path dependency' of MBS securitisation. Durations for callable bonds are similarly dependent on interest rates, although they are not path-dependent. In order to give an accurate valuation of an MBS securitisation and estimate the associated risks, we need complete information about past rate movements, the composition of the pool and the volume of prepayments to date. However, this makes the task of providing exact analytical MBS valuations very time-consuming and difficult.

*2.3.4.3 Agencies – once again**

The pronounced sensitivity of MBS debt instruments makes them a difficult choice for many groups of investors. MBS are often incompatible with investment objectives that are based in many cases on predictable investment terms. As the market grew, it was always harder to find enough investors for MBS securitisations. Consequently, as time passed, the agencies began to buy up their own securitisations and to include them in their balance sheet. Indeed, the volume of securitisations on Fannie Mae's books rose continuously from around 1995 onwards to reach a high-point of around USD 1,000 billion in 2003 (as we saw earlier in Fannie Mae's balance sheet). This balance sheet growth was halted from 2004 following political intervention. After years of debate, the accompanying risks were causing many to 'develop cold feet'. At the peak, approximately one third of all securitised mortgages were held by the agencies themselves.

The agencies financed their MBS portfolios simply by issuing fixed-term agency bonds. These have a relatively stable duration (e.g. 5 years). In order to keep their balance sheet risks under control, the agencies had to match the duration of their (sharply fluctuating) MBS portfolios to the more stable durations that characterised their financing arrangements.

As we have seen, when interest rates go down, prepayments go up. MBS bond durations fall. This leaves the agencies with a duration shortfall on the investment side, and they are forced to buy additional duration, e.g. via the swap market. This mortgage rehedging therefore generates considerable additional demand (at times the volume of MBS has exceeded that of government bonds), thus driving bond prices even higher. On account of this link, we can identify a correlation between swap spreads (difference in yield between swap rates and government bonds) and MBS durations. More pronounced changes in MBS market durations lead to narrower or wider swap spreads. Agencies are the biggest market participants in the US swap market.

This effect is particularly marked – due to path dependency – when the market reaches a new low or high after a lengthy period.

The correlation also works in reverse. When bond markets are falling, the agencies sell duration. Interestingly, they were able to rehedge without any great difficulty during the financial crisis. It was always possible to cover the costs of ongoing rehedging through the difference in yield between bonds (MBS bonds with a higher yield) and cheaper financing (simple agency bonds with AAA rating).

*2.3.4.4 Mortgage Pass-Through Securities**

A mortgage pass-through security as described in section 2.3.4 has the following attractive features for the individual investor:

- it is a liquid asset due to large number of identical claims, the relatively small denomination, and therefore the potentially large and efficient market;
- it provides a good diversification of default risk; agency pass-throughs carry no default risk;
- it also provides a diversification of prepayment risk.

*2.3.4.5 Collateralised Mortgage Obligations (CMO)**

The problems inherent in the standard US mortgage carry over into the mortgage pool that constitutes the MBS. To be sure, there is some diversification effect as far as "mobility" risk is concerned. Were it only for mobility risk, the timing of the cash flows of an MBS would be reasonably predictable. Unfortunately, macroeconomic developments, particularly interest rates and real estate prices, affect the prepayment propensity of the whole pool in a similar fashion. Behaviour of the borrowers in the pool is highly correlated with respect to response to macroeconomic developments. Since interest rates and real estate prices are unpredictable variables, the MBS investor inevitably has to bear considerable prepayment risk, so that both the long-term and the short-term investor may shun the MBS.

The CMO unpacks the uncertain cash flow pattern and creates a set of new cash flow patterns that cater to specific groups of investors with specific maturity interests.

A plain vanilla CMO might look as follows: The whole pool, or a substantial part of one, is subdivided into *tranches* whose cash flows are defined by repayment rank. Interest is paid out from the moment of issue on for every tranche, except the last one, until the tranche is fully retired. To illustrate the CMO, let us take a notional pool of mortgages with an initial balance of USD 100'000. The pool is financed by four tranches of equal size:

- **Tranche 1:** USD 25'000. Receives interest on its outstanding principal balance plus *all* principal amortisation and prepayments. Payments to tranche 1 stop when the principal share of tranche 1 is completely retired.
- **Tranche 2:** USD 25'000. Receives *only* interest until tranche 1 is retired. Once tranche 1 is retired, all principal payments go to tranche 2 until it, too, is fully retired.
- **Tranche 3:** USD 25'000. Receives *only* interest from inception to retirement of tranche 2. Then all interest and principal payments go to tranche 3, until it, too, is retired.
- **Tranche 4:** USD 25'000. No payments at all until all senior tranches are retired. From then on, all payments go to this (residual, or Z) tranche.

