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Evidence on The Portfolio Balance Channel of Quantitative Easing

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Abstract

The Federal Open Market Committee has recently attempted to stimulate economic growth using unconventional methods. Prominent among these is quantitative easing (QE)—the purchase of a large quantity of longer-term debt on the assumption that QE reduces long-term yields through the portfolio balance channel. I present several reasons to be skeptical of the theoretical foundations of this channel and offer several arguments for why the effect of QE might be relatively small even if this channel is theoretically valid. Consistent with these arguments, an empirical analysis of the portfolio balance channel provides essentially no support for it.

JEL classification: E52; E58; E43; E44
Keywords: quantitative easing, portfolio balance channel, unconventional monetary policy, zero lower bound, term premium.

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> *"All that quantitative easing (QE) does is to restructure the maturity of U.S. government debt in private hands. Now, of all the stories you've heard why unemployment is stubbornly high, how plausible is this: 'The main problem is the maturity structure of debt. If only Treasury had issued $600 billion more bills and not all these 5 year notes, unemployment wouldn't be so high. It's a good thing the Fed can undo this mistake.' Of course that's preposterous."—John Cochrane, December 7, 2010.* http://www.voxeu.org/index.php?q=node/5900.

The Fed aggressively increased the size of its balance sheet in the wake of Lehman Brothers' bankruptcy announcement on September 15, 2008. Consistent with the massive increase in the supply of reserves, the federal funds rate fell to nearly zero. With the funds rate effectively zero, the Federal Open Market Committee (FOMC) turned to unconventional monetary policy. Prominent among these is large-scale asset purchases (LSAPs) referred to as quantitative easing (QE) which are intended to reduce longer-term interest rates. Bernanke (2008) has suggested that LSAP reduce longer-term interest rates through the portfolio balance channel. A number of studies of QE using event-study methodologies (Gagnon et al., 2011; Krishnamurthy and Vissing-Jorgensen, 2011; Joyce et al., 2010; Neely, 2012; Swanson, 2011; Bauer and Rudebusch, 2011; Wright, 2012) have established that yields on longer-term Treasury and private-label securities declined significantly immediately following key QE speeches and announcements. However, Bauer and Rudebusch (2011) have argued that the portfolio balance channel should be weak and that QE is more likely to work through the so-called signaling channel (also see Kocherlakota, 2010). Unfortunately, comparatively little research has been done to testing the portfolio balance channel using lower frequency monthly data.

This paper contributes to the literature by focusing exclusively on the portfolio balance channel. The analysis is in two parts. First, following up on Bauer and Rudebusch's (2011) skepticism of the portfolio, I advance several additional arguments for why the portfolio balance channel should be weak. Furthermore, I suggest that even if the FOMC's asset purchases caused longer-term rates to decline via the portfolio balance channel, the effect on economic activity would likely be small.

Second, this paper investigates the importance of the portfolio balance channel directly using the model of Gagnon et al. (2011) with a wider array of public debt and bond yield measures than were used in previous research. Moreover, unlike the previous research, the estimation accounts for the trends in interest rates and term premium measures used. To preview the empirical results, once the trends in the data are accounted for, there is little evidence of a statistically significant portfolio balance channel and no evidence of an economically meaningful effect; this finding is invariant to the interest rates or debt measures used.

The remainder of the paper is organized as follows. Section 2 reviews the portfolio balance channel and advances several argument why it may not be important theoretically or empirically. Section 3 reviews the previous work on the portfolio balance channel using monthly data. Section 4 examines a variety of public debt, maturity/duration, and interest rate measures that have been used in the literature and presents the empirical results. Section 5 concludes.

2.0 The Portfolio Balance Channel

The portfolio balance channel assumes that the market for longer-term debt be segmented from the rest of the market, i.e., there is not perfect substitutability across the term structure. There are three problems associated with the portfolio balance channel as applied to empirical tests of the effectiveness of the FOMC's program of QE. First, most of the empirical literature argues that the effectiveness of QE depends on portfolio balance channel, but is either vague about how the portfolio balance channel works. For example, the study that finds the largest effect of QE, Gagnon et al. (2011), suggests that QE reduces long-term yields because the Fed's

LSAPs remove "a considerable amount of assets with high duration from the markets. With less duration risk to hold in the aggregate, the market should require a lower premium to hold that risk."[1] Gagnon et al. (2011) go on to suggest that "This effect may arise because those investors most willing to bear the risk are the ones left holding it. Or, even if investors do not differ greatly in their attitudes toward duration risk, they may require lower compensation for holding duration risk when they have smaller amounts of it in their portfolios." Hence, long-term yields may decline either because a) the riskiest assets will be held by the investors who are the least risk averse, or b) investors' portfolios are less risky because the Fed's LSAP reduced the total amount of duration risk from the market.

The nature of the term premium is not well defined in discussions of the portfolio balance channel. In the Markowitz model the proxy for risk is the standard deviation of the return, which depends on both market risk and default risk. In the case of the term structure of Treasuries, however, the term premium must be due solely to market risk—the fact that prices of longer-term Treasuries are more sensitive to a given change in the interest rate than prices of short-term Treasuries.

Second, the theoretical underpinnings of the segmented market hypothesis appear to be relatively weak. Vayanos and Vila (2009) note that while the preferred habitat model of was suggested more than a half century ago (Culbertson, 1957; and Modigliani and Sutch, 1966) it has not received serious consideration in the academic literature. They attribute this to a) the lack of a formal model and b) the "impression that preferred habitat can conflict with the logic of no-arbitrage.[2] The preferred habitat model of Vayanos and Vila (2009), which is cited by nearly all of the empirical research that is purported to be based on the portfolio balance channel (e.g.,

[1] Gagnon et al. (2011, p. 7).
[2] Vayanos and Vila (2009, p. 1).

Doh, 2010; Greenwood and Vayanos, 2010; Gannon et al., 2011; Bauer and Rudebusch, 2011; Hamilton and Wu, 2012; Neely, 2012; and D'Amico, 2012 et al.) requires an assumption that Vayanos and Vila (2009) acknowledge is "extreme" but "renders the analysis manageable, while not detracting from our main focus which is how limited arbitrage can integrate segmented maturity markets."[3] The "extreme assumption" is that preferred-habitat investors demand only the bond corresponding to their desired maturity because "if preferred-habitat investors could move away from their maturity habitat, they would do so when other bonds offer more attractive returns."[4] The problem they encounter is that "segmented markets can clear…only if the demand of preferred-habitat investors is elastic in the yield of the bond corresponding to their maturity habitat."[5] To achieve this, their model must allow preferred-habitat investors to substitute outside the bond market to generate this elasticity. This assumption appears to be critical to their major results because they note that if preferred-habitat investors "demand were inelastic, arbitrageurs would not trade with preferred-habitat investors," which is critical for several of their results.[6] They suggest that this elasticity can be motivated in a number of way; however, their example is preferred-habitat investors substitute between real estate long-term Treasuries. Their example is motivated by the large drop in long-term yields in the U.K. in 2004 which "induced pension funds to substitute towards both shorter-maturity bonds and non-bond investments. The non-bond investments included real estate."[7] However, the fact that pension funds also substituted into shorter-maturity bonds suggests that the degree of bond market segmentation was perhaps not large enough for these preferred-habitat investors. Indeed, there was virtually no change in the spread between 10-year and 1-year U.K. government bond yields during this period, which

