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VALUE OF RISK-TAKING IN A MORTGAGE PORTFOLIO: A PERFECT FORESIGHT STUDY

Objectives and Formulation

Successful money managers constantly shift scarce research resources in search of performance alpha. One way to evaluate the potential value-added of various investment strategies is to employ the "perfect foresight" approach. The first step of this approach identifies investment skills relevant for a particular market. In most cases, these skills align with the important risk dimensions in the market. For example, in the corporate market, credit quality is a key risk factor, and credit analysis is a valuable skill. Once the risk and skill are identified, the portfolio is structured to profit from perfectly anticipated (hence, "perfect foresight") changes in the risk factor while maintaining neutrality to the benchmark along all other risk dimensions (*e.g.,* duration and sector). To compare results fairly, achieved outperformance is adjusted by the accompanying risk, defined as the variability of the portfolio's outperformance over the benchmark. A widely accepted measure of investment success is the *information ratio,* which is the mean of monthly outperformance divided by its standard deviation. This exercise is repeated for all identified skills and risk factors, and information ratios are compared. The results reveal the skill with the most potential for adding value.

Recently, we examined the relative value-added of different skills within the corporate market.[1] The benchmark (the Lehman Brothers Credit Index) was divided along term structure (*i.e.,* duration), sector, and quality. Then, for example, to measure the value of sector selection skill, we constructed a portfolio that matched benchmark allocations along term structure and quality but was invested solely in the best-performing sector. The perfect foresight to choose the best-performing sector was based on curve-adjusted excess returns over a particular horizon. We measured security selection skill by matching the portfolio to the benchmark along all three dimensions while investing in only the best-performing bonds. This corporate study demonstrated that the most effective way to outperform the benchmark was security selection, or a "bottom-up" investment style.

Mortgage investors are equally interested in evaluating different investment skills, so now we are exploring this issue within the mortgage market. The approach to this study, however, has to be somewhat different. Instead of dividing the index into cells (*e.g.*, low, par, and high coupons), we identify the three most important risk factors[2] affecting the mortgage market. The three factors we chose are realized volatility, spread movements, and prepayments. The majority of portfolio decisions that mortgage managers make revolve around these risk factors. Prepayment uncertainty leads managers to overweight current coupons. In anticipation of increased interest rate volatility, managers often reduce the negative convexity of their portfolios by staying away from the cusp. Thus, the first condition of successful portfolio decisions in the mortgage market is the managers' ability to forecast changes in these risk factors.

The second and equally important step is to structure a portfolio by appropriately adjusting its sensitivities to these risk factors. The sensitivities to the risk factors we use are, respectively, convexity, spread duration, and prepayment duration (approximated by $\delta P/\delta PSA$[3]). The link between correctly anticipated risk factor changes and the correct portfolio restructuring response may not be as straightforward as it is in the corporate market and merits a separate investigation.

As a consequence, we pose the following questions:

- Assuming perfect foresight, how much value (defined as outperformance of the Lehman MBS Index) can be gained from boosting a portfolio's sensitivity (exposure) to each

[1] L. Dynkin, P. Ferket, J. Hyman, E. van Leeuwen and W. Wu, *Value of Security Selection versus Asset Allocation in Credit Markets: A Perfect Foresight Study*, The Journal of Portfolio Management, Vol. 25 No. 4, Summer 1999 and L. Dynkin, J. Hyman and W. Wu, *Value of Security Selection versus Asset Allocation in Credit Markets: Part II—An "Imperfect Foresight" Study,* The Journal of Portfolio Management, Vol. 27 No. 1, Fall 2000

[2] The conclusion about relative importance was based on the comparison of explanatory power of various risk factors, presented in A. Arora, D. Heike, and R. Mattu, *Risk and Return in the Mortgage Market: Review and Outlook*, The Journal of Fixed Income, Vol. 10 No. 1, Summer 2000

[3] In this measure, PSA represents the *yield-equivalent* prepayment speed, i.e., a constant prepayment level at which the static PSA model produces the same yield as the prepayment model using zero-volatility assumption.

one of the three main risk factors while staying neutral in the other two? In this case, perfect foresight is based simply on the known outcomes. Here we are not concerned with the link between correctly predicting market risk factors and making correct sensitivity adjustments, but investigate relative merits of creating maximum achievable isolated exposures to one risk factor at a time.

