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8 Institutional and Regulatory Influences on Price Discovery in Cash and Futures Bond Markets

Kenneth J. Singleton

8.1 Introduction

Compared to the U.S. Treasury bond (UST) market, the Japanese (JGB) and German (GGB) cash bond markets are illiquid, face more institutional "frictions" in the market-making process, and evidence a larger impact of accounting standards and regulatory restrictions on the trading strategies of final investors. Though the details of the corresponding bond futures contracts differ, there is at the same time notable similarity in the liquidities of these futures contracts. Indeed, all three contracts are among the most liquid financial instruments traded globally. This paper explores the implications of the differences in institutional frictions in cash bond markets for the joint distributions of futures and cash bond prices and, in particular, for the role of futures in the price discovery process for government bonds.

Institutional arrangements typically change slowly over time, so identification of the effects of particular frictions from a single time series for a given country is often tenuous. Accordingly, I examine securities prices that are stratified along several dimensions. First, I consider three countries that are at different stages of the financial liberalization process and have different market organizations. There are also substantial differences in the costs of market making, which include the costs of financing and hedging the risks of positions; in accounting practices, which in some cases induce preferences for par bonds and affect attitudes toward coupon versus capital gain income; and in the objectives of portfolio managers and the implied trading practices.

Second, the distributions of futures prices are compared with those of deliverable and nondeliverable bond prices and, within the deliverable sectors in

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Germany and the United States, the prices of bonds with the same maturity but different deliverability status. These comparisons reveal insights into the nature of illiquidity in the cash markets and the role of futures as a price discovery vehicle for illiquid bonds. The differences in liquidities of government bonds across the three countries are large and certainly much greater than the differences that one typically sees within the UST market. I interpret these differences and the associated differences in the distributions of bond prices in the light of the differences in institutionalized frictions.

The nature of informational *spillovers* from futures to cash prices has been widely studied at the individual market level (see, e.g., Stoll and Whaley [1990]; Schwarz and Laatsch [1991]; and Quan [1992]). To the extent that the implications of regulatory constraints for price behavior have been examined, the focus has typically been on such "micro" factors within futures markets as margin requirements, within-day price limits, and so forth. Much less attention has been given to comparative analysis of the implications of the broader "macro" frictions outlined above for the joint distribution of cash and futures prices. Surely both types of frictions are important, though their effects may manifest themselves over different time frames. The daily and weekly data studied in this paper are well suited to investigating the effects of institutional frictions on cash and futures relations that persist over days at the expense of identification of the effects of frictions that only affect within-day cash and futures price changes.

Though institutional frictions in cash markets might be expected to affect significantly the joint distribution of cash and futures prices, the nature of these effects does not seem a priori obvious. Consider for instance the relation between the prices of a futures contract and an underlying deliverable bond. Frictions in the cash market that limit exploitation of deviations from the *cost-of-carry* relation might lead one to expect systematic violations of this "arbitrage" relation. On the other hand, the same frictions may compromise price discovery in the cash market to the extent that the market's pricing of cash instruments may be directly linked to the futures through the cost-of-carry relation. Indeed, I find that both scenarios occurred in the JGB and GGB markets during the sample period.

No attempt is made to develop a formal model of price discovery in the presence of institutional frictions. Rather, this study represents an effort to characterize the properties of the distributions of cash and futures prices in order to guide such modeling efforts in the future. In section 8.2, I begin by comparing the institutional environments in which cash trading takes place in the United States, Germany, and Japan. Then descriptive statistics for the yields on government bonds are presented and interpreted in the light of the background discussion on market structure. Comparing across the maturity spectrum within a bond market, the yield distributions are found to be notably different in Germany and Japan depending on whether the maturity of a bond meets the criteria for deliverability into a futures contract. The markets in Germany and the United States also permit comparisons of yield distributions for bonds with identical maturities but different deliverability status. Overall, the findings from this preliminary analysis suggest that the presence of a liquid futures market has a significant effect on the distributions of cash bond yields.

In section 8.3, I overview the structure of the primary bond futures markets in the three countries. Then descriptive statistics for futures prices and the prices of individual deliverable bonds are presented and compared. Cash prices for deliverable bonds appear to inherit the distributional characteristics of futures prices, especially in Germany and Japan. More direct evidence that futures are central to price discovery in the presence of illiquid cash markets is presented for Japan, where at times cash bonds throughout the deliverable sector were priced directly off futures in terms of conversion-factor adjusted prices.[1]

Concluding remarks are presented in section 8.4.

8.2 Structural Impediments to Price Discovery in Cash Bond Markets

The *price discovery process* for newly issued bonds is accomplished through an auction with a known price (par) or coupon. The resulting yields embody all of the information about bond markets used by traders in formulating investment decisions, as well as their own attitudes toward risk and the constraints they face in making portfolio allocations. The constraints include not only the limit of each trader's wealth, but also the legal and accounting regulations that might limit participation of some types of traders in the cash market or limit their ability to hedge cash positions with derivative products.

Subsequently in the secondary markets, price discovery is accomplished through organized trading in over-the-counter (OTC) markets. The markets for bonds are not all equally liquid or deep across the maturity spectrum. While many factors contribute to the liquidity of secondary markets, I focus on three: (1) issuing patterns in the primary market, (2) the costs of financing positions for dealers making markets, and (3) accounting standards that influence secondary market trading by final investors.

Regular issuance at a specific maturity in relatively large size through auctions provides a natural set of "benchmark" or reference bonds, relative to which other bonds with comparable characteristics can be valued. Moreover, dealers have an incentive to maintain an active secondary market and accurate price discovery following a new auction as they place their bonds. Subsequently, large issue sizes facilitate market participation by a wide variety of investors with different portfolio strategies and anticipated holding periods. Indeed, final investors who follow portfolio strategies with high turnover rates may prefer (collectively as an equilibrium) to trade primarily in the *on-the-run*

1. This characteristic of the Japanese market was noted by Kikugawa and Singleton (1994) and interpreted in terms of the relative liquidity of the cash versus futures markets in Japan.

issues because a concentration of trading in these issues allows dealers to quote at relatively narrow spreads for large size.[2]

Table 8.1 displays the maturities and frequencies of the auctions in the three countries we are considering. The United States has the largest number of maturity points at which new bonds are issued and the most regular issue calendar (at least quarterly). Newly issued, on-the-run bonds serve as pricing benchmarks. The liquidity premiums associated with the benchmark status of these bonds are typically on the order of five to eight basis points (bp).

Several different federal bonds are issued in Germany.[3] BUNDs (*Bundesanleihe*) are issued on an irregular basis with maturities of eight to thirty years. Most of the issuance has had a ten-year maturity, and issues with maturities over ten years have been rare. Historically the issue sizes of BUNDs have been quite small, ranging from DM2 to DM4 billion. However, starting in 1990, the federal issuing authorities increased the issue sizes and started augmenting existing issues rather than always opening new issues. Consequently, the issue sizes have grown substantially and now regularly exceed DM10 billion. This change in issuing policy has contributed substantially to the liquidity of the BUND markets. New issue premiums are ten to fifteen bp in the five-year sector, and have been closer to twenty bp in the ten-year sector. Irregular issuance remains a limiting factor in price discovery and liquidity, however, as the values of both the option to retrade and the delivery option associated with the futures contract may be affected by the uncertainty surrounding new issue announcements.[4]

BOBLs (*Bundesobligationen*) are issued on an irregular schedule in sizes between DM4 and DM10 billion (a minimum issue size of DM4 billion is required for the bond to satisfy the delivery criteria into the Deutsche Terminbörse [DTB] five-year futures contract). SCHATZs (*Bundesschatzanweisungen*) are issued bimonthly and may have maturities of one to seven years, though most issues are in the four- to five-year maturity sector with typical sizes of about DM5–6 billion. The reference bonds for the under-five-year maturity bonds are current or seasoned issues of these medium-term notes. There are large differences in liquidity among reference and off-the-run bonds at the short end of the German yield curve, with BUNDs under five years to maturity being particularly illiquid. Traders sometimes express the view that the liquidity of the cash market compares more favorably with the futures in the five-year than in the ten-year sector in Germany. The regular issue calendar may be a factor underlying this view.

Until recently, all of the JGB issuance with maturity less than ten years was

2. The notion that the right to retrade in a liquid market lowers yields relative to otherwise equivalent illiquid bonds is proposed by Amihud and Mendelson (1991), among others, as an explanation of the spreads between bill and seasoned bond yields of the same maturity in the UST market.

