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Positive feedback trading in the US Treasury market[1]

Government bonds are at the heart of the global financial system. Because they usually represent the most creditworthy obligations in the economy, they are commonly used as benchmarks for pricing other obligations, as vehicles for hedging against changes in broad levels of interest rates, and as collateral for credit exposures. In recent years, other instruments have also begun to perform some of these functions. For example, interest rate swap yields have become pricing benchmarks in many fixed income markets, and exchange-traded derivatives such as futures and options have steadily gained importance as hedging vehicles.[2] Nevertheless, government bond markets continue to play a central role in virtually all of the major economies.

Any disruption to the trading or pricing of government bonds, such as happened at certain points during the market turbulence that followed Russia's default in August 1998, has the potential to spread rapidly and to disrupt market functioning throughout the financial system (CGFS (1999, 2001) and Borio (2000)). The use of government securities as hedging vehicles means that price movements in related markets, such as those for bond options or mortgage-backed securities, can sometimes cause unexpectedly sharp movements in cash bond prices as well. Research on these dynamics has been limited; two recent examples are Kambhu and Mosser (2001) and Fernald et al (1994).

Despite the systemic importance of government bond markets, relatively little is known about how price discovery takes place in these markets. This note examines one aspect of the price discovery process in the US Treasury bond market, namely the short-term interactions between market prices and new buy and sell orders. Confirming the results found by other researchers, we find that trades have a strong impact on prices, and that this impact is stronger on days when trading is relatively rapid and volatile than it is on quieter days. However, we also find that traders tend to reinforce price movements by buying

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[2] Wooldridge (2001), McCauley (2001) and BIS (2000 pp 116–18, 2001) look at shifts in the use of government bonds as benchmarks in fixed income markets.

when prices rise and selling when they fall, at least in the very short run. Moreover, this tendency is somewhat stronger in more volatile trading conditions.[3] This second result is familiar to market practitioners, but has not yet been conclusively documented in the scholarly literature. A concluding section discusses some of the implications of this result for market functioning.

Past research on price discovery

Past research has looked at how order flow influences prices ...

One of the principal findings of researchers in the area of market microstructure is that order flow – the balance of orders for purchases and sales of financial assets received by dealers over a specified period of time – contains information that is rapidly incorporated into market prices.[4] This has been found to be the case for numerous markets, including equities (Hasbrouck (1991)) and foreign exchange (Evans and Lyons (2002)). Fleming (2001) tests this result for the US Treasury market. Using data for the period from 30 December 1996 to 31 March 2000, he finds that order flow during a given five-minute price interval does indeed have a significant impact on price changes during the same interval for on-the-run (recently issued) Treasury securities.

Theoretical researchers such as Glosten and Milgrom (1985) and Kyle (1985) view this effect as stemming from the presence of both informed and uninformed traders in the market. A dealer who receives a new buy order may not know whether the order actually reflects an accurate valuation of the asset being traded, but as long as there is a sufficient possibility that this is the case the dealer will respond to a new buy order by increasing the price that is quoted to subsequent traders. Similarly, a new sell order should lead to a lower price quote.

... but Treasury prices sometimes move sharply without a change in order flow

Yet it is also the case that US Treasury prices can change dramatically without any trading. Fleming and Remolona (1999) find that a scheduled public announcement of macroeconomic data tends to be immediately followed by a near-instantaneous change in bond prices and a severe *decline* in trading volume. This is followed by a period of higher trading volume and much smaller price changes as investors adjust their positions based on their differing interpretations of the news.

If price changes can be exogenous in this way, this raises the question of what this means for market dynamics, and specifically the effect of price changes on trades. Hasbrouck (1991) finds evidence of negative feedback from price changes in the US equity market. Examining intraday trades and quotes of the common stock of a US department store, he finds that price increases tend to be followed by increased selling activity, and price decreases by increased buying activity. He views this as resulting from a number of possible

3 A more detailed econometric analysis of trade-quote interactions in the US Treasury market, including how and why these patterns differ depending on market conditions, can be found in Cohen and Shin (forthcoming).

