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## The liquidity premium of safe assets: The role of government debt supply

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## The Liquidity Premium of Safe Assets: The Role of Government Debt Supply

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# The Liquidity Premium of Safe Assets: The Role of Government Debt Supply\*

## Abstract

The persistent premium of government debt attributes to two main reasons: absolute nominal safety and liquidity. This paper employs two types of measures of government debt supply to disentangle the safety and liquidity part of the premium. The empirical evidence shows that, after controlling for the opportunity cost of money, the quantitative impact of total government debt-to-GDP ratio is still significant and negative, which is consistent with the theoretical predictions of the CAPM with utility surplus of holding convenience assets. The relative availability measure, the ratio of total government liability to all sector total liability, separates the liquidity premium from the safety premium and has a negative impact too. Both theoretical and empirical results suggest that the substitutability between government debt and private safe assets dictates the quantitative impact of the government debt supply.

*Keywords: safe asset, government debt, liquidity premium, safety premium*

*JEL Classification: E41 , E43, G12*

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## 1 Introduction

The persistent premium of government debt often attributes to two main reasons: absolute nominal safety and liquidity. Such near-money quality allows the government debt to offer much lower yields compared with private safe assets that can potentially provide a similar level of safety and liquidity. The yield spread is also known as “convenience premium”. The possible quantitative impact of government debt supply on convenience premium puts the government debt premium at the intersection of fiscal policy and monetary policy. A better understanding of the government debt premium and its dynamics can offer valuable guidance to both monetary and fiscal policy implementation. This paper employs two types of measures of government debt supply to study the quantitative impact of government debt supply and disentangle the safety and liquidity part of the premium. The empirical investigation abstracts away from the risk premium by only using private safe assets to construct the spreads against Treasury Bills.

The theoretical approach of this paper follows the standard practice in the literature that holding assets with safety and liquidity derives extra utility. Government debt is thus the ideal asset to provide such service. First, backed by the future tax revenue and the credibility of sovereign authority, government debt is the safest asset available on the financial market. Until recently, highly rated government debt, such as US Treasury bills, is perceived almost immune to any default risk. This makes government debt the perfect asset to store value for future periods, especially in a crisis. Such certainty in nominal payback offers investors additional utility in holding safe assets besides the usual safe asset demand from CAPM. Second, thanks to the credibility of the government, the large volume and highly standardized simple contract form, government debt is very liquid and has negligible bid-ask spread. It provides additional liquidity service such as being used as collateral and as payment.<sup>1</sup>

The demand for government debt should be growing if the government debt can maintain its safety and liquidity advantage. The accumulation of wealth leads to growing demand for safe asset simply due to a larger balanced portfolio given constant risk preference (same need for safety and liquidity). Moreover, in crisis periods such as the recent Great Recession, investors tend to “flight to liquidity” and “flight to safety”. Such market panic further boosts the demand for government debt. The global imbalance in safe asset creation brings more demand for government debt of developed economies,

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<sup>1</sup>Note that the liquidity of government stems from its safety. No asset with considerable level of credit risk can be liquid.

which are the real safe government debt. Due to the unstable political and institutional environment in many emerging markets, investors in those countries turn to US or EU for safe storage of value. [Caballero and Krishnamurthy \(2009\)](#) documents and analyzes such global imbalance in more details.

The supply of safe assets, however, especially the safest government debt, has no “supply function” to endogenously keep up with the growing demand. The supply of government debt is relatively exogenous. For most of the governments, issuance of government debt follows their fiscal needs rather than financing cost. Although temporary fiscal expansion is often ordered to combat economic downturn, such expansion will be cut back once the economy recovers. Crisis can sometimes destroy safe assets to reduce the total supply of private and public safe assets. During the European Sovereign Debt Crisis, many safe assets in normal times, such as government debt of smaller European economies, became no longer safe.

The ever growing demand and the sluggish supply of safe asset create a lasting shortage of safe asset. This problem has become more pronounced in recent years since the Great Recession. For instance, Barclay’s 2012 report, [Gorton and Ordoñez \(2014\)](#), and [Caballero and Krishnamurthy \(2009\)](#) all address this very problem and discuss its impact on global economy. Theoretically, the growing gap between safe asset demand and supply will push the yields on government debt lower and lower. Empirically, despite the fact that most of the government around the world increased the total amount of government debt to finance the stimulus package required to bring the economy out of recession, the yields of government debt keep reaching a record low, especially for high credit rating countries such as USA and Germany. If one stays true to the face value of the empirical evidence, she would conclude that the supply of government debt has no quantitative effect of its price. However, one can also argue that if were not the increased supply, the yields of government debt would be even lower. To make the problem even more complicated, one should notice that it is not easy to single out the quantitative effect of the total supply of government debt because monetary policy also has an impact on the price of government debt. For instance, crisis period often induces loose monetary policy that makes yields of all assets lower. Therefore when the yields of government debt drop, it always coincides with the supply increase and short-term interest rate decrease. It is evident that low short-term interest rate will push down the government debt yield. The question is whether the total supply of government debt still has an impact on its pricing. If there is no quantitative effect on the premium of government debt, the more puzzling

question is why not.<sup>2</sup>

It is also critical to understand the driving forces of government debt premium variation. Greenwood, Hanson, and Stein (2015) and Krishnamurthy and Vissing-Jorgensen (2012) assumes that the safety and liquidity premium comes from the intrinsic safety and liquidity service government debt provides on top of the general consumption smoothing purpose. They also assume that such utility surplus of holding safe asset has decreasing marginal utility just like the consumption. If we incorporate this assumption with the canonic CAPM, the variation in the premium of government debt comes from three possible driving forces: risk preference (this part of the premium is known as risk premium), safety preference and liquidity preference. Safety preference can vary when investors suddenly realize that certain government's balance sheet is no longer sound. For instance, when investors observe the level of government debt being too high compared with the future tax revenue, such government debt is no longer nominal safe and thus will have a lower safety premium. Therefore, it is very likely that the total government debt-to-GDP ratio influences investors' opinion on the safety of government debt since GDP also captures the tax revenue of an economy. Liquidity preference, however, depends on the relative availability of high-quality, safe asset like government debt. The ratio of government liability to all sector liability ratio, for instance, is likely to capture the scarcity of government debt on the financial market. However, this is unlikely to have much safety implication.

This paper uses the public data on the national account and financial market interest rates to test the quantitative impact of government debt supply. The empirical evidence shows that, after controlling for the opportunity cost of money, the quantitative impact of total government debt-to-GDP ratio is still significant. The relative availability measure, the ratio of total government liability to all sector total liability, disentangles the liquidity part of convenience premium. It also helps us understand the dynamics of the premium measured by the spreads of Treasury bills and different private safe assets. The premium of government debt against various private safe assets tend to differ based on how much safer and more liquid government debt is compared with other private safe assets. The empirical evidence also suggests that the substitutability between government debt and private safe assets dictates the quantitative impact of the government debt supply.

The paper is organized as follow. Section 2 discusses the alternatives of government

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<sup>2</sup> Common economic intuition would lead us to believe that the total supply of government debt must matter. For instance, if the government issues debt to an unsubstantiated amount by its tax income, the perceived safety and liquidity would all disappear. The premium of government debt against other safe assets will be gone, thus leads to a higher yield.

debt when investors are looking for safety and liquidity. Section 3 presents the theoretical framework of convenience premium. Section 4 empirically investigates the quantitative effect outgrows supply. Section 5 looks at some more puzzling empirical evidence and offers a brief discussion of their policy implications. Finally, section 6 concludes the paper.

## 2 Safe Alternatives

To understand the pricing of government debt, one has to start to consider what is the alternative of government debt for investors who seek safety and liquidity. Within the basket of relatively safe assets, there are bank deposits, money market mutual fund shares, commercial paper, federal funds and repurchase agreements (repo), short-term interbank loans, Treasuries, agency debt, municipal bonds, securitized debt, and high-grade financial-sector corporate debt. This list comes from [Gorton, Lewellen, and Metrick \(2012\)](#). We compare the safe alternatives with government debt regarding both safety and liquidity. [Golec and Perotti \(2014\)](#) provide a more detailed review, which also provides an intuitive diagram that places those assets on their safety and liquidity. Theoretically, the safest and liquid asset should always have the lowest yield regardless of the macroeconomic situation.

Some prominent and reputable institutes in private sector have the capacity of providing assets with very low credit risk, that can sometimes be treated almost as a zero-credit risk. Meanwhile, for liquidity measures, obvious alternatives are money (usually in the form of deposit) and cash for utmost liquidity and safety. If an investor holds cash and bears all the inflation risk and storage cost, she would have the highest liquidity service and absolute nominal certainty. Let's look into those two types of alternatives closely.