3. See McLean (1993) for an overview of the structure of the German bond market.

4. Since unification of East and West Germany, Unity bonds have been issued with ten-year maturities that are essentially equivalent to BUNDs. And Treuhand bonds have been issued in both the ten- and five-year sectors. Though Treuhands and TROBLs (as the five-year issues are called)

Table 8.1 **Structure of Government Bond Markets**

	Auctions		Futures		
	Maturity	Frequency	Maturity	Deliverables	Taxes
United States	2	Monthly	CBT 5 yr	5 yr	None
	3	Quarterly	CBT 10 yr	6 1/2–10 yr	
	4	Quarterly	CBT Bond	15–30 yr	
	5	Quarterly			
	7	Quarterly			
	10	Quarterly			
	30	Quarterly			
Germany	SCHATZ 1–7	Bimonthly	DTB 5 yr	3 1/2–5 yr	Withholding
			LIFFE 5 yr		
	BOBL 5	Irregular	LIFFE 10 yr	8 1/2–10 yr	
	BUND 8–30	Irregular	DTB 10 yr		
Japan	4	Monthly	JGB 10 yr	7–11 yr	Transactions
	6	Irregular			
	10	Monthly			Withholding
	20	Irregular			

Notes: CBT denotes Chicago Board of Trade futures, and *CBT Bond* is the futures on the long bond. *DTB* denotes the Deutsche Terminbörse, and *LIFFE* denotes the London International Financial Futures Exchange.

issued with an original maturity of ten years. Starting in November 1993, the Japanese Ministry of Finance has issued a four-year bond and more recently has started issuing six-year bonds. The issuing process in Japan is closely linked to the annual fiscal plans by the Ministry of Finance. Projections are made in December each year for the following fiscal year starting in March. Ten-year and four-year bonds are auctioned monthly, though the exact amount and coupon may not be known long in advance, since the Ministry of Finance adjusts issue sizes depending on its views about the impact of supply on the market at the time of issuance. The six-year issues have been on an irregular schedule.

The benchmark selection process in Japan is different. Though newly issued ten-year bonds often trade at a premium to their seasoned counterparts, these bonds are not the most liquid in their sector. Instead there is a specific bond—typically between eight and ten years to maturity—which is designated as the benchmark bond. A majority of the trading volume in all JGBs is concentrated in this one bond. As a consequence, this bond trades at a lower yield (rich) to JGBs with similar maturities, with the difference occasionally reaching more than twenty bp. This "benchmark premium" fluctuates substantially over time, so there is no simple relation between the yield on the benchmark and other

are guaranteed by the German government and deliverable into the associated futures contracts, they are not treated as equivalent by the market and often trade at relatively high yields (cheap) compared to their BUND or BOBL counterparts.

off-the-run bonds. Partly as a consequence, the JGB benchmark does not serve as the primary benchmark for price discovery of other JGBs.[5] Instead, the *on-the-run* ten-year and ex-benchmark bonds serve as key reference bonds for pricing. Ex-benchmarks play a key role in price discovery since they have relatively large issue sizes and, after losing their benchmark status, they maintain some of their liquidity relative to bonds that were never benchmarks. There are now ex-benchmark bonds along the entire maturity spectrum under ten years.

A tentative issuing plan for twenty-year bonds is also developed in December, but the issuing calendar is irregular, with new issues announced usually within a month of the auction. In the superlong (twenty-year) sector, certain bonds among those with the larger issue sizes have emerged as reference bonds for pricing and evaluating the shape of the yield curve. The typical issue size and the trading volumes in these bonds are small compared to the JGB benchmark, though recently the turnover in the secondary market for superlongs has at times been as high or higher than some ex-benchmarks.

Large issue sizes and regular issue calendars are not sufficient to guarantee that the market for a bond will be liquid or deep. Another important consideration is the dealers' cost of making markets. One particularly important influence on a dealer's cost structure is the inventory position that a dealer maintains for facilitating flow trading. Limited secondary trading in a bond may influence both the ability of dealers to satisfy demand for this bond and their willingness to absorb large blocks from sellers. Neither consideration would be a major issue if dealers were willing to maintain large inventories of individual bonds. However, these positions must be hedged against interest rate risk. Furthermore, large inventories tie up financing lines, lead to regulatory capital charges, and may affect the dealer's credit rating.

These costs can be largely avoided in the presence of an active bond borrowing and lending market, as dealers can efficiently carry small inventory positions. Borrowing of bonds can be effected in two ways: buy/sell agreements in which the purchase and sale prices are determined on the agreement date with a difference that reflects the borrowing rate, and a repo agreement, which is essentially a collateralized loan for which title to the bonds does not change hands. The repo market is well established in the United States and is actively used by dealers for financing their inventory positions. Bond lending is also viewed as an important source of portfolio yield enhancement by institutional investors. These borrowing markets are somewhat less developed in Germany. Both buy/sell and repo arrangements are available, with the former being the most common.

Japan has the least well developed borrowing/lending market. There is no repo market; all borrowing is based on a buy/sell arrangement. Moreover, a dealer cannot "fail"—fail to deliver bonds on the settlement date—in Japan.

5. This is not to suggest that market participants do not condition on the yield on the benchmark when setting prices of nonbenchmark bonds, but rather that other bonds are likely to serve as the primary pricing benchmarks.

While failing is a last resort and costly action, the possibility of failure facilitates a dealer's efforts at making active markets in bonds. Potential sources of bonds for borrowing are also somewhat limited by internal policies of financial institutions or regulatory considerations. For instance, banks that lend bonds must treat this activity as a risky loan with a 100 percent risk weighting under international capital standards, and, consequently, they may be reluctant to lend around fiscal year ends.

Investment practices by final investors have several additional significant effects on the liquidity of bond markets. In all three markets, there is some tendency for institutional investors to hold (with limited intentions of selling) newly acquired bonds in their portfolios. The motivations for this activity vary across countries as does their importance for the overall level of trading activity in secondary markets. In the United States, most institutional accounts must mark to market their bond portfolios on a regular basis. Therefore, buy/sell decisions are made in terms of current market values. In contrast, in both Germany and Japan, many accounts carry bonds at book value. Consequently, accepted accounting standards may discourage investors from selling bonds at below book value and, thereby, contribute to a buy and hold approach to portfolio management. Buy and hold investment strategies reduce the effective supplies of bonds into the market.

There are also institutionally induced preferences for high coupon bonds in Japan, associated in large part with the requirement that insurance companies pay most policy dividends from coupon income and not capital gain income. Similarly, tax policies in Germany induce a preference for low coupon bonds so that a larger share of a bond's total return is in the form of a capital gain. At times, these coupon effects manifest themselves as notable spreads between otherwise equivalent high and low coupon bonds.

Related accounting standards also increase the desire for par bonds. In Germany, bonds purchased above par must be booked at par, so that the capital loss implicit in the premium over par must be realized immediately for accounting purposes. A similar accounting "friction" exists in Japan: for bonds purchased at a discount, investors can include only the coupon payment in current income (they must defer accretion to par); for bonds purchased at a premium, they must amortize the premium, and this amortization overstates the economic reduction in value associated with the passage of time. Consequently, there is an accounting bias toward par bonds, with premium bonds tending to trade cheaply relative to otherwise comparable low coupon bonds when both are selling at a premium, and vice versa when both are discounted.

In summary, there are notable differences in institutional factors affecting price discovery in the United States, Germany, and Japan. Consequently, the nature of the benchmarks that market participants use for assessing value in the cash markets varies across markets. So does the quality of the benchmarks, in the sense that not all benchmarks are equally free of important institutional effects that may lead a reference bond to be valued implicitly by a different discount function than a nonbenchmark with comparable maturity.

If the institutional frictions outlined above have significant effects on the price discovery process, then, in light of the differences across countries, one might expect the distributions of bond yields also to differ. To investigate this possibility, descriptive statistics for a cross-section of bonds along the maturity spectrums were computed using daily and weekly data over the period October 1, 1991, through November 30, 1993. The characteristics of the bonds selected for the three countries are presented in table 8.2. When a choice was available, UST bonds with above-average issue sizes were selected among those with similar maturities.[6] In addition to a cross-section of bonds across the maturity spectrum, pairs of bonds with identical or nearly identical maturities, but different status regarding deliverability into the five- and ten-year futures, were examined. This comparison is possible because bonds that are deliverable into the five- and ten-year contracts must have an original issue maturity that satisfies the delivery criterion. To make this comparison, the sample periods for some bonds were shorter than the full sample, since over the two-year sample period some bonds that were deliverable lost their deliverability status. The delivery status of the bonds is indicated in the last column of table 8.2.[7] Similar criteria were used in selecting GGBs, and similar comparisons are possible. In addition, we compare the distributions of short-term BOBLs and BUNDs, none of which are deliverable into the five-year futures.

In the case of Japan, we chose ex-benchmark bonds since they serve as the local benchmark bonds along the yield curve.[8] All JGBs satisfying the maturity criterion are deliverable, so a deliverable/nondeliverable comparison is not possible.

All of the statistics are for the first differences of the logarithms of bond yields. In the cases of the United States and Japan, yields are measured on a bond equivalent yield basis, and for Germany, quoted yields were used. Results for daily and weekly data are displayed in tables 8.3 and 8.4, respectively. There is a tendency for the annualized standard deviations to decline with maturity (table 8.3). In the cases of the United States and Germany, the values of the standard deviation for daily and weekly data are comparable (compare tables 8.3 and 8.4). However, the volatilities of bond yields in Japan tend to be larger for the weekly data than for the daily. This suggests that the changes in bond yields exhibit little autocorrelation in the United States and Germany, but are positively autocorrelated in Japan.

The first-order autocorrelations of yield changes are displayed in the rows labeled ρ. In fact, in the United States and Germany, the daily autocorrelations are typically less than .1 in absolute value, though there is some evidence that

6. Yields for the on-the-runs were typically not selected, because of the need to have a yield history for calculating the statistics.

7. See section 8.3 for a description of the available futures contracts in each country and their delivery requirements.

8. Kikugawa and Singleton (1994) present similar descriptive statistics for the case of JGBs for an earlier sample period. They find similar patterns to those described subsequently.

