Let's Twist Again:
A High-Frequency Event-Study Analysis
of Operation Twist and Its Implications for QE2

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Abstract

This paper undertakes a modern event-study analysis of Operation Twist and uses its effects to estimate what should be expected for the recent quantitative policy announced by the Federal Reserve, dubbed "QE2". We first show that Operation Twist and QE2 are similar in magnitude. We identify six significant, discrete announcements in the course of Operation Twist that potentially could have had a major effect on financial markets, and show that four did have statistically significant effects. The cumulative effect of these six announcements on longer-term Treasury yields is highly statistically significant but moderate, amounting to about 15 basis points. This estimate is consistent both with Modigliani and Sutch's (1966) time series analysis and with the lower end of empirical estimates of Treasury supply effects in the literature. The effects of Operation Twist on long-term Agency and corporate bond yields are statistically significant but smaller, about 13bp for Agencies and 2 to 4bp for corporates. Thus, the effects of Operation Twist seem to diminish substantially as one moves away from Treasury securities and toward private credit instruments.

1. Introduction

On December 16, 2008, the Federal Reserve's Federal Open Market Committee (FOMC) lowered the target for the federal funds rate to essentially zero in response to the most severe U.S. financial crisis since the Great Depression. Since U.S. currency carries an interest rate of zero, it is virtually impossible for the FOMC to target a value for the federal funds rate that is substantially below zero. Faced with this zero lower bound, the FOMC in 2008 and 2009 endeavored to find alternative ways to stimulate the weak U.S. economy, such as by purchasing large quantities of mortgage-backed securities and longer-term Treasuries in an effort to improve the functioning of those markets and reduce long-term interest rates.[1]

In late 2010, in response to continuing weakness in the economy and the zero lower bound, the FOMC embarked on a second round of quantitative policies, announcing its intention to purchase "a further $600 billion of longer-term Treasury securities by the end of the second quarter of 2011."[2] This program has subsequently become known as "QE2" by the financial community and financial press.

The QE2 program has been controversial, with detractors conjecturing that the risks or costs of the policy are large while the benefits are small. For example, an open letter to Federal Reserve Chairman Bernanke signed by several prominent economists and published in full-page ads in *The Wall Street Journal* and *The New York Times* asserted that the purchases "risk currency debasement and inflation" and could "distort financial markets" while "we do not think they will achieve the Fed's objective of promoting employment" and are "neither warranted nor helpful in addressing either U.S. or global economic problems" (e21 Team, 2010).

The present paper aims to estimate the potential benefits of QE2 by measuring the effect on long-term interest rates of Operation Twist, a very similar program undertaken by the Kennedy Administration and the Federal Reserve in 1961. Although previous studies of Operation Twist using low-frequency, quarterly data have generally found no significant effect of the program on long-term interest rates—see, e.g., the exhaustive time series analysis

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[1] On November 25, 2008, the FOMC announced it would purchase $500 billion of mortgage-backed securities and $100 billion of debt directly issued by the housing-related government-sponsored enterprises (GSEs). On March 18, 2009, the FOMC announced that it would purchase an additional $750 billion of mortgage-backed securities, an additional $100 billion of GSE debt, and $300 billion of longer-term Treasury securities. FOMC statements and minutes are available from the Federal Reserve Board's public web site.

[2] FOMC statement, Nov. 3, 2010, available from the Federal Reserve Board's public web site.

by Modigliani and Sutch (1966, 1967)—the present paper undertakes a more modern high-frequency event-study approach. The event-study methodology restricts attention to major announcements in the course of Operation Twist that can be pinpointed to a single day. By focusing on changes in Treasury yields in a narrow window surrounding each announcement, an event study holds other factors affecting the macroeconomic outlook constant, and thereby isolates the effects of the announcement itself on the yield curve. Lower-frequency time series analyses must attempt to control for other factors affecting the yield curve directly, which is fraught with difficulties such as unobserved variables (financial market expectations of future interest rates and inflation), large residual errors, and endogeneity, as discussed in Section 3, below.

In contrast to Modigliani and Sutch, we find that Operation Twist had a highly statistically significant effect on longer-term Treasury yields. However, consistent with Modigliani and Sutch's (1966) finding that any effects of Operation Twist "are most unlikely to exceed some ten to twenty base points" (p. 196), we estimate that the size of these effects is moderate, with a cumulative effect on long-term Treasury yields of about 15 basis points. This is also consistent with the lower end of Treasury supply effects estimated in the literature, discussed in Section 4, below. Finally, we examine to what extent the effects of Operation Twist spilled over to credit markets other than the Treasury market. We find that long-term government agency yields declined by almost as much as long-term Treasuries, but that long-term corporate bond yields declined by substantially less, only 2 to 4bp. We present evidence that this is at least partly due to limited substitutability between corporate bonds and long-term Treasuries.

Operation Twist has several advantages over more recent episodes as a laboratory for estimating the likely effects of QE2. For example, estimates of the effects of the Fed's initial round of quantitative policies in 2008 and 2009—what one might call "QE1"—such as the studies by Gagnon, Raskin, Remasche, and Sack (2011) and D'Amico and King (2010), are subject to the concern that the 2008–9 financial crisis was a time of severe financial market disruption and low liquidity (see, e.g., Gürkaynak and Wright, 2011). The exceptionally poor functioning of financial markets during this period may have led Federal Reserve purchases to have an uncharacteristically large effect on markets. Thus, it is not clear that the effects of Fed purchases during QE1 are representative of the effects we might expect in more normal

times, such as the present environment in which QE2 is being conducted.

In addition, foreign governments have become increasingly large participants in the U.S. Treasury market over time, with foreign official institutions now holding almost \$3 trillion of U.S. Treasury securities—about one-third of the market—of which more than \$2.3 trillion is held in longer-term Treasury notes and bonds.[3] Foreign official purchases of U.S. Treasuries often vary by \$100 billion or more over the course of just a few months, due to largely exogenous factors such as domestic economic developments and exchange rate interventions (Warnock and Warnock, 2009). Warnock and Warnock estimate that these purchases have a large effect on Treasury yields, implying that studies of Treasury supply effects using data since the 1980s must control for variation in foreign official purchases. An advantage of the Operation Twist period is that the extent of foreign government involvement in the U.S. Treasury market was so small that it can safely be ignored.

The remainder of the paper proceeds as follows. Section 2 provides the historical context for Operation Twist and shows the remarkable similarities between that program and QE2. Section 3 describes our event-study methodology and the data. The effects of Operation Twist on Treasury yields are analyzed in Section 4. Section 5 investigates to what extent the effects of Operation Twist spill over to markets other than the Treasury market. Section 6 concludes.

2. Operation Twist

John F. Kennedy was elected President of the United States in November 1960 and inaugurated on January 20, 1961. The U.S. economy had been in recession since April of 1960 and the recession was ongoing (it would ultimately end in February 1961, although the level of economic activity would remain low for several months into the recovery). The incoming Administration wanted to stimulate the economy with easier monetary as well as fiscal policy, but European interest rates were higher than in the U.S., leading to substantial flows of dollars and gold to Europe under the Bretton Woods fixed exchange rate system. The Federal Reserve (and also the Kennedy Administration) were very reluctant to lower short-

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[3] Data are for October 2010 from the U.S. Treasury's "Major Foreign Holders of U.S. Treasury Securities" report, available at http://www.treasury.gov/resource-center/data-chart-center/tic.

term interest rates any further for fear of worsening the U.S. balance of payments and the outflows of gold to Europe.

The Kennedy Administration's proposed solution to this dilemmma was to try to lower longer-term interest rates while keeping shorter-term interest rates unchanged. The idea was that business investment and housing demand were primarily determined by longer-term interest rates, while the balance of payments and gold flows were determined by cross-country arbitrageurs who act on the basis of short-term interest rate differentials.[4] If longer-term Treasury yields could be lowered without affecting short-term Treasury yields, the reasoning went, then investment could be stimulated without worsening the balance of payments and gold outflow.[5]

Thus, on February 2, 1961, Kennedy announced to Congress a policy in which the Treasury and Federal Reserve would cooperate to change the relative supplies of long-term and short-term Treasury securities in the open market. The Federal Reserve would maintain the current level of the federal funds rate,[6] but would buy longer-term Treasury securities to try to nudge longer-term interest rates lower. The Treasury would reduce its issuance of longer-term notes and bonds and instead issue primarily short-term securities.[7] At the time, this policy was referred to by Fed staff as "Operation Nudge," but in retrospect it has become known as "Operation Twist," in homage to the dance craze that swept the nation at about the same time.[8]

According to statistics from the Federal Reserve Bank of New York, the Fed ultimately purchased about $8.8 billion of longer-term bonds as part of Operation Twist.[9] Recent authors have sometimes dismissed this program as being very small (e.g., Gagnon et al., 2011),

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[4] The price of a Treasury bill is much more stable than the price of a longer-term Treasury bond, making bills and other short-term debt a much more appealing vehicle for short-term arbitrage across currencies.

[5] See *The Wall Street Journal,* Feb. 3, 1961, p. 2, and Feb. 9, 1961.

[6] Technically, the Federal Reserve in the late 1950s and early 1960s followed a policy of targeting the quantity of free reserves rather than the level of the federal funds rate (Friedman and Schwartz, 1963, chap. 11). However, it was recognized that the federal funds rate varied inversely with the quantity of reserves, so for practical purposes this policy can be thought of as a loose federal funds rate target.

[7] For additional details and discussion, see *The Wall Street Journal,* Feb. 3, 1961, p. 2, and Feb. 9, 1961.

[8] Meulendyke (1998), p. 39.

[9] Meulendyke (1998). In particular, the Fed increased its holdings of longer-term Treasury securities by $8.8 billion and reduced its holdings of short-term Treasury bills by $7.4 billion. For several years prior to Operation Twist, the Federal Reserve had subscribed to a "bills-only" policy and bought no longer-term Treasury securities (*The Wall Street Journal,* Feb. 21, 1961, p. 3.)