[3] Vayanos and Vila's (2009, p. 7).
[4] Vayanos and Vila's (2009, p. 7).
[5] Vayanos and Vila's (2009, p. 7).
[6] Vayanos and Vila's (2009, p. 13).
[7] Vayanos and Vila's (2009, p. 8).

would seem to suggest a high degree of substitution between the long and short ends of U.K. government bond market. My point is not that Vayanos and Vila (2009) is somehow flawed. Indeed, I believe it is extremely well done. I am simply noting how difficult it is to provide realistic foundations for the portfolio balance channel, which is nearly uniformly offered as the theoretical basis for the effectiveness of QE in the empirical literature. Nevertheless, I am inclined to believe that incredulity of behavioral requirements of the preferred-habitat theory is one of the reasons why it has found little favor among academics. Others are: a) the belief that the number of arbitragers is sufficiently large that markets will be more adequately represented by a model where there is a high degree of substitution across the term structure, and b) the degree of substitution is sufficiently high that the effect of an exogenous change in the supply of a particular maturity on maturity rate spreads will die out over time, i.e., the implications of the segmented market hypothesis for the term structure are only relevant at relatively high frequencies.

Hence, while Vayanos and Vila (2009) have shown that it is possible to construct a model where market segmentation affects the structure of rates, it is not clear that such a model adequately reflects the real-world behavior of market participants or financial markets more generally.[8]

Third, several analysts have suggested reasons Fed's LSAP should be relatively weak. For example, Cochrane (2011) argues the effect of the Fed's LSAP on the structure of rates should be insignificant because the Treasuries-only supply measure is too narrow. Specifically, he notes that "much of the Treasury bond supply is locked away in central bank and pension fund vaults" and "arbitrageurs take duration risk in mortgage-backed, corporate, and other

[8] It should be noted that Vayanos and Vila (2009, p. 32) note that their model is not ready to be taken to the data for a variety of reasons.

markets.[9] If the real duration risk by the investing public occurs in the broader credit market, there is little reason to expect a significant portfolio balance channel in the market for Treasuries.[10] Cochrane (2011) notes that the Fed's QE operations are "just a drop in the bucket." Bauer and Rudebusch (2011) make this point by noting that "the scale of the Fed's purchases of $1.725 trillion of debt securities is small relative to the size of [domestic] bond portfolios" and "the global bond market—arguably, the relevant one—is several times larger."[11]

Finally, there is an issue of policy effectiveness that goes beyond the theoretical relevance of the portfolio balance channel. Specifically, even if the effect of LSAP on long-term rates was large, the effect of QE on economic activity would be comparatively small. The reason is simple: the more segmented the long end of the Treasury market, the larger the effect of LSAP on longer-term Treasury rate, but the smaller the effect on interest rates that are more important for economic activity. If the effectiveness of QE is due to the long-term Treasury market being segmented from the rest of the market, QE would have a limited affect on economic activity because the impact on interest rates that matter for economic activity would be comparatively small.

3.0 Previous Research

The existing research has mostly focused on the effectiveness of QE and not the portfolio channel per se. Moreover, much of this work has been event-studies (Neely, 2012; Krishnamurthy, A., and A. Vissing-Jorgensen, 2011; Gagnon et al. 2011; Joyce et al. 2010). Event studies have found a relatively large effect of key QE announcements on longer-term

[9] Cochrane (2011, p. 16).

[10] On a more controversial note, Cochrane (2011, p. 6) pointed out that "any risk 'borne' by the government is still risk borne by us," so that in a Ricardian world there could be no portfolio balance effect.

[11] They note further that other assets including equities bear interest rate risk, which makes the total amount of interest-rate risk even larger. Thornton (2010) argues that the conventional liquidity effect should be small, perhaps trivial, for some of the same reason—historically open market operations have had a trivial effect on the total supply of credit (see Friedman, 1999) for a similar argument.

yields and term premiums. However, Wright (2011) has shown that these announcement effects are short lived, lasting only a few months.

Hancock and Passmore (2011) and Stroebel and Taylor (2009) investigate the effect of the FOMC's MBS purchases using lower frequency monthly data and find mixed results. Hancock and Passmore (2011) find a relatively large impact while Stroebel and Taylor (2009) find a relatively small or statistically insignificant effect.

D'Amico and King (2010) and D'Amico et al. (2011) investigate the effects of QE on the Treasury yield curve using micro-transactions data. . D'Amico and King (2010) estimate both flow and stock effects—the former being the response of prices to ongoing purchases; the latter being changes due to expectations about future withdraws of supply. They find small and temporary flow effects. The stock effect based on a counterfactual yield curve from their model suggests that the nearly $300 billion purchase of Treasuries flattened the yield curve in the range of 10 to 15 years by 45 basis points. However, when the observations on key QE announcements days are omitted only one of the own response or cross response coefficients is statistically significant at any reasonable significance level. Hence, their results appear to depend significantly on an announcement effect.

D'Amico et al. (2011) suggest that QE can affect long-term yield and term premium through three channels. The first is called the scarcity channel; "a mechanism under which the purchase by the Federal Reserve of assets with a specific maturity leads to higher prices (and lower yields) of securities with similar maturities." The second is called the duration channel; "a mechanism under which the removal…of aggregate duration from the outstanding stock of Treasury debt reduces term premiums on securities across maturities." The duration channel seems to be identical to the portfolio balance channel. The third is the signaling channel. They identify scarcity by creating maturity "buckets" consisting of the public's holdings of Treasury securities of given maturities relative to total Treasury debt outstanding.[12] They find that both the scarcity and duration channels are statistically significant; however, the duration channel accounts for only a third or a fourth of their estimate of the total effect. They find no evidence of an important signaling channel.

Doh's (2010) analyzes the effects of QE using a simplified version of Vayanos and Vila's (2009) model. He shows that the magnitude of the decline in the term premium depends critically on the risk aversion of the arbitrageurs. When arbitrageurs are risk neutral, exogenous changes in the maturity structure of Treasury debt has no effect on the term structure. Not surprisingly he finds that the effect of QE is larger when the short-term rate is at its zero lower bound. However, he does not estimate the effectiveness of QE.

Greenwood and Vayanos (2010) focus more directly on the portfolio balance channel in that they organize their empirical analysis around predictions from Vayanos and Vila's (2009) model. Specifically, they estimate regressions of bond excess returns and yield spreads on three measures of the maturity structure of the public's holding of government debt—the average maturity of the debt, the fraction of the debt with maturity of 10-years or longer, and the duration of the debt. Their results are mixed. Evidence of a portfolio balance channel is strongest for longer-horizon excess returns, controlling for the slope of the yield curve. The long-horizon excess returns could be spurious given the persistence in the debt measures.