### 2.1 *Private Safe Assets*

The safe assets that private sectors can provide include deposits, repurchase agreement, highly rated corporate bonds (i.e. Aaa Moody ratings), commercial papers, and priority loans. Conditional on providing the similar level of liquidity and safety, private safe assets are substitutes to government debt. However, considering the moral hazard problem of private investors and financial intermediaries (see [Holmström and Tirole \(1998\)](#) and [Holmström and Tirole \(2001\)](#)), private safe assets can never be truly as safe as government debt. Private safe assets also cannot match the volume of government debt. Therefore private safe assets are the dominated choice regarding both liquidity and safety. That is



the reason that we consistently observe yield discount on government debt over the private alternatives, which is also known as “convenience premium”. However, the existence of convenience premium does not disqualify private safe assets as substitutes of government debt. [Krishnamurthy and Vissing-Jorgensen \(2015\)](#) find that privately provided safe asset and Treasury bills are substitutive. With the US historical data from 1875 to 2014, they verify that government debt crowds out financial sector lending financed by short-term debt. Instead, the inferior efficiency of private safe assets in providing liquidity and safety service suggests that they are the partial substitutes of government debt. This is a common assumption adopted by many papers in the recent literature.

While the spread between government debt and private safe assets persists, its size keeps varying, which indicates that convenience premium varies too. This begs the answer to the question what are the key driving forces of convenience premium variation. Recent literature focuses its attention on the supply of government debt, a natural suspect for convenience premium variation according to our most intuitive economic knowledge. When there are exogenous shocks to the supply and demand of safe asset, how would convenience premium change? [Krishnamurthy and Vissing-Jorgensen \(2012\)](#) claims that government debt supply has a negative quantitative effect on the premium. [Vayanos and Vila \(1999\)](#) shares the same opinion with a study of two types of risk-less assets. [Rocheteau \(2009\)](#) claims that there is no clear implication as for why liquidity premium should exist in both relatively liquid assets compared with equity. Their model explains the yield spread between typical risky corporate bonds and Treasury bills should decrease as government debt supply goes up. However, [Nagel \(2016\)](#) disagrees with the findings and favors the opportunity cost of money, short term interest rate, the actual reason of liquidity premium variation. [Vissing-Jorgensen \(2015\)](#) shows that the quantitative effect persists and the true difference lies in how to test the premium of government debt. This paper will try to contribute to the discussion with a recently updated post-crisis data and at a quarterly frequency.

Based on the partial substitutability, the total supply of government debt will change the relative demand of government debt and private safe asset, and thus the convenience premium. [Carlson, Duygan-Bump, Natalucci, Nelson, Ochoa, Stein, and Van den Heuvel \(2014\)](#) summarize the following four testable hypotheses:

- The supply of government debt is negatively correlated with the quantity of private safe assets. Such crowding out effect has been proven by [Krishnamurthy and Vissing-Jorgensen \(2015\)](#).
- Increases of supply of government debt should lead to decreases in the convenience

premium on government debt compared with assets without liquidity and safety (higher yields).

- Increase of supply of government debt should lead to decreases in the convenience premium on private safe assets compared with assets without liquidity and safety (higher yields).
- Increases in the supply of government debt should lead to decreases in the spread between public and private safe asset yields. (government debt have better safety and liquidity service, thus would react more than the private safe assets. both should increase their yields.)

Some empirical evidence is gathered to test these hypotheses. In Figure 1, I plot the historical record of Treasury bill yields (three months and one year), Aaa corporate bond yields and government debt to GDP ratio. We can see that Treasury bill yields seem to move in opposite direction of debt to GDP ratio. For instance, the obvious low government debt level during the early 80s, T-bill yields reach a record high. For a short period, T-bill yields were even greater than the Aaa corporate bond, which is very puzzling considering that government debt is superior to corporate bonds regarding credit risk, liquidity, and nominal safety. During two Iraq wars in the early 1990s and 2000s, the raising government debt to GDP was accompanied by decreasing yields of T-bills. However, the robust fiscal era during Clinton administration saw a decline in government debt to GDP and a high yield period for T-bill. Finally, it is most evident after the Great Recession that a high debt to GDP ratio is synchronized with a period of very low T-bill yields. Once we have a clear idea about the evolution of those yields and government debt to GDP ratio, we will test the latter three hypotheses.

Figure 2 plots yields and spreads of safe assets against government debt-to-GDP ratio. The level of government debt and the quarterly average yields of T-bills seem to have a negative correlation. Moreover, the yields of corporate bonds are also negatively correlated with the debt to GDP ratio; even the Baa-rated risky corporate bonds. Clearly, the empirical evidence goes against the second and third hypotheses. Moreover, the spreads do not have a very clear correlation with the government debt to GDP ratio, if not a slightly positive correlation. This contradicts with the fourth hypothesis. Moreover, [Krishnamurthy and Vissing-Jorgensen \(2012\)](#) find that the spread in yields between Aaa bonds and Treasury bills decreases with the total supply of T-bills at a yearly frequency and with a longer time series. To find out why we have such different observation, I, therefore, try to plot again at an annual frequency with only the post-war data in Figure 3. The first row is the replications without post-Great-Recession data, and the second row

is the ones with. It does not look likely that the post-war correlation between convenience premium and government debt-to-GDP ratio is negative.

It is worth noticing that in [Krishnamurthy and Vissing-Jorgensen \(2012\)](#), they have the low spreads and high debt-to-GDP ratio observations from the era when US government had to finance their arms during World War 2 and Korean War. If we exclude those observations, the negative correlation will be less evident. Moreover, our data also includes many high spreads and high debt-to-GDP ratio observations after the Great Recession. By different sampling period, it seems that we end up with entirely different implications. It appears that some other very important explanatory variables are missing.

## *2.2 Trade-off Between Government Debt and Money*

Money is theoretically the safest and liquidity asset that does not offer any yield. However, it is costly to hold money in the portfolio considering the inflation risk and storage cost. Therefore government debt, in particular, the US Treasury bills and German federal government bonds, is the second best way to store value safely. In the theoretical framework, [Nagel \(2016\)](#) argues that when considering obtaining liquidity service investors turn to the more liquid and safe option, money, instead of private safe assets. He assumes that money and near-money assets like Treasury bills are substitutes in providing liquidity service and the opportunity cost of money is the main driving force of liquidity premium. If the opportunity cost of holding government debt is high (high fed effective rate periods), investors are less willing to hold government debt thus leads to a high yield of government debt.

The discussion boils down to the question that whether the supply of safe asset has an impact on the convenience premium when the short-term interest rate is taken into account. [Nagel \(2016\)](#) builds a model where money and government debt are imperfect substitutes to explain that supply of government has very limited ability in explaining the liquidity premium variation.<sup>3</sup> He argues that when the central bank is pledged to keep its independently targeted short-term interest rate, the central bank will have to react to the injection of “near money” government debt as an increase in total money supply. Therefore the subsequent open market operation will accommodate and neutralize shocks to government debt supply and demand. He uses the spread between Generalized Collateral Repurchase Agreement and Treasury bills to measure the liquidity premium

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<sup>3</sup>[Nagel \(2016\)](#) does not use the term “convenience premium”, but the liquidity premium is very similarly defined in his paper. We can treat them equivalently.

and find that government debt-to-GDP ratio does not have any significant impact on the premium.

It is well documented that the Fed effective rate is highly and positively correlated with Treasury bills. It is not surprising that short-term interest rate can affect the premium of Treasury bills. However, as pointed out by [Vissing-Jorgensen \(2015\)](#), the relation between Reserves and Treasury supply is positive, not negative. The central bank does not seem to accommodate liquidity shocks caused by government debt supply. Moreover, there is a more theoretically puzzling empirical evidence. Money is supposed to be safer and more liquid compared with Treasury bills thus enjoys a non-negative yield premium. However, [Figure 4](#) shows that short-term Treasury bills have lower yields than Fed effective rate for most of the quarters since the 1980s. This suggests a reversed superiority regarding safety and liquidity between Treasury bills and money. Although this is not the focus of this paper, it is a remarkable puzzling fact for later discussion.

To sum up, money should certainly be considered as one of the alternatives to government debt when investors seek safety and liquidity. However, it should not be regarded as the only alternative or even the preferred alternative. Therefore empirical analysis of this paper will control for the opportunity of money to investigate the premium of Treasury bills.