TABLE 1: SIZE OF OPERATION TWIST IN COMPARISON TO QE2

	Operation Twist	QE2
Size of Federal Reserve program ($B nominal)	8.8	600
U.S. GDP ($B nominal)	528	14,871
U.S. Treasury marketable debt ($B nominal)	189.3	8,543
U.S. Agency debt ($B nominal)	7.4	6,379
U.S. Agency-guaranteed debt ($B nominal)	0.2	1,166
Size of Federal Reserve program:		
as % of GDP	1.7%	4.0%
as % of U.S. Treasury debt	4.7%	7.0%
as % of U.S. Treasury-guaranteed debt	4.5%	3.7%
Additional supporting program by U.S. Treasury?	Yes	No

Notes: Size of Operation Twist is from Meulendyke (1998) and debt statistics are from the U.S. Treasury and Federal Reserve Flow of Funds. U.S. Treasury marketable debt excludes debt held by the Social Security Administration. U.S. Agencies include Fannie Mae and Freddie Mac, whose debt was implicitly (and later explicitly) guaranteed by the U.S. Treasury. U.S. Agency-guaranteed debt consists primarily of mortgage-backed securities. During Operation Twist (but not QE2), the Treasury deliberately issued securities with shorter maturities than usual, but the size of this shift is difficult to quantify, other than that it amounted to several billion dollars. See text for details.

but in fact the size of Operation Twist is quite comparable to QE2. This is demonstrated in Table 1, which reports the nominal size of both programs along with nominal GDP and various measures of U.S. Government debt outstanding. Marketable U.S. Treasury debt includes nominal and inflation-indexed Treasury securities in the hands of the public and excludes nonmarketable securities issued to the Social Security Administration, state and local governments, and to households in the form of savings bonds.[10] U.S. Agencies include the Federal Home Loan Banks, Federal National Mortgage Association (Fannie Mae), Federal Home Loan Bank Corporation (Freddie Mac), and a few smaller entities.[11] U.S. Agency-guaranteed debt consists almost entirely of mortgage-backed securities.

Although the debt of the U.S. Agencies is not officially backed by the "full faith and credit" of the U.S. Government, these agencies had close historical ties to the government and

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[10] Data are from the U.S. Treasury's Office of Public Debt Management for January 1961 and October 2010. Data on nominal GDP are from the Bureau of Economic Analysis for 1961Q1 and 2010Q4.

[11] The data in the table are from the Federal Reserve's Flow of Funds accounts, Tables L.124–125, for 1961Q1 and 2010Q4. Note that, in the first quarter of 2010, about $4 trillion of mortgage-backed securities guaranteed by Fannie Mae and Freddie Mac were shifted directly onto the balance sheets of those agencies in the Flow of Funds. This reclassification does not affect the sum of U.S. Agency debt and U.S. Agency-guaranteed debt, but it has a large effect on the breakdown between these two categories.

their securities were widely viewed as having an implicit government guarantee (a view that was subsequently confirmed in September 2008, when the U.S. Government placed Fannie and Freddie into receivership and explicitly guaranteed their debt obligations).[12] As a result, Agency-issued and Agency-backed securities have been, *ex ante* and *ex post*, close substitutes for U.S. Treasury securities.

As can be seen in Table 1, the Federal Reserve's purchases of long-term Treasury securities during Operation Twist were roughly comparable to QE2 in several respects. First, Operation Twist was about half as large as QE2 relative to GDP—smaller, but similar enough in magnitude to be informative. Second, if changes in the supply of long-term Treasuries have any effect on long-term Treasury yields, then the initial quantity of long-term Treasury securities in the market should be the relevant initial condition, rather than GDP. This observation suggests that the total Treasury market would be a better benchmark for the size of each program, and by this metric, Operation Twist was closer in size to QE2. Third, to the extent that U.S. Agency and Agency-guaranteed debt are close substitutes for Treasury securities, then the relevant market arguably includes all three of these Treasury-guaranteed classes of assets.[13] Relative to this market, Operation Twist was an even larger program than QE2.

Finally, a key feature of Operation Twist, emphasized by the Kennedy Administration from the outset, was the joint participation by *both* the Federal Reserve and Treasury. While the Fed was purchasing $8.8 billion of longer-term Treasuries in the open market, the Treasury was actively supporting this policy by concentrating its issuance of new debt at shorter rather than longer maturities, by an amount that totaled at least several billion dollars.[14] By contrast, QE2 has had no support from the Treasury (Hamilton and Wu, 2011).[15] Taking

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[12] The U.S. Treasury initially announced a capital injection into Fannie and Freddie of up to $100 billion each. This guarantee was later doubled to $200 billion each and then made unlimited in December 2009.

[13] One could extend this argument to all AAA-rated debt securities, or even to all debt securities, but at each successive step the similarity of state-contingent payoffs to U.S. Treasury securities diminishes. In Table 1, we end the scope of the market at U.S. Agency and Agency-backed debt, since the substitutability and set of state-contingent payoffs of those securities is the closest to U.S. Treasuries.

[14] For example, the Feb. 2 Treasury announcement in Table 2 had a total issuance size of $6.9 billion. However, Treasury's Mar. 15 announcement revealed that its commitment to Operation Twist was only partial, rather than full—see the discussion of that announcement in Section 3.2. Thus, it is difficult to come up with a more precise estimate of the size of Treasury's participation in the program, other than that it amounted to several billion dollars.

[15] In fact, during late 2010 and early 2011 the average duration of Treasury securities issued and outstanding both *increased,* directly counter to the goals of QE2 (Hamilton and Wu, 2011). Thus, de facto, the effect

into account the Treasury as well as Federal Reserve contribution to Operation Twist, then, the former program appears to have been substantially larger than QE2.[16]

Operation Twist and QE2 are also very similar qualitatively as well as quantitatively. In both episodes, the Federal Reserve was unable or unwilling to lower its target for the federal funds rate—in the case of QE2, because of the zero lower bound on short-term rates, while in the case of Operation Twist, because of the large gold outflows. Thus, the goal of both programs was to lower longer-term Treasury yields without lowering the federal funds rate. The methods used to implement each program are also very similar: for Operation Twist, the Fed and Treasury essentially sold short-term Treasury bills and purchased longer-term Treasury notes and bonds. To implement QE2, the Federal Reserve is financing purchases of longer-term Treasuries by issuing bank reserves. Bank reserves are short-term liabilities of the Federal Reserve rather than the Treasury, but aside from this technical distinction, the implementation of the two policies, Operation Twist and QE2, is essentially identical.

In summary, one of the main points of this section has been to show that Operation Twist and QE2 are much more similar than has generally been appreciated. Nevertheless, there are notable differences between the two programs. First, Operation Twist was strongly endorsed by the Kennedy Administration as well as the Federal Reserve, while QE2 has been backed only by the Fed. Kennedy's strong support for Operation Twist may have been interpreted by financial markets as a signal that the future course of fiscal as well as monetary policy would be more aggressive than expected; moreover, it suggested cooperation between the Treasury and the Federal Reserve that may have boosted financial market expectations regarding the overall size and aggressiveness of the program. Monetary policy in the 1960s was also less transparent than it is today, so the Federal Reserve's explicit endorsement of Operation Twist (discussed in Section 3.2) was more extraordinary and may have sent a stronger signal to the markets regarding the size and importance of the program to the Fed.

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of QE2 has been to partially offset the increase in supply of long-term Treasury securities coming from the Treasury. When we talk about the effects of QE2 in the present paper, we are referring to the effects of the QE2 policy relative to a benchmark in which there is no QE2 by the Federal Reserve—that is, taking the Treasury's increased issuance of long-term Treasury securities as given.

[16] It is sometimes argued that QE2 was an "open-ended" policy, of which $600 billion was expected to be only the first round, and thus QE2 should be regarded as substantially larger than the initial $600 billion figure would suggest. However, Operation Twist was also an open-ended policy and it is not clear that Operation Twist was expected to be any smaller than QE2, especially once the Treasury's participation in Operation Twist is taken into account.

These observations suggest that the effects of Operation Twist may have been even larger than what we might expect for QE2. Other differences between Operation Twist and QE2 include background factors such as a fixed vs. floating exchange rate regimes, the fact that financial markets are more globally integrated at present, and long-term government budget outlooks that are currently more dire than in the 1960s. However, it is less clear whether these background factors would increase or decrease the expected effectiveness of Operation Twist relative to QE2.

3. Methods and Data

Given the similarities between Operation Twist and QE2, it seems reasonable to use the former program to estimate the likely effects of the latter. However, previous studies of Operation Twist using lower-frequency regression methods, such as the the exhaustive analysis by Modigliani and Sutch (1966, 1967) using quarterly data, have generally found no statistically significant effects of the program. Here we reexamine the episode using a high-frequency event-study approach.

3.1 High-Frequency Event Study Analysis

A high-frequency event-study analysis uses changes in financial markets in a narrow window of time around major, discrete announcements to measure the effects of those announcements. Under the hypothesis of rational expectations in financial markets, asset prices should completely incorporate all information from a public announcement shortly after the announcement is made. In particular, studying the one- or two-day change in Treasury yields around a major macroeconomic announcement should be sufficient to provide an unbiased estimate of the complete effect of that announcement on the yield curve. Jones, Lamont, and Lumsdaine (1998) and Fleming and Remolona (1999) provide evidence supporting this hypothesis, with no evidence of either "momentum" or "backtracking" in yields in the days following such announcements.[17] Intuitively, it also seems reasonable that financial markets

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[17] Although the finance literature has found evidence of over- or underreaction in some cases for small-capitalization stocks, such effects have not been documented for larger, more liquid markets such as the S&P 500 or the Treasury market. Indeed, Jones et al. (1998) and Fleming and Remolona (1999) provide evidence to the contrary for the Treasury market.

would not leave large profitable trading opportunities unexploited for more than a few hours, let alone one or two days.