- How much outperformance can be gained from successful relative value choices when the portfolio is matched to the index in the three main risk dimensions? Perfect foresight, in this case, is based on the known excess return of each security in the MBS Index. We realize that among the sources of this excess return are both non-systematic factors that would merit the term "security selection," and certain systematic risks other than the three factors we control for.

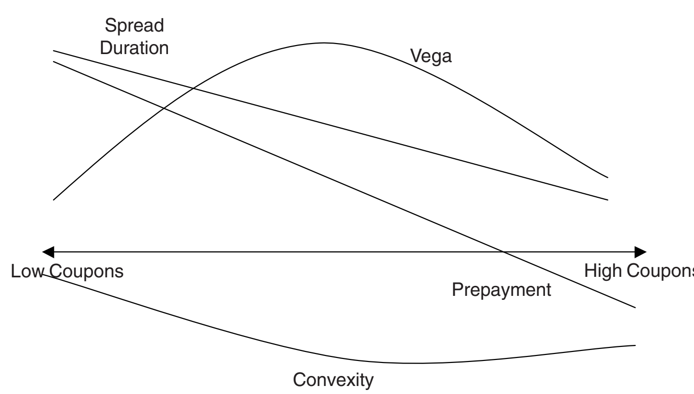
In this report, we do not address the important question of how the manager can profit from a correct view on upcoming risk factor changes. How easy is it to take advantage of even perfect knowledge of the future market moves? In other words, how reliable are the common truths in mortgage portfolio management? For example, if the manager correctly anticipates a mortgage spread tightening, will a portfolio that is long spread duration relative to the index necessarily outperform? Performance in this, more realistic, case is likely to be below that achieved under "direct" perfect foresight of performance outcomes of portfolios containing various exposures. This issue will become a subject for the next stage of the study.

Methodology and Data

The straightforward technique employed in the corporate studies of dividing the benchmark into cells is not easily applicable for mortgages. The corporate cells (buckets) are "orthogonal," or independent from each other in the sense that it is easy to invest in any one of them at a time, and so to construct a portfolio that matches the benchmark along all dimensions but one. In the mortgage market, the risk factors are interrelated. Figure 1 provides a stylized illustration of this interdependence. For example, a security with low spread duration is likely to have a high coupon (to be a premium). In turn, this means that it is also likely to have low prepayment duration. As a result, it is not obvious how to construct a portfolio with spread duration significantly higher than the benchmark but perfectly matched to it in terms of prepayment sensitivity. In fact, any method of isolating one risk exposure while neutralizing all the others will meet with difficulties and can have only limited success. One could break down the mortgage index along such dimensions as pricing tiers, seasoning, and mortgage sector (GNMA 30-year, conventional 30-year, 15-year). Yet an attempt to concentrate the portfolio in premiums, for example, while matching the index seasoning and sector distributions would fail in months in which the index was dominated by discounts. A concentration in seasoned paper would make it impossible on many occasions to match the index coupon distribution, and so on.

As a result, we had to look beyond the simple "manual" breakdown and search for other means of isolating individual risk exposures. We chose to use linear optimization to achieve the maximum possible exposure to one risk factor while maintaining the best possible (never perfect) neutrality to the others. The "bet-factor" sensitivity is constrained to the index value plus or minus the maximum bias (bet) that would still yield a solution. The other two (non-bet factors) sensitivities are constrained to the index levels with certain tolerances that allow a solution to be found. Both the maximum bets and tolerances for the neutral variables had to be found by an extensive trial-and-error process. Besides the three main risk sensitivities, we imposed additional constraints on the portfolio's overall price, coupon, and Treasury duration to make sure the solution portfolio does not significantly deviate from the index in any important dimension. Tolerances for these additional constraints also had to be

Figure 1. **Risk Sensitivities as a Function of Coupon in the MBS Market**



determined empirically. Finally, we constrained contributions to spread duration from 30-year and 15-year mortgages to match the index levels. Figure 2 summarizes the constraints and tolerances used in the study.

