Journal Of Investment Management, Vol. 16, No. 4, (2018), pp. 29–46

www.joim.com

TRADING METHODS AND TRADING COSTS FOR AGENCY MORTGAGE-BACKED SECURITIES

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Investors can trade individual agency mortgage-backed securities (MBS) as specified pools (SPs), or trade them through TBA forward contracts. Sellers in the TBA market deliver the cheapest possible pool that fulfills the contracts, so they are traded on a cheapest to deliver basis. More valuable mortgage-backed securities are traded as SPs. We show that trading costs are far, far lower for TBA trades. Trading costs are lower for large trades, for trades with more active dealers, for trades of MBS with a large balance outstanding, and for trades where dealers act as brokers rather than commit capital.

1 Introduction

Agency mortgage-backed securities (MBS) offer several advantages for fixed income investors. First, they are free of default risk. MBS issued by the Government National Mortgage Association (Ginnie Mae) are backed directly by the U.S. Government. MBS issued by the Federal National Mortgage Association (Fannie Mae) and the Federal Home Loan Mortgage Corporation (Freddie Mac), while not directly backed by the Federal government, are widely believed to carry an implicit backing. Second, MBS make monthly payments rather than the semiannual coupon payments made by most bonds. Third, agency MBS have traditionally offered attractive yields. Finally, the agency MBS market is more liquid than the corporate or municipal bond market.

The liquidity of agency MBS can be a significant advantage for investors who want higher yields than are available with treasury securities, but are uncertain of their future liquidity needs. To take advantage of the liquidity in the MBS market requires an understanding of the ways that MBS are traded and the tradeoffs between immediacy, price, and trading costs. The MBS market has the unique feature of parallel trading in to-be-announced (TBA) forward contracts on MBS,

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and a spot market for specified pools (SPs). As we will show, the TBA market is much more liquid than the SP market, but the most attractive MBS are sold as SPs. TBA trading also makes the SP market more liquid. If an SP is eligible for TBA trading, a dealer has a valuable option to unwind an SP position through TBA trades. This lowers trading costs for the SP.

Our findings in this paper provide several suggestions about how investors should choose MBS investments, and how they should trade them. First, the TBA market is much more liquid and trading costs are lower than for SP trades. Investors who anticipate selling MBS in the near future, or who are making a short-term investment should trade in the TBA market rather than the SP market. Second, trading costs are lower for larger trades than small trades. Diversifying by holding smaller positions in more MBS comes at a cost if an investor needs liquidity. Third, both SP and TBA trading costs decline as the outstanding balance of MBS with the same maturity and coupon increases. A larger number of outstanding MBS means a more active and liquid market. Fourth, trading costs are lower when an investor buys or sells from an active dealer than when the investor buys or sells through an inactive one. It is possible that more active dealers learn more about market conditions and therefore face less risk and charge less as a result. Before concluding that it is cheaper to trade through active dealers however, fixed costs of establishing trading relationships with the dealer must be considered. Fifth, for both SP and TBA trades, brokered or prearranged trades are much cheaper than trades in which the dealer commits capital. The lower trading costs come with a downside though. An investor who is selling through a brokered trade has to wait until the dealer finds a counterparty before trading. We cannot tell if sellers wait only for a few minutes, or several hours, or even days before brokered trades are completed. Finally, an MBS with particularly desirable prepayment characteristics should be sold through an SP trade rather than a TBA trade. When there are large differences in prepayment characteristics across MBS with the same coupon and maturity, SP prices are significantly higher than TBA prices.

2 Agency mortgage-backed securities and how they are traded

Agency mortgage-backed securities are pass-through securities, so the principal and interest payments made by the mortgage holders are passed on directly to the MBS investors. The agencies that issue the MBS guarantee that the payments will be made, so default risk is not a concern for investors. The risk that investors do face is that mortgage rates will fall and mortgage holders will pay off their mortgages early. In this case, MBS investors will be forced to reinvest the early principal payments at lower rates. In addition, prepayments mean that the value of an MBS position decays over time. Atanasov *et al.* (2016) note that custodial fees charged to institutional investors are often a fixed amount per position. Fees that are small when an MBS is acquired increase steadily as prepayments occur and the investor buys additional MBS with the proceeds. In this light, MBS with fewer early principal payments are valuable because investors do not have to incur additional custodial fees when reinvesting the prepayments. So, MBS investors prefer that few mortgage holders refinance when mortgage rates fall.

Each MBS is made up of a different pool of mortgages and each has unique prepayment characteristics. To some extent, prepayment is predictable. Mortgage holders may be less likely to refinance if they have small mortgages, if they have high loan-to-value ratios, or poor credit ratings. The state in which a homeowner resides may also affect the likelihood of prepayment. An MBS will be more valuable when interest rates fall if the mortgages in the pool are less likely to be refinanced. Conversely, if mortgage rates rise, MBS made up of mortgages in transient areas where houses are likely to be sold and refinanced are especially valuable.

Atanasov *et al.* (2016) observe that there are over a million unique Agency MBS outstanding, and each has its own prepayment characteristics. The fragmentation of trading across hundreds of thousands of infrequently traded MBS reduces liquidity. Investors need to evaluate the unique prepayment risk of an MBS before trading it. This means that it will take dealers longer to unwind positions, and repeated interactions with customers may be necessary. In addition, dealers have a difficult in time shorting as part of their market making because it may be difficult to locate a particular MBS to cover shorts.

As noted by Vickery and Wright (2013) and Gao *et al.* (2017), TBA trading creates liquidity by allowing sufficiently similar MBS to be traded interchangeably. In a TBA trade, buyers and sellers agree on six parameters for the trade: issuer (Fannie Mae, Freddie Mac, or Ginnie Mae), coupon, maturity, settlement date, price, and the par value of the securities. Settlement dates for a given issuer and maturity occur once per month. Most TBA trades settle at the next settlement date, but trades that settle one or two months later are also common. The specific pool of mortgages that is delivered to fulfill a trade is not known until two days before the settlement date. Sellers will attempt to deliver the least valuable MBS consistent with the parameters of the trade. Hence, TBA prices are based on the value of the cheapest-to-deliver MBS.

TBA trading works because prepayment characteristics are similar for many MBS and therefore, from the buyer's perspective, they are good substitutes for each other. This homogeneity is due in part to restrictions on the characteristics of MBS that can be delivered to fulfill a TBA trade. Homeowners with jumbo mortgages, for instance, have a different propensity to prepay their mortgages than homeowners with smaller mortgages. Similarly, mortgages with very high loan-to-value (LTV) ratios are less likely to be paid off early than mortgages with lower LTV ratios. Hence MBS that contain jumbo mortgages or mortgages with very high LTV ratios are not eligible for TBA trading.

