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Government Debt, Limited Foresight, and Longer-term Interest Rates

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Abstract

We study the relationship between government debt and interest rates in an environment where financial market participants have limited foresight about the future path of government debt. We show that limited foresight substantially attenuates estimates of the effect of government debt on longer-term yields relative to the benchmark of rational expectations often used in empirical analysis.

JEL Classification**:** E7, E4, G1

Keywords**:** *government debt, longer-term interest rates, term premiums, limited foresight*

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1 Introduction

With the issuance of U.S. Treasury debt having risen substantially in recent years, the effect of government debt issuance on longer-term interest rates has come under renewed attention. While government debt can affect economic outcomes in a variety of ways, its effect on interest rates is an important determinant of the consumption and savings decisions of households as well as the investment decisions of firms and hence of macroeconomic activity.

In this note, we study the role of expectations formation in influencing the relationship between government debt and longer-term interest rates. While it is common to analyze the effects of government debt on interest rates in a dynamic setting under the assumption of full information, rational expectations, the realism of this assumption is questionable. In particular, this assumption implies that economic decision makers know all possible future situations that will arise and can use that knowledge to formulate complete state-contingent plans into the distant future. A key contribution that we make in this paper is to depart from this assumption and study the effects of government debt on interest rates when economic decision makers are 'boundedly rational' and only have limited foresight about future events.[2] In particular, we adopt the approach of Woodford (2018) in which agents can only engage in sophisticated forecasting and planning out to a finite horizon.[3] We embed this approach into the model of Li and Wei (2013), as it provides a simple relationship linking the future path of government debt to longer-term yields and is an empirically relevant model for the effects of the supply of government debt on longer-term interest rates.[4] We illustrate how limited foresight attenuates the effect of the supply of government debt on longer-term interest rates. Calibrating the model to recent empirical evidence implies that limited foresight diminishes the effects of government debt substantially relative to the benchmark of rational expectations.

Our paper proceeds as follows. Section 2 presents an overview of the literature on government debt and interest rates which we later use to calibrate the degree of limited foresight. Section 3 presents the implications of limited foresight for the relationship between government debt and longer-term interest rates, our calibration, and results. Section 4 concludes.

[2] The literature on finite horizon planning has largely focused on its monetary policy implications. An important exception is Woodford and Xie (2022). They emphasize the ability of countercyclical fiscal policy to provide stimulus in situations where the nominal interest rate is constrained by a lower bound, while we focus on the relationship between government debt and interest rates.

[3] Our approach is consistent with other papers, such as Gabaix (2020), that deviate from rational expectations by introducing myopic behavior of economic agents into macroeconomic models.

[4] While we use the Li-Wei model to illustrate how expectations formation can affect the relationship between government debt and interest rates, Board staff regularly use this model to assess the effects of changes in the Federal Reserve's securities holdings on longer-term interest rates (e.g., Bonis, Ihrig, and Wei, 2017).

2 A Review of the Literature on Government Debt and Interest Rates

Determining the empirical effect of government debt on interest rates is a challenging task, and the voluminous literature estimating this effect has produced a wide range of estimates. This literature has emphasized that the relationship between debt and interest rates is endogenous and can vary depending on a variety of factors, including the type of fiscal action—taxes, transfers, or spending—associated with the change in debt. The literature has also pointed to several channels through which issuance of government debt can affect interest rates in the long run.[5] In models in which financial markets are incomplete and risk is uninsurable, a permanent increase in government debt can increase the supply of financial assets in the economy and raise the long-run level of the short-term real interest rate (hereafter referred to as r^*), crowding out private capital.[6] In addition, Krishnamurthy and Vissing-Jorgensen (2012) have documented that there are safety and liquidity benefits associated with government securities, and in models such as Mian et al. (2022) a permanent increase in government debt can increase r^* by reducing the convenience value associated with these benefits. Issuance of longer-term government securities can also raise the exposure that investors have to interest-rate risk on the value of longer-term securities in preferred habitat models of the yield curve (e.g., Vayanos and Vila, 2021, Greenwood and Stein, 2014). As a consequence, an increase in the supply of longer-term debt can reduce bonds prices through an increase in the term premium component of yields.[7]