4 O'Hara (1995) surveys the academic literature on market microstructure. See CGFS (2000) for a discussion of policy issues related to market microstructure and bond market liquidity.

causes, including measurement error, stale quotes, inventory control and price experimentation. As will be discussed below, we find the opposite result for the US Treasury market: price increases tend to be followed by relatively more buying and decreases by relatively more selling. A possible explanation for this, also discussed below, is that changes in prices change the perceived risk attributes of a given exposure, and that institutional characteristics of bond trading operations require a rapid adjustment of one's position in response.

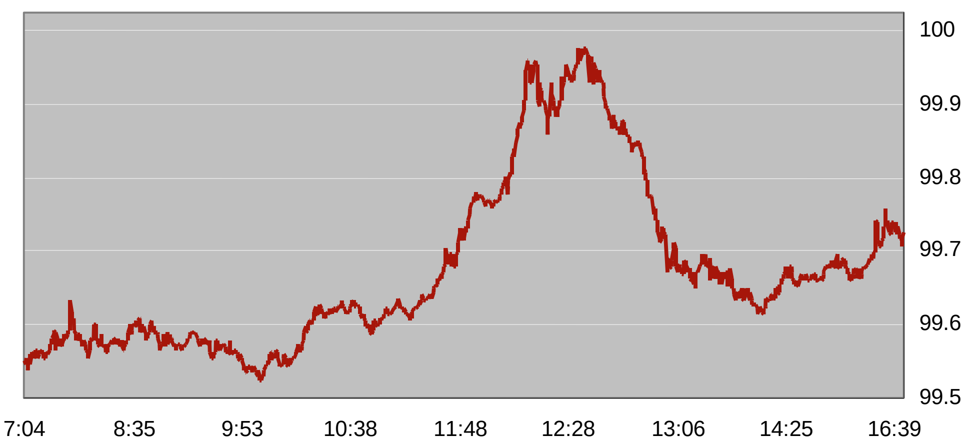
A case study: 3 February 2000

Our study of the US Treasury market, like those by Fleming (2001) and Fleming and Remolona (1999), uses data from GovPX, Inc., a consortium of inter-dealer brokers. For each outstanding Treasury security, GovPX posts the best available bid and offer prices from participating dealers, along with the amount the dealer is willing to trade, on a trading screen which is accessible to subscribers. The screen also records when a trade is executed, the amount traded, and whether the trade was initiated by the buyer of the securities or the seller. Each "tick" in the GovPX data represents either a new bid price, a new offer price, a trade, or some combination thereof. Normally, the time from one tick to the next is about one minute. According to Fleming, trading on GovPX represented about 42% of daily market volume in the first quarter of 2000, with a greater coverage at shorter than longer maturities.

The interactions between prices and trades are often complex

GovPX data for 3 February 2000 provide an example of the complexities of trading interactions in the Treasury market (Graph 1). During trading hours on the previous day, the US Treasury had announced a change in issuance procedures which was expected to result in a sharply reduced supply of 30-year bonds. This led to a rally in the price of the 30-year bond and a great deal of price volatility at other maturities. During the morning of the 3rd, rumours circulated that the Federal Reserve Bank of New York was organising a rescue for a large trading institution that had suffered severe losses, and that the institution would be forced to liquidate its short positions. This led to a rally in

Price of two-year US Treasury note, 3 February 2000[1]



[1] Midpoints of prevailing bid and ask quotes.

Sources: GovPX, Inc.; authors' calculations. Graph 1

Trading epochs for two-year US Treasury note, 3 February 2000				
	Return[1]	Percentage buys	Mean time between ticks (minutes)	Mean bid-ask spread[2]
7 am–11 am	0.00063	52.6	0.61	0.0097
11 am–12.15 pm	0.00340	65.9	0.53	0.0102
12.15 pm–2 pm	–0.00317	40.9	0.48	0.0181
2 pm–5 pm	0.00090	66.7	0.96	0.0120
Memo:				
Full sample (1/99–12/00)	*0.00067*[3]	*52.9*	*0.98*	*0.0065*

[1] Log change in quote midpoint. [2] Difference between prevailing ask and bid quotes. [3] Mean absolute value of daily log quote midpoint changes.

Sources: GovPX, Inc.; authors' calculations.

