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Intraday Trading in the Overnight Federal Funds Market

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Transaction-level data for the federal funds market provide a rare look at the intraday behavior of trade volume and prices. An analysis of the data reveals that trade volume exhibits large swings over the course of the day while prices remain fairly stable, with rate volatility rising sharply only in the late afternoon. The analysis underscores the important role played by institutional deadlines—most notably, the close of trading—in driving movements in this market.

The federal funds market is a key component of the U.S. financial system. In this market, depository institutions borrow and lend the balances, or reserves, that they hold in accounts at the Federal Reserve. Through open market operations, the Federal Reserve's Trading Desk keeps the rate of interest charged on these interbank loans—the federal funds rate—near a target set by the Federal Open Market Committee. Market expectations for the federal funds rate play a central role in monetary policy and are a primary determinant of almost all other dollar interest rates.

A significant body of research has emerged in recent decades on the behavior of the federal funds market and its relationship to monetary policy. Because of data limitations, however, analysts have had to focus on the day-to-day behavior of the market, often treating the market as if it cleared at one single instant and at one rate each day. As a result, issues important for financial analysis—such as the behavior of prices and trading activity during each business day, and the role of the institutional framework in shaping such behavior at different times of the day—have remained largely unexplored.

In this edition of *Current Issues*, we use a new set of transaction-by-transaction data to derive information on the *intraday* life of the federal funds market.[1] Emerging from our analysis is a picture of a smoothly operating market in which large swings in trading activity during each business day tend to leave the price side of the market fairly undisturbed, with overnight interest rates displaying stable behavior until the end of the trading day nears. At that point, rate volatility rises sharply in tandem with trade volume—evidence, we suggest, of the substantial role played by trading closures in determining activity in this market.

We begin with a brief overview of the institutional arrangements of the federal funds market that are key to understanding our results. We then describe intraday trading and rate behavior, offering—when appropriate—tentative explanations for the patterns observed.

The Federal Funds Market Defined

The federal funds market is commonly defined as a venue for U.S. depository institutions (banks) to borrow reserve balances directly from other banks on an uncollateralized

basis, generally for same-day delivery and for very short terms. A more accurate definition of this market, however, would reflect the distinction the Federal Reserve makes between various types of bank borrowings, some of which qualify as federal funds, and some of which do not.

The Federal Reserve's Regulation D requires banks operating in the United States to hold reserves, either in the form of balances in deposit accounts at the Federal Reserve or as cash in their vaults, in a fixed proportion to some of their deposit liabilities.[2] Reserve requirements represent a cost to banks because reserve holdings yield no interest. But Regulation D exempts from the definition of a "deposit," and hence from reserve requirements, bank liabilities arising from borrowings from other banks, from various government agencies and, under certain conditions, from securities dealers. These exemptions from Regulation D effectively make the federal funds market a distinct market in which trades giving rise to exempt bank liabilities are arranged.[3]

The federal funds market is divided into two segments—brokered and direct trading—that differ markedly in trading methods, price dynamics, and institutional participation. In the market's brokered segment, trades are initially matched through a handful of brokers, and participation is mostly confined to larger banking institutions that are active in other financial markets or that settle large volumes of financial transactions on behalf of their depositors.

By contrast, in the market's direct trading segment, trades are arranged directly between institutions, one of which is often a smaller, more retail-oriented institution while the other tends to be a larger institution, active in the brokered segment. Of the thousands of banks eligible to trade in the federal funds market, only about two or three hundred are active in the brokered segment. Rates in the brokered segment are especially responsive to shifting conditions in the aggregate supply or demand for reserves, while rates in the direct market are often determined with reference to prevailing brokered rates.[4]

Other key distinctions among federal funds trades are those between overnight and term loans, and between trades that settle on a same-day (spot) basis and those that settle on a forward basis. Spot trades of overnight loans account for the vast majority of trading. Accordingly, our analysis focuses solely on spot overnight trading in the brokered segment of the federal funds market.

Uses of the Federal Funds Market

Trading in the federal funds market serves two broad purposes.[5] First, a bank may borrow or lend federal funds to alter its interest rate exposure, either to take advantage of an interest rate outlook or to guard against a particular interest rate risk. Used in this way, federal funds borrowed or lent are similar to many other assets or liabilities on bank balance sheets except for their unsecured nature and generally short maturity.

