A Monetary-Fiscal Theory of the Price Level

David S. Miller
Federal Reserve Board
This draft: February 14, 2019*

Abstract

Treating nominal government bonds as safe assets leads to a new theory of the price level. Holmstrom (2015) and Gorton (2017) define safe assets as having opaque backing with costly-to-forecast returns. I confirm this definition's empirical implications for government bonds, and analyze the theoretical implications. Government bonds' nominal return is their face value, however their real return is determined by the government's surplus. While consumers hold uninformed beliefs about the surplus, the monetary authority exerts control of the price level. In troubled times, the fiscal authority exerts control as consumers worry about default and pay a high cost to accurately forecast the surplus.

JEL classification: E31, E51, E52, E63

Keywords: Price Level Determination, Monetary Fiscal Interaction, Fiscal Theory of the Price Level, Safe Assets

---

*E-mail: david.s.miller@frb.gov. The author thanks discussions with Chris Vickers, Nic Ziebarth, Ed Nosal, Jeff Campbell, Alexander Richter, and seminar participants across the Federal Reserve System.

1 Introduction

Holmstrom (2015) and Gorton (2017) explain banks' ability to issue money-like debt as originating from the banks' ability to keep secret the value of the assets that back the debt. Optimally, consumers are symmetrically ignorant about the debt's backing, making the debt itself a safe asset that can be used in a liquid, money-like fashion without adverse selection issues. I translate and empirically establish this explanation to nominal government bonds, where a government's ability to issue safe assets comes from the difficulty in forecasting the government surpluses that finance repayment, and then apply the explanation to price level determination. The result is a theory of the price level with endogenous control of the price level by the monetary or fiscal authority that is similar to the Woodford (2000) intuition that the monetary authority controls the price level in normal times, while the fiscal authority matters in more stressful times.

The foundational analogy of the Monetary-Fiscal Theory of the Price Level (MFTPL) is that a nominal government bond is a bond that should be priced like other bonds. Buying a bond is an investment in a project that has an uncertain payoff. If the project's outcome is higher than the face value of the bond, the bond holder receives the face value of the bond, no matter how high the outcome is. If the project's outcome is lower than the face value of the bond, the bond defaults and the bond holder receives a share of the project's liquidation value. Buying a nominal government bond is an investment in the government. Without default, the bond's nominal payoff is guaranteed to be the face value of the bond. However, the bond's real payoff is determined by the government's surplus. If the surplus is higher than the face value of the bond, the price level is unchanged and the bond holder receives the face value of the bond in real terms, no matter how high the surplus is. If the surplus is lower than the face value of the bond, the price level will rise, decreasing the real payoff of the nominal bond to a share of the government's surplus.

Government bonds are not only bonds, they are safe assets due to the exceptional difficulty in forecasting the government's future surplus. Safe assets are defined both by their payoff structure, and by the difficulty in generating private information about the assets' backing. Without private information, market participants will have (relatively) homogenous information sets, and symmetric ignorance about the assets' true values will prevail, enabling high liquidity. With private information, adverse selection concerns about why others are selling will collapse the market, leading to low liquidity. As illustrated by Figure 1, generating private information is only worthwhile if beliefs about the backing project's outcome are near the default boundary, where different project outcomes lead to different bond payoffs.

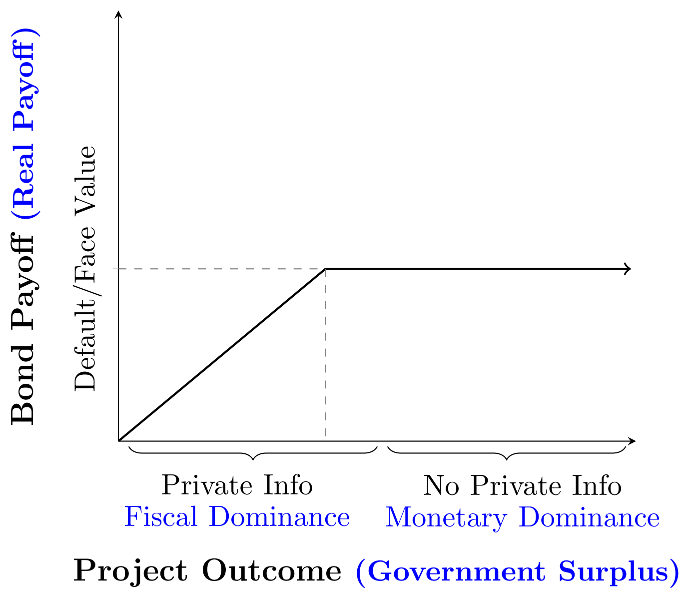


Figure 1: Bond Payoff With Private Info/Dominance Regions

The regions of information – whether there is private information or not – define the regions of monetary and fiscal dominance that arise endogenously in the MFTPL. If consumers believe the government will be able to repay its bonds, the cost of acquiring information dissuades consumers from doing research. The monetary authority dominates, effectively setting the price level by determining bond revenue via the interest rate and bond demand. Government debt will be cheap and liquid. If consumers worry the government won't be able to repay its bonds – that the surplus is near the face value of the bonds – they will expend utility to learn about future surpluses in order to inform their bond purchases. The fiscal authority dominates: the fiscal authority's future choices of spending and taxes will help determine repayment and hence affect bond prices today. Government debt will be expensive and illiquid. This split mirrors the intuition that while the monetary authority generally controls the price level, in times of budgetary stress such as wars and hyperinflations, the fiscal authority's choices matter.

The model predicts a negative causal relationship between yields and liquidity. As default risk rises, yields rise. Market participants generate private information, leading to adverse selection issues, and liquidity to fall. I empirically test and confirm this relationship using data on European government bonds. To establish causality, I use information on credit default swaps and equities as instrumental variables. When countries are thought to be able to repay their bonds, yields are low, liquidity is high, and private information is scarce. When countries are thought to be near default, such as Greece in the early 2010s, yields are high. Concurrently, as the theory predicts, liquidity and trades are low as private information enters the market.

The paper includes two models. The first model, inspired by the simpler model in Bassetto (2002), uses a basic reduced form to illustrate the foundational analogy of the MFTPL: that nominal government bonds are priced as other safe assets. Nominal government debt is assumed to be a safe asset. The two regions of information, and fiscal or monetary authority dominance arise endogenously. The second model, inspired by Dang et al. (2017), provides microfoundations for treating nominal government debt as a safe asset, and illustrates the welfare gains from doing so. The consequence of the MFTPL, price level determination with endogenous dominance, is similar in both models. The cause of fiscal dominance is different between models: the reduced form model requires only that government choices be in certain ranges while the microfounded model requires both government choices and an unfortunate liquidity shock.