### 3 Theoretical Framework

The theoretical framework is largely based on the modified representative agent asset-pricing model in [Krishnamurthy and Vissing-Jorgensen \(2012\)](#) whereby agents can derive utility directly from holding safe assets. Such modification goes back to the model of [Sidrauski \(1967\)](#) in which one can derive utility from holding money. We further modify the model by introducing relative availability measure and the opportunity cost of money as preference shifter. The representative agent maximizes

$$\mathbf{E} \sum_{t=1}^{\infty} \beta^t u(C_t).$$

$C_t$  is the combined consumption of traditional goods and service  $c_t$  and “convenience” service from holding safe assets:

$$C_t = c_t + v(\theta_t^A; \xi_t).$$

The function  $v(\ast)$  measures the convenience service an agent gets from holding safe asset  $\theta_t^A$ , which is the market value of the weighted total safe asset:

$$\theta_t^A = \theta_t^T + k^P \theta_t^P.$$

The government debt  $\theta_t^T$  (Treasury bills) is superior in providing convenience service than the private safe asset  $\theta_t^P$ .  $k^P$  captures the agent's opinion on the efficiency of a private safe asset in providing convenience service compared with government debt. This also measures the elasticity of substitution between government debt and private safe asset regarding providing convenience service. We will later consider that this opinion can vary when the relative availability of government debt changes.  $\xi_t$  is the preference shock that changes the curvature of the convenience function. We also assume that the convenience function is concave with respect to  $\theta_t^A$  based on [Vayanos and Vila \(1999\)](#) and [Rocheteau \(2009\)](#) **Find more literature on this.**

When the agent purchases a zero-coupon nominal Treasury bill for convenience service at a price  $P_t^T$  where over all price level is  $Q_t$ , her holding of  $\theta_t^A$  increases by  $P_t^T/Q_t$ . Therefore the first-order condition for government debt holding is

$$-\frac{P_t^T}{Q_t} u'(C_t) + \beta \mathbf{E}_t \left[ \frac{P_{t+1}^T}{Q_{t+1}} u'(C_{t+1}) \right] + \frac{P_t^T}{Q_t} v'(\theta_t^A; \xi_t) u'(C_t) = 0. \quad (1)$$

Denote the pricing kernel for nominal payoff as

$$M_{t+1} = \beta \frac{u'(C_{t+1})}{u'(C_t)} \frac{Q_t}{Q_{t+1}}. \quad (2)$$

Then the expression of equilibrium price for Treasury bill can be simplified as

$$P_t^T = \frac{\mathbf{E}_t[M_{t+1} P_{t+1}^T]}{1 - v'(\theta_t^A; \xi_t)}. \quad (3)$$

Similarly, we can derive the expression for the private safe assets:

$$P_t^P = \frac{\mathbf{E}_t[M_{t+1} P_{t+1}^P]}{1 - v'(\theta_t^A; \xi_t) k^P}. \quad (4)$$

### 3.1 The Spread of Private Safe Asset and Government Debt

We are interested in the premium of government debt over the private safe assets, which is the yield difference between private safe asset and Treasury bills. Using equation 3 and

4, we can construct the spread:

$$S_t^{PT} \equiv i_t^P - i_t^T = \frac{P_{t+1}^P}{P_t^P} - \frac{P_{t+1}^T}{P_t^T} = \frac{[v'(\theta_t^A; \xi_t) - v'(\theta_t^A; \xi_t)k^P]}{\mathbf{E}_t[M_{t+1}]} = \frac{v'(\theta_t^A; \xi_t)(1 - k^P)}{\mathbf{E}_t[M_{t+1}]} \quad (5)$$

The spread thus depends on the first derivative of convenience function, the elasticity of substitution and the pricing kernel. The pricing kernel depends mainly on the curvature of the utility function and the inflation rate, which are often not directly correlated with the supply of government debt. The variation of the spread is likely to come from the numerator of the right hand side of equation 5. We take the partial derivative of  $i_t^P - i_t^T$  with respect to  $\theta_t^T$ :

$$\frac{\partial(i_t^P - i_t^T)}{\partial\theta_t^T} = \frac{1}{\mathbf{E}_t[M_{t+1}]} \frac{\partial[v'(\theta_t^T + k^P\theta_t^P; \xi_t)(1 - k^P)]}{\partial\theta_t^T} \quad (6)$$

Researches such as [Krishnamurthy and Vissing-Jorgensen \(2015\)](#) and [Gorton and Ordoñez \(2013\)](#) provide theoretical and empirical evidence that private safe assets are substitutes of government debt and are likely to respond quantitatively to a change in the supply of government debt. Therefore we can rewrite equation 6 as

$$\frac{\partial(i_t^P - i_t^T)}{\partial\theta_t^T} = \frac{1}{\mathbf{E}_t[M_{t+1}]} (1 - k^P) [v''(\theta_t^A; \xi_t) (1 + k^P \frac{\partial\theta_t^P}{\partial\theta_t^T})] \quad (7)$$

$\partial\theta_t^P/\partial\theta_t^T$  is also known as the crowding out effect. Since government debt is superior in both liquidity and safety, it is clear that  $1 - k^P$  is positive.  $v''(\theta_t^A; \xi_t)$  is assumed to be negative due to the concavity of the convenience function. Therefore, the quantitative impact of government debt supply hinges on the last part of the equation —  $(1 + k^P \frac{\partial\theta_t^P}{\partial\theta_t^T})$ .

**Proposition 1.** *The quantitative impact of government debt supply on convenience premium depends on how sensitive private safe assets are to the crowding out effect. If the crowding out effect is mild, i.e.  $k^P \partial\theta_t^P/\partial\theta_t^T > -1$ , the spread between private safe asset and government debt is negatively correlated with the supply of government debt. If the crowding out effect is drastic, i.e.  $k^P \partial\theta_t^P/\partial\theta_t^T < -1$ , it is possible that the spread is positively correlated with the government debt supply.*

We test this proposition in the empirical analysis section using private safe assets with different supply flexibility.

### 3.2 Short-Term Interest Rate and Relative Availability

The opportunity cost of money, often measured by short-term interest rate, is highly correlated with most of the short-term private safe assets and Treasury bills. Intuitively, it is very likely that it will affect the spread of private safe assets and government debt. Nagel (2016) verifies such intuition by showing a strong correlation between the spread of GC repo and Treasury bills and Fed effective rate. To include the impact of short-term interest rate without overly complicating the model, I assume that the global economic impact of short-term interest rate channels through by changing the curvature of the convenience function. For instance, a decrease in short-term interest rate would lead to more supply of overall liquidity on the financial market, which will make the liquidity feature of government debt less desirable. This is likely to make the marginal convenience gain smaller at the same level of weighted safe asset holding. Thus we can have the following expression:

$$\left. \frac{\partial v'(\theta_t^A; \xi_t)}{\partial r^F} \right|_{\theta_t^A = \theta_t^A} > 0, \quad (8)$$

where  $r^F$  is the short-term interest rate.

**Proposition 2.** *The short-term interest rate is positively correlated with the convenience premium. A higher short-term interest rate would lead to a larger spread of private safe asset and government debt.*

As mentioned in the introduction, the relative availability can influence how much investors value the liquidity service provided by government debt compared with the liquidity service provided by private safe assets. We introduce such influence through the elasticity of substitution  $k^P$ . When the government debt becomes more available on the financial market, its liquidity service becomes less superior to the private safe asset. Therefore we are likely to see the elasticity of substitution parameter  $k^P$  go up:

$$\frac{\partial k^P}{\partial l_t} > 0. \quad (9)$$

$l_t$  measures the relative availability of government debt. In later section, I use the total government liability to total all sector liability ratio as a proxy for  $l_t$

**Proposition 3.** *The relative availability of government debt is negatively correlated with the convenience premium. A higher relative availability would lead to a smaller spread of private safe asset and government debt.*

### 3.3 Assets Without Convenience

For the assets that do not offer any convenience service, I follow the same approach as [Krishnamurthy and Vissing-Jorgensen \(2012\)](#) and assume a default probability  $\lambda_t$  and a default payoff  $(1 - L_{t+1})$ . If the asset does not default, it is worth  $P_{t+1}^C$ . Then we would have the following pricing equation:

$$P_t^C = \lambda_t \mathbf{E}_t[M_{t+1}(1 - L_{t+1})|\text{Default}] + (1 - \lambda_t) \mathbf{E}_t[M_{t+1}P_{t+1}^C|\text{No Default}] \quad (10)$$

We consider one-period zero coupon bonds just like the case in Treasury bills. We can thus normalize the price at  $t+1$  —  $P_{t+1}^C = P_{t+1}^T = 1$ . Then I approximate the yields in continuous time.