Second, a bank may use the funds market to offset other transactions—whether initiated by its depositors or by the bank itself—that would otherwise leave it with a reserve position out of compliance with Federal Reserve regulations.

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Banks pay penalties if they end any day overdrawn on their account at the Fed or if they hold an insufficient cumulative level of reserves at the end of each two-week interval, or "reserve maintenance period."[6] However, because they earn no interest on reserve holdings, banks also try to minimize the amount of reserves held in excess of their requirements.

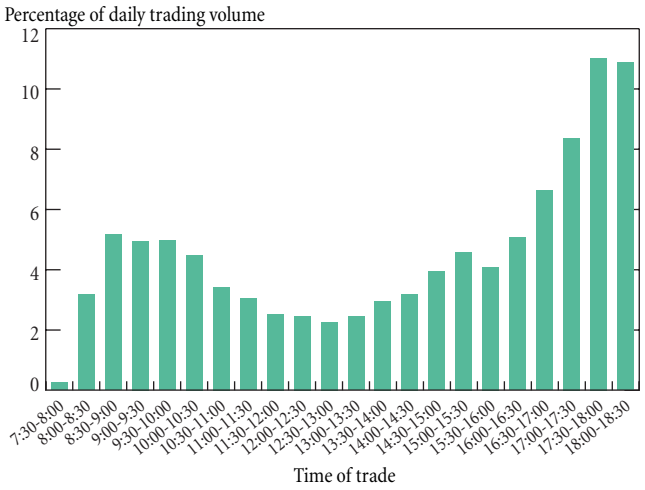
When used to maintain compliance with Federal Reserve regulations, the funds market may be viewed as an extension of the wholesale payments framework. To settle large financial payments undertaken either at their own initiative (including lending of federal funds) or on behalf of depositors, the banks making payments instruct the Fed over its electronic payment system—known as Fedwire—to transfer reserve balances from their accounts to the accounts of the banks receiving payments. Fedwire instructions are processed as soon as they are received.[7]

Because of the large, often uncertain flow of payments clearing on Fedwire every day, banks rely extensively on federal funds trading to maintain their reserve balances within desirable ranges. It is not surprising, then, that many of the intraday patterns in the federal funds market described in this article can be related to institutional features of the Fedwire payment infrastructure. The most important of these features, as we shall see, is the closing of Fedwire, scheduled for 18:30, at which point trading in the funds market for same-day settlement also ends.

Federal Funds Micro Data

To study the intraday behavior of the funds market, we acquired records of all federal funds transactions executed by Euro Brokers, one of the largest brokers in this market,

Chart 1
Trading Volume



Sources: Euro Brokers; authors' calculations.

from February 2002 to September 2004. For each transaction, we obtained information on the amount traded, the agreed-upon interest rate, starting date, term, and trade completion time.[8] (We obtained no information on trading parties.) After dropping forward and term transactions and a few anomalous data, we were left with a sample of more than 100,000 individual trades over 660 business days. We arranged these trades by completion time into twenty-two half-hour intervals beginning at 7:30, when an appreciable volume of trading in this market begins, and ending at 18:30, when trading normally ceases. We used data aggregated over these half-hour intervals as the basic inputs for our analysis.[9]

Intraday Patterns in Trading Activity

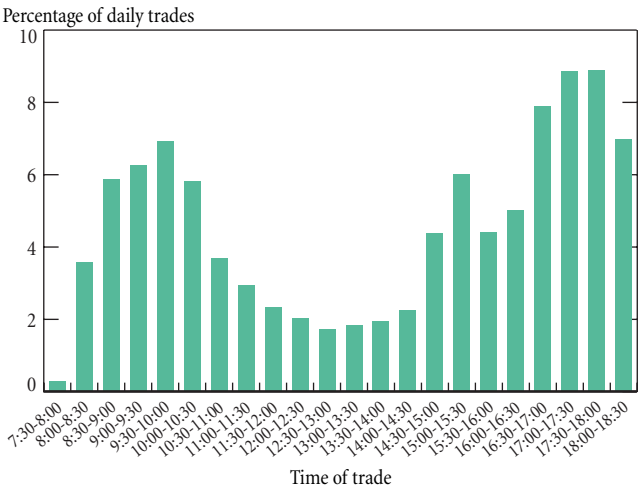
Measures of trading activity exhibit large swings over a typical business day. Trading volume first peaks in the morning, between 8:30 and 10:00, dips from late morning through mid-afternoon, and then peaks again at even higher levels late in the afternoon, with nearly 40 percent of total trading condensed in the last two hours (Chart 1).[10] Several factors likely contribute to this pattern. The morning peak in activity may stem from efforts by banks with more predictable payment flows and trading needs to get much of this trading out of the way early on, thereby preserving maximum flexibility to respond later in the day to trading needs brought on by unexpected payment flows. The temporary overlap with trading in European financial centers, when institutions based in these areas are more active, also likely contributes to a higher volume of federal funds trading during the morning hours.