In the reduced form model, a consumer is offered the opportunity, at an interest rate chosen by the monetary authority, to buy nominal government bonds with an uncertain real payoff. The real payoff is determined by the government's future surplus as chosen by the fiscal authority: either the face value if the surplus is high enough to repay the bonds with a constant price level, or a share of the surplus when the price level rises to equate the surplus and the face value of the bonds.

The consumer has uninformed beliefs about the government's future surplus. He can expend a fixed utility cost to learn the true future surplus. The higher the interest rate, the more bonds the consumer wants to purchase. However, the more bonds the consumer purchases, the higher the risk that not all of the bonds will be fully repaid in real terms due to the uncertain government surplus. Thus, as the interest rate increases, the benefit to the consumer of learning the truth about the government's future surplus increases as well. There will be a cutoff level of the interest rate such that above that level the consumer will pay the fixed cost and learn future surpluses while below that level the consumer will utilize his uninformed beliefs.

Whether or not the consumer learns future surpluses determines which authority is dominant. Government choices of the interest rate and fiscal surplus determine the benefit of bonds to the consumer. If the monetary authority offers an interest rate below the cutoff, the consumer will make bond buying decisions based on the interest rate and his beliefs of the surplus. This is monetary dominance: the true future surplus chosen by the fiscal authority will not matter for the price level today. If the monetary authority offers an interest rate above the cutoff, the consumer will choose to learn the fiscal authority's surplus. If the consumer learns the future surplus will be high, he'll happily take advantage of the high interest rate to gain a guaranteed payoff. If the consumer learns future surpluses will be low, he won't buy bonds he knows won't be repaid in real terms. This is fiscal dominance: the true future surplus chosen by the fiscal authority will matter for the price level today.

In the microfounded model, there are two consumers, an early consumer who can buy nominal government bonds from the government but is subject to a liquidity shock, and a late consumer who can buy bonds from the early consumer and has the ability to learn future fiscal surpluses. Bonds are necessary to enable welfare maximizing risk sharing and income smoothing for the consumers, but they will be affected by the late consumer's option to learn surpluses. The early consumer won't be willing to buy bonds if he can't sell those bonds to the late consumer when the liquidity shock hits. As with the consumer in the reduced form model, the late consumer's ability to look ahead implies limits to his willingness to take on bond risk. Symmetric uninformed beliefs result in higher expected welfare because they allow both consumers to insure intertemporally, and for the early consumer to insure against the potential liquidity shock.

The endogenous dominance of the reduced form model also appears in the microfounded model. The late consumer decides whether or not to learn future surpluses after observing the interest rate the early consumer offers him. The early consumer will only offer an interest rate that impels the late consumer to learn surpluses if the early consumer is hit by the liquidity shock and must sell all his bonds. Fiscal dominance in the microfounded model depends on both the government choices offering a good deal on bonds to the early consumer, and for the early consumer to be hit by the liquidity shock.

This paper ties together two literatures: Fiscal Theory of the Price Level (FTPL) papers that link the value of nominal government debt to a theory of the price level, and papers creating a theory of safe assets. Leeper (1991), and earlier T.J. Sargent (1985), begin the FTPL literature that claims the price level is determined by the price of nominal government bonds. Since nominal government bonds are repaid by the government's future surplus, the surplus will determine the price of government bonds and hence the price level. Woodford (2000) posits that FTPL behavior is more likely in times of fiscal stress, a result found endogenously in this paper. Cochrane (2005) shows that the FTPL implies that government debt is priced akin to a share of stock in a corporation. For an overview, and criticism, see Bassetto (2002). This MFTPL paper diverges from the FTPL literature by pricing nominal government bonds as bonds that are safe assets rather than as shares of stock.

The MFTPL shares with the Fiscal Theory of the Price Level (FTPL) of

Leeper (1991), Sims (1994), and others, a concern with the government budget constraint. In both theories, the present value of future government surpluses determines the price level as the price level moves to equate the assets and liabilities of the government. In the fiscal theory, the government can specify off-equilibrium surplus values in order to change the price level. This ability has led to considerable debate such as Bassetto (2002). In the MFTPL, the true present value is not known to the consumer, who only has beliefs about that object. In buying a bond, the consumer is taking the risk that he may not be repaid if the future surplus is below the amount of bonds extant.

Pricing safe assets, and defining what safe assets are, has undergone intensive research since the Great Recession. The MFTPL translates this work to price nominal government debt. Holmstrom (2015) and Gorton (2017) summarize a research agenda that views safe assets as special, and necessary for their ability to provide savings and insurance. Safe assets are differentiated from other assets by the high cost to research their backing. All consumers will have uninformed beliefs about the repayment of a safe asset, hence the safe asset can be used as a money-like security without adverse selection issues. In a crisis, when consumers doubt the backing of the assets, they will pay the high price to research it. As shown in Dang et al. (2017), actual knowledge of the safe assets' backing destroys the symmetric ignorance and leads to lower welfare through lack of insurance. Most closely related in macroeconomics is Andolfatto (2010) which embeds a version of the symmetric ignorance of safe assets in a macro money search model, but without the price level effects of the MFTPL.

Benmelech and Bergman (2017b) and Benmelech and Bergman (2017a) take the model of Holmstrom (2015) and Gorton (2017) to data. They examine corporate bonds to establish the theorized link between yields and liquidity. They find that the link exists, and establish causality using an instrumental variable analysis. Additionally, they describe how their findings serve to distinguish the model from other possible models of bonds and safe assets. This paper uses their empirical analysis as a guide for an empirical analysis of government debt rather than corporate debt. I find that government debt is a safe asset that matches all the predictions of the model.

The next section analyzes the empirical evidence that the Holmstrom (2015) and Gorton (2017) model applies to government bonds by using data on European government bonds. Government bonds are safe assets, and fulfill the liquidity predictions of the model. Section 3 present the reduced form model that illustrates the endogenous regions of fiscal or monetary dominance. Control of the price level is connected to the choice of the consumer whether or not to learn the future surplus. The microfounded model in Section 4 extends the reduced form model to enable microfounding the safe asset nature of government bonds. Finally, Section 5 concludes.

2 Empirical Analysis

I establish that government bonds are safe assets by exemplifying the difficulty in forecasting the government's surplus. Then I analyze the liquidity predictions of the model.

Forecasting the government's future surplus requires forecasting the economic growth that determines the tax base, the political process that determines government spending and taxes, and the revenue the government may raise from future bond sales. The difficulty in jointly forecasting all of these quantities is exceptional. For example, Figure 2 shows that the Federal Reserve makes significant errors in forecasting various measures of the surplus.

