EUROPEAN CENTRAL BANK

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EVIDENCE FROM THE ABX.HE INDICES

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In 2009 all ECB publications feature a motif taken from the €200 banknote.

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Abstract

This paper investigates the market pricing of subprime mortgage risk on the basis of data for the ABX.HE family of indices, which have become a key barometer of mortgage market conditions during the recent financial crisis. After an introduction into ABX index mechanics and a discussion of historical pricing patterns, we use regression analysis to establish the relationship between observed index returns and macroeconomic news as well as market-based proxies of default risk, interest rates, liquidity and risk appetite. The results imply that declining risk appetite and heightened concerns about market illiquidity—likely due in part to significant short positioning activity—have provided a sizeable contribution to the observed collapse in ABX prices since the summer of 2007. In particular, while fundamental factors, such as indicators of housing market activity, have continued to exert an important influence on the subordinated ABX indices, those backed by AA and AAA exposures have tended to react more to the general deterioration of the financial market environment. This provides further support for the inappropriateness of pricing models that do not sufficiently account for factors such as risk appetite and liquidity risk, particularly in periods of heightened market pressure. In addition, as related risk premia can be captured by unconstrained investors, ABX pricing patterns appear to lend support to government measures aimed at taking troubled assets off banks' balance sheets—such as the US Troubled Asset Relief Program (TARP) in its original form.

Keywords: ABX index, mortgage-backed securities, pricing, risk premia.

JEL classification numbers: E43, G12, G13, G14.

Non-technical summary

Since the 1990s, the financial system underwent a number of material changes. In particular, the strong expansion of securitisation has had a major impact on the functioning of financial markets as well as financial institutions. Securitisation can be defined as the issuance of claims backed by a pool of default-risky instruments where the new claims frequently have varying exposures to the underlying pool of collateral. Overall, the most commonly securitised assets are mortgage loans, which are packaged into MBS (mortgage backed securities). In recent years, more sophisticated forms of securitisation have also been developed, such as for example collateralised debt obligations (CDOs).

The market for mortgage backed securities has traditionally been considered as a relatively stable market. It was, however, in this market segment where the global repricing of credit risk started. In particular the financial market turmoil started on the secondary market for subprime mortgages in the U.S., but quickly expanded to the broader mortgage markets and to credit markets in most other countries. At the core of the repricing was the “subprime” mortgage market where borrowers with poor credit histories were given very high loan to value mortgages. While significant macroeconomic factors – including the search for yield in credit markets – seem to have been at work contributing to problems on the subprime mortgage markets, a number of market frictions in mortgage markets also contributed to the ferocity of the crisis. These mortgages were then sold as MBS and frequently tranches of tehse MBS were again sold in the form of CDOs.

In contrast to previous episodes of financial market stress such as the LTCM collapse in 1998 the subprime crisis has had a particularly severe and protracted impact on the banking system. This rise in systemic risk was to a large extent due to the fact that reliable pricing for the large exposures to securitisation instruments which banks had built up during the boom period of the credit risk transfer markets had become almost impossible. Hence, banks were faced with the problem that they were holding large positions on their books for which no reliable valuation was available and selling into the market was also impossible due to the collapse in market liquidity.

Since the start of the financial turmoil in the summer of 2007, the ABX index family has provided a widely followed “barometer” of the collapsing valuations in the US subprime mortgage market. The ABX.HE indices, which are based on credit default swaps (CDS) written on US home equity loan (HEL) MBS, track the price of credit default insurance on a basket of such deals. The ABX family of indices, which started trading on 19 January 2006, consists of a series of equally-weighted, static portfolios of credit default swaps referencing 20 subprime MBS transactions. These contracts, which allow investors to buy and sell protection against the default risk of subprime mortgages, had seen particularly strong growth due to their inclusion in synthetic CDOs. The mechanics of the ABX indices, which are offered for trading by a consortium of major credit derivatives dealers, are determined by vintage- and credit rating-related considerations. New on-the-run ABX series were introduced every six months, and each of these index vintages references 20 completely new subprime MBS deals issued during a six month period prior to index initiation. Trade documentation excludes any form of physical settlement, thus decoupling ABX trading from the availability of the underlying cash instruments. This has aided market development, supporting the adoption of ABX index contracts as a tool for trading and hedging.

Despite some shortcomings, ABX price information appears to have been widely used by banks and other investors as a tool for hedging and for gauging valuation effects on subprime mortgage portfolios more generally. After credit traders started their reassessment of the pricing of credit risk in the summer of 2007, credit spreads jumped upwards over a short period of time, leading to large mark-to-market losses

Understanding the specific factors driving the variation of ABX prices is important for market participants and policy makers because changes in the weight of credit and non-credit related elements may have different implications. For instance, indications of changes in risk appetite with regard to subprime mortgage risk may help explain any discrepancies between observed ABX prices and projections of default-related losses on the underlying pool of subprime MBS. These discrepancies, in turn, can have consequences for investors, for example when ABX quotes are used to value existing holdings of subprime MBS. Yet, despite the importance of these issues, analytical work on the ABX indices has so far been rather scarce.

The purpose of this paper is to analyse the empirical determinants of ABX prices. The specific approach adopted below proceeds in three steps. First, ABX returns will be analysed by way of a factor decomposition, to illustrate broad correlation patterns between ABX prices and other financial market variables. Second, simple panel regressions are used to establish the effect of these variables on ABX returns. Finally, blockwise regressions of individual ABX indices are employed to investigate changes in the importance of different pricing factors over time. In implementing these three steps, the various pricing factors will be proxied by macroeconomic and financial market variables combined with, where available, survey information and publication dates to capture any announcement effects.

The results presented in this paper suggest that declining risk appetite and rising concerns about market illiquidity have provided a sizeable contribution to the observed collapse in ABX prices since the summer of 2007. While proxies for fundamental drivers of subprime mortgage risk, such as indicators of housing market activity, have continued to exert a strong influence on the subordinated ABX indices, the AA and AAA indices have tended to react more to the general deterioration of the financial market environment.

These results underline the well-established view that risk premia are important components of observed prices for default-risky products, and that the relative importance of non-default related risk factors will tend to increase in periods of strong repricing of risk. This suggests that theoretical pricing models that do not sufficiently account for these factors may be inappropriate, particularly in periods of heightened market pressure.

Introduction

The evolution of index products in credit risk transfer markets has allowed market participants to trade standardised contracts on pools of a variety of underlying credit instruments. This, in turn, has added a degree of transparency and liquidity to market segments as diverse as leveraged loans or commercial and residential mortgage-backed securities (MBS). For instance, the ABX.HE indices, which are based on credit default swaps (CDS) written on US home equity loan (HEL) MBS, track the price of credit default insurance on a basket of such deals. Since the start of the recent financial turmoil in the summer of 2007, the ABX index family provided a widely followed barometer of the collapsing valuations in the US subprime mortgage market, which have been at the core of observed credit market developments.[1] In addition, and despite some shortcomings, ABX price information appears to have been widely used by banks and other investors as a tool for hedging and for gauging valuation effects on subprime mortgage portfolios more generally.[2]

On 19 December 2007, Markit, the administration and calculation agent for the ABX indices, announced that the scheduled index "roll" on 19 January 2008 would be postponed for three months due to a lack of eligible collateral. The postponement was repeatedly extended and eventually called off,[3] marking a serious dent in what had been a very successful, though brief, history of the first benchmark indices referencing subprime mortgage collateral—a history that had taken these indicators from a somewhat obscure corner of the US financial system right into the centre of developments in global financial markets.

In this paper, we analyse ABX prices to study the importance of different pricing factors, and how they have changed over time. For this purpose, we relate a variety of variables to the first differences of logarithmic ABX prices (log returns) and test how the turmoil in credit markets has affected the explanatory value of the determinants of observed market prices. We include proxies for house price developments, market-based indicators of the strength of mortgage markets, the yield curve, risk appetite and measures of market liquidity. Furthermore, we conduct a variety of robustness tests and discuss the economic significance of our results.

Understanding the specific factors driving the variation of ABX prices is important for market participants and policy makers because changes in the weight of credit- and non-credit related elements may have different implications. For instance, indications of changes in risk appetite with regard to subprime mortgage risk may help explain any deviations between observed market prices for the ABX indices and projections of default-related cash flow shortfalls on the underlying subprime MBS. This makes the ABX indices an interesting object for research.

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1 Gorton (2008) argues that the introduction of the ABX indices was instrumental in actually starting the price adjustment in subprime mortgage markets (and subsequent crisis), as hitherto unknown information about the value of these mortgages (ie, information that had been lost or clouded in the securitisation process) was revealed.

2 According to the Wall Street Journal (2007), when Swiss bank UBS wrote down its subprime-mortgage investments by $10 billion in December 2007, it looked to the ABX as a guidepost in determining values for its holdings. Likewise, Morgan Stanley and Citigroup reportedly cited the ABX as a factor in the sizeable writedowns announced in late 2007. Gorton (2008), in turn, claims that accountants initially seized on the ABX indices as the "price", even for earlier vintages, of mortgage securitisations, which may have led to feedback effects by triggering repeated rounds of sales, markdowns and further sales.

3 Instead, on 10 September 2008, Markit announced the launch of a new ABX.HE 05-2 index series, to be based on qualifying MBS deals issued in the first half of 2005.

A related motivation for research into the pricing of subprime mortgage risk and the approach chosen in this paper is found in the violence of the observed re-pricing of credit risk since the summer of 2007. With market liquidity vanishing and entire market segments becoming largely dysfunctional, factors other than credit risk became increasingly important drivers of observed prices. This, in turn, rekindled earlier doubts concerning the validity of currently available models for the pricing of credit risk, particularly for portfolio instruments such as mortgage-backed securities and other complex securitisations. Our data-driven methodology does not rely on the functional form of a specific pricing model, but rather tests the explanatory power of variables which should in theory explain price variation. This avoids any shortcomings of model-based approaches.

In doing so, we complement the growing number of empirical papers on the market pricing of credit portfolio instruments. Research targeting the ABX indices, however, has so far been rare. Mizrach (2008) analyses the jump risk in ABX prices and its determinants, and Bank of England (2008) compare actuarial and market-implied measures of subprime losses. While not focusing on the ABX directly, Perraudin and Wu (2008) examine the determinants of prices for asset-backed securities in two distinct crisis periods.

Other related papers focus on the pricing of actively traded synthetic collateralised debt obligations (CDOs), namely the CDS index tranches. Longstaff and Rajan (2008) find that a three-factor portfolio credit model explains virtually all of the time-series and cross-sectional variation in CDX tranche premia. Bhansali et al. (2008) use a more simplified specification of the same model to study the turmoil period. They find that the subprime turmoil has more than twice the systemic risk of the May 2005 downgrade of GM and Ford. Coval et al. (2007) apply fundamental asset pricing theory to price CDX tranches and find that actively traded CDOs resemble economic catastrophe bonds. Scheicher (2008) shows that, even in actively traded and standardised CDOs, liquidity is priced.

Finally, our approach is also related to the literature on the determinants of corporate credit spreads and the pricing of individual firms' CDS, which includes Collin-Dufresne et al. (2001), Campbell and Taksler (2003), Zhang et al. (2005) and Ericsson et al. (2008).

One of our main findings is that declining risk appetite and heightened concerns about market illiquidity have provided a sizeable contribution to the observed collapse in ABX prices since the summer of 2007. In particular, while fundamental factors, such as indicators of housing market activity, have continued to exert an important influence on the subordinated ABX indices, those backed by AA and AAA exposures have tended to react more to the general deterioration of the financial market environment. This points to important differences across the various indices, likely reflecting fundamental factors (such as credit quality) as well as technical factors (such as clientele effects).

