The 1932 Federal Reserve Open Market Purchases as a Precedent for Quantitative Easing

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Abstract

The $1 billion open market operation conducted by the Federal Reserve, at the height of the Great Depression, was a successful precedent to the recent QE programs. The 1932 program entailed large purchases of medium- and long-term securities over a four-month period. An event study analysis indicates that the program dramatically lowered medium- and long-term Treasury yields. A segmented markets model is used to analyze the effects of the open-market purchases on the economy. A significant degree of financial market segmentation is estimated, and partly explains the observed upturn in output growth. Had the Federal Reserve continued its operations and used the announcement strategy used in QE1, the Great Contraction could have been attenuated earlier. Our historical analysis suggests that the Federal Reserve in 2008 had a good predecessor to its actions.

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How effective are targeted open market purchases in invigorating the economy during a severe downturn? If they have stimulatory effects, can a credible central bank boost their impact by using forward guidance, an unconventional tool of monetary policy? During the financial crisis of 2007-09 in the United States, and the continuing recessionary trends in Europe and Japan, one of the key strategies of central banks has been to purchase specific maturities of government debt, while at the zero lower bound. For instance, in the first Quantitative Easing (QE) program, the Federal Reserve purchased $300 billion in long-term Treasury securities, and this purchase program was expanded in the successive QE programs. To examine the impact of the QE purchase programs, the most prominent approach has been to estimate the effect of the programs on the term structure of different types of yields; an expanding literature has examined the effect on Treasury yields[3]. However, there has been considerable debate about the effect of these purchases on the economy[4]. There are two main challenges in estimating the effects of the open market purchases during the QE1 program: first, the decline in the state of the economy during the financial crisis period was unprecedented, and the effects of the monetary policy intervention were complicated by the freezing up of credit markets; and second, there were several unconventional monetary policy tools deployed in the QE1 program: forward guidance which provided guidelines about the size and length of the programs, the presence of the zero-lower bound and the payment of interest rate on excess reserves.

In this paper, we use a new historical perspective to analyze the effectiveness of the central bank's targeted bond purchases during an economic crisis, by considering the largest open-market operation conducted by the Federal Reserve during the Great Depression of 1929 to 1933. After three years of severe recession, in the face of Congressional pressure, the Federal Reserve undertook a significant open market purchase operation between April and August 1932, in which it bought $1 billion of medium term securities ($16 billion in today's prices).

[3] Swanson (2011), Krishnamurthy and Vissing-Jorgensen (2011).

[4] Recent work by Greenlaw et al. (2018) finds that the Long Security Asset Purchases undertaken during the 2007 crisis had modest effects.

At approximately 2% of 1932 GNP, this was comparable to the open market purchases announced during the first QE operation. The New York Times noted, "By entering upon a policy of controlled credit expansion, designed to turn the deflation in bank credit and to stimulate a rise in prices, the Federal Reserve System has undertaken the boldest of all central bank efforts to combat the depression."[5] Although the operation has been noted by previous studies, it has been overlooked by much of the literature commenting on monetary policy in the Great Depression.

Our event study analysis reveals that the purchase operation had large and substantial effects of Treasury yields. This is despite the fact that the 1932 program was not announced by the Federal Reserve[6], focused only on buying medium-term Treasury securities, and provided no indication of how long the program would last. Friedman and Schwartz (1963) also note that during the second quarter of 1932, the economy experienced an uptick in output growth. This was precisely the period during which the Fed's open market purchases were being ramped up, and these authors posit that if the Fed had continued with its program, the economic recovery could have been much faster. We investigate this hypothesis using our modeling framework which suggests that the effects of the program on the real economy can be explained by the large degree of financial segmentation during the 1932 period. The main counterfactual suggests that had the program lasted for longer, and been credibly communicated to the public in advance, the decline in economic activity could have been attenuated sooner. We posit that the structure and design of the QE1 program circumvented many of the shortcomings of the 1932 program. The provision of forward guidance to financial markets, the size of the purchase operation, and the wider scope of assets being purchased were designed to boost real economic activity in a substantial way in 2008.

Using the 1932 operation to inform the debate about the effectiveness of the open market purchases undertaken during QE1 is only valid to the extent that economic conditions were comparable at the time of the two operations. As we show below, the states of the economy

[5] The *New York Times*, quoted in the *Commerical and Financial Chronicle*, April 16, 1932, p. 2774.
[6] The balance sheet of the Federal Reserve was also much smaller.

during the 1932 operation, and the first QE program were, in fact, quite similar in terms of key macroeconomic and financial terms. There were also political similarities: at the time of the 1932 operation, the Congress and the public were desperate for active intervention by the central bank. In 2008, there was widespread discussion among the public about the need for intervention by the Federal Reserve[7]. Therefore, we propose to use the 1932 operation to provide a historical perspective for examining the effectiveness of the QE1 open market purchases, and the importance of using forward guidance. In this analysis, we will only consider the first QE program, as the successive programs were anticipated to some degree by financial market participants.

A brief overview of our methodology and findings follows: we first analyze the effect of the operation on the cross section of Treasury yields using an event study methodology. Since there were no announcements, we construct a narrative record of the period preceding and during the operation. Around the dates identified from the narrative record, there were significant changes in the yields on Treasury securities. For instance, the maximum cumulative effect from the daily changes on Treasury Bills was a decline of 90 basis points (b.p.); Certificates and Notes yields fell by 114 b.p. and the yields on Bonds fell by 42 b.p. Therefore, even though the purchase program was motivated by the economic and political conditions of a very different era, the program had important effects on the term structure of Treasury yields.

The event study analysis is very informative about the effects of the purchase program on the yield curve. In the quarter that the Fed's purchases were being conducted, there was also the first uptick in output growth that the economy had seen in several quarters; between the second and third quarters of 1932, output growth rose by 0.38% after several quarters of negative growth rates. Therefore, we are interested in examining whether the Fed's purchases could have had the stimulative effects on output, and we use a modeling framework for this purpose. We use quarterly data from 1920-32 to estimate the effects of the

[7] There was comprehensive coverage in various news publications. An example of this: "As Credit Crisis Spiraled, Alarm Led to Action", New York Times, October 1, 2008.

open market operation in a general equilibrium model with segmented markets. Anecdotal evidence suggests that there was a significant degree of market segmentation in the 1930s as the non bank public had limited access to the government securities markets which was dominated by a few investment banks (Garbade, 2012; Perkins, 1999). As we show below, the denomination of Bonds issued may have precluded large sections of households from accessing them[8].

The main hypothesis of the model is that there are two types of financial market participants: households can hold both long- and short-term Treasury securities; however, they are required to pay a transactions cost to hold the long bonds. The institutional investors, on the other hand, only hold long-term assets, without paying any costs. Since private domestic households had limited access to long-term bonds during the 1920s and 1930s, we find this to be a plausible way to model their holdings of Treasury securities. Using data to estimate the degree of segmentation, we find that it was much higher for 1920-32 than for 2008-2009; thus, agents were not able to readily substitute between the different types of Treasury securities (as they would have without any frictions). The purchases of long-term securities by the central bank in this model then affects the long-term yield, and consequently, the savings and consumption decisions of households. Thus, the open market operation in 1932 was effective in lowering Treasury yields and boosting output growth, even though it lasted less than two quarters. In our benchmark simulation, as a result of the Fed's purchases, we generate 19% of the increase in output growth that was observed. Our model does not model the many banking suspensions that occurred (and were a key feature of the Great Depression), that the Fed's provision of liquidity would have prevented. Thus, we posit that our estimates are a lower bound of the effects of the Fed's purchase operation on the economy.

[8] Additionally, as reported by Banking and Monetary Statistics (1914-1941), discount rates of different Federal Reserve districts varied for the same time period, providing further evidence of market segmentation. The disparity was as much as between 50 and 150 basis points (for example, in December 1930, the discount rate reported in New York was 2%, and San Francisco it was 3.5%; Banking and Monetary Statistics of the Federal Reserve, 1914-1941, Table 115, pp. 441). The difference in rates was also evident in other types of loans. For instance, in December 1930, the rate charged on commercial loans by banks was 3.82% in New York, 4.38% in seven other Northeastern cities and 5.01% in eleven Southern and Western cities (Banking and Monetary Statistics of the Federal Reserve, 1914-1941, Table 125, pp. 464).

In our counterfactual simulation, we ask the following question: holding the size of the operation constant, if the Federal Reserve had carried out the operation for a longer duration, and announced the full length of the program, what would the effects be? Our results indicate that the impact on output growth and long-term yields could have been significantly larger; our estimates indicate that the recovery in output could have been as much as 30% larger than what was actually observed. This supports the Friedman and Schwartz (1963) hypothesis that if the Federal Reserve had continued its operation, the continued decline in the economy could have been attenuated much faster.

Finally, this study contributes to the literature on not only on unconventional QE policy, but also on the Great Depression by addressing another counterfactual question: could the U.S. have rebounded from the Great Depression had the Fed conducted QE on a scale and in a way that it did in the Great Recession? Using our model simulations, we find that if the Fed in 1932 had used a QE1-sized operation, the effect on output growth would have been approximately twice as large as was generated by the actual Fed operation undertaken in 1932.

The paper is organized as follows: the context and implementation of the 1932 operation are discussed in section 1. Narrative evidence and the event study methodology is discussed in section 2. Section 3 presents the model and the results, and section 4 concludes.

1 Context for the 1932 Operation

We discuss here the institutional characteristics that were in place for the 1932 operation, as well as the comparisons with QE1 policy. The channel through which the 1932 operation is hypothesized to affect the real economy, namely the portfolio balance channel, is analyzed below as well.

1.1 General Economic Conditions and the Start of the Program

Before discussing the institutional context for the 1932 operation, it is useful to provide an overview of the economic conditions in 1932. To the extent that the historical program can prove informative for the QE1 debate, we compare key macroeconomic statistics between the two periods. The unemployment rate in April 1932 was 21.0%, and it had risen to 25.0% in August 1932[9]. In the 2008-09 episode, the unemployment numbers were also rising, from 6.8% in November 2008 to 8.7% in March 2009. Real GDP had declined by more than 20% in 1932 since the start of the Great Depression, and in December 2008, real GDP in the U.S. had fallen by approximately 4% since December 2007. Table 1 shows the comparison between the periods on two dimensions - the states of the economy, as well as the size of the Federal Reserve programs.[10] An overview of the Federal Reserve's purchases, and economic conditions are shown in figures 1 through 4.

Other than the depressed states of output and employment, Treasury yields were at historically low levels in 1932, as they were in 2008. Cecchetti (1988) estimates the term structure of Treasury yields from 1929 to 1949 using raw data on the prices of Treasury securities outstanding reported in the New York Times. Using the Nelson and Siegel (1985) methodology, Cecchetti shows that between May and October 1932 (at the time of the Federal Reserve operation), the three-month yields were between 10 and 25 basis points.[11]

The Federal Reserve began its massive (for the time) open market purchases in April 1932. This was after two and a half years of recession in which the Fed had followed a very passive policy, and had failed to prevent three banking panics. Friedman and Schwartz (1963) attribute the Fed's failure to act to serious flaws in the organization of the System which impeded coordination between the Reserve banks and the Federal Reserve Board in

[9] Unemployment data from NBER, Unemployment Rate for United States [M0892AUSM156SNBR], retrieved from FRED, Federal Reserve Bank of St. Louis.

[10] While the macroeconomic trends were similar during the two episodes, they were substantially worse in 1932: GDP had been declining for more than eight quarters and unemployment had been hovering around 20%.

[11] The three-month yield remained in this approximate range in the remaining period of Cecchetti's study.

Washington DC, especially after the death of Benjamin Strong in 1928. Meltzer (2003) largely attributes it to adherence to a flawed policy doctrine - the Burgess Rieffler Strong doctrine (a variant of the real bills doctrine) that relied on nominal interest rates and the level of discount window borrowing as policy guides. Others attribute it to adherence to the gold standard and the absence of a clear lender of last resort policy (Bordo and Wheelock 2013).