Table 8.2 **Characteristics of Bonds**

Maturity	Coupon	Issue Date	Issue Size (million)	Comments[b]
		U.S. Treasury Bonds[a]		
5/15/95	5.875	5/15/92	$15,086	ND
5/15/96	7.375	5/15/86	$20,085	ND
4/30/97	6.875	4/30/92	$10,256	ND
4/30/98	5.125	4/30/93	$11,024	CBT 5 yr
4/15/98	7.875	4/15/91	$ 8,534	ND
4/15/99	7.000	4/15/92		ND
8/15/00	8.750	8/15/90	$10,503	CBT 10 yr
11/15/01	7.500	11/15/91	$12,004	CBT 10 yr
11/15/01	15.750	10/07/81	$ 1,800	ND
2/15/15	11.250	2/15/85	$12,667	CBT Bond
8/15/21	8.125	8/15/91	$12,008	CBT Bond
		German Government Bonds		
7/20/95	8.750	7/20/90	DM 8	BOBL92, ND
7/20/95	6.750	7/20/85	DM 2	BUND, ND
4/22/96	8.500	4/22/91	DM 10	BOBL96, ND
6/20/96	5.750	6/20/86	DM 3	BUND, ND
7/21/97	8.250	7/21/92	DM 10	BOBL00, DTB 5 yr
7/21/97	6.125	7/21/87	DM 4	BUND, ND
12/22/97	7.000	12/22/92	DM 10	BOBL04, DBT 5 yr
1/20/98	6.375	1/20/88	DM 4	BUND, ND
6/21/99	6.750	6/21/89	DM 4	BUND, ND
8/21/00	8.500	8/21/90	DM 8	BUND, ND
9/20/01	8.250	9/20/91	DM 18	BUND, LIFFE 10 yr
7/22/02	8.000	7/22/92	DM 15	BUND, LIFFE 10 yr
		Japanese Government Bonds		
7/20/95	6.20	8/20/85	¥1,300	#78, ND
6/20/96	5.10	4/25/86	¥2,707	#89, ND
6/20/97	4.70	4/20/87	¥1,400	#99, ND
6/22/98	4.60	4/25/88	¥2,000	#111, ND
6/21/99	4.80	3/20/89	¥1,852	#119, ND
3/20/00	6.40	3/20/90	¥2,300	#129, TSE 10 yr
6/20/01	6.60	4/22/91	¥2,400	#140, TSE 10 yr
3/20/02	5.50	1/27/92	¥3,200	#145, TSE 10 yr
3/20/07	5.70	10/20/86	¥1,008	#S02, ND
3/20/09	4.90	2/20/89	¥ 411	#S10, ND

[a]All bonds are noncallable.

[b]*ND* denotes not deliverable into a futures contract. *CBT* denotes Chicago Board of Trade futures, and *CBT Bond* is the futures on the long bond. *DTB* denotes the Deutsche Terminbörse, *LIFFE* denotes the London International Financial Futures Exchange, and *TSE* denotes the Tokyo Stock Exchange.

Table 8.3 **Descriptive Statistics for Daily Yield Changes, October 1, 1991–November 30, 1993**

United States

Security	5/95	5/96	4/97	4/98	4/99	8/00	11/01	2/15	8/21
Standard deviation	.22	.18	.18	.16	.16	.15	.13	.10	.09
				.16			.13		
Kurtosis	4.27	4.10	3.85	3.49	3.82	3.80	3.62	3.36	3.47
				3.76			3.58		
ρ	.06	.08*	.08*	.07	.07	.10*	.09*	.01	.03
				.11*			.09*		

Germany

Security	BOBL92 BUND	BOBL94 BUND	BOBL00 BUND	BOBL04 BUND	BUND	BUND	BUND	BUND
Standard deviation	.11	.11	.12	.11	.08	.07	.08	.08
	.13	.11	.10	.08				
Kurtosis	5.37	4.82	3.72	2.77	4.35	3.65	3.84	3.34
	7.32	4.62	5.34	5.43				
ρ	.01	.00	−.08	−.05	.01	.05	−.02	.02
	−.10	−.05	−.11	.09				

Japan

Security	78	89	99	111	119	129	140	145	S02	S10
Standard deviation	.13	.15	.15	.15	.14	.14	.13	.12	.08	.07
Kurtosis	12.33	9.83	8.04	6.59	6.70	5.51	4.86	4.24	5.26	5.02
ρ	.40**	.31**	.28**	.20**	.18**	.08	.05	.07	.19**	.26**

Notes: ρ denotes the first-order autocorrelation coefficient. * (**) denotes rejection of the null hypothesis of zero autocorrelation at the 5 percent (1 percent) level, using heteroskedastic standard errors (Hansen 1982).

the low autocorrelation in daily U.S. data is statistically significant. The autocorrelations in the short-term BUNDs are also larger in absolute value than the autocorrelations of the corresponding BOBLs, but none of these estimates is statistically significant at conventional levels. In contrast, yield changes in Japan exhibit substantial positive autocorrelation, with ρ often larger than .2. In all three countries, there is little evidence of autocorrelation in the weekly data, which suggests that the sources of persistence in Japan have effects that dissipate within a week.

The kurtoses (K) of the daily data are larger than three in all three countries, indicating that the distributions of yield changes have fatter tails than a normal.[9] The values of K for the United States are generally smaller than the corre-

9. The kurtosis measures the shape of the tail region of a distribution. A kurtosis greater than three indicates that the probability of a "tail event"—that is, a very large positive or negative yield change—is higher in the sample than in a normal distribution with the same mean and variance.

Table 8.4 **Descriptive Statistics for Weekly Yield Changes, October 4, 1991–November 26, 1993**

United States

Security	5/95	5/96	4/97	4/98	4/99	8/00	11/01	2/15	8/21
Standard deviation	.22	.19	.18	.18 .17	.16	.15	.14 .14	.11	.10
Kurtosis	3.40	3.32	3.11	2.92 3.01	3.41	3.45	3.32 3.39	3.06	3.09
ρ	.01	.04	−.05	.06 −.01	−.11	−.07	−.04 −.04	−.07	−.03

Germany

Security	BOBL92 BUND	BOBL94 BUND	BOBL00 BUND	BOBL04 BUND	BUND	BUND	BUND	BUND
Standard deviation	.12 .13	.11 .12	.11 .10	.10 .10	.09	.08	.09	.09
Kurtosis	6.41 6.16	5.29 5.68	2.80 5.71	3.15 6.15	5.71	3.89	3.74	3.44
ρ	.01 −.05	.04 −.05	−.08 .10	−.13 .10	.08	.06	.02	−.01

Japan

Security	78	89	99	111	119	129	140	145	S01	S10
Standard deviation	.17	.18	.18	.16	.15	.14	.12	.11	.09	.09
Kurtosis	6.76	7.32	6.17	5.50	4.66	5.80	6.31	5.90	3.68	4.47
ρ	.16	.02	−.02	−.07	−.04	−.09	−.11	.02	.16	.20*

Notes: ρ denotes the first-order autocorrelation coefficient. *denotes rejection of the null hypothesis of zero autocorrelation at the 5 percent level, using heteroskedastic standard errors (Hansen 1982).

sponding values for Germany and Japan. The smaller values of K for the weekly U.S. data compared to the daily data suggest that the daily data may be nonnormal.

The estimates of K for GGB and JGB yields are often much larger than three, especially for JGB yields. Furthermore, the sample kurtoses of the bonds with the highest values of K in the daily data also have estimated values of K much larger than three in the weekly data. Thus, the relatively high probabilities of large positive or negative yield changes in Germany and Japan seem to be associated with events that impact yields for at least a week. These comparisons are, of course, subject to the well-known caveat that kurtosis is determined by the fourth moment of a distribution, and fourth moments are difficult to estimate accurately.

Additional interesting patterns emerge when the results for different bonds with similar maturities are compared. In the United States, the pairs of bonds

Table 8.5 Futures Contract Specifications

	Contract	Size	Notional Coupon (%)	Deliverable Maturities (years)	Average Volume[a] 11/93	Average Open Interest[a] 11/93
CBT	5 yr note	$100,000	8	4.25–5.25	45,188	180,630
CBT	10 yr note	$100,000	8	6.5–10.0	91,717	273,295
CBT	BOND	$100,000	8	15.0–30.0	390,114	339,690
DTB	BOBL	DM250,000	6	3.50–5.0	18,693	126,914
LIFFE	BOBL	DM250,000	6	3.50–5.0	2,850	23,239
DTB	BUND	DM250,000	6	8.50–10.0	40,076	111,871
LIFFE	BUND	DM250,000	6	8.50–10.0	100,330	176,636
TSE	10 yr	¥100 million	6	7.0–11.0	59,925	NA

[a]Average volume and open interest is a daily average for all contracts available for each futures.

with maturities April 1998 and November 2001 include one deliverable and one nondeliverable bond for the associated futures contracts.[10] The results for each pair are virtually indistinguishable using both daily and weekly data.

In the case of Germany, the first two pair of BOBLs and BUNDs have similar maturities, but neither is deliverable into a futures contract. The BOBLs in the third and fourth pairs of bonds are deliverable into a futures contract, while the associated BUNDs are not. The results for the first two pairs of bonds are largely the same in both the daily and weekly data. On the other hand, for the third and fourth pairs of bonds, the values of K for the deliverable bonds are notably smaller than those for the nondeliverable bonds, and this is true in both daily and weekly data.