There are several reasons to think that a high-frequency event-study analysis would be more powerful than lower-frequency time series methods for detecting the effects of Operation Twist. First, longer-term Treasury yields are very sensitive to market expectations about macroeconomic variables such as inflation and the expected path of the federal funds rate. Unfortunately, these expectational variables can change quite dramatically from one quarter to the next and are unobserved by the econometrician, making them very difficult to incorporate into a regression framework.[18] A high-frequency event-study analysis holds the macroeconomic outlook essentially constant by considering changes in yields across a one- or two-day window surrounding the announcement, across which the macroeconomic outlook changes very little except for the possible effects of the announcement itself.[19]

Second, the effects of Operation Twist may have been relatively small, on the order of ten or twenty basis points, which is no bigger than the quarterly standard deviation of long-term Treasury yields. Modigliani and Sutch's (1966) quarterly regression model has a residual standard error of 9.3 basis points, which they characterize as "remarkably low" (p. 190) relative to the rest of the literature. Given the size of this standard error, it might be impossible to find statistically significant effects of Operation Twist even if the regression model is correctly specified and the size of those effects is correctly estimated. By contrast, daily changes in long-term interest rates are about two basis points, so it is relatively easy to determine whether a major announcement regarding Operation Twist had a statistically significant impact on long-term bond yields that day.

Finally, there is an endogeneity problem with monthly or quarterly interest rate data that can make obtaining structural or causal estimates of the effects of Operation Twist difficult, if not impossible. This is similar to the problem of identifying the effects of a monetary policy shock in a vector autoregression, which requires an identifying assumption to disentangle the effects of changes in interest rates on the macroeconomy from the effects

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[18] One can try to control for expectations to some extent by using survey data; however, such survey data do not exist for the Operation Twist period.

[19] Of course, this requires that no other major macroeconomic data surprises or announcements occur on the same day as the announcement in which we are interested. For each of our identified announcements below, we verify this assumption by reading the bond market commentary for that day.

of changes in the macroeconomy on interest rates (e.g., Christiano, Eichenbaum, and Evans, 1999). Modigliani and Sutch (1966, 1967) estimate a reduced-form time series model for long-term interest rates and then investigate to what extent changes in the relative supply of longer-term Treasury securities can explain the residuals of that reduced-form model. But if the Federal Reserve tended to step up its purchases of longer-term Treasuries whenever long-term interest rates started to rise—a plausible hypothesis—then Modigliani and Sutch's reduced-form approach will be biased toward finding no effect of Fed purchases on longer-term yields, or even the perverse effect that Fed purchases caused longer-term yields to *increase*. A high-frequency event-study analysis avoids this endogeneity problem as long as each major announcement being considered was not a response to changes in long-term interest rates *on that same day*.[20]

For all of these reasons, then, an event-study approach offers many advantages over— or at least a worthwhile alternative to—low-frequency time series analysis for estimating the effects of Operation Twist.

3.2 Six Major Announcements

To perform an event-study analysis, we must first identify major announcements in the course of Operation Twist that carried significant news about the program and whose release can be pinpointed to a single day or two. We first performed a search in the ProQuest Historical Newspapers database for all articles in *The Wall Street Journal* in 1961 and early 1962 that mentioned the Federal Reserve or Treasury.[21] This produced several hundred results. We quickly read through these articles, and the *WSJ*'s weekly bond market recaps, to identify episodes that were related to Operation Twist—that is, the objective of lowering longer-term interest rates. This narrowed the number of relevant articles down to a few dozen. Of these, we identified six that, rather than rehashing the goals and methods of the program, represented major new announcements in the development of Operation Twist. These six announcements are summarized in Table 2.

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[20] For more discussion of this point and an application of high-frequency methods to identify the effects of monetary policy shocks in a VAR, see Faust, Swanson, and Wright (2004).

[21] Unfortunately, a search for the phrase "Operation Twist" over this period yields no results because the program did not come to be known by that name until a few years later. Also note that the widely-used LexisNexis database does not cover news articles before 1977.

TABLE 2: SIGNIFICANT ANNOUNCEMENTS REGARDING OPERATION TWIST

Announcement Date	Time	Description	Exp. Effect on Long-Term Treas. Yields	Event Window
Feb. 2, 1961 (Thurs.)	"early Thursday"	Kennedy announces goals and methods of Operation Twist; announces Federal Reserve and Treasury will both participate	decrease	1 day (Feb. 1–2)
Feb. 2, 1961 (Thurs.)	"after the end of regular trading hours"	Treasury announces it will auction $6.9B of new debt at only the 18-month maturity, instead of longer maturities	decrease	1 day (Feb. 2–3)
Feb. 9, 1961 (Thurs.)	time not reported	Federal Reserve statistics released, show Fed made rare purchase of longer-term Treasury securities	decrease	2 days (Feb. 8–10)
Feb. 20, 1961 (Mon.)	2:45pm, "too late for the investment community... to become heavily involved in the market"	Federal Reserve releases rare public statement explicitly endorsing Operation Twist; announces a new policy of buying Treasury securities with maturity longer than 5 years	decrease	2 days (Feb. 17–21)
Mar. 15, 1961 (Wed.)	after the market close	Treasury announces "surprise" refunding using 5- and 6-year notes, longer maturities than expected; markets interpret this as a decrease in Treasury and Fed commitment to Operation Twist	increase	1 day (Mar. 15–16)
Apr. 6, 1961 (Thurs.)	"after the market had closed"	Federal Reserve statistics released, show sharp increase in Fed buying of longer-dated Treasuries on open market, including maturities longer than 10 yrs. for first time	decrease	1 day (Apr. 6–7)

Notes: Quotes in the second column are from *The Wall Street Journal*, 2/6/61, 2/3/61 p. 18, 2/21/61 p. 21, and *The New York Times*, 4/7/61, respectively. Event study windows are in business days, begin with the market close before the announcement and end with the market close after the announcement; the announcements on Feb. 9 and Feb. 20 occurred late enough in the day that markets may not have fully incorporated the announcement into prices by the end of trading that day, so we use the market close on the following day for those announcements. See text for details.

The first of these announcements is President Kennedy's introduction of the program on February 2, 1961. According to *The Wall Street Journal*, the announcement took place early in the day as part of an "economic message" from the President to Congress, in which the President outlined the rationale, goals, and methods of Operation Twist and announced that the Federal Reserve would support the Treasury in its implementation.[22] According to bond market commentary in *The Wall Street Journal,* the announcement had a significant impact on bond markets and was the main driver of bond yields that day. Because the announcement occurred early in the day, leaving plenty of time for markets to respond, we use a one-day event window, from the market close on Feb. 1 to the market close on Feb. 2, to measure the effects of the announcement on Treasury yields.

A few hours after the President's message, "after the end of regular trading hours," the Treasury declared that its upcoming refunding of $6.9 billion of Treasury debt would be concentrated entirely at the 18-month maturity, instead of longer maturities.[23] The announcement was obviously intended to bolster the President's introduction of Operation Twist earlier in the day, but the size and complete concentration of the refunding at shorter maturities may have been a surprise to financial markets and could have created additional follow-on effects on bond yields the next day. Because the announcement occurred after the close of trading on Feb. 2, we use a one-day event window, from the market close on Feb. 2 to the market close on Feb. 3, to measure the announcement's effects.

Several days later, on February 9, the Federal Reserve released its weekly breakdown of Treasury security holdings by maturity for the week ended Wednesday, February 8. The report showed the Fed had made a rare addition to its holdings of longer-term Treasury securities during the week, which was noteworthy because for the previous ten years the Fed had followed a "bills-only" policy of purchasing only Treasury bills with 12 months or less to

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[22] This economic message should not be confused with *The Economic Report of the President,* which was released by President Eisenhower on January 18, 1961. Kennedy's economic message announced and outlined Operation Twist, and the details were subsequently filled in by Administration officials in conversations with reporters. Although the economic message contained other economic proposals, such as a temporary extension of unemployment benefits, many of these other proposals had been anticipated by Kennedy's Jan. 30 State of the Union Address, executive orders, and speeches. Contemporary accounts in *The Wall Street Journal* focus almost entirely on Operation Twist, so there appears to have been little else in the message of comparable interest to financial markets. See *The Wall Street Journal,* Feb. 3, 1961, p. 2., p. 18, and Feb. 6, 1961. For the text of Kennedy's economic message, State of the Union Address, and executive orders, see Woolley and Peters (2010).

[23] Articles describing this announcement are the same as for the previous announcement. The quote is from *The Wall Street Journal*, Feb. 3, 1961, p. 18.

maturity except in the event of a substantial disruption in longer-term Treasury markets.[24] Although the Fed's purchase was not particularly large and the maturity was not very long (just over 1 year), it was a clear departure from its bills-only policy and the first signal from the Fed (rather than the Administration) that it was at least tentatively supporting Operation Twist.[25] The timing of the Fed's statistical release on Feb. 9 is not reported by either *The Wall Street Journal* or *The New York Times*, but other such releases were typically made late in the day (see, e.g., the April 6 announcement, below). Since the timing of the release on Feb. 9 is unclear, we use a two-day event window from the market close on Feb. 8 to the market close on Feb. 10 to measure the impact of this announcement.[26]

The Federal Reserve dramatically increased its commitment to Operation Twist a few days later, on February 20, 1961. That afternoon, the Federal Open Market Committee released what was then an extremely rare public statement, describing a change in its government bond-buying policy. The announcement read, in part:

> During recent years, transactions for the system account, except in correction of disorderly markets, have been made in short-term U.S. Government securities. Authority for transactions in securities of longer maturity has been granted by the open market committee of the Federal Reserve System in the light of conditions that have developed in the domestic economy and in the U.S. balance of payments with other countries. (*The Wall Street Journal*, Feb. 21, 1961, p. 3)

The release also explicitly extended the scope of Federal Reserve purchases of Treasury securities to maturities greater than five years.[27] The announcement was striking, both for the manner of its release and because of its clear endorsement of the goals and methods of Operation Twist. Any previous doubts about the degree to which the Fed was committed to the Kennedy Administration program were immediately dispelled with this announcement.