Cheapest to deliver pricing of TBA trades implies that investors with the most valuable MBS will trade them as SPs. To illustrate this, we calculate average prices for Fannie Mae TBAs and SPs each day during our sample period. We use Fannie Mae MBS to demonstrate the differences in prices because they account for the most trades. To compare prices in the TBA and specified pool markets, we first calculate the average price of interdealer trades in the TBA market for combinations of maturity and coupon for the nearest settlement date each day. We use interdealer prices to avoid incorporating markups. Likewise we calculate the average price for interdealer trades of specified pools for maturity and coupon combinations each day.

Prices of TBA and specified pool securities cannot be directly compared because they have different settlement dates. To adjust for this, we calculate the "drop" as the difference in price between the Fannie Mae TBA with the nearest settlement, and the Fannie Mae TBA with the second nearest settlement. The daily drop is calculated by dividing the drop by the number of days between the two settlement dates. We then multiply the daily drop by the number of days between a specified pool's settlement date and the nearest TBA settlement date and add this to the specified pool price. This adjusted specified pool price can then be compared with TBA prices. In practice, adjusting for the drop does not have much impact on the difference between TBA and specified pool prices.

Figure 1 shows, for 30-year 4% MBS, the five-day moving averages of specified pool and nearest-settlement Fannie Mae TBA prices for each day. Figure 2 is similar, but shows prices of 30-year 5% TBA and specified pool trades. In each case, SP and TBA prices track each other. There are, however, few SP trades and the values of the SPs differ with their prepayment characteristics, so the series of average specified pool prices is more volatile. In both cases, SP prices are higher. MBS are traded in the SP market rather than the far more liquid TBA market because they have more desirable prepayment characteristics and their full value cannot be realized in TBA trades.

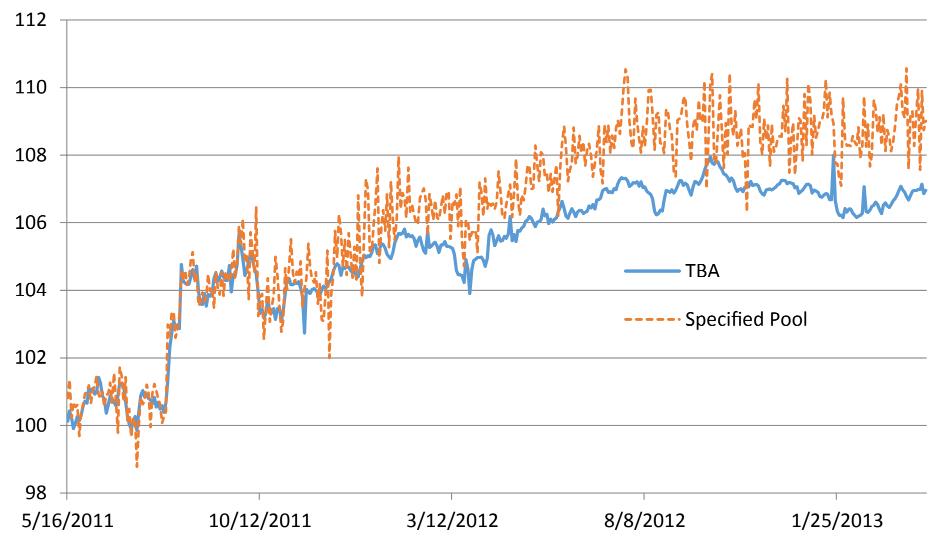

Figure 1 Mean daily TBA and SP prices for interdealer trades of 4% 30-year Fannie Mae MBS.

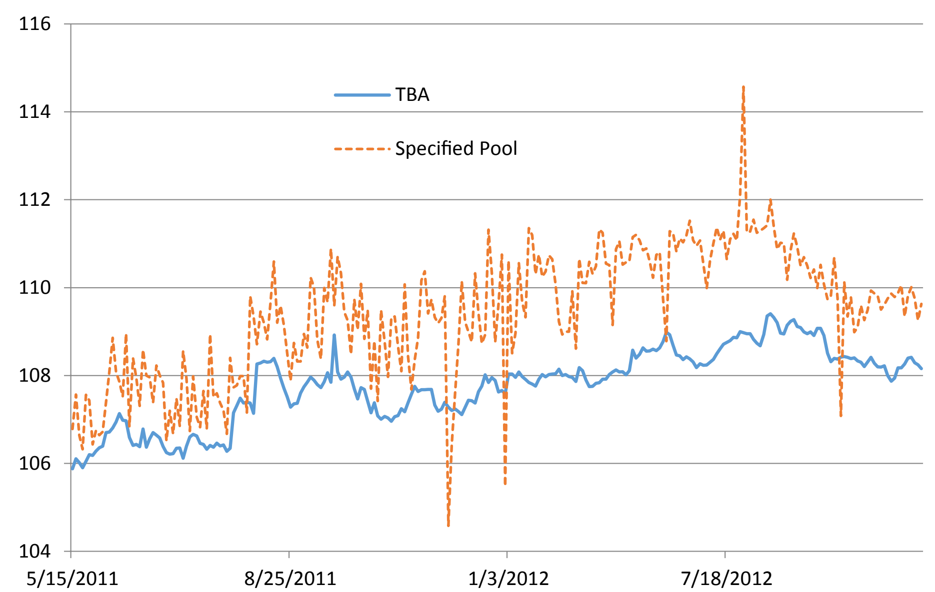

Figure 2 Mean daily TBA and SP prices for interdealer trades of 5% 30-year Fannie Mae MBS.

In both of the graphs, TBA prices and specified pool prices increase over the sample period. This can be attributed to falling mortgage interest rates over this time period. Of more interest is that the gap between SP and TBA prices increases as mortgage rates fall. When mortgage rates are high, homeowners are not motivated to refinance their mortgages and prepayment differences across MBS are unimportant. As rates fall, MBS with homeowners that are unlikely to refinance become especially valuable and the difference between SP and TBA prices increases. This helps to explain why trading costs are lower for TBA-eligible SPs. Figures 1 and 2 show that the gap between SP and TBA prices increases as interest rates fall. If rates were instead to increase, SP and TBA prices would move closer together. With a small difference in prices, dealers may prefer to unwind SP inventory through trades in the more liquid TBA market. This option to deliver is valuable to dealers and hence they will charge less for trades if an SP is TBA-eligible.

3 Data

Our data is an enhanced version of FINRA's TRACE data. It consists of information on every trade conducted by a FINRA member in agency mortgage-backed securities from May 16, 2011, through April, 2013. The record for each trade includes the CUSIP identifier for the MBS, an indicator for a TBA trade, the time and date of the trade, the settlement date, the trade price, and the par amount of the trade. TRACE caps trade sizes at $5 million, but trade sizes in our data are the actual par value of the trade. Also unlike TRACE, identities are included for each dealer. Identities are masked - we can not tell who the dealer is—but we can examine the sequence, history, and patterns of individual dealer trades.