The deliverable bonds in Japan were #129, #140, and #145 for a substantial part of the sample period. The values of K for these bonds are somewhat smaller than those for other JGBs in daily data, but not substantially so. Moreover, there is little difference between the sample kurtoses of these bonds and those with shorter maturities in weekly data. What is most striking about the results for JGBs is the relatively low autocorrelation in yield changes for the deliverable bonds, especially in daily data. Whereas all of the nondeliverable bonds have first-order autocorrelations that are significantly different from zero at the 1 percent level and often much larger than .2 in magnitude, the autocorrelations for the deliverable bonds are insignificantly different from zero at conventional significance levels and are less than .1 in magnitude.

Several observations emerge from these findings. First, changes in bond yields in Germany and Japan have higher kurtoses and, in the case of Japan, much higher autocorrelations, than the UST yield changes. This is consistent with there being important effects of the institutional frictions in the cash markets of Germany and Japan on the liquidity of GGBs and JGBs and hence the

10. See table 8.1 for a precise description of the bonds included.

distributions of yield changes compared to USTs.

Second, though Japan and Germany have many institutional frictions in common, the sample autocorrelation properties of the yield changes are very different. Two contributing factors to this difference may be the relatively larger number of auctions along the German yield curve facilitating price discovery, and the more well-developed repo market in Germany. A more efficient borrowing and lending market for bonds reduces the price-pressure effects of trading large blocks through the OTC dealer network and, therefore, would be expected to reduce the propensity for adjacent price changes to have the same sign.

Third, deliverability into a futures contract appears to alter the distributional properties of bond yields. Specifically, deliverable GGBs and JGBs have lower kurtoses and autocorrelations, respectively, than their nondeliverable counterparts. One explanation for this finding is that price discovery is more effective in the futures markets in Japan and Germany, so the relatively illiquid deliverable bonds are priced in terms of the associated futures. The results for Germany suggest that this pricing mechanism affects primarily the deliverable bonds for which the cost-of-carry relation provides potential arbitrage opportunities. The relatively illiquid, nondeliverable BUNDs of comparable maturity to the BOBL00 and BOBL04 have much larger kurtoses, which suggests that price setting in the BUND market is not as closely tied to price formation in the futures market as price setting for BOBLs.

Even if largely true, my interpretation of the markets' pricing rules is not complete, as the effects of delivery status on the distributions of bond yields differ across markets. With these differences in mind, I next describe briefly the characteristics of the primary futures markets in the United States, Germany, and Japan, and then examine in more depth the role of futures in the price discovery process.

8.3 Futures and Price Discovery in Cash Markets

If futures are central to the pricing of illiquid, deliverable cash instruments, the distributions of cash and futures prices should exhibit similar characteristics. In general, they would not be identical, of course, because futures serve at least two additional roles besides signaling value: bond futures are a key tool for managing interest rate risk associated with cash positions, and they provide a venue for investors to express views about the direction of interest rates. After briefly reviewing the contractual specifications of some of the key futures markets in the three countries being examined, I present preliminary results on the distributions of futures prices and their relations to cash prices.

Table 8.5 displays the deliverability criteria for several bond futures markets. In the United States, there are three actively traded futures markets for Treasury notes and bonds. In the cases of the five- and ten-year note contracts, the original maturities of the notes must satisfy the maturity criterion for delivery to be deliverable. The trading activity in these futures increases with maturity, as is illustrated by the average daily volumes and open interest levels for November 1993.

The London International Financial Futures Exchange (LIFFE) introduced the first BUND futures contract in 1988. Contractual obligations may be satisfied by physical delivery of any BUNDs, Unity bonds, or Treuhands with maturities between 8.5 and 10 years. In 1990, the German DTB launched an identical contract. The average daily trading volumes and open interest levels are higher on the LIFFE than on the DTB. Furthermore, the ratio of trading volume to open interest is higher at the LIFFE than at the DTB, suggesting that intraday trading is also more pronounced at the LIFFE.

A five-year futures contract was introduced by the DTB in 1991, and recently the LIFFE introduced a similar five-year contract. BOBLs, SCHATZs, and TROBLs are deliverable into these contracts if their maturity is between 3.5 and 5 years. Seasoned BUNDs are not deliverable. Among the two contracts, the DTB is clearly the more liquid (table 8.5), so price discovery within the five-year futures markets is likely to be primarily at the DTB. Also, comparing the BUND and BOBL futures for November 1993, the ten-year contract had nearly seven times the trading volume and about twice the open interest as the five-year contracts combined.

For the JGB contract, bonds with maturities between seven and eleven years are deliverable, though there are currently no deliverable bonds with maturities between ten and eleven years. Thus, bonds issued with original maturities of twenty years do not currently satisfy the deliverability requirements.

The specific terms of these futures contracts differ in regard to the treatment of margin, the nature of "delivery" and "wild card" options, the conventions for computing conversion factors, the accounting treatment of gains and losses, and so forth. Moreover, whereas the Chicago Board of Trade (CBT) and Tokyo Stock Exchange (TSE) impose daily price limits, there are no daily limits on the DTB or the LIFFE. These considerations are clearly significant from the point of view of an individual investor computing the cost of a futures position and in assessing the likely effectiveness of a hedge. To the extent that these costs affect participation, the liquidities and depths of the futures markets may be enhanced or limited by their presence. An equally important determinant of the levels of trading activities in futures markets is the *relative* cost of trading in cash compared to futures markets. The presence of the institutional frictions in the cash markets outlined in section 8.2, combined with the high degree of leverage achievable in the futures markets, suggest that the relative costs of transacting in the futures market are at times much lower than in the cash market. This may explain the relative liquidity of the futures markets, especially in Japan and Germany. The higher costs of regulatory frictions in the cash markets may also increase the weight on futures prices in the price discovery process for cash instruments.

The notion that futures contracts are central to the pricing of cash instruments can be made precise through the standard cost-of-carry relation. Let $P^N(t_c)$ and $P^N(t_M)$ denote the prices of a cash bond at the futures contracting and maturity dates, respectively. Suppose this bond pays c per year for each 100 of face value. Also, let i denote the annualized borrowing rate the investor must pay to finance the bond between t_c and t_M. Let τ denote the fraction $(t_M - t_c)/365$ of a year that the futures contract is active, and $f^\tau(t_c)$ denote the futures price at date t_c and CF the conversion factor for the Nth bond. Then the cost-of-carry relation for this market is

$$(1) \qquad CF \times f^\tau(t_c) = P^N(t_c) \times [1 + (i - c/P^N(t_c)) \times \tau].$$

The right side of equation (1) gives the "theoretical" forward price implied by the cash price at the contract date and the terms for financing the investment, and the left side is the invoice price for delivery of the bond into the futures contract. Equivalently, for a given futures price and conversion factor, (1) implies that the present value of the adjusted futures price gives the current cash price:

$$(2) \qquad P^N(t_c) = CF \times f^\tau(t_3)/[1 + (i - c/P^N(t_c)) \times \tau].$$

For at least two reasons, (2) will typically not hold for all deliverable bonds. First, there are biases inherent in using conversion factors to determine invoice prices for delivery. These biases will generally lead one bond to be cheapest-to-deliver (CTD; have the highest implied repo rate), which the futures price will tend to track over time. Second, as the shape of the yield curve changes during the futures contract period, so might the CTD bond. Since the futures track the price of the CTD bond, a potential change in the CTD bond adds an additional source of risk beyond the usual price risk of being long a futures contract. The difference between the left and right sides of (2) in the UST markets is often interpreted as the value of this delivery option implicit in the conversion factor system. In Germany and Japan, there seems to be little value to the delivery option. This may partly be a consequence of the narrower range of deliverable maturities compared to the UST contract, and to the recent slopes of the deliverable yield curves.

In its strongest form, pricing off futures can be formalized by viewing (2) as a pricing rule the market uses to price the deliverable bonds: cash prices are set approximately to the discounted values of the associated conversion-factor-adjusted futures prices. A weaker interpretation is that there may be systematic deviations from the cost-of-carry relation, especially for non-CTD bonds, but the shape of the distribution of the futures largely determines the characteristics of the distributions of cash prices in the deliverable sectors.[11] I examine each of these in turn, starting with the weaker notion.

11. In some markets at some times, one need not restrict attention to deliverable bonds only. For example, for an extended period of time in Japan during 1992, the superlong bonds were

Descriptive statistics for daily changes in the logarithms of futures prices on the ten-year contracts and associated deliverable bond prices are presented in the last three columns of table 8.6. The bonds chosen were the 11/15/01 7.5% UST, the 9/20/01 8.25% BUND, and the 6/20/01 6.6% JGB #140 (see table 8.2 for the characteristics of these bonds). Pairwise comparisons of the sample statistics show that the distributional characteristics of the cash and futures prices are very similar, with the only exception being the pair of kurtoses for the UST cash and futures prices.

Further insights about the nature of both the volatilities and kurtoses of futures and cash prices are obtained from estimating first-order generalized autoregressive conditional heteroskedasticity (GARCH; Bollerslev 1986) models for the daily changes in prices. More precisely, changes in the logarithms of prices, Δp_t, were assumed to be described by a normal distribution conditional on information available at date $t - 1$ with conditional mean $\beta_0 + \beta_1 \Delta p_{t-1}$ and conditional variance h_t given by[12]

$$h_t = \alpha_0 + \alpha_1 u_{t-1}^2 + \alpha_2 h_{t-1}, \tag{3}$$

where $u_t \equiv (\Delta p_t - \beta_0 - \beta_1 \Delta p_{t-1})$. As noted by Bollerslev (1986) and others, (3) is a parsimonious statistical representation that accommodates persistent conditional variances ($\alpha_1 + \alpha_2 \neq 0$) and the possibility that the marginal distribution of Δp_t is fat-tailed relative to a normal distribution. The excess kurtosis (relative to normal) in the context of a GARCH model can be expressed as $6\alpha_1^2(1 - \alpha_2^2 - 2\alpha_1\alpha_2 - 3\alpha_1^2)^{-1}$. Thus, the excess kurtosis is increasing in α_1 if $\alpha_1 > 0$ and $(1 - \alpha_2^2 - \alpha_1\alpha_2) > 0$, and is increasing in α_2 if $(\alpha_2 + \alpha_1) > 0$.