To be sure, the CMO does not eliminate aggregate prepayment risk of the pool, neither does it completely eliminate prepayment risk for the various tranches, but it does repackage it in such a way as to respond to the needs of specific investors. It thereby renders the MBS more attractive. It also was a way to use the balance sheet of the agencies more effectively. The most interest-rate sensitive tranches (C and Z) were often bought by the agencies or other professional buyers, whereas the less risky tranches (A and B) would be bought by investment funds or private investors.

COLLATERAL		CMO		
			Principal	Interest
Principal	USD 100'000	Bond A:	USD 25'000	7.5%
Interest	9%	Bond B:	USD 25'000	8.0%
Maturity (in months)	360	Bond C:	USD 25'000	9.0%
PSA* prepayment rate	200%	Bond Z:	USD 25'000	11.0%

* PSA = Public Securities Associations

Table 2-5: Parameters to calculate a four-tranche CMO. For the prepayment rate, we use the PSA standard prepayment benchmark[32].

Figure 2-8 shows the expected cash flows generated by the pool of mortgages using the parameter of Table 2-5. Figure 2-9 and Figure 2-10 illustrate the way the expected cash flows from the collateral are split among the four tranches of the CMO.

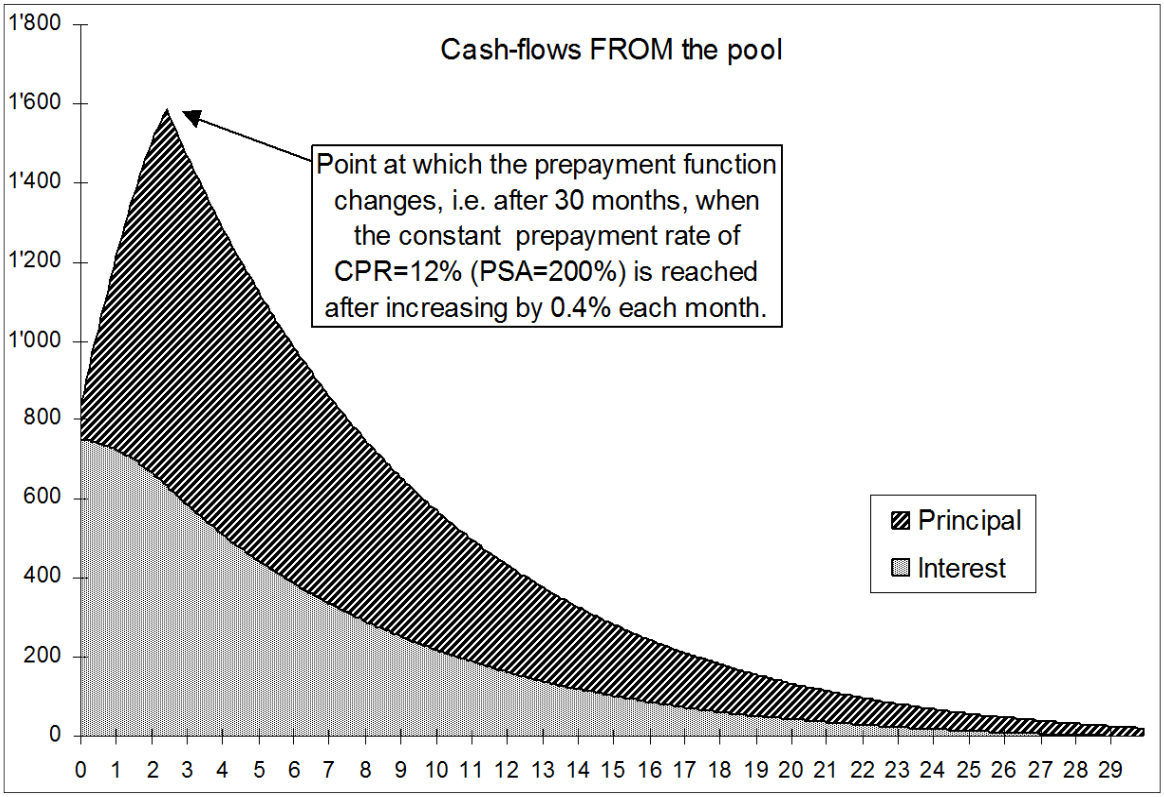

Figure 2-8: Cash flows generated by the pool of collateral under the prepayment rate assumption of the PSA (200%) benchmark. After 30 months of 0.4% monthly increase, the constant prepayment rate remains unchanged at 12% until expiration.