There are several types of TBA trades. A dollar roll consists of a simultaneous TBA purchase with one settlement month and an otherwise identical sale with a different settlement month. Stipulated trades are TBA trades in which buyer and seller agree on parameters of the trade in addition to the usual six parameters. Stipulated dollar rolls are dollar rolls with parameters in addition to the usual six. We ignore these trades to concentrate on the outright trades in which an investor simply buys or sells in the TBA market. These outright trades serve as substitutes for SP trades.

Summary statistics are shown in Table 1. Over the two years of our sample period, there were 3.8 million trades with a total par value of $61.2 trillion. Outright TBA trades make up 61.7% of the trades and 85.7% of the total trade value. SP trades tend to be smaller. They make up 38.3% of trades, but only 14.3% of volume. Dealers trade with each other to unload inventory or to hedge SP positions with TBA trades. Interdealer trades represent 52.3% of trades, but only 44.8% of the trading volume. Dealer trades with customers tend to be larger than dealer trades with each other.

Over the entire sample period, 780 dealers make at least one MBS trade. We rank the dealers from the highest to the lowest total number of trades

Table 1 Total trades and volume for different types of MBS trades.

Total trades	3,835,514	Total volume	$61.19 trillion
% TBA trades	61.7%	% TBA volume	85.7%
% SP trades	38.3%	% SP volume	14.3%
% Interdealer trades	52.3%	% Interdealer volume	44.8%
% Dealer–customer trade	47.7%	% Dealer–customer volume	55.2%

Table 2 Proportion of trades by dealer activity ranking.

Dealer rank in # trades	% All trades	% All TBA trades	% All SP trades	% All volume
1–5	38.9	52.0	12.8	48.5
6–15	26.9	27.2	26.4	34.5
16–50	25.3	17.7	40.3	13.2
51–100	6.7	2.7	14.7	3.1
101–780	2.2	0.3	5.8	0.6

during the sample period. Table 2 provides statistics, by dealer rankings, on the proportion of different types of trade accounted for by the dealers. The top five dealers are responsible for 38.9% of all trades, 52% of TBA trades, and 48.5% of the total dollar volume of trades. In contrast, they only account for 12.8% for SP trades. Results for the next 10 dealers are shown in the following row of the table. These 10 dealers account for 26.9% of all trades, 27.2% of all TBA trades, and 34.5% of volume. Their mean TBA and SP trade sizes are smaller than the corresponding trade sizes for the top five dealers. To summarize, trading is concentrated in this market. The top 15 dealers account for 65.8% of all trades, 79.2% of all TBA trades, and 83% of all volume. Less active dealers focus on SP trades. Dealers outside of the top 50 are responsible for 20.5% of SP trades, but only 3% of TBA trades.

4 TBA vs SP trading costs

We estimate trading costs for specified pool and TBA trades by examining how prices change in consecutive trades when one trade is a dealer purchase from a customer and the other is a sale by the dealer to a customer. Suppose that the price of the first trade was \$100.00 and the price of the second was \$100.04. ΔP_t, or the percentage change in price from one trade to the next is (100.04 – 100.00)/100.00 or 0.04%. If the first trade was a dealer purchase from a customer and the second was a dealer sale to a customer, the difference in prices of 0.04% serves as an estimate of round-trip trading costs. On the other hand, suppose the first trade was a dealer sale to a customer at \$100.03 and the second trade was a dealer purchase from a customer at \$100.00. Now, ΔP_t, or the percentage change in price, is $(100.00 - 100.03)/100.03 = -0.03\%$. Because the dealer first sold and then bought, the price change of -0.03% is the *negative* of the round-trip trading costs paid by an investor.

That is the idea behind the regression that we run to estimate trading costs. Using all pairs of consecutive trades of the same MBS, we regress the change in prices, ΔP_t, on a variable ΔQ_t that is one if the first trade was a dealer purchase from a customer and the second was a dealer sale to an investor, and negative one if the first trade was a dealer sale to a customer and the second was a dealer purchase from an investor. That is

$$\Delta P_t = \alpha_1 \Delta Q_t \qquad (1)$$

ΔQ_t can be thought of as adjusting the order of trades so that the difference in prices is an estimate of trading costs. Think of our examples. If the first price was \$100.00 and the second was \$100.04, ΔP_t would be 0.04%. Since the first trade was a dealer purchase and the second a dealer sale, ΔQ_t would equal one. Plugging these numbers into Equation (1) we get $0.04\% = \alpha_1 \times 1$, so $\alpha_1 = 0.04\%$, the round-trip trading costs. Likewise, in the second example where the first price was \$100.03 and the second price was \$100.00, ΔP_t would be equal -0.03%. But, the first trade was a dealer sale to an investor and the second was a dealer purchase from an investor, so $\Delta Q_t = -1$. Plugging these numbers into Equation (1) we get $-0.03\% = \alpha_1 \times -1$ so $\alpha_1 = 0.03\%$, which again equals the round-trip trading costs. These examples were individual pairs of consecutive trades. If we were to estimate Equation (1) as a regression using a large number of trade pairs, α_1 would be an average of the trading costs.

By adding a trade size variable to Equation (1) we can estimate how trading costs are affected by the size of the trade. In addition, in some cases, consecutive trades did not occur on the same day. By adding index returns to the regression we can adjust for changes in the value of MBS from changes in interest rates and other economic variables that occurred over days between the consecutive trades. The following regression contains these modifications:

$$\Delta P_t = \alpha_0 + \alpha_1 \Delta Q_t + \alpha_2 \Delta Q_t \times \left(\ln\left(\frac{\text{Trade size}_t}{\$1{,}000{,}000}\right) + \ln\left(\frac{\text{Trade size}_{t-1}}{\$1{,}000{,}000}\right)\right) + \sum_{i=1}^{5} \beta_i R_{i,t} + \varepsilon_t, \quad (2)$$

where Trade Size_t is the par value of the MBS in trade t, and R_{it} is the return of index i over the days from the previous trade to trade t. The indices include (1) Barclay Capital's U.S. MBS Index, (2) Barclay's 7–10 year U.S. Treasury Bond Index, (3) Barclay's U.S. Corporate Bond Index, and (4) Barclay's U.S. Corporate High Yield Index. In addition, we use returns on the S&P 500 as a fifth index.[1,2] If consecutive trades occur on the same day, there are no index returns to include in the regression. Inclusion of these indices is important for SPs, which have a significant fraction of consecutive trades on different days. Consecutive trades are always trades of the same SP or TBA contract, but observations of different MBS with similar characteristics (e.g. 30-year TBA) are included in the same regression.