Like Greenwood and Vayanos (2010), Gagnon et al. (2011) investigate the portfolio balance channel's implication that long-term yields should be positively related to measures of the maturity structure of public debt. However, rather than focusing on excess returns, they

[12] This formulation seems at odds with the idea of scarcity. A more natural measure would seem to be the public's holding of Treasuries of given maturities relative to the total supply of those maturities.

investigate the effect on the 10-year Treasury term premium. Specifically, Gagnon et al. (2011) estimate the equation

(2) $$i_t = \alpha + X_t\beta + \delta pd_t + \varepsilon_t.$$

Gagnon et al. (2011) use two measures of i, the 10-year Treasury yield and an estimate of the 10-year Treasury term premium. X is a [1 x K] vector of macroeconomic variables and pd is a measure of the public's holding of Treasury debt. They estimate the equation over the period January 1985 through June 2008. Their estimates suggest that FOMC's $1.75 trillion asset purchase (QE1) should have reduced the term premium by about 52 basis points and the 10-year Treasury yield by about 82 basis points.

Hamilton and Wu (2012) investigate the effect of QE by estimating a three factor affine term structure model and employing assumptions motivated by Vayanos and Vila's (2009) model. Their estimates of the effect of QE1 on the 10-year Treasury yield and term spreads are smaller than those reported by Gagnon et al. (2011), Greenwood and Vayanos (2010), and D'Amico and King (2010). Moreover, when the model was updated for QE2, Hamilton and Wu (2012) found a perverse effect—the Fed's asset purchase program should have increase Treasury yields and term premiums. They attribute this to the fact that the average maturity of the debt and the proportion of long-term debt held by the public increased over the QE2 period because the Treasury issued more long-term debt than the Fed purchased.

4.0 An Investigation of the Portfolio Balance Channel

This section investigates the empirical relevance of the portfolio balance channel using Gagnon et al.'s methodology and macroeconomic variables. The analysis differs from theirs in that a larger number of measures of the maturity structure of the debt are used and, following

Hamilton and Wu (2012), the slope of the yield curve is also used as the dependent variable. The analysis begins with a discussion of the public debt measures used.

4.1 The Data: Measures of the Public's Holdings of Government Debt

This section analyzes the various debt measures used to investigate the portfolio balance channel. The debt measures are from Gagnon et al. (2011) and Hamilton and Wu (2012).[13] Both Gagnon et al. (2011) and Hamilton and Wu (2012) use data on the public's holding of Treasury debt, less that held by the Fed in the System Open Market Account (SOMA). Figure 1 shows both series for the period January 1990 through June 2008. The series are nearly identical until the late 1990s when they begin to diverge. The difference is likely due to the fact that Gagnon et al.'s data includes Treasury inflation-protected securities (TIPS), while Hamilton and Wu's does not.[14] Following Greenwood and Vayanos (2010), Hamilton and Wu (2012) use the average maturity of public debt and the proportion of public debt with maturities greater than 10 years. These series are shown in Figure 2. Both series behave similarly; the correlation is 84 percent. Moreover, both series trend down over the sample period.

Gagnon et al. (2011) consider only the public's holdings of government debt with maturities of one year or longer net of SOMA. This series $(S1)$ is shown in Figure 3. However, they make several adjustments to this series. First, they subtract foreign official holdings of Treasury securities with maturities of one year or more because foreign governments are unlikely to have a term premium similar to that of the private sector. The resulting series $(S2)$ is also shown in Figure 3.

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[13] I would like to thank the authors of both studies for providing the data. The data for the Hamilton and Wu paper can be found at http://dss.ucsd.edu/~jhamilto/zlb_data.html.

[14] The results are quantitatively similar and the qualitative conclusions identical if the Hamilton and Wu base series is used, suggesting that including or excluding TIPS securities has only a minor effect on the results.

Rather than using $S2$, they also subtract foreign official holdings of agency and private sector debt with maturities of at least one year. This adjustment is highly unusual because agency and private securities are not in $S2$. No reason for the adjustment is given. The resulting series $(S3)$, also shown in Figure 3, is negative beginning November 2007, foreign official holdings of the agency and private sector debt becomes larger than $S2$. As a final adjustment Gagnon et al. (2011) express $S3$ as percent of nominal GDP $(S3^{gdp})$.

4.2 The Data: Term Premiums and Treasury Yields

This section considers alternative measures of interest rates used to investigate the portfolio balance channel. Gagnon et al. (2011) evaluate the effectiveness of QE by estimating the effect of the Fed's purchase of securities on an estimate of the 10-year Treasury term premium (TP) and the zero-coupon 10-year Treasury bond yield ($T10$).[15] Their estimate of TP is obtained from the term structure model of Kim and Wright (2005). Figure 4 shows both $T10$ and TP. These series have strong negative trends and similar cycles. The correlation between TP and $T10$ is very high, 94 percent. Relatively little of the correlation is due to their common trends. When both series are detrended using a Hodrick-Prescott (HP) filter correlation is 88 percent; the correlation is 69 percent when a simple linear trend is used. Given the similarity of these series it is likely that the results will be qualitatively similar with either measure.

Hamilton and Wu (2012) investigate the effectiveness of the portfolio balance channel using the slope of the yield curve (SYC), measured by the difference between the constant maturity 10-year Treasury zero coupon bond yield and the 6-month T-bill rate. Figure 5 shows

[15] Bauer and Rudebusch (2011) have an alternative estimate of the risk premium. However, their measure behaves similar to Gagnon et al.'s (2011). Indeed, the qualitative conclusions presented in Section 4 are the same when Bauer-Rudebusch's measure is used.

SYC and TP over the period January 1985 through June 2008. The two series are highly correlated, 46 percent.

4.3 The Effectiveness of the Portfolio Balance Channel

This section reports the estimates of equation (2) using these alternative measures of i_t $(T10, TP, \text{and } SYC)$, and a variety of measures of pd_t. The macroeconomic variables are those used by Gagnon, et al. (2011); the unemployment gap (gap), core consumer price index inflation (cpi), long-run inflation disagreement ($lrid$), and 6-month realized daily volatility of the on-the-run 10-year Treasury yield (rv).[16]

Table 1 presents the estimates using TP as the dependent variable and the alternative measures of the public's holding of Treasury debt discussed in Section 3.1. Contrary to the implication of the portfolio balance channel, the coefficient on the public's holding of debt net of SOMA, $S1$, is negative and statistically significant. However, when foreign official holdings of Treasury debt are netted out, the estimate is positive and statistically significant. A coefficient of the same magnitude and statistical significance is obtained when foreign official holdings of agency and private debt are netted out. Hence, despite the abnormal nature of this adjustment, it has no effect on the results: a $600 billion LSAP would reduce the term premium by 40 basis points.

The estimates using $S3^{gdp}$ are, of course, identical to Gagnon et al.'s (2011). While the coefficient on $S3^{gdp}$ is larger than that on $S3$, the estimated magnitude of the effect of LSAP is smaller. A $600 billion LSAP is about 4.0 percent of 2009 GDP, so the estimated effect of the same $600 billion LSAP would be half as large, about 19 basis points.

[16] See Gagnon et al. (2011) for the precise definitions of these variables.

