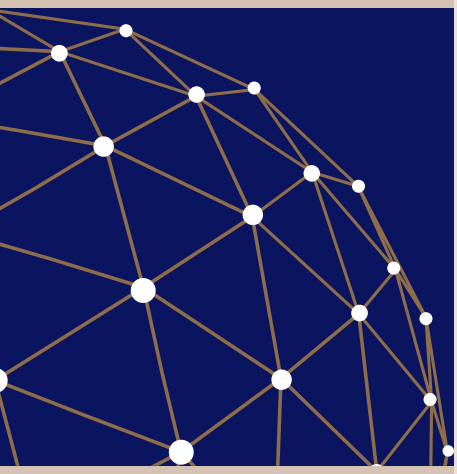
MAGYAR NEMZETI BANK



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ATTILA TAPASZTI – TAMÁS TÓTH

# The US Agency Mortgage-Backed Securities (MBS) Market


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# 1 Introduction

Mortgage bonds, a trailblazing instruments in securitisation, emerged and quickly gained popularity in the second half of the 1970s to facilitate home ownership, which is part of the American Dream. Mortgage-backed securities consolidate cash flows from a large number of combined mortgages, and, after deducting the costs of debt servicing, pass them on to bond buyers proportionately (participatory notes). In the jargon, they are called pools, a term which refers to the underlying mortgages, or they are denoted using the acronyms PT (pass-through), MBS (mortgage-backed securities) or RMBS (residential MBS – as opposed to commercial MBS [CMBS]).

In the basic form, the underlying financial building block of mortgage-backed securities is the 30-year (or 15-year) fixed-rate mortgage, where over the lifetime of the loan, from the debtor's perspective, the diminishing interest payment and increasing principal payment add up to the same payment instalment each month. Later, mortgages with other maturities also developed (10-, 20- and 40-year maturities), the variable element emerged in the interest rate (ARM – adjustable-rate mortgage; Hybrid – fixed for a given period, then variable interest rate), and innovative solutions were introduced into the amortisation of the principal (grace period, mortgages with lump sum payment upon maturity and negative-amortisation mortgages [which increase the principal]).

The feature of American (and Danish) mortgages that sets them apart from the European standards is that a portion or the entirety of the loan can be repaid at any time, without additional banking costs, i.e. the debtors have a prepayment right i.e. option. For mortgage-backed security investors, this means that in a pass-through structure, they may receive their invested capital ahead of schedule, perhaps even at a time when reinvesting it is not favourable in the prevailing investment environment. Structured securities (CMO [collateralized mortgage obligation], REMIC [real estate mortgage investment conduit], IO/PO [interest only – principal only]), which channel cash flows in various ways, emerged in order to contain this so-called prepayment risk, and investors classes (so-called tranches) with varying prepayment risk levels were offered, providing some extra yield in exchange for the additional

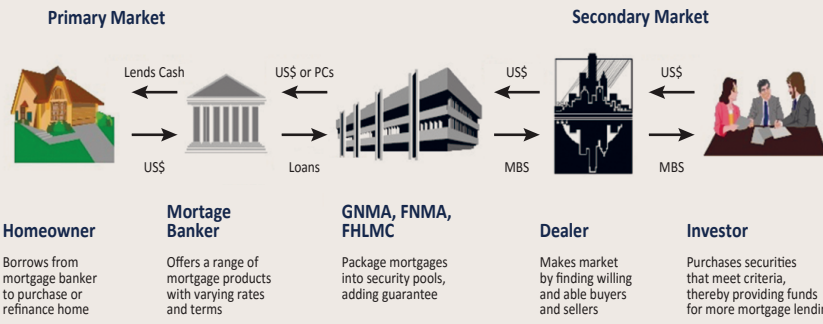
risks taken. These increasingly complex structured securities then started to be sold with subprime mortgages as the underlying loans, and when the real estate market bubble burst, the entire mortgage sector was branded as subprime by association.

This methodological handbook presents the so-called agency MBS market, which, due to its size and efficiency, simply cannot be disregarded when developing a global portfolio.

## 1.1 The origin of agency mortgage-backed securities

The simplified agency mortgage market model is summarised in the flowchart below (Chart 1).

**Chart 1**
**The agency mortgage market model**




*Source: FFTW, MNB*

The bank grants a loan with real estate collateral to the debtor, but usually not from depositors' money, since this would make the difference between the maturities of the assets and liabilities in the bank's balance sheet too large (deposits normally have short maturities, while mortgages have long ones). Instead, the bank sells the mortgage to an agency for cash, which the bank can use to extend more loans. The agency then packages loans with similar characteristics into pools, thereby creating tradeable, liquid securities, and sells them to investors through market-making market makers. There are

numerous unique pools, but they can be classified based on certain shared characteristics: agency (FNMA, FHLMC or GNMA – see next chapter), coupon, original maturity (15, 20 or 30 years – the latter being the most common), year of lending. A given group in the MBS universe with the same shared characteristics (generic) is usually denoted by the agency's name, the original maturity and the coupon: e.g. FNMA 30yr 4.0%.

## 1.2 Mortgage agencies and their market model

The three major players in the US agency mortgage market are Fannie Mae (FNMA), Freddie Mac (FHLMC) and Ginnie Mae (GNMA). After extending the loans, banks providing mortgages contact the agencies which buy mortgages from market participants (the banks granting the loans), for cash or securities representing repackaged loans and guaranteed by the agencies. They only buy loans which meet predetermined conditions (conforming loans), in order to boost credit quality; this is a precondition for the guarantee. They charge a monthly fee for the guarantee, which on the one hand changes over time and on the other hand may vary across the three agencies, but it is usually around 5–50 basis points. In exchange for this fee, the agencies guarantee that the principal and the interest will be passed on to the MBS investors in a timely manner, even if the mortgagor defaults. The other source of profit for agencies is the difference between their financing costs and the yields on the mortgages in their balance sheet.

Fannie Mae, or the Federal National Mortgage Association, was founded in 1938 in the US within the framework of the New Deal to support the housing market, mortgage financing and the establishment of the secondary mortgage market. In 1968, it was converted into a limited company and was later listed on the stock exchange. Its competitor, Freddie Mac, or the Federal Home Loan Mortgage Corporation, was established in 1970 on the initiative of the Congress. This institution was mainly created to foster home ownership among medium-income households. Its activities and characteristics are similar to those of Fannie Mae, whose monopoly was intended to be prevented by the establishment of the new institution. The third agency, Ginnie Mae (the Government National Mortgage Association) was formed in 1968 by

breaking up Fannie Mae, and it came under the auspices of the Department of Housing and Urban Development (HUD). In 1970, it was the first to issue an MBS product. After Fannie/Freddie were listed, they became the only mortgage market participants with an implicit US state guarantee. They mostly concentrated on providing state support for low-income borrowers and war veterans.

The Fannie–Freddie duo were able to finance their operation as profit-orientated firms and do so at a low rate due to their state origins and the safety net of the implicit state guarantee stemming from their critical role in the financial system. Ostensibly in order to support the secondary market, they amassed a large portfolio of their own and others' MBS issues in their balance sheets, which generated substantial extra profits in the course of normal business. However, the real estate market crisis interrupted this trend, and the losses on this portfolio undermined the financial strength of the companies. The two firms were placed in state conservatorship in September 2008, thereby enabling them to raise capital in the long run but at the same time the state drew up the expected schedule of reducing the portfolio. Regulatory tasks were taken over from the OFHEO (Office of Federal Housing Enterprise Oversight), founded under government control in 1992, by a new regulatory body with greater power, the Federal Housing Finance Agency.