The rest of this paper is organised as follows: Section 1 provides a brief overview over the ABX indices and their mechanics, including basic pricing relationships. Section 2 describes our sample. Section 3 applies regression analysis to investigate the determinants of ABX index returns, analysing the relationship between ABX pricing and macroeconomic news as well as market-based proxies of interest rate risk, liquidity risk and risk appetite. Section 4 concludes the paper by summarising the main results.

1. An introduction into the ABX

Index mechanics

The ABX family of indices, which started trading on 19 January 2006, consists of a series of equally-weighted, static portfolios of asset-backed CDSs referencing 20 HEL MBS transactions. The ABX indices were introduced on the back of strong issuance activity in subprime MBS markets (Graph 1) and the successful launch of single-name asset-backed CDS contracts in 2005, following the advent of standardised ISDA documentation. Permitting straightforward referencing of subprime exposure, these contracts had seen particularly strong growth due to their inclusion in synthetic CDOs, eventually triggering demands for a benchmark index.[4]

Trading in the ABX contracts is offered by a consortium of major credit derivatives trading desks; the same group already offering trading of other key CDS indices. Following the example of these other indices, new "on-the-run" ABX series are being introduced every six months. However, unlike their counterparts in the world of corporate and sovereign credit, each ABX index series references 20 completely new subprime MBS deals issued during a six month period prior to index initiation.[5] As a result, the resulting risk profiles can differ substantially across index series, reflecting vintage-related factors such as underwriting standards or collateral composition. Trade confirmation excludes any form of physical settlement, which decouples ABX trading from the availability of the underlying cash bonds.

Each index series (with two series per vintage year) consists of five sub-indices, each referencing tranche exposures to the same 20 underlying HEL deals, though at different levels of the capital structure (Graph 2). It is those sub-indices, at the AAA, AA, A, BBB and BBB- levels of credit quality, rather than the overall index, that are traded and for which prices are quoted.[6] Underlying deals are selected on the basis of set criteria, targeting large and liquid structures with at least $500 million of deal size at issuance, using a dealer polling process. For example, average FICO scores[7] are set at a maximum of 660 per deal, and tranche average lives below the AAA level are restricted to 4-6 years at issuance (and must be greater than 5 years for AAA bonds). Concentration limits apply to the number of deals with the same originator or master servicer, and each underlying obligation is required to carry ratings by both Moody's and Standard & Poor's.[8] Once created, index composition remains static. The maturity of each ABX contract corresponds to the underlying CDS with

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4 Ashcraft and Schuermann (2008) offer a detailed description of the subprime US mortgage market and of the factors contributing to its performance over time. See also Kiff and Mills (2007) and Gorton (2008).

5 Overall, the structure of the ABX indices of subprime mortgage-based CDS shows a number of similarities with the iTraxx and CDX credit index families, which are based on baskets of corporate CDS. Some of the more important differences are the underlying assets, the securitised nature of the ABX underlyings and the fact that there can be multiple credit events whereas corporate CDS contracts tend to terminate after one single event.

6 Supplementary indices, called ABX.HE.PENAAA, were introduced in May 2008 to provide additional pricing information for all four existing index vintages.

7 FICO (Fair Isaac Corporation) scores measure the credit risk of individual borrowers based on a statistical analysis of their credit files. FICO scores range between 300 and 850, and subprime loans are often defined as those to borrowers with limited income and/or a score of 620 or below. See Frankel (2006) for details.

8 A requirement like that should provide a degree of protection against possible "ratings shopping". See Fender and Kiff (2005).

the longest legal maturity, which results in exposures that are very similar to those of the underlying cash MBS bonds.[9]

Given the minimum size requirement of $500 million on each of the 20 underlying HEL deals, each individual index series references at least $10 billion worth of subprime mortgage exposure at issuance. In fact, for the four 2006 and 2007 series combined, original balance has averaged about $31 billion or 1.54 billion per underlying MBS deal. This compares to average monthly issuance amounts of about $36 billion over the 10 quarters through mid-2007, or almost one month's worth of subprime MBS supply per index series (Graph 1). At the same time, with 2004-2007 vintage subprime MBS bonds estimated to total around $600 billion in outstanding amounts, each series represents some 5% of the overall subprime MBS universe on average—or around 20% for all four existing series taken together. While these are large amounts, they have still been criticised by some observers for misrepresenting the market.[10] At the same time, ABX deal composition is known to be quite similar in terms of collateral attributes (such as FICO scores, loan-to-value ratios and the like) to the overall market by vintage, which will help limit any biases arising from incomplete market coverage.[11]

Coverage of actual MBS transactions, however, is lower than these numbers suggest. This is because only parts of the capital structure of the underlying deals are actually referenced by the various indices of a given series (see Table 1 and Graph 2b for an illustration). Typical subprime MBS deals issue several so-called A class securities (ie, senior tranches that are usually rated AAA), a number of M and B class pieces (ie, mezzanine tranches rated somewhere between AA and BB) as well as more subordinated classes (with and without face value). The overall number of tranches is around 15 per deal, of which only 5 (one AAA, AA, A, BBB and BBB- quality tranche each) were originally included into the ABX indices of the respective series. This is particularly relevant at the AAA level, which accounts for around 80% of the outstanding balance at issuance, as the AAA tranches referenced by the corresponding ABX indices are not the most senior pieces in the capital structure of their constituent MBS deals. As a result, limited index coverage makes it difficult to translate the performance of, say, the ABX 07-1 AAA index into information on how other AAA subprime bonds originated in the second half of 2006 have or should have performed. This, in turn, suggests that users of ABX price quotes (for purposes such as the "marking" of subprime MBS bonds or the estimation of market-wide subprime-related valuation losses for a universe of instruments that includes bonds not referenced by the ABX indices) have to be careful to avoid misrepresenting actual valuation effects.[12]

Pricing mechanics

The ABX.HE indices trade on price rather than in spread terms. These prices, which reflect the willingness of investors to buy or sell default protection on the basis of their views about the risk of the underlying subprime loans, are quoted as a percentage of par. With the terms of the underlying CDS contracts fixed, premia or discounts relative to par indicate the amount that is to be exchanged upfront. Payments reflect the present value of the difference between

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9 See, for example, Lehman (2006). The ABX indices have typically referenced collateral from more than 15 originators and serviced by a similar number of master servicers.

10 See, for example, Economist magazine (2008) and Wall Street Journal (2007).

11 Note, however, that simple metrics such as FICO scores and LTVs can be "gamed" and that there is evidence that underwriting quality erosion occurred primarily in the "soft" data that was less readily available to investors in securitised pools (and the ABX). See Anderson et al (2008) and Keys et al (2008); Gorton (2008) offers an opposing view.

12 See Box 1 in Fender and Hoerdahl (2008) for details.

the current index spread and the fixed coupon of the index plus accrued interest. As investors may have different views on, for example, the prepayments on the underlying bonds, assumed average lives for individual ABX bonds (and hence duration) can differ markedly. Particular spread quotes would thus yield different net present value solutions. Trading on price removes this problem and allows, on the basis of an assumed duration, calculation of implied spreads in basis points per year. These spreads, in turn, are broadly comparable to the basis point spreads quoted on other credit products (Graph 3 a and b).

As with other CDS contracts, ABX prices are determined by two payment legs.[13] The first leg, which is paid by the protection buyer, is based on the index coupon[14], which, in turn, is fixed in percent of notional over the life of the index on the day of the index roll. As payments are made on a pay-as-you-go basis, the fixed valuation leg can be approximated by the present value of the monthly stream of fixed, no-default coupon payments, adjusted for any prepayments on the underlying bonds. (As premiums are based on monthly bond balance, fixed leg payments will look similar to interest payment streams of identical size during the first years, until stepdowns reduce the outstanding balance on the underlying bonds and hence the premium stream).[15] The second, floating leg is paid by the protection seller, who makes conditional payments equivalent to any principal writedowns or interest rate shortfalls as they occur. Reflecting these factors, ABX prices can therefore be written as:[16]

$$p = 100 + c\sum_{i=1}^{n} z_i s_i t_i f_i - (1-\delta)\sum_{i=1}^{n} z_i (s_{i-1} - s_i) f_i ,$$

where p is the ABX price, c is the fixed coupon payment, z is the effective risk-free discount factor, s is the no default probability, t is the accrual period (from t_{i-1} to t_i), δ is the recovery rate, and f_i is the bond factor measuring prepayments on ABX bonds. Or, in simplified terms:

$$price = 100 + PV(premium) - PV(writedowns,\ shortfalls).$$

On this basis, market participants' expectations regarding future writedowns of tranche principal are key factors in determining ABX prices. These, in turn, depend on information such as prepayments and delinquencies, while writedown timing assumptions and discount rates are important parameters in calculating present values. Specifically, if writedowns are assumed to occur immediately (zero months to default) and with coupon payments given, prices will be determined by the number of bonds written down. Broadly put, 10 complete writedowns (ie, half of the underlying MBS tranches) will result in a price of 50, whereas 15 writedowns (75% of all tranches) imply a price of 25.[17] Alternatively, if all tranches are assumed to be written down, expectations about writedown timing translate directly into ABX prices.

Recent ABX pricing can be used to illustrate these effects. While house prices had been weakening and delinquencies on the rise for some time, the year 2007 in particular saw very

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13 A second fixed leg may be paid to reimburse the protection seller for reversed writedowns and interest rate shortfalls, but is irrelevant for our purposes here and thus ignored through the remainder of this paper.

14 The 2006-1 AAA index is quoted with a coupon of 18 basis points, whereas the corresponding BBB- index has a coupon of 267 basis points. The respective coupons for the 2006-2 vintage are 11 basis points at the AAA and 242 basis points at the BBB- level.

15 See, for example, Lehman (2005).

16 See Markit (2008).

17 See UBS (2007b); calculation of writedowns requires deal-level knowledge about the effective attachment and detachment points of the various tranches of ABX constituent deals, which will depend on the amount of overcollateralisation and accumulated excess spread.

severe deterioration in the subprime mortgage segment. As mortgage delinquencies ramped up, so did loss projections on subprime mortgage bonds, implying loss rates far exceeding historical precedents.[18] As a result, the most junior indices of the more recent ABX series (which are backed by lower quality exposures than the original 06-1 index vintage) quickly started to trade on an interest-only (IO) basis, ie at levels essentially pricing complete principal writedowns of all 20 underlying MBS tranches.[19] The 06-1 and 06-2 BBB– indices, in turn, began to follow the same pattern during the first quarter of 2008, suggesting that writedown expectations were approaching 100% (Graph 3a).[20]

Given the above, ABX pricing is a complex process that involves the use of cash flow models to project payments, delinquencies, defaults, and losses based on collateral characteristics (such as FICO scores, loan-to-value ratios, and loan size), interest rate assumptions and assumptions about house price appreciation (HPA). Modelling, in turn, results in cash flow projections across various HPA paths, which can then be aggregated to derive the appropriate price, given probability assumptions for the various scenarios. Other price determinants will include interest rates (both via discounting and in determining prepayments, defaults and effective subordination)[21] as well as factors such as market liquidity and risk appetite (which will influence any risk premia priced). Time is another factor in that, as highlighted above, for given expected writedowns and writedown timing, ABX prices will tend to fall as the projected losses draw closer. Similarly, as default as well as prepayment performance are known to have strong seasoning effects, average loan age (which grows over time) will feed into prices.

2. Sample description

Our analysis focuses on the ABX 06-1 and 06-2 indices, which are the oldest of the four available index vintages, offering the longest time series. While subsequent index series, especially the latest so-called on-the-run series, are likely to have cannibalised some of the liquidity in the 06-1 and 06-2 market, index underlyings are different from series to series. This should help limit any adverse liquidity effects from the trading of other index vintages (but not those resulting from the deteriorating market environment witnessed from mid-2007). At the same time, underlying credit quality of the 06-1 and, to a lesser extent, 06-2 series is known to be better than for the subsequent vintages, as mortgages originated in the second half of 2005 and in early 2006 have benefited from the tail end of strong HPA observed until 2006. The same applies to underwriting standards, which are known to have deteriorated over time.[22] This will have to be taken into account in the econometric procedure and when interpreting any of the results.