Unfortunately the results in Table 1 are the consequence of common trends in TP and public debt measures. This is shown in Table 2, which reports the estimates of equation (2) when a simple linear trend is included in the equation. The coefficient on $S1$ is negative, but not statistically significant. The coefficients on the other debt measures are smaller and, more importantly, none is statistically significant at even the 10 percent significance level. When the trend is accounted for, the statistical support for the portfolio balance channel vanishes. Hence, there is no evidence supporting the portfolio balance channel using any of the debt measures discussed in Section 3. This conclusion is the same if the HP trend for TP is included rather than the simple linear trend or if the equation is estimated in first differences. Also, though not reported here, the results are qualitatively identical if $T10$ is the dependent variable.

Table 3 presents the results using five alternative supply measures: the average maturity of the debt (AM), the percent of the public's holding of debt with maturity of 10 years or longer $(P10)$, the duration of the public's holding of the debt (DUR), the duration of the on-the-run 10-year Treasury securities $(DUR10)$, and the $S2$ debt measure adjusted for the duration of the debt using of Gagnon et al.'s (2011) adjustment procedure $(S2^{duradj})$. AM and $P10$ are calculated from Hamilton and Wu's data, which begins in January 1990. Hence, when these variables are used, the sample period is January 1990 through June 2008. DUR and $DUR10$ were provided by Gagnon et al. (2011).

The coefficients on AM and $P10$ are positive, but neither is statistically significant. The estimates for the two duration measures are negative and statistically significant, suggesting that a shortening of the duration of the public's holding of government debt due to LSAP would increase the term premium. The coefficient on $S2^{duradj}$ is positive, but not statistically significant. Hence, these alternative measures also provide no support for the portfolio balance channel.[17] Again, the conclusion is robust to the measure of trend used, whether the equation is estimated using first differences, or if $T10$ is the dependent variable.

The portfolio balance channel is thought to reduce longer-term rates relative to shorter-term rates, so equation 2 is estimated using SYC as the dependent variable and all nine of the supply measures. Unlike TP and $T10$, there is no significant trend in SYC. However, SYC is highly persistent, so SYC_{t-1} is included in the regression.

The results using the $S1$, $S2$, $S3$, and $S3^{gdp}$ supply measures are presented in Table 4. None of these measures provides support for the portfolio balance channel. The coefficients on $S1$ and $S3$ are positive, but not statistically significant. The coefficients on $S2$ and $S3^{gdp}$ are negative. Neither is statistically significant at the 5 percent significance level; however, the coefficient on $S3^{gdp}$ is significant at the 10 percent level.

The results using the five other supply measures are presented in Table 5. These results are somewhat more encouraging for the portfolio balance channel. The coefficient estimates for AM and $P10$ are positive but not statistically significant at the 5 percent level. The coefficient on $P10$ is marginally significant at the 10 percent level, but small: A one-percentage-point increase in the percent of debt 10-years or longer increases SYC by only 2 basis points. Moreover, $P10$ increased slightly from March 2009 through January 2011, suggesting the yield should have steepened rather than flattened as suggested by the portfolio balance effect.

The coefficient on DUR is positive and statistically significant. A one-year increase in the duration of the debt would increase the slope of the yield curve by nearly 14 basis points.

[17] As before, the qualitative conclusions are unchanged if the 10-year Treasury yield or Bauer and Rudebusch's (2011) measure of the term premium is used. For completeness Hamilton and Wu's (2012) supply factors were also used. These factors are available for the period January 1990 through July 2007. None of these supply factors was statistically significant when either TP or $T10$ was the dependent variable. All were positive and statistically significant when SYC was the dependent variable; however, the sum of the coefficients was not statistically significant.

However, the standard deviation of DUR over the sample period is about 0.5 years. Consequently, it would take a relatively large change in DUR to have much of an effect on the slope of the yield curve. More important for the effectiveness of QE via the portfolio balance channel, D'Amico et al. (2011) indicate that during the first LSAP the average duration of the Treasury securities held by the public was reduced from 4.42 years to 4.30 years. Hence, this could account for only about a 2 basis-point flattening of the yield curve during. They note that QE2 only removed 0.10 years of duration from the market, so the duration effect of QE2 would be even smaller.

The duration-adjusted $S2$ supply measure also provides no support for the portfolio balance channel. The estimated coefficient is positive, but very small and not statistically significant.

The results are more encouraging using Hamilton and Wu's (2012) measure of the slope of the yield curve are more encouraging for the portfolio balance channel in that two of the nine supply measures are correctly signed and statistically significant. However, neither can account for the well-documented decline in long-term interest rates and the term premium reported in the event-study literature.

5. Conclusions

With its principal policy tool—the federal funds rate—effectively at zero, the FOMC attempted to stimulate aggregate demand by reducing longer-term rates through the so-called signaling and portfolio balance channels of policy. The portfolio balance channel is hypothesized to lower longer-term rates by reducing the term premium that investor require to hold government securities. This can be accomplished by purchasing large quantities of longer-term Treasury debt through LSAP, or by purchasing longer-term securities while simultaneously selling an equal quantity of shorter-term securities. The effect of LSAP on long-term rates is hypothesized to result from a reduction the maturity/duration of the public's holding of Treasury debt via the portfolio balance channel. This paper investigates the portfolio balance channel using three interest rate measures and nine public debt supply measures that have been suggested in the literature. There no evidence that the decline in longer-term rates and term premiums identified in the event-study literature is due to the portfolio balance channel. If the FOMC's LSAP has reduced longer-term yields or flattened the slope of the yield curve as the event studies suggest, the effect appears to be the consequence of the signaling channel as Bauer and Rudebusch's (2011) contend. The problem, of course, is that the signaling channel depends on the expectations hypothesis of the term structure of interest rates which has been massively rejected by the data (e.g., Bekaert et al., 2001; Campbell and Shiller, 1991; Kool and Thornton, 2004; Thornton, 2005; Sarno et al., 2007). Moreover, investigations of the signaling (or forward guidance) channel has not produced significant evidence of the signaling channel either. More work is necessary to reconcile the evidence of a large and statistically significant high-frequency response of Treasury yields to major QE announcements with the lack of evidence of an important portfolio balance channel and the lack of empirical support for the expectations hypothesis.