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[24] For more discussion of the Fed's bills-only policy, see *The Wall Street Journal*, Feb. 21, 1961, p. 3.

[25] For example, *The Wall Street Journal,* Feb. 10, 1961, reported that "The Kennedy Administration has been seeking the cooperation of the Federal Reserve Board to bring down long-term interest rates," but that "The Federal Reserve has not said whether it plans any change in its open-market operations to nudge long-term rates downward."

[26] Given the timing of the Apr. 6 announcement, it is very likely that the Feb. 9 announcement also occurred after the market close. We use a two-day window here to be on the conservative side, but using a one-day window would make essentially no difference in the results (see Table 3, below).

[27] *The Wall Street Journal*, Feb. 21, 1961, p. 3 and p. 21. A few days later, on Feb. 23, the Federal Reserve's weekly balance sheet report confirmed that it had in fact purchased a significant quantity of such securities. However, these purchases were not a surprise given the Feb. 20 statement (*The Wall Street Journal,* Feb. 24, 1961), so we do not include Feb. 23 among our announcements in Table 2.

The Fed's statement was released at 2:45pm, reportedly "too late for the investment community at large to become heavily involved in the market."[28] Thus, we use a two-day event window for this announcement, from the market close on Friday, Feb. 17, to the market close on Tuesday, Feb. 21.

The four announcements above each signaled an increasing degree of commitment by the Treasury or the Federal Reserve to Operation Twist. In contrast, on March 15, 1961, a Treasury announcement was perceived by financial markets as a *decreased* degree of commitment to the program. After the markets closed that afternoon, the Treasury announced an advance debt refunding operation, in which an offer is made to exchange soon-to-mature Treasury securities for newly-issued, longer-maturity Treasuries.[29] The refunding itself was not so much a surprise as was the timing of the announcement (during Operation Twist) and the surprising length of the debt maturities being offered in exchange (five and six years). As reported by *The New York Times*, "Market circles had expected that the advance refunding device... would be used by the Treasury again, but not so soon, and especially not while the Federal Reserve System was engaged in a market operation... aimed at reducing long-term interest rates."[30] According to the *The Wall Street Journal*, "Some interpreted the advance refunding as indicating a change of thinking by the Treasury and the Federal Reserve System," in particular that it "'may mean the monetary authorities, including the Federal Reserve, are satisfied with prices and rates prevailing in the bond market [and] may believe that business in general is on the road to recovery.'"[31] James Tobin, a member of Kennedy's Council of Economic Advisors in 1961, was reportedly "furious" with the Treasury for this

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[28] *The Wall Street Journal*, Feb. 21, 1961, p. 21. In the early 1960s, Government securities trading desks typically closed at 3:30pm. Moreover, daily quotation sheets distributed to clients and newspapers typically were based on 2:30pm price quotations, so it is unclear whether any effects of the Fed's 2:45pm announcement are reflected in our market quotations for Feb. 20. See Scott (1965), Chap. 3, for more details.

[29] *The New York Times*, Mar. 16, 1961.

[30] *The New York Times*, Mar. 17, 1961.

[31] *The Wall Street Journal*, Mar. 20, 1961. The market's interpretation of Treasury's announcement was at least partly correct: Treasury staff had decided that *new* Treasury issuance would continue to focus on short maturities (consistent with Operation Twist), but that refundings of *outstanding* Treasury debt would continue to take place at long maturities (*The Wall Street Journal*, Mar. 16, 1961). The thinking behind this policy was that holders of outstanding Treasury debt would roll their debt over, anyway, so that issuing longer-term securities to these investors would not affect the spread between long- and short-term yields and thus would not interfere with Operation Twist (ibid.). However, the market reaction to the Treasury announcement suggests that this policy in fact may have been misguided and counterproductive. Thus, after the Mar. 15 announcement, one could reasonably characterize the Treasury as being "partially committed" to Operation Twist rather than fully committed.

announcement.[32] The expected effect of the announcement on long-term Treasury yields is thus opposite to the effects of the first four announcements discussed above. Because the announcement was made after the market close, we use a one-day event window to measure its effects, from the market close on March 15 to the market close on March 16.

Our sixth and final announcement regarding Operation Twist occurred on April 6, 1961, and again corresponds to a weekly statistical release by the Federal Reserve. The release showed a substantial increase in the Fed's holdings of longer-term Treasury securities for the week ending Wednesday, April 5, and in particular the first purchase by the Fed in many years of Treasury bonds with greater than ten years to maturity. These purchases provided renewed confirmation of the Fed's commitment to Operation Twist, and were reported as such by the press.[33] The statistical release occurred "after the market had closed," so we use a one-day event window for this announcement, from the market close on Thursday, April 6, to the market close on Friday, April 7.[34]

For each of these six announcements, we then collected data on Treasury market closing prices from the Government Securities column of *The Wall Street Journal* for the business days before, during, and after the announcement.[35] (Although daily yield curve data are available in electronic format from the Federal Reserve Board and other sources, these data do not begin until 1962.) We focused on collecting data for a wide range of maturities that accurately characterize the yield curve at both the short and long ends; in particular, we collected data on Treasury securites with 3 months and 1, 2, 5, 10, and 30 years remaining to maturity. To reduce the influence of idiosyncratic changes in price for any single Treasury security on our results, we computed the average yield to maturity for the three Treasury securities closest to each target maturity listed above.[36]

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[32] Cooper (2011). Cooper served as a senior staff economist on the CEA in 1961.

[33] *The Wall Street Journal,* Apr. 7, 1961, and Apr. 10, 1961.

[34] *The New York Times,* Apr. 7, 1961.

[35] As discussed above, these reported yields come from quotation sheets distributed by Treasury market dealers that were typically based on 2:30pm price quotations and thus do not correspond exactly to the 3:30pm closing prices in the market (Scott, 1965). However, they would typically be very close to the closing prices and we will refer to them as being closing prices for expositional convenience. Also, in a few cases (Mar. 15–16 and Apr. 7), data from *The Wall Street Journal* were unavailable or illegible, in which case we used Treasury yields for the same securities as reported by *The New York Times.*

[36] We exclude callable bonds from this analysis (which are quoted with a range of maturity dates spanning several years), in order to ensure that the maturity of the bond is accurately measured and that the price is free from any implicit option premia associated with callability. At the five-year maturity, there were only two noncallable securities with close to five years remaining to maturity, so we use two rather than three

3.3 Hypothesis Tests

The null hypothesis for our analysis is that Operation Twist announcements had no effect on Treasury yields at any maturity. Under the alternative hypothesis, there are two main channels through which the announcements in Table 2 might have affected yields. First, there is the direct effect of changes in the expected supply of long-term Treasuries on yields. A reduction in the net supply of Treasuries—either through a decrease in Treasury issuance or an increase in Federal Reserve purchases of long-term securities—should cause long-term Treasury yields to fall.[37] In addition, the announcements in Table 2 may also have been interpreted by financial markets as signals about the future course of monetary or fiscal policy. For example, announcements by the Fed that it was supporting Operation Twist may have been interpreted by markets as a signal that the federal funds rate also would be held at its current low level for a greater length of time.[38] Similarly, Kennedy's announcement of Operation Twist may have signaled to the markets that the new Administration would be more aggressive and imaginative than expected with respect to stimulating the economy, which may have led to increased expectations of fiscal stimulus.

In contrast to Treasury supply effects, the response of long-term Treasury yields to the signals described above does not have a clear sign prediction—for example, increased expectations of fiscal stimulus would tend to cause longer-term interest rates to rise. However, given the Federal Reserve and Administration's stated commitment to lowering long-term Treasury yields, the net effect of Operation Twist announcements, under the alternative hypothesis, should be to cause longer-term Treasury yields to decrease.

A similar line of reasoning implies that Operation Twist announcements, under the alternative hypothesis, should cause *short*-term Treasury yields to increase or stay the same.[39]

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securities to measure yields at that maturity.

[37] This sign prediction follows from a downward-sloping demand curve for long-term Treasuries: as the available quantity decreases, the equilibrium price should increase and the yield to maturity fall. Greenwood and Vayanos (2008) and Vayanos and Vila (2009) provide a formal model with preferred-habitat investors and risk-averse arbitrageurs that implies a downward-sloping demand curve for Treasury securities of each maturity. Note that this modeling framework is arbitrage-free, so that the alternative hypothesis does not require an assumption of irrational expectations or arbitrage opportunities.

[38] As discussed in footnote 6, the Federal Reserve targeted a measure of reserves rather than the federal funds rate during this period, but for practical purposes and expositional convenience this policy can be thought of as a loose federal funds rate target.

[39] President Kennedy and the Treasury gave no indication that the total quantity of Treasury issuance would change under Operation Twist, only its composition. Thus, the Treasury's issuance of *short*-term securities

Short-term interest rates shoud not fall because of the Fed and the Administration's commitment to prevent such a decline, due to concerns about U.S. gold outflows.

To estimate the effects of Operation Twist, we would ideally like to have data on financial market expectations regarding the net supply of long-term bonds, and the paths of fiscal and monetary policy, both before and after each announcement in Table 2, in order to measure the change in market expectations attributable to each announcement. Unfortunately, no such data exist.

Nevertheless, we can test the null hypothesis by measuring the change in yields across each announcement and determining whether and to what extent the change is statistically significant—that is, how large is the change in yields relative to the unconditional standard deviation of Treasury yields—and whether the change is in the direction predicted by the alternative hypothesis. If the announcements consistently lead to significant effects in the direction predicted by the alternative, then we would reject the null and turn to the question of estimation of the total size of the effects of Operation Twist.

