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The Benchmark U.S. Treasury Market: Recent Performance and Possible Alternatives

The U.S. Treasury securities market is a benchmark. As obligations of the U.S. government, Treasury securities are considered to be free of default risk. The market is therefore a benchmark for risk-free interest rates, which are used to forecast economic developments and to analyze securities in other markets that contain default risk. The Treasury market is also large and liquid, with active repurchase agreement (repo) and futures markets. These features make it a popular benchmark for pricing other fixed-income securities and for hedging positions taken in other markets.

The Treasury market's benchmark status, however, is now being called into question by the nation's improved fiscal situation. The U.S. government has run a budget surplus over the past two years, and surpluses are expected to continue (and to continue growing) for years. The debt held by the public is projected to fall accordingly and, under reasonable assumptions, much of the outstanding debt could be paid back within the next decade. The declining stock of debt may impact Treasury market liquidity and efficiency, thereby making Treasuries a less useful benchmark of risk-free interest rates as well as a less useful benchmark for pricing and hedging other fixed-income securities.

Moreover, recent market events have heightened concerns about the Treasury market's benchmark role and provided insight into how the market may perform in the future. For instance, yield spreads between Treasuries and other fixed-income securities widened sharply amid the financial markets crisis in the fall of 1998 in a so-called "flight to quality." A related "flight to liquidity" also caused yield spreads among Treasury securities of varying liquidity to widen sharply. Consequently, some of the attributes that make the Treasury market an attractive benchmark were adversely affected.

This paper examines the benchmark role of the U.S. Treasury market and the features that make it an attractive benchmark. In it, I examine the market's recent performance, including yield changes relative to other fixed-income markets, changes in liquidity, repo market developments, and the aforementioned flight to liquidity. I show that several of the attributes that make the U.S. Treasury market a useful benchmark were negatively affected by the events of fall 1998, and that some of these attributes did not quickly return to their precrisis levels. Furthermore, I demonstrate that the agency debt, corporate debt, and interest-rate swaps markets have features that might make them attractive benchmarks, and that the agency debt and swaps markets in particular are already assuming a limited benchmark role.

The Benchmark U.S. Treasury Market

A number of features contribute to the U.S. Treasury market's role as a benchmark. Treasuries are backed by the full faith and

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credit of the U.S. government and are therefore considered to be free of default risk.[1] Issuance to pay off maturing debt and raise needed cash has created a stock of Treasuries held by the public that totaled $3.6 trillion on September 30, 1999. The creditworthiness and supply of Treasury securities have resulted in a highly liquid round-the-clock secondary market with high levels of trading activity and narrow bid-ask spreads. Treasuries trade in an extremely active repo market in which market participants can borrow securities and finance their positions, as well as in an active futures market in which market participants can buy and sell securities for future delivery.

As Treasuries are considered to be free of default risk, yields on these securities represent risk-free rates of return. These risk-free rates are used in a variety of analytical applications to forecast interest rates, inflation, and economic activity. The rates are also used as benchmarks in the analysis and monitoring of other fixed-income and non–fixed-income securities. The performance of corporate bonds, for example, is often examined relative to that of Treasury securities, as the comparison allows one to separate yield changes due to changes in the risk-free rate from yield changes due to changes in credit risk (or due to the pricing of such credit risk).

Treasury securities are also used extensively for pricing securities and hedging positions in other U.S. dollar fixed-income markets. When a fixed-rate corporate debt issue is initially sold, for example, it is typically marketed in terms of a yield spread to a particular Treasury security rather than at an absolute yield or price.[2] Similarly, a position taken in a corporate debt issue is frequently hedged in the Treasury market. The ability to hedge in the Treasury market increases dealers' willingness to make markets and take positions in other markets, and thereby improves the liquidity of these other markets.

While the creditworthiness of Treasury securities is critical to their use as benchmark risk-free rates, the liquidity and efficiency of the market are also important. A highly liquid Treasury market ensures that observed Treasury prices are close to the market consensus of where prices should be and that changes in prices reflect revisions in the market consensus. An efficient market ensures that the risk-free rates implied by Treasury yields closely reflect the market's views of risk-free rates and that prices are no more than minimally affected by issue-specific differences in liquidity, supply, or demand.

When one evaluates the Treasury market's use as a benchmark for pricing and hedging purposes, features such as relative market performance, well-developed repo and futures markets, and liquidity are important. To be a good pricing or hedging vehicle, Treasury prices should be highly correlated with prices in other markets. A loss in a dealer's long position in mortgage-backed securities, for example, could then be offset by a dealer's short position in Treasuries. Hedges frequently involve taking short positions, so the ability to borrow Treasury securities at a low cost in the repo market is important. (The futures market can also be used to take short positions.) Finally, Treasury market liquidity is important, as hedgers must be able to buy and sell large Treasury positions quickly with minimal transaction costs.

Features of the Treasury market that make it a good benchmark thus depend on how one uses the market as a benchmark. Creditworthiness, liquidity, and efficiency are important as a reference benchmark for risk-free rates, but relative market performance is not important and active repo and futures markets are important only so far as they benefit liquidity. Relative market performance, active repo and futures markets, and liquidity are important as a pricing and hedging benchmark, but creditworthiness and efficiency are important only so far as they influence liquidity and relative market performance.

The Shrinking Public Debt

As noted, the benchmark status of the U.S. Treasury market is being called into question by the country's improved fiscal situation. In fiscal year 1999, U.S. government revenues exceeded outlays by $123 billion, resulting in the first consecutive budget surpluses since 1956-57. As of July 1999, the U.S. Congressional Budget Office (1999), or CBO, was projecting growing budget surpluses for the next ten years (under existing laws and policies), rising from $161 billion in fiscal year 2000 to $413 billion in fiscal year 2009 (including Social Security trust funds).

The budget surpluses are reducing the stock of Treasury debt outstanding. Debt held by the public stood at $3.6 trillion on September 30, 1999, down from its peak of $3.8 trillion a year and a half earlier.[3] As of July 1999, the CBO was projecting that such debt would continue to fall over the next ten years, to $0.9 trillion at the end of fiscal year 2009. As a percentage of GDP, debt held by the public was projected to fall from 40.9 percent in 1999 to 6.4 percent in 2009.

The U.S. Treasury Department initially responded to its decreased funding needs by cutting issue sizes. In particular, bill sizes were cut sharply in March 1997 such that three-month bill sizes, for example, fell from the $11-$14 billion range to the $6.0-$8.5 billion range (excluding amounts issued to Federal Reserve Banks).

To continue to ensure large, liquid issues, the Treasury announced in May 1998 that it would limit further contraction of bill sizes and concentrate coupon offerings around larger, less frequent issues.[4] The Treasury thus reduced issuance of the five-year note from monthly to quarterly and eliminated issuance of the three-year note altogether. In August 1999, the Treasury announced that is was reducing the issuance frequency of the thirty-year bond from three times a year to twice a year and that it was considering reducing the issuance frequency of one-year bills and two-year notes.

To maintain large auction sizes and the liquidity of the most recent (on-the-run) issues, the Treasury proposed a debt buyback program in August 1999 and announced a revision to the original issue discount (OID) rules in November 1999. Under the buyback program, launched in January 2000, the Treasury will redeem outstanding unmatured Treasury securities by purchasing them from their current owners.[5] Changes to the OID rules allow the Treasury to reopen its most recent issues within one year of issuance without concern that the price of the issues may have fallen by more than a small amount.

Changes in policy or economic conditions may forestall a considerable shrinkage of the Treasury debt. Even if the market does shrink substantially, the Treasury Department's efforts to maintain large and liquid issues may stave off significant market repercussions. Nonetheless, the improved fiscal situation advances the possibility that the Treasury market will shrink considerably and that issuance sizes and/or frequencies will have to be reduced further.[6]

Reduced debt outstanding and reduced issuance sizes and/or frequencies would likely impact several Treasury market attributes. The market would likely become less liquid, with wider bid-ask spreads, reduced depth, and less trading activity. Reduced issuance sizes and/or frequencies would likely decrease the supply of lendable securities and thereby drive up the cost of borrowing issues in the repo market. Issue-specific differences in liquidity would probably become more important in determining prices. In turn, Treasuries might perform more disparately from other fixed-income securities.