Table 8.6 displays the maximum likelihood estimates of the GARCH parameters for cash and futures prices under the assumption that the conditional distribution of u_t is normal. The GARCH parameters α_1 and α_2 of the CBT T-note contract and the associated UST prices are insignificantly different from zero at conventional significance levels. That the implied excess kurtosis is near zero was anticipated by the results in table 8.3. The new information in table 8.6 is the evidence of weak temporal dependence in the conditional variances of both UST cash and futures prices.

There is much stronger evidence of conditional heteroskedasticity in the prices for the German and Japanese markets, and, within each market, the structures of the conditional variances of cash and futures prices are strikingly similar. The autocovariances of the squared disturbances, u_t^2, $\gamma_n \equiv Cov[u_t^2, u_{t-n}^2]$, are given by

$$\gamma_n = (\alpha_1 + \alpha_2)\gamma_{n-1}, \tag{4}$$

priced off the futures in the sense that price changes on twenty-year bonds moved one-to-one with changes in the JGB futures price.

12. Without exception, the estimate of β_1 was insignificantly different from zero, so estimates of the parameters of the conditional mean are not reported subsequently.

Table 8.6 **Descriptive Statistics for Futures and Individual Bond Prices: Daily Changes, October 1, 1991–November 30, 1993**

Security	α_0	α_1	α_2	K	σ	ρ
CBT T-note 10 yr	1.16×10^{-5}	$-.019$	.287	4.40	.0039	.01
	(2.0×10^{-5})	(.030)	(1.30)			
UST 11/15/01	4.63×10^{-6}	-2.95×10^{-4}	.643	3.53	.0036	.07
	(7.30×10^{-6})	(3.38×10^{-2})	(.565)			
LIFFE BUND 10 yr	1.20×10^{-6}*	.006*	.732*	3.73	.0024	$-.05$
	(3.68×10^{-7})	(.002)	(.007)			
BUND 9/20/01	3.98×10^{-7}**	.003	.886*	3.49	.0021	$-.02$
	(2.05×10^{-7})	(.002)	(.005)			
TSE JGB 10 yr	2.41×10^{-6}*	.260*	.428*	4.64	.0027	.02
	(6.66×10^{-7})	(.053)	(.110)			
JGB #140	1.06×10^{-6}*	.198*	.650*	4.46	.0025	.05
	(2.41×10^{-7})	(.041)	(.054)			

Notes: Standard errors of the estimates are in parentheses. *(**) indicates that the estimate is significantly different from zero at the 1% (5%) significance level. K = kurtosis; σ = standard deviation; ρ = first-order autocorrelation of the changes in the bond or futures prices. *CBT* denotes Chicago Board of Trade futures, *LIFFE* denotes the London International Financial Futures Exchange, and *TSE* denotes the Tokyo Stock Exchange.

where $\gamma_0 = \sigma^2_u$, the variance of u_t. It follows that the rates at which the autocovariances of squared residuals decay in Germany and Japan are very similar. Nevertheless, the distributions of the conditional variances are notably different. Compared with the German LIFFE contract, a given percentage change in the TSE futures price at date $t - 1$, u_{t-1}, has a much larger impact effect on the conditional variance, and the effects of shocks dissipate more rapidly in Japan than in Germany. Consequently, the mean lag in the conditional variance equation (expressed as a function of past squared shocks) is about 3.7 days for the LIFFE BUND future and 1.7 days for the TSE JGB future.[13]

All of these findings are consistent with the view that deliverable, cash instruments inherit the distributional properties of futures. Changes in futures prices exhibit little autocorrelation, and this may explain the low autocorrelation of changes in JGB prices for deliverable bonds (table 8.3) compared to nondeliverable bonds. Moreover, the high kurtoses of all cash bonds in Japan is consistent with the high kurtosis of the JGB futures price (the highest among the securities considered). Similarly, the relatively low kurtoses for deliverable German bonds compared to nondeliverable bonds can be explained by the low kurtosis of the LIFFE BUND futures contract and the relative liquidity and depth of the futures compared to the cash market.

While these pairwise, cash-futures comparisons are suggestive of a key role for futures in price discovery, I have not documented a close linkage for the entire deliverable sector. Such evidence is presented in Kikugawa and Single-

13. See Bollerslev (1986) for the formula for the mean lag.

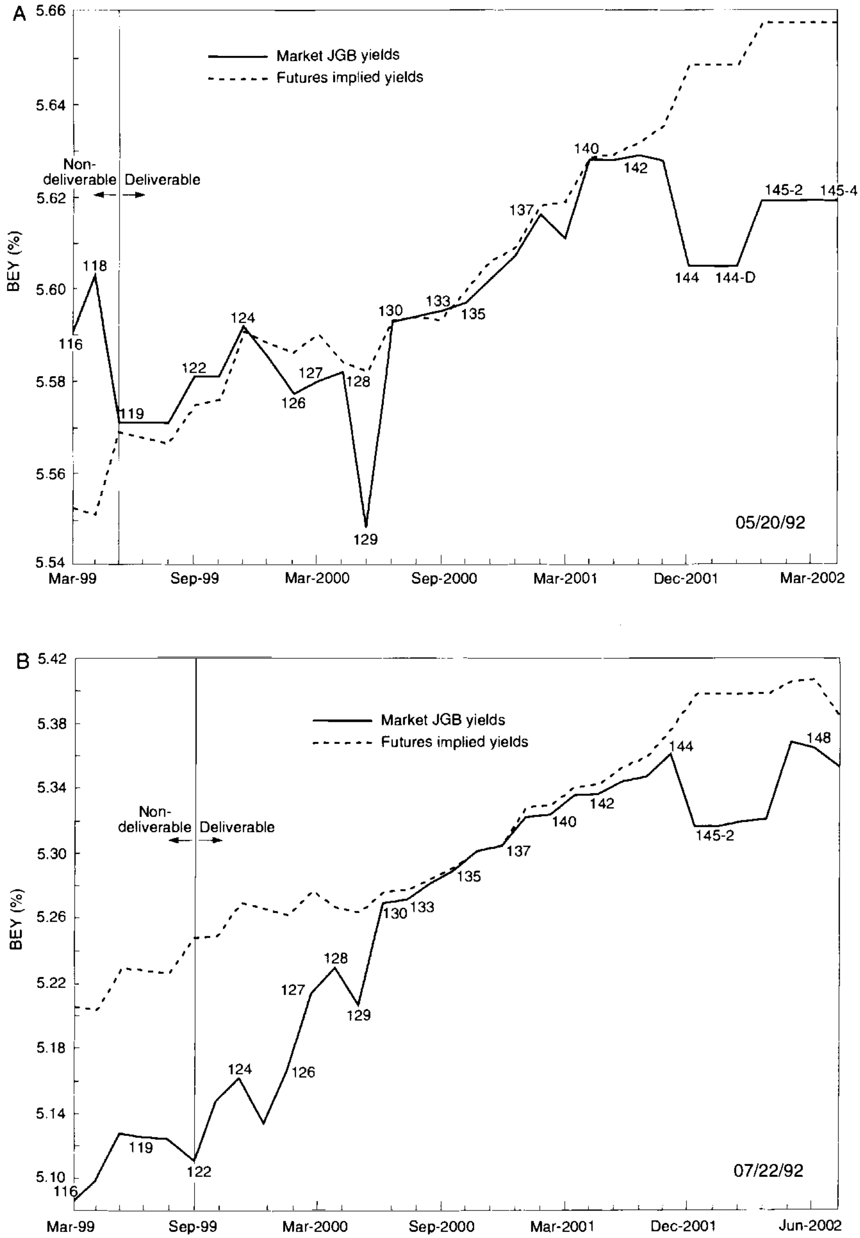
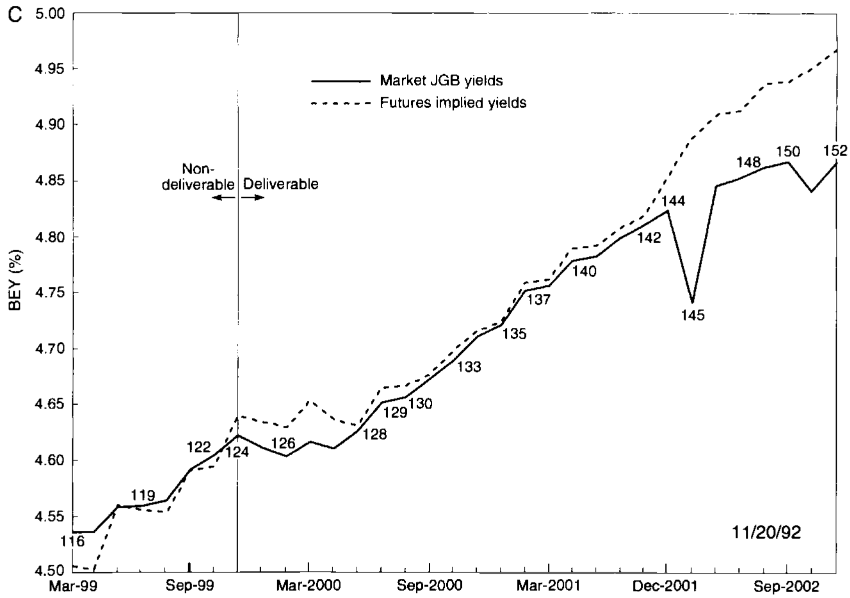