Consider the regression estimate when both of the trades are $1,000,000 of par value and both occur on the same day. Trade size is normalized by dividing it by $1,000,000. Natural logs of the ratio of trade size to $1,000,000 will equal zero when the trade size is $1,000,000. So, if both trade $t-1$ and trade t are for $1,000,000 par value, the second term in the regression drops out. If the trades occur on the same day, all of the terms involving daily index returns also drop out and Equation (2) becomes a regression of ΔP on ΔQ. As before, α_1 is the estimate of round-trip trading costs, but now for the case where the trade size is $1,000,000 for each trade and the trades occur on the same day. The α_2 coefficient tells how trading costs change as the size of the trade changes. A negative α_2 means that the change in price from a dealer purchase from a customer to a dealer sale to a customer, in other words the trading cost, decreases with trade size.

Regression results are reported in Table 3. The estimates for 30-year TBA trades are described in the first row. To save space, and because they are of less interest to us, we do not report the coefficients on the index returns. The α_1 coefficient on ΔQ_t is 0.0375, indicating that round-trip trading costs are about 3.75 basis points for 30-year TBA trade of $1 million par value. Underneath the coefficient, in brackets are the upper and lower bonds of the 95% interval. Given the large number of observations in the regression, we would expect the coefficient to be estimated accurately. That is what we find. The confidence interval indicates that there is a 95% chance that the round-trip trading costs are between 3.61 and 3.89 basis points. The coefficient on trade size is −0.0058, indicating that round-trip trading costs fall with trade size. As we will see, trading costs also fall with trade size of SPs. Inserting $5 million into the equation yields a round-trip trading cost of 1.88 basis points. When both trades are for $500,000, trading costs are estimated to be 4.55 basis points.

The TBA market for mortgage-backed securities is very liquid. Trading is cheap. Trading costs

Table 3 Trading cost estimates for TBA and SP trades.

TBA/SP	Maturity	α_1	α_2	Obs.	R^2
TBA	30-Year	0.0375	−0.0058	655,487	0.0459
		[0.0361, 0.0389]	[−0.0060, −0.0056]		
SP, TBA-eligible	>15 Year	0.8210	−0.2034	455,742	0.0893
		[0.8143, 0.8277]	[−0.2053, −0.2015]		
SP, TBA-ineligible	>15 Year	0.9611	−0.1773	63,947	0.1562
		[0.9481, 0.971]	[−0.1814, −0.1732]		
TBA	15-Year	0.0475	−0.0057	160,088	0.0540
		[0.0450, 0.0500]	[−0.0060, −0.0054]		
SP, TBA-eligible	≤15 Year	0.8825	−0.3015	201,527	0.0517
		[0.8691,0.8959]	[−0.3075, −0.2955]		
SP, TBA-ineligible	≤15 Year	0.9640	−0.1838	18,231	0.0775
		[0.9349, 0.9931]	[−0.1814, −0.1732]		

are lower for larger trades, but even a trade of \$500,000, which is significantly smaller than the typical TBA trade, has an expected round-trip cost of less than five basis points.

The next row of the table reports trading costs for SPs with more than 15 years to maturity that are TBA-eligible. With more than 15 years to maturity they can be delivered in 30-year TBA trades. Here, α_1 is 0.8210. Expected round-trip trading costs are 82 basis points for an SP trade of \$1 million par value, more than 20 times the round-trip costs for TBA trades. Regression results for SPs with maturities greater than 15 years that are not eligible to be delivered in a TBA trade are reported next. Expected round-trip trading costs for a \$1 million trade are 96.11 basis points as compared to the 82.1 basis points for the otherwise similar but TBA-eligible SP trades. The 95% confidence intervals of 94.81 basis points to 97.10 basis points for TBA-ineligible SP trading costs versus 81.43 to 82.77 basis points for TBA-eligible SPs suggest that the difference is statistically significant. For both TBA-eligible and TBA-ineligible SPs, trading costs fall with trade size.

The next three rows of the table contain results for 15-year TBA trades, for SP trades with maturities of 15 years or less that are eligible for delivery in 15-year TBA trades, and for SP trades of TBA-ineligible MBS with 15 years or less to maturity. Here again we see that TBA trading costs are much, much lower than SP trading costs. The α_1 coefficient for 15-year TBA trades is 0.0475, indicating that expected round-trip trading costs are only 4.75 basis points for a \$1 million par value TBA trade. By comparison, expected round-trip costs are 88.25 basis points for the same size trade of SPs with 15 or fewer years to maturity that can be delivered to fulfill a TBA trade. For SPs that are not eligible for TBA trading, expected round-trip costs are 96.4 basis points. Trading costs are slightly higher for all types of trades of these shorter maturity MBS, but results are similar to those obtained with 30-year MBS trades.

Both for maturities of more than 15 years, and for maturities of 15 years or less, round-trip trading costs are lower for TBA-eligible SPs than for TBA-ineligible SPs. When a dealer buys a TBA-eligible SP, he can sell it as an SP. The TBA eligibility, however, gives him an option to deliver it to fulfill a TBA trade. Like all options, this option is valuable to the dealer and may lead him to charge lower markups.

The main lesson of the regressions in Table 3 is that the TBA market is much more liquid than the SP market, and TBA trading costs are much lower than SP trading costs. Investors who intend to take an MBS position for a short period of time, or who are uncertain about their liquidity needs are better off trading in the TBA market than the SP market.

To add perspective to our estimates of TBA trading costs, we calculate the average quoted bid–ask spreads for treasury bonds over part of our sample period: May 16, 2011 through October 9, 2012. Mean quoted spreads were 3.92 basis for 30-year on the run treasury bonds, and 5.54 basis points for off-the-run 30 year bonds. Some caution is needed in comparing these costs with our estimates of TBA trading costs. The treasury spreads are quoted spreads and investors may receive better prices on trades. Nevertheless, trading costs for 30-year treasuries are very similar to costs for 30-year TBA trades. Round-trip trading costs for 5 and 10-year treasuries are less than half of the 4.75 basis points trading costs that we estimate for 15-year TBA trades. Trading costs for 15-year TBA trades are, however, much closer to trading costs for treasuries than to SP trading costs.

4.1 Why TBA trading is cheaper: It creates a liquid market by reducing fragmentation

In this section, we show how TBA trading creates liquidity by allowing many different SPs to be traded in a small number of active and liquid TBA contracts. For each month over our sample period, we count the total number of different TBA CUSIPs that trade, and the total number of SP CUSIPS that trade. We also calculate a Herfindahl index for TBA trades and SP trades each month. This index is calculated by taking the proportion of total volume for each CUSIP, squaring it, and summing across all CUSIPS. We then multiply by 100 to express the index as a percentage. The greater the Herfindahl index, the greater the concentration of trading. If one dealer was responsible for 100% of trading volume, the Herfindahl index would be 100. If four each accounted for a quarter of the trading volume, the index would be 25.

The number of TBA and SP CUSIPS that trade each month and the Herfindahl indices for TBA and SP trades are shown in Table 5. During June, 2011, the first complete month of our sample period, a total of 466 different TBA CUSIPs traded. Recall that six parameters are used to specify a TBA trade—issuer, maturity, coupon, settlement date, price, and trade size. Each combination of issuer (Fannie Mae, Freddie Mac, or Ginnie Mae), maturity, coupon, and settlement

Table 4 Quoted bid–ask spreads for treasury bonds, 5/16/2011–10/9/2012.