[32] For more details about the calculations, refer to section 2.3.5.

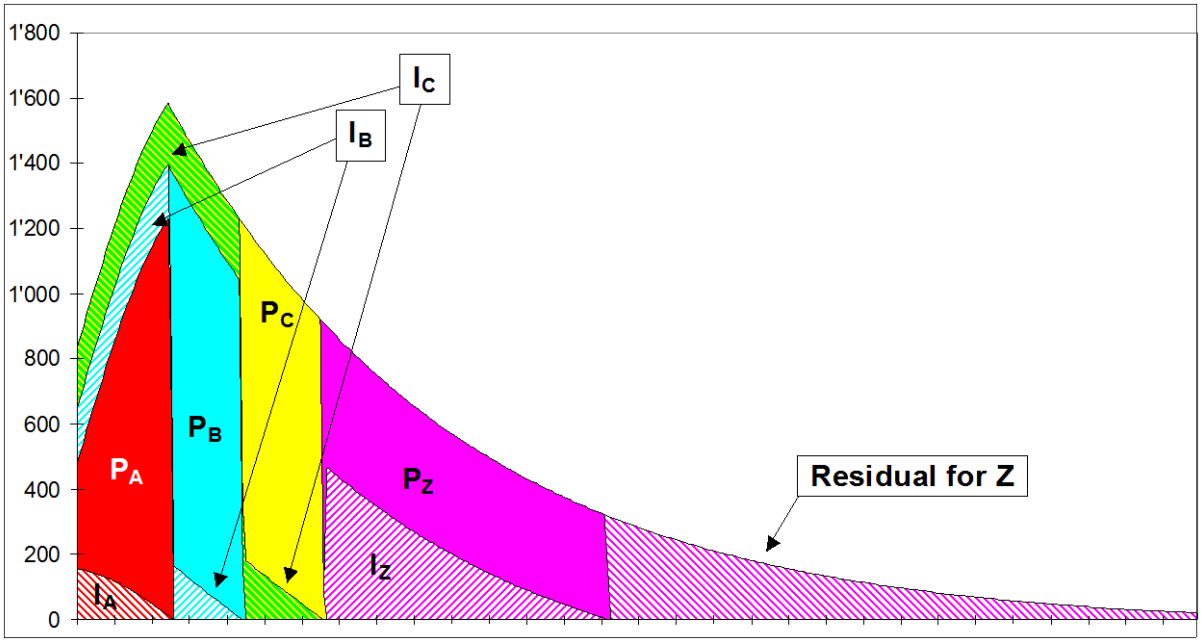

Figure 2-9: The expected cash flows of the collateral are split into the payment of the interests of the tranches A, B and C until the principal of tranche A is fully paid back. Then, until tranche B is fully paid back, the interests of the tranches B and C must be paid. Tranche Z starts receiving cash only when the interests and the principal for tranche C are fully paid back. The residual amount goes to tranche Z.