Finally, note that five of the six announcements in Table 2 represent a perceived increase in the commitment of the Kennedy Administration, Treasury, or Federal Reserve to Operation Twist. Each of these five announcements thus should lead to a decrease in long-term Treasury yields under the alternative. By contrast, the March 16 announcement was seen as a decrease in the commitment of the Treasury (and perhaps also the Fed) to the program, and thus should lead to an increase in long-term Treasury yields.

4. The Response of Treasury Yields to Operation Twist

The results of the event study analysis described above are summarized in Table 3. The top panel reports Treasury yields at the market close the day before, the day of, and the day after each announcement. The second panel reports the change in Treasury yields across the event window for each announcement. The bottom panel reports the unconditional

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would have to increase, which would push short-term Treasury yields upward under the alternative. Signals about the future course of fiscal policy would also tend to push yields upward, although this might be offset to some extent by signals about easier monetary policy in the future. However, even under the alternative hypothesis, short-term Treasury yields could remain unchanged if the Fed maintains a constant target for the federal funds rate, since short-term Treasury yields are closely linked to the funds rate.

standard deviation of Treasury yield changes over one- and two-day windows as benchmarks for comparison.[40]

The statistical significance of each Treasury yield response in the table is assessed relative to the unconditional standard deviation for the same maturity and window size in the bottom panel. One, two, or three stars next to a number denote statistical significance for a *two*-sided *t*-test, even though the alternative hypothesis provides us with clear sign predictions for the shortest and longest maturities; we do this both to minimize confusion (since the one-sided tests go in opposite directions for short and long maturities and have no clear sign prediction at the intermediate, 2-year maturity) and to avoid the appearance of overstating the significance of the results in the table. However, we also discuss in the text statistical significance relative to a one-sided *t*-test when those results are interesting.

Of the six announcements in Table 3, the most remarkable is the Federal Reserve's endorsement of Operation Twist on February 20. Treasury yields with five or more years to maturity fell by 6 to 9 basis points (bp), with *t*-statistics in excess of 3. But what makes these movements even more striking is the response of 3-month and 1-year Treasury yields, which simultaneously *rose* by 11 and 6bp, with the former statistically significant at the 1 percent level and the latter significant at the 5 percent level for a one-sided test in the direction of the alternative. The Wald statistic for the joint movement of all six Treasury yields during this two-day window is 53.5, corresponding to a *p*-value of less than 10^{-9}. Moreover, the yield curve response is completely consistent with the alternative hypothesis and thus raises serious questions about the validity of the null.

President Kennedy's introduction of Operation Twist on February 2 is almost as interesting. Longer-term yields fell by about 4bp that day, while short-term yields were about unchanged. The 10- and 30-year yield responses are significant at the 5 percent level or better, while the 5-year yield response is significant at the 5 percent level for a one-sided test in the direction of the alternative. The Wald statistic for the joint change in yields is 16.6, with a *p*-value of 1.1 percent, and the change is in the direction predicted by the alternative.

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[40] We discuss the 6- and 8-day changes below. Unconditional standard deviations are computed for 1962, for two reasons: First, daily data on Treasury yields are available from the Federal Reserve Board beginning on January 2, 1962, but not before. Second, we want to compute an unconditional standard deviation that is not unduly influenced by Operation Twist itself, and 1962 largely postdates the Operation Twist period. The unconditional standard deviation of Treasury yield changes in 1963 and in 1964 are less than in 1962, so our measure of standard deviation here is conservatively large.

Table 3: Treasury Yields around Operation Twist Announcements

Date	3-mo.	1-yr.	2-yr.	5-yr.	10-yr.	30-yr.
Treasury Yields around Announcement Dates (percent):						
Feb. 1 (Wed.)	2.263	2.787	3.05	3.565	3.783	3.90
Feb. 2 (Thurs.)	2.273	2.78	3.007	3.53	3.747	3.86
Feb. 2 (Thurs.)	2.273	2.78	3.007	3.53	3.747	3.86
Feb. 3 (Fri.)	2.272	2.81	3.043	3.51	3.713	3.845
Feb. 8 (Wed.)	2.327	2.81	3.077	3.51	3.753	3.84
Feb. 9 (Thurs.)	2.327	2.827	3.077	3.51	3.753	3.835
Feb. 10 (Fri.)	2.355	2.85	3.097	3.52	3.743	3.83
Feb. 17 (Fri.)	2.387	2.827	3.037	3.49	3.73	3.795
Feb. 20 (Mon.)	2.422	2.833	3.023	3.47	3.713	3.795
Feb. 21 (Tues.)	2.497	2.887	3.01	3.40	3.65	3.735
Mar. 15 (Wed.)	2.353	2.805	2.947	3.395	3.69	3.795
Mar. 16 (Thurs.)	2.328	2.77	2.937	3.48	3.723	3.81
Apr. 6 (Thurs.)	2.283	2.858	2.993	3.445	3.733	3.82
Apr. 7 (Fri.)	2.282	2.808	2.98	3.435	3.73	3.805
Responses to Announcements (basis points):						
1-day change, Feb. 1–2	1	−0.7	−4.3*	−3.5*	−3.7**	−4***
1-day change, Feb. 2–3	−0.2	3	3.7	−2	−3.3*	−1.5
2-day change, Feb. 8–10	2.8	4	2	1	−1	−1
2-day change, Feb. 17–21	11***	6*	−2.7	−9***	−8***	−6***
1-day change, Mar. 15–16	−2.5	−3.5*	−1	8.5***	3.3*	1.5
1-day change, Apr. 6–7	−0.2	−5**	−1.3	−1	−0.3	−1.5
Cumulative Response (bp):						
first four announcements	14.7***	12.3**	−1.3	−13.5***	−16***	−12.5***
all six announcements	12*	3.8	−3.7	−6	−13***	−12.5***
Unconditional Standard Deviation of Treasury Yield Changes (bp):						
1-day changes	2.14	1.99	2.25	1.93	1.73	1.15
2-day changes	3.18	3.08	3.50	2.95	2.58	1.67
6-day changes	5.41	5.19	5.88	4.99	4.39	2.87
8-day changes	6.20	5.90	6.68	5.68	5.02	3.30

Notes: Treasury yields are averages for the three non-callable Treasury securities with remaining maturity closest to that listed. The choice of a 1- or 2-day event window is based on the timing of each announcement reported in Table 2. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively; significance for 1- and 2-day changes is relative to the unconditional standard deviations of 1- and 2-day changes in the bottom panel; significance for the cumulative changes is relative to the 6- and 8-day changes. The cumulative change for the first four announcements captures the initial effects of Operation Twist, since the fifth announcement was seen by markets as a policy reversal (see Table 2). Unconditional standard deviations are for 1962, due to data availability and to exclude the Operation Twist period. See text for details.

The response to the Treasury's announcement after the market close on Feburary 2 is not as strong as for the Fed's and President's announcements, above; nevertheless, the changes in the 10-, 30-, and 1-year Treasury yields are all statistically significant at the 10 percent level or better for one-sided tests in the directions predicted by the alternative (downward for the 10- and 30-year yields, and upward for the 1-year yield). The Wald statistic for the joint change in yields is 28.6, even larger than for Kennedy's announcement, because of the stronger upward "twist" at the 1- and 2-year maturities, a more unusual pattern. The p-value for this move is less than 10^{-4}, and it is again in the direction predicted by the alternative.

The Treasury's surprise refunding announcement on March 15 is the one announcement in our sample that was perceived as a decrease in the government's commmitment to Operation Twist. Thus, the alternative hypothesis predicts that long-term interest rates should increase in response to that announcement. In fact, this is what we see in the data, particularly at the 5-year maturity, which was precisely the maturity at which the Treasury announced that the new supply would be forthcoming. Yields rose by 8.5bp at the 5-year maturity with a t-statistic of more than 4, but the increases at the 10- and 30-year maturities are also statistically significant at the 5 and 10 percent levels, respectively, for a one-sided test in the direction of the alternative. At the same time, short-term yields twisted downward by 2.5 to 3.5bp, with the 1-year yield response significant at the 5 percent level for a one-sided test. The Wald statistic for the joint movement of yields is 73.5, with a p-value of less than 10^{-13}, and this movement is in the direction predicted by the alternative.

Finally, the Federal Reserve's statistical releases on February 9 and April 6 seem to have had little effect on the bond market. Although there is a statistically significant drop in the 1-year yield around the April 6 announcement, that response is not in the direction predicted by the alternative, so it would not be significant for a one-sided test. The Wald statistic for the Feb. 9 announcement is 5.0, with a p-value of 55 percent, while the Wald statistic for April 6 is 10.9, with a p-value of 9.2 percent.

Beyond the size and statistical significance of individual announcements, we investigate the size and significance of Operation Twist as a whole in two ways. First, we look at the cumulative effect of the first four announcements in our sample, each of which represented an increase in Treasury or Federal Reserve commitment to Operation Twist. Taken together,

these first four announcements provide a reasonable estimate of the initial effects of Operation Twist on the yield curve: Not only is each of these announcements in the same direction, but they all occur within a period of three weeks during which essentially no other news regarding Operation Twist was released. As a result, we can have a high degree of confidence that these first four announcements capture essentially *all* of the information regarding Operation Twist that was released within the first three weeks of the program. One can interpret this cumulative effect as the *initial* effect of Operation Twist or what the total effect *could have been* with no future policy reversals or mixed signals.

The second way we investigate the overall effect of Operation Twist is by looking at the cumulative effect of all six of the announcements in our sample. Here, the interpretation is less clear-cut: For example, the fifth announcement, on March 15, reversed some of the initial effects of the program. There is also more time between the fourth, fifth, and sixth announcements and after the sixth announcement for more incremental information about Operation Twist to come to light, such as the weekly breakdown of Treasury holdings released by the Federal Reserve, the periodic issuance and refunding announcements by the Treasury, and the actual purchases and issuance of Treasury securities made by the Fed and Treasury. Nevertheless, summing up the effects of the six announcements in our sample gives an estimate of the *total* effects of Operation Twist, inclusive of the effects of policy reversals.