The objective function in this setup plays a subordinate role, with constraints being both the means and the end. We chose to maximize liquidity (amount outstanding) to make the solution portfolios represent the most realistic and easy-to-implement strategies.

The linear optimizer faced, of course, the same fundamental problem of interdependence of risk sensitivities in pass-through mortgage securities. It was just "better equipped" for dealing with it. In every month, to find the maximum achievable exposure for each risk variable, the process first attempted to find a solution using a relatively high setting (bet). The initial bet was chosen such that in most cases, the first attempt would fail. Then the optimizer went through iterations gradually reducing the bet until a solution was found. We anticipated that the way to solve this problem would be to use relatively few securities to create a portfolio with a difficult-to-achieve risk profile. This insight was confirmed. Attempts to force greater diversification by setting relatively low maximum per-security allocation limits prevented the process from finding a solution. In the end, the limit of 10% was used, ensuring that the portfolio will have the minimum of ten securities. In fact, the number of securities in the solution portfolios was between 12 and 16.

Figure 2. **Optimization Constraints**

Controlled Portfolio Sensitivities	**Index + Bet**	**Index Value**
Spread Duration (years)	±0.01	±0.05
Convexity	±0.01	±0.05
$\delta P/\delta PSA$*	±0.01	±0.05
Contribution to Spread Duration (years)		
30-year MBS		±0.05
15-year MBS		±0.05
Other Factors		
Price (in 100s)		±0.025
Coupon (%)		±0.025
OA Duration (years)		±0.05

* Change in price (in decimals) per unit change of PSA, scaled by 10000.

The small number of securities posed an additional problem of idiosyncratic influences on performance. To prevent what would essentially be security selection (or, even worse, occasional pricing errors) from tainting results, we restrict the investable universe (and the benchmark) to a highly liquid portion of the MBS Index. We imposed minimum liquidity thresholds of $1 billion on 30-year paper and $500 million on 15-year securities. In addition, we entirely excluded less-liquid segments of the index such as balloons, GNMA II, older Freddie Mac cash bonds, FNMA governments, and 20-year mortgages. These restrictions are summarized in Figure 3. This strict filtering eliminates more than half of the securities in the index but provides a reasonable assurance that results do indeed reflect the effects of risk positioning. At the same time, as Figure 3 shows, the reduction in market value was modest.

The methodology used for the security selection part of the study employed the same linear optimization process, with all variables constrained to the index values. In this setup, of course, one was assured of a solution (with the limiting case of buying the index), so very tight constraints were placed on all parameters (0.001). Unlike the risk sensitivities optimization setup, here the objective function played a critical role, determining the choice of securities. The process maximized the portfolio's next month excess return (reflecting perfect foresight) while maintaining a close match to the index along all

Figure 3. **Filtering Rules and Statistics**

Security Type Exclusions
All Balloons
All 20-Year MBS
All GNMA II
All FHLM Cash (non-Gold)
All FNMA Government

Liquidity Thresholds ($ million)

30-Year	1,000
15-Year	500

After-Filtering Statistics

	Issues Accepted	**% of Index MV Used**
Minimum:	152	80.2
Maximum:	228	90.9
Average:	195	86.6

risk dimensions. The minimum number of bonds was no longer a limiting factor. This allowed us to produce and compare results at varying diversification levels. In the next section, we present results obtained in both the risk sensitivities and security selection parts of the study.

Results

Risk Sensitivities

We define perfect foresight as knowledge of performance outcomes from various risk exposures relative to the benchmark. Each month, for each risk sensitivity, we calculate the next-month's performance for the following three portfolios: one with the maximum achievable positive risk exposure bet, one with the maximum achievable negative bet, and one that is neutral to the benchmark (the index return).

Figure 4 summarizes the performance for strategies based on risk sensitivities. Contrary to what one might expect, the index is not outperformed by one of the bet portfolios every month. As the figure shows, in some months both underperform, in which case we assume that the strategy earns the index return (thus both the minimum bet level and the minimum outperformance are zero). The number of such months ranges from 18 for the spread duration bets portfolios to as high as 29 for the prepayment bets portfolios. One reason for the relatively frequent underperformance of both positive and negative exposure portfolios is the presence of other systematic risk factors (*e.g.*, vega) that the strategy does not control for. The other is idiosyncratic risk that is not diversified away sufficiently in portfolios of only about 14 issues.