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[18] See Box 1 in Fender and Hoerdahl (2007) for an illustration on the basis of the approach described in UBS (2007a).

[19] See UBS (2008) for details.

[20] It took until June 2008 for the first ABX index, the 06-2 BBB-, to actually suffer its first principal writedown event (an amount of 1.278 cents per dollar traded); further writedowns on the lower-rated ABX 06-2 and ABX 07-1 indices followed in July and in subsequent months.

[21] Sensitivities for assets and liabilities in a HEL MBS transaction will be different in that interest payments on liabilities will tend to reset faster. Abstracting from any hedges that may be in place, declining interest rates will thus translate into increasing "excess spread" earned on the assets relative to what is paid out on the liabilities. Excess spread, in turn, offers additional protection for HEL investors. See UBS (2007b).

[22] See Demyanyk and van Hemert (2008) who use logit regressions to find that the quality of subprime loans deteriorated for six consecutive years before the crisis, with the decline masked by high house price appreciation between 2003 and 2005. Similarly, Anderson et al (2008), employing a hazard rate model to

Casual inspection of ABX price data yields a number of interesting observations. One is the massive blow-out in observed spreads (steep decline in prices) observed since June 2007, following an initial spread increase early in the same year (Graph 3b).[23] The developing subprime crisis then caused price deterioration to travel through the liability structure of the various ABX indices, with prices up to the A index converging at very low levels. A closer comparison of two pricing snapshots (30 June 2008 and 1 June 2007; Table 2) for the first two ABX vintages shows that the AAA tranches were trading close to par in June 2007, whereas they were quoted at around 92 and 69, respectively, at end-June 2008. This movement also illustrates how the market had started to differentiate between the two adjacent vintages. In total, the strongest price declines were observed in the A/BBB segment, which saw the average credit rating of the underlying MBS securities decline by between 3 and 9 notches. With the average rating of the underlying MBS bonds coming down to the B level, prices dropped from around 94 to less than 10 for the 2006-1 BBB index, which was slightly higher than the price of the 2006-2 index that was originally rated A (but with the same average rating of B in June 2008).

In distributional terms, logarithmic ABX returns exhibit negative skewness and excess kurtosis, implying strong non-normality. The probability mass of the return distribution is concentrated on the right, with an extended left-hand tail, and observed variance is dominated by infrequent extreme return realisations, particularly for the higher quality tranches (Table 3). Return correlation among tranches and vintages is high, but tends to decline as the distance between any two tranches in the capital structure increases (Table 4). This points to some degree of price differentiation across the various indices, in line with the pricing changes documented in Table 2.

Correlation patterns over time also offer some insights into how the market perceives the riskiness of different ABX tranches. For example, rolling 90-day correlations between 06-1 AAA and BBB– index prices show a pronounced increase during the onset of the subprime crisis in the summer of 2007, and have remained at elevated levels of around 0.5–0.6 since (Graph 4). This followed a brief volatility spike in January/February 2007, consistent with the initial subprime jitters during that period, and correlations around 0.3 throughout much of 2006. These patterns, which are similar for the ABX 06-2 index, are broadly consistent with observed correlations between senior ABX and investment grade CDS prices. As these have very different underlyings, factors other than the risk of mortgage default seem to have played an important role in driving ABX returns.

3. Determinants of ABX prices

Explanatory variables

In the literature on credit spreads, econometric methods have been used frequently because they avoid being constrained by any particular pricing model and allow for a wide set of explanatory variables to be employed (eg, Collin-Dufresne et al, 2001). The set of potential determinants can therefore include also factors such as liquidity and risk tolerance, which are typically understood to be important determinants of asset prices, while being difficult to incorporate into theoretical models.

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decompose foreclosure rates for subprime mortgages, attribute foreclosures about equally to underwriting quality and economic conditions.

[23] See chapter VI in BIS (2008) for a description of market developments during the onset of the financial crisis.

Our approach proceeds as follows. First, we analyse ABX returns by way of a factor decomposition, to illustrate broad correlation patterns among ABX prices and between the ABX and other financial market variables. Second, we use panel regressions to establish the effect of these variables on ABX returns in more detail. Third, we employ blockwise regressions to investigate changes in the importance of different pricing factors over time. Finally, we perform a number of robustness checks and supplementary regressions.

In implementing these steps, the ABX determinants will be proxied by macroeconomic and financial market variables combined with, where available, survey information and publication dates to capture any announcement effects. Specifically, the following variables are used (the list of explanatory variables and the way they are expected to correlate with ABX returns is also summarised in Table 5):

Housing and related fundamentals. Detailed data on the subprime mortgage market is scarce, especially at the higher frequency level, which makes it difficult to come up with appropriate proxies for fundamental drivers of mortgage default. We consider three groups of housing-related indicators for inclusion, many of which have similar properties. The first of these consists of contemporaneous indicators, such as macroeconomic data releases, which tend to be available at a weekly or monthly frequency. The second group contains daily pricing factors with forward-looking information, such as those derived from prices for financial products. The third group is based on ABX-specific performance data.

Contemporaneous data. From a modelling perspective, the inclusion of most lower-frequency measures of housing fundamentals in the regression setup is difficult, as precise time stamps (ie, announcement dates) and estimates of analysts' forecasts are required in order to properly test the reaction of daily market prices to these fundamental factors.[24] In the regression setup, mortgage applications, building permits, Case-Shiller home prices, and the RPX residential property price index will thus proxy the overall state of the US housing sector and other mortgage market-related factors. The mortgage applications index, a measure of mortgage loan application volume, is based on weekly data compiled by the Mortgage Bankers' Association (MBA); building permits, an indicator of new privately owned housing units authorised for construction, are put together by the US census bureau; the Case-Shiller 10 index, which tracks changes in the value of the residential real estate market in 10 metropolitan regions, is provided monthly by Standard & Poor's with a two month lag; the RPX residential property composite index, which is based on daily transaction prices per square foot paid for US residential real estate in 25 regional markets, is published by Radar Logic with a lag of about 2 months. The RPX property price series enters the analysis both in levels and in terms of observed volatilities over a moving 20-day window to capture housing market trends as well as associated uncertainties. The key macroeconomic control variable used is the surprise component in the monthly net change in US employees on non-farm payrolls.[25] Finally, to capture news about activities in the banking sector, we include a leverage measure (assets over equity) calculated from the Federal Reserve's weekly H.8 balance sheet statistics.

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[24] Asset pricing theory suggests that current prices fully reflect the publicly available information about the state of the economy. Therefore, it is not the published level of a macroeconomic variable that affects the prices of securities or derivatives, but the unexpected component of the new information (see, eg Fleming and Remolona (1997)).

[25] Non-farm payrolls are known to be the single most important macroeconomic news release in the United States, with well documented effects for a variety of financial assets (see Fleming and Remolona (1997)). The other variables are suggested by authors such as Calomiris et al (2008), who employ a panel VAR model to investigate the interaction of foreclosure rates, house prices and other economic variables. They find that employment shocks explain some 7-9% of the forecast variance of foreclosure rates at horizons of 8 and 20 quarters. Similar effects are found for (existing) home sales and building permits, whereas shocks to house price growth explain some 25% of the 20-quarter forecast variance of foreclosure rates.

Forward-looking information. Expected developments in the housing sector are captured by a set of financial market variables, which have the advantage of being available at a daily frequency: logarithmic excess returns of the homebuilders equity sub-index over the S&P 500 index as well as price data for futures contracts on the Case Shiller house price (SPCS10) index. These futures, which are traded on the Chicago Mercantile Exchange's Globex trading platform, are available for the contract months of February, May, August and November and are cash settled on the day the SPCS10 index is released. For simplification, we average available observations across the various contracts at any given point in time into a single daily number, which can be interpreted as the average futures-implied house price over the period spanned by those contracts.

ABX-specific data. Deal specific news for each of the constituent MBS bonds of the ABX indices are proxied by information on rating downgrades by the three major rating agencies and delinquency data from the monthly so-called remittance reports. For the first of these ABX-specific indicators, downgrade events by Moody's, Standard and Poor's and Fitch for the underlyings of the 06-1 and 06-2 ABX indices are coded by date, vintage and ABX rating category.[26] The second indicator summarises underlying deal performance on the basis of observed changes in average 60 day-plus delinquencies for the same set of MBS instruments. In addition, we include a measure of average expected duration across the various ABX 06-1 and 06-2 contracts, which is backed out from observed prices and (implied) spreads across all 10 indices included in our setup.[27]

Interest rates. The series that is commonly seen as market participants' preferred discount rate is Libor and, by extension, the rate on US dollar swaps. In addition to its impact on the present values of the two payment legs via the discount factor, as argued above, interest rates (via the excess spread) are also going to determine the effective subordination of the various ABX tranches. Finally, through the yield curve relationship, interest rates will capture expectations of monetary policy and the economic climate, including those regarding mortgage prepayment behaviour. In the econometric setup, these interest rate effects are going to be proxied by 3-month US dollar Libor[28] and by the spread between 10-year and 3-month US Treasury yields.

Investor risk appetite and liquidity. Spreads for credit-risky products are known to compensate investors for more than pure expected losses from default (see, for example, Berndt et al, 2005). These risk premia are typically assumed to correlate with investor attitudes towards risk. Given its forward-looking character, the VIX implied volatility index derived from option prices on the S&P 500 equity index is a common measure used to capture these effects. In the econometric setup, risk appetite is proxied as the ratio of the VIX and realised S&P volatility over a leading 20 day window (ie, positive forecast errors of the VIX index relative to realised equity market volatility), where higher readings of the VIX ratio correspond to declining risk appetite (see also Coudert and Gex, 2008). In addition, specific liquidity proxies are included to better gauge associated risk premia. Longstaff et al. (2005) show that risk premia in credit spreads are positively related to average bid-ask spreads,

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[26] The resulting downgrade counts, aggregated into vintage-specific indices covering all five rating categories (RAT061 and RAT062) and an overall index (RAT06X), identify 48 days with downgrades on at least one underlying instrument over the period through end-June 2008. The maximum count for the 06-1 and 06-2 vintages is 14 and 51 downgrades/day, respectively, on 8 April 2008 and 30 January 2008. With 100 MBS bonds referenced by each individual ABX vintage, individual readings of our ratings indices can be interpreted as the percentage of underlyings downgraded (in numbers of bonds).

[27] The source for both sets of data is JP Morgan Chase, which allows us to back out the index- and vintage-specific duration assumptions used in the calculation of JP Morgan's implied spreads. (See section on pricing mechanics above).

[28] Part of the observed Libor movements is going to reflect changes in counterparty credit and liquidity premia; see the section on risk appetite and liquidity below.

which in turn capture changes in market liquidity. As bid-ask spreads for the ABX indices are not readily available, two different indicators are going to be used in the econometric setup. First, we proxy bid-ask spreads with the average of observed bid-ask spreads across tranched CDX investment grade contracts. Second, we use US dollar 10-year swap spreads. These are known to contain a liquidity premium, along with a premium reflecting the default risk embedded in the Libor rate (which is known to have risen during the crisis), due to banks' funding operations in the interbank market.[29] All three variables together would be expected to provide a reasonable summary proxy of the dynamics of risk appetite- and liquidity-related price premia, which we expect to be interrelated and do not aim to disentangle.