According to Friedman and Schwartz,[12] the Fed, under the leadership of Governor Harrison of the New York Federal Reserve voted to begin purchases of government securities on April 13, 1932 in the amount of $100 million per week for 5 weeks. Then on May 17, another $500 million was voted on.

Friedman and Schwartz argue that the Fed adopted this dramatic change in policy to forestall several radical pieces of legislation in the Congress including the Thomas bill which would have created $2.4 billion dollars in greenbacks and a veterans bonus. Meltzer (pp. 360) posits that the open market purchases would have been consistent with the Burgess Rieffler Strong doctrine since member bank borrowing was high as were short-term interest rates. He also states that the passage of the Glass Steagall Act of 1932 and the beginning of Reconstruction Finance lending to troubled banks in February encouraged the Fed to act.[13] However, we note that in the first year of its operation, the effects of Reconstruction Finance were very limited, and only became more effective after the Emergency Banking Act of 1933 was passed (Mason and Mitchener, 2010). Thus, the Fed's 1932 operation was the most significant intervention at the time which was affecting Treasury yields.

The policy was short lived. By July 1932 mounting opposition within the Federal Reserve System to continued purchases overwhelmed Harrison's pleas to continue. Many Fed officials, following real bills thinking, were worried that continued purchases would be inflationary and

[12] See pps 385-389.

[13] The Glass-Steagall Act of 1932 allowed the Fed to rediscount from member banks using government securities as collateral. This alleviated the "free gold" constraint, which in 1930 and 1931 had constrained the willingness of the Fed to conduct expansionary policy (Meltzer, 2003 and Bordo, Choudhri and Schwartz, 2002).

would stimulate an asset boom. They believed that the purchases had not encouraged the banks to lend as intended but instead they were just accumulating as excess reserves (Hetzel 2012 p.31).[14] Others worried that further purchases would severely reduce the System's holding of free gold and threaten the U.S. adherence to the gold standard. When the Congress recessed for the summer in July, the Fed stopped the program.

Some of the institutional background and consequences of the 1932 open market operation for the economy have been explored elsewhere in the literature. Friedman and Schwartz (1963) highlighted the 1932 operation as the best policy the Federal Reserve undertook in combating the economic slump. Meltzer (2003) discusses the economic and political context of the operation. Both Friedman and Schwartz and Meltzer provide evidence that the expansionary policy led to a turnaround in the economy[15]. They posit that had the Fed continued the policy that the Great Depression would have ended significantly earlier than it did. Hsieh and Romer (2006) examine the effects of the operation on expectations of devaluation, and whether the Fed could have continued the operation without a loss of credibility and commitment to the gold standard. Bordo, Choudhri and Schwartz (2002) argue that since the United States was a large open economy in 1932, and had vast gold reserves, the expansionary open market operations would not have caused an outflow of gold, even under the extreme assumption of perfect capital mobility. However, to our knowledge, this is the first paper to analyze the effects of the purchase operation on the full term structure of daily yields and on the real economy in terms of output growth. We also provide estimates of the effects on corporate bond price changes.[16]

[14]Starting in February 1932, banks began reducing their borrowed reserves and increasing their excess reserves which grew from $44 million to $526 million in December 1932. Given that the banks had just experienced two years of liquidity panics, the build up of excess reserves was understandable (Hetzel 2012 p 31.).

[15]M2 stopped declining and flattened out; Federal Reserve Credit picked up as did bank credit. Industrial production and real GDP began expanding after a lag. Interest rates reversed their rise and dropped precipitously. See Bordo 2013.

[16]Some other recent analyses compare the Fed's operations in the recent financial crisis with the historical period pre-war period. For example, Carlson and Duygan-Bump (2018) compare the Fed's operations in the 1920s (1923-29) with those undertaken in the 2007.

1.2 Institutional Context of the Operation

Our main hypothesis is that the 1932 operation provides a unique historical perspective for examining the open market purchases of the first Quantitative Easing program. Before undertaking the analysis, we identify the key similarities between the two episodes, as well as discuss the implications of the main differences in the institutional setups.

Both episodes were conducted in the midst of severely depressed economic activity. These were large scale open market operations, and the magnitude of the bond purchase programs were unprecedented relative to past bond purchase programs in both cases. The programs were initiated to boost the economy, and were not planned to continue indefinitely.

The key institutional differences between the implementation of the two programs were: (a) the operation of the Gold Standard in 1932 instead of a floating exchange rate, (b) the announcement of the size and duration of the program during the first QE episode in 2008-2009 and (c) the use of other unconventional policy tools in 2008-2009. While these aspects were important, we hypothesize that they do not make the comparison between the 1932 and 2008-2009 operations invalid.

The U.S. remained on the Gold Standard throughout the operation of the bond buying program, but there was considerable concern among Federal Reserve officials that the bond purchases would affect the commitment of the Fed to the Gold Standard. However, the program did not threaten the credibility of the Federal Reserve or cause expectations of a devaluation. According to Bordo, Choudhri and Schwartz (2002), since the U.S. was a large open economy, with vast gold reserves, the expansionary monetary program would not cause markets to question the Federal Reserve's commitment to the Gold Standard. Hsieh and Romer (2006) find that there were no significant expectations of devaluation of the U.S. dollar (as measured by forward and spot exchange rates) in the spring of 1932. Thus, although there was disagreement among the Federal Reserve officials about the conduct of the program, it did not cause the Fed to lose any credibility in terms of its commitment to the Gold Standard.

The second difference between the programs is the provision of forward guidance in 2008-2009. While the size of the bond purchases was discussed in the Open Market Policy Conference (the precursor of the Federal Open Markets Committee), these discussions were not made public. Thus, the size and duration of the program was not publicly announced. However, it did not go completely unnoticed. We construct a narrative record using reports from the New York Times (section 2) which indicates that financial markets were aware of the program, as well as its potential implications for liquidity in the system and the economy. Hsieh and Romer (2006) also discuss narrative accounts from different news sources, which reported the weekly balance sheet of the Federal Reserve. They find that business analysts were able to discern that the Federal Reserve was buying bonds at an accelerated pace, and that this program could help in stemming the deflationary spiral. Thus, financial markets understood that the program was ongoing in the second quarter of 1932. Although the press was aware of the Fed's actions in 1932, because the Fed did not attempt to directly shape public expectations or make commitments about future interest rates, interest rates in 1932 were not also affected by forward guidance. This is in contrast to the QE undertaken during and after 2008-2009.

Finally, the recent QE1 operation included the purchase of other assets (mortgage-backed securities). The Federal Reserve was also transitioning to the payment of an interest rate on excess reserves held by banks in 2008. Neither of these aspects were present during the Fed's 1932 operation. We are, therefore, only analyzing the Treasury bond-buying purchase programs of the Fed in 1932, and the effects of these operations on the economy.

1.3 Portfolio Balance Channel for the Effects of the 1932 Operation

The primary channel through which the 1932 open market purchases by the Federal Reserve are hypothesized to affect the economy is the portfolio balance channel. The main thesis of the channel is that assets of different maturities are not perfect substitutes. The portfolio balance channel for a similar era (1934-39) has been investigated by Hanes (2019). He shows how the rapid trend high-powered money growth between 1934 through December 1936 was accompanied by substantial declines in medium- and long-term nominal yields, consistent with a portfolio effect of high-powered money growth on term premiums. Gagnon et. al. (2011) and Bauer and Rudebusch (2014) note, in the context of the QE operations, that the purchases of medium- and long-term securities by the Federal Reserve altered the supply of these bonds available to these private investors. As the holdings of the risk-free short-term bank reserves by the private investors increased, the yields on the bonds being purchased by the Federal Reserve would fall, to ensure that private investors are willing to make an adjustment in their holdings. Thus, the term premia (the largest component of risk premia) will be lowered, as the assets of longer duration are removed from the supply available to private investors. In contrast, in a frictionless asset pricing model, a change in the supply of long-term or short-term bonds will not have an effect on Treasury bond yields. In this case, the term premia will be a function of the riskiness of the bonds, and the risk aversion of investors. Both these characteristics are unaffected by changes in the supply of bonds.

In order to examine the operation of the portfolio balance channel in the 1932 episode, we first analyze the holdings of U.S. Treasury bills, notes and bonds by the Federal Reserve, as a fraction of its total holdings. As figure 3 shows, the fraction of the Federal Reserve's holdings of U.S. Treasury Notes increased from 10% of total holdings to more than 20%, between April and August 1932. The fraction of Bill holdings stayed fairly constant, fluctuating between 54% and 63%, and the fraction of Bond holdings *decreased* from 36% to 23%. Therefore, the largest change in the Federal Reserve's portfolio during this operation was an increase in the fraction of Note holdings. In contrast, during the 2008-2009 episode, the Federal Reserve's holdings of Notes (with 1 to 5 years to maturity), as a percentage of its total holdings, increased from 36% to 39% approximately. The fraction of Bond holdings (with maturity 15 years or more) increased from 20% to 21% between July 2008 and March 2009. Thus, the operation by the Federal Reserve in 1932 was more significant on the medium-term securities, relative to the long-term operation, unlike the more recent 2008 operation. Both operations caused a compositional difference in the Fed's portfolio of securities.[17]

2 Evidence from the Narrative Record and Event Study

In this section, we first present the evidence from the narrative record, and then examine the effects on Treasury yields.

2.1 Narrative Evidence

Our strategy for estimating the effects of the Federal Reserve's actions on yields is similar to the analyses of QE1 by Krishnamurthy and Vissing-Jorgensen (2011) and Swanson (2011): we estimate the changes in Treasury yields around announcements by the Federal Reserve. In the case of the 1932 operation, no public announcements were made by the Federal Reserve regarding these purchases. Therefore, we construct the narrative record of the period preceding and during the purchase operations from the New York Times. The results of the event study methodology suggest that the 1932 operation had a significant effect on yields.These are reports from the New York Times, in the section "Topics in Wall Street: News, Comment and Incidents on the Stock Exchange and In the Financial Markets".[18] On each of the following dates, there was some new information or speculation being reported about the open-market purchase program.

[17] To analyze the changes in the overall supply of these Treasury securities to the rest of the economy, it is also useful to consider the holdings of the Federal Reserve as a fraction of the total marketable debt outstanding from the Treasury. In the 1932 operation, the Fed's holdings of Treasury Notes averaged 13% of the total marketable debt issued in Notes, and Bond holdings were approximately 7% of the total debt issued in Bonds. We also find that the Treasury was issuing more debt than before in the Great Depression: between December 1930 and December 1932, the issuances of notes and bonds increased by approximately 41% and 17.5% respectively. In contrast, in the 2008-09 episode, the Fed's holdings of Notes and Bonds were 6% and 33% of the total. Thus, the Federal Reserve's holdings of Bonds during the latter episode were more than four times its holdings in the 1932 operation. These numbers are based on the bills, notes and bonds issued as public debt, recorded in the Statement of Monthly Statement of Public Debt obtained from Treasury Direct.

[18] We also read the "Bond Market Comment" section published in the Wall Street Journal to corroborate the narrative record from the New York Times.

Even before the Federal Reserve began its operations, the media began to note a change in the inclinations of financial markets and the Federal Reserve towards conducting open market operations. On February 17, 1932, the Times reported:

> There is much conjecture in Wall Street whether the Federal Reserve authorities will utilize the excess reserves, to be liberated by the Glass-Steagall bill [...], to increase their holdings of "governments."

About two weeks later, on February 28, 1932, the Times noted the willingness of the Federal Reserve to carry out a credit expansion program, which was initiated by a change in the bank rate:

> Now that the Federal Reserve has given unmistakable signs, by the reduction of the New York bank rate of its intentions to relax credit, the chief interest of the financial community is centered upon speculating as to how far the central banking system is likely to go. [...] Under present conditions, open market buying of government securities appears to be the only effective means whereby the Federal Reserve can pump out credit.

On March 11, 1932, the first inklings of a purchase operation by the Federal Reserve were observed, and it was considered to be encouraging news for financial markets:

> The open market operations to expand credit, begun a week ago, were pursued with increased vigor. Holdings of United States Government securities rose [...].