$$e^{-i_t^T} = P_t^T = \frac{\mathbf{E}_t[M_{t+1}P_{t+1}^T]}{1 - v'(\theta_t^A; \xi_t)} \approx e^{v'(\theta_t^A; \xi_t)} \mathbf{E}_t[M_{t+1}] \quad (11)$$

$$\begin{aligned} e^{-i_t^C} = P_t^C &= \mathbf{E}_t[M_{t+1}] - \mathbf{E}_t[M_{t+1}] \mathbf{E}_t[\tilde{L}_{t+1}] - \mathbf{Cov}_t[M_{t+1}, \tilde{L}_{t+1}] \\ &\approx e^{-\lambda_t \mathbf{E}_t[L_{t+1}] - \mathbf{Cov}_t[M_{t+1}, \tilde{L}_{t+1}]/\mathbf{E}_t[M_{t+1}]} \mathbf{E}_t[M_{t+1}] \end{aligned} \quad (12)$$

$\tilde{L}_{t+1}$  is zero in the case of no default and is  $L_{t+1}$  in the case of default. We can then construct the spread

$$S_t^{CT} \equiv i_t^C - i_t^T = v'(\theta_t^A; \xi_t) + \lambda_t \mathbf{E}_t[L_{t+1}] + \mathbf{Cov}_t[M_{t+1}, \tilde{L}_{t+1}]/\mathbf{E}_t[M_{t+1}]. \quad (13)$$

The quantitative effect of government debt supply will channel through by the term  $v'(\theta_t^A; \xi_t)$  similarly as discussed in the previous case of  $S_t^{PT}$ . Therefore we shall expect a negative impact of the government debt supply to this spread. However, it is less clear how the short-term interest rate is going to affect the spread.

$$\frac{\partial(i_t^C - i_t^T)}{\partial r^F} = \frac{\partial v'(\theta_t^A; \xi_t)}{\partial r^F} + \frac{\partial \lambda_t \mathbf{E}_t[L_{t+1}] + \lambda_t \partial \mathbf{E}_t[L_{t+1}]}{\partial r^F} + \frac{\partial \mathbf{Cov}_t[M_{t+1}, \tilde{L}_{t+1}]}{\partial r^F \mathbf{E}_t[M_{t+1}]} \Bigg|_{\theta_t^A = \theta_t^A} \quad (14)$$

Finally, the relative availability measure is not likely to have any direct impact on this spread. <sup>4</sup>

**Proposition 4.** *For convenience premium measured by the spread of assets without con-*

<sup>4</sup>One possible channel is through  $v'(\theta_t^A; \xi_t)$ :  $\frac{\partial(i_t^C - i_t^T)}{\partial l_t} = v''(\theta_t^A; \xi_t) \theta_t^P \frac{\partial k^P}{\partial l_t} < 0$ . However, this is likely to be negligibly small.



*venience service and Treasury bills, the quantitative impact of government debt supply is likely to be negative, while the impact of short-term interest rate is unclear. The effect of relative availability will be indirect and insignificant.*

## 4 Empirical Analysis

This paper conducts a series of empirical analysis based on the previous theoretical framework to test the propositions from the theoretical predictions. The data mainly comes from the public data of FRED St. Louise. For the variables that are not available on FRED, such as stock market index and repo interest rate, Datastream is the data source. The empirical analysis is organized in such a way that readers can quickly draw a comparison with the previous literature.

The key explanatory variable in all the following regressions is the measure of total government debt supply. I use the market value of total government debt outstanding to GDP ratio (debt-to-GDP ratio) to measure the government debt supply in the model. The observation is at a quarterly frequency, which offers enough variation in the debt-to-GDP ratio and larger sample size than the annual data. The Fed effective rate is used to measure the short-term interest rate. This paper primarily concentrates on safe assets, but most of them cannot be completely credit risk free. Therefore VIX index is used to control for credit risk and financial market volatility. The VIX index is a widely used indicator of financial market stress. The CBOE S&P500 implied volatility index is available since 1986. Before January 1986, VIX is the quarterly average of the imputed daily VIX index using a projection of observed VIX on S&P500 squared daily return. VIX can also help us to catch the demand shocks in convenience function and the variation of pricing kernel.

### 4.1 Total Government Debt Supply and Relative Availability

The common measure of government debt is the total government debt-to-GDP ratio. By normalizing by GDP, we control for the price level. However, total government debt is a stock variable that measures all the government debt outstanding. While GDP is a flow variable that measures how much product and service is created in a certain period. The ratio measures the relative size of total government debt to production, but it does not measure the relative availability of government debt. Hypothetically speaking, if the total asset creation outgrows GDP, even total government debt to GDP is increasing, the relative supply of government debt could be decreasing, which will lead to larger safe asset

supply deficit. If we do not distinguish the difference, such negligence can prompt us to completely different implication when we look at the quantitative effect on the premium of government debt.

It is necessary to devise a measure of government debt supply that captures more the liquidity than the safety. In theory, the safety and liquidity premium comes from the intrinsic safety and liquidity service government debt provides on top of the general consumption utility. If we incorporate this assumption with the canonic CAPM, the variation in the premium of government debt comes from three possible driving forces: risk preference (this part of the premium is commonly captured as risk premium), safety preference and liquidity preference. Safety preference can be altered when investors suddenly realize that certain governments balance sheet is no longer sound. For instance, when investors observe the level of government debt being too high compared with the future tax revenue, such government debt is no longer nominal safe and thus will have a lower safety preference. Tax revenue is a certain percentage of the GDP. Therefore, it is very likely that the total government debt to GDP ratio influences investors opinion on the safety of government debt. We call government debt-to-GDP ratio relative safety measure.

Liquidity preference, however, depends on the relative availability of high-quality, safe asset as government debt as its function is primarily quick and costless liquidation for payment and collateral. One possible measure for relative availability is the ratio of total government liability to all sector liability, which directly measures the relative scarcity of government debt on the financial market. We, therefore, construct the ratio of all government liability to all sector liability as an additional measure of government supply to capture the liquidity part of the convenience premium. Figure 5 clears the concern that these two measures are the two sides of a coin as it shows a negative correlation between the two. The hypothetical case mentioned earlier can indeed happen and does occur in the periods from the 1980s to mid-1990s and from early 2000s to the Great Recession.

#### *4.2 Convenience Premium over Aaa Rated Corporate Bonds*

We first look at the spread between Aaa-rated corporate bonds and 3-month Treasury bills to see the quantitative effect of government debt supply. By adding the relative availability measure, we can test whether this measure can capture the liquidity part of the convenience premium. Moreover, it is not certain that whether Aaa corporate bonds can provide convenience considering they are riskier and much less liquid than

the government debt. The empirical evidence here could correspond to either equation 5 or equation 13. Table 1 presents the results of such exercise. Column 1 to 3 uses the debt-to-GDP ratio and VIX as the baseline explanatory variables and column 4 to 6 uses the relative availability measure and VIX as the baseline regression.

Column 1 replicates the [Krishnamurthy and Vissing-Jorgensen \(2012\)](#) results with different sampling period. We can see that without control for cost of money, regression results lead us to the confusing positive correlation between debt-to-GDP ratio and convenience premium. This leads to the implication that corporate bond supply is very sensitive to crowding out effect according to Proposition 1. However, corporate bonds often have much longer maturity than 3-month Treasury bills, and the supply of corporate bonds is not as flexible neither. However, when we include short-term interest rate as one of the explanatory variables in column 2, the coefficients of debt-to-GDP becomes negative, which is consistent with the prediction in Proposition 1 and 4. When we further add the relative availability measure in column 3, the coefficient remains negative and significant. This is also consistent with the results from [Krishnamurthy and Vissing-Jorgensen \(2012\)](#) and [Greenwood, Hanson, and Stein \(2015\)](#).

Interestingly, the coefficients of Fed effective rate and the relative availability are negative and positive respectively. This strongly contradicts the prediction from Proposition 2 and 3. Fed effective rate is supposed to have a positive impact, and the coefficient of the relative availability measure is supposed to be negative. Thus, Aaa corporate bond is more likely to be the asset without convenience service, and the spread we measure here is  $S_t^{CT}$ . The negative coefficient is due to the negative impact from the second and third terms in equation 14.<sup>5</sup> The remaining problem is that when all explanatory variables are included, the relative availability measure is negative and significant. We need to interpret this result with the findings of [Gorton, Lewellen, and Metrick \(2012\)](#). Investors have a very consistent preference and demand for safe assets in broader definition. The positive correlation between relative availability measure and spread is the result of government debt crowding out corporate bonds. When the total available government debt increases, the demand for highly rated corporate bonds decrease, which leads to a higher yield to obtain a new market clearing price. Therefore the positive coefficient suggests that the crowding out effect trumps the reduced liquidity service due to higher availability of government debt. In other words, safety premium is likely to be the predominant concern when investors choose government debt over corporate bonds.

Results in column 4 to 6 of Table 1 confirms that relative availability measure is not

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<sup>5</sup>The author is not sure what type economic intuition is behind this.

likely to be the main driving force of Aaa-Treasury spread variation. Moreover, when we do not control for debt-to-GDP ratio and Fed effective rate, we are very likely to suffer from the omitted variable bias. It is also worth noticing that large part of the variation of the spread is explained by Fed effective rate and adding the new relative availability measure also improves the estimation significantly.