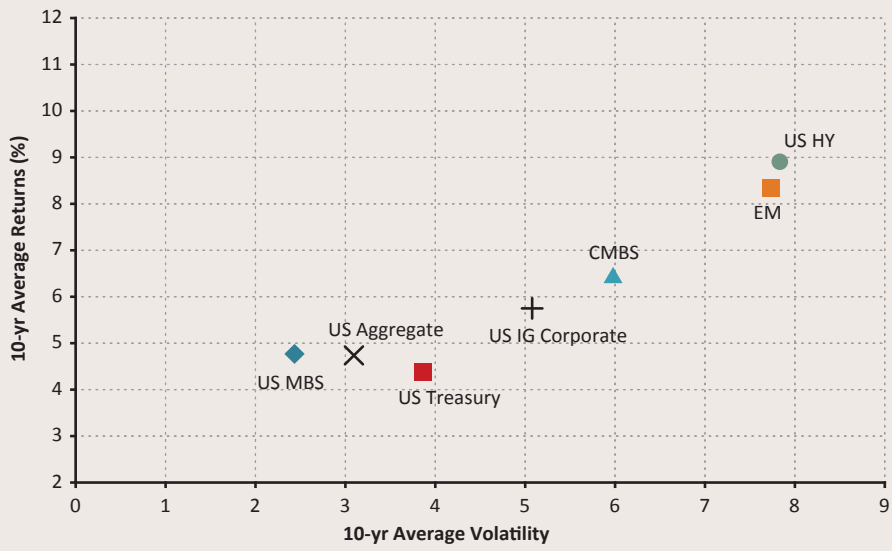
This move proved that government-sponsored enterprises (GSEs) were key systemic risk factors from the perspective of the mortgage market and the American economy. From 2009 until the end of 2012, the two companies were assured that they would receive basically unlimited capital support. After these measures and on account of the explicit state support, S&P reaffirmed the AAA rating for the agencies' unsecured debt securities and mortgage bonds.

## 1.3 Market features

Although few would think it, the US mortgage market is one of the largest bond markets in the world, and therefore an almost vital element in a diversified, global portfolio. With a size of over USD 10 trillion, it is not much smaller than the Treasury market (where government bonds issued

by the US are traded). Agency MBSs account for about half of this, while the remaining portion is made up of the so-called private label MBSs that are issued by private market participants which do not enjoy agency guarantees. Due to its size, the agency mortgage market is one of the most liquid bond markets, its securities are almost as liquid as US Treasury bonds. Not only their credit rating is noteworthy – the mortgage-backed securities guaranteed by agencies have a triple A rating at the three large credit rating agencies (S&P, Moody's, Fitch) – but also their exceptionally positive yield/risk profile. As can be seen in Chart 2, the MBS asset class has had a better yield/risk profile than the US Treasury bonds in the past 10 years: it generated higher yields with lower historical volatility.

**Chart 2**
**10-year average yield/risk profile (2005–2015)**




*US MBS: US residential mortgage-backed securities*
*US aggregate: Aggregate US bonds rated by rating agencies as investment-grade*
*US Treasury: US Treasury bonds*
*US IG corporate: Aggregate US corporate bonds rated by rating agencies as investment-grade*
*CMBS: US commercial mortgage-backed securities*
*EM: Emerging market bonds*
*US HY: US bonds rated by rating agencies as speculative, non-investment-grade*
*Source: Barclays, FFTW, MNB*

Agency MBS securities are purchased by a wide range of clients: investment funds, pension funds, banks, central banks, hedge funds. While banks mainly prefer this product due to its favourable risk weight (Basel III) and exceptional liquidity, central banks usually introduce this asset class into their foreign reserves for diversification purposes and for boosting yields. Since 2008, the Federal Reserve (Fed), serving as the central bank of the US, has become the largest player on the market: within the framework of its quantitative easing (QE) programmes, it has purchased large batches of agency mortgage-backed securities that is has kept on its balance sheet ever since.

# 2 Pool characteristics

Pool characteristics describe the special features of the loans that form the basis of the individual MBS securities, which help investors evaluate the assets. It is important to note that on account of the state guarantee, the evaluation is primarily necessary for assessing and pricing prepayment risk. The major characteristics monitored by the market are the following:

### WAL – Weighted average life

In agency MBS trading, the most important points of reference are the payment dates of the principal. As in the case of an MBS, principal is repaid according to a previously undetermined schedule over the maturity period, and an estimated maturity has to be calculated. The WAL plays a critical role in comparing the individual MBSs. To take a simple example, if a given MBS with a principal value of USD 2.4 million pays USD 100,000 at the end of each month for 2 years, the WAL is 12.5 months. Estimating the WAL facilitates the comparison to the yield of US government securities with similar maturity. The WAL's formula is the following:

$$WAL = \sum_{n=1}^{n} t_n \frac{P_n}{P},$$

where:

*P:* the whole principal

$P_n$*:* the principal instalment repaid on the nth date

$t_n$*:* the period between the date of calculation and the payment of the nth principal instalment in months or years

### WAC – Weighted average coupon

The WAC is the average of the interest rates of the live loans still in the pool weighted by the residual loan amount, calculated at the end of the month. Investors receive the net WAC, which is derived from the following formula:

*WAC – the commission of the institution providing the mortgage – guarantee fee for the given agency = net WAC*

In a concrete example, the figures are the following:

5.332% – 0.25% – 0.082% = 5.000%

### WALA – Weighted average loan age

The WALA is the average of the life of the loans in the MBS weighted by the residual loan amount. In this case, life means the period between disbursement and the date of calculation in months.

### LTV – Loan-to-value ratio

The ratio of the residual loan amount and the estimated value of the given property. Higher LTV means greater risk, for which the party assuming the credit risk can receive a higher mortgage interest premium.

### WAOCS – Weighted average original credit score

In the US, several organisations are engaged in the risk rating and credit risk assessment of the individual mortgage applicants. Perhaps the most widely known is the so-called FICO score that rates clients on a scale from 300 to 900 as follows:

- 720 and above: excellent credit
- 660–719: good credit
- 620–659: fair credit
- 619 and below: bad/poor credit

Of course, a higher score may mean borrowing on better terms. It is important to note that scoring systems are a very cost-effective way of preliminary risk assessment, but according to certain experts, they have several disadvantages (e.g. they are easy to manipulate and historical experiences suggest that they do not always predict real risk).

### Factor

Factor is the ratio of the current total principal and the original principal at the outset. Factor decreases continuously during the maturity period due to the principal payments, and the rate of decrease depends on the volume of prepayments. The ratio of the current factor and the hypothetical factor calculated on the basis of the principal payment schedule determined at the outset shows the unscheduled principal prepayment propensity (the lower the ratio, the higher the prepayment propensity).

### Delay

Service providers pass on the cash flows derived from the loans to MBS investors with some delay. For example in the case of a payment scheduled for September, a 55-day delay means payment on 25 October.

The probability of prepayment is estimated from the characteristics, and the most important decision factors are presented below. It is worth noting that characteristics also play a major role in modelling prepayment, and will thus be discussed in later chapters as well.

- The first factor that indicates prepayment activity is the size of the loans in the pool. Prepayment entails some fixed costs (e.g. legal costs, but there are no prepayment fees in banks), therefore in the case of smaller loans this represents a relatively larger cost element. As a result, in the case of mortgagors with smaller loans, the probability of prepayment is lower, since a considerable interest advantage is necessary to compensate for this fixed cost with the refinanced loan over a short period. In addition, smaller loans are generally taken out by debtors with poorer credit rating, and in their case the probability of prepayment is lower, and in the case of the steadily diminishing loans disbursed a long time ago, the burnout effect is greater (see later).

- The loan-to-value ratio is another important factor: the higher it is, the lower the probability of prepayment. This is because with a higher LTV, mortgagors are much less likely to decide to move. Moreover, in most cases, a higher LTV means poorer solvency, which, to a certain extent, can be deemed favourable from an investment perspective.

- The residual maturity of loans is mainly important because of the burnout effect (see later).
- The institution disbursing the loan also plays a central role in the decision, i.e. whether the loan was disbursed by a bank or not, which is important in terms of the historical analysis of the targeted clients' prepayment propensity.
- In the case of coupon size, a higher coupon may indicate higher prepayment propensity.
- The averaging and weighting in characteristics should be approached with caution. The distribution of the underlying loans' characteristics may be significantly different even when the average values are the same. For example, a pool with an average loan amount of USD 100,000 may consist of loans of USD 100,000 or a couple of loans of USD 400,000 and many loans of USD 25,000. They represent completely different prepayment propensities.

Overall, it must be borne in mind that as in the case of agency MBSs the main point is not the payment of principal itself but the date of payment, and thus highly rated, very liquid and solvent loans are not the best investment. In most cases, these clients may more easily choose prepayment (they have more savings, they move more often, etc.), and they make much more conscious decisions, therefore they may decide to prepay their loan even if smaller incentives are offered. In other words, in the case of these clients, the option in the MBS is worth less, since the owners of the option exercise their rights more efficiently.

Therefore, in the case of agency MBSs, the most special and most expensive papers – somewhat counter-intuitively – are those that are made up of small loans of debtors with high LTV, who are only just able to service their debt. It is important to note that in this case, a risk may be posed by the considerable deterioration of the macroeconomic environment, which may cause mass defaults among the previously described clients, and, due to the agency guarantee, mass prepayment. Furthermore, on account of the expected loose monetary policy of the Fed, the spike in prepayments may be coupled with nosediving yields, i.e. pressure to reinvest at lower returns.

