

## Companies | International

## Time to turn prop trading poachers into gamekeepers

## INSIDE BUSINESS



**Francesco Guerrera  
on Finance**

If he wasn't an expert on securities trading, William Silber could have been a character in one of Woody Allen's films.

Tall and rangy with a bushy white moustache and a bracing New York wit, he would have been perfect as one of Mr Allen's world-weary sidekicks in *Annie Hall* or *Manhattan*.

Mr Silber is professor of finance and economics at New York University's Stern business school. It is in that capacity that I visited him on a crisp New York morning.

My goal was to obtain the answer to the question that has been vexing bankers, regulators and investors since the passage

of new US financial rules in July: what is the "proprietary trading" that banks do with their own money?

The elusive concept has been catapulted to the top of Wall Street's agenda because the new law makes it illegal. Under the auspices of Paul Volcker, the former chairman of the Federal Reserve, Congress decreed that banks should never again place bets that do not involve their clients.

The problem is that no one, including the regulators charged with defining and policing the Volcker Rule, quite knows what proprietary trading is.

Its simplest definition – buying and selling securities on a bank's own accounts – fails to capture the reality of modern markets.

Some of that pure prop trading did take place, and banks such as Goldman Sachs, JPMorgan Chase and Morgan Stanley have dismantled those teams.

But there is a vast grey area that has led critics, including Mr Volcker, to fear that banks will hide prop activities among others carried out by their customer-facing trading desks.

Take a bank that buys securities in the

hope of selling them to a client but ends up holding them for several weeks. Is that market-making or speculation?

How about financial groups that hedge positions taken on behalf of clients by buying and selling shares?

If regulators define prop trading too broadly, they will cut off large parts of the capital markets from much-needed liquidity. But if they go for a narrow definition, the risk-reducing effects on the system of the Volcker rule would disappear.

Paradoxically, both Mr Volcker and the banks he is trying to rein in argue for a broad interpretation of prop trading.

To prevent banks from getting round the law, Mr Volcker would like the Federal Reserve to adopt the attitude of Potter Stewart, the former US Supreme Court justice, who said of pornography: "I know it when I see it."

Meanwhile Sifma, the banks' lobbying group, wants regulators not to "hard-code detailed distinctions" between prop trading and other activities. In the industry's view, the authorities should merely set principles and tell banks to comply.

Recognising that such a *laissez-faire* approach did not work too well before the crisis, some regulators want to come up with a more scientific definition, ideally centred around measurable variables, including size of the position, holding time, risk, etc.

Prof Silber, who has traded both as a market maker and a prop trader during his career, believes he can help. His approach, first detailed in a little-noticed paper in 2003, is: follow the money backwards.

He believes that, for all the talk of complexity on today's Wall Street, prop traders do leave footprints in their wake. He believes that the simplest way to determine whether a trader is a marketmaker or a speculator is to establish how they got into a particular position.

In his view, there are two crucial differences in the behaviour of the two types of traders.

Customer-facing traders follow the market, buying and selling at the prevailing prices, while the prop guys think they can beat the rest of the Street

and therefore act in anticipation of future movements, buying at what they regard as a low price and selling when they think prices have reached a high.

As a result, market makers tend to move quickly in and out of positions while speculators can hold on for months until the opportune moment to act.

This empirical way of identifying prop trading is less precise than the authorities would like because it lacks hard and fast metrics.

But examining trading records and interviewing traders – just like banks' risk officers do – should offer trained eyes enough clues about compliance with the Volcker rule.

The best way to police the new provisions is not to get bogged down in definitions but to hire former traders to help regulators with the unique insights of poachers-turned-gamekeepers. If they can afford them.

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# On the Nature of Trading

*Do speculators leave footprints?*

William L. Silber

**T**rading is a risky business. How risky depends on exactly what traders do to make money. We identify two types of traders: 1) speculators, sometimes referred to as proprietary traders, who earn money trying to anticipate the direction of future price movements; and 2) customer-based traders, usually called market makers, who earn money on the bid-ask spread without speculating on future prices. Customer-based trading is less risky than speculation. Thus, assessing a trading firm's risk exposure and its implications for appropriate capital requirements depends in part on distinguishing high-risk speculators from low-risk market makers.

Separating speculators from market makers is difficult in practice. The problem is that speculators sometimes have customers, allowing them to look like market makers. And market makers sometimes become speculators despite their regular access to customers.