Persistent fiscal surpluses could thereby make the Treasury market a less attractive benchmark. While Treasuries will remain free of default risk, the reduced market liquidity and efficiency would decrease their usefulness as risk-free benchmarks. Greater costs of borrowing securities in the repo market combined with reduced liquidity and increasingly disparate performance would make Treasuries less desirable benchmarks for pricing securities or hedging positions in other markets.

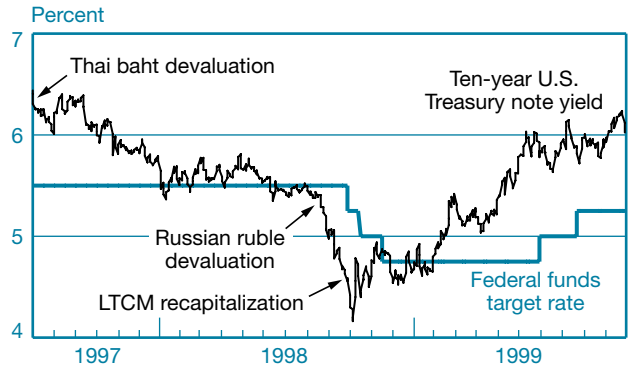
The Recent Performance of the Benchmark U.S. Treasury Market

Recent financial market events have heightened concerns about the U.S. Treasury market's benchmark role and have provided direction as to how the market may perform in the future. In the fall of 1998, global financial market turmoil spurred investors to seek the safety of U.S. Treasury securities, driving prices up and yields down. As shown in Chart 1, the yield on the ten-year U.S. Treasury note dropped 125 basis points, to 4.16 percent, between August 19, 1998, and October 5, 1998. While this paper does not explain the events behind the financial crisis, a few notable events are included in the chart as reference points.[7]

One aspect of the financial crisis was a flight to quality in which yield spreads widened sharply between Treasuries and other fixed-income securities. Another aspect was a reduction in market liquidity, as an aversion to risk-taking decreased dealers' willingness to take positions and make markets. An increased cost of borrowing securities in the repo market also resulted from the financial crisis as did a sharp widening in yields between more and less actively traded Treasury securities.

This paper's analysis of these disruptions demonstrates why the benchmark topic is receiving increased attention and, more importantly, clarifies the market attributes that should be examined when evaluating alternative benchmarks. It also provides insight into how the Treasury market may perform if the outstanding debt starts declining more quickly, although it does not attribute the market's recent performance to the

Chart 1
Ten-Year U.S. Treasury Note Yield and Federal Funds Target Rate



Source: Bloomberg.

Note: LTCM is Long-Term Capital Management.

improved fiscal situation. Moreover, the analysis does not rate the Treasury market's performance as a benchmark, but rather illustrates the growing prominence of the benchmark topic and the features that are important to a benchmark market.

Relative Market Performance

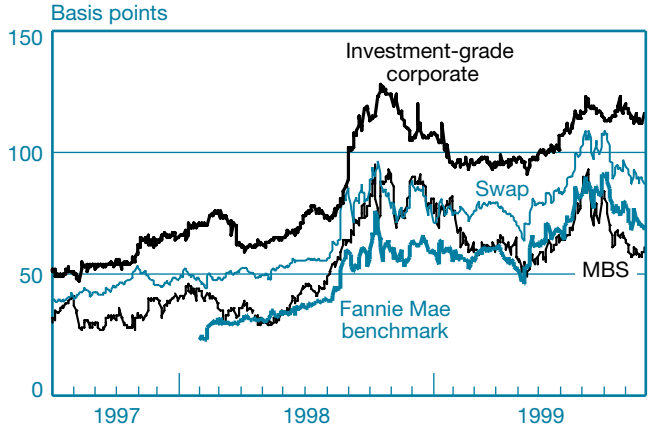
The performance of Treasuries and other fixed-income securities diverged sharply in the fall of 1998. Investors sought the safety of risk-free Treasuries at the expense of securities with credit risk in the so-called flight to quality, driving a wedge between their performance. Chart 2 shows that yield spreads of various fixed-income securities over Treasuries widened between mid-August and mid-October 1998, and remained fairly wide afterward. The yield spread between investment-grade corporate debt securities and Treasuries, for example, widened from 74 basis points on August 13, 1998, to 128 basis points on October 19, 1998. It was 116 basis points on October 31, 1999.

The widening of the spread in the fall of 1998 is not unprecedented. Credit spreads often rise during or preceding a recession, and they were quite high in the early 1980s, for example. One of the attractive features of Treasury securities is their absence of default risk. This means that Treasury yield changes do not reflect changes in credit risk, by definition, and that Treasuries are inherently limited in their ability to serve as good hedges of fixed-income securities that contain credit risk.

Despite the widening of the spread, there does not seem to have been a fundamental shift in the relationship between Treasury yield changes and other fixed-income yield changes. An analysis of weekly yield changes shows that Treasuries remained highly correlated with other fixed-income securities during the height of the financial crisis (Table 1). The correlation between ten-year Treasury yield changes and investment-grade corporate yield changes, for example, fell only slightly—from 0.975 before the crisis to 0.965 during the crisis and to 0.963 after the crisis.[8, 9]

The disparate performance of Treasury securities and other fixed-income securities raises questions about the attractiveness of Treasuries as hedging vehicles. Those who shorted Treasuries as a hedge preceding the widening of the spread in the fall of 1998 found that their losses on Treasuries more than offset any gains they may have had on their long positions. Nonetheless, the widening of the spread was not unprecedented, and Treasury yield changes maintained a high correlation with other fixed-income yield changes.

CHART 2
Yield Spreads to the Ten-Year U.S. Treasury Note



Sources: Bloomberg; Goldman Sachs; Merrill Lynch.

Notes: The investment-grade corporate yield is the industrials ten-year A2/A yield from Bloomberg. The swap rate is the ten-year semiannual fixed rate versus three-month LIBOR compiled by Bloomberg from various sources. The mortgage-backed security (MBS) yield is a weighted-average, option-adjusted yield calculated by Goldman Sachs. The Fannie Mae benchmark yield is the on-the-run ten-year benchmark note yield from Merrill Lynch, via Bloomberg.

Market Liquidity

While the Treasury market was seen as a safe and liquid haven for investors in fall 1998, its liquidity was adversely affected nonetheless. One measure of liquidity is the bid-ask spread, or the difference between quoted bid and offer prices. As shown in Chart 3, spreads in the interdealer Treasury market widened sharply in fall 1998 for the on-the-run ten-year note and had not returned to precrisis levels as of October 1999. The ten-year note typically trades with a spread of 1/64 or 1/32 of a point (where one point equals 1 percent of par), but it traded with nearly a 3/32 average spread on October 9, 1998, and just over a 1/32 spread on October 29, 1999. For the ten-year note, 1/32 of a point equals just under half a basis point in yield terms.

Another measure of liquidity is the depth of the market. Market depth refers to the quantity of securities that dealers are willing to buy and sell at various prices, and is measured here by the average quantity firmly offered at the best quoted bid and offer prices in the interdealer market. As shown in Chart 4, the quoted depth of the on-the-run ten-year note fell from the $9-$11 million range in July and August 1998 to roughly $6 million in October 1998. Quoted depths did not recover quickly after fall 1998, averaging slightly more than $5.5 million in 1999 (through October).

Table 1

Correlations of U.S. Treasury and Other Fixed-Income Yield Changes

Period	Investment-Grade Corporate	Mortgage-Backed Security	Fannie Mae Benchmark	Swap	High-Yield Corporate
Precrisis: July 3, 1997-Aug. 14, 1998	0.975	0.956	0.976	0.987	0.473
Crisis: Aug. 14, 1998-Nov. 20, 1998	0.965	0.957	0.970	0.968	0.199
Postcrisis: Nov. 20, 1998-Oct. 29, 1999	0.963	0.924	0.956	0.961	0.429
Full sample: July 3, 1997-Oct. 29, 1999	0.966	0.945	0.964	0.970	0.286

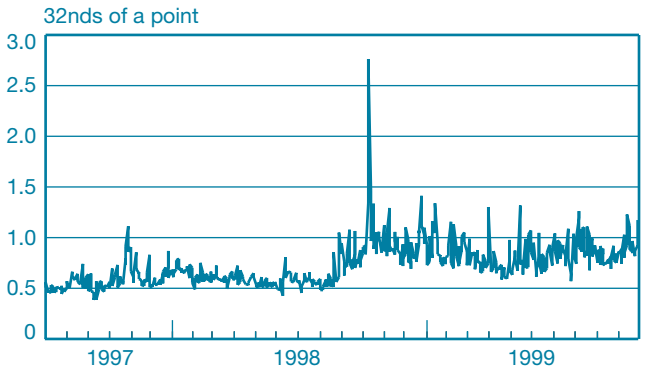
Source: Author's calculations, based on data from Bloomberg, Goldman Sachs, and Merrill Lynch.