Table 1 presents selected estimates from the literature that focus on the longer-run relationship between these variables. Studies such as Engen and Hubbard (2004) and Laubach (2009) take a reduced-form approach and do not impose economic theory in estimating the effect of government debt on interest rates. In order to abstract from business cycle dynamics that might influence the shorter-run relationships between these variables, these papers use data on longer-term debt projections and the level of longer-run real interest rates. For these papers, the effect of government debt on longer-run interest rates could arise either through movements in the term premium or through r^*. Other researchers take a more structural approach in order to estimate or calibrate models that use economic theory to help determine the effect of a permanent change in government debt. For instance, Mian et al. (2022) study the issue of debt sustainability in a model in which higher levels of longer-run debt can increase r^* and calibrate this effect to be consistent with empirical estimates in the literature. In addition, Li and Wei (2013) estimate a term structure model that builds on theoretical models in which the preferred

[5] While we focus on the empirical literature studying the longer-run relationship between debt and interest rates, Coenen et. al. (2012) provide a discussion of short and medium-run determinants of this relationship, including the role of monetary policy.

[6] See, for example, Aiyagari and McGrattan (1998) as well as the discussion and references in Rachel and Summers (2019).

[7] In addition, Mian et al. (2022) and Vissing-Jorgensen (2023) emphasize that long-term government securities can have safety and liquidity benefits separate from that of short-term securities. As a result, the outstanding stock of long-term government securities can influence long-term interest rates through the convenience that these securities bring.

habitat that investors have for different maturities of government debt gives rise to a term premium that depends on the amount of longer-term securities that investors hold. Reflecting the differences in methodologies, data sources, and sample periods, the effect of a 1 percentage point increase in the debt-to-GDP ratio on longer-run real interest rates ranges from 1 to 6 basis points. Importantly, these estimates are based on the historical U.S. relationship between government debt and interest rates and would not necessarily apply, for instance, to situations in which the level of government debt is much higher.[8]

Table 1: Selected Estimates of the Effect of Government Debt on Long-Run Real Interest Rates

Source	Estimation Period	Effect of 1 pct. pt. increase in debt/GDP (basis points)	Methodology	Term Premium or Expected Short-Rate
Engen and Hubbard (2004)	1976-2003	3 bps	OLS and VAR	both
Gale and Orszag (2004)	1976-2004	4-6 bps	OLS	both
Kinoshita (2006)	1971-2004, international data	4-5 bps	Panel regression	both
Laubach (2009)	1976-2006	3-4 bps	OLS	both
Chadha et al. (2013)	1986-2008	2 bps	OLS	both
Gamber and Seliski (2019)	1976-2017	2-3 bps	OLS	both
Coenen et al. (2012)	N/A	1 bp	Calibrated structural model	Expected short-rate (*r**)
Mian et al. (2022)	N/A	1-2 bps	Calibrated structural model	Expected short-rate (*r**)
Li and Wei (2013)*	1994-2007	6 bps	Estimated term structure model	Term premium

*The model of Li and Wei (2013) uses the outstanding and projected volume of Treasury ten-year equivalents (TYEs) as inputs. The volume of TYEs in a given period represents the amount of interest rate risk of the par amount of Treasury debt in terms of an equivalent number of Treasury securities issued with 10 years to maturity. In order to make estimates from Li and Wei (2013) comparable to others in the table, we translate par values of government debt supply to TYEs with an approximation using historical averages of Treasury duration.

[8] Cechetti et al. (2011) provide evidence that suggests that there may be threshold effects at which a high level of government debt is associated with lower economic growth. They postulate that high levels of government debt may constrain the government's capacity to engage in countercyclical stabilization policies or act as a lender of last resort during financial crises, leading to larger economic downturns and lower average growth.

3 Limited Foresight and the Term Premium Effect of Debt Issuance

With these empirical estimates as background, we now turn to showing the important influence expectations formation can have on the relationship between debt and interest rates. To illustrate this point, we use the term premium model of Li and Wei (2013). Table 1 shows that the magnitude of the estimated effect from that model is on the high end of the literature.[9] As we show, this result reflects the assumption that investors have perfect foresight about the expected path of government debt and that altering this assumption to allow for limited foresight can reconcile estimates from the Li-Wei model with the other estimates shown in Table 1.[10]

In the context of the Li-Wei model, the assumption of perfect foresight implies that investors have perfect certainty and knowledge about the future path of Treasury debt and its effect on term premiums. While perfect foresight may be reasonable when considering expected changes in securities in the near-term, it is more questionable for financial market participants' expectations of the longer-run path of Treasury debt outstanding, which is highly uncertain. An alternative, perhaps more reasonable assumption, is that investors have limited foresight about the future path of Treasury debt, particularly for changes in that path that may occur in the distant future.