Maturity	On/off run	Mean % spread	Spread σ	Observations
5 Year	On-the-run	0.0098	0.0038	352
5 Year	Off-the-run	0.0210	0.0017	353
10 Year	On-the-run	0.0174	0.0029	352
10 Year	Off-the-run	0.0297	0.0033	353
30 Year	On-the-run	0.0392	0.0100	353
30 Year	Off-the-run	0.0554	0.0074	353

Table 5 Number of TBA and SP CUSIPS trade and TBA and SP Herfindahl indices.

Month	Number of TBA CUSIPS traded	TBA Herfindahl	Number of SP CUSIPS traded	SP Herfindahl
5/2011	342	7.894	13,713	0.033
6/2011	466	5.243	24,010	0.026
7/2011	419	5.177	20,773	0.025
8/2011	442	5.145	25,646	0.021
9/2011	471	4.697	22,359	0.023
10/2011	413	4.621	21,882	0.033
11/2011	421	4.259	22,977	0.031
12/2011	415	4.507	25,921	0.027
1/2012	416	5.102	23,120	0.031
2/2012	425	4.516	23,463	0.030
3/2012	470	5.588	23,738	0.034
4/2012	434	4.478	21,307	0.031
5/2012	448	4.298	22,805	0.029
6/2012	455	4.259	22,793	0.026
7/2012	463	4.945	23,456	0.027
8/2012	486	4.351	24,268	0.035
9/2012	433	5.291	22,339	0.031
10/2012	454	5.004	23,148	0.034
11/2012	457	4.493	25,553	0.028
12/2012	421	4.749	20,655	0.033
1/2013	427	5.434	25,221	0.031
2/2013	428	5.026	21,249	0.035
3/2013	431	5.171	23,657	0.030
4/2013	446	4.936	26,816	0.026

date has its own CUSIP. By far the most common maturities are 30 and 15 years, but we do see other maturities as well (e.g. 20 years or 40 years). Most TBA trades settle on the next settlement date, but some settle the following month or two months later. The Herfindahl index reported in the next column shows that trading is more concentrated than indicated by the number of CUSIPs traded. For June, 2011, the TBA Herfindahl index is 5.243, approximately what it would be if all of the trading was split equally among 19 TBA CUSIPs.

Results for SPs are in the next two columns. A total of 24,010 different SPs traded in June, 2011, over 50 times the number of TBA CUSIPs that traded that month. The Herfindahl index is only 0.026, less than 1/200th of the TBA Herfindahl index. This Herfindahl index value is what we would observe if trading was split equally among 3,846 SPs. So, trading is far, far more concentrated in the TBA market than the SP market. The number of TBA and SP CUSIPs traded and the Herfindahl indices are consistent across our sample period. In each of the 24 sample months trading is far less fragmented in the TBA market than in the SP market.

This shows why TBA trading costs are so much lower than SP trading costs. In any given month, thousands of SPs trade, and volume is relatively evenly distributed. Dealers will be reluctant to short an SP as part of their market making activities, because it will be hard to cover the short. Each SP is unique, so investors need to examine the characteristics of each SP before trading. This in turn raises costs to dealers because it means more contact between dealers and investors and that it takes dealers longer to unwind inventory. Finally, because a particular SP will trade infrequently, past trade prices are usually not useful in determining current trade prices.

In contrast to the 20,000 or so SPs trading during a month, there are typically 400–500 different TBA contracts traded. But, trading is concentrated among a small subset of these TBA contracts. The Herfindahl index is what we would observe if all trading was split evenly among 20 or so contracts. Concentrating trading in a small number of contracts creates liquidity. Dealers can go short with confidence that they can cover their positions. With TBA purchases, investors do not know which MBS they will receive, but TBA contracts trade frequently and it is easy to determine the market price.

To summarize, the same MBS can be traded as an SP or delivered to fulfill a TBA trade, but TBA trading costs are much, much lower. This is because TBA trading creates liquidity by reducing fragmentation and allowing many different MBS to be traded as one.

4.2 *Other factors that affect trading costs*

A factor that affects the trading costs for an MBS is the amount of MBS outstanding with the same coupon and maturity. The balance of outstanding MBS with a given coupon and maturity increases as new MBS are produced, and falls as mortgages are paid off. Over our sample period, mortgage rates declined. As a result, the outstanding balance of MBS with high coupons (e.g. 6%) declined as new MBS with that coupon were no longer issued and mortgages in existing MBS were prepaid and refinanced. At the same time, the balance of outstanding MBS with low coupons (2.5%, for example) increased as new MBS were produced.

We would expect trading costs for an MBS with a given coupon and maturity to be affected by the amount of the MBS outstanding. A greater outstanding balance of MBS with a given maturity and coupon implies a deeper market for TBA trading. It suggests that dealers may know more potential buyers (or sellers) for MBS with the particular coupon and maturity characteristics. It also suggests higher trading volume as some investors unwind positions.

We obtain the amount of MBS outstanding each month for 14 coupon–maturity combinations: 30-year MBS with coupon rates of 2.5%, 3%, 3.5%, 4%, 4.5%, 5%, 5.5%, and 6%, and 15-year MBS with coupon rates of 2.5%, 3%, 3.5%, 4%, 4.5%, and 5%. We sum the amount of MBS outstanding across issuers. As an explanatory variable for trading costs, we use the natural logs of the total amount outstanding the previous month interacted with the change in the trade type (buy or sell). Specifically, for SP trades we estimate the following regression

$$\begin{aligned}\Delta P_t = {} & \alpha_0 + \alpha_1 \Delta Q_t + \alpha_2 \Delta Q_t \\ & \times \left(\ln\left(\frac{\text{Trade size}_t}{\$1{,}000{,}000}\right) \right. \\ & \left. + \ln\left(\frac{\text{Trade size}_{t-1}}{\$1{,}000{,}000}\right)\right) \\ & + \alpha_3 \Delta Q_t \ln(\text{MBSOut})_t \\ & + \alpha_4 \Delta Q_t \text{TBA-Eligible}_t \\ & + \alpha_5 \Delta Q_t \text{TBA-Eligible}_t \\ & \times \ln(\text{MBSOut})_t + \sum_{i=1}^{5} \beta_i R_{i,t} + \varepsilon_t. \quad (3)\end{aligned}$$

When this regression is run for TBA trades rather than SP trades, we drop the terms that include TBA eligibility. If the SPs are TBA-eligible, maturities of greater than 15 years can be delivered to fulfill 30-year TBA trades, whereas maturities of 15 years or less can be delivered to fulfill 15-year trades. So, for SP trades, we use maturities greater than 15 years as 30-year maturities and maturities of 15 years or less as 15-year maturities. Note that in previous regressions we had used MBS with coupons ending in quarter percents (3.25% or 3.75%) and MBS with high coupons (7%, 8%, etc). We lose these observations when we restrict the regressions to the 14 coupon–maturity combinations, but still retain 96% of the trades.