The late afternoon rise in activity coincides with a clustering of several institutional deadlines late in the day. Settlement of securities transactions ends at 15:00, causing securities dealers to defer much of their trading in the money market until that time, when their security-related balance sheet position becomes certain. Banks' trading of federal funds late in the day may also be spurred by diminishing uncertainty about client transactions and other payment flows in the hour or two before Fedwire closes at 18:30. By postponing trading until such transactions have largely been completed, banks subject to uncertain cash flows can avoid transaction and other costs associated with being both a lender and a borrower of funds on the same day.

Trading volume may be broken down further into trading intensity and average trade size. The distribution of the total number of trades across half-hour intervals in each day is similar to the distribution of total trading volume (Chart 2). Average trade size, however, presents a somewhat different pattern, peaking shortly before security markets close at 15:00 and again just before the funds market closes at 18:30 (Chart 3).

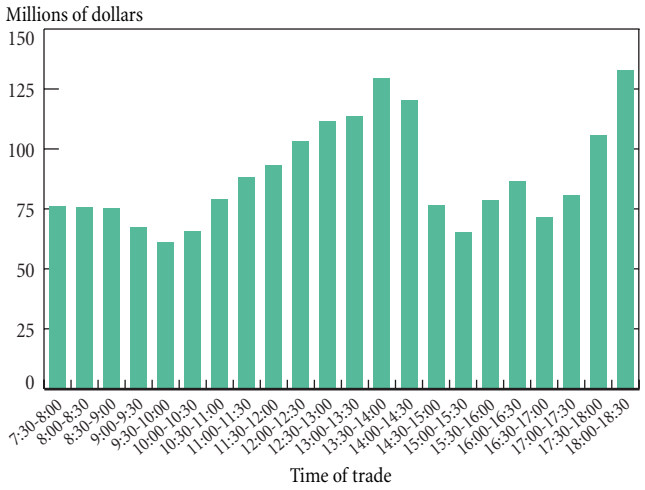
The smaller average trade sizes observed in the morning likely reflect more active participation by smaller institutions, which face less uncertainty about payment flows and prefer to avoid the rate volatility prevailing later in the day. The mid-afternoon peak in trade size may reflect a relatively greater contribution from large banks involved in clearing security-related flows, while the late-day peak can probably be tied to heavier activity by large money-center banks, which are subject to the greatest uncertainty about their

Chart 2
Trading Intensity



Sources: Euro Brokers; authors' calculations.

Chart 3
Trade Size



Sources: Euro Brokers; authors' calculations.

payment flows. Furthermore, as the deadline for trading approaches, banks often arrange trades in larger blocks to ensure that all needed trading is completed quickly before the market closes, even if this requires sacrificing some potential rate advantage.

Intraday Behavior of the Federal Funds Rate

While trading activity fluctuates markedly over the course of the day, the price side of the market displays more uniform and purposeful patterns, many of which can be related to the approaching end-day deadline at 18:30.

One such pattern is the smooth decline in average funds rates—measured in Chart 4 as the average deviation from the federal funds target in each half-hour interval—over a typical business day. This pattern likely reflects the different risks faced by net borrowers and net lenders in choosing the best time to complete their trading.