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Table 1: Estimates of Equation (2): January 1985 – June 2008								
	Coef.	P-value	Coef.	P-value	Coef.	P-value	Coef.	P-value
Const.	0.203	0.775	-3.277	0.000	-2.730	0.000	-2.182	0.000
gap	0.241	0.000	0.220	0.000	0.211	0.000	0.180	0.002
cpi	0.320	0.000	0.497	0.000	0.433	0.000	0.307	0.000
$lrid$	0.250	0.015	0.374	0.001	0.381	0.000	0.377	0.001
rv	0.492	0.053	1.225	0.000	1.094	0.000	0.943	0.000
$S1$	-0.001	0.003						
$S2$			0.001	0.000				
$S3$					0.001	0.000		
$S3^{gdp}$							0.044	0.000
$\bar{R}^2$	0.812		0.816		0.842		0.847	
$s.e.$	0.402		0.398		0.365		0.363	

Table 2: Estimates of Equation (2) including a Trend: January 1985 – June 2008

	Coef.	P-value	Coef.	P-value	Coef.	P-value	Coef.	P-value
Const.	1.035	0.058	0.164	0.850	-0.380	0.671	-0.071	0.945
gap	0.205	0.000	0.200	0.000	0.201	0.000	0.192	0.001
cpi	0.109	0.097	0.156	0.054	0.207	0.024	0.158	0.056
$lrid$	0.244	0.029	0.276	0.020	0.301	0.009	0.292	0.016
rv	0.394	0.056	0.574	0.005	0.665	0.001	0.590	0.003
Trend	-0.006	0.000	-0.006	0.000	-0.004	0.010	-0.005	0.053
$S1$	-0.0001	0.533						
$S2$			0.0002	0.409				
$S3$					0.0003	0.145		
$S3^{gdp}$							0.016	0.368
$\bar{R}^2$	0.855		0.856		0.856		0.857	
$s.e.$	0.353		0.352		0.348		0.352	

Table 3: Estimates of Equation (2) Using Alternative Supply Measures and a Trend: January 1985 – June 2008

	Coef.	P-value	Coef.	P-value	Coef.	P-value	Coef.	P-value	Coef.	P-value
Const.	0.0831	0.9198	0.6770	0.2145	2.4388	0.0092	9.0658	0.0000	-0.0500	0.9602
gap	0.2169	0.0002	0.2068	0.0003	0.2055	0.0002	0.3410	0.0000	0.2028	0.0002
cpi	0.1874	0.0006	0.1882	0.0006	0.0923	0.2075	0.0227	0.6266	0.1670	0.0399
$lrid$	-0.0577	0.4817	-0.0611	0.4622	0.1729	0.0904	0.0821	0.1560	0.2898	0.0143
rv	0.6981	0.0007	0.6682	0.0012	0.4253	0.0507	0.5823	0.0000	0.6110	0.0027
Trend	-0.0060	0.0000	-0.0069	0.0000	-0.0061	0.0000	0.0002	0.7840	-0.0055	0.0001
AM	0.0130	0.1439								
$P10$			0.0246	0.2020						
DUR					-0.2569	0.0497				
$DUR10$							-1.1908	0.0000		
$S2^{duradj}$									0.0003	0.2970
$\bar{R}^2$	0.8366		0.8357		0.8588		0.9227		0.8540	
$s.e.$	0.2995		0.3003		0.3452		0.2555		0.3511	

Table 4: Estimates of Equation (2) with *SYC* as Dependent Variable, January 1985 – June 2008

	Coef.	P-value	Coef.	P-value	Coef.	P-value	Coef.	P-value
Const.	0.0568	0.8479	0.2655	0.1046	0.1996	0.0456	0.1632	0.0646
gap	0.1086	0.0071	0.1135	0.0050	0.1088	0.0053	0.1137	0.0034
cpi	0.0338	0.2599	0.0264	0.1451	0.0326	0.0637	0.0486	0.0148
$lrid$	-0.1099	0.0001	-0.1194	0.0001	-0.1189	0.0000	-0.1212	0.0000
rv	0.2528	0.0013	0.2125	0.0037	0.2214	0.0027	0.2343	0.0015
SYC_{t-1}	0.9085	0.0000	0.9066	0.0000	0.9112	0.0000	0.9112	0.0000
$S1$	0.0000	0.8088						
$S2$			-0.0001	0.3315				
$S3$					0.0000	0.1937		
$S3^{gdp}$							-0.0051	0.0795
$\overline{R}^2$	0.9686		0.9687		0.9688		0.9691	
$s.e.$	0.2024		0.2018		0.2015		0.2007	

Table 5: Estimates of Equation (2) with *SYC* and Alternative Debt Measures: January 1985 – June 2008										
	Coef.	P-value	Coef.	P-value	Coef.	P-value	Coef.	P-value	Coef.	P-value
Const.	-0.4507	0.0115	-0.5291	0.0013	-0.8071	0.0531	-0.5240	0.3026	0.1946	0.1944
gap	0.1708	0.0021	0.2173	0.0002	0.1289	0.0013	0.0998	0.0119	0.1105	0.0049
cpi	0.0257	0.1834	0.0189	0.2795	0.0482	0.0124	0.0568	0.0414	0.0282	0.1149
$lrid$	-0.0387	0.4037	-0.0399	0.3751	-0.0709	0.0150	-0.0998	0.0005	-0.1161	0.0001
rv	0.5325	0.0001	0.5211	0.0001	0.2856	0.0006	0.2563	0.0006	0.2257	0.0022
SYC_{t-1}	0.8471	0.0000	0.8177	0.0000	0.8905	0.0000	0.9112	0.0000	0.9075	0.0000
AM	0.0027	0.3846								
$P10$			0.0201	0.0959						
DUR					0.1375	0.0268				
$DUR10$							0.0705	0.2073		
$S2^{duradj}$									0.0000	0.6032
$\bar{R}^2$	0.9740		0.9741		0.9699		0.9689		0.9686	
$s.e.$	0.1948		0.1940		0.1980		0.2014		0.2023	