Correlations among the explanatory variables, which tend to be are moderate overall, are given in Table 6. In absolute terms, the largest correlations are observed between the US dollar swap spread and the yield curve proxy (.175), and between the swap spread and homebuilder excess returns (-.176).

Preliminary steps

As a first step, we analyse the information content of ABX returns by way of a simple factor analysis. The factor decomposition uses maximum likelihood estimation and determines the overall number of factors on the basis of their shares in total observed variance. Tables 7a and b show the loadings and the correlations with the factors from Table 5.

The results of this decomposition suggest that the correlation structure of logarithmic ABX returns can be explained by (only) two separate factors. The first of these, which accounts for a share of some 87% of common variance (87% for the 2006-1 vintage and 83% for the 2006-2 vintage), is strongly related to a number of financial market variables, including those proxying illiquidity effects. Changes in both swap (USSW10-USGG10YR) and bid-ask (CDX_BA) spreads show more or less identical contemporaneous correlations of about –.27 with the first factor of both the 2006-1 and 2006-2 vintages. Similar patterns are found across most of the other explanatory variables in that correlations with the first factor of both 2006 index vintages are very similar. The second factor, in turn, accounts for a much smaller share of the overall return variance and, at least in the case of the 2006-2 vintage, appears to be correlated significantly (at around -.11) only with measures of ABX duration (which, in turn, embody projections for factors such as prepayment behaviour on the underlying mortgage pools).

Overall, these patterns suggest that variation in ABX returns may be due not only to changes in house prices and other drivers of fundamental mortgage risk, but also to more general pricing factors, such as liquidity and investor risk attitudes.

Regression setup

The baseline regression is estimated by pooled OLS with cross-sectional fixed effects and White period standard errors, which are robust to within cross-section heteroskedasticity and serial autocorrelation.[30] Price and interest rate observations are daily, enhanced with time-stamped macroeconomic and financial data releases at a monthly or weekly frequency. A time trend is included to capture maturity effects. All right hand side variables except the

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29 See Huang and Neftci (2003) for details on the importance of liquidity premia in swap spreads.

30 An alternative setup using feasible GLS with cross-sectional fixed effects was run to check our results for robustness and generated broadly similar results with regard to the size and significance of the various coefficients.

surprises and S&P excess returns are specified as first differences, and the left-hand side variables are logarithmic ABX price changes for the 10 indices of the combined 06-1 and 06-2 vintages.[31] As such, the setup can be interpreted as a "news arrival" framework, where new information is expected to affect market prices once it becomes available, even if the news item relates back to a past period (as in the case of the Case Shiller index, which is published with a lag of two months).

To capture the effects of the financial crisis on the pricing of the ABX indices, all pricing factors that are available at a daily frequency are also interacted with the crisis dummy (D_TOIL). Finally, the same variables are interacted with the ratings indicator (RAT06X) to gauge any effects from rating downgrade-induced changes in market sentiment. The sample period extents from 19 June 2006, the initiation date of the 06-2 index series, to end-June 2008.[32]

Hence, we estimate the following equation, where P denotes the stacked ABX price quotes and FE represents the fixed effects:

$$D(\log(P)) = c + A\Lambda + \mathrm{B}_1\Gamma + \mathrm{B}_2 D\_TOIL\,\Gamma + \mathrm{B}_3\, RAT06X\,\Gamma + FE$$

with:

Λ	{TIME, NFPR, DMBA, NHSPA, DH8AOE, RAT061, RAT062, DDQ06X, DCSI10},
A	9*1 vector of coefficients,
B_1, B_2, B_3	10*1 vectors of coefficients, and
Γ	{D(DUR06X), D(RPX1), D(RPX1_20), D(CME_MEAN), SPHOMEXR, D(3M_LIBOR), D(USGG10YR-USGG3M), D(VIX/RVOLA_SPX), D(USSW10-USGG10YR), D(CDX_BA)}.

Baseline results

The results of the baseline regression setup are reported in Tables 8 and 9, on a block-wise basis as well as including all four sets of explanatory variables simultaneously. Several interesting observations can be made:

First, most of the macroeconomic and housing market variables have positive, statistically significant effects on ABX prices. Both mortgage loan application volume and building permits are positively related to changes in ABX prices over the sample period, as are nonfarm payrolls and the Case-Shiller index. That is, as expected (see Table 5), ABX valuations tend to rise in response to news suggesting strong employment and housing markets. Bank leverage, as measured by the DH8AOE variable, also has a positive sign, in line with the assumption that news about bank deleveraging tend to depress ABX prices. In contrast, changes in futures-implied Case Shiller house prices appear to have the wrong sign. The relationship is negative and significant, unless the futures variable is interacted with the crisis dummy or the ratings indicator, which turns the sign positive.

Second, interactions with the crisis dummy yield significant add-on effects across most of the pricing factors during the latter part of the sample. Indeed, the RPX house price index is significant only in-crisis, which would be consistent with extra attention by market participants

31 First order differences can be interpreted as pure surprises in a random walk model (along with the surprise components of economic data announcements), which justifies regression setups without lagged variables.

32 This setup extends Fender and Scheicher (2008), who estimate a very similar model based only on ABX 06-1 returns.

to indicators of mortgage default risk during times of general market weakness. The same is true for the volatility of the RPX index, which takes the expected negative sign during the latter part of the sample.

Third, delinquency information and rating downgrades on the securities referenced by the ABX 06-1 indices are found to have negative effects on subprime mortgage pricing. Both effects are statistically significant, which is interesting, as rating downgrades are typically found in the literature to lag market information.[33] This, in turn, would tend to limit the information content and, hence, the impact of rating changes on ABX prices. The sign of the coefficient for the RAT062 measure, in contrast, is positive, perhaps due to confirmatory effects regarding the quality of ABX 06-1 collateral on days with ABX 06-2 rating downgrades that do not coincide with downgrades on the ABX 06-1. In addition, the ratings variables (merged into the RAT06X measure) are significant when interacted with some of the other pricing factors, suggesting added or offsetting effects from the negative sentiment associated with rating downgrades. Homebuilder excess returns, for example, are found to negatively affect ABX prices on days with rating downgrades—an observation that doesn't seem to apply for estimates over the entire sample or over the crisis period. The same is true for the RPX house price index. ABX duration, finally, affects ABX returns negatively (and more so in-crisis), consistent with the increased riskiness arising from higher durations.

Fourth, we find significant risk appetite and liquidity effects, as illustrated by swap and CDX bid-ask spreads, which are found to correlate negatively with ABX prices, particularly in-crisis. Our VIX-based measure of "forecast errors" with regard to investor risk appetite also has a negative sign, although the added effect during the crisis period turns out to be positive and insignificant. Interest rate effects are also significant, with higher rates and rising yield curve slopes associated with negative add-on effects on ABX returns during the latter part of the sample; a reaction broadly neutralising the positive effect found without the interaction term.

Finally, the results are consistent with a considerable common unobserved component in the variation of ABX prices, as the R-squared is only about 25%. In line with the results of the principal component analysis of ABX returns reported above, this points to the existence of a sizable driver of subprime mortgage risk that is not captured satisfactorily by any of the explanatory variables in the econometric setup.

The explanatory value for ABX market prices is somewhat lower than those documented elsewhere, eg in Scheicher (2008) for CDS index tranches.[34] The first principal components of the residuals of the baseline regression contribute, at 46-62%, a variance proportion that is some 30-40 percentage points smaller than the proportion contributed by the first principal components of ABX 06-1 and 06-2 returns. While this points to correlations between the residuals that are substantially smaller than those for the dependent variables, the remaining interdependence is still consistent with a sizable unobserved common component in the regressions.[35]

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[33] A key empirical finding from the ratings literature is that spread changes tend to anticipate negative rating announcements, especially when extreme deterioration in credit quality materialises within a short time period; see Hull et al (2004). Nevertheless, negative rating events (ie, downgrades and announcements of reviews for possible downgrade) are generally found to give rise to statistically significant contemporaneous price or spread movements. However, the changes are often economically insignificant and much smaller than would be suggested by the magnitude of the rating change itself; see Cantor (2004).

[34] Across CDS index tranches, Scheicher (2008) finds R-squared values ranging from 0.11 (most senior CDX tranche) to 0.55 (mezzanine CDX tranche).

[35] Alternatively, the regression setup may be inappropriately specified.

One possible explanation of this finding is in terms of a broad interpretation of the ”credit spread puzzle” (see, for example, Amato and Remolona (2003)), which describes the observation that fundamental factors are usually found to explain only a small fraction of observed credit spreads. These findings on the level of spreads are also applicable to the present case of first differences if the unexplained component is time-varying, implying similar effects in terms of observed returns.

Turning to the economic significance of the results, we compare the reaction of observed ABX prices to one-standard-deviation changes in the set of explanatory variables. Graph 5 shows the impact of a change of one standard deviation of the explanatory factors. We find that, in percentage terms, two of the interest rate factors deliver the biggest impact on the dependent variables, with the interest rate (3M_LIBOR) and swap spread (USSW10-USGG10YR) showing up with values of around 0.30-0.40%.[36] Similar economic significance, at 0.25%, is attached to changes in the yield curve (USGG10YR-USGG3M). Among the housing market-related variables, implied ABX duration has the biggest effect on ABX log price changes (at -0.12%), followed by RPX price changes (at 0.10%). The Graph also illustrates the economic significance of the add-on effects applying in-crisis (in terms of standard variations over the respective part of the sample). Duration yields an add-on effect of almost -.80%. Again, relatively large negative effects for Libor and the yield curve are found to compensate the estimate across the entire sample.

Assessing the impact of the turmoil

To illustrate the impact of the recent financial market crisis on the pricing of the ABX indices, the next step of the analysis focuses on changes in the weight of the different pricing factors over time, ie pre- and in-crisis, where the start of the crisis period is once again set at 9 August 2008. For this purpose, relative contributions of R-squared “goodness of fit” measures are compared on the basis of block-wise regressions of ABX 06-1 and 06-2 returns. Following the description of the various data series above, the different blocks are housing and other fundamentals (including ABX rating changes and delinquencies), market-implied housing market indicators (including ABX duration and RPX house prices), interest rates as well as risk appetite and liquidity.

Results are reported in Graphs 6a and b and suggest some important changes in the relative explanatory power across the four sets of pricing factors. Importantly, for the entire sample, risk appetite and market liquidity risk seem to account for a sizeable part of observed variation in ABX returns. Patterns, however, differ across the various rating categories and vintages. While risk appetite and liquidity risk have grown in importance for the AAA[37] and AA indices across both vintages, they have tended to diminish in importance for the lower quality segments. For the BBB- indices, in particular, risk appetite and liquidity became less of a factor in-crisis, which may be consistent with an increasing likelihood for all underlying MBS bonds to be written down completely—that is, the transition to IO pricing for the BBB- indices at some point in early 2008. As this made it expensive to express negative trading views on the US housing market with the junior ABX 06-1 and 06-2 indices, the most senior contracts were becoming more attractive for such purposes and as a macro hedge, while remaining less likely than the subordinated indices to take sizeable losses in the wake of a deteriorating

[36] This is in line with Danis and Pennington-Cross (2005), who examine the performance of subprime mortgage loans on the basis of a set of logit models to find, among other things, that changes in interest rates affect prepayments, defaults and delinquencies. Changes in interest rates, therefore, are going to convey information about subprime mortgage risk that goes beyond the technical factors mentioned earlier.

[37] This is consistent with market practitioners’ beliefs that pricing for the ABX 06-1 AAA index is driven largely by market liquidity premia. See Lehman (2008).

housing market. Overall, the role of housing fundamentals has tended not to change much across the two sub-periods. Interestingly, however, the importance of housing data releases appears to decrease in relative terms, while more indirect and more frequent proxies for mortgage fundamentals increase in importance, possibly reflecting market participants' attempts to broaden the set of indicators used to gauge current and future housing market developments.