# 3 TBA market

One of the features of the MBS market is the trading on the so-called TBA (to-be-announced) forward market. The overwhelming majority (75–85%) of pass-through agency MBS papers are traded on the TBA market, while the rest change hands on the so-called "specified pool" market segment. The precondition for trading on the TBA market is the fulfilment of certain well-defined conditions that ensure the homogeneity of TBA assets. The structure and operation of the TBA market is crucial in ensuring the high liquidity of the MBS market, and therefore its significance goes beyond the simple technical transaction conditions.

With respect to its standardisation and settlement principle, the TBA market is similar to the normal stock exchange forward markets, but it is an OTC forward instrument. In a TBA transaction, the parties agree on a sales transaction of a given amount of MBS papers at a given price and at a given future date. The TBA market is the most liquid in the first 1-, 2- and 3-month maturities, a significant portion of trading occurs in this segment. The special characteristic of the TBA market is due to the fact that – in the overwhelming majority of cases – at the time of trading, only 6 parameters of the MBSs to be delivered are determined, and these are as follows: coupon rate, issuer, maturity, par value, settlement date and, of course, the price derived from these parameters. The coupon rates are determined in 50-basis point increments, in line with the underlying loans. Some other parameters may also be defined in a so-called "stips" TBA transaction, where in addition to the previously mentioned characteristics, the exact geographical exposure, the number of pools and seasonal provisions may also be stipulated.

"Specified pool" trading, which amounts to 15–25% of MBS trading, differs from the TBA market in that in the former's case, the specific securities to be delivered are specified at the time of the trade. This may be possible if the underlying loan pools do not fulfil the TBA trading criteria, or if the loans have better-than-average prepayment characteristics and can therefore be sold at

a higher price. Thus, one of the main areas of active portfolio management is the assessment of these pools and the identification of investment opportunities. Due to the lack of standardisation, this market is much less liquid than the TBA market, and therefore the incentives for leaving the TBA market are shaped by the balance between the quality premium and the liquidity discount.

The TBA market offers lenders an opportunity to cover for the interest rate risk even during the lending process: if the assessment is successful, the borrower may fix the mortgage interest rate until disbursement 30 or 90 days in advance. This is important from the perspective of market competition, since borrowers know the exact interest rates even before disbursement. Due to efficient and cheap hedging, the lender is able to make a more favourable offer to its clients with respect to the lending conditions as well.

## 3.1 Lack of transparency as a liquidity-boosting factor?

Mortgage market analyses monitor dozens of parameters, for example Freddie publishes 64 different factors in its monthly data reports. Although normally only 6 parameters are determined on the TBA market at the time of the transaction, the liquidity of the TBA market is comparable to that of the US government securities market. At first sight, this runs counter to the widely held notion that the transparency of a given market is in direct proportion to liquidity. It is important to note that this statement cannot be applied to all markets in general (BIS Working Papers No. 479),[1] especially in the case of assets with low credit risk and high coverage, where the primary aim of the market is not to explore the prices (as on the stock market) but to avoid the necessity and costs of price exploration. Overall, this may lead to a reduction in lending costs and thus favourable real economy effects.

The implicit or explicit state guarantee behind the homogeneous agency MBSs and their standardised underlying mortgage-backing enables liquid trading

[1] BIS Working Papers No. 479: Understanding the role of debt in the financial system; Bengt Holmstrom, January 2015.

based on few parameters. Nevertheless, the most important parameter of agency MBSs, the prepayment risk for the given pool, is unknown to the client at the time of the transaction. Agency issues are not bound by the registration requirements stipulated in the Securities Act, and therefore at the time of the transaction, the assets to be delivered often do not even exist, which further increases the information asymmetry between the buyer and the seller.

Due to the information asymmetry, trading on the TBA market takes place on a "cheapest-to-deliver" basis, i.e. the seller is obviously interested in delivering the pool with the worst prepayment structure as a result of the TBA transaction. This practically means an MBS made up of the loans where borrowers are expected to be the most effective in exercising their prepayment option (e.g. in the case of a larger loan amount, refinancing offers relatively greater advantages). The seller may employ adverse selection in a TBA transaction, which is of course known to the buyer and taken into account. Owing to this, the value of the adverse selection option, held by the TBA's seller, reduces the TBA's equilibrium price.

The efficiency of the TBA market, including the efficient pricing of the adverse selection stemming from the cheapest-to-deliver principle, is attested by the fact that the MBSs made up of considerably heterogeneous loans can be traded in TBA contracts described by a few parameters, and therefore within the individual TBA contracts, they can be considered completely homogeneous before delivery. Homogeneity is also ensured by the standardisation of loans' securitisation. Substitutability and the efficiency of pricing (according to market opinions, the value of the TBAs in general exceeds the disadvantage arising from the cheapest-to-deliver effect, which enables physical delivery in large batches) both contribute to the avoidance of the negative effect of adverse selection and the reduction of the costs of acquiring information.

In some cases, the seller on the TBA market may be interested in prolonging delivery in order to maximise the adverse selection effect. This increases the possibility that a collateral with worse prepayment structure is received, which can be included in the delivery. Therefore, market conventions are aimed at

reducing the motivation for late delivery. Buyers pay the original quoted price, while the accrued interest and the prepaid principal are due to them, and they may invest the principal into short-term assets until delivery. In addition, a fee is charged for late delivery, and in the case of a delay of over 60 days, a buy-in may also be ordered.

## 3.2 The peculiarity of the TBA market: the dollar roll

The dollar roll is made up of two separate TBA transactions in which the market participant sells (buys) a TBA for an earlier date and buys (sells) a TBA for a later date. This is basically the same as a normal repurchase agreement, except that, and this is crucial, while in the case of a repo, the two legs of the transaction are negotiated for the same asset, due to the peculiarity of the TBA market, in the dollar roll only the TBA characteristics (issuer, coupon, maturity, par value, price and delivery date) are agreed upon. The seller of the roll sells the MBS fulfilling the parameters for the earlier date, while repurchasing an MBS fulfilling the parameters for the later date. It is important to note that in the dollar roll, the cash flows from the given MBS (coupon, principal payment) are due to the roll buyer, and therefore the prepayment risk is not run by the roll's seller during the maturity period of the transaction. Thus, the dollar roll's seller foregoes all the cash flows derived from the instrument.

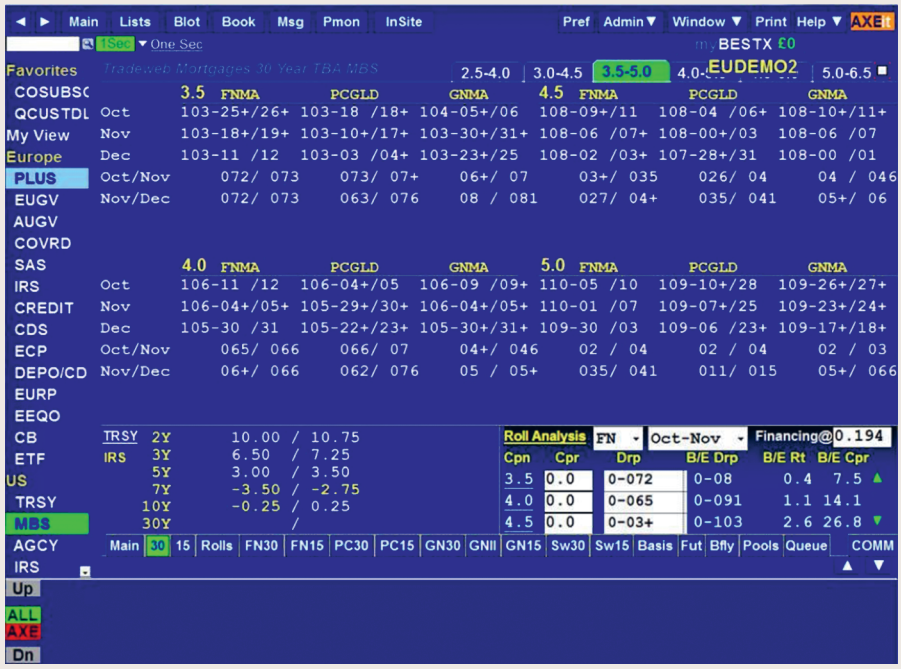
As can be seen, this puts the seller in a synthetic cash position (TBA transactions are conducted on a margin basis), and the seller assumes the risk that it will receive an MBS of poorer quality, i.e. with less favourable prepayment characteristics, upon the maturity of the transaction. The seller is entitled to compensation for taking on this risk, which in certain cases can reduce the implied price of the transaction, and thus the implied price of financing the MBS. If this rate is lower than the normal repo rate available on the market (in the case of a normal repo, the same concrete asset is sold in the transaction), the dollar roll is said to be "on special".