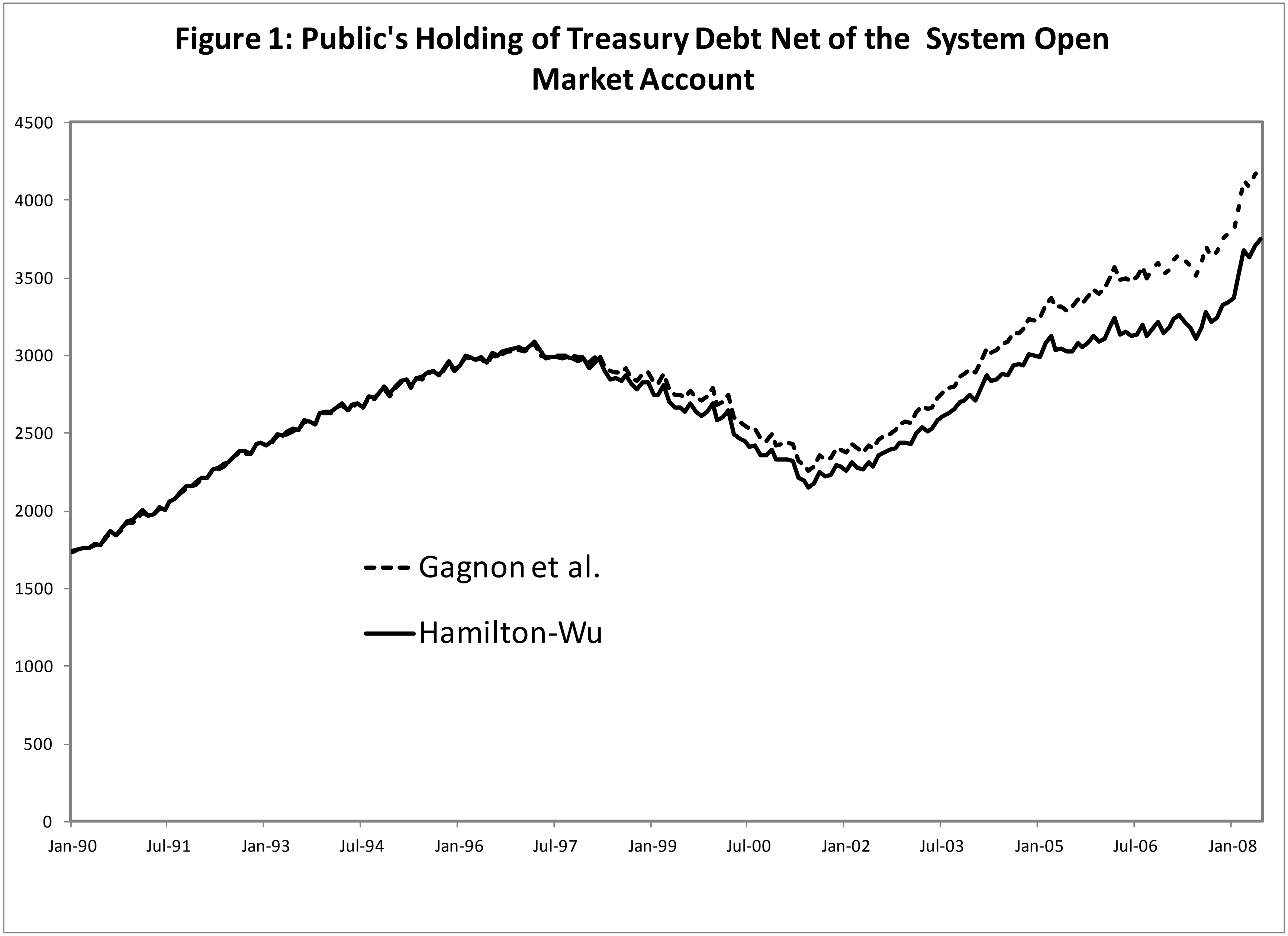


Figure 1: Public's Holding of Treasury Debt Net of the System Open Market Account
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Jan-90
Jul-91
Jan-93
Jul-94
Jan-96
Jul-97
Jan-99
Jul-00
Jan-02
Jul-03
Jan-05
Jul-06
Jan-08
Gagnon et al.
Hamilton-Wu

Figure 2: Average Maturity and Proportion of Debt of Maturity Greater Than 10 Years

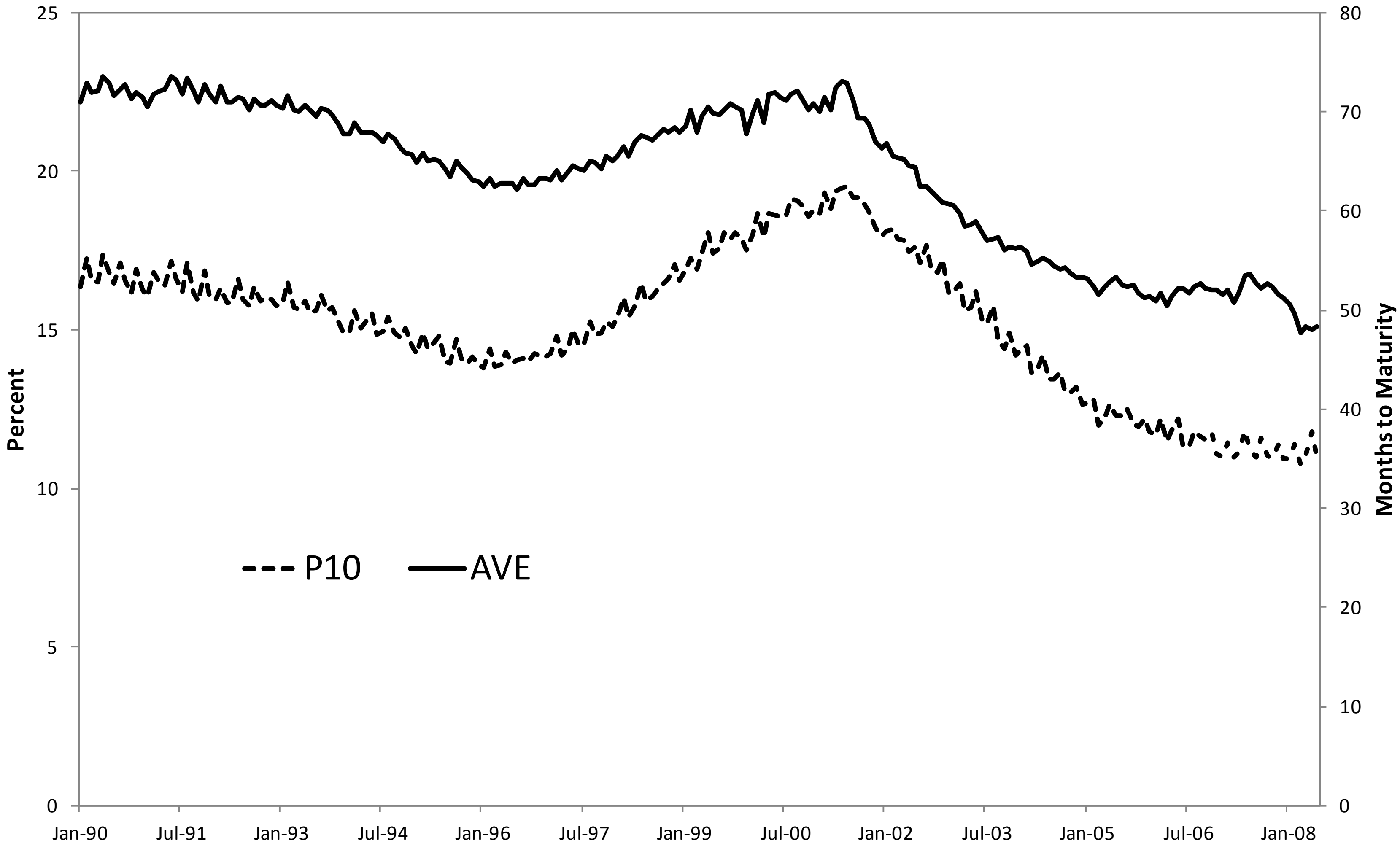
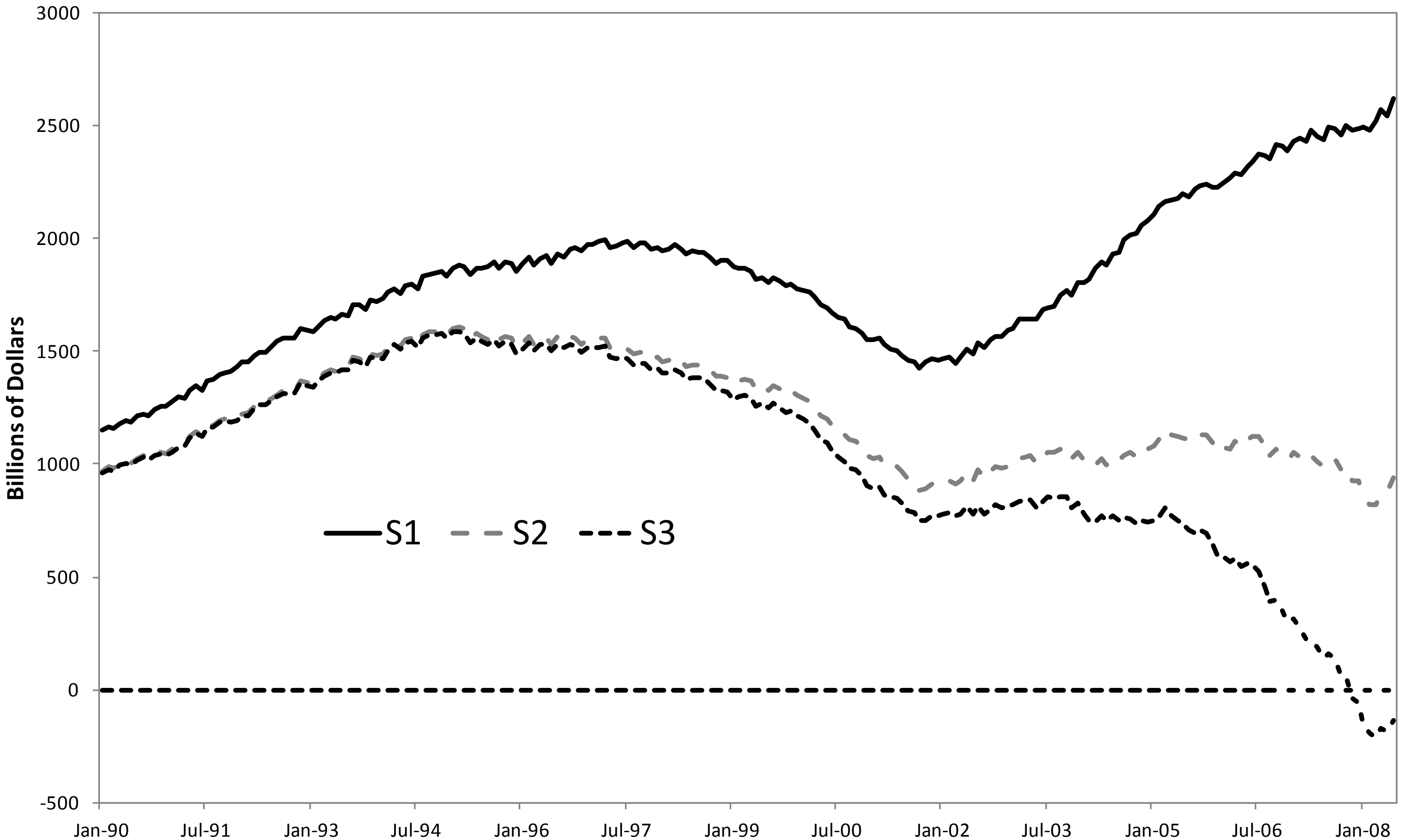