We explain how an outsider such as a potential merger partner or a regulator can verify the trading profile of a firm. That is, we will show how trading records describing the evolution of a position over time can help us discriminate between market makers and speculators.

Understanding and verifying trader behavior is important, because leveraged trading firms and individual traders have traditional incentives to mask their risk-taking activities (see Jensen and Meckling [1976]). Without proper monitoring, traders can substitute risky speculation for less risky market-making to reap potential payoffs. This is best illustrated by two examples.

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## Risk Assessment

The value at risk (VaR) approach to measuring risk exposure combines the amount of a security on the firm's balance sheet with the security's variability of returns to calculate the likely losses on a position.<sup>1</sup> We will see that the time period over which the variability of returns should be measured depends in part on whether a position is traded by a market maker or a speculator. Thus, even though the balance sheet does not reveal the trader's intent in establishing the position, the proper application of VaR in measuring risk should distinguish between speculators and market makers.

Consider, for example, an options trading firm whose balance sheet shows that it is long out-of-the-money six-month calls on IBM and short the "right amount" of out-of-the-money three-month calls on IBM. It is impossible to tell from the balance sheet alone whether this is a market maker's position or a speculator's. But a market maker's tendency to close out positions quickly means that the likely losses on the position will be smaller under a market maker's strategy than a speculator's.

Lower prospective losses means that a market-making trading firm (or a trading division within a firm) can safely operate with less capital than a trading firm with a speculator's strategy. If market makers are rewarded with lower capital requirements than speculators, traders will try to misrepresent themselves as market makers, unless they can be prevented from doing so by proper monitoring.

## Contract Enforcement: MAC Clauses

Merger agreements typically include a clause prohibiting any "material adverse change" (MAC) in a company's business until the merger is approved by stockholder vote. Understanding and verifying the nature of a trading business can be important in determining whether a material change has occurred in mergers involving companies such as investment banks or deregulated gas and electric utilities, where trading activities play an important potential role in profitability.

Consider, for example, a firm that enters into a merger agreement with a company representing itself as a low-risk customer-based trading company. Suppose that following the signing of the agreement, but before the closing of the merger, the trading firm shifts from market-making to speculation and loses a lot of money. Case law suggests that successful invocation of the MAC clause depends in part on whether the acquirer could have rea-

sonably expected the loss, given the nature of the target's business.<sup>2</sup>

That is, the acquirer can invoke the MAC clause to terminate the merger only if it can show that: 1) the trading company made an adverse change in the nature of its business by shifting from low-risk market-making to risky speculation; and 2) as a consequence, it lost much more money than the acquirer could have reasonably expected in the normal course of business. The acquirer must be able to verify that the trading company behaved as a market maker before the merger agreement and as a speculator afterward.

## NATURE OF TRADING

These examples indicate the importance of distinguishing between market makers and speculators for risk assessment and contract enforcement of trading firms. We will show that trading records detailing how a position evolves through time can offset the shortcomings of balance sheets in identifying the footprints of speculators versus market makers. Given the right information, we can determine whether, for example, the firm trading IBM options violated any contractual rules against speculation and exposed itself to more risk than if it had been a market maker.

Both market makers and speculators (collectively referred to as traders) expect to earn a profit by committing capital to buying and selling assets, usually in leveraged transactions. Taking on price risk by committing capital is what distinguishes traders from salespeople and brokers. Leverage means that, unlike investors, traders cannot theoretically wait forever to unwind a position; they face bankruptcy risk if they lose too much money. But within this framework, trading can be carried out in a variety of ways and with a wide range of risk.

Substantive differences in behavior turn on whether a trader's profitability requires a change in the equilibrium price of the underlying asset. Market makers can earn profits without changes in the equilibrium price, while speculators must try to anticipate equilibrium price changes in the underlying asset.

Market makers earn profits by quoting bids and offers to provide immediate execution for their customers' market orders. Market makers can earn the bid-ask spread, referred to as the cost of immediate execution or the price of liquidity services, even with an unchanged equilibrium price. Speculators, on the other hand (who do not have customers), earn profits by successfully anticipating

equilibrium price movements. Despite some limitations, this distinction between customer-based trading and speculation is a useful point of departure.