The price difference between the earlier and the later maturity is called the drop, as it can be seen in the chart below (e.g. October–November drop 3.5 FNMA 7.2/32 dollars – prices on the US market are quoted in 32nds – see later). The "on special" phenomenon mainly depends on supply and demand:

the lower the volume of the MBSs that can be delivered in the earlier month, the greater the drop's value (the price of the earlier leg increases due to the scarcity of supply).

The dollar roll offers market makers an opportunity to close their uncovered short positions by buying it, while investors can use it to prolong the MBS delivery date by selling it, i.e. by assuming a synthetic MBS exposure.

**Chart 3**
**TBA quotation in practice in the Tradeweb system**




*Source: Tradeweb*

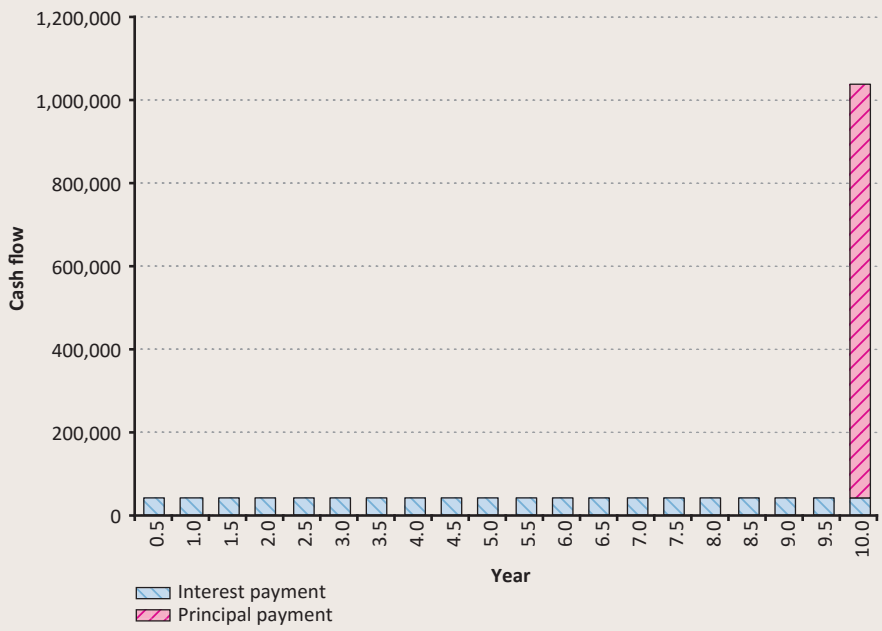
*Explanation of Chart 3:* The screenshot from the Tradeweb system shows TBA quotations for MBSs with different coupons (3.5%; 4%; 4.5% and 5%) and issuers (FNMA: Fannie Mae; PCGLD: Freddie Mac; GNMA: Ginnie Mae) with deliveries in October, November and December. The purchase or bid quotations are on the left side of the slash (/), while the sale or offer quotations are on its right side. On the US market, prices are quoted in 32nds, which means that the figure after the dash (-) has to be divided by 32 to arrive at

the digits after the decimal point. For example 103-25 in "traditional" figures means 103.78125 (103 + 25/32). The little plus sign means 0.5/32, for example 106-04+ has to be interpreted as 106.140625 (106 + 4.5/32). If the figure after the dash is a 3-digit number, the last digit has to be interpreted as a decimal figure, and then divided by 32. For example 072 means 7.2/32.

# 4 Measuring and modelling prepayment

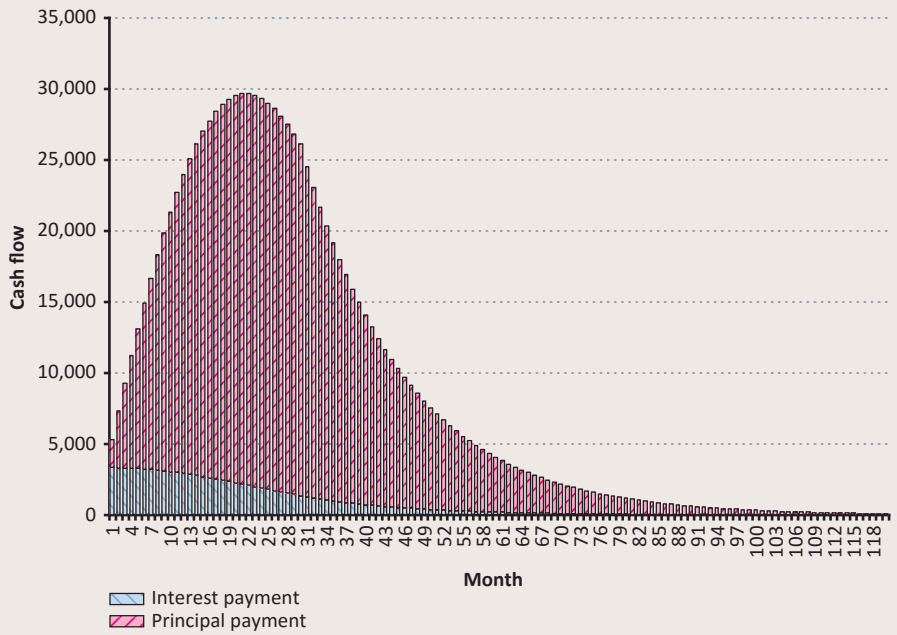
One peculiarity of US mortgages is that a portion or the entirety of the loan can be repaid at any time, without additional banking costs. This concerns MBS investors through the so-called pass-through structure, since they receive the prepaid amount earlier than expected. At first sight, this does not seem to be negative, as investors receive their money earlier, but it is not by chance that the jargon refers to this phenomenon as prepayment risk. This is because debtors usually prepay their mortgage when the prevailing interest rates are lower than when they took out the loan. In such a scenario, they refinance their loan with a new one, which has a lower interest rate, because the new one is more advantageous. Yet on the other side of the transaction, we find the MBS

**Chart 4**
**Cash flows of a traditional bond with fixed interest**




*Source: MNB*

**Chart 5**
**Modelling the cash flows of agency MBSs**




*Source: MNB*

investors who received their money earlier than expected, and are forced to reinvest it at the prevailing, lower interest rates. Thus, in the case of the agency mortgage-backed securities, on account of the agency guarantee, the main point is not whether investors receive their money, but when they receive it. With MBSs, there is a so-called extension risk, which means that investors may receive their money later than expected. It is important to note, however, that this does not refer to the extension beyond the original maturity, but to the inflow of principal at a later date than expected. The cash flow of MBSs is therefore uncertain over time, which has to be modelled in some way if papers are sought to be priced. The previous charts (Chart 4–5) clearly show the difference between the cash flows of a traditional bond with a par value of USD 1 million paying fixed interest biannually and an MBS.

## 4.1 Measuring prepayment

All extra payments that happen in addition to the "scheduled" principal payment determined by the maturity of the loan are considered prepayments. Market participants refer to the phenomenon as the prepayment rate or prepayment speed, which is measured with the following indicators.

**Single monthly mortality rate (SMM):** the ratio of the amount prepaid in the given month and the maximum amount that can be prepaid. It is important to bear in mind that the latter is not the principal at the beginning of the month but that amount less the principal payment scheduled for the given month.

$$SMM_t = \frac{Prepayment\ in\ month\ t}{principal\ at\ the\ beginning\ of\ month\ t - \text{principal payment scheduled for month t}}$$

Let us look at an example for the above formula.

Principal in the pool at the beginning of the 18th month: USD 781,547,209

Principal payment scheduled for the 18th month: USD 697,891

Prepayment received in the 18th month: USD 4,101,500

$$SMM_{18} = \frac{4,101,500}{781,547,209 - 697,891} = 0.005256 = 0.5256\%$$

In the above example, debtors prepaid 0.5256 per cent of the principal that could be prepaid in the 18th month, which the MBS investors receive earlier than expected due to the pass-through structure. The SMM indicator is also used for estimating cash flows, i.e. for projecting the prepayments expected in the months ahead. If, for example, the principal is USD 250 million, the expected principal payment for the given month is USD 1 million, then, assuming an SMM of 0.5256%, the expected prepayment is 0.005256 x (250,000,000 – 1,000,000) = USD 1,308,744.

