“If you know the enemy and know yourself, you need not fear the result of a hundred battles. If you know yourself but not the enemy, for every victory gained you will also suffer a defeat. If you know neither the enemy nor yourself, you will succumb in every battle.”

— Sun Tzu, The Art of War. 6th century BC

Interest rate volatility can cause significant anguish and distress to fixed income managers and investors. As interest rates fluctuate over time, yields and returns can change dramatically, creating uncertainty. Since the mid-70’s duration and its derivatives have been universally used to evaluate risk on fixed income. In particular, effective duration, or the sensitivity of a bond’s price to changes in interest rates, has commonly been used to judge the amount of interest rate risk that a particular bond or portfolio is exposed to. While effective duration does give good insight to yield curve positioning, it lacks the breakdown necessary to measure and analyze conscious interest rate bets. As effective duration makes the assumption that interest rates are shifting on a parallel basis, one may ask how to look at risk from non-parallel term structure shifts, which are usually the case in fixed income environments. One answer is Key Rate duration.

Key rate duration is defined as the measure of interest rate sensitivity of a security or portfolio to specific key rates on the yield curve, holding all maturities constant. Yield curves typically go through stages that involve steepening, leveling, and curvature, creating an environment that requires specific data to analyze risk properly. Steepening would imply short-term interest rates shifting more than long rates, level movements mimic a parallel shift, and curvature would imply short rates falling and mid to long rates increasing, creating a protrusion within the yield curve. As yield curves experience shifts that are not parallel, a more in-depth risk tool that brings the true risk of cash flow volatility to light becomes essential. Unless the portfolio and benchmark hold only zero coupon bonds, for which the duration equals the maturity, key rate duration is essential in determining interest rate differentials. This analysis becomes indispensable for managers and investors that are passive to an index and need to determine any mismatches in their portfolio relative to an index. In conjunction with such complimentary tools such as Value at Risk (VaR) and the dollar value of one basis point (DV01), key rate duration offers managers a means to examine their risk exposures. In our opinion, key rate duration also provides an excellent source of information for plan sponsors in determining what type of risks their managers are taking against their respective index.

Plan sponsors can use such data to understand the active risks their managers have undertaken and determine their suitability for the totality of the plan. Sponsors can use this information to help them understand why a specific manager has over- or under-performed
their relative index, while maintaining similar, if not the same, total fund risk profile of the index. Key rate risk is especially important to defined benefit pension plans that rely heavily on liability driven investing (LDI) to ensure that their assets can meet obligations to their beneficiaries over time. According to the Pension Management Research Panel, as of November 2009, approximately 54% of pensions being polled used an LDI strategy to assist in minimizing the year-to-year volatility of their funding status\(^1\). In an LDI strategy, in which plan sponsors attempt to match the plan’s cash flows with those of their liability streams, larger funds may have long-term obligations that are subject to considerable changes in interest rates. These risk measures are also important for client bases such as Central Banks who employ external managers to manage sovereign assets and are passive to strategies employed through the country’s prospective investment policy statement (IPS). Ultimately, such measures can help spur dialogue with managers about the sources of relative returns.

**KEY NODES**

Being able to differentiate risk into multiple key rates allows analysts to better understand risk relative to their benchmark and to prevent any unnecessary mismatches in the underlying duration of the portfolio’s maturity buckets. Typically, key rate durations are measured along eleven key rates along the spectrum: 3 months, and 1, 2, 3, 5, 7, 10, 15, 20, 25, and 30 years. However, any key rates along the yield curve may be used to compute the key rate duration of a portfolio. The points that are chosen along the curve drive the analysis, since the impact of the change in interest rates will be the most volatile further down the maturity spectrum. The key nodes that are selected also encompass the risk that is derived by the surrounding nodes if maturity ranges are aggregated together. For instance, if a portfolio contains securities that correspond to all eleven relevant nodes, but the analysis only calls for the 3, 7, and 10 year buckets, the risk decomposition will look a lot different than if all eleven nodes were analyzed. This is due to duration bucketing, which would place the 0-3 term structure risk at the 3 year node, the 3-7 year risk at the 7 year node, etc. When maturity limitations are set in key rate duration, securities with similar volatilities will most likely be bucketed together as they display similar properties. The ability to identify different shifts along key rates will provide portfolio managers and asset owners with adequate tools to perform fixed income strategies such as hedging and immunization\(^2\). Such strategies require more information and data than that which the more conventional effective duration and convexity measures may offer. Plan sponsors tend to diversify their fixed income holdings into buckets such as short-term, core, and long duration to smooth out the volatility of interest rate movements. If an investor’s intent is to negate partial or all interest rate exposure, it is necessary to determine the underlying effects of different key nodes and how they contribute to their fund’s risk profile.