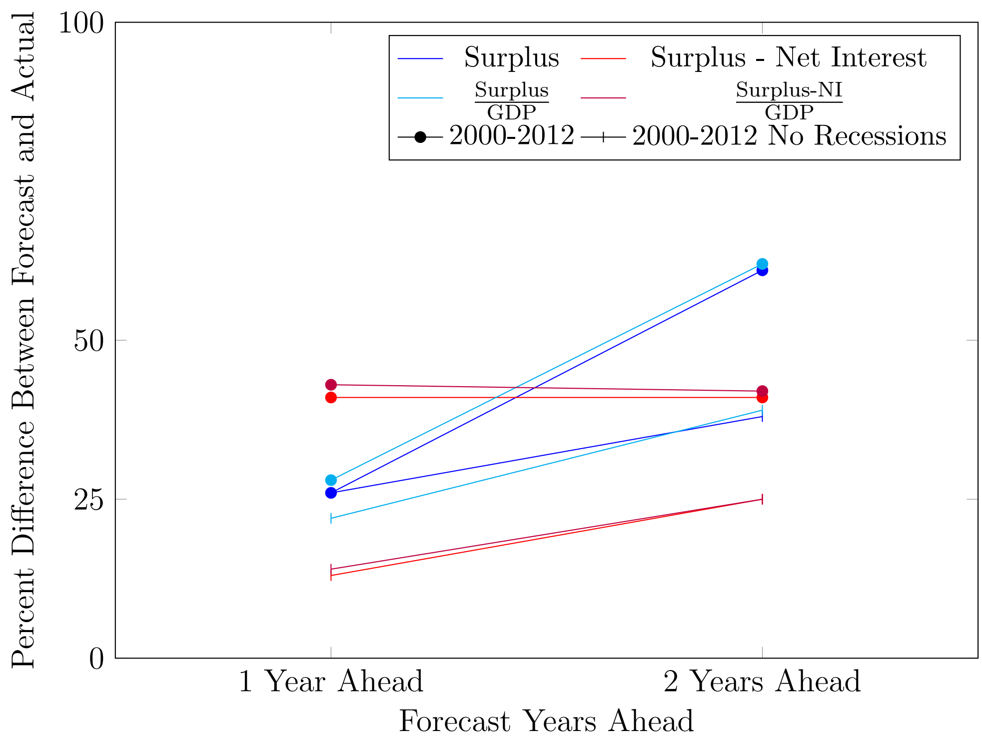


Figure 2: Forecasts of Measures of Government Surplus by the Federal Reserve

I verify that the liquidity predictions of the Holmstrom (2015) model of safe assets hold for government bonds. To do so, I follow the outline of Benmelech and Bergman (2017b) and Benmelech and Bergman (2017a) who analyze the implications of the model in the context of corporate debt and find both that the model holds, and that its predictions distinguish it from other models. The underlying claim is that yields are inversely linked to liquidity through the generation of private information and associated adverse selection issues. In simple terms, as Benmelech and Bergman (2017a) says "The main prediction of the... model is... that bond illiquidity will rise as bond value declines [yield rises], with the bond moving from the informationally insensitive to the informationally sensitive regions." Key to the analysis are the two regions of private information illustrated in Figure 1.

If default is unlikely, yields will be low, and private information will be unlikely to reveal possible default. If beliefs about the outcome of the bond's backing are high enough, additional information is unlikely to move beliefs to near the default boundary, and the bond's payoff will be constant. The value of private information will be low, and traders won't pay the high price to develop it. Without private information, beliefs will be homogenous and bonds will trade with high liquidity in a money-like fashion.

If default is likely, yields will be high, and private information could make the difference between being full or partial repayment. If beliefs about the outcome of the bond's backing are near the default boundary, additional information about the outcome of the bond's backing will affect the bond's payoff. The value of private information will be high, and traders will pay the high price to develop it. With private information, liquidity is low and bond trades are limited due to adverse selection: bond holders fear their trading partner knows more than they do, and will take advantage of them.

2.1 Regression Results

In order to analyze these predictions, I construct data on yields and liquidity. I use daily data from Bloomberg on generic 10-year government bonds from Portugal, Ireland, Italy, Greece, and Spain (PIIGS) over the period 2000-2015 in panel regressions with country and year-month fixed effects. (A larger panel of European countries shows the identical effects.)

I construct the bid-ask spread using yields in percent terms in order to measure illiquidity of the bonds.

$$\text{Bid-Ask Spread} = \frac{Ask_t - Bid_t}{Ask_t}$$

Thus a higher bid-ask spread corresponds to lower liquidity, and a lower bid-ask spread corresponds to higher liquidity.

I first check that the hypothesized link between yields and liquidity exists. Column 1 of Table 1 shows the result of a simple regression of yield on the measure of liquidity. Liquidity falls as yields rise, as the model would predict. A higher yield indicates that default is more likely, hence the value of private information is high. With private information, bond trades are limited due to adverse selection: bond holders fear their trading partner knows more than they do and is taking advantage of them.

Specific to the model is a prediction that this fall in liquidity will be non-linear. The shape of the bond payoff curve means higher yields, indicating higher likelihood of default, should result in even lower liquidity as more information is in the market and adverse selection is highere. In order to capture this effect, Column 2 of Table 1 shows the effect of splitting yields into quintiles (by country) and re-running the regression of yield on liquidity. The results follow the model: higher yields have an increasingly large effect on liquidity.

The model predicts that information will enter the market when yields are high, and that more information will inevitably lead to heterogenous beliefs and disagreement about the proper price, depressing liquidity. In order to test this prediction, I look to see whether disagreement about the default probability of bonds leads to lower liquidity. I collect the Moody's and S&P ratings of the government bonds, then construct a measure of the rating difference between Moody's and S&P by calculating the number of bond rating notches between the two ratings

$$\text{Rating Difference}_t = |\text{Moody's Rating}_t - \text{S\&P Rating}_t|$$

Using this rating difference measure as a proxy for disagreement about the default probability, I split the rating difference into quantiles and regress them on the liquidity measure (excluding the no-disagreement quantile). Column 3 of Table 1 confirms that more disagreement leads to lower liquidity as the model would predict.

Columns 4, 5, and 6 of Table 1 show that the results above continue to hold when we include the entire EU rather than just the PIIGS countries.