**Conditional prepayment rate (CPR):** this is the SMM rate in an annualised form, since market participants usually prefer using annual rates in their calculations for the sake of simplicity and better comparability.

$$CPR = 1-\left(1-SMM\right)^{12}$$

Using the above example, the following CPR corresponds to the SMM of 0.5256%:

$$CPR = 1-\left(1-0.005256\right)^{12} = 1-\left(0.994744\right)^{12} = 0.06128 \approx 6.13\% .$$

The CPR of 6.13% means that in addition to the scheduled principal payments, 6.13 per cent of the principal outstanding at the beginning of the year will be prepaid by the end of the year. The calculation also works backwards, i.e. we can calculate the SMM from the CPR as follows:

$$SMM = 1-\left(1-CPR\right)^{\frac{1}{12}}.$$

### PSA prepayment benchmark

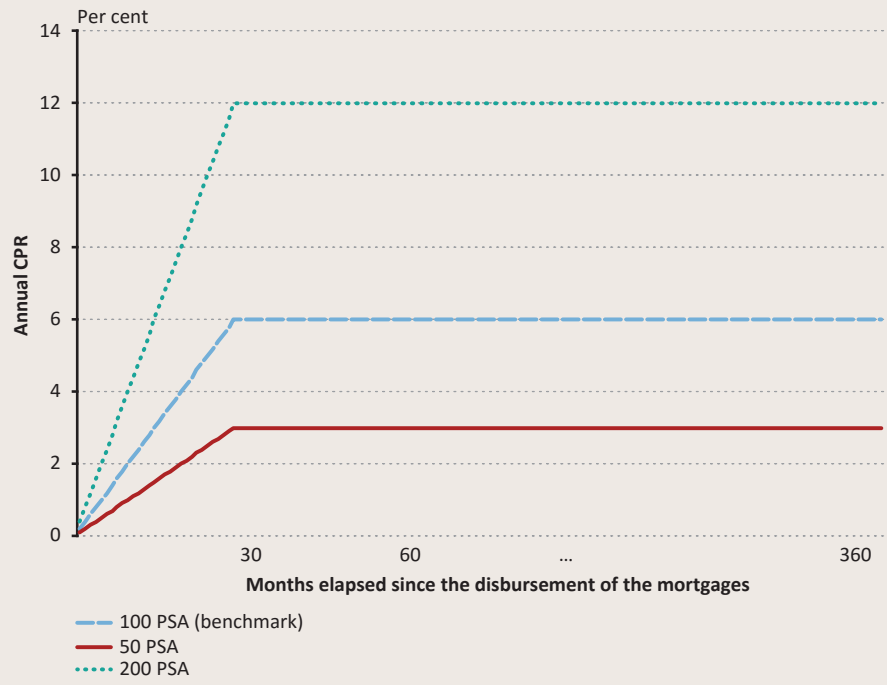
The SMM shows the prepayment rate or speed for one month ahead, while the CPR does so for one year ahead. However, if MBSs are to be priced, all the cash flows should be forecast, i.e. during the maturity period of the security we should assume a prepayment speed, or more precisely a pattern, as the prepayment rate is not stable over time. In the 1980s, the Public Securities Association (PSA) analysed the historical prepayment pattern of a typical MBS pool containing mortgages, then based on that, they created the so-called PSA benchmark. This is a series of the monthly CPRs as a function of the maturity. Based on historical studies, the PSA benchmark assumes that prepayment speed is low in the first months of the loans taken out recently, then over time it gradually increases up to a certain speed. The 100% PSA benchmark, or 100 PSA for short, assumes a CPR of 0.2% in the first month of a typical 30-year mortgage, which increases by 0.2 percentage points every month up to the 30th month when it reaches 6%. Then it is assumed that the CPR remains steady at 6% until maturity. Thus we can denote the 100 PSA with the following formula:

if $t < 30$ then $CPR = 6\% \times {}_{30}{}^{t}$, if $t \geq 30$ then $CPR = 6\%$,

where *t* is the number of months elapsed since the disbursement of the mortgages.

Higher or lower prepayment speed can be expressed as a percentage of the PSA benchmark. For example a 50% PSA, or 50 PSA for short, assumes a lower prepayment speed, where the monthly CPRs are lower, while a 200 PSA assumes higher CPR rates and more rapid prepayment. In the case of the 50 PSA, the monthly CPRs are 0.5 times the PSA benchmark's CPRs, while in the case of the 200 PSA, they are twice the PSA benchmark's CPRs.

**Chart 6**
**Graphic representation of the PSA benchmark**




*Source: MNB*

## 4.2 Modelling prepayment

There are several models for the prepayment of MBSs, but it is probably impossible to find one that would produce perfect projections. In this respect, predicting prepayment is a mixture between art and science where psychology, finance, economics and demographics all play a role.[2] Investors, global banking houses and mortgage institutions usually use their own models for estimating prepayment rates. In order to model prepayment, we first have to identify the factors that influence the prepayment propensity and ability of mortgagors. According to historical data, the following factors are the most important in the development of the prepayment rate, and most models use these (at least as a starting point).

- The prevailing mortgage interest rate: this is certainly the most significant factor. If the prevailing interest rates are lower than those fixed at the time of borrowing, prepaying their old loan and taking out a new one, i.e. refinancing it, is worth it for debtors. Although in the case of most US mortgages there is no straightforward penalty fee for prepayment, debtors should expect additional fixed costs (legal expenses, insurance premium etc.). Refinancing their current mortgage pays off for the debtors if the savings generated from this exceed the costs incurred in connection with refinancing due to lower interest rates.

- The so-called "lock-in" effect follows from the above, where if the interest paid on the given mortgage is lower than the available mortgage market interest rate and the given mortgage's LTV (loan-to-value) ratio is high, the probability of prepayment decreases considerably. In the case of a low LTV ratio, the "lock-in" effect is more subdued, i.e. the lower outstanding debt relative to the property value increases the probability of prepayment, even under more unfavourable market conditions.

- The development of mortgage interest rates over time, i.e. the path lending rates have followed until reaching their present level. This is vital because of the so-called "refinancing burnout". To illustrate this with an example, let

[2] Citi – Prepayment Modeling – Melding Theory and Data into One (Reel, Joseph et al. 2013)

us assume that in a given year debtors obtain mortgages at an interest rate of 10%, then a year later, lending rates drop to 7%. Most debtors refinance their existing mortgage with a cheaper loan. After this, interest rates rise to 11%, then shortly fall back to 7%. The propensity for refinancing and the prepayment rate are lower than in the first period when interest rates dropped, since those who could/wanted prepaid their loan then.

- Housing market turnover: during times of improving economic developments, the housing market usually strengthens too, which leads to increased prepayment speed.

- Unique, special effects such as a change in the number of family members, which entails moving into a smaller or larger home with a refinanced loan. Seasonal effects may also play a role, since for example in winter, the number of removals drops, around Christmas, the prepayment propensity decreases, while in summer, during the school holidays, it increases. These factors substantially influence the TBA dollar roll's conditions.

- Events that are impossible or almost impossible to predict, to which the market refers with the symbolic acronym 3D, i.e. death, divorce and disaster. All of these factors point towards an increase in prepayments.

- The prepayment rate is also influenced by the MBS pool's characteristics, of which the following three are the most dominant: the time elapsed since the disbursement of the mortgages (seasoning), geographical location and the average size of loans. The first is captured well by the PSA benchmark, which determines the CPR depending on this. Geographical location is important because of the differences in local economic developments, while the average size of loans enables us to reach conclusions about the prepayment propensity through the ratio of fixed costs related to refinancing. The so-called "low-loan-balance" pools, which contain loans of USD 50,000–100,000, usually have lower prepayment rates, since, when refinancing the mortgages, debtors face considerably high fixed costs relative to the size of the loans.

- In the case of a default on the given mortgage in the pool, the agency, in line with the guarantee, pays back the loan to the MBS's owner at par

value, which, in practice, appears as a prepayment. As has been previously emphasised, during housing market upheavals and mass defaults, the MBS principal prepayment rate increases as a result of this. Housing market turbulences are usually coupled with the Fed's rate-cutting cycle, which further increases the prepayment rate due to the rise in refinancing. Therefore, such an environment poses significant risks to MBS investors despite the fact that, on account of the state guarantee, they do not incur capital losses.