Fig. 8.1 Deliverable yield curves, Japan
Source: Data provided by Goldman Sachs and Co.



ton (1994), where it is shown that the deliverable sector in Japan was essentially priced directly off futures during much of 1992. Figure 8.1A displays the actual bond equivalent yields (BEYs; dark squares, labeled with bond numbers) of the JGBs in the deliverable sector on May 20, 1992, and the BEYs implied by the conversion-factor-adjusted futures prices discounted by the common implied repo rate on the CTD bond (i.e., BEYs implied by equation [3] with i set at the implied repo rate of the CTD bond). Consistent with pricing off futures, the two lines are virtually identical. The exceptions are #129, which was the benchmark at the time, and #144 and #145. The richness of the latter two bonds probably reflected the market's assessment of their potential benchmark status in the future; #145 became the subsequent benchmark.

Figure 8.1B displays the comparable yield curves for July 22, 1992. The shortest-maturity deliverable bond on this date was #122. Furthermore, the coupon rates on #127 and below are under 6 percent, while the coupon rates for #128–#144 are equal to or greater than 6 percent. For several months prior to April 1992, the low coupon, intermediate-maturity bonds were trading at relatively high yields and with light trading volumes, and there was a pronounced hump in the yield curve over the five- to seven-year sector. Between May and July 1992, the JGB market experienced a strong rally, especially in the five- to seven-year maturity sector of the yield curve. As trading activity increased in the low coupon nondeliverable bonds, the price discovery process changed for the similar low coupon deliverable bonds. Instead of being based on the bond future, which was tracking the longer-maturity higher coupon bond prices (#130–#144), the prices of #122 to #128 were set in relation to the more comparable low coupon (nondeliverable) #105, #111, and #119.

There are two complementary interpretations of this change in cash/futures price relations. First, the increased trading activity during July in the nondeliverable sector provided cash market benchmarks for pricing the short-maturity, deliverable bonds with comparable durations. Less weight was therefore given to the futures. A second, related consideration was that a market rally lead to the complete disappearance of a pronounced hump in the five- to seven-year sector of the JGB yield curve and a substantial steepening of the curve. Exact pricing off futures constrains the shape of the yield curve in the deliverable sector. Although the futures-implied yield curve steepens in a rally, the actual yield curve became much steeper than the futures-implied yield curve. Concurrently, the market priced in the shape of the curve. Thus, as yield curves steepen or flatten to the point that pricing off futures would create substantial arbitrage opportunities at the boundaries of the deliverable sector, market pricing reflects the importance of curve steepness.[14] Notice, however, that pricing cash bonds in terms of the futures is not a phenomenon that occurs only when market yields are near the notional yield on the futures. In late fall of 1992, there was a sell-off in the intermediate JGBs, and on November 20, 1992, for instance, the futures and implied yield curves were once again virtually indistinguishable (fig. 8.1C), with market yields well below 5 percent.[15]

Though the close relation between the cash and futures prices in figure 8.1 is striking, it is important to recognize that these patterns can exist yet there can be significant departures from the cost-of-carry relation for all bonds. The curves in figure 8.1 were derived by using the implied repo rate on the then current CTD in the right-hand side of (2) to compute implied cash prices. If the futures become very cheap (for instance) relative to cash, then this will be "absorbed" into the implied repo rate for the CTD. What figure 8.1 demonstrates is that the same implied repo rate priced all deliverable bonds during extended periods in 1992.

The absence of a well-developed repo market and the consequent high costs of shorting cash bonds mean that many market participants rely on the futures market for short selling. The consequent selling pressure on the futures mar-

14. In Japan, there were times during late 1991 and early 1992 when the gap between the yields on the shortest-maturity deliverable bond and the longest-maturity nondeliverable bond was over fifteen bp just before the expiration of the futures contract. Initially this gap represented a near-riskless trade opportunity in that, once the deliverable bond lost its delivery status (after expiration of the futures contract), it cheapened up to a comparable yield as other nearby nondeliverable bonds. Once this opportunity was recognized by most market participants, however, the gap was not tradable. TSE closing prices at times showed a yield gap, but no trades were being executed at TSE prices. As the intermediate sector rallied in mid-1992, such gaps largely disappeared.

15. Similar pricing in terms of futures has been observed in Germany. The recent steepening of the German yield curve has similarly led to discrepancies between the futures-implied and actual yield curves.

kets leads at times to the futures price in fact being very cheap relative to the cash market. The effects of these frictions can be seen graphically in figure 8.2, which displays the time series of implied repo rates on the CTDs (which change across contracts) relative to the short-term London interbank offer rate (LIBOR) for yen. Notice that for most of the first half of 1992, when there was pricing off futures in Japan, the differences between the implied repo (*CRPO*) and LIBOR (*R*) were relatively small. Thus, pricing off futures was approximately based on the cost-of-carry relation. Subsequently, LIBOR and the implied repo rate on the CTD bond have differed by up to one hundred bp. Thus, pricing of the cash market reflected the markets' assessment of an appropriate spread between the implied repo rates and LIBOR given the forces of supply and demand and the costs preventing attempts to arbitrage this gap.

8.4 Concluding Remarks

I have argued that there are important links between the institutional settings within which investors perform price discovery and the resulting distributions

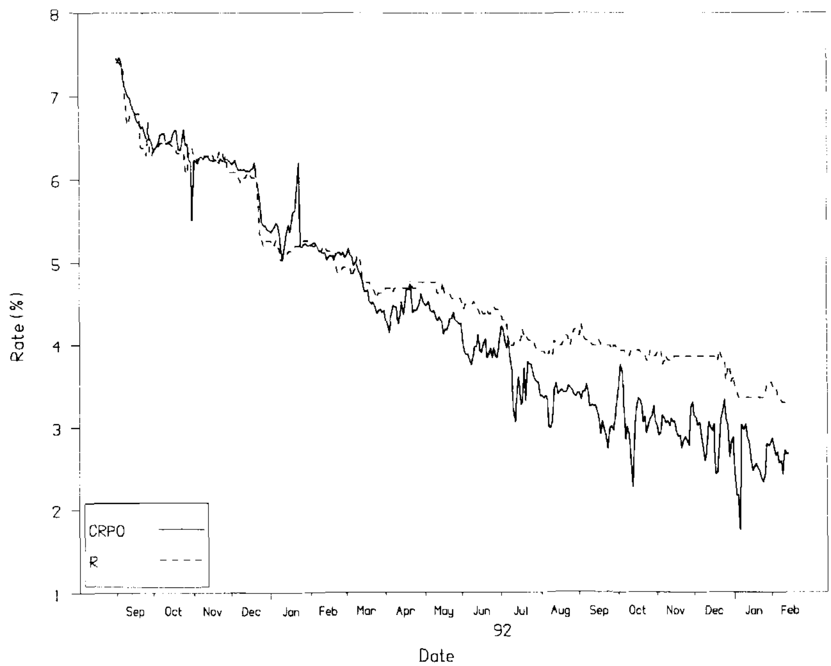


Fig. 8.2 Implied repo on CTD bond and short-term rate, Japan, September 2, 1991–November 15, 1993

Source: Data provided by Goldman Sachs and Co.
Note: R = LIBOR; *CRPO* = implied repo from the CTD bond.

of prices of fixed-income instruments. In environments like the United States, liquid UST markets are facilitated by regular auctions of new bonds of various maturities, "market-to-market" accounting, electronic settlement, a competitive dealer market with low transaction costs, and an active borrowing and lending market that makes selling short a low-cost endeavor. The institutional settings in Germany and Japan involve many more frictions, which inhibit price discovery in the cash markets. The empirical evidence suggests that these institutional factors are reflected in fatter-tailed distributions and, in the case of Japan, substantial autocorrelation of yield changes.

In the presence of institutional frictions in the cash markets, the relatively frictionless and liquid futures markets play more central roles in the price discovery process. This was reflected in the distributions of yields for cash bonds having notably different characteristics depending on whether the bonds were deliverable into a futures contract or nondeliverable. Moreover, the distributions of the cash and futures prices within the deliverable sectors were very similar. More direct evidence of the importance of futures for price discovery was presented for Japan, where the cash prices of all deliverable bonds were shown to have been, at times, set approximately to their associated conversion-factor-adjusted futures prices.

The evidence presented for Japan on pricing off futures is an extreme case. Indeed, the results suggest that nearly exact pricing off futures persisted for several months, but recently the prices in the cash market and those implied by the futures have differed by amounts that are more typical of markets in the United States. The recent patterns are consistent with the increased trading activity along the JGB yield curve, which would facilitate price discovery in the cash market. Also, though the focus has been on deliverable versus nondeliverable bonds, the thesis that cash and futures prices may be closely related during periods of low volume in the cash market suggests that under some circumstances pricing off futures might extend to bonds outside the deliverable sector. This was in fact the case in Japan during some periods in the past. Specifically, the superlong (twenty-year) bonds were for a while priced in terms of the futures.