By April 1, 1932, the increases in the Federal Reserve holdings of government securities were noted to be the highest on record,

> The week's bank report displayed the same trend in evidence since the end of February. Holdings of United States Government securities rose $36,620,000 to $871,618,000, the largest on record.

and on April 8, 1932, the Times reported that

> The weekly Federal Reserve statement shows no let-up in the open-market purchases of government securities [...]. The Reserve System has been adding to its holdings of United States securities at the rate of $25,000,000 a week since the end of February.

Despite the purchases being conducted by the Federal Reserve, there was a growing momentum among financial markets that a larger open market operation was needed, as noted on April 13, 1932:

> The Federal Reserve system has been engaged [...] in an easy-money campaign carried out through the medium of purchases of United States Government securities [...]. The question has arisen, accordingly, whether the time is not now ripe for the Federal Reserve to enlarge its campaign by stepping up the rate of weekly purchases of "governments" to say $75,000,000.

On April 14, 1932, the Times noted the rise in projected purchases of the Federal Reserve,

> [T]here was evident in banking circles yesterday marked hopefulness for the outcome of the effort newly undertaken by the Federal Reserve System. [...] The Federal Reserve's projected purchases of "governments" at a rate as high as $100,000,000 a week [...].

and on April 15, 1932, the balance sheet of the Federal Reserve was noted to rise to a high record:

> Interest in the weekly bank statement converged upon the single item of United States Government securities which showed a rise of $100,010,000, lifting the system's holdings to a high record at $985,024,000.

While there were concerns about "...whether the banks, under the pressure of mounting excess reserves, can be persuaded to forego their passion for liquidity above all else"[19], the

[19] April 16, 1932, New York Times.

change in loans and investments was considered encouraging. On April 22, 1932, the Times noted that the decline in loans and investments had been stemmed.

In the remaining weeks of April 1932, and in early May 1932, the financial markets were reported to fully support the purchase operation. Starting in the second week of June 1932, financial markets begin to note the slackening in the Federal Reserve's purchases, and by mid July 1932, the easy-money policy of the Federal Reserve was perceived to be coming to an end[20]. By August 13, 1932, the Times reported that "...there appears to be no further need for continued purchases of United States Government securities by the Federal Reserve Banks.". On August 19, 1932, the purchase operation was considered to be at an end:

> Open market purchases of United States Government securities by the Federal Reserve Banks, which had been an uninterrupted weekly occurrence since Feb. 24, came to the expected end this week. [...] The current holdings' of $1,851,000,000 are $1,110,000,000 above where they stood when the passage of the Glass Steagall bill gave the signal for the start of the credit expansion program.

The narrative record indicates that although there were no specific announcement effects, financial markets were aware of the purchase program being conducted. The markets also perceived (to some degree) that the program was being used by the Federal Reserve to deal with deflation.

Given the above discussion, we identify eight dates from the narrative record, regarding the start of the open market operation in 1932: February 17^{th} and 28^{th}, March 11^{th}, April 1^{st}, 8^{th}, 13^{th}, 14^{th} and 15^{th}. The effects of the reports in August, about the end of the

[20] On July 19, 1932, the Times reported: "The adjournment of Congress has recalled the prediction in some quarters that when this event occurred the Federal Reserve System would terminate its policy of keeping money easy through the purchase of United States Government securities. There are indications that this may prove to be the case. It is generally admitted that it has been rather difficult to persuade bankers outside of large money centres that any great benefit can accrue from such a policy. Since early in April the System has increased its holdings of government securities by $936,000,000, of which $310,444,000 has been bought by the New York Reserve Bank and the remainder by the eleven other regional banks."

program, are considered separately. The event study methodology below uses these dates to estimate the effects of the operation on the term structure of yields.

2.2 Effects of the 1932 Operation: Event Study Methodology

We use the event study methodology to examine the effects of the Federal Reserve operations on the term structure of Treasury yields and corporate bond prices. To our knowledge, the 1932 operation has not been analyzed from this perspective before. We conduct the analysis at a daily frequency. Studies such as Gagnon et al. (2011) and Swanson (2011) determine key dates on which the Federal Reserve announcements were made, and examine the effect on yields in one- and two-day windows around the announcements. These dates correspond to announcements about the size of the program, and explicit indications about the Federal Reserve's expectations about how long the operation would continue. However, in the 1932 episode, there was no equivalent forward guidance about the program, its size or the duration from the Federal Reserve. Therefore, to analyze the effects of the operation, we use the dates from the narrative record about the purchase operation.

To conduct the analysis, we construct the series on yields on Treasury bills, notes and certificates and bonds reported in daily newspapers. The first two series are obtained from the Wall Street Journal, and the bond yields are taken from the New York Times. During the course of the operation, the maturity of these Treasury assets were as follows: bills were of 3-month maturity, most of the certificates of indebtedness issued were of 1-year maturity, Treasury notes were for a 4-5 year maturity and the maturity of the bonds ranged from 18 to 30 years[21].

One-day changes in the yields on these assets, around the dates from the narrative record identified above, are presented in tables 2, 3 and 4. These changes are the differences between the closing yields reported for the respective securities the trading day before the news report, and the day of the report. The cumulative decline in Treasury Bills ranged from 20 to 90 basis

[21] This data is obtained from the Monthly Statement of Public Debt.

points[22]. For Treasury Certificates and Notes, the decline in yields ranged from 79 to 114 basis points; for Treasury bonds, the cumulative decline ranged from 24 to 42 basis points. For the securities considered here, the majority of the changes in yields are concentrated around the April dates.

To further understand the importance of the narrative dates, we compute the daily changes in yields over the mid-February to mid-April period, as well as the changes in yields around the release of the balance sheets of the Federal Reserve. These balance sheets became available to financial markets on Thursdays, and we compute the yield changes between the end-of-day yields on Thursday, and those on Wednesday. These changes are shown in tables 5-7. The yield changes around the narrative dates account for approximately 47% (58%) of the decline in yields on notes and certificates[23] (bonds) over this period. Once the changes around the balance sheets are excluded, the narrative record still accounts for 42% of the yield changes for notes and certificates, and 26% of the change in bonds.

An additional concern that we address is the following: was the reporting on the actions of the Federal Reserve driven by large changes in yields? Or were the yield changes in response to the newspaper reports? To examine this, we first identify the dates on which the daily changes in yields exceeded 5 b.p. (in either direction), for two or more of the series being considered, for each asset. Then we examine if there were any reports in the New York Times or the Wall Street Journal around these dates. The most frequent movement in yields is found for Treasury notes and certificates. Between mid-February and mid-April, there are 24 dates on which the yields changed by ± 5 b.p.[24]; of these dates only 5 dates coincide with any report of the Federal Reserve purchases. Thus, we conclude that the narrative dates identified above are dates of true news.

Finally, we examine the August dates, which reported the end of the program. In terms of the Federal Reserve's balance sheet, holdings of bills began to decline, and by September

[22] For the Bills for which a majority of yields were reported in the newspaper.

[23] We have averaged the changes across the different notes and certificates, as well as for bonds.

[24] These are other than the narrative dates identified above, and dates on which the weekly Federal Reserve balance sheets were released.

21st, the holdings had declined by 2.5% (relative to the levels on August 24th). For notes, the increases in purchases slowed down in the month after August 19th, and by October 19th, the holdings had declined by 7.5%. The holdings of bonds remained largely unchanged in the two months after the August 19th report. The movement in yields around August 13th and 19th are reported in table 8.[25] We note that many of the yields on these securities rose when the end of the operation was reported.

The evidence above suggests that the portfolio composition channel was operating during the 1932 episode. The reduction in supply of medium term securities to the domestic economy, as the holdings of the Bank increased, lowered yields in successive weeks. For the majority of the Certificates and Notes, the cumulative decline in these yields exceeded the decline in the Bill yields.[26]

Our results are qualitatively similar to the analyses of Krishnamurthy and Vissing-Jorgensen (2011) and Swanson (2011). However, we do not conduct a more extended analysis as the one done by Greenlaw, Hamilton, Harrison and West (2018). In this investigation, the authors find the effects of the LSAP operations were much more muted as they expand the scope of dates considered, by using other information sources as well. The tamped-down effects are attributed to factors such as the markets correcting the initial over-reaction and the possibility of the Treasury undercutting the Fed's operations. A similar analysis for the 1932 episode is left to further research.

We note here that while the corporate bond market was important, it experienced a reduction in size and significance during the Great Depression. Thus, in modeling the effects of the Fed's operation on the real economy, we focus on the channel via the holdings of government debt. In the appendix, we discuss the effects of the operations on the corporate

[25] Since the full series of Bills is unavailable, we only report results for Treasury Notes and Bonds.

[26] Other channels may also be applicable. For the more recent QE programs, the signaling channel has been estimated by Bauer and Rudebusch (2014). The authors find that the purchases lowered future expected short term rates. Other channels are also found to operate during the 2008 crisis: D'Amico and King (2013) quantify the magnitudes of the scarcity and duration risk channels. McLaren, Banerjee and Latto (2014) also estimate the supply effects of QE, by considering the effects of the Bank of England's announcements on the remaining stock of gilts in the market. Relatively scarce data availability for the 1932 episode, however, limit our investigation of these other channels.

bond market.

3 Consequences for the Real Economy in 1932

The event study methodology above presents evidence that the two purchase operations had significant effects on Treasury yields. In the present section, we are interested in estimating the effects of the purchase operation on the real economy.

An upturn in economic activity was observed between the second and fourth quarters of 1932. Between 1932 Q2 and Q3, real GNP recovered by 0.38% (on an annual basis) after declining for several straight quarters. This was also the period during which the Federal Reserve operation was conducted. The purpose of the modeling framework is to better understand to what extent the Fed's purchase operation could have affected real output growth and stimulated the economy. The Friedman and Schwartz (1963) and Meltzer (2003) hypotheses are that the Fed's purchases stimulated the economy, and had they lasted longer the upward trend in output growth would have continued. In this section, we use the segmented markets model to understand the recovery in output growth.

Our analysis uses a general equilibrium model, and a number of papers have modeled the Great Depression using general equilibrium. Cole and Ohanian (2004) model the wage bargaining between workers and firms, and generate a slow recovering economy in 1933 resulting from the excessive labor market power of workers. The authors abstract from monetary and financial factors. Eggertsson (2012) reconsiders the impact of the National Industrial Recovery Act (NIRA) in a New Keynesian DSGE model without capital. Nominal rigidities are introduced via Calvo (1983) price setting in wages and prices of intermediate firms, and the zero lower bound is considered in the nominal interest rate path. One of the main results of the analysis is that NIRA raised output in the Great Depression by allowing firms and workers to collude and raise mark-ups. Bordo, Erceg and Evans (2000) and Christiano, Motto and Rostagno (2003) incorporate monetary shocks in DSGE models calibrated for the

Great Depression, and the results confirm the Friedman-Schwartz hypothesis that monetary tightness and banking failures drove Great Depression. In both these analyses, rigidity in wage-setting is central.

The above analyses are mostly successful in simulating the dynamics of macro variables during the Great Depression. The focus of the present analysis is to investigate how the Federal Reserve's purchases of Treasury securities of different maturities would have affected the consumption and savings decisions of optimizing agents. Therefore, in contrast to the above analyses, we incorporate government bonds of different maturities in the budget constraints of the households. The government bonds of different maturities are assumed to be imperfectly substitutable (holding the longer-term bond incurs a transaction cost), and the set of optimizing households are heterogeneous in the assets they hold. We also explicitly model the supply of long-term and short-term bonds by the government, as well as its budget constraint. The presence of segmented asset markets implies that changes in holdings of long- versus short-term debt will have consequences for the real economy.