To understand the difference between perfect and limited foresight, we reproduce the equation in the Li-Wei model relating the term premium on a longer-term yield to the supply of government debt held by financial market participants:

$$\tau_t = E_t \sum_{i=0}^{n} \theta_i b_{t+i.} \tag{1}$$

In this equation, E_t denotes investors' (model-consistent) expectations, b_{t+i} denotes the shocked path of the private sector's holding of government debt in period $t+i$ in terms of Treasury ten-year equivalents (TYEs) as a fraction of nominal GDP, and the parameters, θ_i, $i=0,1,2,\ldots n$, are estimated coefficients from Li and Wei (2013) that determine the impact effect of an expected future change in debt at quarter $t+i$ on the term premium at date t. Importantly, the relationship between the term premium on a longer-term security depends on the expected future path of government debt over horizon n, and for the 10-year Treasury term premium, Li and Wei (2013)

[9] Li and Wei (2013) focus only on the term premium component of yields, while many of the other papers in the table focus on the overall effect on longer-term yields, inclusive of both the term premium component and expected short-rate component. If one takes into account that an increase in debt issuance can raise the expected path of short-term rates, then the difference in the estimate of Li and Wei (2013) with these other papers is even larger than suggested by the numbers in the table.

[10] Li and Wei (2013) impose perfect foresight to estimate the effects of the Federal Reserve's asset purchases on term premiums, whereas the estimate in Table 1 reflects the assumption of perfect foresight for the effect of an increase in Treasury issuance. By altering the amount of longer-term Treasury securities held by private investors, both Treasury issuance and the Federal Reserve's asset purchases affect the term premium component of longer-term yields. Asset purchases can additionally affect longer-term yields by signaling monetary policymakers' intentions regarding the future policy-rate path; a channel not captured by term structure models such as Li and Wei (2013). For a comprehensive review of the literature on asset purchases, see Bhattarai and Neely (2022).

set the horizon *n* to correspond to a period of 10 years. To evaluate this expected path, Li and Wei (2013) impose that investors have perfect foresight, setting $E_t b_{t+i} = b_{t+i}$ for *i=0,1.2,…n*.

We modify the assumption regarding investors' expectations formation to allow for limited foresight following the approach of Woodford (2018). Under that approach, there are limitations on the ability of investors to foresee and forecast future events. When investors differ in the horizon over which they use economic relationships to make forecasts, this heterogeneity gives rise to a relationship between the term premium and changes in debt issuance in which changes in debt issuance in the far future are discounted more heavily than those occurring in the near future. Specifically, as shown in the appendix, when investors have limited foresight, the aggregate effect on the term premium of the path of government debt is given by:

$$\tau_t = E_t \sum_{i=0}^{n} \theta_i \gamma^i b_{t+i}. \qquad (2)$$

Accordingly, the limited foresight of financial market participants introduces an additional parameter, $\gamma,$ into the relationship between government debt and the term premium relative to the case of perfect foresight. The parameter γ corresponds to how far in the future the average financial market participant uses information on government debt to form beliefs about the term premium. As γ approaches 1, equation (2) implies the same term premium effects as under perfect foresight. However, for $\gamma < 1$, future projections of government are discounted more heavily under equation (2) than equation (1), implying smaller term premium effects under limited foresight than under perfect foresight.

3.1 Calibration

We calibrate γ so that the term premium effect implied by equation (2) is consistent with recent evidence. In an update of the analysis of Laubach (2009), Gamber and Seliski (2019) study the effects of changes in longer-run forecasts of Treasury debt on longer-term interest rates. As indicated in Table 1, Gamber and Seliski (2019) find that each 1 percentage point increase in the 5-year-ahead debt-to-GDP ratio is associated with a 2 to 3 basis point increase in 5-year-ahead, 10-year forward real interest rates.[11]

Because the estimate of Gamber and Seliski (2019) applies to a longer-term rate rather than the term premium, we infer the effect of government debt on the term premium using estimates of the effect on *r** from the literature. For these estimates, we turn to Mian et al. (2022), who present an overview of estimates from the literature.[12] While noting uncertainty surrounding these estimates, the evidence in Mian et al. (2022) spans a range of about 1 to 2 basis points for the effect on *r** of a 1 percentage point increase in the debt-to-GDP ratio.