Many questions remain for future study. In particular, why is the distribution of futures prices in Japan fat-tailed relative to the futures prices for the United States and Germany? I conjecture that the high borrowing and lending costs in the cash market, which contribute to the systematic violations in the cost-of-carry relation for the CTD bond, at least partially explain this result. If futures are the primary vehicle for shorting bonds, then the effects of institutional frictions in the cash market will spill over and help shape the distribution of the futures prices. Also, are the joint distributions of the cash and futures prices different for the five- and ten-year futures in Germany? These markets differ in their organizational design. Equally, if not more, important, the relative liquidities of the cash and futures markets appear to be different across the two sectors of the yield curve. A more thorough analysis of these differences using a bivariate model may be enlightening. In the cases of both Japan and Germany, establishing a tighter link between trading activity in the cash market and the correlation between cash and futures prices would be useful for verifying the conjectured links between these features of the markets. Addressing these issues requires the development of a much richer database of volume data and time series on the implied forward prices for individual bonds using equation (2). In future research, I plan to develop such databases for Japan and Germany and examine spillovers between cash and futures markets.

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Comment William P. Albrecht

In this paper Kenneth Singleton approaches the question of what might cause a market to be efficient (or inefficient) from a broader perspective than the typical market microstructure paper. He examines how what he calls macroinstitutional arrangements can affect price discovery and the relationship between cash and futures markets. The purpose of the paper, therefore, is not to debate whether the cash or futures market is more efficient or whether the cash market drives the futures market or vice versa. Singleton does not attempt to show that one market is necessarily more or less efficient than the other. Rather, he demonstrates that a market with fewer impediments to using it is more efficient than one with more impediments to using it.

It would be very comforting if the political discussion about the relationship

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between cash and derivative markets would adopt this perspective more often. If this were to occur, governmental agencies that are concerned about why a market is not working well would spend more time looking for restrictions on voluntary exchange that may be responsible for the poor performance. This, in turn, would lead them to devote more resources to the task of eliminating such restrictions. The result would be a better balance in the types of activities engaged in by many governmental agencies. That is, they would spend more time looking for ways to remove restrictions on voluntary exchange and less time looking for ways to impose additional restrictions.

The basic structure and approach of this paper are quite sound. Singleton's macroapproach is appropriate. The purpose of this paper is set out quite clearly in the introduction, and the main conclusions appear to be consistent with the data and the statistical analysis. There are, however, a number of questions raised by Singleton that are not fully answered. The explanations of his results are not as well tied together as they might be, and there is an ad hoc nature to some of the explanations of the statistical results. This reader was left with the feeling that there is more to the story than is presented in the paper. There is, of course, always more to the story, but in this case telling a somewhat fuller story would be very helpful.

First, a number of statements about the markets in Germany and Japan raise interesting questions. Why, for example, are Treuhand and TROBLs not treated by the market as equivalent to their BOBL and BUND counterparts? Another example concerns the benchmark bonds. We learn that these bonds are designated in Japan, but it would be interesting to know more about how and why bonds are so designated. Not only would at least some readers be interested in the answers to these questions, but they might have some relevance for the analysis in the paper.

For the same reasons, I would like to know more about why the benchmark premium in Japan fluctuates and why certain ex-benchmark bonds often serve as key reference points for pricing. One reason cited is that they have large issue sizes, but surely that is why they were benchmarks. Are there other reasons? Or do all ex-benchmarks serve this function? A fuller discussion of how the lack of a repo market in Japan affects price discovery would also be useful. Singleton says that the absence of a well-developed repo market means that many market participants rely on futures markets for short selling, thereby putting downward pressure on futures prices. This, he says, causes a substantial bias toward futures' being cheap relative to cash bonds. Since the use of futures for price discovery is a central theme of the paper, this issue would seem to merit more examination.

There also appear to be some problems with identifying and explaining cause and effect. The paper states, for example, that increased trading in July 1992 in the nondeliverable sector provided cash market alternative benchmarks for price discovery. This is cited as an illustration of the prevalent phenomenon of benchmarks changing as the liquidities of candidate instruments change over time. But what causes these liquidities to change? Or is the point simply that, when volume is high in the cash market, it is used for price discovery?

Some further discussion of autocorrelation and kurtosis would also help. Why, for example, do changes in bond yields in Japan show positive autocorrelation for daily but not for weekly data? On the kurtosis issue, all three countries have fatter tails than normal for changes in yield, but the values of K are smaller for the United States. The paper also reports that there are smaller values of K for weekly data but it does not make clear exactly where these values are smaller. Nor does it explain the significance of this finding.

Finally, some of the explanations of the results that are offered in the paper are tentative or incomplete. For example, "two contributing factors to this difference may be the relatively larger number of auctions along the German yield curve facilitating price discovery, and the more well-developed repo market in Germany." And "even if largely true, my interpretation of the markets' pricing rules is not complete, as the effects of delivery status on the distributions of bond yields differ across markets."

A paper that presents as much information and analysis as this is bound to leave a number of unanswered and partially answered questions. Singleton cannot possibly address all the issues raised. These comments, in fact, point out the hazards of presenting so much information and raising so many issues. On the one hand, I have suggested that he try to provide answers to questions suggested but not explicitly addressed by the paper. On the other hand, I have complained about the tentative nature of the explanations when they are offered. Moreover, I undoubtedly would have complained if Singleton had been less tentative, on the grounds that his analysis does not support stronger answers. But, as I said earlier, there is more to the story than is presented in the paper. It would benefit from a concerted effort to tie up as many loose ends as possible.

Some of the aforementioned task could be accomplished by fuller explanations of some of the characteristics of the markets in Japan and Germany. Some of it could be accomplished by a section near the end of the paper that summarizes the major unanswered or partially answered questions and that discusses their significance for the paper's conclusions. These steps would improve what is already a solid paper—one that adds to our understanding of how the markets under discussion work.

Comment T. Eric Kilcollin

I found it very difficult to review this paper since there's not much here you can really sink your teeth into: There is no well-defined hypothesis to be tested;

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rather, as Singleton says in the paper, he's trying to characterize the properties of the joint distribution of cash and futures prices in order to guide modeling efforts in the future. He provides some institutional details about government securities and futures markets, but it is by no means a definitive treatment of these issues. He provides some data; but they, too, are certainly not exhaustive. Finally, he provides some statistics; but they, too, could certainly be expanded upon.

Fundamentally, the story line of the paper is that a host of largely unspecified accounting, regulatory, and cultural differences somehow aggregate to produce a Japanese government bond market that is less efficient than that of Germany, which, in turn, is less efficient than that of the United States. Somehow the futures markets escape these differences and are efficient in all three countries, and this relative efficiency spills over into the cash markets for deliverable securities in Germany and Japan.

The principal hypothesis is that, where cash markets don't work well, futures markets improve or at least affect cash market pricing. But we only have three data points (United States, Germany, and Japan) to test this hypothesis.

Clearly there are lots of holes in this study: for example, I did a paper on the various schemes for making a variety of bond issues deliverable against futures contracts (Kilcollin 1982). In that paper, I showed that, with the factor pricing scheme that these futures contracts use, the relation between the futures price and the prices of the various deliverable bonds is a complicated function that depends on the term structure of interest rates, the coupon structure of interest rates, and the general level of interest rates in relation to the par delivery instrument. It also depends on the volatility of these parameters. The JGB yield curve in Singleton's figure 8.1 may well be simply a reflection of these factors at work, rather than any tendency to price some cash bonds off futures prices.

As another example, Singleton notes that the JGB bonds that are deliverable against the futures contract have low autocorrelations. But these bonds also happen to be the highest-coupon, longest-maturity, and largest-issue bonds in his sample. How do we know it is deliverability against futures instead of these other factors that account for the autocorrelation numbers?

As a final example, Singleton asserts that the futures markets are largely free of the accounting, regulatory, and cultural influences he postulates for the cash markets. In the United States this is certainly not the case. U.S. futures markets have more regulation and are subject to more accounting anomalies than is the government securities market. The futures markets in Germany and Japan are also subjected to heavy regulation.

Notwithstanding these criticisms, there is an intuitive appeal to Singleton's findings—they just need more work. Longer time series covering more market conditions would bolster confidence that these results are real. Also, I'd like to see the factor-pricing issue investigated more fully. Some bonds, while *legally* deliverable, will turn out not to be *economically* deliverable. Why should their behavior be influenced by futures prices? Can other factors that might generate these results be ruled out? Ultimately, I don't think the "macro" relations of concern in this paper can be convincingly tested using a single set of data. Rather, it will be scraps of evidence from a variety of sources that together will support or reject Singleton's hypothesis.

I would suggest Singleton expand the range of his data. Certainly, France, the United Kingdom, and Australia could be included. Italy and Spain also have newer futures markets that might shed light on his hypothesis. I would also suggest looking at agricultural markets. There is a great variety of regulatory and "cultural" differences in these markets, and it is usual in agricultural markets for futures to be the main price discovery mechanism.

Finally, I would like to venture into the normative economics that Martin Feldstein warned us against. Suppose we find that futures markets do influence the distribution of cash market prices. Is this good or bad? Low autocorrelations seem desirable, but how about fat-tailed distributions? The Brady commission seemed convinced that futures cause fat-tails in equity market prices and that this is bad. Singleton finds the opposite and seems to believe that this is good. I'd like to see some discussion in future versions of this paper of what Singleton's work implies about economic efficiency.