These cumulative changes are reported in the third panel of Table 3. The statistical significance of the cumulative changes is assessed by comparing them to the unconditional standard deviations of yields over a correspondingly-sized 6- or 8-day window, reported in the bottom panel.[41] As can be seen in the table, the cumulative change in yields after the first four announcements is highly statistically significant and in the direction predicted by the alternative. The Wald statistic for the joint yield curve response is 61.3, with a p-value of less than 10^{-10}. The cumulative effect, however, is moderate, amounting to no more than about 15bp even at the longest and shortest maturities.

The cumulative effect of all six announcements is somewhat smaller, and is only statistically significant at the longest and shortest maturities (10 years, 30 years, and 3 months), although the t-statistics for the long maturities remain close to 3, and the 3-month response

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[41] These 6-day and 8-day standard deviations are computed as $\sqrt{2\text{sd}_1^2 + 2\text{sd}_2^2}$ and $\sqrt{4\text{sd}_1^2 + 2\text{sd}_2^2}$, respectively, where sd_1 and sd_2 denote the standard deviation of 1- and 2-day changes.

is significant at the 5 percent level in the direction of the alternative. The Wald statistic for the joint response is 30.2, with a p-value of less than 10^{-4}. Again, the total effect on the longest and shortest maturities appears to have been about 12 to 13bp.

Thus, even though we have found that Operation Twist had a cumulative effect on the yield curve that is highly statistically significant, one could argue that, at 15 basis points, the effect is not very important economically. Indeed, Modigliani and Sutch argued:

> Any effects, direct or indirect, of Operation Twist in narrowing the spread which further study might establish, are most unlikely to exceed some ten to twenty base points—a reduction that can be considered moderate at best.
>
> (Modigliani and Sutch, 1966, p. 196)

However, it should be noted that a 15bp decline in the 10-year Treasury yield would be a typical response to a 100bp surprise cut in the federal funds rate target (Gürkaynak, Sack, and Swanson, 2005). Such a change in the federal funds rate would usually be regarded as a non-negligible easing of financial market conditions.[42]

Whether a reduction of 15bp in long-term interest rates is economically significant or not may ultimately lie in the eye of the beholder. Nevertheless, it is reassuring that the effects in Table 3 are consistent with Modigliani and Sutch's findings. As discussed above, the standard error of those authors' quarterly regression specification is over 9 basis points, too large for the effects in Table 3 to show up with any statistical significance in their analysis.

4.1 Comparison to Other Studies

While consistency of our results with Modigliani and Sutch's (1966, 1967) extensive analysis is reassuring, there are a number of more recent studies of Treasury quantity and quantitative announcement effects in the literature. For the purpose of comparability across studies, we normalize each estimate in terms of its predicted effect for QE2; that is, we report what effect each study would estimate an announcement of a $600 billion reduction in the supply of longer-term Treasury securities would have on longer-term Treasury yields.[43] As discussed

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[42] However, note that a 100bp cut in the fed funds rate would also typically imply large declines in short-term rates, whereas the effect of Operation Twist on short- and medium-term rates was zero or even positive. Thus, the effect of Operation Twist on the macroeconomy should not be thought of as equivalent to a 100bp cut in the funds rate.

[43] Some of the studies below focus only on changes in the supply of Treasury securities, while others (particularly the event studies) implicitly include signaling effects as well as direct effects of changes in

in Section 2, we regard Operation Twist and QE2 as being roughly similar in size, so that the predicted effect of the present paper for QE2 would be about 15bp.[44]

Gagnon, Raskin, Remasche, and Sack (2011) study the Federal Reserve's purchases of longer-term Treasury and mortgage-backed securities between 2008 and mid-2009—what one might call "QE1". They estimate the effects of QE1 using both high-frequency event study methods and a lower-frequency, monthly time series analysis. Gagnon et al. estimate that QE1 had an effect on the 10-year Treasury yield of about 91bp, using their event study methodology, or 52bp according to their monthly time series regressions. Since the $1.7 trillion QE1 program was roughly three times the size of QE2, this would imply an effect of QE2 on the 10-year Treasury yield of about 14 to 30bp. Our estimates in this paper are consistent with the very bottom of this range. To the extent that this represents a discrepancy, it may be due to the fact that QE1 took place during a period of severe disruption and very low liquidity in financial markets (see, e.g., Gürkaynak and Wright, 2011), an environment in which those markets may have been more segmented and supply effects may have been correspondingly more potent.[45]

D'Amico and King (2010) estimate the effects of Federal Reserve purchases of Treasury securities during QE1 using a panel data set containing the quantity, maturity, date of purchase, and CUSIP of each Treasury security purchased by the Fed through the program. They use differences in the cross-section of Treasury bond prices to estimate the effect of the Fed's purchases on Treasury yields. They estimate that, overall, the effect of the $300 billion Treasury component of QE1 on the 10-year Treasury yield was about 50bp. Scaling this up to the size of QE2, this would imply an effect on the 10-year Treasury yield of about 100bp, far larger than the effect we estimate in the present paper. As with Gagnon et al. (2011), D'Amico and King's (2010) larger estimates may be due to greater market segmentation during the QE1 period, making it easier for the Fed to move yields in any given market

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Treasury supply. In each case, we simply scale up the study's coefficient estimate to correspond to a change in Treasury supply of $600 billion. If the study in question excluded signaling effects, then the scaled-up estimate reported below also excludes signaling effects.

[44] Implicit in this comparison is an assumption that any signaling effects of QE2 regarding fiscal and monetary policy are also roughly similar in size to any signals that markets inferred from Operation Twist.

[45] It is also possible that QE1 was interpreted by financial markets as a signal that the Fed would do what was necessary to prevent a complete financial collapse, and thus the signaling effects of QE1 were greater than those of QE2 and Operation Twist. However, the sign of this effect is not clear—for example, such a signal could have *increased* Treasury yields by reducing the demand for default-free assets.

segment. Nevertheless, their estimates are substantially larger than the Fed's experience during Operation Twist.

Hamilton and Wu (2011) relate Treasury supply effects to an affine term structure model using a preferred-habitat framework developed by Vayanos and Vila (2009). Hamilton and Wu estimate that $400 billion of Treasury purchases by the Fed, focused on $2^1/_2$- to 10-year maturities as in QE2, would decrease the 10-year Treasury yield by about 11bp. Scaled up to the size of QE2 and Operation Twist, this would imply an effect of about 17bp, consistent with the present paper.

Greenwood and Vayanos (2008) regress the monthly Treasury yield spread—the difference between long-term and short-term Treasury yields—on measures of the long-term (10+ years to maturity) share of Treasury debt outstanding. They estimate that a 1% increase in the long-term share of Treasury debt increases the 20-year Treasury yield by 7.7bp. Scaling this up to the size of QE2, this would seem to imply an effect of those programs of about 39 to 54bp. However, most of the Federal Reserve's purchases of Treasury securities during Operation Twist and QE2 were concentrated at intermediate maturities of less than 10 years, and only a small fraction (about one-fourth) took place at maturities of 10 years or more. Taking this into account, Greenwood and Vayanos' estimates would imply an effect of those programs of roughly 10 to 16bp, consistent with the present paper.

Krishnamurthy and Vissing-Jorgensen (2010) (KVJ) measure the effect of total Treasury supply on the overall level of Treasury yields, relative to Aaa-rated corporate bonds. They estimate that an increase in the total quantity of Treasuries outstanding equal to 1% of U.S. GDP raises Treasury yields overall by about 1.5 to 4bp. This estimated effect is of the same order of magnitude as in the present paper (QE2 is about 4% of GDP), but the two estimates are nevertheless not directly comparable, because KVJ's analysis focuses on the total quantity of Treasury debt outstanding, while Operation Twist and QE2 involved no change in total Treasury debt, only a change in the relative supply of shorter vs. longer maturity Treasury securities.

Warnock and Warnock (2009) estimate the effect of foreign official purchases of U.S. Treasury securities on Treasury yields. The idea is that purchases of U.S. Treasury securities by the Bank of China or Bank of Japan are made primarily for exogenous reasons relating to the domestic economy or exchange rate interventions, and thus represent exogenous changes

in the net supply of U.S. Treasuries to the private sector. They estimate that a decrease in the supply of Treasury securities of about 1% of U.S. GDP reduces the 10-year Treasury yield by about 19bp. Scaling this up to the size of QE2 and Operation Twist would imply a reduction in longer-term Treasury yields of roughly 38 to 76bp, substantially larger than the effect estimated by Krishnamurthy and Vissing-Jorgensen (2010). Again, Warnock and Warnock's estimates are not directly comparable to those of the present paper, since Operation Twist and QE2 did not change the total quantity of Treasury debt outstanding, only the relative suppply of shorter vs. longer maturity Treasury securities.

It is reassuring that several of the studies above, using completely different methods, arrive at estimates of the effects of QE2 that are in line with those of the present paper. A potential concern with the event-study methodology in general is that it restricts attention to only those news-worthy announcements that can be pinpointed to an exact date. If much of the news regarding Operation Twist was released incrementally, in between and after the six major announcements in Table 2, then it is possible that the cumulative effect of the six discrete announcements would miss much of the true cumulative effect of Operation Twist as a whole. The studies by Hamilton and Wu (2011) and Greenwood and Vayanos (2008) do not suffer from this criticism, and so their findings provide some evidence that our six major announcements may indeed have captured a large majority of the information and effects of the Operation Twist program.

5. The Response of Agency and Corporate Yields to Operation Twist

The previous section showed that Operation Twist had highly significant but moderate effects on Treasury yields. The results in Krishnamurthy and Vissing-Jorgensen (2010, 2011) suggest that these effects may not pass through completely to bond yields other than Treasuries, so here we investigate to what extent the effects of Operation Twist spilled over to borrowing rates more generally. Table 4 reports the behavior of short- and long-term Agency and corporate bond yields around the six Operation Twist announcements identified above.