Treasury prices along the entire yield curve. Around 12.30 pm, the Fed publicly denied that such a rescue was taking place. This led to an immediate and very steep drop in Treasury prices, followed by a mild recovery.

Order flows are not the whole story

The trading atmosphere on 3 February 2000 was clearly one of great uncertainty. A view of market microstructure that emphasises the role of order flow in transmitting information would predict that the upward and downward movements in Treasury prices corresponded to greater order flow, with more buyer-initiated trades when the price rose and more seller-initiated trades when the price fell. This is confirmed by the 3 February data – up to a point (see table). There are more buys than sells during the period of the strongest upswing, from 11 am to 12.15 pm. Yet the imbalance between buys and sells is even greater from 2 pm to 5 pm, when prices rose by only a quarter as much. Furthermore, when one examines these data in more detail, it proves hard to associate the turning points in the price series with specific clusters of buy and sell orders. It appears that, while the order flow hypothesis has some truth to it, there are also other factors at play.

Interactions between trades and prices

To gain a broader understanding of these issues, we study trading activity in the on-the-run two-year note during normal trading hours (7 am to 5 pm) on all business days in the period from 4 January 1999 to 29 December 2000. This was an especially interesting period for the US Treasury market, because mounting fiscal surpluses had led to a decline in new issuance and, some observers claimed, a decline in liquidity in certain market segments. GovPX provides 358,361 ticks of data on the two-year note on the 501 business days during this period. Of this total, 40% represent trades without a change in quotes, 49% changes in the prevailing quote without any trade, and 11% trades accompanied by a change in the prevailing quote.

Analysing these data through econometric methods in Cohen and Shin (forthcoming), we find that not only does order flow cause price changes in the predicted way (with buying causing prices to rise and selling causing prices to fall), but in some circumstances price changes are followed by trades in a way that reinforces these effects (with price increases causing more buying and decreases causing more selling). This effect becomes more pronounced in relatively volatile trading conditions, especially for the on-the-run two-year note. These results derive from a vector autoregression analysis similar to the one used by Hasbrouck (1991) in his study of the equity market. In this section, we will illustrate these effects using a less technical analysis of the data.

For the two-year US Treasury note, the price impact of order flow …

To begin with, it is clear that buys tend to be followed by a small but pronounced positive return, while sells tend to be followed by a negative return. In other words, we confirm the order flow effect that has now been verified for several classes of financial instruments. During the 20 ticks following a new buyer-initiated trade, a period of time lasting about 19.6 minutes, the price of the on-the-run two-year Treasury note rises by an average of 0.0028%.[5] During the 20 ticks following a new sell, the price falls by an average of 0.0033%. For comparison, the average absolute value of daily returns during the sample period is 0.0667%. A new buy or sell order thus induces a price movement that is about 5% of the total change in prices that takes place in an average trading day.

To see how the price impact of a trade changes depending on trading conditions, it is instructive to divide the 501 trading days in the sample into "active", "normal" and "quiet" days. This corresponds to the tendency for market participants to characterise a given day's trading as being unusually turbulent or unusually calm, because the influence of a statistical release or other news event tends to last throughout the trading day. Our criterion for assigning days to these three groups is a measure of the average time between ticks, with adjustments for the time of day, month of the year and long-term trends in the data. Active days are those where price quotes are changed frequently and trades occur rapidly, while quiet days see less frequent quote changes and slower trading. The active days will be defined as the 50 days (10% of the sample) when this time gap was at its shortest; on these days, new trades or quotes arrived every 40 seconds or so. On quiet days, the 50 days when this gap was longest, the time between ticks averaged about two minutes.

… is stronger on busy trading days

The impact of trades on prices is clearly stronger during days when price changes and trading were unusually active than it is on other days (Graph 2, left-hand panel). On an active day, a new sell order is followed by a cumulative decline in the prevailing price quote averaging 0.0047% over the next 20 ticks, which in this case represents a period of about 13 minutes. A new buy order leads to a price increase of about 0.0050% on active days. The impact of both buys and sells is much smaller during normal days, and even less on quiet days.