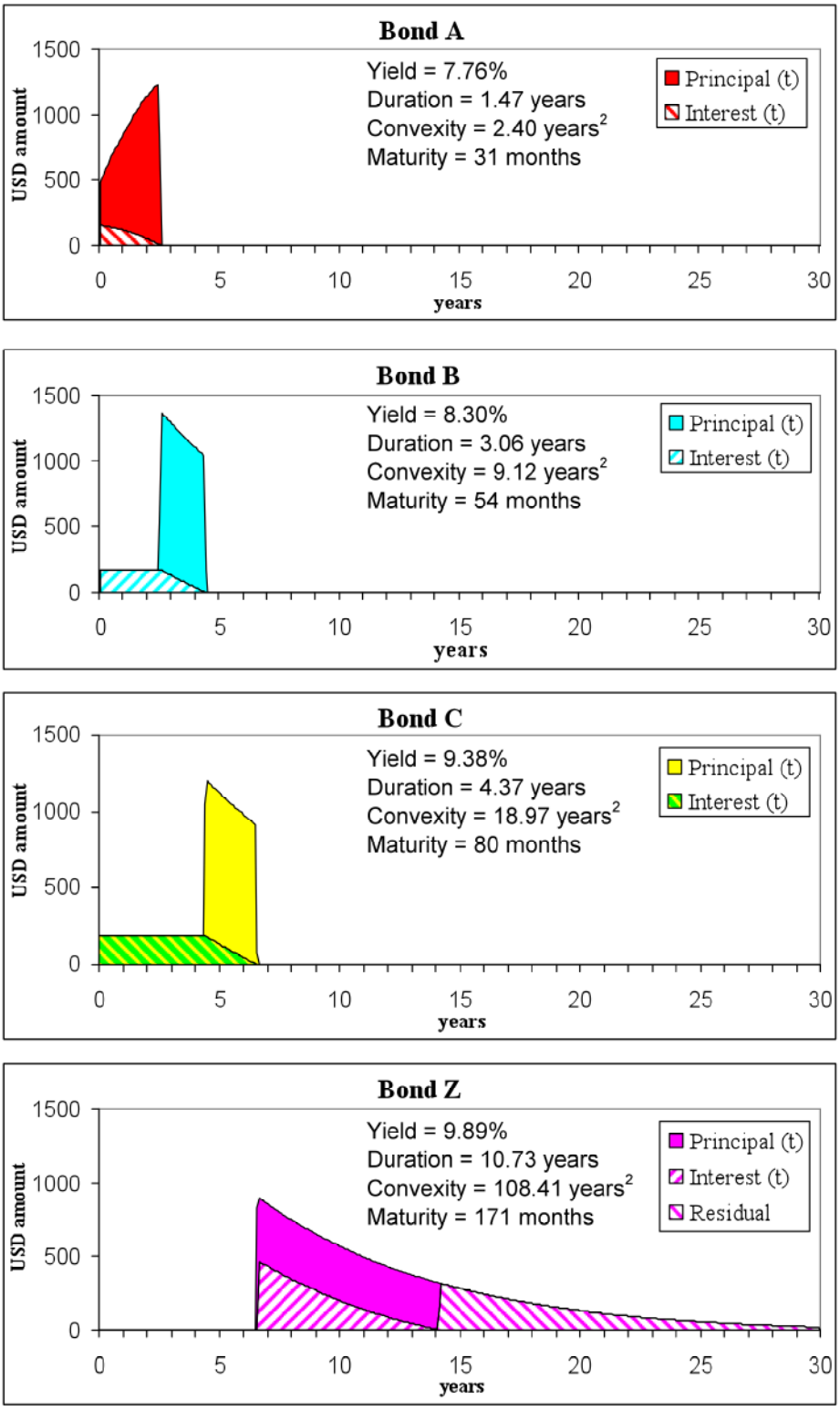

Figure 2-10: Cash flows of the various tranches of a plain vanilla CMO. Note that with the assumptions made, the principal of the Z-tranche is paid back after 171 months. Thereafter, the residual cash flows are paid to the holder of bond Z, achieving a yield of 9.89%, if one neglects the fees. The expected cash flows are also used to determine the expected duration and convexity of each CMO tranche. The maturity indicates the time when the principal is entirely paid back.

*2.3.4.6 Stripped Mortgage-Backed Securities**

Another way to unpack the cash flows from a pass-through is the STRIP. The simplest type of stripped mortgage-backed security is the PO-IO-security. Whereas the cash flows of a simple pass-through are distributed in equal proportions to all investors, the PO-IO approach creates two securities, one that gets all interest flows, the **IO (interest only) security**, and one that gets all principal flows, the **PO (principal only) security.** POs and IOs are useful devices for hedging interest rate and prepayment risk.

*2.3.5 The Cash Flows from a Mortgage Backed Security**

Since the value of a financial claim in one way or another reflects the present value of the cash flows that it will produce, the crucial question with each of the three types of MBS is, what are those cash flows, given the nature of the underlying mortgage contracts. By definition, the cash flows going to the MBS investors have three components:

$$CF_t = NI_t + SP_t + PR_t$$

where:

CF_t	total cash flow to investor
NI_t	monthly interest payment net of servicing and other fees
SP_t	scheduled principal payment for month t
PR_t	forecasted unscheduled principal repayments in month t (prepayments)

The critical magnitude is the prepayment PR_t, which occurs at the discretion of the borrowers. Table 2-6 shows the mechanics of the cash flows of a classical pass-through MBS.