In particular, banks seeking to lend out their excess reserves often have the flexibility to defer lending from the present day until later in the reserve maintenance period without risking accumulating too many reserves for the maintenance period. For this reason, reserve-rich banks tend to play a more subdued role in the determination of interest rates around the close of business. In contrast, banks that keep relatively low reserve balances and must borrow to meet their reserve requirements are often in the position of having to borrow some reserves before close of business every day, to avoid ending any day overdrawn on their account at the Fed. Because of this risk, these banks may defer their borrowing from early until late in the day only if slightly lower expected borrowing costs compensate for the risk that they might not be able to find a lender before the market closes.

Intraday patterns in fed funds rate volatility also illustrate how participants in this market respond to liquidity changes with the aim of minimizing the cost of holding

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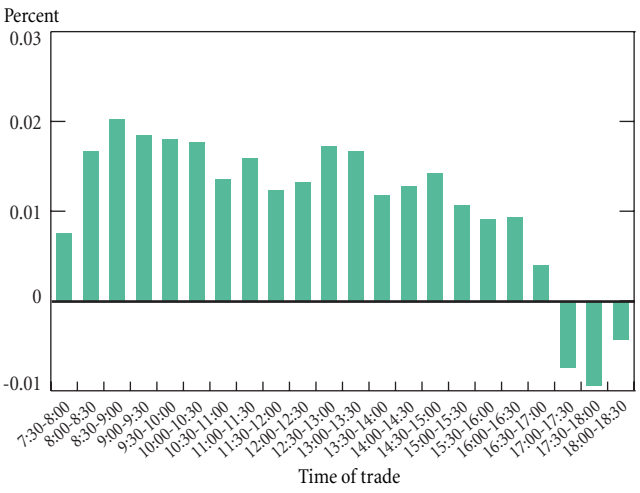
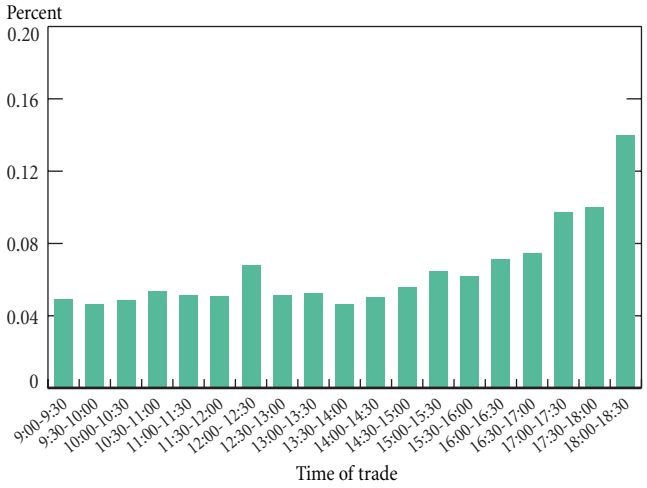
reserve balances while meeting reserve requirements. Our data show that interest rate volatility remains stable until mid-afternoon, after which time it rises sharply until day's end (Chart 5). Clearly, rate volatility may be higher late in the day because mismatches between the trading needs of borrowers and lenders are often realized only at that time. For instance, mismatches may occur if banks with available funds to lend have exhausted (or never had) a lending line of credit to banks needing to borrow. More widespread disparities may also arise if the supply of reserves left by the Fed's Trading Desk after arranging open market operations in the morning does not match banks' aggregate demand for

Chart 4
Deviation of Average Rate from Target



Sources: Euro Brokers; authors' calculations.

Chart 5
Standard Deviation of Rates



Sources: Euro Brokers; authors' calculations.

reserves. These imbalances are generally not recognized until rather late in the day, thus increasing the potential for abrupt rate movements at that time.

There is, however, a more subtle reason for the intraday rise in volatility. Over the course of each day, banks are subject to recurrent shocks to their holdings of reserves when they make or receive payments on behalf of their depositors or when they settle the trades they have arranged in other markets. Initially, these shocks poorly predict banks' net need for reserves during the rest of the day, since many other, possibly offsetting shocks may occur before day's end. As a result, banks need not enter the funds market to respond fully or immediately to payment surprises coming early in the day, and so these shocks tend to have little impact on rates. However, as the day advances and payment shocks begin to signal more clearly banks' net borrowing or lending needs during the time remaining before market close, banks respond more promptly to payment surprises.