Notes: The table reports the correlations of weekly yield changes between the on-the-run ten-year U.S. Treasury note and the indicated index or security. Correlations with the Fannie Mae benchmark are limited to the period starting February 3, 1998. The investment-grade corporate yield is the industrials ten-year A2/A yield from Bloomberg. The mortgage-backed security yield is a weighted-average, option-adjusted yield calculated by Goldman Sachs. The Fannie Mae benchmark yield is the on-the-run ten-year benchmark note yield from Merrill Lynch, via Bloomberg. The swap rate is the ten-year semiannual fixed rate versus three-month LIBOR compiled by Bloomberg from various sources. The high-yield corporate yield is from Merrill Lynch's High-Yield Master Index, via Bloomberg.

One other measure of liquidity is trading volume. Volume is not an ideal measure of liquidity, as it may reflect dealers' eagerness to rebalance and hedge positions amid market turmoil, rather than their willingness to take positions and make markets. In fact, the volume numbers in Chart 5 show that trading activity actually increased throughout August and into early September 1998. Trading activity then declined fairly steadily throughout the fall before dropping off sharply at the end of the year; it remained lower than usual through October 1999.

Chart 3

Bid-Ask Spread of Ten-Year U.S. Treasury Note



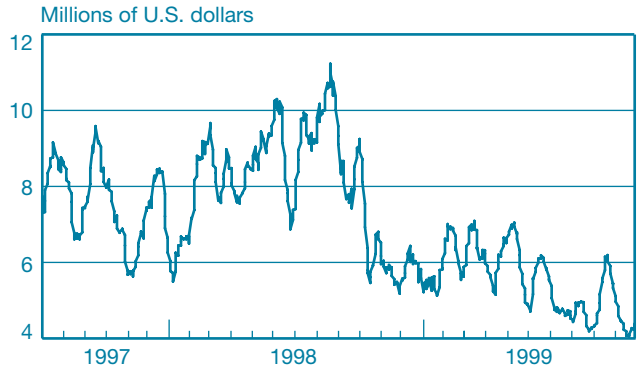
Source: Author's calculations, based on data from GovPX.

Note: The chart plots the mean daily bid-ask spread in the interdealer market for the on-the-run ten-year note.

The evidence suggests that Treasury market liquidity was adversely affected by the events of fall 1998 and that it did not recover quickly. While the market was quite volatile in fall 1998—and somewhat more volatile after the crisis than before it—such volatility does not explain the diminished liquidity.[10] The events of fall 1998, concerns about Y2K, the withdrawal of market participants, and the reluctance of remaining participants to take risks are some of the factors that may have inhibited market liquidity even after the crisis.

Chart 4

Quote Depth of Ten-Year U.S. Treasury Note

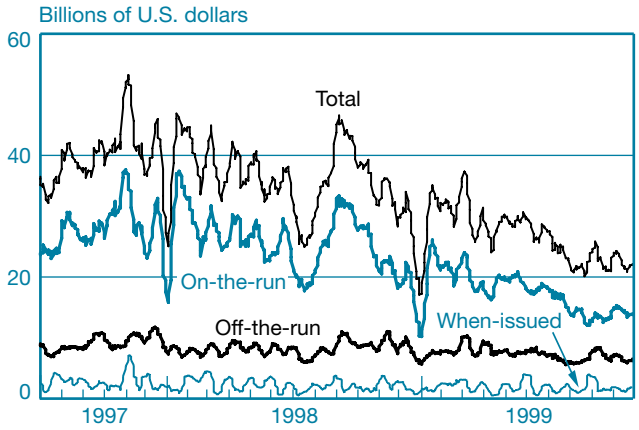


Source: Author's calculations, based on data from GovPX.

Notes: The chart plots the ten-day rolling average of the mean daily quote size in the interdealer market for the on-the-run ten-year note. The quote size refers to the quantity of securities bid for or offered for sale at the best bid and offer prices posted by GovPX; the mean daily figure is calculated with both bid and offer quantities.

Chart 5

Daily Trading Volume of U.S. Treasury Securities



Source: Author's calculations, based on data from GovPX.

Notes: The chart plots the ten-day rolling average of daily trading volume in the interdealer market. The volume figures are reported on a one-way basis (so that a trade between two parties is counted only once) and cover about 65 percent of the interdealer broker market.

Reduced market liquidity can diminish the attractiveness of the Treasury market both as a risk-free benchmark and as a benchmark for pricing and hedging. Decreased liquidity increases the chances that implied risk-free rates will deviate from the market consensus as to where risk-free rates should be. Decreased liquidity also raises hedgers' direct costs of trading and reduces their ability to take or unload large positions quickly with minimal price impact. Despite the disruptions to Treasury market liquidity, it should be noted that the market remains highly liquid and that it may have been less disrupted by liquidity problems in fall 1998 than were other fixed-income markets.

The Repo Market

A repo is an agreement to exchange collateral for cash with a simultaneous agreement to buy back the collateral at a specified price at some point in the future. A dealer owning a particular Treasury note, for example, might agree to sell that security to another dealer while simultaneously agreeing to buy back the security the next day. The first dealer can thus use the repo market to finance its positions, often at a favorable rate, while the second dealer can use the repo market to borrow and then sell securities it does not hold in its portfolio.

The repo market for Treasury securities was temporarily disrupted by the events of fall 1998. One measure of disruption examines the spread between the general collateral rate and the collateral rate on a particular security. When an issue is in high demand, a dealer in effect lends funds at a rate below the rate that would otherwise be required to borrow a security, and the issue is said to be "on special." Table 2 shows that the on-the-run two-year note, five-year note, and thirty-year bond (but not the ten-year note) traded at an increased rate of specialness during the fall 1998 crisis, but that specialness declined after the crisis. The five-year note, for example, was lent at an average overnight rate that was 77 basis points below the general collateral rate before the crisis, 126 basis points during the crisis, and 75 basis points after the crisis.

Repo activity in on-the-run coupon securities was not negatively affected by the events of fall 1998. As shown in Table 3, overnight repo trading volume increased in fall 1998 for the two-year and five-year notes, but it fell for the ten-year note and thirty-year bond. After fall 1998, repo activity changed little for the two-year and five-year notes, but it increased for the ten-year note and thirty-year bond. Overall, repo activity was higher after the crisis than it was before it for three of these four securities (all but the ten-year note). Repo trading volume numbers do not suggest that the use of Treasuries as hedging vehicles declined as a result of the fall 1998 crisis.

Table 2

Repo Specialness of On-the-Run U.S. Treasury Coupon Securities

Basis Points

Period	Two-Year	Five-Year	Ten-Year	Thirty-Year
Precrisis:				
July 1, 1997-Aug. 14, 1998	21.0	76.9	165.8	120.6
	(30.4)	(80.5)	(135.8)	(135.0)
Crisis:				
Aug. 17, 1998-Nov. 20, 1998	52.8	126.1	115.6	211.1
	(86.6)	(149.3)	(143.4)	(164.9)
Postcrisis:				
Nov. 23, 1998-Oct. 29, 1999	35.3	75.0	200.3	120.1
	(48.6)	(86.2)	(155.0)	(123.9)
Full sample:				
July 1, 1997-Oct. 29, 1999	30.4	81.8	173.9	130.8
	(48.5)	(94.3)	(146.8)	(137.4)

Source: Author's calculations, based on data from GovPX.

Note: The table reports the means and standard deviations (in parentheses) of the daily average differences between the overnight general collateral rate and the collateral rates on the indicated on-the-run securities.