Our framework is the medium-scale DSGE model of Smets and Wouters (2007) and Christiano, Eichenbaum and Evans (2005), augmented with the segmented markets features of Andrés, López-Salido, Nelson (2004) and Chen, Cúrdia and Ferrero (2012).[27] In our view, this is a plausible way to model the financial markets of the Depression era since several features of the data suggest significant segmentation in these markets. As shown in table 9, the modal denominations of Liberty Bonds was $1000, which was large relative to per capita income[28]. Goldsmith and Lipsey (1963) construct the asset portfolios for different investors in the economy. Non-farm households held very little debt (short- or long-term), and it was held largely by the Finance sector (table 10). These households also had much

[27] The approach of using segmented markets as a channel for analyzing the effects of open-market operations have been widely used in the literature. Occhino (2004) develops a model in which households are permanently excluded from the market in government securities, and he is able to replicate the persistent decrease in money growth and increase in real interest rates following an unexpected increase in the nominal interest rate. Alvarez, Atkeson and Kehoe (2002) introduce endogenous market segmentation by introducing a fixed cost which agents must pay to exchange bonds and money.

[28] Data from the April 1932 Monthly statement of Public Debt indicates that the average maturity of Liberty Bonds (computed as the difference between payable date and date of issue) was 30 years.

smaller holdings of bonds relative to the Finance sector, but they were more heavily invested in stocks. This suggests that a large percentage of the long-term debt was bought, and held by, wealthy investors.

Table 11 shows data from the 1932 Statistics of Income, published by the Internal Revenue Service. The lower-income households report having no income from "interest on government obligations that are not wholly tax-exempt". As reported in this publication, only federal government bonds were categorized as wholly or partially tax-exempt.[29] As noted above, the average maturity of these government bonds was 18-30 years. Therefore, the IRS statistics suggest that the lower income households were not holding long-term federal bonds[30].

Before presenting the model, we provide a brief overview here: we augment a New-Keynesian general equilibrium framework with two types of investors: the households who can trade in an unrestricted way in long and short bonds, and the institutional investors, who only trade in long-term bonds. The unrestricted households are required to pay a transaction cost for every long bond purchased. This transaction cost for long bonds gives rise to a risk premium, which has two components: the first arises because the households face a portfolio adjustment cost (this is modeled as a function of the relative quantity of the short and long bonds), and the second component is an exogenous error. The assumptions of the transactions cost, as well as the heterogeneity among households in holding assets, are both central to our framework. We first present the optimization decisions and policy rules of the households, firms, central bank and the government. In the model simulation, we allow for the short-term interest rate being at the zero-lower bound for several periods, as was observed in the 1932 data. We use the framework to analyze the effects of the purchase operation on the economy, and perform counterfactual analyses.

Our analysis of the open market operations in 1932 is conducted in an economic environment with very low policy interest rates. While we focus on the portfolio composition

[29] This is reported in the Statistics of Income, in the table titled "Estate tax returns of resident decdents, by net estate classes", pg. 50-52. The document was retrieved from the IRS website: https://www.irs.gov/pub/irs-soi/31soirepar.pdf.

[30] We thank Gary Richardson for helping us identify these two measures of asset market segmentation.

effects of the purchase operation, a number of papers have analyzed the transmission effects of open market operations and other monetary policy actions in economies with low interest rates. Bernanke and Reinhart (2004) present an overview of strategies that can be used to stimulate economic activity when interest rates are very low: managing interest rate expectations, changing the composition of the central bank's securities portfolio and expanding the size of the bank's balance sheet. Grossman and Weiss (1983) use a transactions cost based framework to show that open market purchases of bonds lower nominal and real interest rates and lead to a positive response of prices. In the context of Japan, Auerbach and Obstfeld (2005) show how these bond purchases can generate substantial welfare effects by reducing the real value of public debt, and are able to counter deflationary price paths.

3.1 Model

3.1.1 Households

There is a continuum of households of measure one, and households $i \in \{u, r\}$ have identical preferences. Household i consumes C_t^i, and gets disutility from supplying labor L_t^i. These households supply differentiated labor inputs, and the utility for the $i-th$ household is:

$$E_t \sum_{j=0}^{\infty} \beta_i^j b_{t+j}^i \left[\frac{1}{1-\sigma_i} \left(\frac{C_{t+j}^i}{Z_{t+j}} - h \frac{C_{t+j-1}^i}{Z_{t+j-1}} \right)^{1-\sigma_i} - \frac{\varphi_{t+j}^i \left(L_{t+j}^i \left(k \right) \right)^{1+\nu}}{1+\nu} \right]. \tag{1}$$

Here β_i^j is the discount factor of household i, b_t^i is the preference shock, σ_i is the coefficient of relative risk aversion, h is the habit formation parameter, φ_t^i is the labor supply shock and ν is the inverse of the labor supply elasticity.[31]

Households have access to long and short-term bonds. Short-term bonds are one-period, and a security purchased in t pays a return of $R_{s,t}$ in the next period. Following Woodford (2001), long-term bonds are perpetuities, which cost $P_{L,t}$ in time t, and pay exponentially decaying coupon κ^j in time $t+j+1$, for $\kappa \in (0, 1]$.In this case, the gross yield to maturity

[31] Utility is a function of detrended consumption following Chen, Cúrdia and Ferrero (2012), to ensure the existence of a balanced growth path with the CRRA preferences.

is $R_{L,t} = \frac{1}{P_{L,t}} + \kappa$, and the duration of the bond is $\frac{R_{L,t}}{R_{L,t-\kappa}}$[32].

Asset market segmentation is introduced by assuming there are two types of households: households and the institutional investors. Although both these households have identical preferences as shown above, a fraction ω_u of households trade in both short and long term government bonds. These are considered to be "unrestricted". They must, however, pay a transaction cost of ζ_t per unit of the long bond purchased (it costs them $1 + \zeta_t$ dollars per unit, instead of 1 dollar). For these households, short- and long-term bonds are imperfectly substitutable. The remaining investors $1 - \omega_u = \omega_r$ only trade in long term bonds but pay no transaction costs (these are "restricted"). Both types of households are identical in all respects, other than their access to financial markets.

The budget constraint of the unrestricted household is:

$$P_t C_t^u + B_{S,t}^u + (1 + \zeta_t) P_{L,t} B_{L,t}^u \leq R_{S,t-1} B_{S,t-1}^u + \sum_{j=1}^{\infty} \kappa^{j-1} B_{L,t-j}^u + W_t^u(k) L_t^u(k) + \mathtt{P}_t - T_t^u. \quad (2)$$

Here P_t is the price of the consumption good, $B_{S,t}^u$ are the holdings of the one-period (short) bond, ζ_t is the transaction cost paid by the unrestricted household to purchase the long bond, $B_{L,t}^u$ is the stock of the long-term bond, W_t^u is the wage paid by firm k, $\mathtt{P}_t$ is the sum of profits accruing to the household from ownership of final, intermediate and capital producers. The household pays lumpsum taxes T_t^u. The constraint of the restricted household does not include the transaction cost ζ_t for the purchase of long-term bonds, along with their corresponding choices of consumption, bond holdings, labor supply and tax burden. The households optimally choose consumption, holdings of long and short-term bonds and labor supply. The Euler equations are central to the effects of the financial market segmentation, and are shown here. The remaining optimizing conditions are shown in the appendix. For

[32] Also, the price of a bond issued j periods before is $P_{L,t}(j) = \kappa^j P_{L,t}$. Then flow budget constraints will be written as a function of stock of total long-term debt $B_{L,t}$, instead of the purchases of long-term debt in period t.

the short-term bond, the Euler equation is:

$$1 = \beta_u E_t \left[\frac{MU_{t+1}^u}{MU_t^u} \frac{R_{S,t}}{\Pi_{t+1}} e^{-\gamma - z_{t+1}} \right], \tag{3}$$

where MU_t^u is the marginal utility of detrended consumption in real terms, and $e^{-\gamma-z_{t+1}}$ accounts for growth in productivity. Also, $\Pi_{t+1} = P_{t+1}/P_t$. For the long bond, the presence of transaction costs for the unrestricted households modifies the Euler equation to:

$$1 + \zeta_t = \beta_u E_t \left[\frac{MU_{t+1}^u}{MU_t^u} \frac{R_{L,t}}{\Pi_{t+1}} \frac{P_{L,t+1}}{P_{L,t}} e^{-\gamma - z_{t+1}} \right]. \tag{4}$$

Finally, the pricing equation for the institutional investors is given by:

$$1 = \beta_r E_t \left[\frac{MU_{t+1}^r}{MU_t^r} \frac{R_{L,t}}{\Pi_{t+1}} \frac{P_{L,t+1}}{P_{L,t}} e^{-\gamma - z_{t+1}} \right]. \tag{5}$$

The transaction cost ζ_t generates a risk premium, and can be quantified in terms of the difference between the long-term yield with and without the transactions cost[33]. Chen, Cúrdia and Ferrero (2012) show that the difference between these long-term yields is the present discounted value of the current and future expected transactions costs. Following Andrés, López-Salido, Nelson (2004) and Chen, Cúrdia and Ferrero (2012), the transaction cost is modeled as a function of the ratio of long and short-term debt held by the public, and an exogenous error term:

$$\zeta_t = \zeta \left[\frac{P_{L,t} B_{L,t}}{B_{S,t}}, \varepsilon_{\zeta,t} \right]. \tag{6}$$

Assuming that the function ζ and its first derivative are positive, a reduction in the outstanding debt held by the public will result in a fall in the yield on long-term bonds. This is the mechanism through which asset purchases by the central bank will affect the term structure of yields: a change in the holdings of outstanding debt will affect the savings decisions of

[33] This requires the marginal utility of consumption to be held constant. In the first-order approximation, $\hat{R}_{L,t} - \hat{R}_{L,t}^{EH} = \frac{1}{D_L} \sum_{j=1}^{\infty} \left[\frac{D_L - 1}{D_L} \right] E_t \zeta_{t+j}$

the institutional investors through a change in the long-term yield, and consequently, output and inflation in general equilibrium.

The presence of transaction cost, and the heterogeneity among the households and institutional investors in holding the assets are both central to the results of the model. If there is no heterogeneity (that is, all types of investors have access to short- and long-term bonds, and pay ζ_t for the longer-term bond), then the households could conduct all their savings decisions using just the short-term asset. With no transactions cost, and homogeneous households, the aggregate demand would be determined by the real short-term interest rate, and output. In the present case, the long-term interest rate and risk premium implied by the transaction cost are also relevant. Andrés, López-Salido, Nelson (2004) note that these features imply that the central bank open market purchases affect aggregate demand, and the real economy via two channels: the traditional channel of affecting the current and expected future short-term interest rate, and also by altering the risk premium generated by ζ_t.

Both households and investors set their wages on a Calvo staggered basis (wages are reset with probability $1 - \zeta_w$), and this decision is based on the demand for their specific labor input $L_t(i)$. This is supplied to perfectly competitive labor agents, which aggregate the labor inputs into L_t. The details of the wage setting decisions are contained in the online appendix.

3.1.2 Firms

There are three types of firms in the economy: capital goods producers, which are competitive and make investment decisions. These firms rent capital to intermediate goods producers, and the amount of capital rented is determined by the utilization rate chosen by the capital goods producer. The intermediate goods producers combine labor hired from households and the rented capital to produce output using the Cobb-Douglas production function. In the production of intermediate goods, technology is assumed to be labor augmenting. Prices of intermediate goods are set using the Calvo staggered price mechanism. The last type of firms are the perfectly competitive final goods producers: these combine differentiated intermediate goods into a homogeneous product, with a price markup. The firms' optimizations are presented in the appendix.

3.1.3 Central Bank

Orphanides (2003) analyzes the historical behavior of the interest rates of the Federal Reserve, and finds that for the 1920s, the interest rate rule could be well approximated using the Taylor rule. Taylor (1999) further discusses how during the international gold standard era, the interest rate would react positively to change in inflation and real output. Therefore, the central bank is assumed to set the interest as:

$$\frac{R_{S,t}}{R_S} = \left(\frac{R_{S,t}}{R_S}\right)^{\rho_m} \left[\left(\frac{\Pi_t}{\Pi}\right)^{\phi_\pi} \left(\frac{Y_t/Y_{t-4}}{e^{4\gamma}}\right)^{\phi_y}\right]^{1-\rho_m} e^{\varepsilon_{m,t}}. \tag{7}$$

The Taylor parameters are $\phi_\pi > 1$, and $\phi_y \geq 0$. The interest rate smoothing parameter $\rho_m \in (0,1)$ [34].