### Customer-Based Trading

Customer-based trading, as its name implies, involves buying and selling assets while accommodating customer purchase and sale orders. The concept of customer-based trading applies to market-making in financial assets, in commodities, and in contracts for future delivery of any asset. Somewhat more broadly, a customer-based trader commits capital to make a consistent markup on the price of the asset while avoiding the risk exposure associated with unanticipated equilibrium price changes. In fact, customer-based traders take specific efforts to minimize their exposure to changes in the equilibrium price of the asset they trade.

One way customer-based traders reduce their exposure to equilibrium price movements is to minimize the length of time they hold an asset. For example, when an investment bank manages a public offering of stock, it charges a markup (the underwriter spread), which is the difference between the price paid to the company issuing the stock and the price the public pays for the shares. To avoid the risk associated with unanticipated equilibrium price changes in the stock, the investment bank will try to identify likely buyers of stock in the pre-offering period to minimize the time the stock remains in inventory. This is a low-risk, inventory-minimizing, strategy that is typical of customer-based trading.

It is often impossible for customer-based traders to avoid temporarily holding an open position—either holding an asset in inventory (being long the asset) or having an obligation to deliver an asset in the future that is not currently owned (being short the asset). Since the goal of customer-based trading is to capture the markup without speculating on the direction of equilibrium price movements, customer-based traders engage in a number of practices to minimize their risk exposure when they have open positions. Such practices include hedging away price exposure and imposing limits on the magnitude (and dollar risk) of open positions.

A common form of hedging for a trader who has an obligation to deliver an asset in the future is to secure a future supply of that asset. Securing that supply at a fixed price locks in the profit. For example, a heating oil trading company that commits to deliver its product at a fixed price over the next year would eliminate its risk

exposure to increases in the price of heating oil by locking in the price it pays to suppliers. Failure to hedge (that is, not locking in the price) leaves the heating oil company exposed to future changes in the equilibrium price of heating oil. If the equilibrium price of heating oil rises, the trading company loses money because it will have to pay a higher price for the oil that it has committed to deliver at a fixed price. If the price of heating oil falls, however, it makes money, because it pays a lower price for the oil it has contracted to deliver at a fixed price.

A second form of hedging is *cross-hedging*, or taking an offsetting position in a related asset. Suppose a trader has assumed the obligation to deliver heating oil at a fixed price one month from now, but does not yet own the heating oil. The trader is short heating oil and is exposed to the risk that the equilibrium price of heating oil will rise before it is purchased. The trader can hedge that risk exposure by buying a related commodity, crude oil. As long as the prices of crude oil and heating oil move together—that is, as long as price changes are correlated—the cross-hedge will reduce the trader's aggregate risk exposure. For example, if the equilibrium price of heating oil increases before the trader covers the short position, the price of crude oil will also tend to rise, and the trader will be able to sell the crude oil at a profit to offset the higher cost of the heating oil.

The trader might choose the strategy of cross-hedging heating oil with crude oil, rather than buying heating oil directly, because the crude oil market is more liquid than the heating oil market. In fact, the trader could hedge by buying heating oil, even though it is less liquid, as long as the trader spent some time searching for a trading partner. But during the search for a price-compatible trading partner, the position would have been unhedged. Thus, hedging in a related liquid asset reduces risk exposure while enabling a search for the best price of a less liquid asset.

In addition to hedging, a company engaged in customer-based trading can minimize its exposure to unanticipated price movements by imposing quantitative limits on open (unhedged) inventory positions. The role of such position limits is best illustrated by examining the behavior of a stock trader at a brokerage firm.

The typical trader in over-the-counter stocks at broker-dealer firms is a market maker. The trader will buy stock at a quoted bid price (e.g., \$20.25) from investors, and then try to sell that stock at its offer price (e.g., \$20.50) to other investors. The objective is to capture the spread between the bid and offer prices. Between the time

it takes the trader to sell at the offer price what was bought at the bid, the stock remains in inventory. This exposes the firm to inventory risk if the stock remains unhedged.

The firm can control its risk exposure by placing limits on the size of the unhedged inventory. For example, if a trader holds 10,000 shares of a stock in inventory, and the stock declines by \$1, the net worth of the trader's firm declines by \$10,000. The firm can limit its risk exposure to unanticipated price changes by placing size limits on a trader's open position. If the firm restricts open positions to 1,000 shares, its maximum risk exposure is one-tenth that of a firm that has a 10,000 share limit on similar unhedged inventory.