Reference

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Author's Reply

Let me begin by taking a broader perspective on the research agenda for which this paper represents an early progress report. Virtually all models of the term structure of interest rates that are studied in the finance literature or used in practice by the investment community assume the absence of arbitrage opportunities and frictionless markets. Though there are in fact many institutional and regulatory restrictions on trading practices, these models have proven to be useful abstractions for the U.S. Treasury bond markets. For other government bond markets, bond swaps along the maturity spectrum, short selling, and other trade strategies that potentially bring market prices approximately in line with the implications of models assuming frictionless markets may be significantly limited. This has been the case for Japan and Germany. Bonds of nearly identical maturities are priced to reflect accounting standards and transaction costs that impinge on these bonds in substantially different ways. In other words, the market effectively uses different discount functions to value the cash flows of these bonds. These observations have important implications for both valuation and risk management.

Consider for instance the problem of risk management. Typically, the primary objective is to find the portfolio of securities that matches the price movements of the target security. Clearly, whether prices track each other depends fundamentally on how the market sets prices. And price discovery is not independent of the institutional frictions faced by investors. This paper represents the first step of a longer-term research agenda attempting to expand our understanding of the relations between price discovery and the institutional/regulatory environment in which trades are undertaken. What surprised me, and may surprise others, is the extent to which the distributions of bond yields differ with maturity in Japan and Germany, and how they differ across markets. These differences represent in my view serious challenges for existing valuation models as well as for the design of effective hedging strategies.

The comparison across the bond markets of the United States, Germany, and Japan suggests that some of these differences can be explained by differences in the cost structures of market making, institutional frictions that affect liquidity, and the issuing practices of federal authorities. To draw out the relations between market structure and the distributions of yields and to gain some insight into how price discovery is accomplished in the presence of significant frictions, I explored the linkages between cash and futures prices. Regulatory guidelines and accounting standards appear to have contributed significantly to illiquidity in the cash market and a consequent greater reliance on the relatively liquid futures for price discovery in cash markets. This in turn can explain the substantial differences in distributions of bond yields along the yield curves and across countries.

Popular and political debates about the economic consequences of financial regulation often focus on specific aspects of contract design for derivative instruments. In particular, the focus is often on how regulatory change (e.g., margin requirements or circuit breakers) affects the costs of the economic insurance that a security provides. These issues are clearly important for determining competitive advantage among providers of insurance (the exchanges) and influencing risk management strategies of investors.

More fundamentally, regulation may affect the nature of the insurance provided by the security (i.e., its payoff distribution conditional on the state of the economy). In Japan and perhaps Germany, the steps being contemplated toward liberalization of bond markets are as much of the latter variety as the former, in part because these countries are at earlier stages of the liberalization process. For this reason, I believe that the more "macro" costs associated with market access, settlement, legality and costs of certain collateralized loans, and so forth, are much more significant for understanding price discovery in these markets than changes in the remaining regulations related to the design of futures contracts. In this regard, Kilcollin's comments suggest that he is fixated on regulations in the futures market that may be of second-order importance for price discovery rather than the more important issues facing countries that are behind the United States in liberalizing their cash markets.

I now turn to the specific comments of the discussants. Albrecht raises several interesting issues that were not fully addressed, and, as he suggests might be the case, the answers provide further support for the thesis of this paper. Addressing them in order, let me begin with the apparent differential treatment of Treuhands and BUNDs by the market. Treuhand will continue issuing until 1995, at which time it will become part of the Bundespost system. Bonds issued by the latter institution have recently been trading at about a thirty-basis-point spread to BUNDs, so investors are unsure how Treuhands will be priced in the market after they lose their deliverability status in the ten-year sector. Consequently, they trade cheap to BUNDs and are typically cheapest to deliver. In contrast, in the five-year sector, when TROBLs lose their deliverability status and Treuhand joins the Bundespost system, TROBLs will have about two years remaining until maturity, and most two-year bonds have been liquid and have little credit risk. Therefore the spreads of TROBLs to BOBLs have been much smaller.

Next Albrecht wonders about the benchmark selection process in Japan. The benchmark bond must have a large enough issue size to accommodate the high volume of trading and trade near par so that accounting considerations will not render the bond unattractive to many investors. At times the change in benchmark is perfectly predictable. This was the case, for example, with #157. The change date was the first trading date of the new settlement period after the first coupon payment. The coupon date is significant, because this is when the various tranches of the #157 merged into one tranche, and hence all of the tranches traded as the same bond. A new benchmark was expected because the market had rallied, making #145 a premium bond. On the other hand, as figure 8.1 suggests, there was considerable uncertainty about which bond would follow #129 as the benchmark. Again issue size[1] and coupon were important factors, as were the changes in market prices before the tranches were combined. However, there are no explicitly stated criteria for selecting the new benchmark. Rather, the largest securities companies in Japan seem to have selected both the bond and the change over date.

As for the role of ex-benchmark bonds serving as reference bonds for pricing, yes, it is the case that all ex-benchmark bonds have tended to play this role. In addition, there are a few bonds that were never benchmarks that have also at times served as pricing reference points. Examples include #99 and #140.

Albrecht's concern that the absence of a well-developed repo market in Japan may compromise price discovery based on futures is well taken. This issue is addressed at the end of section 8.3. To reiterate, during the period that there was evidently nearly exact pricing of cash bonds in terms of futures through the cost-of-carry relation, the implied repo rate on the cheapest-to-deliver

1. Bear in mind that between 60 and 90 percent of the trading volume in all Japanese government bonds has been in the single benchmark issue since the mid-1980s.

(CTD) bond and LIBOR were very close to each other.[2] In other words, there was essentially no bias in the pricing of futures. At other times, however, this bias has been substantial, as is evidenced in figure 8.2. To the extent that a subset of the deliverable yield curve was priced off futures during periods when the implied repo rate of the CTD and LIBOR differed, the market was basing pricing on both futures and a perceived reasonable spread between the two short-term rates, given supply and demand factors and the cost of shorting bonds. The periods during which the gaps between LIBOR and the implied repo rates on the CTD were largest correspond to periods during which cash and implied prices from futures evidenced the largest differences.

The high costs of market making in Japan open the possibility that large blocks of bonds will move though the dealer network slowly relative to a comparable block in the United States. Also, accounting factors, for example, may lead many domestic institutional accounts to be on the same side of the market at the same time. For example, if bonds were bought and booked at par and the market subsequently sold off, then there would be tendency for these bonds to be held in portfolios, thereby reducing the effective supply to the market. On the other hand, as the price of these bonds approaches par in a subsequent rally, trading activity may pick up as accounting constraints become less important for these bonds in portfolio rebalancings. In this manner, institutional and accounting factors can lead to large and persistent moves in Japanese government bond (JGB) yields that manifest themselves in large kurtoses and high autocorrelations.[3]

Many of Kilcollin's remarks are factually wrong and his proposed reinterpretations of the evidence suggest that he failed to grasp the meaning of the economic concept of price discovery. The suggestion that the conversion factor system itself can explain the patterns in figure 8.1 and in Kikugawa and Singleton (1994) is completely unsubstantiated. Indeed, the biases inherent in the conversion factor system are well known to induce a single CTD bond, and not the documented pattern of many deliverable bonds being nearly equally CTD for a period of months.

Kilcollin's remarks about autocorrelation and the assertion that I claim futures markets are largely free of regulation show that he did not carefully read the paper. Many of the specific accounting and regulatory factors discussed pertain to the cash markets; as noted in the introduction, the regulations related

2. Even though there was nearly exact pricing of the deliverable sector in terms of the futures price, a cheapest to deliver still existed, because the institutional and accounting factors usually implied that one bond would be slightly cheaper to deliver than all other candidate bonds. The differences in implied repo rates were small, however.

3. Some of the autocorrelation may also be due to the price quotation system for JGBs. The prices are Tokyo Stock Exchange (TSE) closing prices, which may not be exactly equal to transaction prices. This problem is more severe than an infrequent trading problem, since the TSE prices are set by one of the big four securities firms and need not be exactly equal to a recent market trade. Nevertheless, the TSE prices are usually within a few basis points of transaction prices.

to margin and contract design for futures are not the focus of this paper. Additionally, some of the *relative* advantages of executing certain trades in futures markets brought about by these cash market frictions are spelled out in the paper.

As for his remarks about autocorrelation, contrary to his claim, the deliverable bonds are not the longest-maturity bonds examined for Japan. The twenty-year bonds are not deliverable and evidenced high autocorrelations. Similar autocorrelations and kurtoses are obtained in studies of yields for high coupon superlong bonds. Also, compared to say #140, there are other, nondeliverable bonds with higher coupons and larger issue sizes. This is clearly displayed in table 8.2. Moreover, for an earlier sample period Kikugawa and Singleton (1994) found that #111 and #119 bonds also exhibited relatively low autocorrelations compared to nondeliverable bonds. Table 8.3 shows that market conditions changed in such a way that these bonds became significantly autocorrelated.

Finally, I agree with both discussants that more analysis is needed to link more tightly the empirical evidence to the institutional frictions emphasized. This will be the focus of future research. Rather than expanding the scope of the analysis by considering more countries, I am expanding the set of variables used in the empirical analysis in an attempt to better understand the three markets considered in this paper.

Reference

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