Table 3

Repo Trading Volume of On-the-Run U.S. Treasury Coupon Securities

Billions of U.S. Dollars

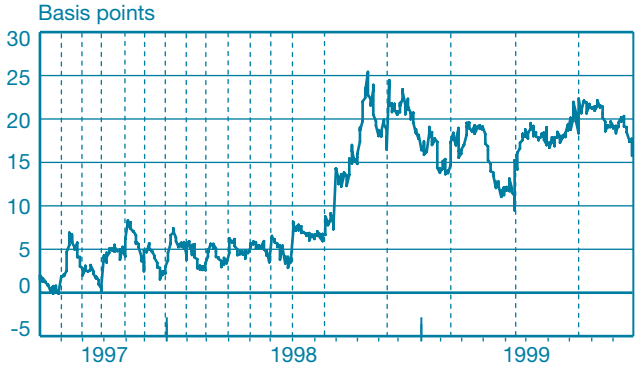
Period	Two-Year	Five-Year	Ten-Year	Thirty-Year
Precrisis:				
July 1, 1997-Aug. 14, 1998	5.69	7.42	10.39	4.09
	(2.94)	(3.09)	(4.00)	(2.10)
Crisis:				
Aug. 17, 1998-Nov. 20, 1998	8.33	8.72	8.44	3.54
	(3.50)	(3.14)	(2.79)	(1.69)
Postcrisis:				
Nov. 23, 1998-Oct. 29, 1999	8.31	8.78	9.54	4.25
	(3.15)	(3.19)	(4.61)	(1.87)
Full sample:				
July 1, 1997-Oct. 29, 1999	7.04	8.11	9.82	4.09
	(3.36)	(3.20)	(4.18)	(1.97)

Source: Author's calculations, based on data from GovPX.

Note: The table reports the means and standard deviations (in parentheses) of daily overnight repurchase agreement trading volume in the indicated on-the-run securities as reported to GovPX.

Chart 6

Off-the-Run/On-the-Run Yield Spread of Five-Year U.S. Treasury Note



Source: Author's calculations, based on data from Bear Stearns and GovPX.

Notes: The chart plots the predicted yield less the market yield on a daily basis for the on-the-run five-year note. The predicted yield is the yield of a comparable-duration off-the-run security as derived from a model of the yield curve estimated with off-the-run prices. Changes in the on-the-run security are indicated by the dashed vertical lines.

Increased repo market specialness can decrease the attractiveness of Treasury securities as hedging vehicles because it makes borrowing securities more costly. Increased borrowing costs may also reduce market liquidity, further hurting the attractiveness of the Treasury market for various purposes, including pricing, hedging, and as a benchmark of risk-free rates. The evidence suggests, however, that the cost of borrowing on-the-run Treasury securities increased only briefly during the fall 1998 crisis and that repo market activity generally did not decline either during or after fall 1998.

Market Efficiency

One of the most striking developments in fall 1998 was a divergence in performance between more and less actively traded Treasury securities. As shown in Chart 6, the yield spread between the on-the-run five-year note and a comparable off-the-run security rose sharply in late August 1998 and again in mid-October 1998, reaching 25 basis points on October 15, 1998.[11] Table 4 shows that the comparable spread also widened sharply in fall 1998 for the two-year note and the thirty-year bond, albeit not for the ten-year note. On-the-run Treasuries generally became relatively more valuable as investors sought not only the safety of Treasury securities but

Table 4

Off-the-Run/On-the-Run Yield Spreads of U.S. Treasury Coupon Securities

Basis Points

Period	Two-Year	Five-Year	Ten-Year	Thirty-Year
Precrisis:				
July 1, 1997-Aug. 14, 1998	2.80	4.48	7.87	5.01
	(1.80)	(1.90)	(1.71)	(1.71)
Crisis:				
Aug. 17, 1998-Nov. 20, 1998	11.62	16.68	6.63	12.99
	(5.76)	(4.89)	(3.30)	(4.65)
Postcrisis:				
Nov. 23, 1998-Oct. 29, 1999	5.02	17.93	13.55	13.50
	(2.37)	(2.75)	(6.93)	(1.83)
Full sample:				
July 1, 1997-Oct. 29, 1999	4.72	11.33	10.03	9.36
	(3.86)	(7.14)	(5.54)	(4.78)

Source: Author's calculations, based on data from Bear Stearns and GovPX.

Note: The table reports the means and standard deviations (in parentheses) of the daily off-the-run/on-the-run yield spreads of the indicated securities. The spreads are calculated as the predicted yields less the market yields, where the predicted yields are those of comparable-duration off-the-run securities as derived from a model of the yield curve estimated with off-the-run prices.

also the liquidity of the on-the-run issues in the so-called flight to liquidity.[12] After the crisis, spreads remained high on the five-year note and the thirty-year bond, they increased for the ten-year note, but they declined for the two-year note.

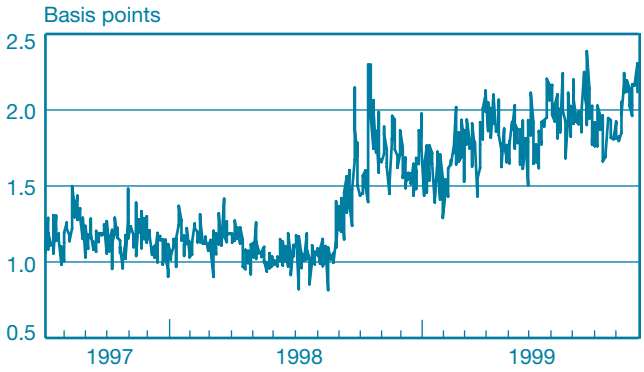
Another development in fall 1998 was a divergence in pricing among off-the-run securities, possibly due to a decline in Treasury market arbitrage. The efficiency of the Treasury market typically results in off-the-run securities of similar maturity trading relatively close to one another in terms of yield. When Treasury yields are plotted against time to maturity, they usually form a relatively smooth curve, as shown for May 13, 1998 (Chart 7). The smoothness of the yield curve over time is estimated here as the median absolute error between market yields and the yields predicted by a term structure model.[13] As shown in Chart 8, the median rose sharply between late August and mid-October 1998—peaking at 2.3 basis points on October 8, 1998—and remained relatively high after the crisis.

The relative performance of Treasuries in the fall of 1998 is summarized in Chart 9, which plots yields against years to maturity for October 9, 1998. The chart shows the wide dispersion of off-the-run yields, as documented in Chart 8. It also shows the wide yield spreads between on-the-run coupon securities and comparable-maturity off-the-run securities, as shown in Chart 6.

The divergent performance of Treasury securities raises concerns about the market's usefulness both as a risk-free interest-rate benchmark and as a benchmark for pricing and hedging. Differences in the liquidity or specialness of Treasury securities can result in different implied risk-free rates, raising the issue of which risk-free rate is the appropriate one. Such differences also create an additional performance wedge between Treasuries and other fixed-income securities, possibly

Chart 8

Median Absolute Error between Predicted and Market U.S. Treasury Yields

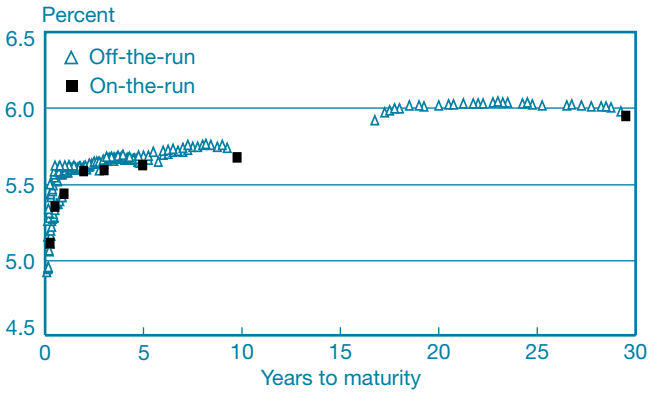


Source: Author's calculations, based on data from Bear Stearns and GovPX.

Notes: The chart plots the median absolute daily error between predicted and market yields for off-the-run notes and bonds with more than thirty days to maturity (excluding callable bonds, flower bonds, and inflation-indexed securities). Predicted yields are derived from a model of the yield curve estimated with off-the-run prices.