2.2 Endogeneity Concerns

The regression results reported in Table 1 are statistically significant, but do not fully establish causation. The model predicts that a high yield causes

Table 1:

	Dependent variable:					
	Bid-Ask Spread					
	(1)	(2)	(3)	(4)	(5)	(6)
Yield	0.340^{***}			0.304^{***}		
	(0.002)			(0.003)		
Yield Q2		0.534^{***}			0.185^{***}	
		(0.032)			(0.021)	
Yield Q3		0.682^{***}			0.464^{***}	
		(0.034)			(0.022)	
Yield Q4		0.917^{***}			0.729^{***}	
		(0.034)			(0.023)	
Yield Q5		1.728^{***}			1.405^{***}	
		(0.039)			(0.024)	
Rating Difference Q2			-0.039^{**}			-0.341^{***}
			(0.017)			(0.014)
Rating Difference Q3			0.472^{***}			0.327^{***}
			(0.028)			(0.028)
Rating Difference Q4			0.699^{***}			1.155^{***}
			(0.036)			(0.038)
Sample	PIIGS	PIIGS	PIIGS	EU	EU	EU
Observations	20,870	20,870	20,870	58,436	58,436	58,436
R^2	0.770	0.576	0.550	0.378	0.284	0.255
Adjusted R^2	0.768	0.572	0.546	0.376	0.282	0.252
F Statistic	360.214^{***} (df = 192; 20673)	143.760^{***} (df = 195; 20670)	130.152^{***} (df = 194; 20671)	184.448^{***} (df = 192; 58230)	118.547^{***} (df = 195; 58227)	102.695^{***} (df = 194; 58228)

Note: *p<0.1; **p<0.05; ***p<0.01

illiquidity. It's possible that the causation runs the other way, illiquidity causes a high yield. For example, investors may fear they won't be able to sell in the future, hence illiquidity goes up today as do yields.

In order to establish causality, I use two different instrumental variables for yields. First, I use the price of a credit default swap (CDS spread) from WRDS for each country. This instrument is obviously related to the yield of that country's bonds, while there is no reason to believe it would be linked directly to the liquidity of those bonds. Second, I use the level of the main equity index in each country. Equity indices fall as a country nears default and yields rise, while again there's no reason to believe it should be linked to the liquidity of the government's bond's directly. .

Column 1 of Table 2 shows that the CDS spread for each country is strongly correlated with the yield on that country's bonds. The positive coefficient shows that a higher price for CDS is connected to a higher yield. Column 2 of Table 2 shows that the log of the equity index for each country is related to the yield. The negative coefficient shows that a higher equity index is connected to a lower yield.

Table 2:

	Dependent variable:			
	Yield			
	(1)	(2)	(3)	(4)
CDS Spread	30.883***		38.151***	
	(0.153)		(0.124)	
Log Equity Index		−1.522***		−0.399***
		(0.054)		(0.031)
Sample	PIIGS	PIIGS	EU	EU
Observations	17,601	19,565	47,059	54,782
R^2	0.851	0.581	0.753	0.230
Adjusted R^2	0.849	0.577	0.752	0.227
F Statistic	590.540*** (df = 168; 17428)	149.060*** (df = 180; 19380)	850.994*** (df = 168; 46877)	90.455*** (df = 180; 54588)
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 3 shows that the results in Table 1 are duplicated when using both instrumental variables. Higher yields cause lower liquidity.

Table 3:

	Dependent variable:			
	Bid-Ask Spread			
	(1)	(2)	(3)	(4)
Yield	0.455***	0.418***	0.257***	0.090***
	(0.003)	(0.004)	(0.004)	(0.005)
Instrument	CDS Spread	CDS Spread	Log Equity Index	Log Equity Index
Sample	PIIGS	EU	PIIGS	EU
Observations	17,601	47,059	19,565	54,782
R^2	0.823	0.379	0.757	0.305
Adjusted R^2	0.821	0.376	0.755	0.303
F Statistic	480.114*** (df = 168; 17428)	169.111*** (df = 168; 46877)	329.961*** (df = 180; 19380)	130.541*** (df = 180; 54588)
Note:				*p<0.1; **p<0.05; ***p<0.01

3 Reduced Form Model

In order to more clearly illustrate the price level consequences of the model, I first provide a simple reduced form model similar to the initial model in Bassetto (2002) that concentrates on a consumer buying safe government bonds, assuming that government bonds are a safe asset. The core of the model is a bond investment decision in two periods. In Section 4 I expand and generalize the model to provide microfoundations for the safe asset nature of government bonds.

3.1 Consumers

A consumer has per-period utility $u(C), U(C) = u(C_1) - \delta_\gamma \gamma + u(C_2)$ and faces the budget constraints

$$\begin{aligned} P_1 C_1 &\leq P_1 E_1 + B_1 - \frac{B_2}{R} \\ P_2 C_2 &\leq P_2 E_2 + B_2 \end{aligned} \tag{1}$$

and first order condition $u'(C_1) = \frac{P_1 R_1}{P_2} u'(C_2)$ where P_2 is unknown to the consumer in period 1. The consumer has constant endowment 1 in both periods. His endowment is diminished by known lump-sum taxes T_1, T_2. Define $E_1 = 1 - T_1, E_2 = 1 - T_2$ as the consumer's post-tax endowment.

He starts period 1 holding B_1 nominal bonds, and buys nominal bonds

$B_2 \geq 0$ backed by the government's surplus next period $S_2 = T_2 - G_2$, where G_2 is unknown. The bonds are sold by the government at the interest rate R and pay out 1 nominal next period.

The consumer has beliefs $d(S_2)$ about what S_2 will be. These beliefs are the consumer's, and may not be related to the true S_2 in any way. The consumer decides whether or not to expend γ utils to learn what the true government surplus in the second period S_2 will be. $\delta_\gamma = 1$ is an indicator of the choice to do so.

3.2 Government

The government combines a fiscal and a monetary authority. The fiscal authority chooses government spending G_1, G_2 which has no utility impact. By choosing G_1, G_2, the fiscal authority determines the government's surplus $S_1 = T_1 - G_1, S_2 = T_2 - G_2$, $S_1, S_2 > 0$. The monetary authority chooses the interest rate R. For ease of exposition, the government's choices $\{G_1, G_2, R\}$ are made prior to period 1 (thus unconditional of consumer choice). Bond supply B_2 is set to the consumer's bond demand $B_2(R)$. The government has access to free disposal of excess revenue.

Free disposal of excess revenue is a simple way to guarantee that consumers do not expect that they will benefit from excess revenue. Practically, free disposal itself could take many forms. The government could burn the revenue, or throw it in the ocean. A simple political economy model could have the government spend the excess revenue rewarding itself.

The government's budget constraints are

$$\begin{aligned} B_1 &\leq P_1 S_1 + B_2/R \\ B_2 &\leq P_2 S_2 \end{aligned} \tag{2}$$

where in the first period it gains revenue from the bonds sold to the consumer, B_2 discounted at R, and the surplus S_1. In the second period the government must repay the B_2 bonds utilizing only the fiscal surplus.