A negative α_3 coefficient says the difference in prices between consecutive trades, or in other words the round-trip transactions costs, decreases with the amount of MBS with the same coupon and maturity that are outstanding. Likewise, a negative α_4 coefficient indicates that trading costs are lower for TBA-eligible SPs than SPs that are not TBA-eligible. Finally, a negative α_5 coefficient means that trading costs decline with the amount outstanding more for TBA-eligible SPs than for other SPs.

Regression results are given in Table 6. The first row contains regression estimates for 30-year TBA trades. As before, confidence intervals are in brackets below the coefficient estimates. The coefficient on the interaction between ΔQ and the log of the value of MBS outstanding is -0.0193 and is highly significant. A 30-year TBA trade is cheaper if there was a large outstanding balance of the same coupon–maturity combination at the end of the previous month.

To put things in perspective, consider 30-year 3.5% coupon MBS. The amount outstanding increased steadily from \$46.4 billion at the beginning of the sample period to \$670.6 billion at the end. The log of the values (in \$ millions) increased from 10.745 to 13.416. Hence our regression results imply that expected round-trip trading costs fell by $-0.0193 \times (13.416 - 10.745) = 5.15$ basis points. On the other hand, the amount of outstanding 30-year 5.5% MBS fell from \$659.8 billion to \$309.6 billion over the sample period. Multiplying logs of these values by the regression

Table 6 The impact of the balance of outstanding MBS on MBS trading costs.

	α_1	α_2 (Tradesize)	α_3 (MBS outstanding)	α_4 (TBA Elgb.)	α_5 (TBA Elgb. × Out.)	R^2
TBA Trades						
30 Yrs	0.2845	−0.0062	−0.0193			0.0509
	[0.272, 0.297]	[−0.007, −0.006]	[−0.020, −0.018]			
15 Yrs	0.1275	−0.0088	−0.0061			0.0886
	[0.110, 0.145]	[−0.009, −0.008]	[−0.008, −0.005]			
SP Trades						
>15 Yrs	1.7597	−0.1710	−0.0610	−0.3008		0.1668
	[1.721, 1.799]	[−0.173, −0.169]	[−0.064, −0.058]	[−0.316, −0.286]		
≤15 Yrs	2.1479	−0.0967	−0.1048	−0.4735		0.1436
	[2.003, 2.293]	[−0.099, −0.094]	[−0.116, −0.093]	[−0.512, −0.435]		
>15 Yrs	0.8786	−0.1706	0.0114	1.9633	−0.1781	0.1681
	[0.841, 0.916]	[−0.172, −0.169]	[0.008, 0.015]	[1.874, 2.053]	[−0.185, −0.171]	
≤15 Yrs	2.1584	−0.0967	−0.1058	−0.4861	0.0011	0.1436
	[1.570, 2.747]	[−0.099, −0.094]	[−0.156, −0.055]	[−1.086, 0.114]	[−0.054, 0.056]	

coefficient indicates that expected trading costs rose by $-0.0193 \times (12.643 - 13.400) = 1.46$ basis points. The second row provides results for 15-year TBA trades. As with 30-year TBA trades, trading costs fall significantly with trade size and the amount of the MBS outstanding.

The next row reports regression results for SP trades with more than 15 years to maturity and coupon rates from 2.5% to 6%. If TBA-eligible, these SPs can be delivered to fulfill 30-year TBA trades. For these SPs, trading costs fall significantly with trade size, with TBA eligibility, and with the amount of MBS with coupon and maturity outstanding. The fourth row of the table provides the regression coefficients for SPs with 15 or fewer years to maturity. Again, trading costs fall significantly with trade size, the amount of similar mortgage-backed securities outstanding, and TBA eligibility.

The last two rows report regression results when an interaction between TBA eligibility and the log of the amount outstanding are included. For the short-term SPs, this interaction term is insignificant and its inclusion has little effect on other coefficients. For longer-term SPs, the interaction between TBA eligibility and the log of the amount outstanding is negative and highly significant, while the coefficient on the amount of MBS outstanding is now positive. For longer-term SPs, TBA eligibility reduces trading costs, but only when there is a significant amount of MBS outstanding. This makes sense. Trading costs are lower for TBA-eligible SPs because TBA eligibility gives dealers an option to unwind positions through TBA trades. This option, however, is only valuable if there are a lot of the MBS outstanding and the TBA market is therefore active for that coupon and maturity.

Investors who are interested in maximizing liquidity and minimizing trading costs should invest in MBS with popular maturity–coupon combinations. If there are few MBS outstanding with particular maturity–coupon combination, it is harder for dealers to cover short positions or to find buyers. Hence they charge more to trade these MBS.

There are reasons to believe that large dealers may be more efficient market makers than small dealers. There are likely to be economies of scale. In addition, a dealer that trades frequently has many opportunities to adjust its inventory positions. Finally, a dealer that trades often will be better informed about market conditions and therefore less likely to lose money on a trade. With lower market making costs, it is possible that active dealers will charge less for trades.

To test this, we calculate the total number of TBA trades for each dealer over the first six months of our sample period. Then, in the trading cost regression, we interact the change in trade type with the sum of the natural log of the number of the dealers' trades in the first six months of the sample period. That is, we estimate

$$\begin{aligned}\Delta P_t = {} & \alpha_0 + \alpha_1 \Delta Q_t + \alpha_2 \Delta Q_t \\ & \times \left(\ln\left(\frac{\text{Trade size}_t}{\$1{,}000{,}000}\right) \right. \\ & \left. + \ln\left(\frac{\text{Trade size}_{t-1}}{\$1{,}000{,}000}\right) \right) \\ & + \alpha_3 \Delta Q_t \ln \text{Dealer Trades}_t \\ & + \sum_{i=1}^{5} \beta_i R_{i,t} + \varepsilon_t. \end{aligned} \tag{4}$$

This is the same as our original regression but now includes an interaction between ΔQ_t and the log of the number of dealer trades. If α_3 is negative, it means that round-tip trading costs decrease with the number of dealer trades. Trades from the six months used to estimate the number of dealer trades are not included in the regressions that estimate trading costs.

Table 7 Trading cost estimates for TBA and SP trades.