Chart 7

May 13, 1998, U.S. Treasury Yields

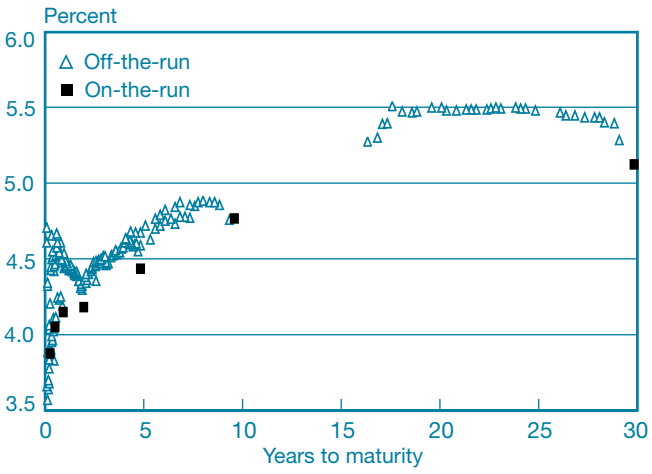


Sources: Bear Stearns; GovPX.

Note: The chart plots yields against years to maturity for Treasury securities with more than thirty days to maturity (excluding callable bonds, flower bonds, and inflation-indexed securities).

Chart 9

October 9, 1998, U.S. Treasury Yields



Sources: Bear Stearns; GovPX.

Note: The chart plots yields against years to maturity for Treasury securities with more than thirty days to maturity (excluding callable bonds, flower bonds, and inflation-indexed securities).

decreasing their correlation.[14] Nevertheless, while the divergent performance of Treasuries may hinder their role as a benchmark, it is noteworthy that this divergence may largely reflect market participants' demand for the securities' safety and liquidity. Characteristics that make the Treasury market an attractive benchmark in some ways may therefore result in performance undesirable of a benchmark in other ways.

Alternative Benchmarks

The recent performance of the benchmark U.S. Treasury market and the improved fiscal situation raise the issue of which market or markets might serve as a future benchmark. While there is no obvious U.S. dollar alternative for risk-free rates, several markets are already assuming a limited benchmark role for pricing and hedging securities and as reference rates for monitoring and analytical purposes. These markets include the agency debt market, the corporate debt market, and the interest-rate swaps market. Each is examined in turn with regard to the features that make a good benchmark market.

The Agency Debt Market

Agency securities are obligations of federal government agencies or government-sponsored enterprises such as Fannie Mae, Freddie Mac, the Federal Home Loan Banks (FHLBanks), the Farm Credit Banks, Sallie Mae, and the Tennessee Valley Authority.[15] The agencies issue debt securities to finance activities that are supported by public policy, including home ownership, farming, and education. The securities typically are not backed by the full faith and credit of the U.S. government, as is the case with Treasury securities, and therefore trade with some credit risk. They are nevertheless considered to be of very high credit quality and are rated Aaa/AAA by the major rating agencies.

Seeking to capitalize on the market's interest in large, liquid issues amid reduced Treasury supply, the agencies have introduced their own benchmark debt issuance programs, starting with Fannie Mae's Benchmark Notes Program in January 1998. The programs provide for the regular issuance of large-size, noncallable coupon securities in a range of maturities (originally two to ten years), and thus mimic the Treasury Department's issuance practices. The benchmark securities are intended to appeal to investors who might typically buy Treasury securities, and are promoted as Treasury substitutes.[16]

The agency benchmark programs have expanded rapidly in their breadth and depth. Freddie Mac introduced its Reference Notes Program in April 1998; the FHLBanks introduced their Tap Issuance Program in July 1999 and also increased issuance sizes in their Global Debt Program; and the Farm Credit Banks introduced their Designated Bonds Program in March 1999. The programs have expanded beyond their original scope with the introduction of callable benchmark programs, the issuance of longer term securities, and the announcements of auction schedules. In November 1999, both Fannie Mae and Freddie Mac announced the introduction of benchmark bill programs, with weekly auctions of large-size discount securities.

As shown in Table 5, benchmark issues of the three largest agencies generally range from $3-$6 billion in size (as of October 1999), and thus are about one-fifth to one-half as large as comparable Treasury issues. As shown in Table 6, total benchmark issuances in 1999 through October were roughly $40 billion for each of the three largest agencies, versus $234 billion in Treasury coupon security issuances. Agency benchmark debt outstanding is even smaller relative to that of the Treasury Department, due to the recent introduction of the agency benchmark programs. Fannie Mae, for example, had $94 billion in noncallable benchmark securities outstanding on October 31, 1999 (Fannie Mae 1999b), whereas the Treasury Department had $2.4 trillion in marketable fixed-rate coupon securities outstanding (Bureau of the Public Debt 1999).

Table 5

Issue Sizes of Agency and U.S. Treasury Coupon Securities as of October 31, 1999

Billions of U.S. Dollars

Issue	Fannie Mae Benchmark	Freddie Mac Reference	FHLBanks Global	FHLBanks Tap	U.S. Treasury
Two-year	—	5.0[a]	3.0	3.5[a]	15.0
Three-year	3.0	5.0	3.0	3.4[a]	—
Five-year	6.5[a]	3.0	—	2.0[a]	15.0
Seven-year	—	—	—	1.1[a]	—
Ten-year	3.5	6.0	—	0.6[a]	12.0
Thirty-year	4.25[a]	—	—	—	10.0

Sources: Bloomberg; FHLBanks, Office of Finance; Freddie Mac.

Notes: The table reports the sizes of the most recent noncallable benchmark coupon issues as of October 31, 1999. Securities more than one year old are excluded. FHLBanks Global Debt Program issues exclude a $1 billion one-year coupon issue and a $3.5 billion issue originally issued with three years to maturity. U.S. Treasury issue sizes exclude amounts issued to refund maturing securities of Federal Reserve Banks as well as amounts bid for by Federal Reserve Banks on behalf of foreign and international monetary authorities.

[a] Reopened.

Table 6

Issuance of Agency and U.S. Treasury Coupon Securities from January to October 1999

Billions of U.S. Dollars

Issue	Fannie Mae Benchmark	Freddie Mac Reference	FHLBanks Global	FHLBanks Tap	U.S. Treasury
Two-year	—	9.0	17.0	3.9	135.0
Three-year	3.0	10.5	9.0	3.4	—
Five-year	19.5	9.0	—	2.3	45.0
Seven-year	—	—	—	1.3	—
Ten-year	15.5	13.0	—	0.7	34.0
Thirty-year	4.25	—	—	—	20.0
Total	42.25	41.5	26.0	11.7	234.0

Sources: Bloomberg; Fannie Mae; FHLBanks, Office of Finance; Freddie Mac.

Notes: The table reports noncallable benchmark coupon security issuance between January 1 and October 31, 1999. The FHLBanks Global Debt Program two-year amount includes a one-year issue as well as the reopenings of an old three-year note at two-and-a-half and two-and-a-quarter years to maturity. The FHLBanks two-year Tap Issuance Program amount includes a one-and-a-half-year issue, the three-year amount includes a two-and-a-half-year issue, the five-year amount includes a four-year issue, the seven-year amount includes an eight-year issue, and the ten-year amount includes a fifteen-year issue. U.S. Treasury issuance excludes amounts issued to refund maturing securities of Federal Reserve Banks as well as amounts bid for by Federal Reserve Banks on behalf of foreign and international monetary authorities.

The stock of agency debt securities outstanding provides a guide as to how large the agency benchmark programs can become. As of June 30, 1999, agency debt outstanding totaled $1.4 trillion, versus $3.7 trillion of Treasury debt held by the public (*Federal Reserve Bulletin* 1999; *Treasury Bulletin* 1999). As shown in Chart 10, the agency debt market has grown rapidly in recent years, whereas the Treasury market has leveled off. Even if agency debt growth slowed to the rate of GDP growth (projected by the CBO), the agency debt market would surpass the U.S. Treasury market in size in fiscal year 2007 if the Treasury market shrinks according to the CBO's July 1999 projections.