The number of months in which bet-containing portfolios outperformed is split roughly equally between positive and negative bets. From this, we conclude that over the eight-year period covered by this study, there were no systematic advantages in taking either a positive or negative exposure to the three risk factors. The average absolute bet sizes are significantly below the maximums in all three cases, which confirms the difficulty of isolating one risk exposure at a time. Another important conclusion is that to the extent that isolated risk exposures are possible in mortgage portfolios, their respective value-added potentials are approximately equal, in terms of both average outperformance and volatility. The three information ratios fall within a very narrow range of 2.61 to 2.74, showing no material advantage of any particular strategy.

Security Selection

Figure 5 summarizes results for the security selection strategy at three different minimum-diversification levels. Each month, the linear optimization process constructs a new portfolio that matches the index precisely along all systematic risk dimensions and, using perfect foresight, maximizes the next-month curve-adjusted return. As in the risk sensitivities-based strategies, there is no attempt at measuring or constraining turnover (or accounting for transaction costs). The solution portfolios were not supposed to represent feasible investment strategies.

The number of securities in the liquid benchmark used in this study ranged from 152 to 228, averaging 195 over the study period (Figure 3). Thus, on average, the portfolios constructed with the 10-, 25-, and 50-bond minimum constraints compose, respectively, 7.4%, 15.0%, and 27.7% of the benchmark issues.

Figure 4. **Results: Portfolio Sensitivities**, February 1993-December 2000

	Spread Duration		Convexity		$\delta P/\delta PSA$	
	Bet Size (abs value)	**Outperf.** (bp)	**Bet Size** (abs value)	**Outperf.** (bp)	**Bet Size** (abs value)	**Outperf.** (bp)
Average:	0.21	4	0.38	4	0.15	3
Maximum:	0.40	39	0.60	36	0.35	26
Standard Deviation:		6		5		4
# of “No-Bet” Months:	18		25		29	
# of Negative Bets:	43		28		31	
# of Positive Bets:	34		42		35	
(Total = 95 Months)						
Ann. Info. Ratio:		**2.74**		**2.68**		**2.61**

Figure 5. **Results: Security Selection**, February 1993-December 2000

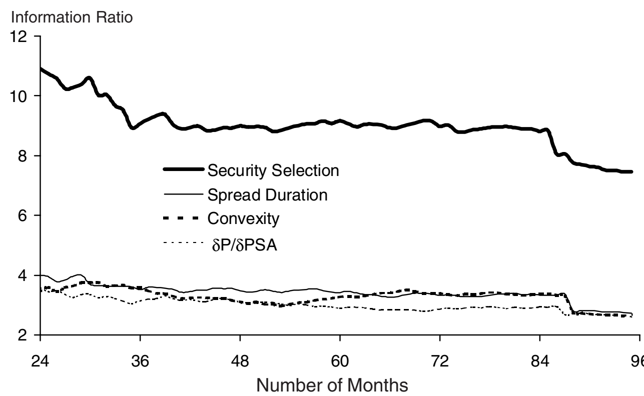
	10 Bonds Min		25 Bonds Min		50 Bonds Min	
	# Issues	**Outperf.**	**# Issues**	**Outperf.**	**# Issues**	**Outperf.**
Monthly:		(bp)		(bp)		(bp)
Average	14	16	29	13	54	10
Minimum	12	3	27	3	52	3
Maximum	16	50	31	40	56	27
Standard Deviation		8		6		4
Ann. Inf. Ratio:		**6.88**		**7.09**		**7.46**

The relative pattern of outperformance for the three levels confirms our expectations that more diversified portfolios would achieve a higher information ratio. Indeed, while the average outperformance declines as more securities are added, the risk reduction outpaces this decline, leading to higher risk-adjusted performance.

To build confidence in the information ratios produced by this study (both for security selection and risk sensitivities), we examine how stable they are over time. Stability of a strategy's information ratio is usually reliable evidence that a true phenomenon, rather than a chance outcome, is being observed. Figure 6 plots information ratios for all four strategies (security selection is represented by the 50-bonds case) over a steadily increasing time frame beginning at 24 months and ending at the 95 months that encompass the whole study period. The figure shows that the information ratios are sufficiently stable, giving us confidence in our conclusions.