Relationship between Intraday Trading Volume and Rate Volatility

To what extent does rate volatility in the federal funds market move with trading volume over the course of the day? A comparison of Charts 1 and 5 reveals a clear correspondence late in the day, just ahead of the close of the market, when both trading volume and rate volatility surge. Earlier in the day, however, no such correlation is evident: trading volume starts out high in the morning and then falls steadily until midday, while rate volatility is relatively stable throughout these hours.

This pattern contrasts with that observed in equity and other markets,[11] where trading volume and rate volatility tend to move together *throughout* the day. Both volume and rate volatility start from high values at market opening, decline until midday, and then—as in the federal funds market—increase steadily ahead of market closing.

One explanation often advanced for the positive link between trading volume and rate volatility in equity and other markets centers on the role of trading closures.[12] According to this explanation, news accumulated during the overnight nontrading period causes both trading volume and rate volatility to spike up at market opening as investors adjust the position inherited from the previous day to reflect overnight news. Similarly, as the end of the trading day nears, investors increase trading in preparation for the overnight closure, and rate volatility rises.[13]

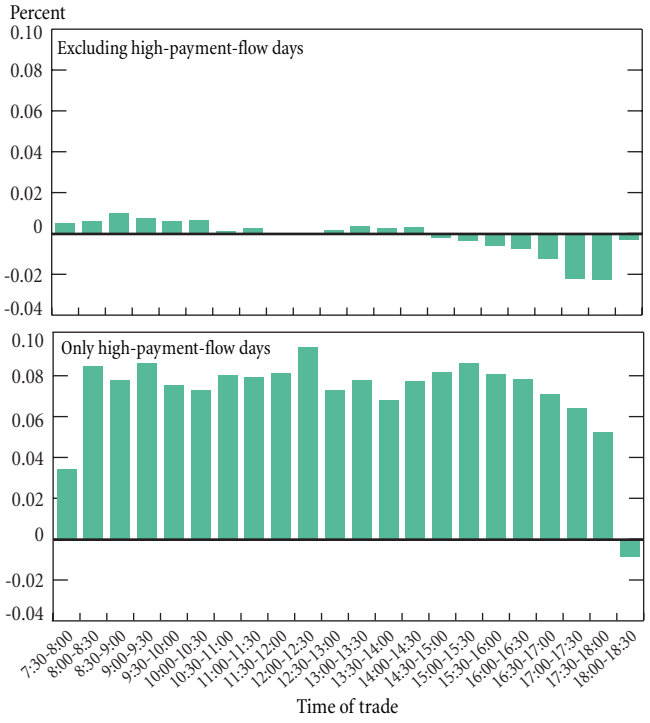
The surge in trading volume and rate volatility in the federal funds market toward the end of the trading session is consistent with the explanation that market closures contribute significantly to the positive link between trading volume and rate volatility.

The surge in trading volume and rate volatility in the federal funds market toward the end of the trading session is consistent with the explanation that market closures contribute significantly to the positive link between trading volume and rate volatility. And the absence of any similar positive correlation between trading volume and rate volatility early in the morning may be attributed to the existence of a closely related market, the Eurodollar market, which opens several hours ahead of the federal funds market, affording many institutions the opportunity to adjust to overnight news well before the opening of the funds market.

Volume and Rate Patterns on High-Payment-Flow Days

Finally, we explore the behavior of the federal funds market on days with a high concentration of securities settlements, government payments, and other systematic shocks to payment flows in the financial system.[14] We find that the intraday deviation of rates from the target shifts up sharply on high-payment-flow days, by about 7 basis points on average (Chart 6). Despite this upward shift, however, the contour of rate movements over high-payment-flow days is qualitatively similar to that observed on other days.[15] Similarly, we find

Chart 6
Deviation of Average Rate from Target



Sources: Euro Brokers; authors' calculations.

no significant difference between high-payment-flow and other days with respect to average daily trading volume, its intraday distribution, or intraday rate volatility. We interpret these patterns as suggesting that higher payment flows serve to increase banks' precautionary demand for liquid funds without altering banks' response to shocks or their incentives to trade at particular times of the day.