TBA/SP	Maturity	α_1	α_2 (Trade size)	α_3 Ln (Dealer trades)	Obs.	R^2
TBA	30-Year	0.3009	−0.0035	−0.0121	459,416	0.0209
		[0.285,0.317]	[−0.004, −0.003]	[−0.013,−0.011]		
SP, TBA-eligible	>15 Year	1.8171	−0.1593	−0.0528	332,324	0.0910
		[1.774,1.860]	[−0.162, −0.157]	[−0.055,−0.051]		
SP, TBA-ineligible	>15 Year	1.9677	−0.1310	−0.0579	45,771	0.1779
		[1.901,2.034]	[−0.136, −0.126]	[−0.062, −0.054]		
TBA	15-Year	0.8659	−0.0041	−0.0360	119,477	0.0377
		[0.819,0.913]	[−0.005, −0.004]	[−0.038, −0.034]		
SP, TBA-eligible	≤15 Year	0.9027	−0.2992	−0.0028	139,369	0.0536
		[0.835,0.971]	[−0.307, −0.292]	[−0.007, 0.001]		
SP, TBA-ineliaible	≤15 Year	2.0735	−0.1342	−0.0710	12,831	0.0734
		[1.942,2.205]	[−0.154, −0.115]	[−0.079, −0.063]		

Results for 30-year TBA trades are reported in the first row of Table 7. The coefficient on the sum of log trades for the dealers in each of the consecutive trades is −0.0121 with a 95% confidence interval of −0.013 to −0.011. The dealer handling the trade is a significant determinant of trading costs. A one-standard deviation change in the number of the dealers' trades changes round-trip trading costs by 3.2 basis points. The next row reports results for SPs that are eligible to be delivered in a 30-year TBA trade. The coefficient on the log of the number of dealer trades is −0.0528. A one-standard deviation increase in the number of trades reduces 30-year SP trading costs by 31 basis points. Similar results are reported in the next row for TBA-ineligible SPs with maturities greater than 15 years. The following three rows report regression results for 15-year TBAs and SPs with maturities of 15 years or less. Results again indicate that trading costs are lower when investors trade with more active dealers.

Note that even when examining SP trading costs, we use the number of TBA trades in the first six months of the sample period. If we use the log of the number of SP trades by the dealer instead, we also find that trading costs decrease with the number of dealer trades, but results are weaker. Larger dealers tend to focus on the TBA market, so TBA trading is a better measure of total trading. In addition, information gained from trading in the TBA market is likely to be more valuable than information gained from SP trades. Each SP is unique, and the dealer may not learn anything that is useful for trading other SPs. On the other hand, SPs are priced at a payup to TBAs. Information on TBA prices may be useful for pricing SPs.

Trading costs are lower for trades with more active dealers. Investors should be cautious, however, in interpreting this to mean that they are better off trading through more active dealers than less active ones. The difference in trading costs could be a result of active dealers having more sophisticated customers than inactive dealers. If the customers of less-active dealers are less knowledgeable about market conditions than the customers of active dealers, it is possible that less active dealers exploit their ignorance by charging them more to trade. In addition, when deciding who to trade with investors need to consider the fixed costs of having a trading relationship, like collateral or margin agreements, and not just the costs per trade.

5 Using brokered trades to lower trading costs

If an investor can afford to wait for a trade to be executed, he can save on trading costs by using a brokered trade. In a brokered, or riskless principal, or prearranged trade, a dealer does not commit capital. Instead of buying an MBS from an investor he instead searches for a buyer. After one is found, the dealer executes both sides of the trade. The buyer that the dealer locates can be either an investor or another dealer.

For each dealer purchase of an MBS from a customer, we search for an offsetting same size sale by the dealer to another dealer or to a customer that occurred within five minutes of the purchase. These are defined as brokered trades. Similar results are obtained when brokered trades are defined using a two-minute window. We miss any brokered trades in which the dealer matches the first trade with two or more trades which together offset the initial trade, but we expect these to be relatively uncommon. It is possible that the trades we define as brokered are actually cases where the dealer bought or sold an MBS and, by good luck, offset the transaction very quickly. This seems especially unlikely for SPs that trade infrequently.

What the time stamps do not tell us is when the investor first approached the dealer to trade. It may have taken the dealer hours or even days to find the other side of the trade. We have no way of knowing how long the first investor waited for the trade to be executed.

Table 8 presents the proportion of dealer purchases from customers that are brokered trades. The first row indicates that when all coupons are considered, 13.63% of all 30-year TBA purchases from customers are part of a brokered trade, and 70.39% of the brokered trades have another investor, rather than a dealer, as the counterparty. The next row shows that 9.73% of all 15-year TBA purchases from customers are part of a brokered trade. The 30-year TBA trades are the most common, and it is quite possible that some of the brokered trades are actually trades in which the dealer had the good fortune to find a counterparty quickly.

The next two columns present results for off-the-run coupons. These are coupons that were unusual during the sample period. Thirty-year MBS with coupons above 6% or below 2.5% were not in

Table 8 The proportion of buys from customers that are brokered. On the run coupons range from 2.5% to 6% for 30 years, 2.5% to 4% for 15 years.

		All coupons		Off-the-run coupons	
		% Buys prearranged	% Prearranged with investors	% Buys prearranged	% Prearranged with investors
TBA	30 Year	13.63	70.39	7.87	76.67
TBA	15 Year	9.73	70.22	7.81	83.81
SP, eligible	>15 Year	17.77	40.84	31.99	42.30
SP, ineligible	>15 Year	30.58	48.88	31.22	55.56
SP, eligible	≤15 Year	21.56	49.70	27.61	47.15
SP, ineligible	≤15 Year	34.39	68.01	36.45	68.68

production during this time and TBA trades with these coupon rates are included in the off-the-run category. For 15-year TBA trades, we consider rates below 2.5% or above 4% to be off-the-run. For both maturities, TBA trades with coupon rates that are neither a full or half percentage (e.g. 4.25%) are also included in the off-the-run coupons. Only 7.87% of the 30-year TBA trades of off-the-run coupons are brokered. Since the unusual coupons make these trades harder to unwind, we would expect a larger proportion of the trades to be brokered. The fact that they suggest that dealers may have been able to unwind some of the 30-year TBA trades very quickly and that we may be overestimating the proportion of 30-year TBA trades that are brokered.

In general, a large proportion of the SP trades are brokered. When all coupon rates are considered, the proportion of dealer purchases from investors that are brokered is 17.77% for TBA-eligible SPs with maturities greater than 15 years, 30.58% for TBA-ineligible SPs with long maturities, 21.56% TBA-eligible SPs with 15-years to maturity or less, and 34.39% for short-maturity TBA-ineligible SPs. The fact that dealers are less likely to commit capital to trades of TBA-ineligible SPs is consistent with the idea that TBA eligibility gives dealers a valuable option to unwind a position in the liquid TBA market. A larger proportion of SP trades with off-the-run coupons than other coupons are brokered. This is not surprising. Positions in SPs with unusual coupons may be harder for dealers to unwind. They may be reluctant to commit capital to holding them in inventory.