Most important, the results presented in Figure 5 indicate that, just as was the case in the corporate market, correct relative value choices (security selection) hold significantly more potential for outperformance than taking systematic risk exposures. Clearly, the nature of these choices in the mortgage market is very different. Unlike the extremely diverse corporate market, mortgage passthroughs have essentially no idiosyncratic (event) risk. Relative value choices are based not on individual credit stories but rather on picking a particular coupon among a few in a relatively narrow range (thus identical from the systematic risk perspective), or preferring a GNMA versus the same-coupon FNMA. A good example can be found if we take a closer look at the dip in the security selection information ratio line in Figure 6.

Figure 6. **Dynamics of Information Ratios**
February 1993-December 2000



This sudden drop was caused by an unusually *large* outperformance (50 bp) over the benchmark in March 2000 (note that when performance is measured on a risk-adjusted basis positive spikes can actually hurt the information ratio, as the spike contributes more to risk than it does to the average outperformance). In that month, GNMAs experienced much larger excess returns than conventionals. With the benefit of perfect foresight, the portfolio was heavily overweighted (89%) in GNMA and outperformed the index.

Conclusions and Further Research

Results of this study suggest that the most valuable skill for mortgage investing is security selection within a portfolio whose systematic risk sensitivities match the benchmark. Skills at correctly positioning the portfolio with respect to spread duration, convexity, or prepayment duration are roughly comparable among themselves but seem to be less valuable than that of security selection. Interestingly, these results mirror those of the corporate bond perfect foresight study.

There are a number of caveats to these results. First, the difficulty of constructing portfolios with exposure to one risk sensitivity while being neutral to the other two indicates that managers either must use non-index securities in their portfolios (*e.g.*, agency issues with positive spread duration and convexity and zero prepayment duration) or take a combination of bets at any given time. Consequently, we may wish to explore whether skill with respect to a combination of risk sensitivities might produce better information ratios.

Second, while security selection is clear in the corporate world, what does security selection mean in the mortgage market? Once all of the risk factors are accounted for, why would some mortgage securities outperform others? Perhaps there is a "political risk factor" priced into the GNMA-conventional spread that a manager skillful in security selection can exploit. Perhaps a "liquidity risk" priced into the 30-year–15-year spread or the FNMA–FHLMC spread? It will be informative to explore the sources of security selection skill.

Third, there may be other mortgage risk factors we have overlooked. One missing factor is changes to implied volatility that affect a portfolio according to its vega. Unfortunately, we had to omit vega, as a complete data set was not available. The relative performance of the three risk factors may have reflected embedded vega positions. For example, if the manager chose to maximize the negative convexity by overweighting cusp coupons, this would have produced a portfolio with the highest vega (Figure 1). Depending on how realized and implied volatilities move relative to each other, this may taint the results for convexity skill.

Finally, so far, this study has assumed perfect foresight of performance of various risk exposures. In other words, the investor correctly over- or underweights his portfolio's risk exposures knowing in advance which will produce a better return. But in reality, managers make bets depending on their forecasts regarding changes in mortgage risk factors. The next part of the study will investigate just how profitable knowledge of changes in mortgage risk factors is in structuring a mortgage portfolio.

The difficulty will be in defining rules to translate signals indicating changes in mortgage risk factors into portfolio risk sensitivities. For example, if a large change in the mortgage par coupon rate (*i.e.,* high realized volatility) is expected over the next month, then the manager might reduce the negative convexity of the portfolio relative to the benchmark. But suppose realized volatility has increased over the past few months as the par coupon mortgage rate declined rapidly. The manager correctly anticipated this and reduced the negative convexity of the portfolio. Now, looking ahead to the next month, the manager accurately predicts a large *increase* in the par coupon mortgage rate. While realized volatility (as measured by the change in the par coupon mortgage rate) remains high and could possibly increase, the manager may choose not to maintain his low negative convexity risk exposure. Instead, the manager might view the abrupt reversal in rates as a signal of a forthcoming range-bound rate environment in which negatively convex mortgages will be more attractive. As a next step, we plan to search for profitable translations of market risk factor signals into portfolio risk sensitivities.