To sum up, the spread of Aaa corporate bonds and Treasury bills is more likely to be  $S_t^{CT}$  based on the signs of the coefficients when all explanatory variables outgrow. The results are mostly consistent with the theoretical predictions. However, some of the irregularity requires economic analysis outside of the model to justify.

#### 4.2.1 Convenience Premium over Commercial Papers

This section investigates another category of private safe assets — commercial papers. Highly rated commercial papers are one of the safest private safe assets on the financial market, and they often have very short maturity just like the short-term Treasury bills. Highly rated commercial papers have close-to-zero default risk, which makes them almost as safe as Treasury bills but not as liquid. Thus the exercise in this part could potentially capture more liquidity premium rather than safety premium. If our safety measure and liquid measure are correctly specified, we shall see the liquid measure playing a larger role in explaining the spread variation. However, the spreads of commercial papers and Treasury bills are not the real liquidity premium. As mentioned in Nagel (2016) and Golec and Perotti (2014), commercial papers cannot be entirely as safe as Treasury bills, which makes the spreads still a mix of safety and liquidity premium. In fact for A2/P2 rated commercial papers have a non-trivial level of credit risk. We will use this to our advantage to construct the safety only premium in the later section.

I select AA rated financial, non-financial and asset-backed commercial papers, as well as the A2/P2 rated commercial papers to construct the yield spreads against the Treasury bills with the same three-month maturity. We run simple OLS regressions on the same set of explanatory variables as in the previous case with Newey-West error term. Table 2 confirms that the theoretical predictions in Proposition 1 to 3. The debt-to-GDP ratio has a positive coefficient, which is not surprising considering commercial papers are usually short-term debt that can quickly adjust its quantity. Krishnamurthy and Vissing-Jorgensen (2015) documents such crowding out effect. The positive correlation means that the crowding out effect of the government debt is large and  $k^P \partial \theta_t^P / \partial \theta_t^T$  is likely to be less than  $-1$ . The short-term interest rate has a significant and positive impact on

the spreads for all commercial papers except for asset-backed commercial papers. It is not clear why asset-backed commercial papers react differently to the short-term interest rate. It might be due to the small sample size. Finally, the relative availability measure has a negative impact, which is consistent with the proposition. More readily available government debt reduces the liquidity superiority of government debt over private safe assets thus increase the substitution parameter  $k^P$  and decreases the spread according to equation 5.

Commercial papers fit more precisely to the role of an alternative to government debt as described in the model. The empirical evidence found in this section are consistent with all the theoretical predictions. Although the safety difference between commercial papers and Treasury bills is not great, there is still a non-negligible amount of safety premium within the convenience premium. It is also evident that adding the relative availability improves the explanatory power of the model significantly.

#### *4.2.2 Convenience Premium over Repo and Certificate of Deposit*

The spread of general collateral repurchase agreement (GC Repo) and Treasury bill is probably the closest to pure liquidity premium since GC Repo often uses Treasury bills as collateral that makes the two almost identical in default risk. Moreover, GC Repo is not liquid as the trading parties are locked in a non-transferable bilateral agreement. Another close candidate is the certificate of deposit at the same three-month maturity. This section conducts the same empirical investigation as in the previous sections. It also corresponds directly to Nagel (2016)'s investigation on the impact of short-term interest rate and government debt supply.

Results of the Repo and Treasury spreads in Table 3 show that neither debt-to-GDP or short-term interest rate alone can explain the variation in the premium. The coefficients of the debt-to-GDP ratio are insignificant across different specifications indicating that the safety premium is no longer present in the spread of Repo and Treasury bills. Moreover, the Fed effective rate has a positive correlation with the spread only when all explanatory variables are included. The positive correlation is consistent with the prediction of Proposition 2 and the results from Nagel (2016). Column 3 in the table has the same qualitative results except for the insignificance of VIX. However, it is alarming that even the constant is insignificant beside the relative availability measure. With the suspicion that it can be a random noise dictates the time variation of the spread of Repo and Treasury bills, I run a time series regression with an autoregressive error lagging four

periods. The result in column 4 shows that none of the explanatory variables is significant anymore. It is also worth noticing that the spread between Repo and Treasury bills is usually slight (less than 30 basis points on average). Thus we cannot rule out that the spreads between Repo and Treasury bills are simply random shocks.

The results of the certificates of deposit, however, fares similarly to the commercial papers, especially when all explanatory variables are included. The positive coefficient of debt-to-GDP ratio suggests some small level of safety premium and Fed rate has a significant positive impact on the spread. The coefficient of the relative availability measure is almost significant.<sup>6</sup> Therefore the implication is also clear that when there is abundance in government debt supply, the liquidity premium is likely to shrink.

#### *4.2.3 Safety Premium in Private Safe Assets*

Most of the private safe assets cannot provide liquidity service; we can therefore also measure the safety premium in private safe assets without worrying the liquidity premium being mixed in. This type of safety difference mainly comes from credit risk. The results in Table 4 shows that the safety and relative availability measure no long have influences on the spreads while the credit risk measure VIX has a very significant impact. This is expected since such spreads are no longer related to the safety superiority of Treasury bills. It also indicates that the quantitative impact of government debt supply on safety premium does not have a global impact on the overall price for safety. It is also reflected in the coefficients of Fed effective rates, which are not significant in all three measures of safety in private assets. Since short-term interest rate can only affect the spread through overall liquidity provision in the whole economy, the safety only spread in private assets is not likely to be affected.

#### *4.2.4 Time-differenced Specification*

All the previous results are from the levels of the variables that could have stochastic trends to induce spurious correlations. To clear such concern, this section conducts time-differenced specification of all the previous regression with all explanatory variables and results are in Table 5. The results of the corporate bonds confirm the findings from the previous section. Corporate bonds are not the private safe asset that can provide convenience service and the premium measured by the spread of corporate bonds, and Treasury bills are more likely to be the safety premium as the coefficient of the

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<sup>6</sup>It is significant and negative if we use standard OLS or Newey-West Error with only two lags.

relative availability measure is no longer significant in the time-differenced specification. Moreover, the results of the commercial papers and certificates of deposit validate all the previous findings. Commercial papers are very likely to be the private safe assets that have a sensitive reaction to crowding out effect. Column 4 to 8 perfectly demonstrates that when private safe assets are sufficient safe compared with government debt, the time variation of the premium is more likely to be captured by the relative availability measure. That is the reason why only the spread of A2/P2 rated commercial papers has a significant coefficient on the debt-to-GDP ratio, while all the coefficients of the relative availability measure are very significant. Finally, the results of Repo spread justifies our concern that most of the time variation is due to stochastic trend, especially when the constant of the time-differenced specification is significant.

## **5 Discussion and Robustness**

The premium of government debt seems to pose a theoretical challenge to the literature. What we do know about government debt and safe asset premium is limited on simple empirical evidence. This paper employs two measures of relative supply of government debt, total government debt to GDP ratio and total government liability to all sector liability ratio, to capture the varying safety and liquidity premium. The quarterly historical data on US financial market suggests that a higher government debt to GDP ratio does not automatically mean a higher availability of government debt. In fact, we find a negative correlation between government debt-to-GDP ratio and government short-term total liability. These two measures of government debt offer us the opportunity to disentangle the quantitative effect of government debt on safety premium and liquidity premium.

## **6 Conclusion**

This paper uses the public data on the national account and financial market interest rates to test the quantitative impact of government debt supply. The empirical evidence shows that, after controlling for the opportunity cost of money, the quantitative impact of total government debt-to-GDP ratio is still significant. The relative availability measure, the ratio of total government liability to all sector total liability, disentangles the liquidity part of convenience premium. It also helps us understand the dynamics of the premium measured by the spreads of Treasury bills and different private safe assets. The premium of government debt against different private safe assets tend to differ based on how much safer and more liquid government debt is compared with other private safe assets. The

empirical evidence also suggests that the substitutability between government debt and private safe assets dictates the quantitative impact of the government debt supply.