3.3 Price Level Determination

The foundation of the MFTPL is that nominal government bonds are a bond consumers hold against government surpluses. Under the MFTPL, the price level is determined by the previous price level and the actions of the government. If, given the price level last period, the government's surplus is smaller than the face value of bonds to be repaid, the price level will increase to equate the surplus and required bond repayment. If, given the price level last period, the government's surplus is larger than the face value of bonds, the government may use free disposal to rid itself of excess revenues and determine the price level.

$$P_1 = \begin{cases} \frac{B_1 - B_2/R}{S_1}, & \text{if } S_1 + \frac{B_2}{R} < B_1 \\ 1, & \text{if } S_1 + \frac{B_2}{R} \geq B_1 \end{cases}, \qquad P_2 = \begin{cases} \frac{B_2}{S_2}, & \text{if } P_1 S_2 < B_2 \\ P_1, & \text{if } P_1 S_2 \geq B_2 \end{cases} \tag{3}$$

Free disposal is only possible when there is excess revenue. For simplicity, I assume the government rids itself of all excess revenue, thus the price level is constant between periods. A more complicated equilibrium could allow the government to specify a free disposal rule and thus choose a price level that requires some disinflation.

While the above explanation suffices to establish price level changes and thus the price level in period 2 given the price level in period 1, it does not necessarily establish the initial price level in period 1. I apply the same MFTPL logic to the price level in period 1, while normalizing the previous period's price, implicitly P_0, to unity. This is a form of the indeterminacy encountered with nominal interest rate targeting, though in this case the indeterminacy only applies if there is excess revenue in the initial period.

3.4 Equilibrium Definition

With initial bonds B_1 and beliefs $d(S_2)$, an equilibrium is a set of consumer choices $\{C_1, C_2, \delta_\gamma, B_2\}$, price levels $\{P_1, P_2\}$, and government choices $\{S_1, S_2, R\}$

such that

1. Given price levels, government policy, and initial beliefs, the consumer maximizes his utility subject to his per-period budget constraints 1

2. Government budget constraints 2 hold. After paying G, B, all excess revenue is disposed of.

3. Given all other choices, price levels are determined by the MFTPL pricing equations 3

4. Given R, hence bond demand $B_2(R)$, the government supplies $B_2(R)$ bonds.

3.5 Analysis of the Reduced Form Model

Claim 1 *There exists R^* such that for all $R \leq R^*$, the consumer will not learn the second period surplus, thus keeping his beliefs $d(S_2)$, while for all $R > R^*$ the consumer will expend γ to learn the second period surplus S_2.*

The higher the interest rate, the more bonds a consumer would buy if he knew for sure they would be repaid. More bonds implies a greater utility gain, while the utility cost γ is constant. The consumer will expend γ if the benefit of knowledge, the difference between expected utility with full knowledge and expected utility without full knowledge, is high enough

$$\underbrace{\int \max_{B_2} \left[u(C_1) + u(C_2)\right] d(S_2)}_{\text{Expected Utility of Full Knowledge with Current Beliefs}} -$$
$$\underbrace{\max_{B_2} \left[\int u(C_1) + u(C_2) d(S_2)\right]}_{\text{Expected Utility with Current Beliefs}} > \gamma$$

The left side of the inequality is increasing in R for $B_2 \leq \sup\left(d(S_2)\right)$. High enough R will provoke the consumer into learning the true surplus. R^* is the value such that the equation holds with equality. I assume the benefit must be strictly greater than the cost to convince the consumer to expend γ.

I define monetary dominance and fiscal dominance to be consistent with the model, and provide the link to the value of R^*.

Definition 1 *The monetary authority is dominant if, given* $\{E_1, B_1, R, S_1, d(S_2)\}$*,* P_1 *is constant for all values of* S_2*.*

Definition 2 *The fiscal authority is dominant if, given* $\{E_1, B_1, R, S_1, d(S_2)\}$*,* P_1 *is not constant for all values of* S_2*.*

Claim 2 *The monetary authority is dominant for* $R \leq R^*$*. The fiscal authority is dominant for* $R > R^*$*.*

The price level P_1 is (partially) determined by the amount of revenue the government raises in the first period by selling bonds $\frac{B_2}{R}$. As shown in Claim 1, there are two regions for the beliefs of the consumer of the second period surplus as a function of R.

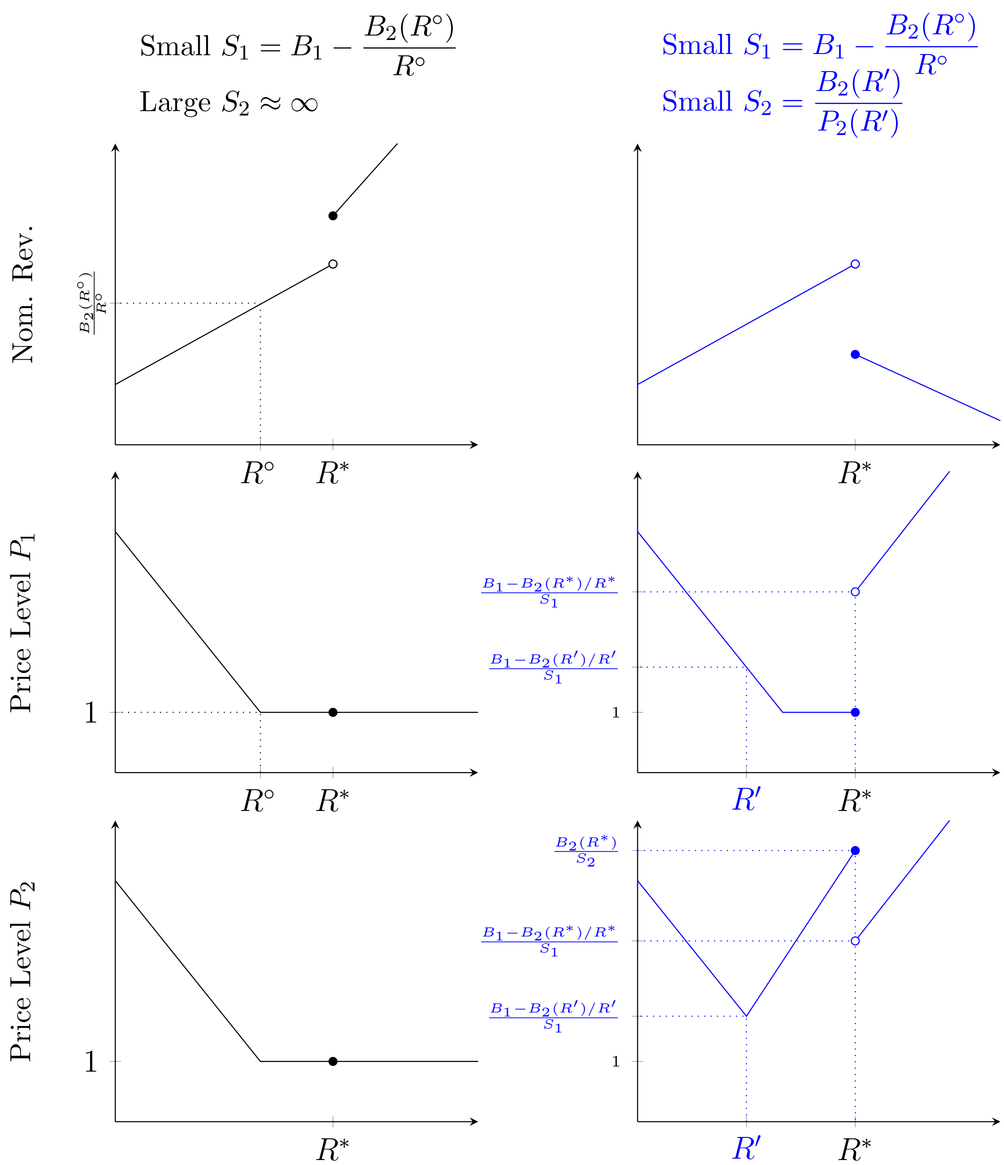
If $R \leq R^*$, the monetary authority is dominant: consumers use their uninformed beliefs of the second period surplus to guide their bond purchases rather than the actual value of that surplus. If $R > R^*$, the fiscal authority is dominant: consumers know the true value of S_2 and thus their purchase decision is affected by S_2. Specifically,