### Speculation

Speculation can be defined as trading in anticipation of future price changes. Traders who speculate are trying to profit on the direction of future equilibrium price movements. For example, a trader who is a speculator and believes that gold prices will fall can enter into an obligation to deliver gold at a fixed price at some future date and will not cover that position immediately. The trader is waiting for the price of gold to decline but is exposed to the risk that gold prices will go up rather than down.

Speculators are in the business of taking on the risk of unanticipated equilibrium price movements in order to earn profits. This risk exposure is precisely the risk that the customer-based trading business tries to limit or avoid by maintaining hedged inventory positions and by imposing size limits on open positions.

## FINGERPRINTING THE SPECULATORS

Separating speculators from market makers seems trivial in light of the discussion so far; traders without customers must be speculators, and traders with customers must be market makers. The problem with this simple solution is twofold. Speculators sometimes try to boost their profitability by providing liquidity to public investors, just like market makers. And market makers often transform their customer-initiated trades into speculations.

Speculators can provide liquidity by placing limit orders rather than market orders. A limit order is an order to buy or sell at a fixed price (e.g., \$20.25), and a market order is an order to buy or sell *immediately* at the best price prevailing in the market. When the speculator submits a limit order, he or she sacrifices immediate execution for

the opportunity to capture at least part of the bid-ask spread, in addition to speculating on future changes in the equilibrium price. In the process, the speculator's limit orders offer immediate execution (liquidity) to other market orders, just like market makers.<sup>3</sup>

Market makers become speculators when they establish positions based on information extracted from customer order flow. For example, a market maker who sees buy orders from many different customers may actively try to accumulate a long position. In this case, the market maker's profitability hinges on whether he or she correctly anticipates future price changes, just like a speculator.

Whether or not a trader maintains an open position is another possible way to discriminate between speculators and market makers. An unhedged long or short position obviously means that unanticipated changes in the equilibrium price of the asset affect the trader's profitability. Moreover, we have noted that traders can control their level of risk exposure by imposing size limits on open positions. Market makers will hold smaller open positions than speculators, all else the same, as they try to avoid equilibrium price volatility.

There are two shortcomings of using open positions to separate market makers from speculators. First, market makers temporarily have open positions in their normal course of business between the time a bid is hit and an offer is lifted. Thus they look just like speculators for that time interval, even though a market maker's open position conveys lower risk exposure and should require less capital as a safety net, compared with a speculator. Second, speculators frequently engage in relative-value trades that may look just like hedged positions on a market maker's balance sheet.

### Value at Risk (VaR) Calculations for Speculators versus Market Makers

The value at risk (VaR) approach to risk measurement illustrates the importance of not equating all open positions with speculation. VaR uses the size of an open position *combined* with a measure of volatility, such as the standard deviation of returns, to assess the riskiness of an open position on the balance sheet. The standard deviation of returns increases with time, i.e., a one-hour standard deviation of returns is lower than a one-day standard deviation, which is lower than a one-week standard deviation. Thus, VaR should use a standard deviation over a shorter time horizon to measure the risk of a market maker's open position as compared with a speculator's. This

follows from a market maker's propensity to eliminate open positions quickly, either by offsetting (buy or sell) transactions or by hedging, given the market maker's objective to earn the bid-ask spread while avoiding equilibrium price volatility.

The implication of this discussion is that regulators and managers in trading firms who use VaR to specify capital requirements to guard against losses that threaten bankruptcy should require more capital for a trading firm with a speculator's strategy than one that follows a market-making strategy.<sup>4</sup> This also means that VaR requires some indicator of speculation versus market-making other than open positions to measure a trading firm's risk exposure properly and to specify appropriate capital requirements for trading firms.

### Relative-Value Trades versus Hedged Positions

The behavior of the hedge fund, Long-Term Capital Management, illustrates the second shortcoming of identifying speculation using open positions, i.e., why the absence of open positions does not necessarily imply the absence of speculation. Long-Term Capital's trades almost always involved offsetting positions in securities whose price spreads were expected to narrow.

The classic example of these relative-value trades occurred in 1994 when Long-Term Capital sold short the most recently issued (on-the-run) 30-year Treasury bond and bought the old 30-year bond, with 29-½ years to maturity (called off-the-run). The most recently issued bond in any maturity category (in this case, 30 years) has the narrowest bid-ask spread and the most liquidity. In 1994, investors bid up the price of the on-the-run 30-year in a flight to liquidity as the Federal Reserve tightened credit. When Long-Term Credit established the spread position of selling the expensive on-the-run bond and buying the cheap off-the-run bond, it speculated that this flight to liquidity would be temporary. It would profit when the relative prices returned to normal (see Lowenstein [2000, p. 43ff]).