The performance of agency securities versus other fixed-income securities suggests that agencies may be good pricing and hedging benchmarks. Fixed-income securities with credit risk (or spread products) largely moved together during and after the fall 1998 crisis, as shown in Chart 2. The correlations of the weekly yield changes of the Fannie Mae ten-year benchmark with those of other spread products are high, as shown in Table 7, and are comparable to those of Treasuries with other spread products (Table 1). The correlation between the Fannie Mae benchmark and mortgage-backed securities, for example, was 0.954 for the postcrisis period, versus 0.924 for Treasuries and mortgage-backed securities.

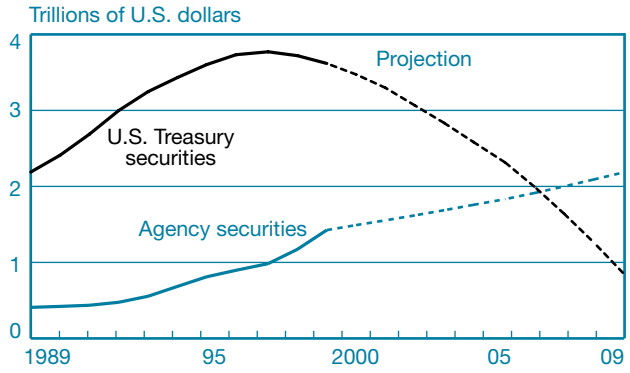
Agency market liquidity does not yet approach that of the U.S. Treasury market. As shown in Table 8, trading in agency coupon securities by the primary government securities dealers averaged $7.9 billion per day before the fall 1998 crisis, versus $183 billion in Treasury coupon securities. Trading in agency coupons increased to $10.7 billion per day after the crisis, while comparable Treasury trading fell, but agency coupon trading still equaled only 6.8 percent of postcrisis Treasury trading. Fannie Mae reports that its benchmark securities have liquidity comparable to off-the-run Treasury securities, with bid-ask spreads of 0.5 to 2.0 basis points (Fannie Mae 1999a).

An active overnight repo market in agency securities has developed, allowing market participants to borrow securities for hedging and trading purposes, although an active term repo market has not yet emerged. Agency issues sometimes trade on special, although typically still close to general collateral. As a result, Fannie Mae reports that its issues are largely unaffected by issue-specific differences in specialness or liquidity (Fannie Mae 1999a). Unlike the Treasury market, there is no futures market for agency securities.[17]

Agency debt securities are treated as benchmarks in a few respects. First, the yields on benchmark securities are used as

Chart 10

Historical and Projected Agency and U.S. Treasury Debt



Sources: Author's projections; U.S. Congressional Budget Office (CBO) projections; *Federal Reserve Bulletin* (various issues); *Treasury Bulletin* (various issues).

Notes: Figures are reported as of September 30, except for the 1999 agency debt figure, which is reported as of June 30. Treasury debt projections are the CBO's as of July 1999; they assume that current laws and policies remain unchanged and they exclude debt held in U.S. government accounts. Agency debt projections assume that the market grows at the same rate as the economy (according to CBO projections of GDP).

Table 7

Correlations of Fannie Mae Benchmark and Other Fixed-Income Yield Changes

Period	Investment-Grade Corporate	Mortgage-Backed Security	Swap	High-Yield Corporate	U.S. Treasury
Precrisis: Feb. 3, 1998-Aug. 14, 1998	0.948	0.926	0.976	0.422	0.976
Crisis: Aug. 14, 1998-Nov. 20, 1998	0.915	0.949	0.990	0.292	0.970
Postcrisis: Nov. 20, 1998-Oct. 29, 1999	0.934	0.954	0.983	0.450	0.956
Full sample: Feb. 3, 1998-Oct. 29, 1999	0.926	0.950	0.985	0.309	0.964

Source: Author's calculations, based on data from Bloomberg, Goldman Sachs, and Merrill Lynch.

Notes: The table reports the correlations of weekly yield changes between the on-the-run ten-year Fannie Mae benchmark note and the indicated index or security. The Fannie Mae benchmark yield is from Merrill Lynch, via Bloomberg. The investment-grade corporate yield is the industrials ten-year A2/A yield from Bloomberg. The mortgage-backed security yield is a weighted-average, option-adjusted yield calculated by Goldman Sachs. The swap rate is the ten-year semiannual fixed rate versus three-month LIBOR compiled by Bloomberg from various sources. The high-yield corporate yield is from Merrill Lynch's High-Yield Master Index, via Bloomberg.

barometers of the agency market for monitoring and analytical purposes. Second, agencies are used as hedging vehicles to a certain extent, particularly for mortgage-backed securities. Finally, at least one new debt issue has been priced relative to a benchmark agency security as of October 1999.[18]

Table 8

Agency and U.S. Treasury Coupon Security Trading Volume

Period	Agency Securities (Billions of U.S. Dollars)	U.S. Treasury Securities (Billions of U.S. Dollars)	Agency-U.S. Treasury Ratio (Percent)
Precrisis:			
Jan. 22, 1998-Aug. 12, 1998	7.9	183.3	4.4
	(1.3)	(29.1)	(0.8)
Crisis:			
Aug. 13, 1998-Nov. 18, 1998	9.5	223.1	4.3
	(1.2)	(34.1)	(0.6)
Postcrisis:			
Nov. 19, 1998-Oct. 27, 1999	10.7	156.7	6.8
	(3.0)	(25.8)	(1.8)
Full sample:			
Jan. 22, 1998-Oct. 27, 1999	9.6	175.2	5.7
	(2.7)	(36.5)	(1.9)

Source: Author's calculations, based on data from the Federal Reserve Bank of New York and *Federal Reserve Bulletin* (1999).

Notes: The table reports the means and standard deviations (in parentheses) of average daily coupon security trading volume (reported weekly) of the primary government securities dealers.

Several attributes favor the agency debt securities market as a benchmark market. Namely, the performance of agency securities is highly correlated with that of other spread products, and agencies—because of their credit risk—have the potential to be better pricing and hedging vehicles than Treasuries. The market is also reasonably liquid, agencies trade in an active overnight repo market, and agencies reportedly have been relatively unaffected by issue-specific differences in liquidity or specialness. Steps taken by the agencies to increase issuance sizes are likely to improve market liquidity, and the announcements of issuance schedules and the resulting predictability of agency issuance are likely to improve activity in the term repo market.[19]

Nevertheless, other attributes do not favor the agency debt securities market as a benchmark. Credit risk, for example, may cause agencies to trade in line with other spread products, but the presence of such risk also means that there is an idiosyncratic risk component to agency securities that could become important in the future. Market liquidity also does not compare with that of the Treasury market, the overnight repo market is less active than the Treasury market, the term repo market is not active at all, and there is not yet an agency futures market. Furthermore, while agency securities may not be affected by issue-specific differences in liquidity or repo market specialness, this condition may reflect the lack of demand among market participants to borrow and trade agency benchmark issues. If the popularity of agency benchmark securities increases, issue-specific differences may become more important.

The Corporate Debt Market

Corporate debt securities are issued to meet a variety of longer term corporate financing needs. Their credit risk varies significantly across issues, from relatively safe Aaa/AAA-rated issues to non–investment-grade Ba/B, B/B, and Caa/CCC issues. The corporate debt market is larger, but far more segmented, than the agency debt market, with debt outstanding totaling $2.9 trillion on September 30, 1999 (Bond Market Association 1999).

Corporate issuers recently have increased issuance sizes and regularity to appeal to investor demand for large, liquid issues. Ford Motor Company, in particular, announced its Global Landmark Securities (GlobLS) Program in June 1999, modeled on the programs of Fannie Mae and Freddie Mac. Under the program, Ford and its financing subsidiary, Ford Motor Credit Company, announced that they would bring offerings of at least $3 billion to market two to four times per year. Ford issued $8.6 billion in four parts in July 1999 as part of the program and $5 billion in a single part in October 1999.

While the Ford issuances are large by corporate standards, they are significantly less than those of the agencies. In 1999, through October, Ford issued $13.6 billion in its GlobLS Program, as opposed to roughly $40 billion each in the three largest agencies' benchmark programs. It is worth noting that Ford's issuances are constrained by the size of the company's balance sheet. Ford had debt outstanding of $144 billion on June 30, 1999 (Ford Motor Company 1999), versus $500 billion for Fannie Mae, $437 billion for the FHLBanks, and $314 billion for Freddie Mac (*Federal Reserve Bulletin* 1999).