The above-mentioned effects are shown in the simplified formula below, which summarises the main factors that influence prepayment dynamics:

*Prepayment rate = refinancing + housing market turnover + defaults / agency guarantee payments + partial/full prepayment*

# 5 Evaluating MBSs

## 5.1 Using the right spread

Evaluating and pricing MBSs may seem considerably easy in theory, since they are bond-type assets, i.e. if we discount the future cash flows, we arrive at the price of the security. However, MBSs' cash flows are not known in advance, they can only be estimated and modelled, and therefore, in practice, evaluating these securities is not easy at all.

The difference between the yield of an MBS and a US Treasury bond with the same maturity cannot be calculated with a simple subtraction, since for this we would have to assume that the MBS pays back the principal in a lump sum upon maturity, and we know that this is not the case. In a more sophisticated approach, taking into account prepayments, we discount the (modelled) cash flows due by adding a given spread to the appropriate points on the forward yield curve to arrive at the market price. In the jargon, this spread is called the zero-volatility spread or the Z-spread for short. The greatest drawback of this is that it is a static indicator, and assumes that the yield curve and cash flows do not change over time.

As the mortgagors have the option of prepaying their debt at any time, from the perspective of the MBS investors, this risk must be assessed as a call option in which they have a short position. Consequently, when evaluating agency MBSs, the option-adjusted spread (OAS) must be regarded as the most relevant. The OAS can be calculated with a Monte Carlo simulation, the steps of which are the following:

1. First, thousands of hypothetical, consistent interest rate paths have to be simulated, including the short-term interest rate – which is used for discounting – as well as long-term interest rates, which are necessary for modelling prepayment. During simulation, short- and long-term interest rates should be matched to different volatilities, which can be derived empirically or from option prices.

2. Based on a prepayment model, the MBS cash flows are projected for each interest rate path.

3. The present value of the projected cash flows is calculated for each interest rate path by using the given interest rate path's short-term forward yields plus a certain spread (OAS) as the discount rate. The average of the present values calculated in this manner gives the value of the MBS.

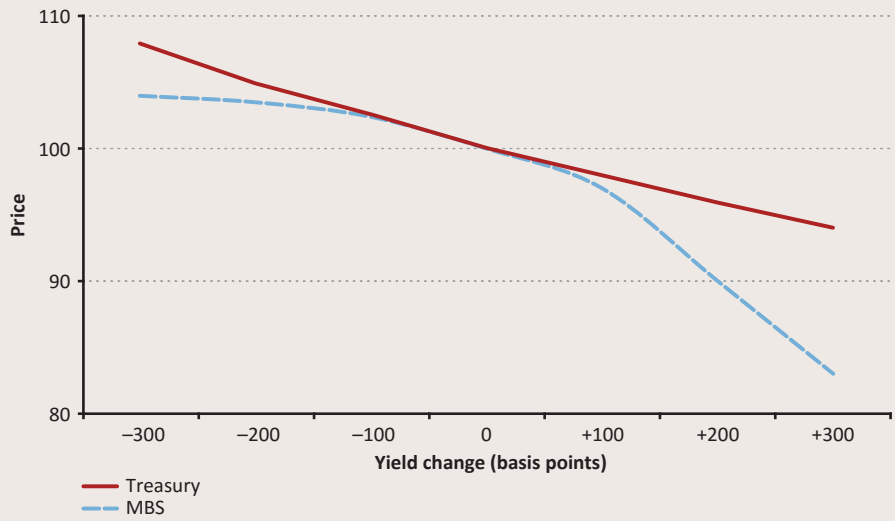
4. Finally, using an initial OAS and an iterative process, the average of the present values is brought in line with the market price.

The difference between the Z-spread and the OAS is basically the price of the option, which compensates investors for the volatility in prepayment speed and yields.

## 5.2 Negative convexity

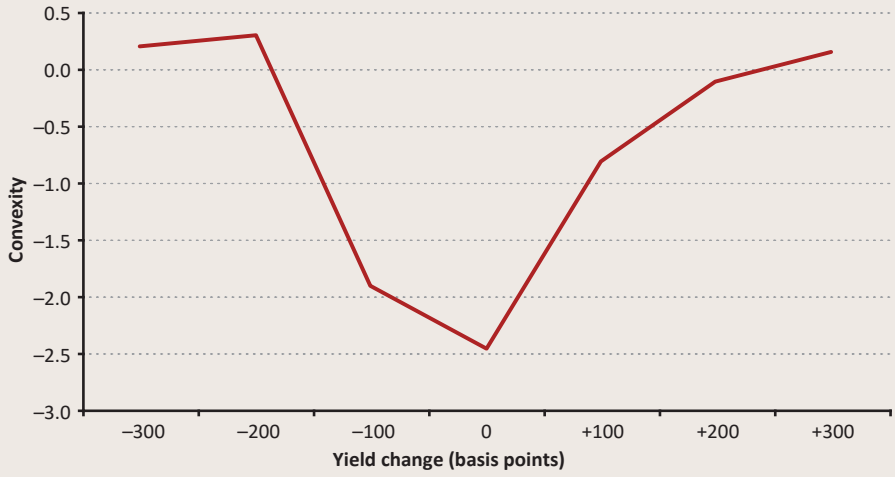
The convexity of a simple, fixed-rate bond without any embedded options is positive. This means that in the case of a drop in yields, the price of the bond rises more than it drops in the case of a rise in yields of the same extent. Not surprisingly, investors strive to build portfolios with high convexity. Nonetheless, in the overwhelming majority of cases the convexity of MBSs is negative, on account of mortgagors' prepayment option. If yields drop, borrowers refinance their existing loans, and therefore prepayment gathers pace, which leads to a decrease in the average residual maturity (duration) of the securities. When yields rise, the situation is exactly the opposite: mortgagors are slower to prepay their loans, which increases the duration of MBSs. However, the change in duration continuously diminishes in proportion to the change in yield, irrespective of whether the latter drops or rises. Accordingly, the price of an MBS drops more in the case of a yield rise than it rises in the case of a yield decrease of the same extent. Convexity turns positive if a sufficiently large drop or rise in yields happens. This is illustrated in the following chart:

**Chart 7**
**The price of an MBS and a Treasury as the function of yield change**




*Source: MNB*

**Chart 8**
**MBS convexity as the function of yield change**




*Forrás: MNB*

The high negative convexity of MBSs means that hedging for the interest rate risk of the securities becomes more complex than in the case of traditional bonds without embedded options. The constant change in duration stemming from the yield changes requires dynamic hedging. In order to effectively hedge against the MBSs' interest rate risk, we must know the securities' duration. As prepayment speed depends on the available yields, the standard duration indicators (modified duration, Macaulay duration) may be misleading in the case of MBSs, and therefore one should use the so-called effective duration instead, which can be calculated with the following formula:

$$ED = \frac{BV_{-\Delta y} - BV_{+\Delta y}}{2 x BV_0 x \Delta y},$$

where:

*Δy = the change in yield*

$BV_{-\Delta y}$ *= the estimated price of the MBS if the yield drops by Δy*

$BV_{+\Delta y}$ *= the estimated price of the MBS if the yield increases by Δy*

$BV_0$ *= the current price of the MBS*

As usual in the case of MBSs, the result for the effective duration is also an estimated value, with several underlying assumptions.

# 6 Trading strategies in practice

Some investors follow a passive, index-tracking strategy, while others employ an active strategy striving to exceed the performance of the the benchmark. The most widely used benchmark is the Barclays US Agency MBS Index which includes hundreds of unique classes (cohorts). In the case of agency mortgage-backed securities, active portfolio management is justified by the fundamentally inefficient market anomalies which emerge despite the huge size and liquidity of the market. Consequently, the mortgage market universe offers several opportunities to achieve a positive risk adjusted yield, primarily through the successful securities selection process. This is attributable to the following reasons.

- Neither investors nor mortgagors behave rationally. Some investors (for example the Fed, which serves as the central bank of the US) do not make their decisions based on valuations, i.e. they are not price-sensitive, and borrowers do not always prepay their loans when it would be advantageous for them, i.e. they do not exercise their call option, despite the fact that it is "in the money".