By definition, key rate duration measures the impact that a change in rates will have, varying across individual nodes. As term structure shifts occur, the measurement of each individual piece is calculated and approximated through linear interpolation of the specific shift. This statistical measure is used to break down each node shift individually, creating an analysis that focuses on the underlying term structure shift.

---

\(^1\) SEI Institutional Solutions: Pension Research Management Research Panel. November 2009

\(^2\) Thomas S.Y. Ho. Key Rate Durations: Measures of Interest Rate Risks; September 1992
Exhibit 1

As depicted in Exhibit 1, each key rate contribution is measured in terms of interest rate shifts before and after the node. There is a linear movement between each key node, representing a minimum and maximum risk contribution per key rate. For example, if we look at the 2, 5, and 10 year nodes, we can determine that the risk contribution is computed in a linear manner. For the 5 year node, the contribution begins at the 2 year, maximizes at the 5 year, and diminishes to zero at the 10 year. This ensures that each key rate has its own contribution and the total of all of the key rate durations will sum up to the portfolio’s effective duration. This analysis assumes that there is no change in spot rates before and after each key rate, leaving the results independent of changes in other key node shifts. The added value of the independent shift is that it captures the true curvature of the yield curve before and after the shift, keeping the term structure spread intact. This assumes the peak of the shift occurs directly at the median of each key rate, starting with the lowest point at the beginning of the node and diminishing to zero at the end of the node. The same assumption can be inferred pertaining to the price of a portfolio of fixed income instruments, in which the incremental bond price shifts within each key node will approximate the total price movement of the fund. By doing so, we measure the effective duration by key rate and not by an overall parallel shift in the yield curve. The process by which key rate duration is market weighted is dependant on the DV01 of the underlying key rate, since the effective duration of the node is a product of a one basis point shift. Due to key rate duration carrying market-weighted risk properties, it can be concluded that active risk incurred throughout the fund is allocated according to its impact on the totality of the plan.

DERIVING KEY RATES

To better display this data, we have constructed a hypothetical U.S. Treasury portfolio with an effective duration of 3.20, and compared the volatility of cash flows with that of the U.S. portion of the Barclays Global Treasury Index, excluding maturities over 7 years (effective duration of 3.20). While the total effective duration of both the portfolio and benchmark is relatively identical, understanding what lies beneath the surface is critical.

3 Thomas S.Y. Ho. Key Rate Durations: Measures of Interest Rate Risks; September 1992
Exhibit 2

In Exhibit 2, the manager has chosen to underweight securities in the two to three year bucket. Meanwhile, the manager has chosen to overweight intermediate term structure risk, with the largest deviations (active risk) at the 7 year key rate. In a scenario involving yield curve steepening, in which intermediate to long-term interest rate increases, the portfolio would come under significant pressure relative to the benchmark due to more active risk being absorbed by the manager’s position on the curve. This would result in underperformance relative to the benchmark. From an allocation perspective, this chart displays the risk allocation of the fund, concluding that the portfolio’s risk composition has a weight of almost 90% in the 5 and 7 year key rate, while the benchmark only has a weight of 79%, creating an active risk allocation of approximately 11%. This analysis would be helpful in determining different interest rate movements along the yield curve and how the total fund could be impacted. As we can see from Exhibit 2, although the portfolio mirrors the benchmark’s total risk profile, the mechanics of the portfolio are quite different from that of the benchmark in the underlying positions. The added value of this analysis is that the key rate duration model incorporates multiple market factors, producing results that are more realistic to the current market and not a static term structure model, such as specific basis point interest rate shock. The level of data that is provided can be used in conjunction with various attribution models to identify sources of relative returns, yield curve positioning being typically more prominent⁴. If we were to examine a long-duration equally allocated basket of coupon-paying treasuries, it would be found that there are larger key rate duration contributions at key nodes closest to their respective maturities. This infers that the individual coupon payments paid at longer dated points carry a higher duration, but less present value. Due to the nature of evaluating key rate risk, when adding more complex