In our benchmark calibration, we take the midpoints of the ranges from Gamber and Seliski (2019) and Mian et al. (2022) and subtract the predicted effect on *r** of 1½ basis points

[11] In comparison, Laubach (2009) estimated an effect of 3-4 basis points using data through 2006.

[12] For an extended discussion and overview of the literature regarding the effect of government debt on *r**, see appendix E of Mian et al. (2022).

from Mian et al. (2022) from the predicted effect on longer-term forward rates of 2½ basis points from Gamber and Seliski (2019). This yields a term premium effect of 1 basis point for a 5-year-ahead 10-year Treasury bond.

Because our calibration involves using information on a forward rate on a 10-year bond rather than the current rate, we need to take into account that investors' beliefs under limited foresight about a forward rate can differ from their beliefs regarding a spot interest rate. In particular, the expected path of debt affecting a forward term premium occurs further in the future than the path necessary to form beliefs about the current term premium, and, as a result, an investor under limited foresight will discount the expected path of debt associated with the forward term premium even more heavily than implied by equation (2). We take this into account using the analogue to equation (2) for a term premium on a 10-year bond, 5 years forward, which as shown in the appendix, is given by:

$$\tau_{t+20,t} = E_t \sum_{i=0}^{n} \theta_i \gamma^{i+20} b_{t+i+20}. \qquad (3)$$

We use equation (3) to calibrate γ, keeping the parameters θ_i, $i = 0,1,2,..,n$, fixed at the values estimated by Li and Wei (2013). Setting $\tau_{t+20,t}$ to be consistent with a 1 basis point term premium effect on a 10-year bond, 5-years ahead, as implied by the empirical literature, yields $\gamma = 0.942$, which corresponds to an average foresight horizon of a little more than 4 years.[13]

Although our calibration does not involve the joint determination of γ and θ_i, we see two benefits to our approach. First, the Li and Wei (2013) model is estimated on data from 1994-2007. Because our calibration of γ targets empirical moments that use recent data, it helps capture changes in the relationship between debt and interest rates that may have occurred since the financial crisis. Second, our calibration strategy uses information about the longer-run relationship between expected debt and interest rates and thus is less prone to being confounded by factors that affect this relationship in the shorter run.

3.2 Term Premium Effects of Government Debt Under Limited Foresight

Using our benchmark calibration, we can estimate the effects of an increase in government debt on interest rates under our revised assumption for expectations formation. Under limited foresight, our calibration implies that a permanent 1 percentage point increase in the debt-to-GDP ratio, all else equal, increases the 10-year Treasury term premium by only

[13] Gust et. al. (2024) use survey data on inflation expectations in addition to macroeconomic time series to estimate a macroeconomic model with finite horizon planning and find that their model fits this data well with a planning horizon of one year. Our benchmark calibration implies a longer horizon, reflecting differences across models as well as the use of financial market data rather than macroeconomic data to calibrate γ. To take into account uncertainty about the degree of limited foresight, we also consider an alternative calibration where γ is smaller.

3 basis points, as opposed to 6 basis points in the original model with perfect oversight.[14] While 3 basis points is our benchmark estimate, this estimate is subject to uncertainty stemming from the effects of fiscal policy on interest rates. To help address this, we consider alternative, plausible calibrations and calibrate γ to a forward term premium effect on a 10-year bond of ½ basis point and 1½ basis points, respectively. With the ½ basis point calibration, the value of γ is about 0.92, the average forecast horizon is 2.5 years, and the term premium effect of a permanent 1 percentage point increase in the debt-to-GDP ratio is estimated to be 2½ basis points. With the 1½ basis points calibration, the value of γ is just above 0.95, the average forecast horizon is about 5 years, and the term premium effect from such an increase is 3½ basis points. These magnitudes lie well outside the confidence interval of the Li-Wei model estimates under perfect foresight.[15]

4 Conclusion

Research analyzing the effects of fiscal actions on the macroeconomy has mainly worked under the assumption of rational expectations. However, economic decision makers have an imperfect understanding of the economy, particularly about relationships that arise in the distant future. We study the relationship between government debt and interest rates in an environment where decision makers are boundedly rational because they have limited foresight about future events and show how this attenuates the effect of the supply of government debt on longer-term interest rates. While we have focused on the effects of government debt on interest rates, limited foresight has broader implications for fiscal policy than considered in this paper, and future work analyzing fiscal policy when decision makers have limited foresight should be an important part of an agenda incorporating imperfect expectations formation into macroeconomic models.