Conclusion

Lying at the heart of the U.S. financial structure, the federal funds market accommodates the trading needs of banking institutions that must borrow or lend reserves on short notice and for short periods. The market's daily life is characterized by a number of institutional deadlines, the most important of which is the cessation of reserve flows between banks on Fedwire at day's end. The final tallying of banks' reserves for regulatory purposes, also occurring at the closing of Fedwire, provides further incentive for banks to trade near the end of the day. Our analysis shows that both trading activity and rates display their most pronounced movements in conjunction with this deadline, although distinctive patterns are also exhibited during the rest of a typical business day.

The intraday patterns that we document warrant closer scrutiny. In principle, they are likely to be more robust over time than those biweekly patterns associated with different days in a reserve maintenance period that have been the focus of previous studies. For while the Federal Reserve's Trading Desk may influence day-to-day rate patterns by adjusting its provision of reserve supply within a maintenance period, under its current operating framework, it lacks a comparable means to alter intraday patterns.

Notes

1. For analyses of the federal funds market that focus on day-to-day developments, see Lucas, Jones, and Thurston (1977) and Hamilton (1996).

2. For details on Regulation D and U.S. reserve requirements, visit <http://www.federalreserve.gov/regulations/> and see the discussion in *The Federal Reserve System: Purposes and Functions* (Board of Governors of the Federal Reserve System 2005, chap. 3).

3. For simplicity in this article, we refer to all institutions active in the federal funds market as "banks." Nevertheless, certain nonbank institutions are important lenders in the market, including government securities dealers and government-sponsored enterprises such as Freddie Mac and Fannie Mae. Accordingly, bank liabilities created by borrowing from these institutions are exempt from Regulation D.

4. See Demiralp, Preslopsky, and Whitesell (2004).

5. Banks may use other markets for these same purposes, particularly the Eurodollar market. An examination of the linkages between the federal funds market and the Eurodollar market may be found in Bartolini et al. (2005).

6. In addition to meeting reserve requirements, banks must also satisfy contractual clearing commitments they have arranged with the Federal Reserve. See the discussion of contractual clearing balances in Board of Governors of the Federal Reserve System (2005, chap. 3).

7. On the day the federal funds transaction matures, the original borrowing bank will instruct the Federal Reserve over Fedwire to move balances from its account to the Fed account of the lending bank for the principal amount of the loan plus the agreed-upon interest.

8. We had to estimate the completion time for a minor fraction of trades whose recording was delayed during the end-day trade reconciliation that Euro Brokers conducts daily over a twenty-to-thirty-minute interval between 17:00 and 18:30.

9. As a preliminary step, we verified that our Euro Brokers data could be viewed as representative of the entire brokered federal funds market by comparing aggregate daily average Euro Brokers interest rates with daily average federal funds rates calculated by the New York Fed and based on data derived from all major brokers. We found only very small and nonsystematic deviations. See Bartolini et al. (2005) for details.

10. In contrast, the distribution of trading volume across the days of a typical reserve maintenance period shows no pattern. See Bartolini et al. (2005).

11. See, for instance, Wood, McInish, and Ord (1985), Gallant, Rossi, and Tauchen (1992), and Abhyankar et al. (1997).

12. See Brock and Kleidon (1992).

13. An alternative explanation sometimes given for the observed link between trading volume and rate volatility found in other markets is that information on the value of assets that is available to some traders but not others induces a positive correlation. According to this explanation, the more an investor is privately informed on the value of an asset, the more he will want to trade with other, less informed investors. Less informed investors, for their part, will require a larger price compensation to be induced to trade with more informed investors, resulting in a positive link between trading volume and price changes. Admati and Pfeidlerer (1988) and subsequent related studies discuss this explanation. However, there is little evidence from the federal funds market to suggest that information on the value of assets available to some traders but not others influences the observed trading and rate behaviors.

14. For the purpose of our analysis, we defined days with high payment flows as the first and last business days of each month, the first business day after the fourteenth of each month, and the first day after each Monday holiday.

15. Chart 6 shows that the federal funds rate tends to be about 7 basis points above the target rate for most of the day on high-payment-flow days (bottom panel) but remains very close to the target on days with normal payment flows (top panel). Hence, the tendency for the funds rate, when averaged over all days, to remain modestly above the target rate until late in the trading day (as shown in Chart 4) can be attributed entirely to the rate's behavior on high-payment-flow days.

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