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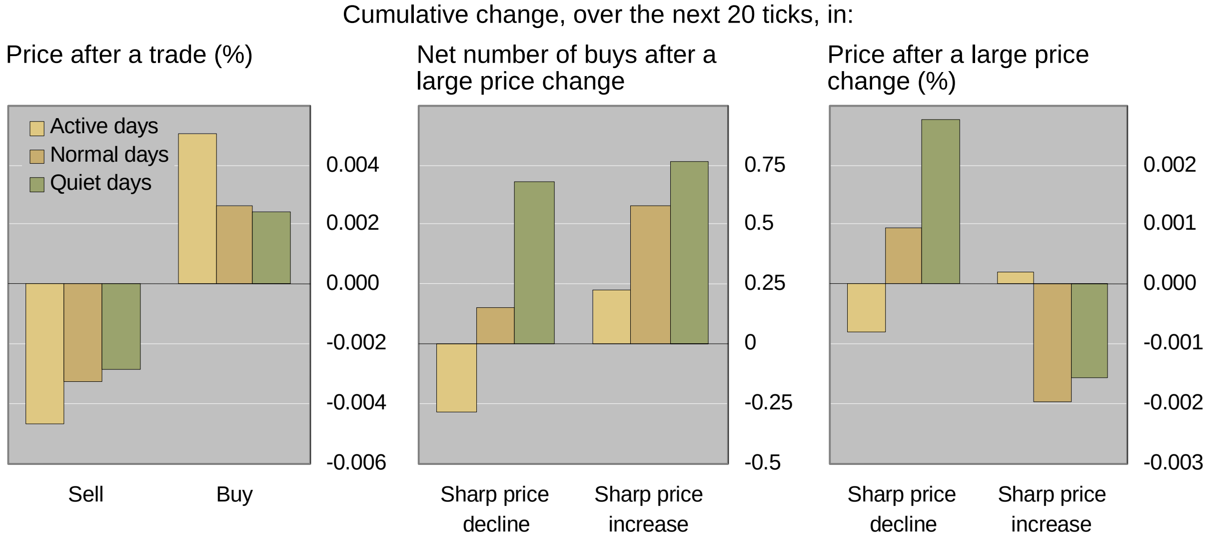
5 This return includes any change in the price that is simultaneous with the trade itself, as do the other 20-tick returns cited in this note. Because of an on-screen "workup" process that allows negotiation on the amount to be traded, it is sometimes possible for GovPX users to be aware that a trade is about to happen a few seconds before it is actually recorded.

Interactions of trades and price quotes in the two-year US Treasury note

January 1999 – December 2000



Note: Each observation ("tick") is either a change in the prevailing quote, a trade, or both. Each price is the midpoint between the prevailing bid and ask quotes on the GovPX system. A "sell" is a seller-initiated trade; a "buy" is buyer-initiated. "Active days" are the 50 days in the sample period when the time between ticks (adjusted for trends and seasonal factors) is at its shortest. "Quiet days" are the 50 days when this time gap is at its longest. A "sharp price decline" is a change in the prevailing quote that is in the lowest 5% of quote changes in the sample. A "sharp price increase" is a change in the prevailing quote that is in the top 5% of quote changes. The "net number of buys" is the difference between buys and sells.

Sources: GovPX, Inc.; authors' calculations. Graph 2

But price changes trigger further buying and selling ...

We also find, however, that price movements themselves sometimes trigger further buying and selling activity, with price increases leading to an increase in buys and decreases leading to an increase in sells (Graph 2, centre panel). This can be seen by comparing trading behaviour following "sharp price declines", defined as the 5% of ticks when the price fell the furthest, with trading behaviour following "sharp price increases", the 5% of ticks when the price rose the furthest.[6] On normal days, there are on average 0.58 more buys than sells in the 20 ticks following a sharp price increase. Following a sharp price decline on such days, buys exceed sells by only 0.15. This effect is exacerbated on active days, while on quiet days it disappears. A sharp price decline on an active day tends to be followed by 0.28 more sells than buys, while a price increase is followed by 0.23 more buys than sells.[7] On quiet days, there is little difference between trading behaviour following price declines and that following price increases.

... especially on more active days

When the price and return effects described so far are considered in tandem, they suggest that price movements should exhibit a certain degree of

6 Sharp price declines averaged –0.0079%, while sharp price increases averaged +0.0080%; for comparison, the standard deviation of price changes during a single tick was 0.0045% and the average absolute value of a price change was 0.0028%.