Given that the market has only been active for about three years, supply–demand imbalances and technical factors, which are not captured by the liquidity proxies in the equations, may also be present. In particular, in addition to the differences across the various index tranches noted above, the market may exhibit "clientele" effects, ie demand may differ among tranches due to differences in risk appetite across different investor groups. Similar clientele effects based on heterogeneous investors have also been observed in other segments of the credit market, eg among commercial paper investors, as documented by Covitz and Downing (2007).

Robustness Tests

We confirm the robustness of our findings by means of three additional tests (results not reported in detail to conserve space). First, we include non-linear effects into the regression by means of squaring the explanatory variables. We find that there are some nonlinear effects, such as the square of the logarithmic excess returns of the homebuilder equity sub-index over the S&P 500 or the square of the swap spread. As the squares can be interpreted as estimates of the second moment, these results indicate that the market participants also consider the volatility of excess homebuilder returns as well as the volatility of the swap spread in the pricing of the ABX contracts. This points to the existence of uncertainty premia in ABX prices. As a second robustness test, we use lagged, rather than contemporaneous, explanatory variables. Again, this modified specification does not materially change the overall results. Our third robustness test is to replace the VIX ratio by the JP Morgan index of risk aversion. Again, our results are largely unchanged.

4. Conclusion

The results presented in this paper suggest that declining risk appetite and heightened concerns about market illiquidity have provided a sizeable contribution to the observed collapse in ABX prices since July 2007. While fundamental factors, such as indicators of housing market activity, have continued to exert an important influence on the subordinated ABX indices, the AA and AAA indices have tended to react more to the general deterioration of the financial market environment, such as declining risk appetite and market liquidity. These results underline the well-established view that risk premia are important components of observed prices for default-risky products, and that the relative importance of non-default risk factors will tend to increase in periods of strong repricing of credit risk. This suggests that theoretical pricing models that do not sufficiently account for these factors may be inappropriate, particularly in periods of heightened market pressure.

A related set of findings concerns the use of ABX price information by market participants and policy makers for the valuation of positions in US subprime instruments. Importantly, observed ABX prices are unlikely to be good predictors of future default-related cash flow shortfalls on outstanding subprime MBS, especially for those at the higher end of the capital structure. This is for at least two reasons. First, coverage of the ABX indices extends only to a small fraction of the outstanding subprime MBS universe, which can lead to significant price divergence across like-rated products even in the absence of sizeable risk premia. Second, as factors other than default risk are important determinants of ABX prices, observed credit spreads will exceed the amount necessary to compensate buy-and-hold investors for appropriately discounted expected future writedowns. Taken together, these factors may limit the usefulness of ABX price quotes for valuation purposes and as indicators of future writedowns and losses by ABX investors.

At the same time, given the role of risk appetite and liquidity proxies in explaining observed returns, ABX-based price quotes and loss estimates are likely to be conservative. This, in turn, implies that default-related losses on subprime MBS instruments, particularly at the more senior levels of the capital structure of the earlier index vintages, may ultimately turn out to be significantly lower than recent ABX prices would seem to imply. As these risk premia can be captured by unconstrained investors (ie, those who can bear the mark-to-market volatility and who aren't funding constrained), ABX pricing patterns appear to lend support to approaches such as the US Troubled Asset Relief Program (TARP)—which (in its original version) was aimed at taking assets off banks' balance sheets and at holding these assets to maturity.

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Table 1: Sample subprime MBS deal structure

Securitized Asset Backed Receivables LLC Trust SABR 2006-HE2

Class	Original balance (US$ millions)	Original balance (in per cent)	Original rating	Type[1]	ABX.HE 07-1[2]
A-1	315.497	30.8	Aaa/AAA	Senior (Pool1)	
A2-A	291.005	28.4	Aaa/AAA	Senior (Pool 2)	
A2-B	56.854	5.5	Aaa/AAA	Senior (Pool 2)	
A2-C	88.953	8.7	Aaa/AAA	Senior (Pool 2)	PENAAA index[3]
A2-D	47.036	4.6	Aaa/AAA	Senior (Pool 2)	AAA index
M-1	54.827	5.3	Aa1/AA+	Subordinate	
M-2	46.629	4.5	Aa2/AA	Subordinate	AA index
M-3	16.397	1.6	Aa3/AA-	Subordinate	
M-4	33.818	3.3	A2/A	Subordinate	A index
M-5	9.736	1.0	A3/A-	Subordinate	
B-1	11.785	1.1	Baa1/BBB+	Subordinate	
B-2	7.686	0.7	Baa2/BBB	Subordinate	BBB index
B-3	12.810	1.2	Baa3/BBB-	Subordinate	BBB- index
B-4	13.323	1.3	Ba1/BB+	Subordinate	
X	18.468	1.8		Residual	
Total	1024.824	100.0			

[1] The A1 and A2 classes are backed by two different portfolios within the underlying mortgage loan pool, while the remainder of the structure relates to the entire pool. [2] Indicates inclusion into one of the ABX.HE 07-1 indices. [3] The so-called penultimate AAA (PENAAA) indices were added to the existing ABX vintages in May 2008 to cover a bigger part of the AAA segment of the underlying MBS instruments.

Table 2: Two snapshots of the pricing of subprime mortgage risk

Observed market prices for the ABX 06-1 and 06-2 index series, by original rating

Price series	30 June 2008	1 June 2007	change	Rating (as of end-June 2008)[1]
ABX 06-1 AAA	91.81	100.10	-8.29	AAA
ABX 06-2 AAA	69.27	99.59	-30.32	AA
ABX 06-1 AA	60.56	100.05	-39.49	AA
ABX 06-2 AA	20.50	99.52	-79.02	A
ABX 06-1 A	21.15	98.72	-77.57	BBB
ABX 06-2 A	9.29	96.15	-86.86	B
ABX 06-1 BBB	9.65	94.45	-84.8	B
ABX 06-2 BBB	5.48	82.68	-77.2	CCC
ABX 06-1 BBB-	8.96	88.22	-79.26	CCC+
ABX 06-2 BBB-	5.17	73.10	-67.93	CC+

[1] Average rating for the 20 individual securities underlying the respective index (based on the lower rating by either Moody's or Standard & Poor's).

Table 3: Descriptive statistics of ABX returns

Logarithmic returns from observed market prices for the ABX 06-1 and 06-2 index series

Price series	Mean	Median	Max.	Min.	Std.dev.	Skew	Kurtosis	Jarque-Bera	Prob.
ABX 06-1 AAA	0.00	0.00	0.03	-0.04	0.00	-1.52	31.42	21202	0
ABX 06-2 AAA	0.00	0.00	0.04	-0.07	0.01	-1.16	17.99	5970	0
ABX 06-1 AA	0.00	0.00	0.10	-0.13	0.02	-0.57	12.67	2462	0
ABX 06-2 AA	0.00	0.00	0.11	-0.18	0.02	-2.58	20.86	8972	0
ABX 06-1 A	0.00	0.00	0.11	-0.12	0.02	-1.25	12.04	2284	0
ABX 06-2 A	0.00	0.00	0.06	-0.06	0.01	-0.50	14.94	2956	0
ABX 06-1 BBB	0.00	0.00	0.09	-0.10	0.02	-0.67	8.83	736	0
ABX 06-2 BBB	0.00	0.00	0.11	-0.17	0.03	-1.07	9.48	959	0
ABX 06-1 BBB-	-0.01	0.00	0.07	-0.13	0.02	-1.64	8.63	875	0
ABX 06-2 BBB-	-0.01	0.00	0.08	-0.11	0.02	-0.94	6.57	334	0

Table 4: Correlation patterns of ABX returns

Logarithmic returns from observed market prices for the ABX 06-1 and 06-2 index series

Price series	ABX 06-1					ABX 06-2				
	AAA	AA	A	BBB	BBB-	AAA	AA	A	BBB	BBB-
ABX 06-1 AAA	1.000									
ABX 06-2 AAA	0.786	1.000								
ABX 06-1 AA	0.715	0.840	1.000							
ABX 06-2 AA	0.622	0.673	0.774	1.000						
ABX 06-1 A	0.510	0.564	0.688	0.851	1.000					
ABX 06-2 A	0.772	0.817	0.788	0.687	0.575	1.000				
ABX 06-1 BBB	0.712	0.830	0.881	0.706	0.616	0.831	1.000			
ABX 06-2 BBB	0.545	0.619	0.717	0.724	0.682	0.655	0.761	1.000		
ABX 06-1 BBB-	0.406	0.495	0.591	0.682	0.676	0.484	0.596	0.695	1.000	
ABX 06-2 BBB-	0.383	0.462	0.527	0.613	0.642	0.396	0.512	0.586	0.783	1.000

Table 5: ABX pricing factors

Explanatory variables used in the regressions[1]

Variable	Variable name	Format	Expected sign
Non-farm payrolls	NFPR	Surprise component	Positive
Mortgage applications	DMBA	Surprise component	Positive
Building permits	NHSPA	Surprise component	Positive
Case-Shiller 10 index	DCSI	Monthly change	Positive
RPX house prices	RPX1	Daily change	Positive-to-neutral[2]
RPX 20-day volatility	RPX1_20	Daily change	Negative-to-neutral[2]
Banking sector leverage	DH8AOE	Weekly change	Positive[3]
ABX rating changes	RAT061, RAT062, RAT06X	Absolute number	Negative-to-neutral[4]
ABX delinquencies	DDQ06X	Monthly change	Negative
ABX duration	DUR06X	Daily change	Negative[5]
CME housing futures	CME_MEAN	Daily change	Positive
Homebuilder returns	SPHOMEXR	Daily excess log return	Positive
Interest rates	3M_LIBOR	Daily change	Direction unclear[6]
Yield curve	USGG10R- USGG3M	Daily change	Direction unclear[6]
VIX ratio	VIX/RVOL_SPX	Daily change	Negative
Swap spreads	USSW10-USGG10YR	Daily change	Negative
CDX bid-ask spreads	CDX_BA	Daily change	Negative

[1] The dependent variables, ABX index prices, enter all regressions in the form of logarithmic returns. [2] In normal situations, delayed daily house prices (and their volatility) wouldn't necessarily be expected to impact ABX prices; in-crisis, however, their influence might be positive (volatility: negative). [3] A reduction in banking sector leverage is expected correlate with selling pressure in the subprime MBS market, thus translating into negative ABX returns. [4] To the extent that downgrades convey new information, their effect on prices would be negative. [5] Positive changes to duration assumptions are likely to reflect declining prepayment speeds, which will tend to make the underlying mortgage pools more risky. [6] Interest rates will influence ABX prices through the discount factor (which will influence both payment legs with a net effect that depends on which one is more heavy) as well as through their contribution to the excess spread and, hence, effective subordination at the individual tranche level. Additional effects will come through any influence of interest rates on economic activity and prepayment behaviour.