$$B_2(R) = \begin{cases} \arg\max_{B_2} \left[\int u(C_1) + u(C_2) d(S_2)\right] \text{ if } R \leq R^* \\ \min\{B_2^*, S_2\} \text{ if } R > R^* \end{cases} \tag{4}$$

where B_2^* is the amount of bonds demanded by the consumer at a given interest rate if the consumer knows the bonds will be repaid (i.e. the government surplus S_2 is larger than B_2^*)

$$B_2^*(R) = \arg\max_{B_2} \left[u\left(C_1\right) + u\left(C_2\right)\right]$$

Figure 3: Examples of the MFTPL



Example 1 Figure 3 illustrates the price level implications of the MFTPL, and the regions of monetary and fiscal dominance. The left and right sides represent two models with only the surplus in the second period S_2 differing between them. In both cases the monetary authority is dominant for $R \leq R^*$ and the fiscal authority is dominant for $R > R^*$.

The left side depicts the MFTPL when there is a very large surplus in the second period. The top graph illustrates that higher interest rates raise more revenue for the government to use in the first period to repay B_1. This is true both for $R < R^*$ and $R \geq R^*$. At R^* and above, the consumer learns the true surplus and continues buying bonds that will be fully repaid. consumer. Since revenue is increasing, the price level in the first period P_1 is weakly decreasing for $R \leq R^*$. Increased revenue drives down the price level in the first period until $P_1 = 1$.

In contrast, the right side depicts the MFTPL when there is only a small surplus in the second period. Specifically, $S_2 = \frac{B_2(R')}{P_2(R')}$ for some $R' < R^*$. On the domain $R \leq R^*$, the price level in the first period P_1 behaves identically to model illustrated on the left side. In both models on this region, the consumer doesn't know the true value of S_2 so bond demand is identical. This is the definition of monetary dominance on $R \leq R^*$.

The price level in the second period on the right side follows the same path as on the left side for $R \leq R'$. At R', the second period inherits the price level from the first period $\frac{B_1 - B_2(R')/R'}{S_1}$. For $R \in (R', R^*]$ the second period surplus is insufficient to cover the bond demand $B(R)$. Hence, the second period price level must rise to equate $B_2 = P_2 S_2$. At R^*, the second period price level reaches $P_2 = \frac{B_2(R^*)}{S_2}$.

For $R > R^*$, the consumer learns the true surplus S_2. Knowing the surplus affects the price level, illustrating fiscal dominance on $R > R^*$. Once the consumer knows the surplus, he won't buy bonds that aren't backed in real terms, hence the amount of bonds demanded falls. Lower bond demand means lower revenue raised by the government in the first period, so a higher price level $P_1 = \frac{B_1 - B_2(R^*)/R^*}{S_1}$ that is also inherited by the second period as illustrated by the lower graph. As R rises past R^*, bond demand increases to make up for the increase in the first period price level caused by shrinking revenue. Increased bond demand means the second period price level rises as well.

4 Microfounded Model

I elaborate on the reduced form model by incorporating aspects of Dang et al. (2017) into the reduced form model. The single consumer of the reduced form model is split into two consumers. An early consumer can purchase bonds from the government but is subject to a possible liquidity shock that requires him to sell some of his bonds. A late consumer can learn the government's future surplus, and can buy bonds from the early consumer.

The microfounded model expands the two periods of the reduced form model into three periods in order to better match the definitions of monetary and fiscal dominance that were used in the reduced form model. Knowledge of the government's surplus will affect choices in the next period rather than the current period, necessitating an intermediate second period.

The timing of the model is illustrated in Figure 4.