7 From these statistics and from Graph 2, one might think that there are simply more sells than buys on active days. In fact the net number of buys in an average 20-tick period is about the same on active days (0.42) as on quiet days (0.39); both see fewer net buys than normal days (0.64).

positive feedback at short time horizons on active trading days. A price increase leads to relatively more buying, which in turn leads to further price increases, and so on.

The net result is positive feedback

This does seem to be the case in our data, though the picture is complicated by a statistical quirk. Price changes calculated using successive midpoints of the bid and ask prices in the GovPX data are slightly negatively correlated – that is, a price increase tends to be followed by a decrease and vice versa. This seems to reflect the fact that the data combine price quotes (albeit firm ones, ie those at which dealers are committed to transact) and transaction prices.[8] Because of this anomaly, on both normal trading days and quiet days, sharp price declines are partially reversed by subsequent price increases, and sharp price increases are followed by small price declines (Graph 2, right-hand panel).

On active trading days, however, there is little or no reversal. Given that a small amount of price reversal appears to be built into the data by the above-mentioned statistical anomaly, it could legitimately be concluded that price movements reinforce each other on these days – price increases lead to further increases, and price declines lead to further declines.

Sources of positive feedback trading

As noted above, there are already strong theoretical and empirical grounds to expect order flow to have an impact on price movements in the short run. Our results, however, suggest that price movements also have a short-run effect on order flow.

This may result from changes in risk

Why might we expect price movements to have an impact on trading activity? One factor might be the way in which changes in the value of a position cause changes in the perceived risk attributes of that position. Thus, a trader attempting to replicate an option position in the cash market (a strategy known as portfolio insurance) is obliged to sell an increasing amount of the underlying instrument as its price falls, and to buy an increasing amount as the price rises. Secondly, there are often institutional constraints on the permitted risk profile of a trading desk or a firm. Such constraints could take the form of stop-loss orders, which trigger sales when an asset declines in price, or margin agreements which require that debts be repaid when a position's value falls below a specified amount.

Mechanisms such as these are all the more likely to have an impact on markets to the degree that there is uncertainty about how widespread they are. For example, a trader may be uncertain as to whether an observed volume of selling in a declining market represents a change in valuation on the part of informed traders, or selling by leveraged traders who need to meet margin calls. If there is a reasonable probability that the former is the case, the result

8 A new trade could be at, above or below the prevailing quoted bid or ask price, though normally it is very close to it. After the trade, the prevailing quotes return. This induces a slight negative autocorrelation as the temporary "price change" is reversed.

will be further selling – thus reinforcing the market's price swing.[9] The key area of market uncertainty in such cases is not the true valuation of the traded asset, but the mix of positions, strategies and constraints faced by market participants. Such uncertainty is likely to be greater at times when prices are moving quickly and traders are scrambling to adjust their positions.

Positive feedback and market functioning

These results suggest that bond markets behave in meaningfully different ways depending on whether market conditions are calm or turbulent. This implies that analysts, market participants and market regulators cannot safely use the experience of calm times as a guide to how market prices will move or how effectively markets will function under specific stress scenarios.

Risk management should account for shifts in market functioning in turbulent times

To the extent that this is the case, it has implications for the assumptions that underlie the ways in which government securities are used to hedge against market and credit risk events. For example, the "haircut" that is applied to the securities provided under a collateral agreement would need to be adjusted to account for the fact that markets are likely to be especially turbulent and one-sided at precisely those times when asset prices are moving sharply and more collateral may need to be provided or disposed of. Similar considerations would be relevant to the calculation of margin requirements for positions taken in organised derivatives exchanges.

A broader implication is that trading and risk management rules that may seem effective from the point of view of an individual trader can potentially have disruptive market-wide effects when put into practice by a significant fraction of market participants. Greater transparency about the strategies and assumptions that underlie the behaviour of important market participants can help to reduce these unintended effects, but a degree of uncertainty of this kind will always be present in some form in traded markets.

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[9] Genotte and Leland (1990) model how this might work in a market in which a significant number of actors follow portfolio insurance strategies.

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