<table>
<tr><td colspan="4">Payments of mortgage borrower: $PR_t + SP_t + I_t$</td></tr>
<tr><td colspan="2">Repayments : $PR_t + SP_t$</td><td colspan="2">(Gross) Interest coupon payments : $I_t = i \cdot MB_{t-1}$</td></tr>
<tr><td colspan="2">Forecasted unscheduled prepayment : PR_t</td><td colspan="2">Monthly scheduled payment of borrowers (coupon plus amortisation on mortgage balance)
$MP_t = MB_{t-1} \cdot \frac{i \cdot (1+i)^{n-t+1}}{(1+i)^{n-t+1} - 1}$</td></tr>
<tr><td>Prepayments

$PR_t = SMM_t \cdot (MB_{t-1} - SP_t)$</td><td>Scheduled repayments

$SP_t = MP_t - I_t$</td><td>Interest net of service fees

$NI_t = MB_{t-1} \cdot (i - s)$</td><td>Service fee (going to servicer)

$S_t = s \cdot MB_{t-1}$</td></tr>
<tr><td colspan="3">Cash flow to MBS investors : $CF_t = PR_t + SP_t + I_t - S_t = PR_t + SP_t + NI_t$</td></tr>
</table>

Table 2-6: The mechanics of current cash flows of a classical pass-through MBS

where:

I_t	Gross interest coupon payments
MB_t	Mortgage balance
MP_t	Monthly scheduled payment of borrowers
SMM_t	Standard monthly mortality rate, i.e. prepayment rate, which can also be modelled using more sophisticated econometric techniques
S_t	Service fee

This process is repeated every month on the basis of the mortgage balance inherited from the previous month. The link between the months follows the dynamic stock adjustment equation

$$MB_t - MB_{t-1} = PR_t + SP_t$$

Through this equation, the events of one period affect the cash flows of all subsequent periods. This is what is meant by **path-dependency.** Clearly, were it not for the uncertain prepayments, PR_t, the process would be perfectly predictable on the basis of knowledge of i, s, n, and MB_0.

There are two classes of approaches to deal with the problem of prepayments:

- schematic conventions, i.e. rough quick-and-dirty rules of thumb;
- formal mathematical models based on (more or less) sound econometric and financial analysis.

We will briefly introduce the most commonly used US convention, i.e. the **Public Securities Association (PSA) standard prepayment benchmark** used to calculate the CMO in section 2.3.4.5. The benchmark is a conjecture of the likely path of the standard monthly mortality rate (SMM_t) during the lifetime of the loan.

The PSA model assumes that prepayments will be low for newly originated mortgages and will speed up as the mortgages become seasoned. It assumes a prepayment rate of 0.2% for the first month, increased by 0.2% per month for the next 30 months until it reaches 6% per year, After reaching this level, it is assumed to remain constant for the balance of the life of the MBS-issue. Or, equivalently:

$$\text{For } t \le 30 \text{ months, } CPR_t = \frac{t}{30} \cdot 6\%$$
$$\text{For } t > 30 \text{ months, } CPR_t = CPR = 6\%$$

where:

t	Number of months since mortgage origination
CPR	Conditional Prepayment Rate. This is an annual prepayment rate, referred to as conditional because it is conditional on the remaining mortgage balance.

This benchmark is referred to as “100% PSA” or simply “100 PSA”. Slower or faster prepayment speeds are then referred to as some percentage of PSA. For example, 200 PSA means 2 times the CPR of the PSA benchmark prepayment rate; 75 PSA means 0.75 times the CPR and so on.

A CPR = 6% means that 6% of mortgage balance is prepaid each year. To estimate monthly prepayments, the CPR must be converted into a monthly prepayment rate, commonly referred to as the single monthly mortality rate (SMM_t). The following formula is used to determine the SMM_t for a given CPR_t:

$$SMM_t = 1 - (1 - CPR_t)^{1/12}$$

*2.3.6 More Sophisticated Methods of MBS Valuation**

Of all the interest rate sensitive securities, MBS are certainly among the more complex ones. The price of an MBS depends on a plethora of factors, many of which are very difficult to model with any degree of accuracy. The previous sections have emphasised that the prepayment behaviour of the mortgage borrowers composing the underlying mortgage pool are an essential feature of any MBS. Although, generally speaking, the prepayment rate is contingent on economic conditions, the current level of the interest rate is likely to be a major determinant. Low interest rates make it more likely that borrowers will prepay their mortgage (i.e. exercise their call option) in order to refinance their property at the lower rate. When considering a pool of mortgages, it is clear that not every home owner will choose to prepay as soon as the call option moves into the money. In this case we expect that the interest rate will be related to the tendency to prepay, specifically that the share of mortgages that is prepaid during any period will be inversely related to the interest rate level.