Long-Term Capital's balance sheet would be indistinguishable from the balance sheet of a Treasury bond dealer who bought off-the-run Treasuries from one of its customers at its bid price and then hedged its price level exposure by shorting the more liquid on-the-run issue that was closest in maturity. In fact, using a liquid asset to cross-hedge price-level risk is precisely how a customer-based trader reduces its risk exposure while trying to earn the bid-ask spread.

### How Trading Records Separate Speculators from Market Makers

Detailed trading records describing how a position was opened, how it evolved through time, and how it was closed are much more informative than balance sheet records in distinguishing between speculation and market-making. Using the 1994 relative-value position as an example, we could rule out market-making as the motivating force if we knew that the illiquid 29-½ year bonds were bought on the offer side of the market. There is no normal circumstance in which a market maker would open a position by lifting the offer on an illiquid security.<sup>5</sup>

Even if the market maker sold the on-the-run 30-year on the offer side, he or she would never hedge the price risk of that bond by lifting an offer on the illiquid off-the-run 29-½ year bond. This would mean providing liquidity when the bid-ask spread is narrow and consuming liquidity when the bid-ask spread is wide.

Is it possible to tell whether a security was purchased on the bid side or on the offer side of the market? Traders usually do not record such information, but knowing the time of the trade as well as the prevailing quotes in the marketplace would make this possible.<sup>6</sup>

For example, assume the prevailing bid on the 29-½ year bond was 108 and the offer 108-¼. If the bond were purchased at 108-¼, the case against market-making is clear. If the off-the-run 29-½ year bond were purchased at 108, the bid side of the market, we would need more information to determine whether speculation played a role in the overall position.

Most important is how long the position remained unhedged. As we described above, a market maker's instinct is to eliminate price-level risk associated with a position in an illiquid asset by taking an offsetting position in a liquid asset. If the long position in the 29-½ year bond were left unhedged for a considerable time, this would imply a speculative component to the trade.

It is difficult to say exactly what a considerable length of time means, of course, as that depends on the equilibrium price volatility of the security. But we do know that a trader is exposed to greater equilibrium price volatility, the longer a security is held. Thus the market maker is anxious to hedge the position quickly.

The market maker's natural anxiety over price risk leads to a curious result regarding the 30-year bond serving as the cross-hedge. If the on-the-run 30-year were sold on the offer side of the market, which is exactly what a market maker would like to do, there is more of a prob-

ability that there was a speculative component to the trade. This follows from the fact that the market maker could hedge *immediately* by hitting the bid in the on-the-run 30-year bond.

Selling the 30-year on the offer side would mean either that the market maker was lucky (an incoming order to buy the 30-year at the offer occurred simultaneously with the dealer's purchase of the 29-½ year bond), or the dealer posted an offer in the marketplace and waited for incoming buying interest in the 30-year. Luck is a less likely explanation; hence, selling the 30-year at the offer is indicative that the market maker waited to hedge, producing a speculative component to the trade.

The lesson: Beware the market maker who *always* looks like a market maker.

Now, can we tell whether the options trader described above, who is long six-month out-of-the-money IBM calls and short the right (delta-neutral) amount of three-month out-of-the-money IBM calls, was speculating or market-making?<sup>7</sup> Note that the most liquid options in most markets are the at-the-money front-month options. In this case, that would be one-month at-the-money IBM puts and calls. Thus we can assume that both of the trader's options are relatively illiquid.

We can try to rule out market-making behavior the same way we did for the government bond trader—by determining whether the options were bought and sold on the bid or the offer side of the market. For example, if the long position in the six-month calls were purchased on the offer side and the short position in the three-month calls sold on the bid side, this position surely was not generated by a market maker, since the trader paid the bid-ask spread in each case. It must be a speculator's relative-value trade, betting that the six-month calls are cheap compared to the three-month calls.

Now turn to the other extreme. Suppose the long position in the six-month calls were purchased on the bid side of the market and the short position in the three-month calls sold on the offer side. This is precisely the desired circumstance of a market maker, as he or she is in a position to earn the bid-ask spread on both sides of the position.