⁴ Thomas S.Y. Ho. Key Rate Durations: Measures of Interest Rate Risks; September 1992

JPMorgan
securities, such as mortgage-backed securities (MBS), the analysis can become a lot more cumbersome to fully understand. Although this reverts to complex calculations of duration pertaining to prepayment speeds and their impact on a security’s effective duration, the impact will roll into each individual key node’s contribution amount. Risk levels depend on how the mortgage-backed security was designed, as a front-loaded mortgage would imply heavier interest rate risk on the shorter end of the curve, while a back loaded mortgage would carry significantly more risk towards its maturity. Depending on the portfolio’s composition, various instruments can carry significantly different risk profiles.

MULTIPLE BENEFITS

Key rate duration portfolio analysis can also be viewed as an attribution tool. In May of 1977, Wagner and Tito proposed replacing beta as a measure of systematic risk with duration for fixed income portfolios. When used in conjunction with benchmark data, key rate duration analysis can determine the amount of interest rate risk the manager or portfolio is undertaking (on an absolute basis), and the deviation from the benchmark, or active risk (on a relative basis). The magnitude of active risk can be defined as the variance of duration allocation among various segments of the portfolio versus that of the benchmark. The breakdown that this analysis provides shows the true granular contribution of the manager’s investment decisions. The sum of all the underlying key rate duration contributions will equal the total effective duration of the portfolio or benchmark. Having the capabilities to determine how to monitor the fund’s duration allocation can not only assist managers in creating an active risk profile similar to that of the benchmark, but also bring transparency to the reasoning behind manager’s alpha, or the lack thereof.

Pension plan sponsors need to be able to determine the impact that cash flow volatility will play in liability streams. Key rate risk may provide the insight to truly understand the active risk and outcome of the fund. Erratic changes in interest rates may have a large impact on the funded status of pension plans.

Typically, during periods of interest rate decreases, pensions will see their present values of benefit obligations (their liabilities) increase, while their asset values may not rise. This can contribute to pension funding status volatility, which may create problems in successfully controlling the risk of the surplus or deficit. Pension plans, particularly in the United States, have been paying closer attention to their funded status in recent years, as the Financial Accounting Standards Board (FASB) and the Pension Protection Act of 2006 have made it a requirement to display the pension plan’s surplus or deficit value on its balance sheet. Key rate duration analyses may capture mismatches in liability streams and help determine what adjustments need to be made to effectively hedge interest rate risk. This insight can be highly insightful for corporate balance sheets, as pension funding statuses and liability figures have the potential to impact the bottom line.

In managing a pension fund’s surplus, it is crucial to identify shifts in interest rates because, without proper risk controls, asset and liability spreads can widen if left unchecked. Properly maintaining sound risk management through the means of key rate surplus risk can identify term structure spreads within the context of the surplus/deficit at risk. Using constituent level data, risk managers and consultants can use liability and asset cash flow streams to dissect key node spreads along the curve. When performing such an analysis, risk managers can analyze and decompose the pension’s assets as long positions and the liability streams as short positions. By doing so, we can create a relative analysis that both focuses on the Relative VaR (Ex-Ante Tracking Error) and interest rate risk of the differential

---

portfolio. While key rate duration focuses on underlying term spreads between key nodes, Relative VaR enhances the analysis by estimating the potential losses incurred by the portfolio’s deviation from the benchmark. Plan sponsors can examine this data and identify, by key node, where underlying VaR and duration spreads lie. For example, suppose a plan sponsor implemented a long duration portfolio to assist in hedging interest rate exposure to that of a hypothetical benchmark representing future liabilities. If the purpose of the portfolio was designed for immunization, this would typically be accomplished by matching the key rate duration exactly as defined by the benchmark. By looking at each underlying key node in an isolated instance, one could determine the underlying interest rate exposure spread over the benchmark, as well as the impact in the surplus or deficit at risk. Accordingly, a plan sponsor could determine the actual value at risk that the fund has taken on by deviating from the benchmark’s interest rate exposure on the yield curve. For example, judging by the hypothetical analysis in Exhibit 3, it can be determined that the surplus at risk carries a larger VaR percentage when significantly more interest rate is absorbed by the portfolio.