Figure 3: Alternative Measures of the Public's Holding of Government Debt



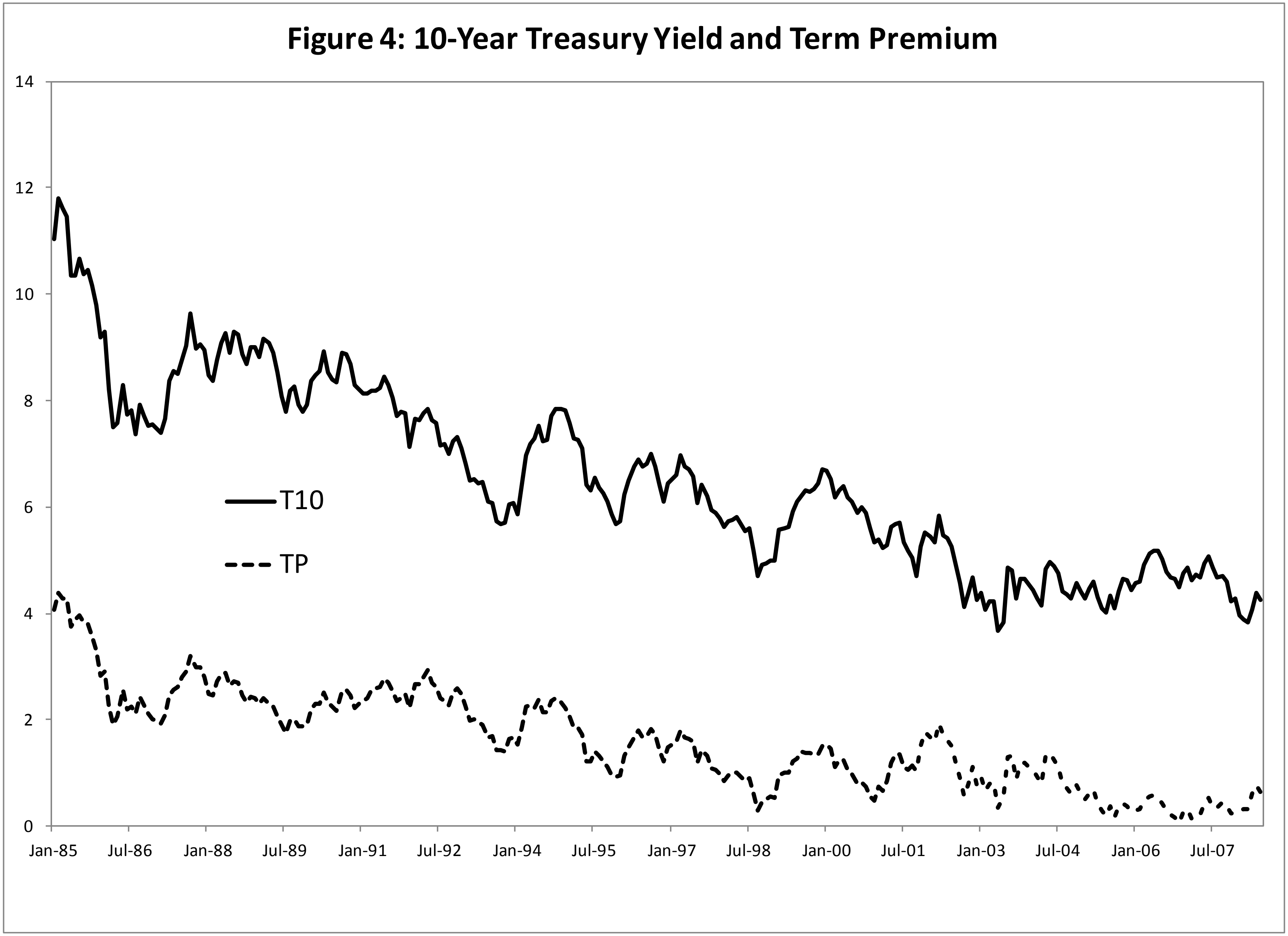


Figure 4: 10-Year Treasury Yield and Term Premium
14
12
10
8
6
4
2
0
T10
TP
Jan-85
Jul-86
Jan-88
Jul-89
Jan-91
Jul-92
Jan-94
Jul-95
Jan-97
Jul-98
Jan-00
Jul-01
Jan-03
Jul-04
Jan-06
Jul-07