Table 6: Correlation patterns of ABX pricing factors

Correlations among the explanatory variables used in the regressions

Data series	DUR 06X	RPX	RPX vola	CME futures	HB returns	Rates	Yield curve	VIX ratio	Swap spread	CDX bid-ask
ABX duration	1.000									
RPX house prices	0.007	1.000								
RPX volatility	-0.019	-0.137	1.000							
CME futures	0.028	0.070	-0.135	1.000						
HB returns	-0.018	0.011	-0.019	-0.023	1.000					
Interest rates	0.001	0.007	0.010	0.088	-0.173	1.000				
Yield curve	-0.015	-0.023	-0.056	-0.120	0.032	-0.145	1.000			
VIX ratio	-0.031	0.052	-0.056	-0.030	-0.121	0.113	-0.004	1.000		
Swap spreads	0.073	0.031	-0.076	-0.019	-0.176	0.046	0.175	0.103	1.000	
CDX bid-ask	-0.002	-0.063	-0.005	-0.031	-0.098	-0.147	0.163	0.048	0.048	1.000

Table 7a: Factor analysis

Factor decomposition

Factor	Variance	Cumulative	Difference	Proportion	Cumulative
F1_2006_1	3.567	3.567	3.041	0.871	0.871
F2_2006_1	0.526	4.093	---	0.128	1
Total 2006_1	4.093	7.660		1.000	
F1_2006_2	3.265	3.265	2.609	0.832	0.832
F2_2006_2	0.656	3.922	---	0.167	1.000
Total 2006_2	3.922	7.187		1.000	
F1_2006_ALL	6.545	6.545	5.554	0.868	0.868
F2_2006_ALL	0.991	7.536	---	0.131	1.000
Total 2006_ALL	7.536	14.08		1.000	

Table 7b: Factor analysis

Correlations

Factor	F1_2006_1	F2_2006_1	F1_2006_2	F2_2006_2
F1_2006_1	1.000	0.021	0.872	-0.215
F2_2006_1	0.021	1.000	0.128	0.458
F1_2006_2	0.872	0.128	1.000	0.015
F2_2006_2	-0.215	0.458	0.015	1.000
D(DUR06X)	-0.088	-0.069	-0.117	-0.113
D(RPX1)	0.069	0.070	0.072	0.004
D(RPX1_20)	-0.126	0.016	-0.137	0.019
D(CME_MEAN)	0.108	-0.014	0.126	0.046
SPHOMEXR	0.225	0.021	0.180	-0.068
D(3M_LIBOR)	0.009	0.056	0.046	0.071
D(USGG10YR-USGG3M)	-0.093	-0.029	-0.078	-0.054
D(VIX/RVOLA_SPX)	-0.086	0.006	-0.072	-0.047
D(USSW10-USGG10YR)	-0.275	-0.017	-0.213	0.040
D(CDX_BA)	-0.271	0.030	-0.264	0.089

Table 8: Block-wise regression results for ABX 06-1 and 06-2 Pooled OLS with cross-sectional fixed effects and White period-robust standard errors[1,2]				
Variable	**Coefficient (t-value)**			
	Housing (data releases)	**Housing (market indicators)**	**Interest rates**	**Risk appetite & Liquidity**
Nonfarm payrolls	**0.008** **(3.845)**			
Mortgage applications	*0.002* *(1.885)*			
Building permits	**0.006** **(3.091)**			
Banking sector leverage	**0.030** **(4.953)**			
ABX 06–1 rating changes	**0.081** **(5.422)**			
ABX 06–2 rating changes	-0.008 (-1.386)			
ABX 06–X delinquencies	**-0.168** **(-2.731)**			
Case-Shiller house prices	**0.001** **(4.304)**			
ABX duration		**-2.556** **(-4.117)**		
RPX house prices		**0.009** **(2.076)**		
RPX 20–day volatility		**0.036** **(2.035)**		
CME housing futures		**-0.126** **(-6.044)**		
Homebuilder returns		**4.619** **(4.278)**		
D*ABX duration		**-159.243** **(-8.229)**		
D*RPX house prices		0.010 (1.600)		
D*RPX 20–day vola		**-0.183** **(-5.319)**		
D*CME housing futures		**0.488** **(6.644)**		
D*Homebuilder returns		**8.608** **(4.672)**		
RAT*ABX duration		**-0.392** **(-3.643)**		
RAT*RPX house prices		**-0.004** **(-2.983)**		
RAT*RPX 20–day vola		**0.041** **(5.016)**		
RAT*CME housing futures		**0.063** **(2.310)**		
RAT*Homebuilder returns		*-0.789* *(-1.707)*		

Table 8: continued				
Variable	Coefficient (t-value)			
	Housing (data releases)	**Housing (market indicators)**	**Interest rates**	**Risk appetite & Liquidity**
Interest rates			**9.585** **(6.390)**	
Yield curve slope			**2.908** **(4.813)**	
D*Interest rates			**-9.540** **(-5.937)**	
D*Yield curve slope			**-5.212** **(-5.660)**	
RAT*Interest rates			0.242 (1.340)	
RAT*Yield curve slope			**0.323** **(8.373)**	
VIX volatility ratio				**-0.727** **(-3.935)**
Swap spreads				**-25.337** **(-4.902)**
CDX bid–ask spreads				**-0.370** **(-3.337)**
D*VIX volatility ratio				0.285 (0.945)
D*Swap spreads				3.960 (0.970)
D*CDX bid–ask spreads				**-0.794** **(-5.342)**
RAT*VIX volatility ratio				**-0.138** **(-2.901)**
RAT*Swap spreads				0.283 (1.139)
RAT*CDX bid–ask spreads				**0.033** **(2.294)**
R-squared	0.0363	0.1752	0.0399	0.1084

[1] Sample (adjusted): 20 July 2006 to 10 June 2008; the crisis dummy is set at 1.0 from 9 August 2007 through the end of the sample; the setup includes a constant and time trend that are not reported. [2] Bolded (italicised) values are significant at the 5 (10)% level.

Table 9: Regression results for ABX 06-1 and 06-2

Pooled OLS with cross-sectional fixed effects and White period-robust standard errors[1,2,3]

Variable	Coefficient (t-value)		
	Variable	Interaction with crisis dummy	Interaction with ABX 06–X rating changes
Nonfarm payrolls	**0.009**		
	(4.101)		
Mortgage applications	**0.002**		
	(2.336)		
Building permits	**0.005**		
	(3.368)		
Banking sector leverage	**0.021**		
	(4.255)		
ABX 06–1 rating changes	**-0.063**		
	(-3.598)		
ABX 06–2 rating changes	**0.064**		
	(4.667)		
ABX 06–X delinquencies	**-0.415**		
	(-5.109)		
ABX duration	**-2.275**	**-140.327**	0.173
	(-4.075)	**(-8.205)**	(1.029)
RPX house prices	0.005	*0.010*	**-0.006**
	(1.140)	*(1.684)*	**(-3.480)**
RPX 20–day volatility	**0.055**	**-0.242**	**0.082**
	(2.634)	**(-5.690)**	**(6.014)**
Case-Shiller house prices	**0.002**		
	(6.602)		
CME housing futures	**-0.071**	**0.382**	**0.206**
	(-3.817)	**(5.626)**	**(4.766)**
Homebuilder returns	**1.720**	**8.483**	**-0.979**
	(3.028)	**(4.811)**	**(-2.419)**
Interest rates	**11.213**	**-10.230**	*0.416*
	(6.131)	**(-5.060)**	*(1.808)*
Yield curve slope	**2.806**	**-2.150**	**0.477**
	(4.911)	**(-3.488)**	**(4.540)**
VIX volatility ratio	**-0.417**	0.014	-0.044
	(-4.026)	(0.060)	(-0.407)
Swap spreads	**-18.560**	-0.919	0.401
	(-4.649)	(-0.314)	(1.145)
CDX bid–ask spreads	**-0.395**	**-0.746**	**0.095**
	(-3.263)	**(-4.779)**	**(4.925)**

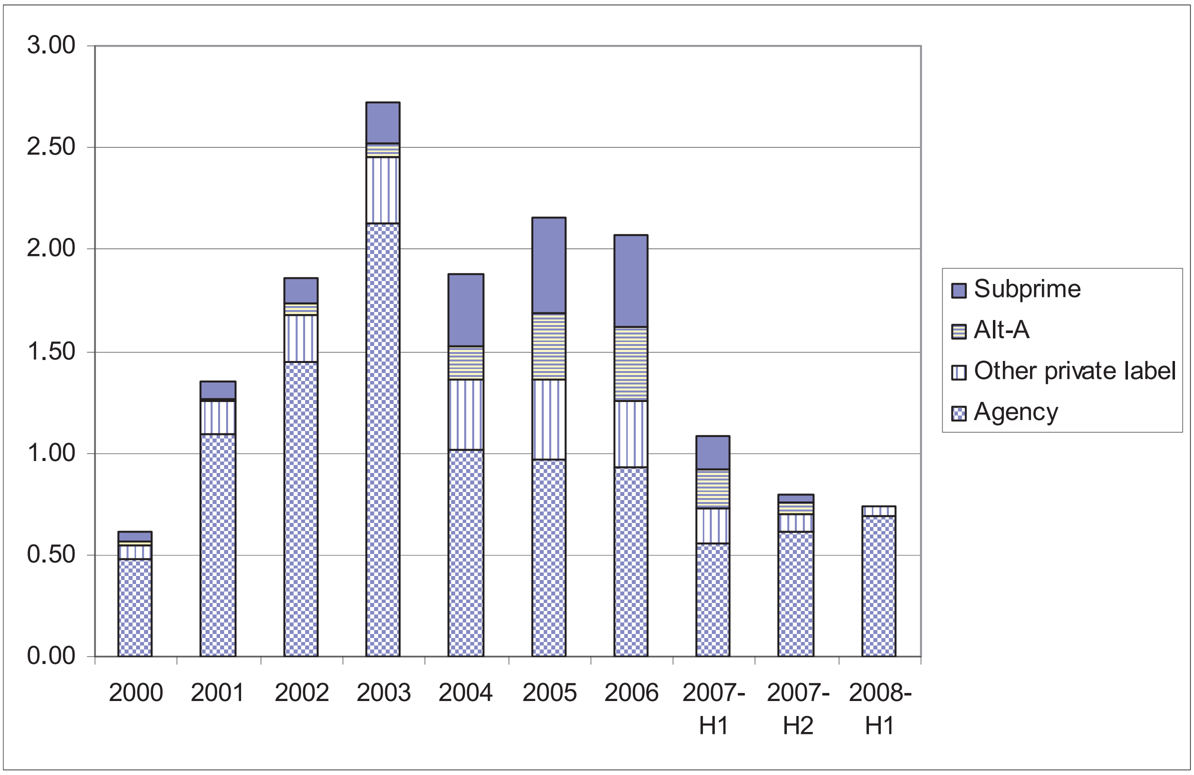
[1] Sample (adjusted): 20 July 2006 to 10 June 2008; the crisis dummy is set at 1.0 from 9 August 2007 through the end of the sample; the setup includes a constant and time trend that are not reported. [2] Bolded (italicised) values are significant at the 5 (10)% level. [2] The adjusted R–squared is 24.1 per cent.