Trading costs are easy to estimate for brokered trades—we simply subtract the price the dealer paid for the MBS from the price they received when they sold it. We then regress the percentage trading costs on the log of each trade's par value divided by \$1 million. That is, we estimate

$$\Delta P_t = \alpha_1 + \alpha_2 \left(\ln \left(\frac{\text{Trade size}_t}{\$1{,}000{,}000} \right) + \ln \left(\frac{\text{Trade size}_{t-1}}{\$1{,}000{,}000} \right) \right) + \varepsilon_t. \qquad (5)$$

As before, α_1 is an estimate of round-trip trading costs when trade sizes are \$1,000,000. We do not need to include ΔQ_t in this regression as the price difference for every round-trip trade is the dealer

Table 9 Trading costs for brokered trades.

		α_1	α_2 (Log size)	Obs.	R^2
TBA	30 Year	0.0209	−0.0059	73,775	0.0099
		[0.020, 0.021]	[−0.0062, −0.0056]		
SP, eligible	>15 Year	0.2792	−0.0332	57,087	0.0192
		[0.276, 0.283]	[−0.034, −0.032]		
SP, ineligible	>15 Year	0.3157	−0.0257	14,268	0.0297
		[0.311,0.321]	[−0.027, −0.024]		
TBA	15 Year	0.0215	−0.0046	12,481	0.0179
		[0.021,0.022]	[−0.005, −0.004]		
SP, eligible	≤15 Year	0.3400	−0.0309	30,818	0.0093
		[0.335,0.345]	[−0.033, −0.029]		
SP, ineligible	≤15 Year	0.4398	−0.0204	5,111	0.0096
		[0.429, 0.451]	[−0.023, −0.018]		

sale price to a customer minus the dealer buy price from a customer.

Results are shown in Table 9. For the 30-year TBA trades, the intercept is 0.0209. For brokered trades with $1 million par value, expected round-trip trading costs are 2 basis points—a bit less than the 3.75 basis points estimated using all consecutive trades. The coefficient on trade size is −0.0059, indistinguishable from the −0.0058 estimated using all consecutive trades. Trading costs fall with trade size for brokered trades as well as those in which the dealer commits capital.

The next row reports results for TBA-eligible SPs with more than 15 years to maturity. These are the SPs that could be delivered in a TBA trade. The intercept coefficient is 0.2792. The expected round-trip trading cost for a $1 million brokered trade is 27.9 basis points, far, far less than the 82.1 basis points estimated using all consecutive trades. An investor who does not need immediate execution and can wait for a dealer to find the other side of an SP trade can save significantly on execution costs through brokered trades. The coefficient on trade size is −0.0332, indicating that trading costs fall for SP trades with trade size. The coefficient is smaller in magnitude than the coefficient of −0.2034 on trade size estimated with all consecutive trades, indicating that trading costs for brokered trades do not fall as quickly with trade size as do trading costs for other trades of 30-year TBA-eligible SPs. It also means that trading costs for smaller trade sizes remain low for brokered trades.

Trading cost regression results for TBA-ineligible SPs with more than 15 years to maturity are shown next. The intercept coefficient is 0.3157, which means that expected round-trip trading costs are 31.57 basis points for $1 million trades of these TBA-ineligible SPs. This is much lower than the 96.11 basis points cost estimated using all consecutive trades. The next three rows of the table provide the regression results for 15-year TBA-brokered trades and trades of SPs with 15 or fewer years to maturity. Results are similar to those obtained with longer maturity MBS. Trading cost estimates are much lower than estimates using all consecutive trades and are less sensitive to trade size.

To summarize, when it comes to trading MBS, immediacy is costly. Investors who can wait for a dealer to find the other side of a trade pay far lower trading costs than those who demand immediate execution. This is especially true for costly SP trades.

6 Conclusion

This paper explores how investors should trade agency mortgage-backed securities. Investors can trade MBS in two ways. They can trade them as specified pools, and both buyer and seller will know which mortgages are contained in the MBS. Alternatively, they can deliver the MBS to fulfill a TBA or forward market trade. In this case, the buyer learns which MBS will be delivered only after the trade is completed. Buyers assume that sellers will deliver the least desirable MBS, and so TBA trades are priced on a cheapest-to-deliver basis.

An investor that has an MBS with desirable prepayment characteristics should sell it as an SP. MBS delivered to fulfill TBA trades receive the cheapest-to-deliver price, which, as we showed, can be quite a bit less than the prices paid for SPs. Investors who buy an SP will pay more, but will receive a more valuable MBS with more predictable prepayments.

Garden variety MBS with typical prepayment characteristics should be traded in the TBA market. That market is more liquid and trading costs are much, much lower. The TBA market is more liquid than the SP market because, as we have shown, trading is concentrated in a handful of contracts while thousands of unique SPs trade every month. Forcing all of the trading into a small number of contracts makes it easy for dealers to cover short positions and to reverse trades. This leads to lower trading costs.

There are other things that investors can do to minimize trading costs. Trading costs are lower for maturity–coupon combinations with a large amount of outstanding MBS. Investors who need liquidity can lower trading costs by avoiding MBS with unusual coupons or times to maturity. We also show that trading costs are lower for trades with active dealers than for trades with inactive ones. It is not clear though, that trading with active dealers is necessarily cheaper when the other costs of trading relationships are included. Also, it is possible that trading costs are lower with active dealers because their clientele consists of more sophisticated investors.

Perhaps, the easiest and most effective way to reduce trading costs is to use brokered or riskless principal trades. Dealers do not use their own capital to buy or sell MBS in these trades, but instead execute both sides of the trade after matching a buyer with a seller. Dealers do not take the risk of holding inventory, so trading costs, particularly for SP trades, are far lower with brokered trades. But, while brokered trades shelter dealers from the risk of holding the MBS, the risk is borne by the seller (or buyer) until the other side of the trade is found. Of course, investors who need immediacy cannot trade in this way. It could take hours, or even days, before a counterparty is found.

Notes

[1] This technique for estimating trading costs in dealer markets has been used in a number of studies including Bessembinder *et al.* (2013) and Gao *et al.* (2017).

[2] These indices are also used in Bessembinder *et al.*'s (2013) study of structured credit products.

References

Atanasov, V., Merrick, J., and Schuster, P. (2016). "Why Do Dealers Buy High and Sell Low? An Analysis of Persistent Crossing in Extremely Segmented Markets," *Review of Finance*, 719–760.

Bessembinder, H., Maxwell, J., and Venkataraman, K. (2013). "Trading Activity and Transaction Costs in Structured Credit Products," *Financial Analysts Journal* **69**, 55–68.

Gao, P., Schultz, P., and Song, Z. (2017). "Liquidity in a Market for Unique Assets: Specified Pool and To-Be-Announced Trading in the Mortgage-Backed Securities Market," *Journal of Finance* **72**, 1119–1170.

Vickery, J. and Wright, J. (2013). "TBA Trading and Liquidity in the Agency MBS Market," *Federal Reserve Bank of New York Economic Policy Review*, May, 1–18.

Keywords: Mortgage-backed securities; trading costs; liquidity