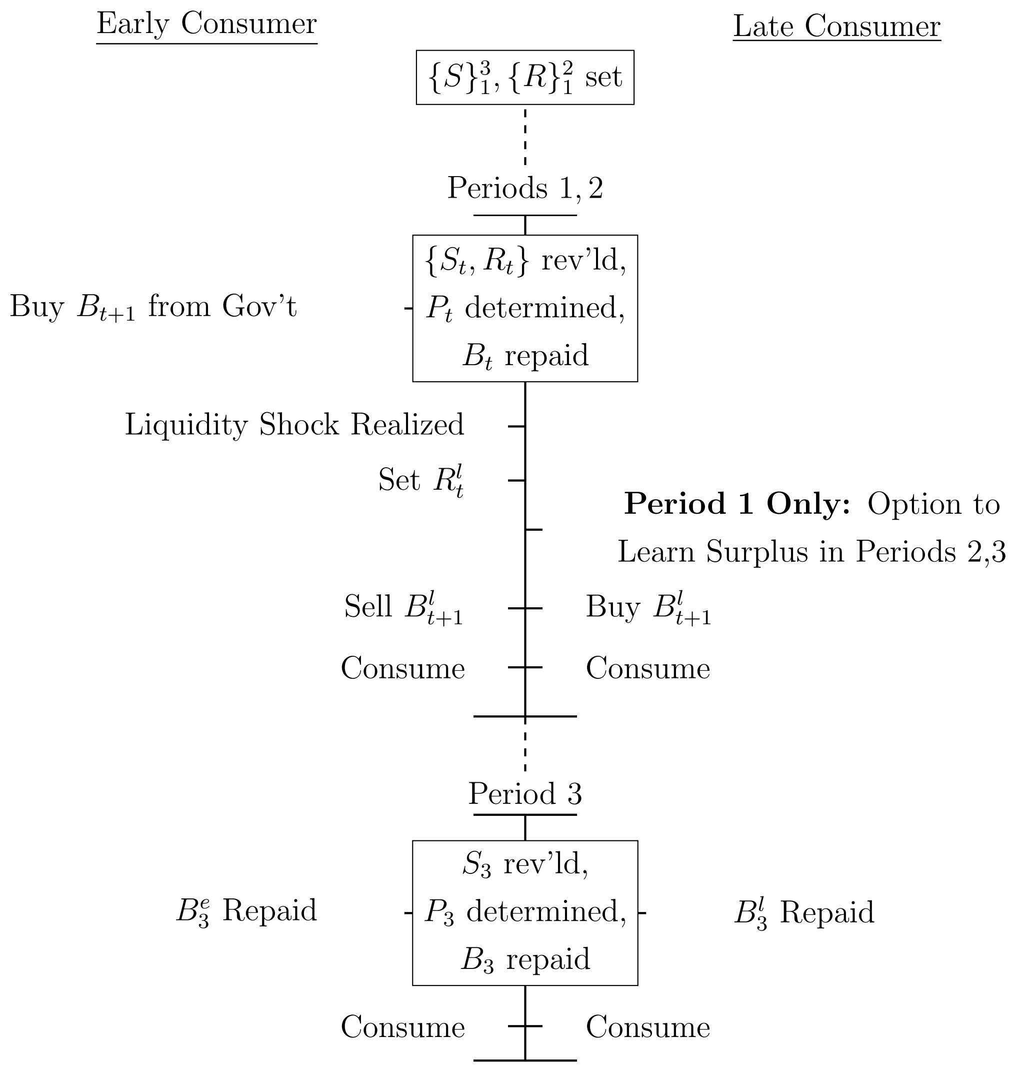


Figure 4: Microfounded Model Timing

4.1 Consumers

There are two consumers, early and late, named for when they enter the market for bonds. The early consumer can purchase bonds directly from the government and is potentially subject to a liquidity shock. The late consumer can purchase bonds from the early consumer, and, in the first period, may pay a cost to look ahead to learn the fiscal surplus in the second and third periods. All information is public: both consumers know whether the liquidity shock hits the early consumer, and both consumers will learn future surpluses if the late consumer chooses to do so.

As in the reduced form model, define $E_t = 1 - T_t$, $S_t = T_t - G_t$. I will describe the model in the first and second periods, and then the ending third period, thus $t \in \{1, 2\}$ and $t + 1 \in \{2, 3\}$. Variables will share the same definitions as in the reduced form model where appropriate.

At the beginning of the first period, consumers learn the government's choices $\{S_1, R_1\}$. They do not know the the government's choices in the second period $\{S_2, R_2\}$ nor third period $\{S_3\}$ that defines the government's surplus, though they have expectations of the surplus. Similarly, at the beginning of the second period, consumers learn $\{S_2, R_2\}$ but do not know $\{S_3\}$ until the third period.

The early consumer can purchase bonds that pay one nominal unit in the second period directly from the government, at the interest rate R_t set by the monetary authority

$$\frac{B_{t+1}}{R_t} \leq P_t E_t + B_t^e$$

After purchasing B_{t+1}, the early consumer is subject to a liquidity shock with probability π. The liquidity shock requires that the early consumer hold their entire endowment after taxes plus initial bonds $P_t E_t + B_t^e$ at the end of the period (at which time they will be free to consume it). There is a utility cost α per unit of shortfall. The shortfall is equal to the amount of revenue the early consumer spends buying bonds from the government minus the amount of revenue raised by selling bonds to the late consumer $\left(\frac{B_{t+1}}{R_t} - \frac{B_{t+1}^l}{R_t^l}\right)$.

Following the possible realization liquidity shock, the early consumer can trade with the late consumer by selling him bonds. In the first period, the late consumer has the option to pay utility cost γ to learn the government's future surplus $\{S_2, S_3, R_2\}$. The term $\delta_\gamma \in \{0, 1\}$ indicates whether or not the late consumer chooses to learn the government's surplus. After deciding on δ_γ, the late consumer purchases bonds from the early consumer subject to

$B^l_{t+1} \leq B_{t+1}$ and

$$\frac{B^l_{t+1}}{R^l_t} \leq P_t E_t + B^l_t$$

The total amount of bonds in the economy is B_{t+1}. The early consumer's bond holdings after trade are $B^e_{t+1} = B_{t+1} - B^l_{t+1}$, hence if the late consumer purchases no bonds, $B^e_{t+1} = B_2$.

In the third period, the government's choice of surplus S_3 is revealed. The early consumer's budget constraint is

$$P_3 C^e_3 \leq P_3 E_3 + B^e_3$$

while the late consumer's budget constraint is

$$P_3 C^l_3 \leq P_3 E_3 + B^l_3$$

Looking at the consumers utility, the early consumer's overall utility is

$$U^e = \begin{cases} u(C^e_1) - \alpha(\frac{B_2}{R_1} - \frac{B^l_2}{R^l_1}) + u(C^e_2) - \alpha(\frac{B_3}{R_2} - \frac{B^l_3}{R^l_2}) + u(C^e_3) \text{ with probability } \pi^2 \\ u(C^e_1) - \alpha(\frac{B_2}{R_1} - \frac{B^l_2}{R^l_1}) + u(C^e_2) + u(C^e_3) \text{ with probability } \pi(1-\pi) \\ u(C^e_1) + u(C^e_2) - \alpha(\frac{B_3}{R_2} - \frac{B^l_3}{R^l_2}) + u(C^e_3) \text{ with probability } \pi(1-\pi) \\ u(C^e_1) + u(C^e_2) + u(C^e_3) \text{ with probability } (1-\pi)^2 \end{cases}$$

where the α terms are the cost of the liquidity shock occurring with probability π. The late consumer's overall utility is

$$U^l = u(C^l_1) - \delta_\gamma \gamma + u(C^l_2) + u(C^l_3)$$

where γ is the utility cost of looking ahead.