Table 10: Factor analysis

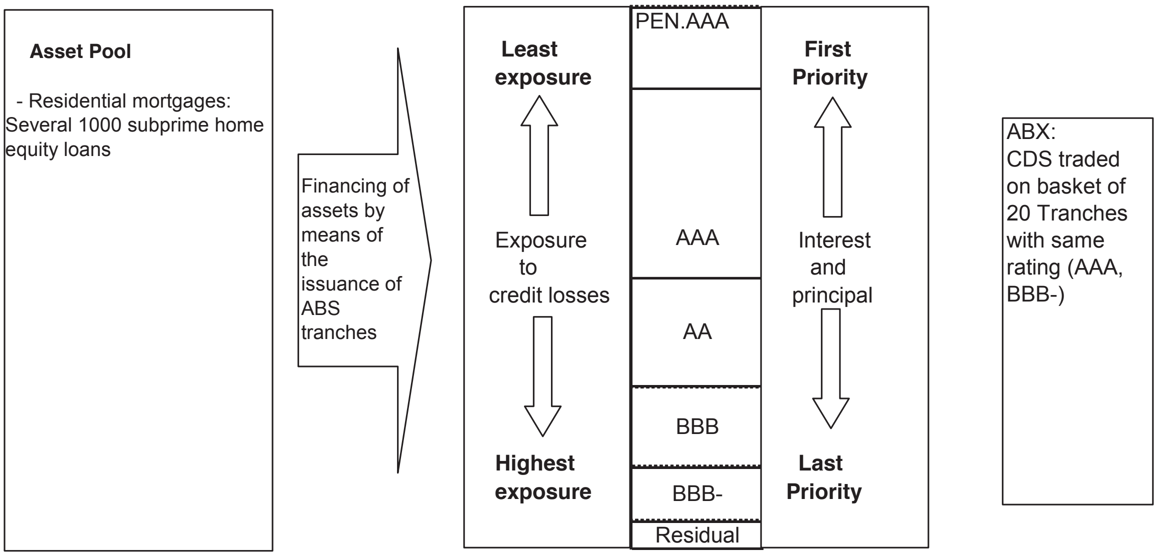
Factor decompsition

Factor	Variance	Cumulative	Difference	Proportion	Cumulative
F1_RESID2006_1	2.108	2.108	0.427	0.556	0.556
F2_RESID2006_1	1.681	3.789	---	0.444	1.000
Total RESID2006_1	3.789	5.897		1.000	
F1_RESID2006_2	2.076	2.076	0.787	0.617	0.617
F2_RESID2006_2	1.289	3.364	---	0.383	1.000
Total RESID2006_2	3.364	5.440		1.000	
F1_RESID2006_ALL	3.369	3.369	0.216	0.455	0.455
F2_RESID2006_ALL	3.153	6.522	2.275	0.426	0.881
F3_RESID2006_ALL	0.879	7.401	---	0.119	1.000
Total RESID2006_ALL	7.401	17.291		1.000	

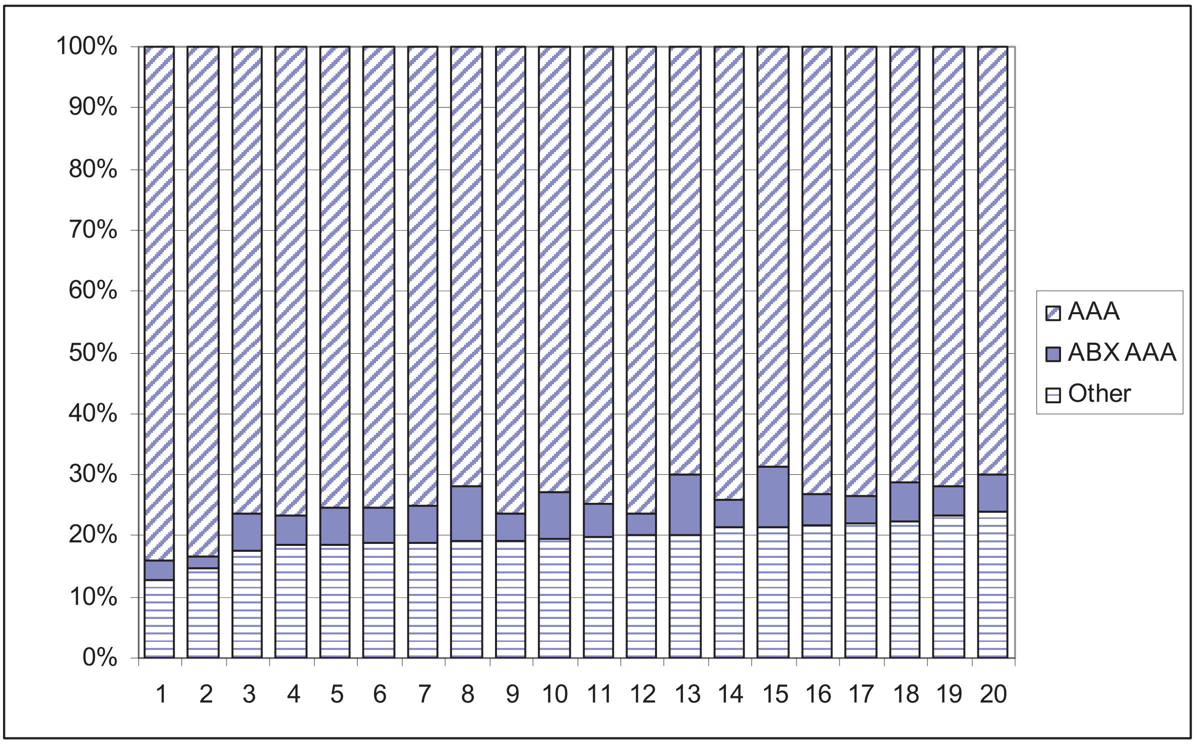
Graph 1: Issuance of subprime MBS (in trillions of US dollars)



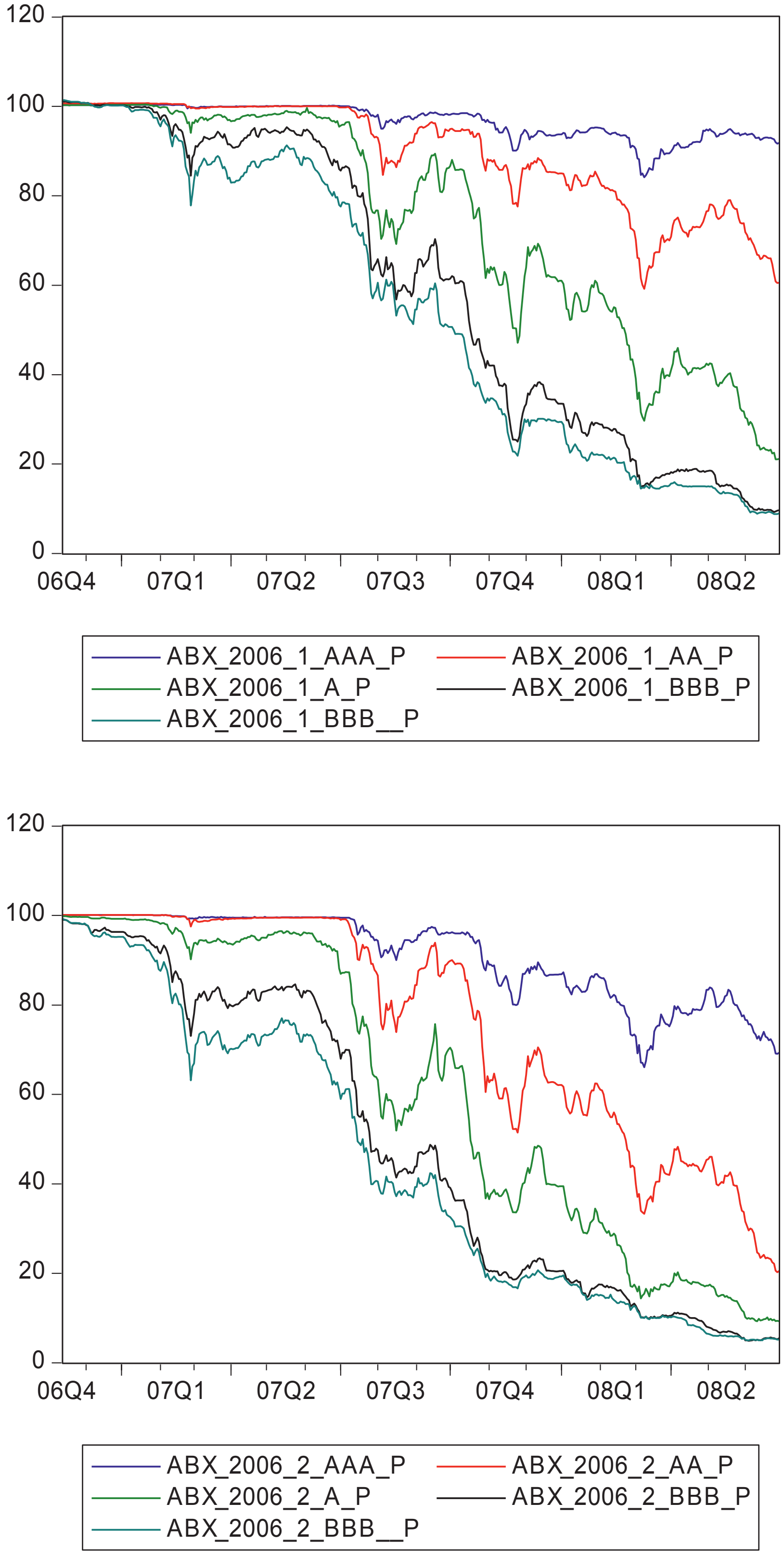
Graph 2a: Simplified structure of ABX contracts



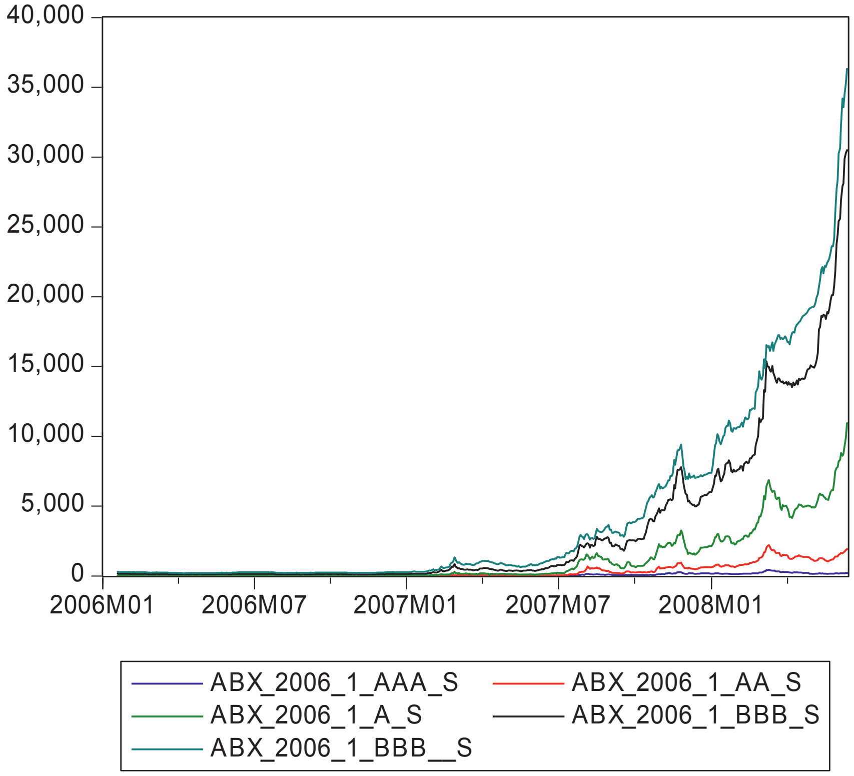
Graph 2b: Simplified capital structure of deals underlying the ABX 07-1 index (in % of outstanding balance at issuance)