3.1.4 Government

The government finances its purchases by collecting lump-sum taxes and issuing long and short-term bonds:

$$B_{S,t} + P_{L,t}B_{L,t} = R_{S,t-1}B_{S,t-1} + (1 + \kappa P_{L,t})\, B_{L,t-1} + P_t G_t - T_t. \tag{8}$$

Long-term debt is issued in non-zero supply, and the real value of this debt assumed to evolve as:

$$\frac{P_{L,t}B_{L,t}}{P_t Z_t} = S\left(\frac{P_{L,t-1}B_{L,t-1}}{P_{t-1}Z_{t-1}}\right)^{\rho_B} e^{\varepsilon_{B,t}}.$$

[34] According to Orphanides (2003), "...the 1920s, [...] appear to be consistent with the key aspects of Taylor's framework for interest-rate-based policy analysis." Thus, our framework is not at odds with Meltzer's (2003) hypothesis of the Fed's adherence to the Burgess Rieffler Strong doctrine.

The issuance of long-term debt is financed according to the following fiscal policy rule:

$$\frac{T_t}{P_t Z_t} - \frac{G_t}{Z_t} \equiv \Phi_{z,t} = \Phi \left(\frac{P_{L,t-1} B_{L,t-1} + B_{S,t-1}}{P_t B_{L,t} + B_{S,t}} \right)^{\phi_T} e^{\varepsilon_{T,t}}. \tag{9}$$

Following Davig and Leeper (2006), the fiscal parameter $\phi_T > 0$. $\varepsilon_{T,t}$ follows the stationary AR(1) process, $B_{Z,t} \equiv B_t / P_t Z_t$ and $B_{LZ,t} \equiv B_{L,t} / P_t Z_t$[35]

3.2 Equilibrium strategy and Model Comparison

In equilibrium, the households and firms maximize utilities and profits respectively, subject to the corresponding budget constraints. The full set of equilibrium relations are noted in the accompanying appendix.

Before presenting the numerical solution of the model, it is useful to take stock of the model structure, and compare it with the existing analyses. The present model applies an essentially post-war model structure to analyze the effects of the Federal Reserve's operation. It captures the segmented asset markets during this period, as well the fiscal financing decisions of the government. Several of the underlying model assumptions used here have been applied elsewhere. For example, price-setting follows the Calvo structure. While this structure is also used in Christiano et al. (2003) and Eggertsson (2012), it is plausible that the price-setting mechanism was different during this period. Our parameters will imply that fiscal policy is "passive"[36], as is implicitly assumed in the Christiano et al. (2003) framework. However, we abstract from a banking sector and other financial frictions. This abstraction imply that the present model will be limited in generating the dynamics obtained by the other analyses, and the framework does not capture the banking panics of the era. Further modifications, such as introducing a liquidity preference shock for the households, which increases their preference for the short-term bond, would alter their savings decision[37].

[35] The online appendix discusses the constant S in the long-term debt equation.

[36] In the terminology used by Leeper (1991).

[37] Christiano et al. (2003) find the liquidity preference shock to be extremely important. In their model, households increase their holding of currency relative to demand deposits. These deposits are used by

Allowing for a time-varying increase in the workers' labor market power would also alter the general equilibrium implications of our model.

3.3 Numerical Solution

The first-order log linearized model is estimated using Bayesian methods, following the strategy of Chen, Cúrdia and Ferrero (2012). Details of the estimation strategy are provided in the online appendix.

3.3.1 Data

In order to estimate the model, the relevant macroeconomic time series are constructed for January 1920 to December 1934. Balke and Gordon's (1986) Real GNP and GNP deflator series are used for the output and inflation measure[38]. Population numbers are taken from the U.S. Census Bureau. The construction of the number of labor hours supplied entails two different data sources. From Beney's (1936) study, the series of average hours worked per week per worker in manufacturing is used to construct average actual hours per quarter per wage earner. This is multiplied with the average number of workers in manufacturing, available from the Bureau of Labor Statistics. Yields on bonds and notes are taken from the Banking and Monetary Statistics for 1914-1941 publication of the Federal Reserve, and the Federal Reserve's holdings of Treasury debt is constructed from the tables on Factors affecting bank reserves and condition statement of the Federal Reserve Banks.

3.3.2 Parameters

We use the period 1920Q2 to 1932Q1 for estimation. In the numerical simulations for the 1932 episode, the prior on output growth in steady state is assumed at 1%, on inflation it is 1%, and the standard deviation is 0.5. The degree of segmentation is assumed at 0.7, with a

entrepreneurs who operate the capital stock.

[38] We have also conducted our estimation exercise with the Gordon and Krenn (2014) dataset, and the results are consistent with those presented here.

standard error of 0.2. Using the data on the Federal Reserve's holdings of Treasury securities, the average duration of debt is found to be approximately 15 quarters, and the steady state level of debt is 15% of GDP. The priors on the remaining parameters are shown in table 12. An expanded discussion of the remaining priors and posteriors obtained is presented in the appendix.

We obtain mean posterior estimates of market segmentation of 0.76[39]. Table 13 shows the posterior estimates obtained from our exercise. This degree of segmentation confirms our original hypothesis of a large degree of financial segmentation during the 1920s. Chen, Cúrdia and Ferrero (2012) estimate the market segmentation parameter to be 0.94, and find significantly smaller effects of the asset purchase program of the Federal Reserve in the posterior distribution. However, our estimates of the degree of relative risk aversion are much lower than those estimated for the 2008 crisis (σ_u and σ_r are estimated to be 1.64 and 1.08 relative to 3.35 and 2.08)[40]. This would attenuate the responses of consumption and savings to the monetary policy operation. Another important parameter to note is ζ', the elasticity of the risk premium to changes in the market value of long debt. Our mean posterior estimate for this is 0.36/100.If this elasticity were zero, the Fed's Treasury purchases would leave the risk premium, and therefore the real economy, unaffected. The 90% interval around our estimate is (0.24, 0.48), implying that the elasticity is low relative to the literature.

How do our estimated parameters compare with other analyses of the Great Depression? Christiano, Motto and Rostagno (2003; CMR henceforth) are successful in generating the dynamics during the Great Depression, and since the optimization by households and firms is follows a similar strategy, we use comparable parameters from that exercise to examine our estimated parameters. The form of nominal rigidities are similar across both analyses;

[39] Following Chen et al. (2012), the posterior distribution is obtained in the following way: after obtaining the posterior mode, the normal approximation around the mode is used to form a jump distribution. This is used to generate a sample of parameter vector draws representative of the posterior, based on the Metropolis random walk MCMC simulation process.

[40] In our view, the lower risk aversion estimates for this period are unsurprising. The economy had already experienced World War I and the 1918 Spanish Flu. This may have contributed to a lower concern among households about the lack of a social safety net.

wage stickiness (the fraction of households do not reoptimize wages in a given quarter) is found to be 0.77 in our analysis, and 0.7 is used by CMR. Our estimate of price stickiness (fraction of firms that do not reoptimize prices in a quarter) is higher at 0.80 than 0.5 from CMR. The curvature on the investment adjustment cost function is very similar (7 in our estimates versus 7.69 used by CMR), while the habit persistence parameter is estimated to be somewhat higher (0.87 versus 0.63 in the CMR paper).

We present more detailed model diagnostics in the appendix. Here, we note that the model is able to generate approximately 63% of the unconditional variance of the output growth series, and 48% of the unconditional variance for the short rate.

3.4 Simulations

First, we consider the effects of the 1932 purchase on the economy, using the timelines from the actual operation itself. In our benchmark simulation, presented in figure 5, we consider an increase of $1 billion of medium- and long-term Treasury security holdings of the Federal Reserve. This was the initial increase in the Federal Reserve's holdings, and we first analyze the case of the effect on the economy if the purchases had stopped there.

Although the Fed did not explicitly follow a policy of setting the Federal Funds Rate at the zero-lower bound, as noted in section 2.2 above, the Treasury yields were effectively at this bound. Our assumption is that economic agents, on observing the low policy rates and the state of the economy, would not have expected these rates to rise in the immediate future. Thus, we assume that the zero-lower bound (ZLB) was active for two years after the start of the operation. The ZLB constraint is implemented here as follows: in the benchmark simulation, the ZLB is assumed to bind for 8 quarters. After this period, the economy is in the normal state. The solution algorithm starts in the last ZLB period and iterates backwards to the initial period to find the rational expectations equilibrium (REE) perfect foresight solution matrices. For the normal periods, the REE matrices are solved recursively.

Consistent with the historical experience, the purchase operation is only assumed to last for two quarters. The Fed is assumed to purchase assets in the first quarter, and it then divests these in the second quarter. Given the unexpected nature of the operation, and no indications that it would continue, we assume that agents only expect the operation to last for this period. In this simulation, the Fed is assumed to not hold the assets on its balance sheets. Following an increase in the Federal Reserve's holdings of the long-term securities, we observe approximately a 0.07% increase in output growth, and a decline of 12 b.p. in the long-term yield. Thus, our benchmark simulation is able to explain about 19% of the recovery in output that was observed between the second and third quarters of 1932. We attribute the timing of these effects (approximately 1/5th of the output recovery following the Fed operation in the first quarter of 1932) to the unanticipated nature and size of the operation which surprised financial markets. The model framework assumes that the optimizing households and firms have perfect foresight and rational expectations. Therefore, they adjust their consumption and investment behaviors over the decision horizon accordingly, as soon as the program is announced. Also, since banking disruptions which the economy was experiencing are not modeled here, the effects generated by the model occur in the same quarter.

The intuition for the effects of the purchase operation operates through the effect of the purchase on the long-term yield on the risk premium ζ; as ζ falls, the return on the long-term bond declines. The institutional investors are not able to arbitrage away the difference between the returns on the long and short term bonds (unlike the households). If there were no segmentation, then all households would be able to adjust their portfolios so that the expected returns would adjust until these are equal again, and the discount factor remains unaffected. Therefore, even though the long-term yield with the transactions cost would be different, there will be no real effects on the economy. With segmentation, however, as the long-term yield falls, the expected return for the institutional investors changes. As their discount factor adjusts, their consumption rises, altering their intertemporal consumption path. In general equilibrium, the pricing decisions of intermediate firms and investment decisions of capital goods producers change, and aggregate consumption and investment are affected.

We consider the predictions of the benchmark model in terms of output growth to be a lower bound on the effects of the Fed's purchases on the economy. In the current framework, the portfolio rebalancing by the Fed interacts with the segmented financial markets to generate real effects. However, as we do not model the banking sector, the framework does not account for the stimulatory effect that the purchases had on overall liquidity, and on limiting further banking suspensions.

Our next simulation considers the following counterfactual: suppose the Federal Reserve had kept the size of the intervention same, but purchased assets over two quarters, held onto these on its balance sheet for another two, and then divested its holdings over the remaining two quarters. That is, it had announced the size and extended duration of the purchase, and agents believed that the perfectly credible central bank would carry out the entire operation. This is similar to the announcement structure followed during the QE1 operation. We find that the real effects are significantly larger: as shown in figure 6, output growth increases by 0.5%, and the long-term yield declines by 23 b.p. In this case, the model-implied upturn in output would be approximately 30% larger than what was observed in the data. To provide context with the recent period, for the LSAP program conducted by the Federal Reserve during the crisis of 2008, Chen, Cúrdia and Ferrero (2012) find that the effect on output growth was approximately 0.13%, which is smaller than what the Federal Reserve could have achieved in 1932 if it had used forward guidance and held on to the purchased securities for a longer period.