*2.3.6.1 Duration and Convexity of MBS**

The duration and convexity can be assessed visually in a graph relating the price of the security under scrutiny and the interest rate. For a regular bond this curve has a negative slope and is convex (c.f. Figure 2-11–a). For every yield, the slope of the price function gives an idea of the duration, while the curvature of the function (i.e. change in the slope) provides information about the convexity.

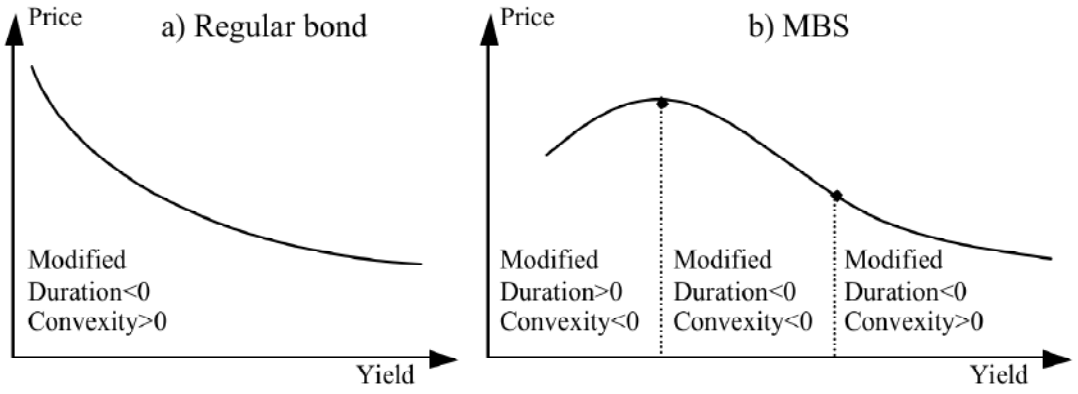

Figure 2-11: Effect of prepayment on duration and convexity

Unlike a regular bond, the price of a MBS is not unambiguously affected by a sinking interest rate. As the interest rate falls, the price of the MBS should tend to rise, all other things held constant, since the stream of cash flows is discounted at a lower rate. Yet, at the same time refinancing becomes more attractive, so that the prepayment rate increases. This partial depletion of the mortgage pool tends to lower the price of the security. This mechanism may be further illustrated if one conceptually separates the cash flows on a pool of mortgages into a claim on the principal repayments only (PO) and a claim on interest payments only (IO).[33] Homeowners go on making their mortgage payments as usual, but now the hypothetical security holders receive payments of their respective categories exclusively.

[33] Although this paragraph should be considered as a thought experiment, the creation of tranches out of a mortgage pool is exactly what is engineered when a CMO (collateralized mortgage obligation) is marketed. Actual CMOs usually contain more tranches than the IO and PO claims in this example.

Given this setting, one can analyse how the prices of the two types of claims vary with the interest rate.