Exhibit 3

As displayed in Exhibit 3, the most volatile movements in relative VaR occur at key nodes that have the largest active interest rate risk deviations from the benchmark. Although counter-intuitive, there can be just as large of an impact at the 2 year key rate, as the 5 year key rate, in incremental interest rate and surplus risk. When maintaining to keep within a bandwidth of risk exposure from a benchmark, plan sponsors can use this data to ensure that the relative estimated losses are kept within tolerance. If plan sponsors feel that there may be too much risk taken, or in the proper environment, not enough risk being taken, they can adjust their duration and/or sector allocation to fit the needs of the plan’s investment policy. By looking at this example, it can be concluded that there is more surplus VaR volatility in the 5-10 year maturity bucket than the 25-30 year bucket. To be more precise, the influx of active interest rate risk in the 7 year maturity bucket carries significantly more active risk than the 25 year maturity bucket. In an absolute comparison of risk allocation, it can be concluded that the fund carries approximately 62% of its interest
rate risk in the 5-10 year maturity bucket, while the active market risk of the fund (VaR) is roughly 53% in the bucket. This analysis is assuming that there is no correlation among asset classes within the fund, since VaR does not carry an additive function (while duration does). In conjunction with Relative VaR (VaR Differential), pensions can also utilize Conditional VaR (CVaR), the average worst case loss beyond the confidence level under normal VaR conditions, to identify tail risk within the surplus/deficit. By identifying specific maturity terms that contribute the largest possible loss to the total fund, sponsors can analyze worst case scenarios to identify weaknesses in the plan’s term structure and allocate accordingly. As identified in Exhibit 3, the largest deviations of active risk generate the largest differential VaR spreads between the fund and its liabilities. If the Investment Committee of the pension sees fit to cut interest rate or market risk, such an analysis would be indispensable when creating an immunization or hedging strategy.

As important as these measures are to pension funds, they also play a vital role in a Central Bank’s portfolio management, since most funds are tied directly to an index and are passive in nature. In order to maintain an absolute risk tolerance, these funds need to match not only the total fund risk, but the risk that is being absorbed by various investment decisions within maturity segments. Without being able to match the benchmark’s granular risk, the total fund risk will not have the same effect on the portfolio as the benchmark. This aspect is crucial, for these funds normally do not deviate from their mandate and are required to maintain the benchmark’s total risk profile at all times. Central Banks typically strive to be as risk averse as possible and not leverage their risk against their benchmark. Although utilized by pensions for its advantages in LDI investing, Central Banks will also employ relative VaR as a standardized risk measure to augment enhanced indexation. By reducing ex-ante tracking error, active risk is curtailed. While Central Banks typically carry a low to moderate risk profile, by carrying curve positioning of two to three years in effective duration, managers have the capability to invest in fixed income instruments that can range anywhere from cash equivalents such as three-month Treasury bills to fifteen-year Treasury notes. Using key rate duration can identify shifts in the portfolio’s interest rate structure, producing active interest rate differentials that are readily comparable to the benchmark. Although managers may mirror the risk profile of the total fund to that of the benchmark, there may be a lot of turmoil within the segmented maturity buckets that differ from those of the benchmark.