Liquidity of the large Ford issues is reportedly favorable, with bid-ask spreads of 1 to 2 basis points, compared with 3 to 5 basis points for smaller issues of similar quality (*Bloomberg* 1999). There is no futures market for Ford or other corporate issues, and corporate issues are not actively traded in the repo market.

Ford GlobLS play a limited benchmark role in the corporate market. They are used as reference rates for monitoring the performance of the corporate market, for evaluating other outstanding corporate debt securities, and for helping to decide how other new corporate debt issues should be priced. Hedging activity using corporate issues is limited.

The corporate market's potential as a benchmark is limited by its fragmented nature, with the largest corporate issuers being smaller than the large agency issuers. Corporates also do not have the creditworthiness of the agencies (Ford is rated A1/A), so that firm-specific developments may be more important in explaining the performance of any particular issuer's securities. Nevertheless, the trend toward increased issuance sizes and regularity will likely increase the role of corporates as benchmarks for monitoring and analysis within the corporate market.

The Interest-Rate Swaps Market

An interest-rate swap is an agreement between two parties to exchange one stream of interest payments for another stream. The most common interest-rate swap is used to exchange fixed interest-rate payments for floating interest-rate payments for a given principal amount and period of time. The floating rate in such contracts is often based on the London Interbank Offer Rate (LIBOR)—the rate that banks charge one another for funds in the Eurodollar market.

Swap rates are quoted in terms of the fixed rate that must be paid to convert to a floating rate. At the close of September 30, 1999, for example, the quoted ten-year swap rate on Bloomberg was 6.85 percent. An entity therefore had to make semiannual fixed interest payments for ten years at an annual rate of 6.85 percent to get semiannual floating interest payments for ten years based on three-month LIBOR (for the same principal amount). Swap rates are often quoted relative to the Treasury benchmark, so that the ten-year spread on September 30 was quoted as 97 basis points (calculated as the 6.85 percent swap rate less the 5.88 percent yield on the on-the-run ten-year Treasury note). Swap rates exceed those on Treasuries mainly because the floating payments are based on a rate that contains credit risk (LIBOR is an Aa/AA rate).

Since they are based on a floating rate that contains credit risk, swap rates often change in line with yields on other spread products. Swap spreads thus widened sharply in fall 1998 along with those of corporates, agencies, and mortgage-backed securities, as shown in Chart 2. Correlations of weekly changes in ten-year swap rates with yields of other spread products, shown in Table 9, are close to those of Treasuries with other spread products (Table 1). The correlation with Fannie Mae's benchmark note, for example, is 0.985 for swaps, versus 0.964 for Treasuries (for the full sample period).

The interest-rate swaps market is very active, with narrow bid-ask spreads. A market survey by the Federal Reserve Bank of New York (1998) found daily trading in U.S. dollar interest-rate swaps to be $22 billion per day in April 1998.[20] Turnover is thus considerably higher than it is in agency coupon securities, but less than it is in Treasury securities. Bid-ask spreads on active contracts reportedly are about 1 basis point, somewhat wider than those on active Treasury securities.

The liquidity of the swaps market is hindered by counterparty credit risk. Counterparty credit risk is the risk that one's counterparty in a swap defaults on its end of the agreement. The risk is an obstacle to liquidity because, by

Table 9

Correlations of Swap Rate and Other Fixed-Income Yield Changes

Period	Investment-Grade Corporate	Mortgage-Backed Security	Fannie Mae Benchmark	High-Yield Corporate	U.S. Treasury
Precrisis: July 3, 1997-Aug. 14, 1998	0.960	0.942	0.976	0.527	0.987
Crisis: Aug. 14, 1998-Nov. 20, 1998	0.918	0.936	0.990	0.291	0.968
Postcrisis: Nov. 20, 1998-Oct. 29, 1999	0.941	0.954	0.983	0.454	0.961
Full sample: July 3, 1997-Oct. 29, 1999	0.938	0.946	0.985	0.346	0.970

Source: Author's calculations, based on data from Bloomberg, Goldman Sachs, and Merrill Lynch.

Notes: The table reports the correlations of weekly yield changes between the ten-year swap rate and the indicated index or security. Correlations with the Fannie Mae benchmark are limited to the period starting February 3, 1998. The swap rate is the semiannual fixed rate versus three-month LIBOR compiled by Bloomberg from various sources. The investment-grade corporate yield is the industrials ten-year A2/A yield from Bloomberg. The mortgage-backed security yield is a weighted-average, option-adjusted yield calculated by Goldman Sachs. The Fannie Mae benchmark yield is the on-the-run ten-year benchmark note yield from Merrill Lynch, via Bloomberg. The high-yield corporate yield is from Merrill Lynch's High-Yield Master Index, via Bloomberg.

definition, it depends on the parties involved in a transaction. A dealer that has engaged in a swap contract and wants to unwind it either has to go back to the original counterparty, which may not want to unwind, or find a third party to take its side of the swap—one that is also acceptable to the original counterparty. To mitigate counterparty credit risk, some dealers execute swaps out of credit-enhanced subsidiaries and structure swaps so that they automatically unwind if a party's Aaa/AAA credit rating is lost.

The absence of an underlying fundamental asset is also an advantage of the swaps market. There is no supply limit on swap contracts and no need to borrow securities to go short, as an entity can enter into as many swap contracts as it wants. Specific issue concerns are also mitigated by the nature of swaps. The ability to create a swap combined with the fungible nature of the underlying cash flows precludes swaps with the same or nearly the same cash flows from trading at widely different rates.

Swaps are used as benchmarks for hedging positions taken in other markets, including the agency debt, corporate debt, and mortgage-backed securities markets. They are used as well for analytical and monitoring purposes in evaluating the performance of other fixed-income markets. Swap rates are also used as reference rates for forecasting, for example, the path of LIBOR.

Several features favor the interest-rate swaps market as a benchmark. As the underlying floating rate has credit risk, the performance of swaps is highly correlated with that of other spread products, and swaps have the potential to be a better hedge than Treasuries. The absence of an underlying asset allows for dealers to take unlimited long or short positions without having to worry about obtaining securities in the repo market. These same features mitigate security-specific issues that might cause a particular maturity swap to deviate sharply from the performance of the whole swaps curve.

However, counterparty credit risk is a feature that does not favor the swaps market as a benchmark. Such risk means that swaps created by different parties have different risks and are not perfectly fungible. Lack of fungibility adversely affects liquidity. Market participants have taken steps to mitigate the effects of counterparty credit risk, but it remains a hindrance to the market's liquidity and to the market assuming a larger benchmark role.

Conclusion

The country's improved fiscal situation raises questions about the U.S. Treasury market's benchmark status. If projected budget surpluses materialize, they could lead to a significant reduction in the Treasury market's size and to a deterioration in the market's liquidity and efficiency. A less liquid and less efficient market would represent a less useful benchmark of risk-free interest rates as well as a less useful benchmark for pricing and hedging positions in other markets.

The financial markets crisis of fall 1998 heightened investors' concerns about the Treasury market's benchmark role and provided insight into how the market may perform in the future. A flight to quality into Treasury securities caused yields between Treasuries and other fixed-income securities to diverge. A related flight to liquidity also led yields among similar Treasury securities to diverge. Market liquidity also

declined, and the cost of borrowing securities through the repo market increased. After fall 1998, market conditions did not quickly return to precrisis levels, possibly reflecting a more general decline in fixed-income liquidity as well as a continued high demand among market participants for benchmark Treasuries.

Other fixed-income markets—including the agency debt, corporate debt, and interest-rate swaps markets—have demonstrated some of the characteristics that potentially make them suitable benchmarks for pricing and hedging purposes. Furthermore, the attributes that are favorable to a benchmark have been improving in the agency and corporate debt markets as benchmark debt issuance programs are expanding and steps are being taken to develop repo market activity. At this point, the agency debt and swaps markets are already assuming a limited benchmark role as hedging vehicles and as reference yields for market monitoring and analytical purposes.