Under this counterfactual simulation, the agents in the economy are assumed to fully understand the path of purchases announced by the central bank. When the Federal Reserve is assumed to hold on to the Treasury assets, instead of divesting them in the next quarter, the risk premium responds more strongly, and this is evident by the much larger response of the long-term yield. This leads to a stronger response of the channel discussed above: via the change in expected returns of the institutional investors, the mechanism leads to magnified responses of output and inflation. [41]

We can also use our model framework to investigate the comparison between the Fed's 1932 QE operation, and the first QE undertaken during the 2007-09 crisis. We first ask the following question: what would be the effects of the 1932 operation, if it was comparable to the 2009 QE operation? To do this, we consider a similar sized shock for long-term debt as used by Chen, Cúrdia and Ferrero (2012). If we use this size of the shock for the 1932 episode, then the uptick in output is 0.148%. Thus, if the Fed in 1932 had used a QE1-sized operation, the effect on output growth would have been approximately twice as large as was generated by the actual Fed operation undertaken in 1932.

The next question we investigate is how large an operation would have been needed in 1932 to get back to the output growth of 3%? To do this, we compute the size of the shock that would be needed to generate an annual output growth of 3.5%. This simulation leads to a purchase operation which is approximately ten times as large as the one used to simulate the actual 1932 operation. Thus we conclude that if the economy had responded fully to a shock as large as this, the Fed operation could have led to an economic turnaround. However, it is unclear whether the size of the Treasury market could have tolerated such as large purchase of bonds by the Federal Reserve.[42]

Finally, we analyze the variance decomposition for estimating the contribution of the different shocks in the model in the appendix. We find that the technology shock was extremely important for this period for output growth at various forecast horizons. The

[41] In the fall of 1932 and spring of 1933, there was a spate of banking activity suspensions. Since our estimation period ends in the first quarter of 1932, we do not capture the effects of these suspensions. However, we hypothesize that if the Federal Reserve had continued its purchase operation, the effects of the suspensions may have been attenuated.

[42] The size of U.S. government debt shrank after World War I as debt was written off. Using the Statement of Monthly Public Debt, we construct the series for Total Outstanding Interest Bearing Debt as a percentage of real GNP for 1920-34. The debt/GNP ratio declined substantially. At the time the Fed undertook it's operation, the debt/GNP was just over 7%.

If, however, the Congress had authorized additional deficit-financed spending programs, the Fed could then have purchased additional bonds via open market operations. The coordination between fiscal and monetary policymakers could have played a key role in designing effective stabilization policy during the depression. A similar point was noted in Friedman (1967) while discussing the policy views of Henry Simons.

importance of technology during the Great Depression has been highlighted in Field (2011) and Bakker, Crafts and Woltjer (2019). The technology shock is also quite important for explaining the long-term interest rate, accounting for approximately 18% of the variation in the long interest rate at the two year horizon.

4 Conclusion

The main hypothesis of this paper is that the 1932 open market operation conducted by the Federal Reserve provides a unique historical precedent for analyzing the effects of such purchases during a period of severely depressed economic activity.

We find that the 1932 open market operations were effective in lowering Treasury yields and boosting output growth. The decomposition of the Federal Reserve's balance sheet over the operation shows that the largest increase in the Fed's holdings of Treasury securities at the medium end of the term structure (i.e., for Treasury notes). Our event study analysis indicates significant responses of Note and Bond yields around the dates identified from the narrative record.

Given that output growth experienced an upturn during the period of the Fed's purchases, after several quarters of decline, we estimate the effects of changes in the central bank's asset portfolio composition on the real economy. Since there are several indicators which suggest financial market segmentation during the 1920s and 30s, we use a segmented markets approach to model the effects of changes in portfolio composition. Households in the economy are subject to transactions cost while purchasing the long-term bonds, while the institutional investors are restricted to holding long bonds. Bayesian estimates of the model indicate a significant degree of market segmentation, and we find relatively large responses of output and inflation following the purchase of longer-term securities by the central bank.

Our benchmark simulation generates 19% of the observed recovery in output, and we consider this to be a lower bound of the effects of the purchases as the banking sector effects are not modeled here. Our main counterfactual simulation suggests that if the Federal Reserve had announced the operation and conducted the operation over a longer period, the effects on the real economy would be magnified, and be larger than the output responses observed. In our forward-looking model, the provision of forward guidance by the Fed leads households to expect the changes in risk premium (resulting from the decline in holdings of the longer-term security) to persist for longer.

The hypothesis that the 1932 purchase operation was important has been discussed in Friedman and Schwartz (1963) and Meltzer (2003). The broad conclusion in the literature has been that the Federal Reserve quit its expansionary program too soon. Our analysis suggests that the segmentation in financial markets of that era allowed the relatively short-lived program to have large real effects. However, had the Federal Reserve expanded its purchase program in duration, and communicated the program scope to financial markets, the effects would have been magnified. In this way, our analysis also contributes to the more general discussion about macroeconomic policy during the Great Depression and the Great Recession.

Our results from the 1932 open market operation suggest that the Fed in 2008-2009 followed a successful strategy not too dissimilar from what it did over eighty years ago but which it had abandoned too soon. Had the early Fed been able to conduct a larger program in a more persistent manner, the Great Contraction would have been attenuated significantly earlier than it did.

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Table 1: Comparison of the 1932 and 2008 Economies

Characteristic	1932	2008
Real GDP	787,518 million	14,833,557 million
Unemployment	21.03%-25.02%	6.8%-8.7%
Size of the program:		
% change in Bills	114%	-0.05%[a]
- % change in Notes	370%	7%[b]
% change in Bonds	32%	-1.5%
As a fraction of U.S. Treasury Marketable Debt:		
Short term	32.5%	2.1%
- Medium term	67.5%	5.8%
Long term	22.9%	7.8%

Notes: The real GDP series is evaluated at 2009 dollars, on an annual basis. The unemployment numbers are monthly and seasonally adjusted. a : This is the average change in the Federal Reserve's holdings of bills with maturity 15 days or less, 15 to 90 days and 91 days to 1 year; b : this is the change in the Federal Reserve's holdings of Notes of maturity 5 to 10 years.
The last row shows the change in the fraction of different Treasury securities of the Federal Reserve, as a fraction of Marketable Debt. Real GDP and unemployment numbers are obtained from the FRED, Federal Reserve Bank of St. Louis.
The series title for Real GDP is GDPMCA1 and for 1932 unemployment is M0892AUSM156SNBR.
Federal Reserve holdings of Treasuries are obtained from the H.4.1 release
(Factors affecting bank reserves and condition statement of Federal Reserve Banks).

Table 2: Daily Changes in Treasury Bill Yields

	Issue and Maturity dates of Treasury Bills					
Dates	1/25/32 4/27/32	2/8/32 5/11/32	2/15/32 5/18/32	2/24/32 5/25/32	3/2/32 6/1/32	3/30/32 6/29/32
2/17/32	0	0	0	-	-	-
2/28/32	-10	-10	-5	-10	-	-
3/11/32	0	0	0	0	0	-
4/1/32	0	0	0	0	0	-5
4/8/32	-10	-10	0	0	0	-10
4/13/32	0	-50	-50	-50	-40	-50
4/14/32	0	0	0	0	-10	-25
4/15/32	0	0	0	0	0	0
Cumt change	-20	-70	-55	-60	-50	-90

Notes: These are the changes in the level of Treasury Bill yields (in basis points) recorded in the Wall Street Journal, around the dates identified from the narrative record.

Table 3: Daily Changes in Treasury Certificate and Note Yields

Maturity dates of Treasury Certificates Notes and Corresponding Rates						
Dates	Cert 6/15/32 $2\frac{3}{4}\%$	Cert 8/1/32 $3\frac{1}{3}\%$	Cert 9/15/32 $1\frac{1}{3}\%$	Cert 9/15/32 3%	Notes 12/15/32 $3\frac{1}{4}\%$	Cert 2/1/33 $3\frac{3}{4}\%$
2/17/32	-30	0	0	0	-3	0
2/28/32	-1	1	12	5	4	7
3/11/32	-3	-1	-24	-6	-5	-7
4/1/32	-6	-13	-6	-8	-10	-8
4/8/32	-24	-24	-13	-17	-14	-30
4/13/32	-7	-32	-29	-23	-16	-22
4/14/32	-4	-13	-8	-9	-10	-15
4/15/32	-13	-29	-31	-27	-25	-42
Cumt change	-88	-111	-99	-85	-79	-114

Notes: These are the changes in the level of Treasury Note and Certificate yields (in basis points) recorded in the Wall Street Journal, around the dates identified from the narrative record. Only the Certificates and Notes for which the full data series is available for the period under consideration are shown here.

Table 4: Daily Changes in Treasury Bond Yields

Maturity dates of Treasury Bonds and Corresponding Rates						
Dates	1946-56 $3\frac{3}{4}\%$	1943-47 $3\frac{3}{8}\%$	1940-43 $3\frac{3}{8}\%$	1941-43 $3\frac{3}{8}\%$	1946-49 $3\frac{1}{8}\%$	1951-55 3%
2/17/32	-2	-3	-3	-6	-2	-2
2/28/32	0	1	-	0	0	-1
3/11/32	0	-	0	0	0	0
4/1/32	-1	-2	0	-1	0	-3
4/8/32	-8	-14	-10	-11	-3	-9
4/13/32	-7	-5	-13	-11	-6	-5
4/14/32	-6	-23	-20	-21	-23	-21
4/15/32	0	9	8	8	4	12
Cumt change	-24	-37	-38	-42	-30	-29

Notes: These are the changes in the level of Treasury Bond yields (in basis points) recorded in the Wall Street Journal, around the dates identified from the narrative record.

Table 5: Daily Changes in Treasury Bills

Dates	Maturity dates of Treasury Bills 1/25/32 4/27/32	2/8/32 5/11/32	2/15/32 5/18/32
Only narr dates	-20	-20	-5
Only Fed releases	-45	-35	-45
All narr dates (incl Fed releases)	-20	-70	-55
Total yield changes (2/17/32-4/15/32)	-180	-200	-210

Notes: The first row shows the cumulative daily changes in yields (in basis points) on the narrative dates, excluding the overlapping dates on which the Federal Reserve statements were released. The second row shows the cumulative daily yield changes when only the Federal Reserve balance sheets were released. The third row is repeated here from table 3, and the last row shows the total change in yields between February 17, 1932 and April 15, 1932.

Table 6: Daily Changes in Treasury Certificates and Note Yields

	Maturity dates of Treasury Certificates and Notes and Corresponding Rates					
Dates	Cert 6/15/32 $2\frac{3}{4}\%$	Cert 8/1/32 $3\frac{1}{3}\%$	Cert 9/15/32 $1\frac{1}{3}\%$	Cert 9/15/32 3%	Notes 12/15/32 $3\frac{1}{4}\%$	Cert 2/1/33 $3\frac{3}{4}\%$
Only narr dates	-80	-80	-71	-61	-63	-96
Only Fed releases	-38	-30	-63	-38	-31	-19
All narr dates (incl Fed releases)	-88	-111	-99	-85	-79	-114
Total yield changes (2/17/32-4/15/32)	-214	-232	-212	-210	-179	-193

Notes: The first row shows the cumulative daily changes in yields (in basis points) on the narrative dates, excluding the overlapping dates on which the Federal Reserve statements were released. The second row shows the cumulative daily yield changes when only the Federal Reserve balance sheets were released. The third row is repeated here from table 3, and the last row shows the total change in yields between February 17, 1932 and April 15, 1932.

Table 7: Daily Changes in Treasury Bond Yields

Dates	Maturity dates of Treasury Bonds and Corresponding Rates					
	1946-56 $3\frac{3}{4}\%$	1943-47 $3\frac{3}{8}\%$	1940-43 $3\frac{3}{8}\%$	1941-43 $3\frac{3}{8}\%$	1946-49 $3\frac{1}{8}\%$	1951-55 3%
Only narr dates	-8	-18	-14	-18	-21	-7
Only Fed releases	-18	-16	-35	-48	-38	-49
All narr dates (incl Fed releases)	-15	-24	-37	-38	-42	-30
Total yield changes (2/17/32-4/15/32)	-41	-37	-56	-69	-71	-51

Notes: The first row shows the cumulative daily changes in yields (in basis points) on the narrative dates, excluding the overlapping dates on which the Federal Reserve statements were released. The second row shows the cumulative daily yield changes when only the Federal Reserve balance sheets were released. The third row is repeated here from table 3, and the last row shows the total change in yields between February 17, 1932 and April 15, 1932.