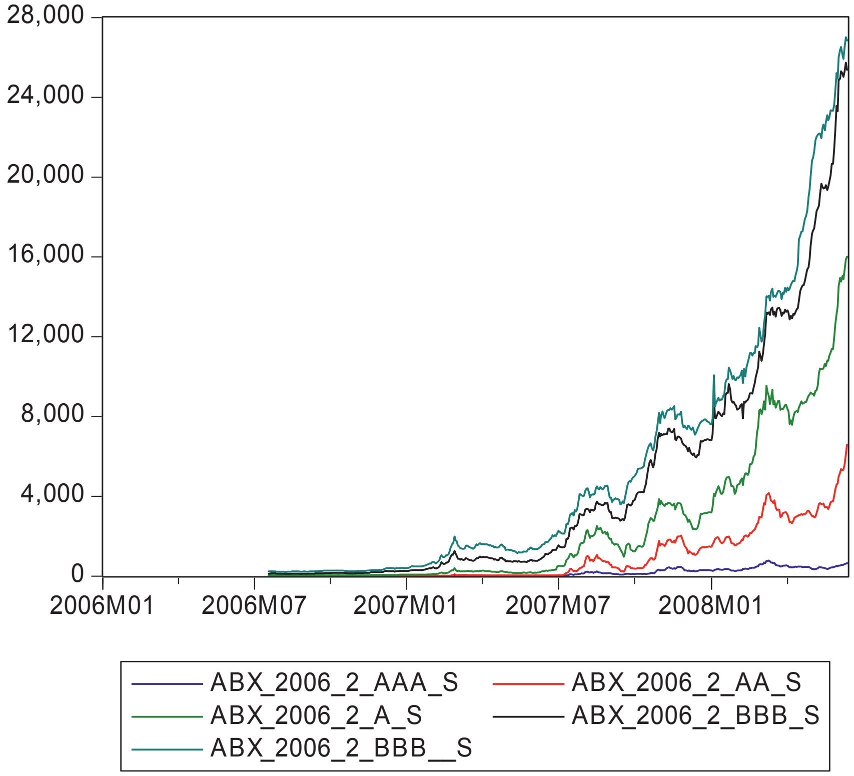


Graph 3a: Time series of ABX prices

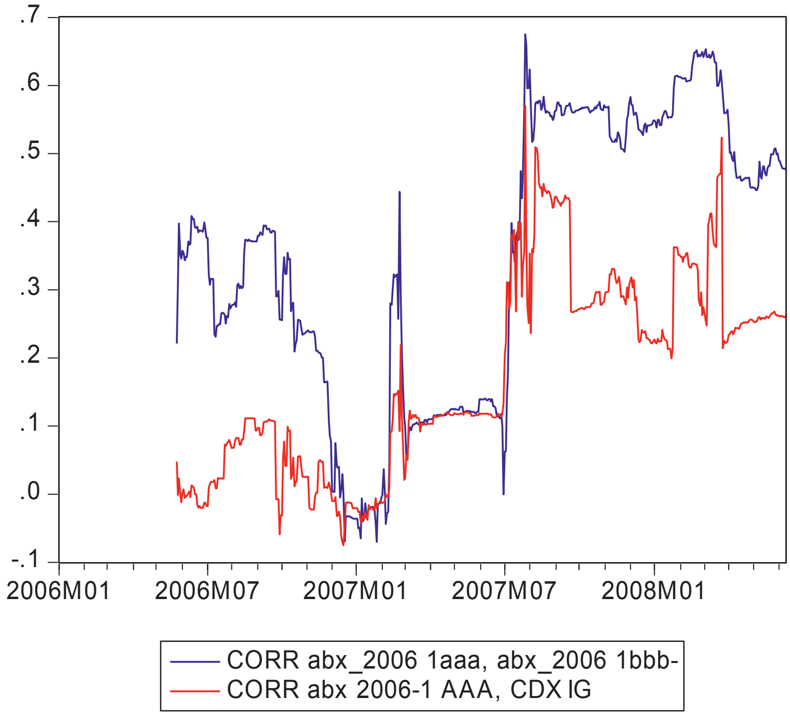


Graph 3b: Time series of ABX spreads

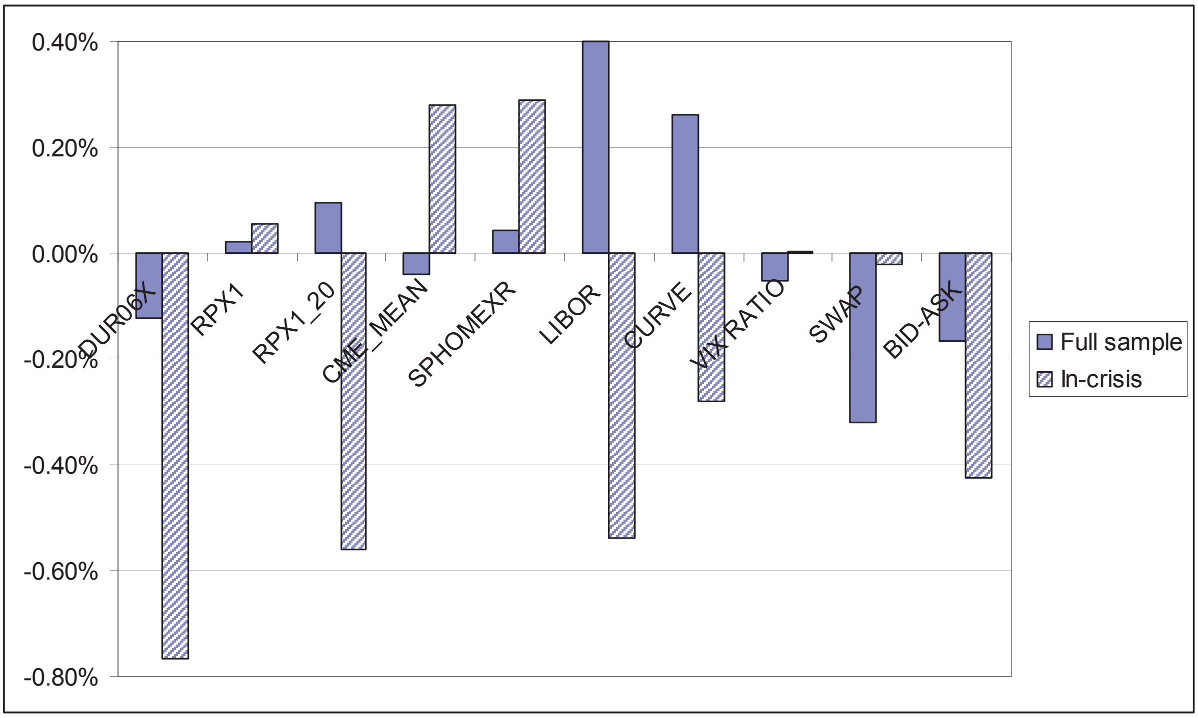




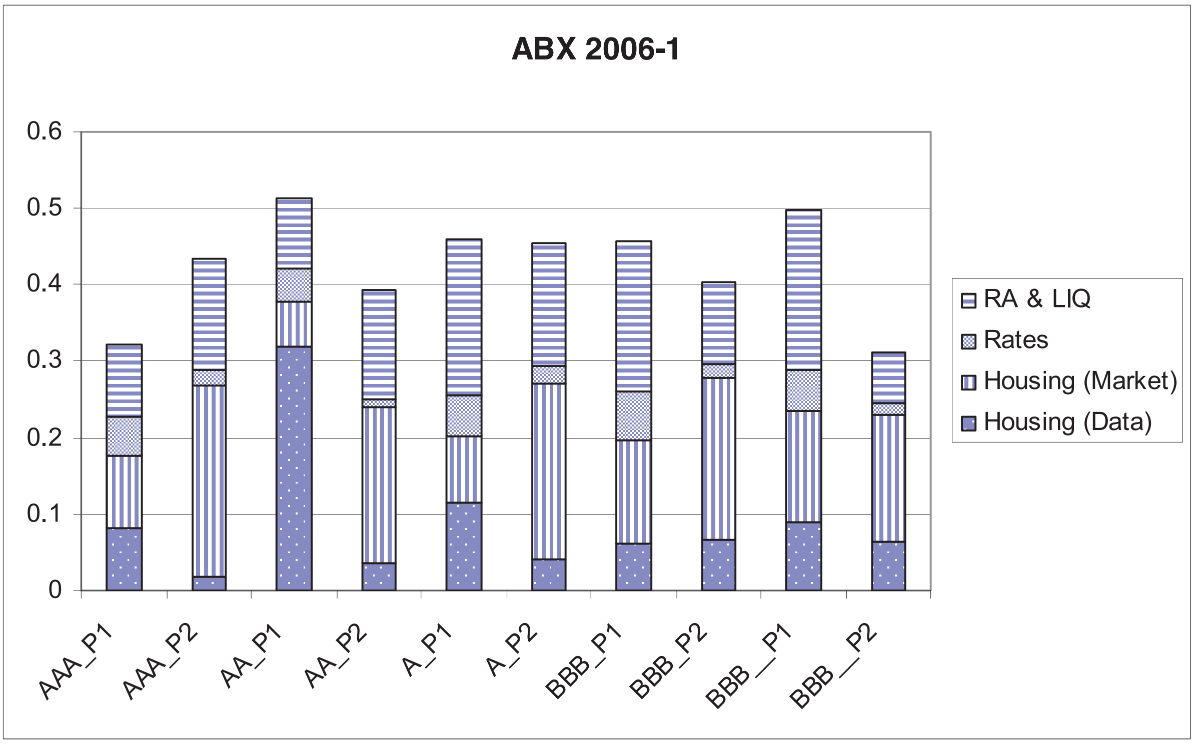
Graph 4: Observed index price correlations



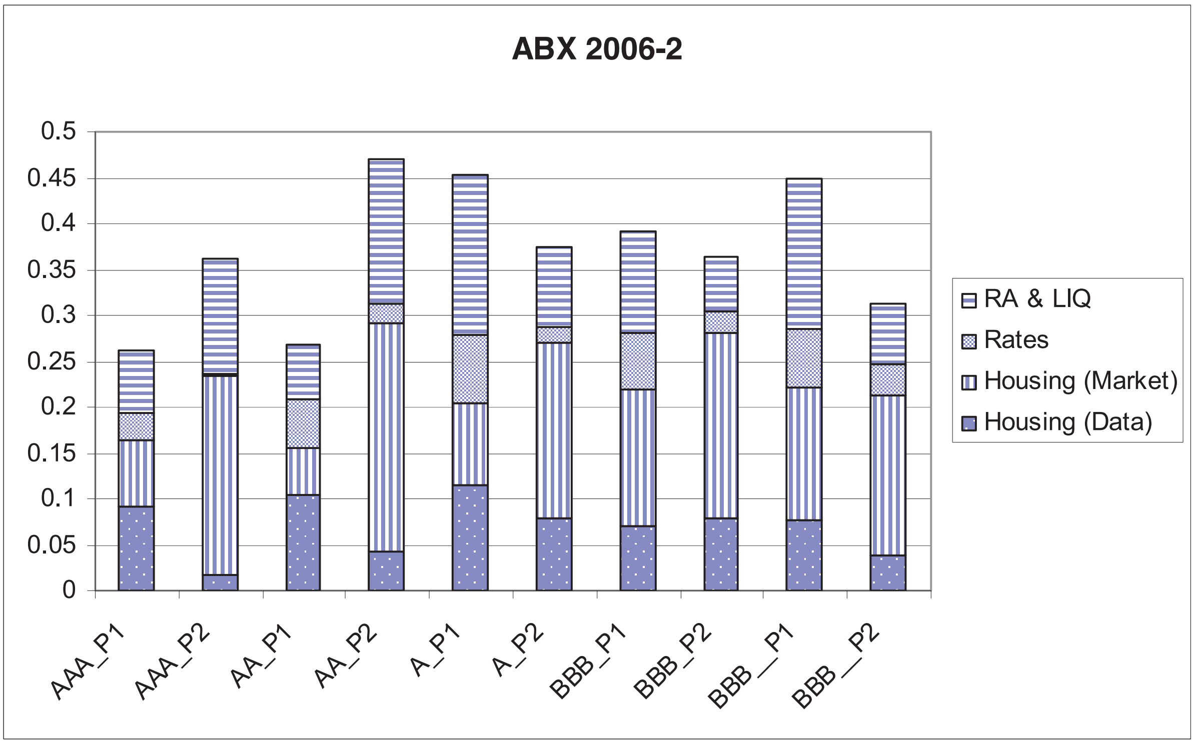
Graph 5: Impact of one-StdDev change in explanatory variables



Graph 6a: Block-wise R-squared estimates (ABX 2006-1)



Graph 6b: Block-wise R-squared estimates (ABX 2006-2)



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