Endnotes

1. For recent reviews of the U.S. Treasury market, see Dupont and Sack (1999) and Fabozzi and Fleming (forthcoming).

2. In contrast, floating-rate issues typically are priced relative to the London Interbank Offer Rate (LIBOR), the short-term rate charged among banks in the Eurodollar market. A recent issue of Daimler-Chrysler AG, for example, had a three-year floating-rate portion priced relative to three-month LIBOR along with five-year and ten-year fixed-rate portions priced relative to comparable Treasuries (*Wall Street Journal* 1999b).

3. Debt held by the public excludes $2.0 trillion held in U.S. government accounts. Debt figures are from the U.S. Congressional Budget Office (1999) and *Treasury Bulletin* (1999).

4. Significant debt management changes typically are announced at the Treasury's Quarterly Refunding Press Conferences. The press releases for such conferences are posted at http://www.treas.gov/press/releases. Also see U.S. General Accounting Office (1999) for a more extensive discussion of recent changes in Treasury debt management.

5. The buyback rules are described in detail in the Federal Register and are available at http://www.publicdebt.treas.gov/gsr/gsrbuyback.htm.

6. In fact, in February 2000, the Treasury announced a number of additional debt management changes at its Quarterly Refunding Press Conference, including a reduction in the issuance frequency of one-year bills from every four weeks to four times per year. This followed the release of a CBO budget and economic outlook in January 2000 that projected even larger surpluses over the next ten years.

7. See Bank for International Settlements (1999) for an analysis of the events of fall 1998.

8. The precrisis, crisis, and postcrisis time periods are defined somewhat arbitrarily. The precrisis period runs from July 1, 1997, through August 14, 1998—the Friday preceding the Russian effective default and ruble devaluation on August 17, 1998. The crisis period runs from the close of August 14, 1998, through November 20, 1998—the Friday after the Federal Reserve System's third and final fed funds target-rate cut of 1998, on November 17. The postcrisis period runs from the close of November 20, 1998, through October 29, 1999.

9. It is possible that such subperiod correlations mask a shift in the relationship among yield changes between periods. To test this possibility, we also estimated correlations between actual yield changes and the yield changes predicted for a security from a least-squares regression of that security's yield changes on Treasury yield changes for the preceding ten weeks. These correlations are similar to those reported in Table 1 and are therefore not reported separately.

10. Volatility was estimated on a daily basis over the full sample period using a GARCH(1,1) model of on-the-run ten-year note yield changes. Predicted volatility from this model helps explain the variation in both bid-ask spreads and quoted depths. However, dummy variables representing the crisis and postcrisis periods remain highly significant explanatory variables, even after controlling for predicted volatility.

11. The comparable off-the-run yield is calculated as the yield predicted for the on-the-run security from a model of the yield curve estimated with off-the-run prices. The model is estimated using a flexible functional form proposed by Fisher, Nychka, and Zervos (1995) in which a set of simple functions (cubic splines) covering different maturity ranges are used to describe the zero curve. The model is estimated to fit Treasury bid prices, excluding the two most recently issued securities of a given maturity, securities with less than thirty-one days to maturity, callable bonds, flower bonds, and inflation-indexed securities.

12. The increased relative value of on-the-run securities also likely reflected the securities' increased specialness in the repo market. The relationship between Treasury security value and specialness is discussed and documented in Duffie (1996) and Jordan and Jordan (1997).

13. The predicted yields are estimated according to the process described in endnote 11. The median is estimated daily for off-the-run notes and bonds with more than thirty days to maturity, excluding callable bonds, flower bonds, and inflation-indexed securities.

14. The premium afforded to liquid on-the-run securities may explain why some market participants started using off-the-run Treasury yields for pricing corporate securities and as market barometers (*Wall Street Journal* 1999a). Unfortunately, the same feature that may make off-the-run Treasuries a better gauge of Treasury market performance—their relative lack of liquidity—also makes them poor vehicles for hedging purposes as well as more susceptible to idiosyncratic price changes.

15. See Fabozzi and Fleming (forthcoming) for a recent review of the agency debt securities market.

16. Fannie Mae stated that "the liquidity of the benchmark notes combined with the outstanding credit quality should cause benchmark notes to be viewed by many investors as a higher yielding alternative to off-the-run Treasuries" (http://www.fanniemae.com/markets/debt/benchmark_prod.html). Freddie Mac indicated that "the fundamental characteristics of reference notes are designed to appeal to investors seeking alternatives to the declining supply of U.S. Treasury notes and bonds" (http://www.freddiemac.com/debt/html/borrowprog.html). Finally, the FHLBanks remarked that "TAP issues have many of the properties of U.S. Treasuries" (Federal Home Loan Banks 1999).

17. However, in January 2000, both the Chicago Board of Trade and the Chicago Mercantile Exchange announced plans to list agency note futures and options contracts.

18. In August 1999, a new issue of Private Export Funding Corp. was marketed in terms of Fannie Mae's benchmark ten-year note, reportedly the first private debt issue priced off an agency security (*Wall Street Journal* 1999c).

19. Freddie Mac, for example, announced a financing calendar in June 1999 (Freddie Mac 1999) and Fannie Mae announced a goal of $6-$8 billion issuance sizes for new benchmark notes in October 1999 (Fannie Mae 1999c).

20. Note that this is the average notional principal amount on which parties agreed to exchange interest payments, rather than the value of securities traded.

References

Bank for International Settlements. 1999. "A Review of Financial Market Events in Autumn 1998." October.

Bloomberg. 1999. "Ford Credit's $5 Billion Sale Taps Demand for Big Issues." October 21.

Bond Market Association. 1999. Research Quarterly (November).

Bureau of the Public Debt. 1999. "Summary of Public Debt Outstanding." October 31.

Duffie, Darrell. 1996. "Special Repo Rates." Journal of Finance 51, no. 2 : 493-526.

Dupont, Dominique, and Brian Sack. 1999. "The Treasury Securities Market: Overview and Recent Developments." Federal Reserve Bulletin 85, no. 12 (December): 785-806.

Fabozzi, Frank J., and Michael J. Fleming. Forthcoming. "U.S. Treasury and Agency Securities." In Frank J. Fabozzi, ed., The Handbook of Fixed Income Securities. 6th ed. New York: McGraw-Hill.

Fannie Mae. 1999a. "Using the Fannie Mae Bullet Benchmark Securities Yield Curve as a Market Pricing Reference." Fundingnotes 4 (September).

———. 1999b. "Fannie Mae Makes Enhancements to the Benchmark Securities Program." Fundingnotes 4 (October).

———. 1999c. "Fannie Mae Announces Monthly Calendar for Issuance of Bullet Benchmark Securities Spanning Yield Curve." News release, October 21.

Federal Home Loan Banks. Office of Finance. 1999. "Investors and Dealers Embrace the New FHLBank Program." OF Interest (November).

Federal Reserve Bank of New York. 1998. "Foreign Exchange and Interest Rate Derivatives Market Survey: Turnover in the United States." September 29.

Federal Reserve Bulletin. Various issues.

———. 1999. November.

Fisher, Mark, Douglas Nychka, and David Zervos. 1995. "Fitting the Term Structure of Interest Rates with Smoothing Splines." Board of Governors of the Federal Reserve System Finance and Economics Discussion Series no. 95-1, January.

Ford Motor Company. 1999. "Quarterly Report, 1999 2nd Quarter." News release, July 14.

Freddie Mac. 1999. "Freddie Mac Announces New Reference Note Financing Calendar." News release, June 8.

Jordan, Bradford D., and Susan D. Jordan. 1997. "Special Repo Rates: An Empirical Analysis." Journal of Finance 52, no. 5: 2051-72.

Treasury Bulletin. Various issues.

———. 1999. September.

U.S. Congressional Budget Office. 1999. "The Economic and Budget Outlook: An Update." July 1.

U.S. General Accounting Office. 1999. "Federal Debt: Debt Management in a Period of Budget Surplus." Report no. AIMD-99-270, September.

Wall Street Journal. 1999a. "Quirk in Yields Is Making Bonds More Attractive." February 2.

———. 1999b. "Treasurys' Trading Volume Is Down Sharply amid Budget Surplus, Weak Market for Bonds." August 17.

———. 1999c. "Bonds Sustain Rally on Low Inflation, Expectation of Fed Restraint on Rates." August 26.