Table 8: Yield Changes in August 1932

Maturity dates of Treasury Certs and Notes and Corresponding Rates						
Dates	Note 12/15/32 $3\frac{1}{4}\%$	Cert 2/1/33 $3\frac{3}{4}\%$	Cert 3/15/33 $3\frac{3}{4}\%$	Cert 5/33 2%	Cert 6/33 $1\frac{1}{2}\%$	Cert 5/34 2%
8/13/32	4	-3	-3	-1	3	1
8/19/32	9	6	6	0	0	0

Maturity dates of Treasury Bonds and Corresponding Rates						
Dates	1946-56 $3\frac{3}{4}\%$	1943-47 $3\frac{3}{8}\%$	1940-43 $3\frac{3}{8}\%$	1941-43 $3\frac{3}{8}\%$	1946-49 $3\frac{1}{8}\%$	1951-55 3%
8/13/32	3	0	4	5	6	11
8/19/32	0	0	0	1	0	0

Notes: The different panels show the daily change in yields on the respective securities around the dates in August 1932, when the end of the purchase operation was reported.

Table 9: Denominations of Liberty Bonds

Denominations on June 20, 1920	Denominations in 2009$	% of All Bonds Outstanding
$50	536.34	7.87
100	1072.69	12.11
500	5363.43	9.33
1000	10,726.85	41.49
5000	53,634.25	7.23
10,000	107,268.50	16.10
50,000	536,342.50	1.32
100,000	1,072,685.00	4.54

Notes: These are taken from Kang and Rockoff (2015).

Table 10: Asset Compositions

	Non-farm households	Finance
	(% of total assets in 1945)	
Financial assets	67.9	99.3
-Bonds	13.0	58.6
-Stocks	17.9	2.1
Debt	4.9	93.9
-Short-term	1.9	72.9
-Long-term	3.0	21.0

Notes: These are obtained from the National Balance Sheet of the United States, Goldsmith and Lipsey (1963).

Table 11: Percentage Distribution of Sources of Income and Deductions, Individual Returns for 1932, by Net Income Classes

Net income classes (Thousands of Dollars)	Wages and Salaries	Profits from sale of real estate, stocks, bonds etc.	Interest on govt obligations not wholly tax-exempt	Dividends on stock of domestic corp.
Under 5	67.38	-	-	4.78
5-10	53.02	-	0.36	14.87
10-25	36.97	0.06	0.74	26.88
25-50	28.27	1.08	0.75	34.57

Notes: These are obtained from the IRS Statistics of Income 1932 (pp. 11). The remaining income sources are omitted here, and include income from Business, Partnerships, Rents and royalties, Fiduciary, Interest other than tax-exempt and Other sources. These Net income classes represent approximately 99% of the returns filed in 1932 (pp. 6, Statistics of Income).

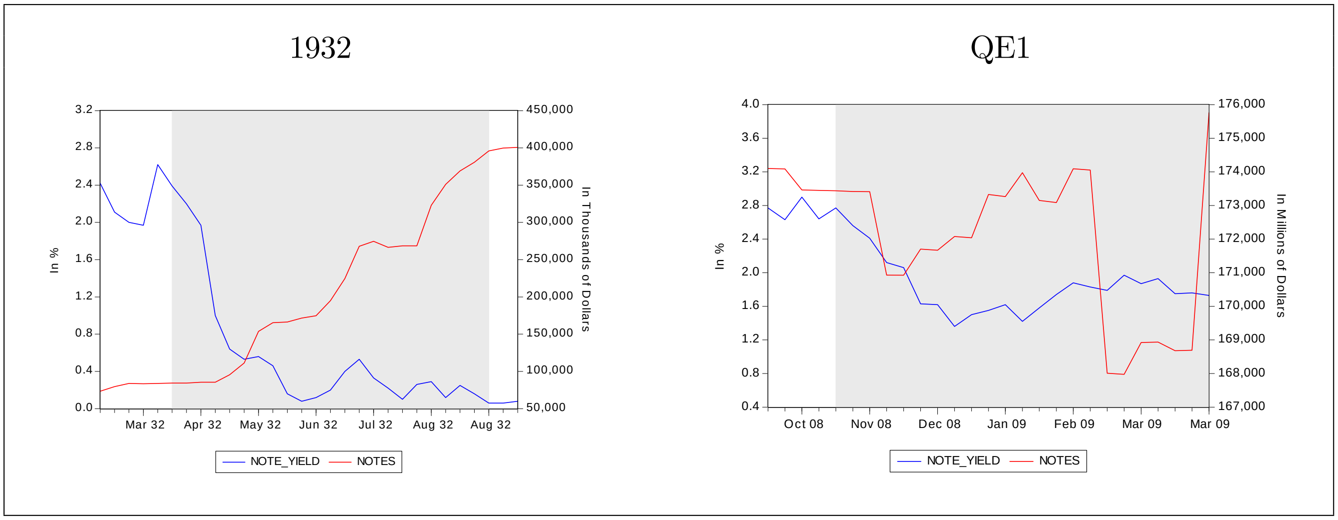
Table 12: Estimates from the Prior Distribution

Coeff	Dist	5%	Median	95%	Coeff	Dist	5%	Median	95%
400γ	G	0.3416	0.9180	1.9384	χ_{wu}	B	0.2486	0.6143	0.9024
400π	G	0.3416	0.9180	1.9384	ν	G	1.2545	1.9585	2.8871
$400(\beta_u^{-1}-1)$	G	0.6272	0.9792	1.4436	ζ_w	B	0.3351	0.5000	0.6649
400ζ	G	0.2558	0.5657	1.0614	ζ_p	B	0.3351	0.5000	0.6649
B^{LMV}/B	G	0.6953	0.9867	1.3501	ϕ_T	G	0.7825	1.4448	2.4058
S''	G	2.5090	3.9170	5.7743	ρ_r	B	0.5242	0.7068	0.8525
a''	G	0.0683	0.1836	0.3877	ϕ_π	G	1.0164	1.7026	2.6453
h	B	0.4302	0.6029	0.7597	ϕ_y	G	0.1366	0.3672	0.7754
σ_u	G	0.6832	1.8360	3.8768	ρ_z	B	0.0976	0.3857	0.7514
σ_r	G	0.6832	1.8360	3.8768	ρ_μ	B	0.5701	0.7595	0.8971
$100\zeta'$	G	0.3067	1.2846	3.4294	ρ_b	B	0.5701	0.7595	0.8971
ω_u	B	0.3214	0.7334	0.9646	ρ_ϕ	B	0.5701	0.7595	0.8971
Ξ^u/Ξ^r	G	0.3416	0.9180	1.9384	ρ_B	B	0.6146	0.8135	0.9389
C^u/C^r	G	0.3416	0.9180	1.9384	ρ_ζ	B	0.6146	0.8135	0.9389
ρ_g	B	0.5701	0.7595	0.8971	σ_μ	IG1	0.1663	0.3433	1.2367
σ_z	IG1	0.1663	0.3433	1.2367	σ_B	IG1	0.1663	0.3433	1.2367
σ_{λ_f}	IG1	0.1663	0.3433	1.2367	σ_ϕ	IG1	0.1663	0.3433	1.2367
σ_b	IG1	0.1663	0.3433	1.2367					

Table 13: Estimates from the Posterior Distribution

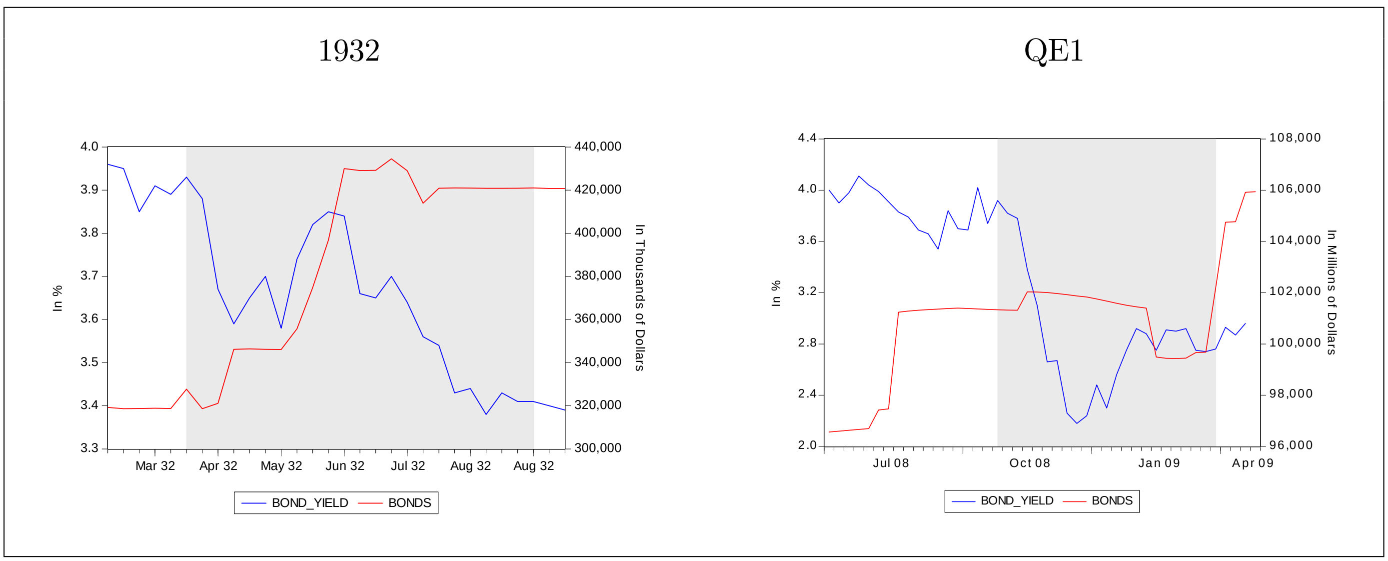
Coeff	Mean	SE	5%	95%	Coeff	Mean	SE	5%	95%
400γ	0.6179	0.3556	0.1804	1.3250	χ_{wu}	0.2936	0.0993	0.1450	0.4988
400π	1.4260	0.7299	0.3725	2.6751	ν	1.9388	0.4955	1.2326	2.7276
$400(\beta_u^{-1}-1)$	1.4826	0.1991	1.1637	1.8232	ζ_w	0.7769	0.0236	0.7338	0.8168
400ζ	0.9253	0.3097	0.5434	1.5123	ζ_p	0.8017	0.0277	0.7626	0.8492
B^{LMV}/B	1.4920	0.1094	1.3181	1.6700	ϕ_T	1.1026	0.2118	0.7862	1.4645
S''	7.0017	0.8785	5.7809	8.4352	ρ_r	0.7611	0.0246	0.7254	0.8080
a''	0.0911	0.0021	0.0875	0.0943	ϕ_π	1.0457	0.0272	1.0059	1.0929
h	0.8729	0.0215	0.8363	0.9036	ϕ_y	0.4369	0.0340	0.3877	0.4950
σ_u	1.6409	0.1463	1.3758	1.8528	ρ_z	0.1728	0.0591	0.0791	0.2810
σ_r	1.0751	0.3069	0.5824	1.6119	ρ_μ	0.6976	0.1261	0.4850	0.8860
$100\zeta'$	0.3635	0.0729	0.2479	0.4884	ρ_b	0.9103	0.0378	0.8370	0.9641
ω_u	0.7624	0.0363	0.7098	0.8292	ρ_ϕ	0.8381	0.0246	0.7967	0.8765
Ξ^u/Ξ^r	0.4669	0.1518	0.2374	0.7325	ρ_B	0.6528	0.0470	0.5735	0.7340
C^u/C^r	0.5370	0.1531	0.2822	0.8091	ρ_ζ	0.9507	0.0069	0.9400	0.9632
ρ_g	0.7733	0.0810	0.6126	0.8938	σ_μ	0.8109	0.1480	0.5831	1.0697
σ_z	1.8703	0.2267	1.5628	2.3089	σ_B	14.2339	0.5736	13.2389	15.0704
σ_{λ_f}	1.2286	0.2656	0.8542	1.6881	σ_ϕ	1.1709	0.2943	0.6266	1.6530
σ_b	3.1861	0.4661	2.4594	3.9191					