The first four columns of Table 4 report U.S. Government-sponsored Agency yields around the same set of announcements as in Tables 2 and 3.[46] The next three columns—columns 5 through 7—report commercial paper yields, which are short-term borrowing rates

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[46] These are the average yield to maturity for the three noncallable FNMA or Federal Land Bank securities

available to large corporations.[47] Columns 8 and 9 report long-term corporate borrowing rates as measured by Moody's corporate bond indexes.[48] The final two columns report the 1- and 10-year Treasury yields as benchmarks for comparison.

The event windows in the top panel of Table 4 are one day longer than in Table 3, for two reasons.[49] First, there is some evidence that the (less liquid) Agency and corporate securities considered here may respond with a longer lag than do the Treasury securities in Table 3. This is particularly evident after the Federal Reserve's announcement late on Feb. 20, for which Treasury yields seem to respond on Feb. 21 and not Feb. 23 (the next trading day after Washington's birthday), while Agency and commercial paper yields show little response on Feb. 21 but a great deal of movement on Feb. 23. The same effect is visible for Agency yields around other announcement dates as well.[50]

The second reason to consider longer event windows in Table 4 is one of pragmatism: because we generally find a small response of corporate bonds to Operation Twist announcements below, we give those markets the benefit of the doubt and allow them more time to respond to each announcement. The longer event windows considered in Table 4 increase the size and statistical significance of the Agency and corporate yield responses to Operation Twist, while using the shorter event windows of Table 3 would cause us to estimate even smaller and less statistically significant effects for these Agency and corporate yields. (The response of Treasury yields over these longer event windows is very similar to the response over the shorter windows, as can be seen by comparing the last columns of Table 4 to the corresponding columns in Table 3.)

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with remaining maturity closest to that listed, as reported in the Government Securities column of *The Wall Street Journal.* The Federal Land Bank system was a large issuer of government agency bonds in the first half of the twentieth century, with more securities outstanding in 1961 than even FNMA. Together, FNMA and Federal Land Bank notes dominated the Government Agency listings in *The Wall Street Journal* and *The New York Times.*

[47] These yields are taken from the Federal Reserve's H15 statistical reports and measure the effective yield on commercial paper directly placed by financial institutions.

[48] These data are from *Moody's Bond Survey,* which each week published daily bond index values for the preceding week (I thank Arvind Krishnamurthy for pointing me to these historical data). Each bond index consists of about 30 of the largest and most liquid corporate bond issues outstanding with roughly 10 to 30 years remaining to maturity.

[49] We continue to use a one-day event window for the first announcement because a longer window would overlap with the second announcement and lead to "double-counting".

[50] Krishnamurthy and Vissing-Jorgensen (2011) also find that more than one day is needed for the effects of announcements during QE1 and QE2 to become evident in less liquid securities markets such as those for Agencies and corporate bonds.

TABLE 4: AGENCY AND CORPORATE YIELDS AROUND OPERATION TWIST ANNOUNCEMENTS

Yields around Announcement Dates (percent):

Date	Agency Debt				Commercial Paper			Moody's Corporate Bond Indexes		memo: Treasury Debt	
	1-yr.	2-yr.	5-yr.	10-yr.	1-mo.	3-mo.	6-mo.	Aaa	Baa	1-yr.	10-yr.
Feb. 1 (Wed.)	2.84	3.163	3.703	4.07	2.375	2.625	2.75	4.31	5.09	2.787	3.783
Feb. 2 (Thurs.)	2.837	3.157	3.703	4.07	2.375	2.625	2.75	4.30	5.10	2.78	3.747
Feb. 2 (Thurs.)	2.837	3.157	3.703	4.07	2.375	2.625	2.75	4.30	5.10	2.78	3.747
Feb. 3 (Fri.)	2.787	3.157	3.703	4.06	2.375	2.625	2.75	4.29	5.08	2.81	3.713
Feb. 6 (Mon.)	2.813	3.193	3.67	4.027	2.375	2.625	2.75	4.29	5.08	2.82	3.723
Feb. 8 (Wed.)	2.827	3.187	3.673	4.013	2.375	2.625	2.75	4.28	5.07	2.81	3.753
Feb. 9 (Thurs.)	2.823	3.187	3.673	4.007	2.375	2.625	2.75	4.28	5.07	2.827	3.753
Feb. 10 (Fri.)	2.88	3.207	3.673	4.007	2.375	2.625	2.75	4.28	5.06	2.85	3.743
Feb. 14 (Tues.)	2.91	3.167	3.683	4.00	2.375	2.625	2.75	4.28	5.08	2.84	3.743
Feb. 17 (Fri.)	2.913	3.187	3.667	3.987	2.375	2.625	2.75	4.26	5.07	2.827	3.73
Feb. 20 (Mon.)	2.913	3.187	3.667	3.977	2.375	2.625	2.75	4.25	5.06	2.833	3.713
Feb. 21 (Tues.)	2.907	3.177	3.667	3.967	2.375	2.625	2.75	4.25	5.06	2.887	3.65
Feb. 23 (Thurs.)	2.897	3.16	3.597	3.90	2.5	2.75	2.75	4.24	5.05	2.883	3.643
Mar. 15 (Wed.)	2.90	3.09	3.547	3.86	2.625	2.75	2.75	4.21	5.02	2.805	3.69
Mar. 16 (Thurs.)	2.903	3.09	3.547	3.86	2.625	2.75	2.75	4.21	5.02	2.77	3.723
Mar. 17 (Fri.)	2.877	3.07	3.58	3.86	2.625	2.75	2.75	4.21	5.02	2.76	3.733
Apr. 6 (Thurs.)	2.887	3.13	3.78	3.967	2.25	2.625	2.625	4.23	5.01	2.858	3.733
Apr. 7 (Fri.)	2.857	3.13	3.79	3.993	2.25	2.625	2.625	4.23	5.00	2.808	3.73
Apr. 10 (Mon.)	2.863	3.123	3.787	3.977	2.25	2.625	2.625	4.23	5.00	2.823	3.747

(continued)

TABLE 4 (CONT.): AGENCY AND CORPORATE YIELDS AROUND OPERATION TWIST ANNOUNCEMENTS

Date	Agency Debt				Commercial Paper			Moody's Corporate Bond Indexes		memo: Treasury Debt	
	1-yr.	2-yr.	5-yr.	10-yr.	1-mo.	3-mo.	6-mo.	Aaa	Baa	1-yr.	10-yr.
Responses to Announcements (basis points):											
1-day change, Feb. 1–2	−0.3	−0.7	0	0	0	0	0	−1*	1	−0.7	−3.7**
2-day change, Feb. 2–6	−2.3	3.7	−3.3	−4.3**	0	0	0	−1	−2**	4	−2.3
3-day change, Feb. 8–14	8.3*	−2	1	−1.3	0	0	0	0	1	3	−1
3-day change, Feb. 17–23	−1.7	−2.7	−7**	−8.7***	12.5	12.5**	0	−2**	−2*	5.7	−8.7***
2-day change, Mar. 15–17	−2.3	−2	3.3	0	0	0	0	0	0	−4.5	4.3*
2-day change, Apr. 6–10	−2.3	−0.7	0.7	1	0	0	0	0	−1	−3.5	1.3
Cumulative Response (bp):											
first four announcements	4	−1.7	−9.3	−14.3***	12.5	12.5	0	−4**	−2	12*	−15.7***
all six announcements	−0.7	−4.3	−5.3	−13.3**	12.5	12.5	0	−4**	−3	4	−10
Unconditional Standard Deviation of Yield Changes (bp):											
1-day changes	2.15	2.19	2.01	1.52	4.44	3.63	5.00	0.56	0.62	1.99	1.73
2-day changes	3.04	3.10	2.84	2.15	6.28	5.14	7.07	0.72	0.87	3.08	2.58
3-day changes	3.72	3.80	3.48	2.64	7.69	5.90	8.65	0.90	1.05	4.17	3.31
9-day changes	6.44	6.58	6.03	4.57	13.32	10.45	14.99	1.56	1.83	6.94	5.62
13-day changes	7.74	7.91	7.25	5.49	16.01	12.73	18.01	1.87	2.21	8.20	6.70

Notes: Agency debt yields are averages of the three FNMA and Federal Land Bank bonds with remaining maturity closest to that listed, from *The Wall Street Journal*. Commercial paper yields are for paper directly placed by financial institutions, from the Federal Reserve's H15 report. Moody's corporate Aaa and Baa indexes are daily index values published in *Moody's Bond Survey* and each comprise about 30 corporate bonds with remaining maturity of 10 to 30 years. Event windows are one day longer than in Table 3 because the securities here appear to take longer than Treasuries to respond to news. 1- and 10-yr. Treasury yields are reported over the same windows for comparison. Note that bond markets were closed on Feb. 13 and 22 in observance of Lincoln's and Washington's birthdays. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively; significance for 1-, 2-, and 3-day changes is relative to the corresponding unconditional standard deviations in the bottom panel; significance for the cumulative changes is relative to the 9- and 13-day changes. See Table 3 and text for additional details.

In the second panel of Table 4, we report the change in Agency, commercial paper, and corporate bond yields across the event window for each announcement. Statistical significance of each response is measured relative to the unconditional standard deviation of the corresponding yield over similarly-sized windows in 1962, reported in the bottom panel.[51]

Of the six announcements, the one that stands out the most is the Federal Reserve's explicit endorsement of Operation Twist on February 20. Long-term Agency, commercial paper, and corporate bond yields all responded substantially, and in most cases significantly, to the announcement. The Treasury's refunding announcement on Feb. 2 is also noteworthy, with moderately large and signficant responses of 10-year Agency bonds and Moody's Baa index (although part of the response may reflect a carry-over from President Kennedy's announcement earlier that same day). The March 15 anouncement is also interesting in that the response of the 5-year Agency yield is moderate (3.3bp) and in the same direction as the 5-year Treasury, although it is not statistically significant (recall that the Treasury's refunding announcement had an outsized effect on yields at precisely the 5-year maturity, at which the new issuance was being concentrated). The Moody's corporate bond indexes, which have 10 to 30 years remaining to maturity and thus differ substantially from the new issues announced by the Treasury, show no response to the March 15 announcement.