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## 7 Tables

**Table 1:** Spreads between Corporate Bonds and Treasury Bills

	Aaa - Treasury					
	(1)	(2)	(3)	(4)	(5)	(6)
Log(Gov Debt/GDP)	1.703*** (0.445)	-3.405*** (0.725)	-5.097*** (0.510)		1.853*** (0.441)	
VIX	0.0514* (0.0218)	0.0262 (0.0196)	0.0326*** (0.00861)	0.0462 (0.0252)	0.0566** (0.0213)	0.0534*** (0.0136)
Fed Fund Rate		-0.498*** (0.0627)	-0.711*** (0.0580)			-0.294*** (0.0479)
Log(Gov Debt/Total)			3.382*** (0.379)	0.569 (1.048)	1.022 (1.034)	2.242*** (0.657)
_cons	2.938*** (0.513)	3.156*** (0.493)	11.61*** (0.967)	3.642 (2.513)	5.464* (2.521)	8.966*** (1.617)
Observation	138	138	138	139	138	139
Adj $R^2$	0.1806	0.5472	0.8042	0.0475	0.2044	0.5441
Periods	82Q1-16Q4	82Q1-16Q4	82Q1-16Q4	82Q1-17Q1	82Q1-16Q4	82Q1-17Q1

$$(Aaa\ yields - T\text{-}bill\ yields) = \_cons + \log(debt/GDP) + VIX + Fed + \log(Gov/Total) + \epsilon$$

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Standard errors are shown in parentheses.

The dependent variable is the yield spread of Aaa corporate bond and three months Treasury bills; Log(Gov Debt/GDP) is the log of total government debt to GDP ratio; Fed Effective Rate is the quarterly average of the monthly Fed effective rate; Log(Gov Debt/Total) is the log of total government liability to total liability of all sectors, computed from Fed's Flow of Funds data series; VIX refers to the CBOE S&P500 implied volatility index, which is available since 1986. Prior to January 1986, VIX is the quarterly average of the imputed daily VIX index using projection of observed VIX on S&P500 squared daily return. We run OLS using Newey-West standard errors with 4 lags.

**Table 2:** Premium of Treasury Bill over Commercial Papers

	Financial		Non-Financial		Asset-Backed		A2/P2	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log(Debt/GDP)	0.283 (0.241)	1.481** (0.490)	0.266* (0.129)	0.849** (0.308)	0.668* (0.287)	3.145*** (0.669)	0.519 (0.389)	2.688** (0.790)
Fed Effective Rate	0.0578* (0.0254)	0.0933*** (0.0265)	0.0624*** (0.0145)	0.0796*** (0.0183)	0.136* (0.0547)	-0.00682 (0.0457)	0.0690 (0.0434)	0.0967** (0.0361)
VIX	0.0262** (0.00960)	0.0323*** (0.00838)	0.0144** (0.00449)	0.0174*** (0.00437)	0.0335** (0.0108)	0.0330*** (0.00536)	0.0655** (0.0222)	0.0758*** (0.0183)
Log(Gov/Total)		-1.523* (0.604)		-0.741* (0.349)		-4.485*** (1.125)		-3.040** (0.939)
_cons	-0.301 (0.166)	-4.165* (1.592)	-0.150 (0.0789)	-2.029* (0.906)	-0.367 (0.195)	-11.39*** (2.816)	-0.747 (0.391)	-8.433** (2.572)
Observations	78	78	78	78	62	62	74	74
Adj $R^2$	0.3250	0.5172	0.3998	0.5140	0.3718	0.6865	0.4988	0.6410

$$(\text{Commercial Papers} - T\text{-bill yields}) = \_cons + \log(\text{debt}/GDP) + VIX + Fed + \log(\text{Gov}/Total) + \epsilon$$

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Standard errors are shown in parentheses.

The dependent variable is the yield spread of commercial papers and three months Treasury bills; Log(Debt/GDP) is the log of total government debt to GDP ratio; Fed Effective Rate is the quarterly average of the monthly Fed effective rate; Log(Gov/Total) is the log of total government liability to total liability of all sectors, computed from Fed's Flow of Funds data series; VIX refers to the CBOE S&P500 implied volatility index, which is available since 1986. Prior to January 1986, VIX is the quarterly average of the imputed daily VIX index using projection of observed VIX on S&P500 squared daily return. Newey-West standard errors with 4 lags are used in the parentheses.

**Table 3:** Spreads between Repo/CD and Treasury Bills

	Repo - Treasury				CD - Treasury		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Log(Debt/GDP)	-0.00875 (0.110)		0.152 (0.264)	0.0377 (0.369)	-0.319* (0.137)		0.618* (0.237)
VIX	-0.00595** (0.00204)	-0.00624* (0.00269)	-0.00414 (0.00254)	-0.00674 (0.00592)	0.0292*** (0.00812)	0.0302*** (0.00813)	0.0321*** (0.00749)
Fed Effective Rate		0.0131 (0.0131)	0.0378* (0.0188)	0.0380 (0.0263)		0.0384** (0.0119)	0.0971*** (0.0224)
Log(Gov/Total)			0.125 (0.387)	0.261 (0.353)			-0.408 (0.222)
_cons	0.208** (0.0603)	0.198** (0.0687)	0.482 (0.962)	0.866 (0.917)	-0.347** (0.130)	-0.376** (0.122)	-1.398* (0.615)
Observations	67	69	67	67	138	140	138
Adj. $R^2$	0.0599	0.1054	0.1331	AR(4)	0.4257	0.3978	0.4652
Periods	99Q4-16Q4	99Q4-17Q1	99Q4-16Q4	99Q4-16Q4	82Q1-16Q4	82Q1-11Q1	82Q1-16Q4

$$(Repo/CD \text{ yields} - T\text{-bill yields}) = \_cons + \log(debt/GDP) + VIX + Fed + \log(Gov/Total) + \epsilon$$

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Standard errors are shown in parentheses.

The dependent variable in columns 1 to 4 is the yield spread of three month repurchase agreement and three months Treasury bills; the dependent variable in columns 5 to 6 is the yield spread of three month certificate of deposit and three months Treasury bills; columns 3 and 4 reports the results from a AR(1-4) regression to control for the seasonal and annual effect since we sample at quarterly frequency. Log(Debt/GDP) is the log of total government debt to GDP ratio; Fed Effective Rate is the quarterly average of the monthly Fed effective rate; Log(Gov/Total) is the log of total government liability to total liability of all sectors, computed from Fed's Flow of Funds data series; VIX refers to the CBOE S&P500 implied volatility index, which is available since 1986. Prior to January 1986, VIX is the quarterly average of the imputed daily VIX index using projection of observed VIX on S&P500 squared daily return. We run OLS using Newey-West standard errors with 4 lags.

**Table 4:** Price of Safety in Corporate Bonds and Commercial Papers

	Baa - Aaa		CPA2/P2 - ABCP		CPA2/P2 - CPF	
	(1)	(2)	(3)	(4)	(5)	(6)
Log(Debt/GDP)	-0.212 (0.157)	0.00305 (0.200)	0.0550 (0.146)	0.521 (0.556)	0.174 (0.144)	0.965* (0.377)
VIX	0.0337** (0.0122)	0.0339** (0.0126)	0.0388** (0.0128)	0.0407** (0.0130)	0.0387** (0.0126)	0.0425*** (0.0112)
Log(Gov/Total)		-0.101 (0.175)		-0.513 (0.783)		-1.092** (0.394)
Fed Effective Rate		0.0312 (0.0235)		0.0163 (0.0280)		0.0117 (0.0158)
_cons	0.256 (0.206)	-0.0173 (0.524)	-0.521* (0.236)	-1.820 (2.004)	-0.437 (0.227)	-3.199** (1.134)
Observations	202	202	62	62	74	74
F	6.685	3.585	4.817	2.958	4.818	3.686

$$(Baa\ yields - Aaa\ yields) = \_cons + \log(debt/GDP) + VIX + Fed + \log(Gov/Total) + \epsilon$$

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Standard errors are shown in parentheses.

The dependent variable in columns 1 to 2 is the yield spread of Baa corporate bonds and Aaa corporate bonds; the dependent variable in columns 3 to 4 is the yield spread of A2/P2 rated commercial papers and asset-backed commercial papers; the dependent variable in columns 5 to 6 is the yield spread of A2/P2 rated commercial papers and AA rated financial commercial papers. Log(Debt/GDP) is the log of total government debt to GDP ratio; Fed Effective Rate is the quarterly average of the monthly Fed effective rate; Log(Gov/Total) is the log of total government liability to total liability of all sectors, computed from Fed's Flow of Funds data series; VIX refers to the CBOE S&P500 implied volatility index, which is available since 1986. Prior to January 1986, VIX is the quarterly average of the imputed daily VIX index using projection of observed VIX on S&P500 squared daily return. We run OLS using Newey-West standard errors with 4 lags.