Figure 1: US Treasury Notes and Yields



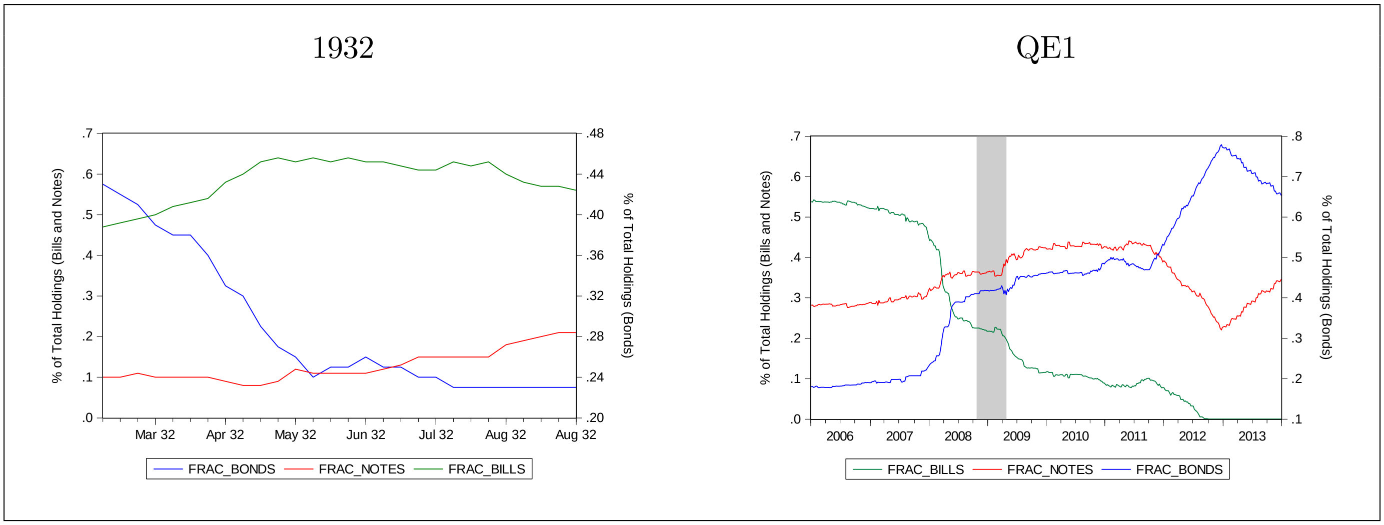
Notes: This figure shows the weekly yields on Treasury notes during the 1932 and 2008-09 operations (on the left axis), and the holdings of these securities by the Federal Reserve. The shaded regions show the period of the operations.

Figure 2: US Treasury Bonds and Yields



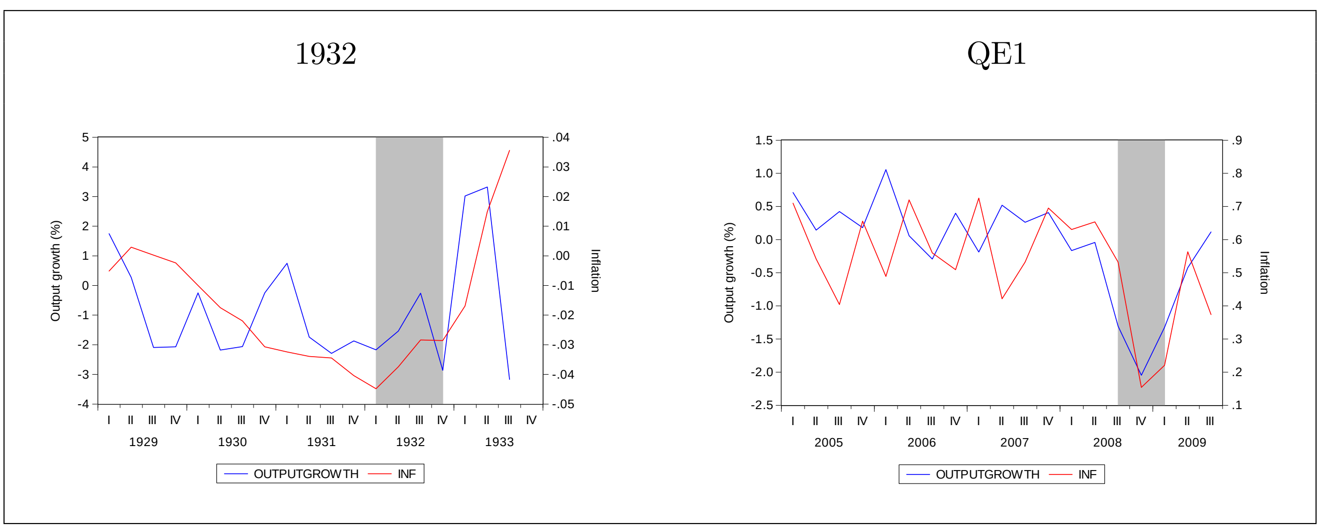
Notes: This figure shows the weekly yields on Treasury bonds during the 1932 and 2008-09 operations (on the left axis), and the holdings of these securities by the Federal Reserve. The shaded regions show the period of the operations.

Figure 3: Treasury Holdings of the Federal Reserve as a Fraction of Total Holdings



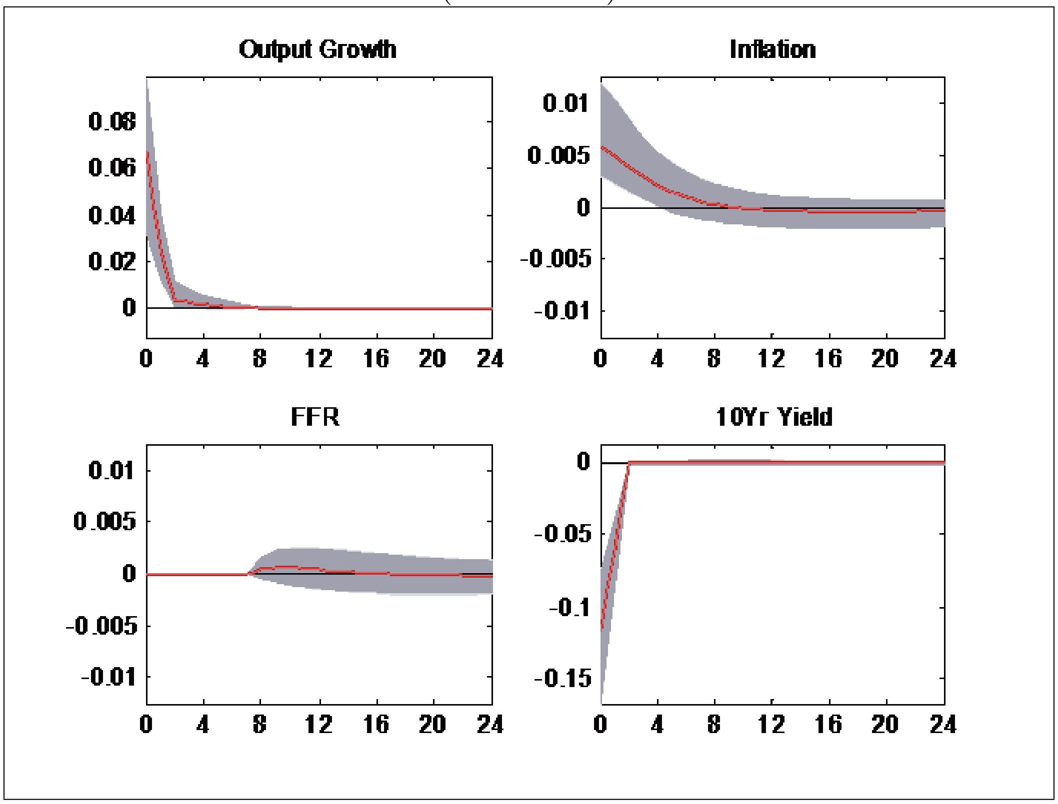
Notes: This shows the Federal Reserve's holdings of Treasury Bills, Bonds and Notes as a fraction of the total holdings, during the 1932 and 2008-09 operations. The percentage holdings of Bonds are shown on the right axis. The shaded regions show the period of the operations.

Figure 4: Output growth and Inflation



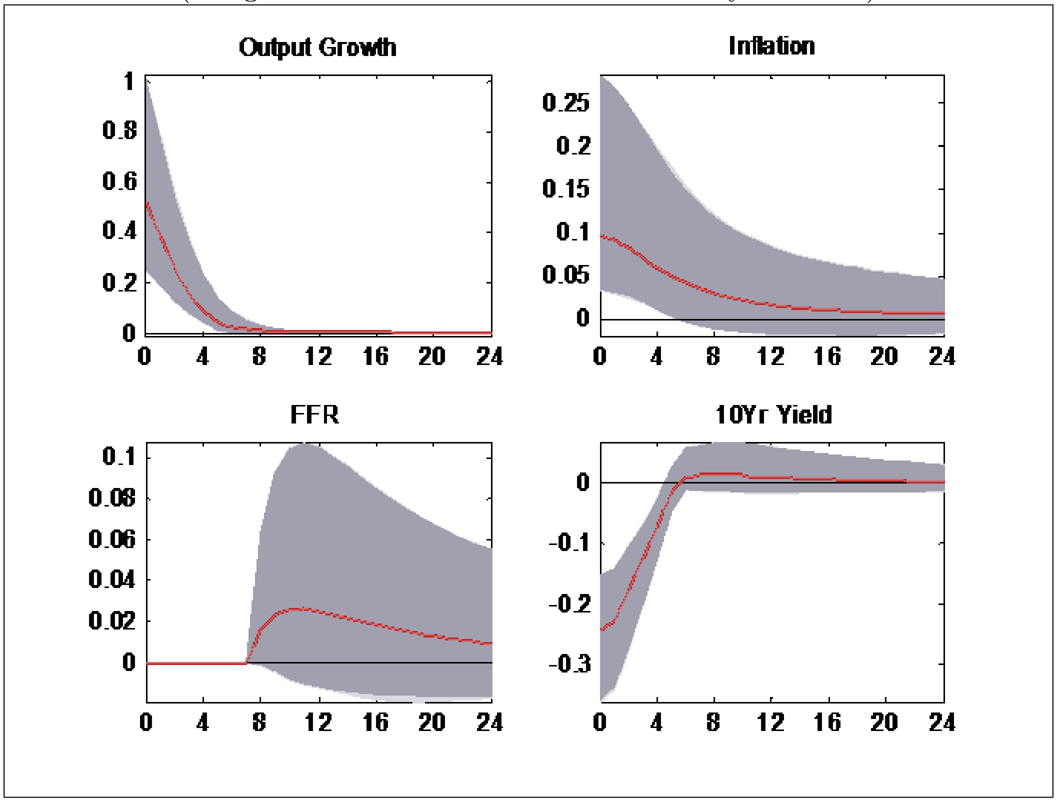
Notes: This shows the evolution of output growth and inflation in the years preceding and following the purchase operations.

Figure 5: Effects of Treasury bond purchases by the Federal Reserve (Benchmark)



Notes: In this simulation, the average duration of debt is 15 quarters, and the purchase operation lasts for one quarter. The Fed then divests its holdings over the next quarter. The shaded regions show the 90 percent confidence bands. The zero-lower bound operates for 8 quarters.

Figure 6: Effects of Treasury Bond purchases by the Federal Reserve
(Long-term securites are not immediately divested)



Notes: In this simulation, the average duration of debt is 15 quarters, and the purchase operation lasts for two quarters. The Fed holds onto the long-term assets for two quarters, and then divests these over the next two quarters. The shaded regions show the 90 percent confidence bands. The zero-lower bound operates for 8 quarters.