As we saw in the case of the government bond trader, however, unless there is an unusual amount of luck involved, capturing the bid and offer on *both* positions makes the market maker look too good. It is likely that he or she waited to execute the hedging side of the trade. Therefore, the trader speculated during the time the position was left unhedged. To paraphrase the lesson from above: Even market makers should occasionally consume liquidity.

The time sequence of the trader's position can resolve the charge of speculation in one of two ways. First, the long six-month–short three-month position might have been initiated by a counterparty as a spread trade. This means that both legs of the trade occur simultaneously, without any unhedged exposure time. Although this is a reasonable possibility, it is unlikely that a spread trade would have been possible on such favorable terms to the market maker (and such unfavorable terms to the customer). More than likely, the spread would have been inside the maximum bid-ask spread. This occurs because spreads have order flow of their own (as opposed to the individual legs), and order flow combined with competition narrows the quotes on a spread trade.

A second possibility is that the two component trades of the position took place sequentially; there was an intermediate hedging step between the two legs of the final position. The trader would be a pure market maker if the trading records show that after purchasing the six-month calls, he or she hedged by selling liquid at-the-money one-month calls (or IBM stock) and then bought back those hedging trades after selling the three-month calls. A market maker's imprint would be clearer if the sale of the intermediate hedge occurred at the bid price and the subsequent purchase occurred at the offer, implying that the hedges were probably executed immediately.

## CONCLUSION

Our discussion of customer-based trading and speculation has provided a framework for determining how traders establish their positions and manage their risk exposure. We show that balance sheets are insufficient to determine whether a trader acted as a market maker or as a speculator in setting up a position. But trading records combined with market conditions such as the prevailing bid-ask quotes at the times trades were executed can help identify the trading strategy pursued. Knowing the trading strategy helps to evaluate contract compliance, risk exposure, and capital requirements of trading firms.

Two provisos are important. First, trading records do not always resolve the issue. Second, many traders combine elements of market-making and speculation, so that the record is not clean. Nevertheless, the analysis presented here shows how to track trader behavior. Sometimes the footprints are clear and sometimes blurred—but that is the nature of trading.

## ENDNOTES

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<sup>1</sup>See Saunders [2000, Chapter 10] for a discussion of alternative calculations of VaR.

<sup>2</sup>Fleischer [2002] cites two cases where the nature of the business mattered. In *Bear Stearns v. Jardine Strategic Holdings*, the court denied Jardine's motion for summary judgment by refusing to invoke the MAC clause, as a matter of law, to void Jardine's agreement to purchase a 20% interest in Bear Stearns, a publicly traded securities firm. Although Jardine agreed to a purchase price on September 30, 1987, immediately prior to the stock market crash of October 19, 1987, the court held that the loss incurred by Bear Stearns during that episode was not a MAC, as a matter of law, because "Jardine understood and knew the volatility and riskiness of the securities business." In the case of *Allegheny Energy, Inc. v. DQE*, the court also analyzed materiality in light of the size and nature of the transaction and the nature of the parties' business.

<sup>3</sup>Note that speculators who place limit orders do not perfectly mimic market maker behavior. Most market makers continuously try to quote a two-sided market, both a bid and an offer, so they gain a reputation for providing liquidity services. Speculators place limit orders only when they are opening or closing a speculative position. Moreover, they usually place only a bid or an offer, depending on what position they want. Thus, they contribute liquidity to the marketplace, just like market makers, on an irregular basis.

<sup>4</sup>Regulators and supervisory agencies such as the Bank for International Settlements do not distinguish between market makers and speculators when they set capital requirements for financial institutions. Thus financial institutions that are primarily market makers are penalized compared to those with more speculative strategies. Anecdotal evidence suggests that managers at trading firms do set different capital requirements for market makers than for speculators (see Silber [1984, p. 943]).

<sup>5</sup>A market maker might *close* a position in an illiquid security by lifting an offer (or hitting a bid) if reducing risk exposure by cross-hedging is not practical or is too costly.

<sup>6</sup>Most interdealer brokers in the government bond market record whether a trade occurred on the bid or the offer side of the market. The New York Stock Exchange Trade and Quote data base records bid-ask quotes as well as transaction prices.

<sup>7</sup>Hedging price risk in options requires an estimate of the delta of an option. Delta is the amount by which the value of the option changes per dollar of change in the underlying asset price. An options position is called delta-neutral if the value of the position is unaffected by price changes in the underlying asset.

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