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[14] Under preferred habitat models of the yield curve that motivate the Li and Wei (2013) model, central bank asset purchases are thought to affect longer-term interest rates by altering the amount of government debt held by private investors. If investors have a similar degree of limited foresight about the future size and composition of the central bank's balance sheet, our calibration results would also apply to the effects of central bank asset purchases on longer-term interest rates.

[15] We construct a 95% confidence interval under perfect foresight that ranges from 5 to 7 basis points using historical averages of Treasury duration and the uncertainty of parameter estimates from Li and Wei (2013). Under limited foresight, we obtain a range of uncertainty of about 2 to 4 basis points using our high and low calibrations of γ while at the same time incorporating sampling uncertainty regarding the estimates of θ_i from Li and Wei (2013) using a 95% confidence interval.

References

Aiyagari, S. R., & McGrattan, E. R. (1998). The optimum quantity of debt. *Journal of Monetary Economics*, *42*(3), 447-469.

Bhattarai, S., & Neely, C. J. (2022). An analysis of the literature on international unconventional monetary policy. *Journal of Economic Literature*, *60*(2), 527-597.

Bonis, Brian, Jane Ihrig, and Min Wei (2017). "The Effect of the Federal Reserve's Securities Holdings on Longer-term Interest Rates," FEDS Notes. Washington: Board of Governors of the Federal Reserve System, April 20, 2017, https://doi.org/10.17016/2380-7172.1977.

Cechetti, S., Mohandy, S., & Zampolli, F. (2011). Achieving Growth Amid Fiscal Imbalances: The Real Effects of Debt. In *Economic Symposium Conference Proceedings* (pp. 145-196).

Chadha, J. S., Turner, P., & Zampolli, F. (2013). The interest rate effects of government debt maturity.

Coenen, G., Erceg, C.J., Freedman, C., Furceri, D., Kumhof, M., Lalonde, R., Laxton, D., Lindé, J., Mourougane, A., Muir, D. and Mursula, S., 2012. Effects of fiscal stimulus in structural models. *American Economic Journal: Macroeconomics*, *4*(1), pp.22-68.

Engen, E. M., & Hubbard, R. G. (2004). Federal government debt and interest rates. *NBER macroeconomics annual*, *19*, 83-138.

Gabaix, Xavier. "A behavioral New Keynesian model." American Economic Review 110.8 (2020): 2271-2327.

Gamber, E., & Seliski, J. (2019). *The Effect of Government Debt on Interest Rates: Working Paper 2019-01* (No. 55018).

Gale, W. G., & Orszag, P. R. (2004). Budget deficits, national saving, and interest rates. *Brookings Papers on Economic Activity*, *2004*(2), 101-210.

Greenwood, R., & Vayanos, D. (2014). Bond supply and excess bond returns. *The Review of Financial Studies*, *27*(3), 663-713.

Gust, C., Herbst, E., & Lopez-Salido, D. (2024). Inflation Expectations with Finite Horizon Planning.

Kinoshita, N. (2006). Government debt and long-term interest rates.

Krishnamurthy, A., & Vissing-Jorgensen, A. (2012). The aggregate demand for treasury debt. *Journal of Political Economy*, *120*(2), 233-267.

Laubach, T. (2009). New evidence on the interest rate effects of budget deficits and debt. *Journal of the European Economic Association*, *7*(4), 858-885.

Li, C., & Wei, M. (2013). Term structure modeling with supply factors and the Federal Reserve's large-scale asset purchase programs. *The International Journal of Central Banking*.

Rachel, L., & Summers, L. H. (2019, March). On falling neutral real rates, fiscal policy and the risk of secular stagnation. In *Brookings Papers on Economic Activity BPEA Conference Drafts, March* (Vol. 7, p. 66).

Mian, A. R., Straub, L., & Sufi, A. (2022). *A goldilocks theory of fiscal deficits* (No. w29707). National Bureau of Economic Research.

Vayanos, D., & Vila, J. L. (2021). A preferred-habitat model of the term structure of interest rates. *Econometrica*, *89*(1), 77-112.

Vissing-Jorgensen, A. (2023). Balance Sheet Policy Above the Effective Lower Bound.

Woodford, Michael (2018). "Monetary Policy Analysis when Planning Horizons are Finite," National Bureau of Economic Research Working Paper 24692.

Woodford, M., & Xie, Y. (2022). Fiscal and monetary stabilization policy at the zero lower bound: Consequences of limited foresight. *Journal of Monetary Economics*, *125*, 18-35.