**Table 5:** Quarterly Changes in Convenience Premium

	Aaa	Baa	Repo	CD	CPF	CPN	ABCP	CPA2P2
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\Delta \text{Log}(\text{Debt}/\text{GDP})$	-4.333* (1.864)	-3.468 (2.722)	-5.227*** (1.199)	1.047 (1.123)	1.845 (0.944)	1.772 (1.004)	1.935* (0.965)	10.28** (3.009)
$\Delta \text{Fed Rate}$	-0.651*** (0.0591)	-0.686*** (0.0762)	0.0385 (0.0400)	0.0639 (0.0495)	0.00739 (0.0348)	0.0479 (0.0307)	0.0419 (0.0541)	-0.0809 (0.0929)
$\Delta \text{VIX}$	0.0166** (0.00557)	0.0361*** (0.00960)	-0.00973** (0.00329)	0.0362*** (0.00669)	0.0340** (0.0107)	0.0222*** (0.00585)	0.0359*** (0.0101)	0.0944** (0.0284)
$\Delta \text{Log}(\text{Gov}/\text{Total})$	0.415 (1.227)	0.136 (1.627)	2.894** (1.017)	-3.559** (1.256)	-4.162* (1.667)	-3.092** (1.017)	-5.456** (2.004)	-12.13** (4.186)
_cons	-0.0146 (0.0306)	-0.0321 (0.0337)	0.0347* (0.0147)	-0.00672 (0.0170)	-0.00926 (0.0192)	-0.00719 (0.0131)	0.0214 (0.0217)	-0.0532 (0.0361)
Observations	137	137	66	137	77	77	61	73
Adj. $R^2$	0.5409	0.5557	0.2057	0.3474	0.3991	0.3507	0.4407	0.5739

$$\Delta(\text{Private safe assets yields} - \text{T-bill yields}) = \_cons + \Delta \log(\text{debt}/\text{GDP}) + \Delta \text{VIX} + \Delta \text{Fed} + \Delta \log(\text{Gov}/\text{Total}) + \epsilon$$

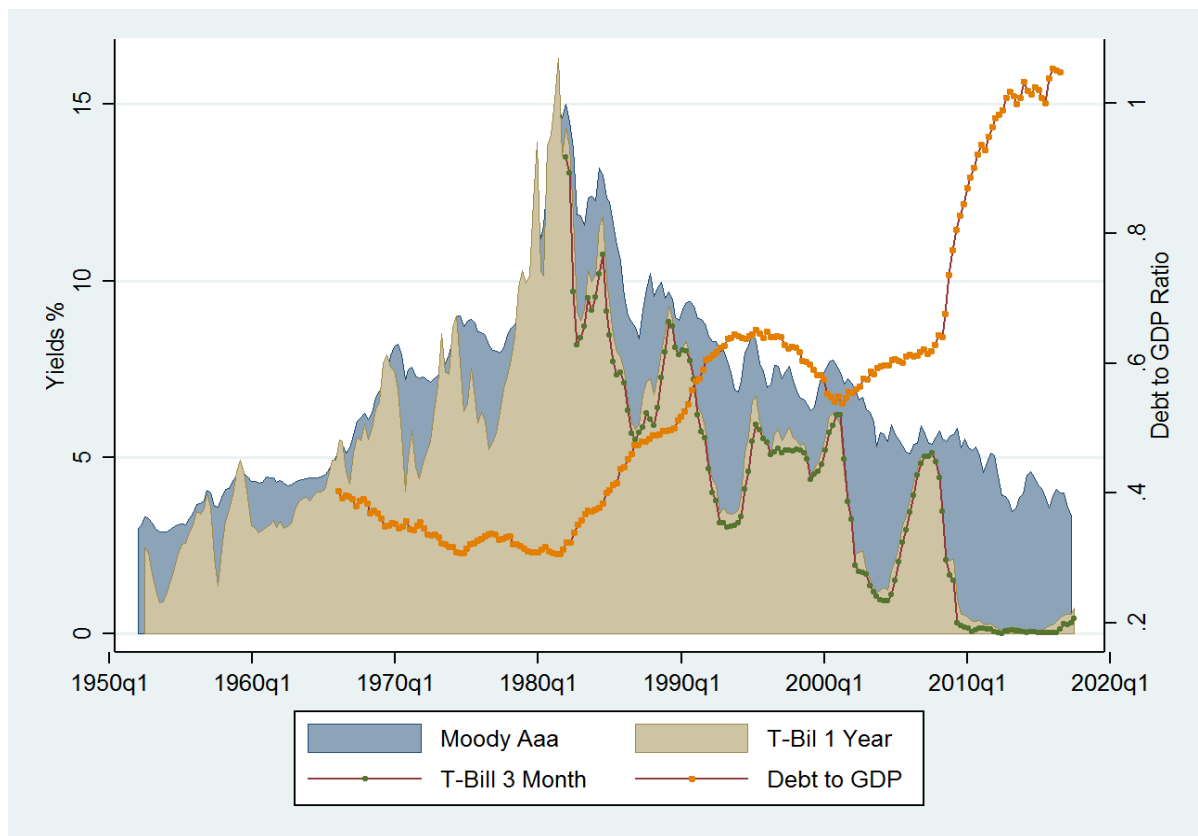
\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Standard errors are shown in parentheses.

The dependent variable is the quarterly change in spreads of all the safe assets mentioned in the first row over 3 month Treasury bills;  $\text{Log}(\text{Debt}/\text{GDP})$  is the log of total government debt to GDP ratio; Fed Effective Rate is the quarterly average of the monthly Fed effective rate;  $\text{Log}(\text{Gov}/\text{Total})$  is the log of total government liability to total liability of all sectors, computed from Fed's Flow of Funds data series; VIX refers to the CBOE S&P500 implied volatility index, which is available since 1986. Prior to January 1986, VIX is the quarterly average of the imputed daily VIX index using projection of observed VIX on S&P500 squared daily return. Newey-West standard errors with 4 lags are used in the parentheses.