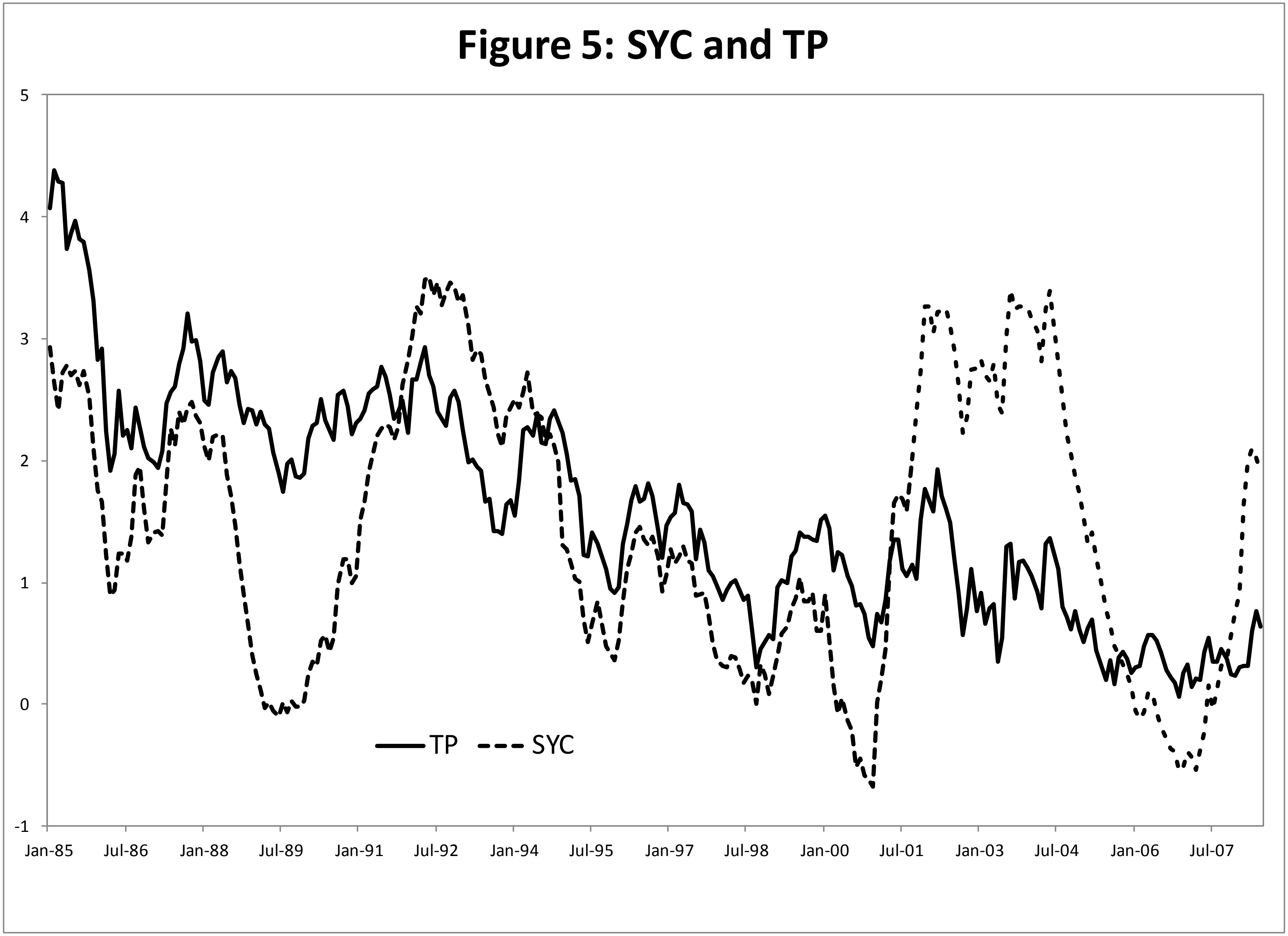


Figure 5: SYC and TP
5
4
3
2
1
0
-1
Jan-85
Jul-86
Jan-88
Jul-89
Jan-91
Jul-92
Jan-94
Jul-95
Jan-97
Jul-98
Jan-00
Jul-01
Jan-03
Jul-04
Jan-06
Jul-07
TP
SYC

Appendix

Table A1: Dependent Variable $T10$, January 1985 – June 2008								
	Coef.	P-value	Coef.	P-value	Coef.	P-value	Coef.	P-value
Const.	4.8405	0.0000	4.0288	0.0018	4.3217	0.0036	4.4339	0.0059
gap	-0.2472	0.0037	-0.2529	0.0035	-0.2477	0.0036	-0.2576	0.0048
cpi	0.3100	0.0044	0.3770	0.0029	0.3734	0.0100	0.3389	0.0092
$lrid$	0.6654	0.0003	0.7113	0.0001	0.7003	0.0001	0.7002	0.0001
rv	0.2827	0.4145	0.4109	0.2282	0.3425	0.3308	0.3032	0.3738
Trend	-0.0146	0.0000	-0.0123	0.0000	-0.0119	0.0000	-0.0117	0.0016
$S1$	0.0003	0.3116						
$S2$			0.0004	0.2610				
$S3$					0.0002	0.4527		
$S3^{gdp}$							0.0165	0.5699
$\overline{R}^2$	0.8999		0.9007		0.8998		0.8995	
$s.e.$	0.5536		0.5513		0.5539		0.5548	

Table A2: Dependent Variable $T10$, January 1985 – June 2008										
	Coef.	P-value	Coef.	P-value	Coef.	P-value	Coef.	P-value	Coef.	P-value
Const.	6.6212	0.0000	6.1643	0.0000	11.0086	0.0000	19.8398	0.0000	4.4411	0.0012
gap	-0.2560	0.0021	-0.2567	0.0021	-0.2396	0.0039	-0.0044	0.9117	-0.2462	0.0035
cpi	0.3168	0.0034	0.3003	0.0045	0.2136	0.0402	0.1312	0.0259	0.3490	0.0052
$lrid$	0.5869	0.0009	0.5998	0.0009	0.3925	0.0088	0.3632	0.0000	0.6992	0.0001
rv	0.0956	0.7541	0.1266	0.6949	0.0761	0.8035	0.3908	0.0098	0.3286	0.3340
Trend	-0.0143	0.0000	-0.0139	0.0000	-0.0125	0.0000	-0.0019	0.0741	-0.0126	0.0000
AM	-0.0146	0.4315								
$P10$			-0.0364	0.3105						
DUR					-0.8946	0.0000				
$DUR10$							-2.0904	0.0000		
$S2^{duradj}$									0.0004	0.4904
$\bar{R}^2$	0.8999		0.9001		0.9238		0.9594		0.8996	
$s.e.$	0.5537		0.5532		0.4831		0.3527		0.5544	