Appendix

In this appendix, we derive expression (2), the aggregate term premium effect of the path of government debt under limited foresight. We also provide details regarding the calibration of γ and the computations of the paths shown in Figure 2.

To derive equation (2), it is useful to re-express it equivalently as:

$$\tau_t = E_t \sum_{i=0}^{\infty} \theta_i \gamma^i b_{t+i}$$

(A-1)

where the impact factors, θ_i, for $i > n$ satisfy $\theta_i = 0$ and the remainder are the same as those in equation (2). The derivation of equation (1) or equivalently equation (A-1) reflects that financial market participants are heterogeneous in the extent that they use information on government debt to determine the term premium. To capture this heterogeneity, we let k denote the forecast horizon of an individual investor where $k \in 0, 1, 2, 3, \ldots$.

An investor with forecast horizon k believes the term premium effect from government debt is given by:

$$E_t^k \tau_t = E_t^k \sum_{i=0}^{\infty} \theta_i b_{t+i} = E_t \sum_{i=0}^{k} \theta_i b_{t+i}^{k-i},$$

(A-2)

where E_t^k denotes the subjective beliefs of an investor with forecast horizon k, reflecting that an investor only takes into the effect of the future path of government debt over the next k periods. Within their forecast horizon, investors use the model's structural relationships to evaluate all possible contingencies for the path of government debt using the model's structural relationships. Hence, in equation (A-2) we can write a k-horizon investor's expectations for the term premium effect the model-consistent expectations operator, E_t, redefining government debt with a $k - i$ superscript to reflect an investor's subjective beliefs.

It is assumed that $(1 - \gamma)\gamma^k$ financial market participants have a k period horizon so that the aggregate term premium effect is given by:

$$\tau_t = \sum_{k=0}^{\infty} (1 - \gamma)\gamma^k \, E_t^k \tau_t$$

(A-3)

Substituting equation (A-2) into equation (A-3) implies:

$$\tau_t = E_t(1-\gamma)\left\{\theta_0 b_t^0 + \gamma(\theta_0 b_t^1 + \theta_1 b_{t+1}^0) + \cdots + \gamma^k\left(\sum_{i=0}^{k}\theta_i b_{t+i}^{k-i}\right) + \cdots\right\}$$

(A-4)

Rearranging terms in the above expression yields:

$$\tau_t = E_t\{\theta_0 b_t + \gamma\theta_1 b_{t+1} + \cdots + \gamma^k\theta_k b_{t+k} + \cdots\} = E_t\sum_{i=0}^{\infty}\theta_i\gamma^i b_{t+i}$$

(A-5)

where

$$b_t = \sum_{k=0}^{\infty}(1-\gamma)\gamma^k b_t^k$$

(A-6)

Finally, we note that this distribution over investors implies that the average horizon over which an investor uses information on debt to evaluate the term premium is given by $\frac{\gamma}{1-\gamma}$.

To calibrate γ, we use the empirical analysis of Gamber and Seliski (2019), who use a 10-year forward rate, 5-years ahead in their empirical analysis. Accordingly, we need the analogue to expression (A-1) for the expected term premium effect on a 10-year bond, 5-years from now. To derive this analogue, note that a k-horizon investor believes that the expected term premium effect h quarters ahead is given by:

$$E_t^k\tau_{t+h} = E_t^k\sum_{i=0}^{\infty}\theta_i b_{t+h+i} = E_t\sum_{i=0}^{k-h}\theta_i b_{t+i+h}^{k-i-h},$$

(A-7)

The average term premium effect, h quarters ahead, aggregating over the different investors is given by:

$$\tau_{t+h,t} = \sum_{k=0}^{\infty}(1-\gamma)\gamma^k E_t^k\tau_{t+h}$$

(A-8)

Substituting equation (A-6) into equation (A-7) and rearranging terms implies that the effect the average investor expects on the term premium effect h quarters from now is:

$$\tau_{t+h,t} = E_t \sum_{i=0}^{\infty} \theta_i \gamma^{i+h} b_{t+i+h},$$

(A-9)

We use equation (A-9) to calibrate γ and set $h = 20$ to be consistent with Gamber and Seliski (2019) while subtracting off the predicted effect of r^* from Mian et al. (2022). Note that equation (A-9) implies that the term premium effect that investors expect h quarters ahead is increasingly discounted, because a decreasing fraction of investors use information on government debt to forecast the term premium as h increases.