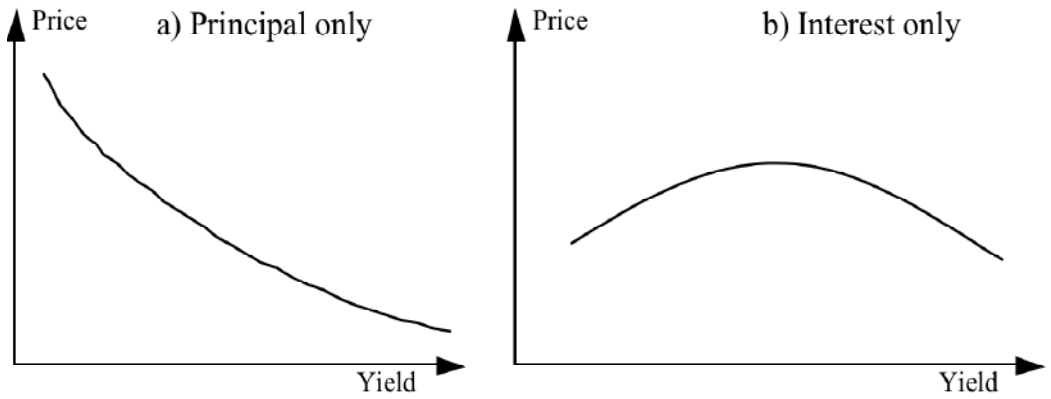

Figure 2-12: Interest rate sensitivity of prices for different tranches

For example, suppose that there is a pass-through with a par value of 100 Mio USD backed by long-term mortgages. The PO security is issued at a substantial discount from par value, for example at 45 Mio USD. The dollar return on this investment is 55 Mio USD, but the realised yield depends on the time needed to recover this amount. The IO has no par value. The investor, as compensation for the amount paid to acquire the IO, receives interest on the amount of the principal outstanding.

The value of a PO claim unmistakably increases with a falling interest rate. The reason is that as the prepayments pick up it takes less time to recover principal repayments, and cash-flows are also discounted at a lower rate.

Two opposite effects affect the price of an IO claim. When interest rates are high, a fall - like in the PO case - increases the present value of the interest payments to come. On the other hand, when interest rates are already low a further decrease has an adverse price effect, because prepayments reduce the amount of principal on which interest will be paid, and so less dollar interest is received. In fact, if prepayments are too fast, the IO investor may not recover the amount paid for the IO. While the present value effect dominates for high yields, the shrinking principal effect is paramount for low yield levels. Thus, for an IO claim, one obtains a bell-shaped price behaviour as depicted in the right-hand side of Figure 2-12. Given that a MBS is a combination of these two hypothetical claims, its price behaviour must also reflect that of its tranches. Thus, the MBS price curve in Figure 2-11 may be thought of as a vertical addition of the PO and IO curves.

It is apparent from Figure 2-11 that the prepayment of a MBS leads to constellations of duration and convexity that significantly differ from those of a regular bond. While for high yields one observes negative duration and positive convexity (as for a regular bond), intermediate yields are accompanied by negative duration and negative convexity. Low interest rates induce positive duration and negative convexity.

Figure 2-11 also highlights the fact that MBS achieve the highest price at the yield on the issue date. From this point onwards, both falling and rising yields will push the price down. The change in prices is always greater for MBS than for conventional bonds, so investors need to be compensated with a higher yield (similar to callable bonds but much more pronounced). The level of this additional yield depends on anticipated rate volatility. If an investor believes that rates will be less volatile than has been priced into the market, it will be worth investing in MBS bonds.

*2.3.6.2 Other Determinants of Prepayment Behaviour**

So far, we assumed that the prepayment rate is solely a function of the market interest rate. A more appropriate model would have to factor in further aspects of prepayment behaviour. Here we consider one additional element.

We have argued that lower interest rates give homeowner strong incentives to refinance their property to lock in a lower coupon rate. Yet, this presupposes that they are in fact able to find a bank willing to lend to them. Whether this is possible depends to a great extent on the loan to value ratio of the current mortgage. It is thus clear that if the property's price has decreased, so that the homeowner has a low, perhaps even negative, equity, refinancing may not be an alternative. Thus, **property prices** also determine prepayment rates.

*2.3.7 Concluding Remarks**

This section has focussed mostly on US securitisation schemes. We may invoke a number of justifications for this choice:

a) The USA is by far the largest market for securitised mortgages.

b) The complexity of the financial analysis of a securitisation scheme reflects the complexity of the underlying mortgage contract. The US standard mortgage contract being a relatively complex instrument.

c) Moreover, contracts similar to the US standard mortgage are well known in other parts of the world as well, notably in Denmark, which has had one of the most sophisticated mortgage security markets since the nineteenth century.

d) A good grasp of the analytics of US mortgage securities is a useful training for the valuation of many modern mortgage designs.

e) Note also that almost every fixed-maturity mortgage contract entails a prepayment problem. After all, Swiss fixed-rate mortgages and German standard mortgages, which are in principle "non-prepayable", involve a mobility-related prepayment risk. So far this has been shifted to the borrower, but there is no inherent reason why Swiss and German banks should not offer a contract in which this risk is borne by the lender.

f) The hedging of changes in MBS durations (e.g. by the mortgage agencies) can strengthen interest rate trends in the US market and influence swap spreads.

As discussed in section 2.3.3 US MBS and CDOs played a central role in the 2008-2009 financial crisis.