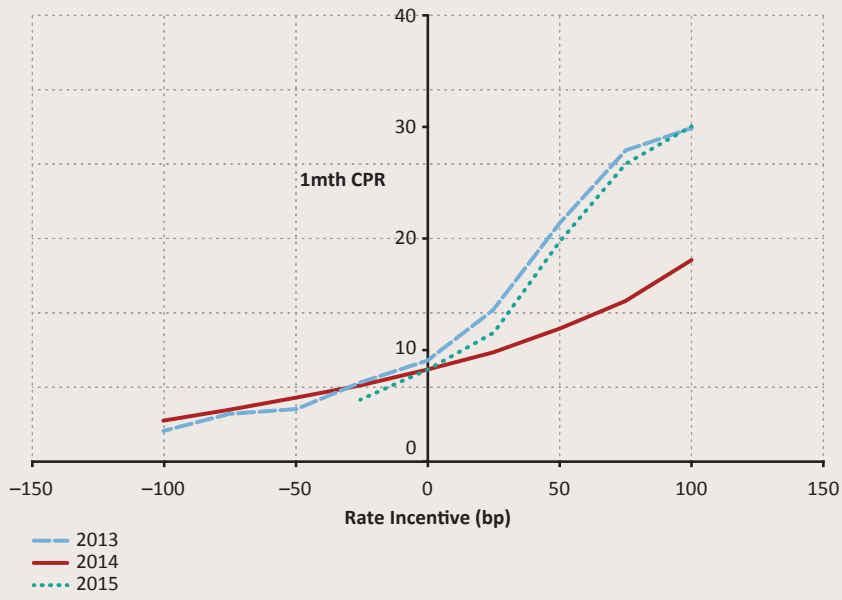
- As the exact cash flows are unknown, and MBSs are evaluated with models, the parameters used in the models of the different market participants may vary of course.

- Negative convexity is often mispriced by the market.

A large portion of the yield spread offered by the MBS stems from the premium of writing the option embedded in the asset which ensures prepayment. The buyer of the MBS assumes a short option position, and therefore it seems obvious that the efficiency borrowers exhibit with respect to exercising the option should be examined. The lower this ratio is, the more profitable it is to write the option, i.e. to buy an MBS. As can be seen in the above chart showing a so-called S-curve, instead of the theoretical maximum CPR of 100, which in the case of another product on the market, e.g. an FX option, is a given, mortgagors are much less efficient in exercising their option. In other

words, they do not exercise their option even if doing so would be possibly favourable for them in the long run, taking into account the legal and other costs of refinancing. For MBS investors, this has the simple consequence that they can earn a significant portion of the option premium written, even in the face of unfavourable market developments. Over the longer term, this provides an adequate explanation for the historical yield spread as compared to the government securities market. In a perfectly functioning market, this yield spread would be much less pronounced, in some cases it would be around zero due to the issuer risk, which is exactly the same, and the high liquidity of the MBS market.

**Chart 9**
**Developments in Fannie's 30-year MBS prepayment rate as a function of the refinancing interest advantage**




*Source: JP Morgan*

The most popular, so-called "relative value" strategies employed in practice are the following:

## 6.1 Agency swaps

One of the most widespread strategies is to trade with the opportunities between the different agencies' MBSs with the same coupon. Yield spreads are mainly influenced by expectations about new issues and prepayments. This may be distorted by, for example, the fact that some investors can only buy GNMA issues, which are covered by an explicit state guarantee. From a credit quality perspective, the issues of the other two agencies are similar, except that their MBSs are covered by an implicit and not an explicit guarantee, but this merely represents a slight additional risk to investors.

**Chart 10**
**Freddie/Fannie 4% Agency Swap**

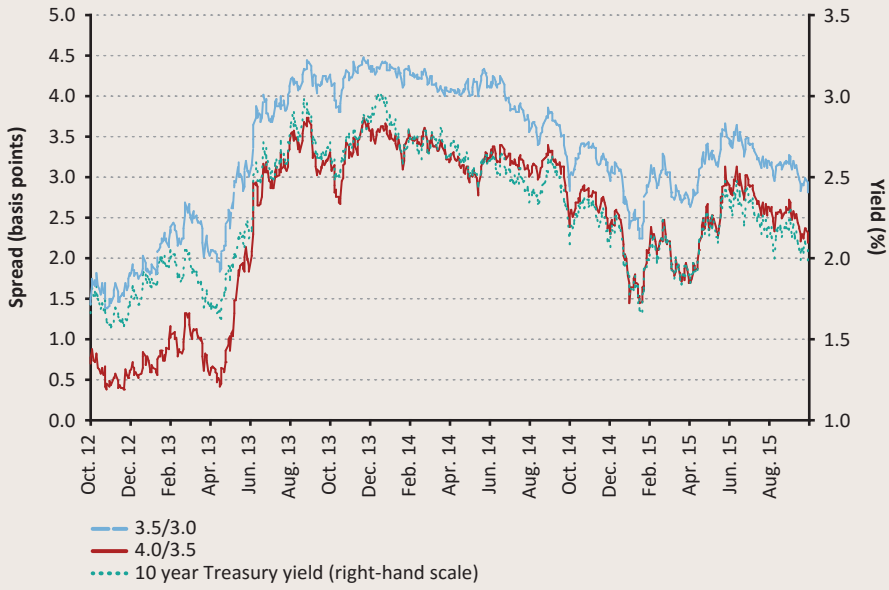

*Source: FFTW, Citi's The Yield Book*

## 6.2 Coupon swaps

So-called coupon swaps offer the most liquid opportunity for expressing prepayment expectations. If MBS investors expect slower prepayment from the market, they buy securities with a high coupon instead of a low one, (up-

in-coupon), while in the case of more rapid prepayment expectations, they prefer low-coupon MBSs to high-coupon ones (down-in-coupon). The price for high-coupon papers is usually above par, i.e. they are traded at a premium, while low-coupon MBSs generally change hands below par, i.e. at a discount. In the former case, investors are interested in receiving the high coupon (interest) for as long as possible, while in the latter case they are better off if they receive the par value as soon as possible. This strategy strongly correlates with movements in yields.

**Chart 11**
**Coupon swap and 10-year Treasury yields**



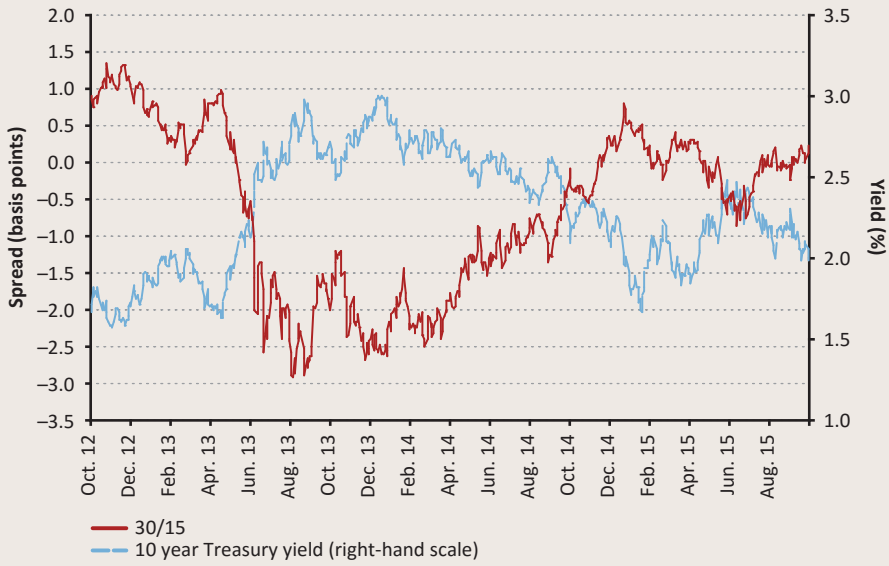

*Source: FFTW, Brean Capital*

## 6.3 Term swaps

This strategy usually means trading the 15-year and 30-year MBSs against each other. Prepayment differences may be significant between debtors obtaining 15-year and 30-year mortgages. Those who take out a loan for less than 30 years, usually do not do so because of the somewhat lower interest rates, but because they wish to amortise their loan faster, which entails higher monthly

instalments. These debtors are usually driven by their emotions and not economic considerations. As the difference in interest rates between the two maturities is not very large, and the option to prepay the debt without penalty is also available to those taking out 30-year loans, shorter mortgages are less enticing. From the investors' side, the 15-year MBSs provide very effective protection against extension risk, but they have lower yields and they are less liquid than the 30-year papers.