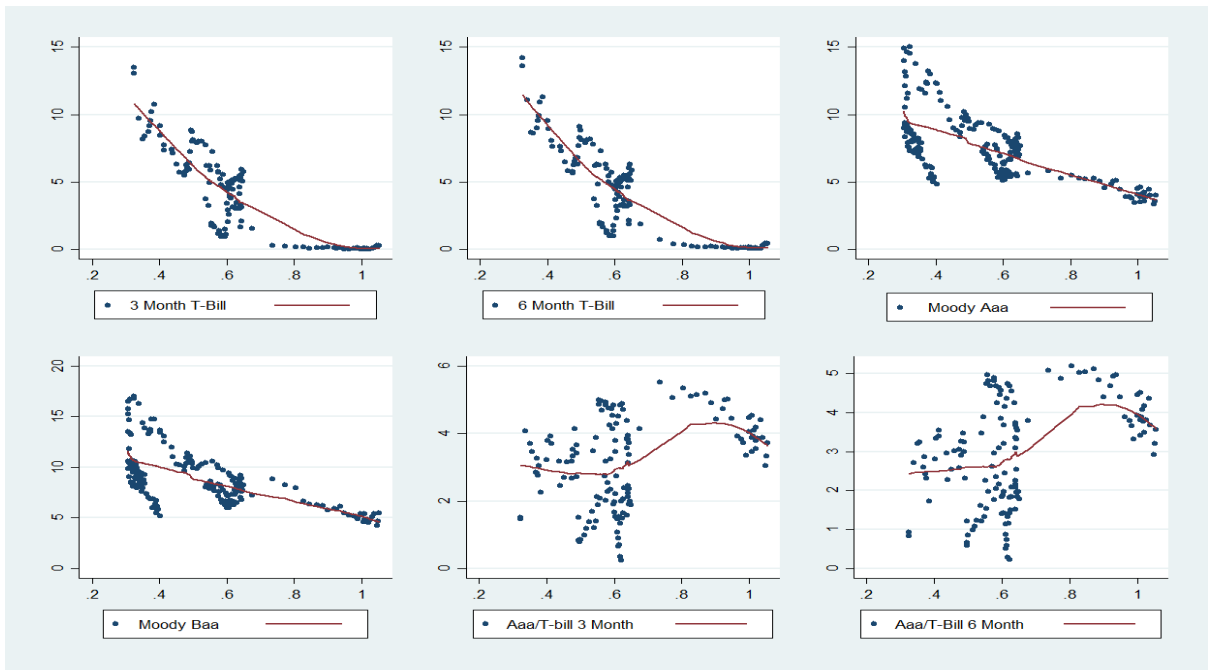


## 8 Figures

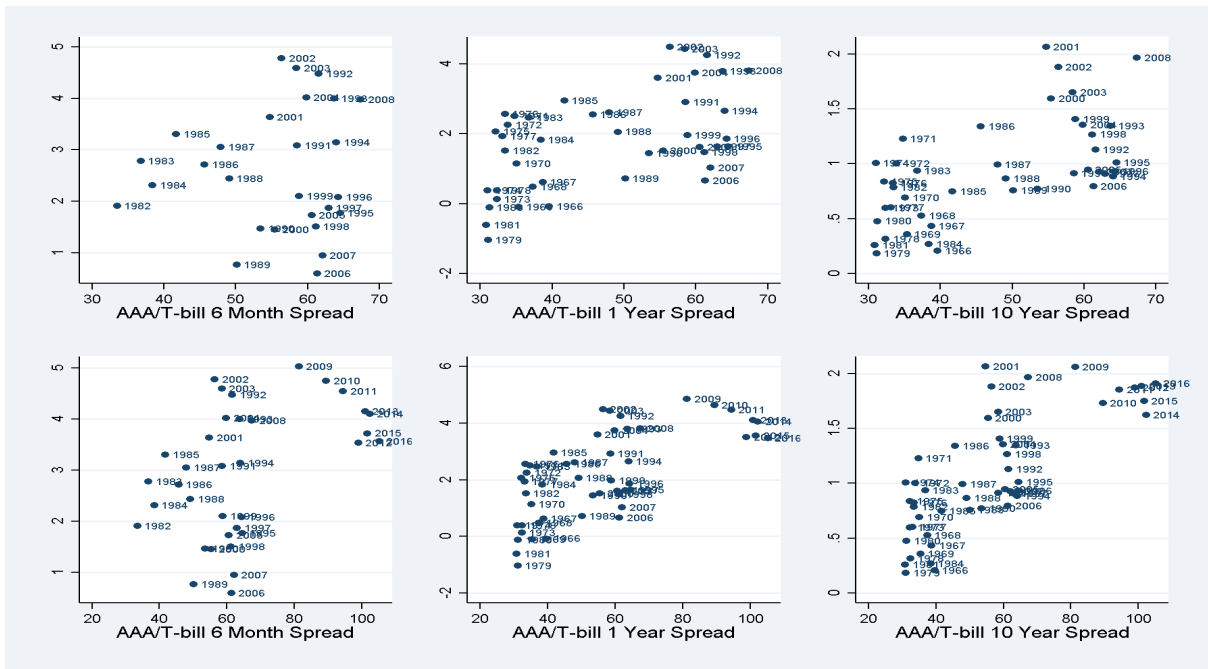


**Figure 1:** Evolution of US Treasury bills and Debt to GDP

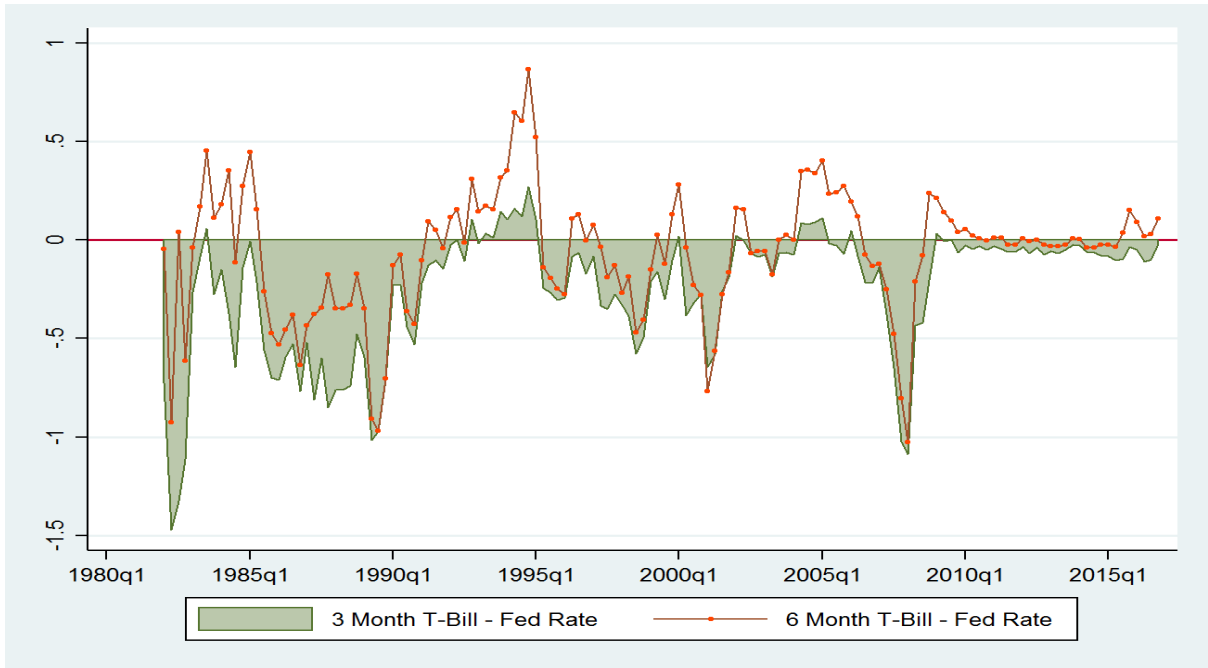
Quarterly average of 1 year fixed term Treasury bill yields and Aaa rated corporate bond yields are the coloured areas under the solid lines, olive and blue respectively. The marron line with green circles is 3 month fixed term Treasury bill yields. The marron line with orange squares is the quarterly total government debt to GDP ratio.



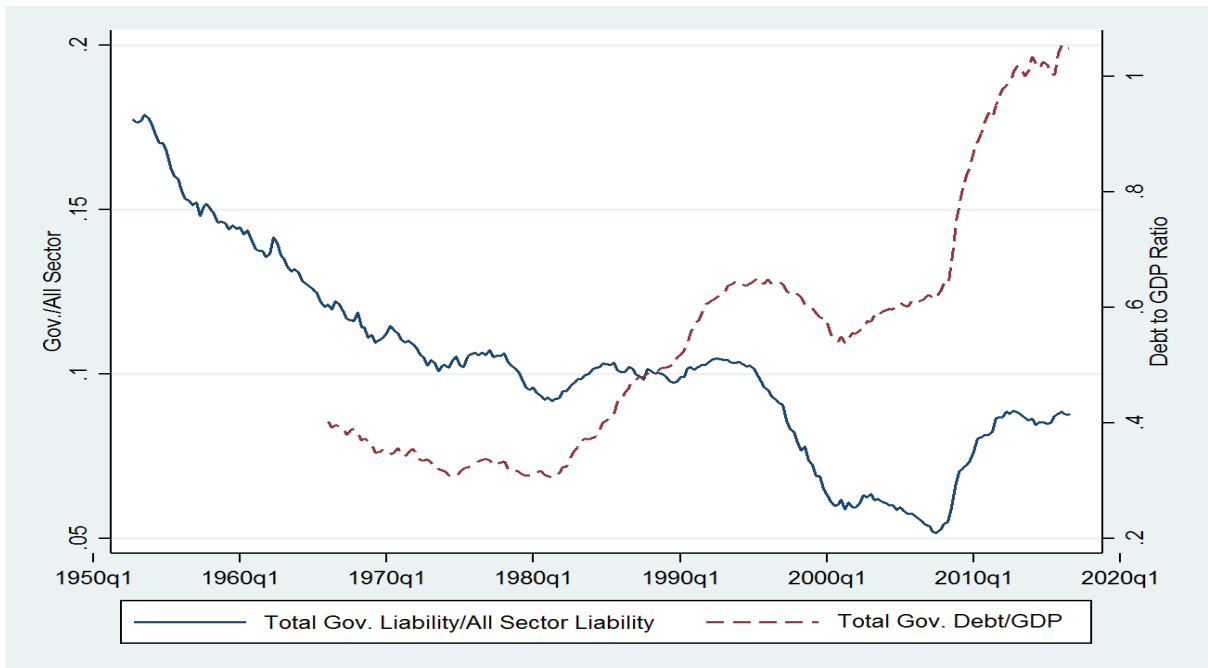
**Figure 2:** Yields and Spreads of Safe Assets and Debt to GDP  
 The Y-axis is the yields and the X-axis is the debt to GDP ratio. The first two subplots are 3 month and 6 month T-bills; the third and fourth are Aaa and Baa bonds; and the last two are spreads between Aaa bonds and 3 month and 6 month T-bills.



**Figure 3:** Aaa corporate bond and T-bill yield spread v.s. Debt to GDP  
 The Y-axis is the yields and the X-axis is the debt to GDP ratio. The first row is the yearly plot of the spread using the data until 2008, prior to Great Recession; the second row includes the post Great Recession years.



**Figure 4: T-bill yield and Fed Effective Rate spread**  
 The green area is the spread between 3 month Treasury bill and Fed Effective Rate; the dotted line is the spread between 6 month Treasury bill and Fed Effective Rate.



**Figure 5: Safety Measure and Liquidity Measure**  
 The blue solid line is the total government liabilities to all sector liabilities ratio; the dashed red line is the total government debt to GDP ratio.

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