As risk managers and plan sponsors continue to search for risk measures that help maintain their investment goals while exposing risk, it must be remembered that the underlying effects explain the final outcome of the fund’s risk to reward profile. Managers cannot diversify away the effects of external interest rate movements, but they can adjust their overall exposure to that of a reference point, particularly by utilizing liabilities and cash flow streams. As the investment world has changed drastically over the past couple of years, institutional investors and portfolio managers have come under a lot of pressure to ensure that risk is being exposed and controlled, and not ignored. A true risk analysis will not only explain why the total fund has performed the way it did, but through the means of key rate risk, will also explain the underlying effects of how the total fund came to that point.
ABOUT MANPREET HOCHADEL

Vice President  
Investment Analytics & Consulting  
J.P. Morgan Worldwide Securities Services

Manpreet Hochadel is a Vice President and Senior Consultant within the J.P. Morgan Investment Analytics & Consulting group. Mr. Hochadel is responsible for providing analytical and consulting services in the areas of ex-ante risk, liability-driven investments, international equity, and capital markets.

Mr. Hochadel has served in the financial services industry for over 15 years. He is a former Senior Analyst for HVB Capital Management, where he provided individual security research and market analysis for institutional clients. In a past position, Mr. Hochadel was a Marketing and Sales Consultant for Neuberger Berman.

Mr. Hochadel earned a B.S. in Accounting from State University of New York at Oswego. He is a Chartered Financial Analyst, and a member of the New York Society of Security Analysts (NYSSA) as well as the Chartered Financial Analyst Institute.

ABOUT WILLIAM MIRRER

Performance Analyst  
Investment Analytics & Consulting  
J.P. Morgan Worldwide Securities Services

William Mirrer is an Officer and Performance Analyst in the J.P. Morgan Investment Analytics & Consulting Group. Mr. Mirrer’s principal responsibility is to provide performance measurement, analytics and risk reporting to several large institutional clients.

Mr. Mirrer has worked with several clients to develop customized analytics and risk solutions across all asset classes. He has specialized in risk analytics reporting, including ex-ante tracking error and surplus volatility analysis.

Mr. Mirrer earned a B.S. in Financial Management with a minor in Economics from The University of New Hampshire at Keene. He is currently enrolled in the Certification of Investment Performance Measurement (CIPM) at the expert level.
ABOUT J.P. MORGAN'S INVESTMENT ANALYTICS & CONSULTING GROUP

J.P. Morgan’s suite of Investment Analytics and Consulting services provides clients with the information they need to make more informed investment decisions and optimize their portfolios through innovative and forward-looking solutions. J.P. Morgan provides Investment Analytics & Consulting services to over 280 clients globally with over 9,000 institutional portfolios, representing approximately $2 trillion in assets. Our diverse client list includes corporate and public DB/DC pensions, investment managers, endowments and foundations, corporate treasuries, insurance companies, central banks, and investment authorities.

Having the broadest and deepest Investment Analytics and Consulting product offering in the market, J.P. Morgan offers security-level, multi-currency performance measurement (monthly and daily) using J.P. Morgan or third party accounting; characteristics and attribution at the asset class, sector, country, and individual security level; ex-ante risk measurement (including Risk Budgeting and security-level VaR); investment manager analysis, universe comparison, and peer grouping; global consolidated reporting for multinational plans; and consultative services in the areas of liability and plan allocation strategy.

For more information, visit www.jpmorgan.com/visit/iac or www.iac-opal.com or contact:

**Americas & Asia:**
Mark Huamani
Managing Director
mark.huamani@jpmorgan.com
212-552-0527

**Europe, Middle East, Africa:**
Alex Stimpson
Vice President
alex.stimpson@jpmorgan.com
44-12-0234-3386

**Australia:**
Stuart Hoy
Vice President
stuart.d.hoy@jpmorgan.com
612-9250-4733

Any opinions, estimates and forecasts offered in this article constitute the author’s judgment as of the date of the materials and are subject to change without notice, as are statements of financial market trends, which are based on current market conditions. We believe the information contained in this article to be reliable but do not warrant its accuracy or completeness. This material is not intended as an offer or solicitation for the purchase or sale of any financial instrument. The views and strategies described may not be suitable for all investors. This material has been prepared for informational purposes only and it is not intended to provide and should not be relied on for investment, accounting, legal or tax advice. Any opinions, estimates and forecasts are solely those of the author and not of J.P. Morgan.

This document contains information that is the property of JPMorgan Chase & Co. It may not be copied, published, or used in whole or in part for any purposes other than expressly authorized by JPMorgan Chase & Co.

Copyright ©2011 JPMorgan Chase & Co. All rights reserved.