The third panel of Table 4 estimates the total effect of Operation Twist on Agency and corporate yields by summing over their responses to the first four and all six announcements, analogous to the third panel of Table 3. The cumulative response of 10-year Agency yields is highly statistically significant and moderate, about 13 to 14bp, similar to the 15bp cumulative response of long-term Treasuries. This suggests that Operation Twist had substantial spillovers from Treasury to Agency yields at the longest maturities. However, the cumulative response of 5-year Agencies to either the first four or all six announcements is not statistically significant and, at 5 to 9bp, is more muted than the 5-year Treasury yield response in Table 3. There is also little evidence of pass-through of Operation Twist to 1-year Agency yields (and the cumulative responses of 2-year Agencies and Treasuries are

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[51] For commercial paper, Moody's bond indexes, and Treasuries, 1-, 2-, and 3-day standard deviations were computed directly from daily data. The 9- and 13-day standard deviations were then computed as $\sqrt{\text{sd}_1^2 + \text{sd}_2^2 + 2\text{sd}_3^2}$ and $\sqrt{\text{sd}_1^2 + 3\text{sd}_2^2 + 2\text{sd}_3^2}$, respectively. For Agencies, we collected weekly data on Agency yields in late 1961 and 1962 from *The Wall Street Journal,* computed the 5-day standard deviation sd_5 directly from the weekly data, and then set $\text{sd}_n = \sqrt{n\text{sd}_5/5}$.

both insignificant).

The cumulative response of commercial paper (CP) yields in Table 4 are also not significant, and those yields do not respond to any of the six announcements in the table except for Feb. 20. To some extent, this may reflect that the CP yields in our sample were only issued in increments of $1/8$ percentage point, which is such a coarse resolution that it may be difficult to see any effects of the announcements showing through. The cumulative effect of Operation Twist on 1- and 3-month CP is of roughly the same magnitude as the effect on short-term Treasury yields—about 12bp—but the effect on CP is not statistically significant, due to the much larger standard deviation of changes in those yields.

In contrast to the CP data, Moody's corporate bond indexes are calculated to the nearest basis point, have small standard deviations, and consist of bonds with 10 to 30 years remaining to maturity, precisely the region of the Treasury yield curve that responded the most to Operation Twist. Nevertheless, the response of corporate bonds to Operation Twist appears to have been quite modest, no more than 1 or 2bp in response to any single announcement, and no more than 2 to 4bp cumulatively (although many of these responses are statistically significant). The cumulative response of Aaa corporate bonds to Operation Twist, at 4bp, is both larger and more significant than the response of the Baa bonds, consistent with Aaa bonds being closer substitutes to long-term U.S. Treasuries. But even the 4bp fall in Aaa bond yields is far less than the 13–14bp drop in Agency yields.

5.1 Discussion

The observation that corporate bonds responded less to Operation Twist than did Agencies and Treasuries is in line with a similar finding by Krishnamurthy and Vissing-Jorgensen (2011) for QE2. There are two main interpretations of this observation. First, it could be that the Moody's Aaa and Baa corporate bond indexes are simply very slow to respond to news and require even more than two days to respond to each of the Operation Twist announcements in our sample. For example, if each of the bonds in the Moody's index were illiquid, and the bond indexes themselves were based on transaction prices, then it could take the Aaa and Baa indexes several days to fully respond to news, depending on the liquidity of the underlying bonds. Alternatively, one could argue that the purchases of long-term Treasury securities in Operation Twist primarily affected long-term Treasury yields, and

spilled over to other markets only to the extent that the securities in those markets were substitutes for long-term Treasuries. If corporate bonds are not very good substitutes for long-term Treasuries, then the spillovers from Operation Twist to even the highest-quality corporate bond markets could have been quite small.

There are a few reasons to be suspicious of an explanation that relies entirely on illiquidity. First, bond yield quotations in the newspapers and in *Moody's Bond Survey* are not transactions prices but rather quotes based on the bid and offer prices of dealers who make a market for each given bond (e.g., the quoted yield is often the midpoint of the bid and offer). Thus, even if no transactions for a particular bond take place, one should still see the quoted yield respond to news as the dealer's bid and offer prices respond. One would think that two days would be a sufficiently long time for dealers to adjust their stated bids and offers.

Second, if Moody's Aaa and Baa indexes were slow to respond to news, then one would expect daily changes in those bond indexes to be positively serially correlated. In fact, the serial correlation of daily changes in Moody's Aaa and Baa indexes in 1962 are $-.09$ and $-.06$, respectively, and are not statistically significant, which is inconsistent with the view that those indexes systematically under-responded to news.[52]

Third, Krishnamurthy and Vissing-Jorgensen (2011) observe the same phenomenon for QE2 that we find for Operation Twist. To the extent that U.S. corporate bond markets have become thicker and more liquid over time, we would expect Moody's corporate bond indexes to behave more like Agency and Treasury yields during QE2. In fact, Gagnon et al. (2011) find that corporate bonds did respond by an amount closer to Agencies and Treasuries during QE1.[53] Thus, the fact that KVJ's estimates for QE2 agree with those in the present paper suggests that low corporate bond liquidity is not by itself a sufficient explanation.

In contrast, the hypothesis that Operation Twist (and QE2) had smaller effects on securities that were less substitutable for long-term Treasuries can potentially explain all of the results in the present paper, and in KVJ. Long-term Treasury yields responded the most

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[52] The serial correlation of Treasury yield changes was also about zero in 1962. The lower standard deviation of Moody's indexes relative to Treasuries does not necessarily imply that the yields diverge over time. In 1962, both Treasury yields and Moody's indexes declined by about 20bp, so the average daily yield change was about the same, but the volatility of the Moody's indexes around that average was lower.

[53] Gagnon et al. (2011) find a cumulative 10-year Treasury response of 91bp to their five baseline QE1 events, while 10-year Agency bonds fell 156bp and Moody's corporate Baa index fell 67bp.

to the program. Long-term Agency debt, which is very similar to long-term Treasury debt in many respects, also seems to have had a large response. Aaa corporate bonds responded less, and Baa bonds even less than Aaa bonds.

Under this interpretation, QE1 could have had a larger impact on corporate debt than did QE2 or Operation Twist, for two main reasons. First, almost $1.3 trillion of the assets purchased in QE1 were mortgage-backed securities rather than Treasuries; since the MBS market is more similar to private-sector borrowing markets, those private-sector markets may have experienced larger effects during QE1 simply because they were closer substitutes to the securities actually being purchased. Second, QE1 took place during a time of severe financial and economic stress, and the program may have been perceived by markets as substantially diminishing the probability of a second Great Depression, which could have been associated with widespread defaults by Baa- and even Aaa-rated corporations. If the markets viewed QE1 as markedly reducing the probability of investment-grade corporate bond defaults, then we would expect to see corporate bond yields fall more significantly.

This is not to say that low liquidity is necessarily unrelated to the small estimated response of corporate bond yields to Operation Twist. The unconditional standard deviation of those bond indexes in 1962 is surprisingly small, and their standard deviation has steadily increased relative to the 10-year Treasury yield over time.[54] But the evidence presented above suggests that there are features of the data that are not well explained by liquidity alone. Meanwhile, the fact that Baa- and even Aaa- rated corporate bonds are imperfect substitutes for Treasuries is consistent with all of our observations.

6. Conclusions

For more than forty years, the conventional wisdom regarding Operation Twist has been driven by the results of low-frequency time series studies, particularly Modigliani and Sutch (1966, 1967). However, there are inherent problems with these lower-frequency methods, such as unobserved expectations variables, large standard errors, and particularly endogeneity,

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[54] In 1962, the daily standard deviation of the Aaa and Baa indexes was about one-third the daily standard deviation of the 10-year Treasury yield (Table 4). In 1986—the first year Moody's daily data are available electronically—the relative standard deviation was 0.5. By the late 1990s, it had risen to 0.8, and by the late 2000s, it was up to 1.0.

which would occur if the Federal Reserve increased its purchases of longer-term Treasury securities in response to upward pressure on longer-term interest rates.

The present paper has reexamined Operation Twist using a modern high-frequency event-study approach, which avoids the problems with lower-frequency methods discussed above. In contrast to Modigliani and Sutch, we find that Operation Twist had a highly statistically significant impact on longer-term Treasury yields. However, consistent with those authors, we find that the size of the effect was moderate, amounting to about 15 basis points. This estimate is also consistent with the lower end of the range of estimates of Treasury supply effects in the literature.

Operation Twist appears to have had diminishing effects as one considers securities that are increasingly different from long-term Treasuries. To some extent, this may reflect a slower response of non-Treasury securities to Operation Twist announcements, but low liquidity alone seems insufficient to explain all the features of the data. Part of the difference in responses may simply reflect that Treasury purchases have the greatest effect on the Treasury market itself, and only affect other markets to the extent that the securities in those markets are substitutes for Treasuries.

Because Operation Twist and QE2 are similar in many important respects, it seems reasonable to expect the effects of QE2 to be similar to Operation Twist, with an effect on longer-term Treasury yields of about 15bp and an effect on Aaa- and Baa-rated corporate bonds of only a few basis points. Thus, if the goal of quantitative programs such as QE2 is to reduce private sector borrowing rates, purchases of Treasury securities may not be the most effective means of attaining that goal. Instead, purchases of mortgage-backed securities, or other securities with more similarity to private borrowing instruments, may reduce private sector borrowing rates more substantially and ultimately have a greater effect on macroeconomic variables.

Finally, the benefits of these programs in terms of lower interest rates must be weighed against their costs to assess their overall desirability. Although we have not attempted to estimate the costs of Operation Twist or QE2 here, those costs are as important as the benefits for policy analysis, and thus future work on the nature and size of such costs would be welcome.

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