**Chart 12**
**Term swap and 10-year Treasury yields**



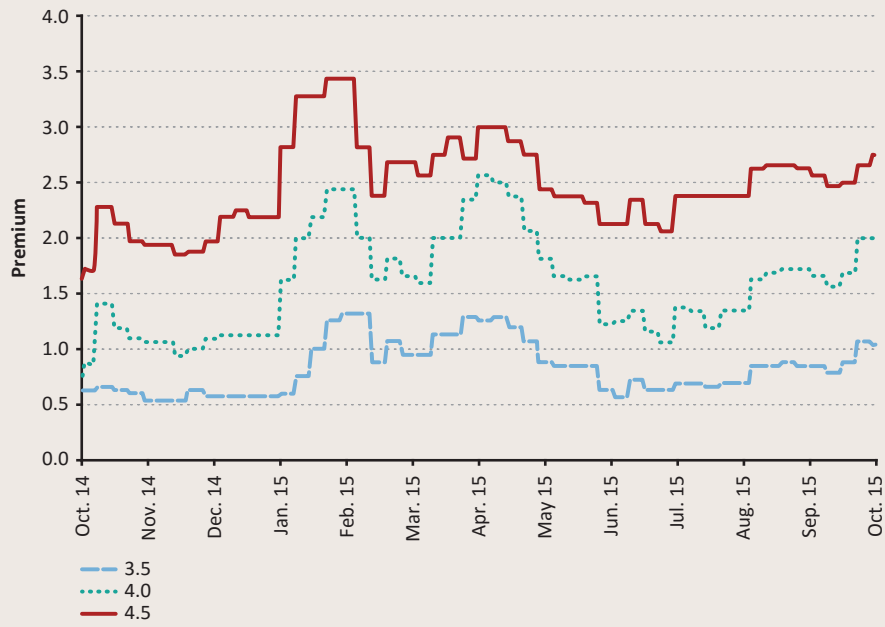

*Source: Citi's The Yield Book, FFTW*

## 6.4 Specified pools

The selection of securities plays a central role in the relative performance against the benchmark. The unique securities of the MBS market are the so-called "specified pools", and detailed, public information is available on the loans serving as their collateral. One of the most important tools of active portfolio management is the in-depth analysis of these MBSs, the exploration of potential underpricings, and the identification of value-based investment opportunities on the market. Based on the characteristics of the individual

pools, the investors express their expectations about the prepayment speed of the given pool. Such a pool characteristic may be the maximum size of the loans: pools in which the maximum size of mortgages is USD 85,000 typically prepay the loans at a slower pace (i.e. their prepayment risk is lower). This is because the fixed costs linked to refinancing (e.g. legal expenses) represent a much larger proportion compared to the outstanding debt than in the case of a loan of hundreds of thousands of dollars. Yet lower prepayment risk comes at a price: these pools typically sell at a premium on the market. Therefore, the investment decision focuses on the return horizon of the premium paid. This is calculated from the ratio of the expected higher yield stemming from the specified pools' more favourable prepayment characteristics and the size of the premium. The shorter this period, the less risk it takes to realise the yield spread.

**Chart 13**
**Premium of small-loan pools**




*Source: FFTW, Morgan Stanley*

The other dominant characteristics of specified pools may include: the geographical distribution of the loans, the time elapsed since the loans were taken out, and debtors' credit risk rating.

Chart 14 employs a real-world example to show how the low maximum loan amount influences the prepayment speed. Two pools with similar characteristics are compared. The first is a so-called general or generic Freddie Mac pool with a 4% coupon that contains 30-year mortgages. The second pool also comes with a 4% coupon, it is also made up of 30-year mortgages, and the loans are also issued by Freddie Mac. As can be seen from the table, the two pools have similar characteristics: year of lending, weighted average coupon (WAC), weighted average maturity of the loans (WAM), loan-to-value ratio (LTV), credit rating of the debtors (FICO). The only main difference is in the size of the loans: in the generic pool, the average size of the mortgages is USD 265,000, and the largest is over USD 950,000. By contrast, the so-called low-loan-balance specified pool's average loan size is below USD 100,000 and the maximum loan size is merely USD 110,000. It follows from this that prepayments are slower in the case of the latter, which is clearly shown by the CPR observed in the past 1, 3, 6 and 12 months. Slower prepayment will definitely continue in the future, and thus the effective duration calculated from the models is also higher in the case of the latter pool. However, investors need to pay a premium for the advantages offered by slow prepayment, and therefore the price of the specified pool is higher than that of the generic.

**Chart 14**
**Comparison of two pools (November 2015)**

| | | Freddie Mac 2014 4% 30Y – Generic | Freddie Mac 2014 4% 30Y – Low Loan Balance |
|---|---|---|---|
| Price | | 105-30 (105.9375) | 106-30 (106.9375) |
| Coupon | | 4% | 4% |
| Year of lending | | 2014 | 2014 |
| Size of total pool | | 3,682,682,568 | 1,759,433,822 |
| Factor | | 0.6858 | 0.8784 |
| WAC | | 4.59% | 4.57% |
| WAM | | 338 hónap | 331 hónap |
| Number of loans | | 14,149 | 18,981 |
| FICO | Average | 750 | 750 |
| | Maximum | 828 | 832 |
| Loan-to-Value (LTV) | | 80% | 74% |
| Loan size | Average | 265,387 | 98,497 |
| | Maximum | 968,000 | 110,000 |
| Prepayment (CPR) | Past 1 month | 18 | 9 |
| | Past 3 months | 16 | 10 |
| | Past 6 months | 20 | 10 |
| | Past 12 months | 27 | 9 |
| Effective duration | | 3.6 | 5 |
| Yield to maturity (calculated with current prepayment speed) | | 2.5% | 2.9% |

*Source: Bloomberg, MNB*

# Glossary

| | |
|---|---|
| *Adjustable rate mortgage (ARM)* | Variable-rate mortgage. The interest payable on the loan changes periodically depending on market interest rates. |
| *Agency MBS* | The agency guarantees to pass on the principal and the interest to the clients in a timely manner. |
| *Conditional prepayment rate (CPR)* | Annual prepayment rate. |
| *Convexity* | Shows how the effective duration of the MBS changes in the case of a unit change in yields. The greater the convexity, the more effective duration changes in the case of a unit change in yields. |
| *Current coupon* | The current market interest rates. |
| *Delinquency* | The ratio of loans in delay within the pool. |
| *Dollar roll* | Selling TBA for an earlier maturity and buying TBA for a later maturity at the same time. |
| *Extension risk* | Principal payments are received by the investor later than projected. |
| *Factor* | The ratio of the current par value and the original par value (can be used for pools and bonds as well). |
| *Loan-to-value (LTV)* | Ratio of the loan amount and the value of the collateral (property). |
| *Mortgage* | Mortgage loan. |
| *Option-adjusted spread (OAS)* | Difference between the yield of an MBS and a Treasury with the same maturity, taking into account the optionality in the MBS. |
| *Pool* | A group of mortgages. |

| | |
|---|---|
| *Prepayment risk* | Principal payments are received by the investor earlier than projected. |
| *Single monthly mortality rate (SMM)* | The ratio of the amount prepaid in the given month and the maximum amount that can be prepaid. |
| *TBA (To be announced)* | A current coupon MBS or one that has a similar interest rate and that is settled 1 month later – similar to the futures market. |
| *Weighted average coupon (WAC)* | The average of the interest rates of the loans in the pool weighted with the outstanding loan amount. |
| *Weighted average life (WAL)* | The average residual maturity of the MBS. |
| *Weighted average loan age (WALA)* | The average of the life of the loans weighted with the outstanding loan amount. Life means the time elapsed since disbursement. |
| *Weighted average maturity (WAM)* | Average maturity weighted with the loan amount expressed in months. |
| *Weighted average remaining maturity (WARM)* | Weighted average residual maturity. |
| *Weighted average original loan-to-value (WAOLT)* | The original LTV value weighted with the loan amounts. |
| *WAOLTV-HPI* | The WAOLTV modified with a given property price index. |

# References

Citigroup (Lakhbir S. Hayre, Robert Young): Guide to Mortgage-Backed Securities, 2004

Citi (Joseph Reel, Mikhail Teytel, Robert Young, Anthony Brown, Jenny Jin): Prepayment Modeling – Melding Theory and Data into One, 2013

Zhaogang Song, Haoxiang Zhu: Mortgage Dollar Roll, 2015

James Vickery, Joshua Wright: TBA trading and liquidity in the agency MBS market, 2013, FRBNY Economic Policy Review

FFTW-BNP Paribas Investment Partner: Mortgage Processing: Mortgage-Backed Securities and TBAs, 2014

BIS Working Paper No. 479 (Bengt Holmstrom): Understanding the role of debt in the financial system; 2015

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