4.2 Government

The government is identical to the government in the reduced form model. Its budget constraints are

$$\begin{aligned} B_t &\leq P_t S_t + B_{t+1}/R_t \\ B_3 &\leq P_3 S_3 \end{aligned} \tag{5}$$

4.3 Price Level Determination

Price level determination is an extension of the price level determination in the reduced form model.

$$\begin{aligned} P_1 &= \begin{cases} \frac{B_1 - B_2/R_1}{S_1}, & \text{if } S_1 + \frac{B_2}{R_1} < B_1 \\ 1, & \text{if } S_1 + \frac{B_2}{R_1} \geq B_1 \end{cases}, \\ P_2 &= \begin{cases} \frac{B_2 - B_3/R_2}{S_2}, & \text{if } P_1 S_2 < B_2 \\ P_1, & \text{if } P_1 S_2 \geq B_2 \end{cases}, \\ P_3 &= \begin{cases} \frac{B_3}{S_3}, & \text{if } P_2 S_3 < B_3 \\ P_2, & \text{if } P_2 S_3 \geq B_3 \end{cases} \end{aligned} \tag{6}$$

4.4 Equilibrium Definition

I describe the equilibrium by period to make the information sets of each consumer clear. An equilibrium is a set of choices by the early and late consumer, conditional on their information sets and liquidity shock. In each period, given price levels, government policy, and beliefs or knowledge, the consumer maximizes his utility subject to his per-period budget constraints

In the first period, given government policy $\{S_1, R_1\}$, price level P_1, with initial bonds B_1 and beliefs $\{d(S_2, R_2), d(S_3)\}$, the early consumer chooses B_2. After the realization of the liquidity shock, the early consumer sets R_1^l. The late consumer knows the liquidity shock and R_1^l, and chooses δ_γ – whether to stick with $\{d(S_2, R_2), d(S_3)\}$ or learn $\{S_2, S_3\}$ – before choosing B_2^l.

In the second period, given government policy $\{S_2, R_2\}$, price level P_2, with bond holdings $\{B_2^e, B_2^l\}$, the early consumer either has beliefs $d(S_3)$ if $\delta_\gamma = 0$ or knowledge S_3 if $\delta_\gamma = 1$. The early consumer chooses B_3, observes the realization of the liquidity shock, and chooses R_2^l. The late consumer has beliefs $d(S_3)$ if $\delta_\gamma = 0$ or knowledge S_3 if $\delta_\gamma = 1$, knows the liquidity shock and chooses B_3^l.

In the third period, markets clear and the consumers do not make choices.

Government budget constraints Equation 5 hold in all periods. After paying $\{G_t, B_t\}$ for $t \in \{1, 2, 3\}$, all excess revenue is disposed of.

Given all other choices, price levels are determined by the MFTPL pricing Equation 6.

Given R in each period $t \in \{1, 2\}$, hence bond demand $B_t(R)$, the government supplies $B_t(R)$ bonds.

4.5 Analysis of the Microfounded Model

I concentrate on illustrating that the analogous result to monetary and fiscal dominance in Claim 2 holds in the microfounded model. Due to the similarity between the microfounded model and the reduced form model, I examine decisions in the first period, and relegate the necessary backward induction to the Appendix. Fiscal dominance will exist, but the proximate cause is the unexpected liquidity shock rather than direct government surpluses.

Additionally, the microfounded model allows a further analysis of the insurance value of safe assets in providing insurance to both consumers. Safer assets, with higher γ, provide more insurance, and thus raise expected welfare.

Claim 3 *There exists R_1^* such that for all $R_1 \leq R_1^*$, the late consumer will not learn the surplus in periods two and three, thus keeping his beliefs $d(S_2, R_2), d(S_3)$, while for all $R > R^*$ the late consumer will expend γ to learn the surplus in periods two and three.*

The late consumer in the microfounded model is similar to the single consumer in the reduced form model. The main difference is that he faces an interest rate R_1^l set by the early consumer rather than the government. As in

Claim 1, the late consumer will expend γ to learn the surpluses if

$$\underbrace{\int \max_{B_2^l}\left[u(C_1^l) + \int \max_{B_3^l}\left[u(C_2^l) + u(C_3^l)\right] d(S_3)\right] d(S_2, R_2)}_{\text{Expected Utility of Full Knowledge with Current Beliefs}} - \underbrace{\max_{B_2^l}\left[\int \left(u(C_1^l) + \max_{B_3^l}\left[\int u(C_2^l) + u(C_3^l) d(S_3)\right]\right) d(S_2, R_2)\right]}_{\text{Expected Utility with Current Beliefs}} > \gamma$$

The definitions of monetary and fiscal dominance now relate to the price level in the second period (and could be extended to the third) because government revenue, and hence the price level, in the first period is determined solely by the early consumer. The price level in the first period will be the same whether or not the late consumer learns future surpluses. The surplus in the second period S_2 is revealed at the beginning of the second period, hence knowledge of S_3 determines dominance for P_2.

Definition 3 *The monetary authority is dominant if P_2 is constant for all values of S_3.*

Definition 4 *The fiscal authority is dominant if P_2 is not constant for all values of S_3.*

Claim 4 *In period 2, the monetary authority is dominant if $R_1^l \leq R_1^*$. The fiscal authority is dominant if $R_1^l > R_1^*$.*

Analogously to Claim 2, R_1^* partitions the space of R_1^l into two regions. If $R_1^l \leq R_1^*$ the late consumer doesn't expend γ and thus retains his beliefs of S_3 rather than the true value. If $R_1^l > R_1^*$, the late consumer expends γ and learns the true S_3.

While Claims 2 and 4 look similar, the reason that fiscal dominance will occur differ. In the reduced form model described by Claim 2, fiscal dominance occurs when the government offers too high an interest rate given consumers existing beliefs ($d(S_2)$) and observed values (S_1). The consumer is suspicious of the good deal the government is offering on bonds and chooses to learn the surplus. Thus fiscal dominance in the reduced form model requires only certain government choices.

In the microfounded model described by Claim 4, fiscal dominance occurs when the early consumer offers too high an interest rate to the late consumer. The government is not the direct cause. The late consumer will offer an interest rate $R_1^l > R_1^*$ when he has bought too many bonds, and he is hit by the liquidity shock. Without the liquidity shock, the early consumer will never need to raise revenue unexpectedly, thus will never take the risk that the early consumer will learn the surplus is insufficient. With the liquidity shock, if it hits, the early consumer must balance the the liquidity penalty α with the risk the the early consumer will discover the surplus is insufficient, and refuse to trade. Thus fiscal dominance in the microfounded model requires both government choices, and bad luck to encounter the liquidity shock.

Claim 5 *The expected utility of both the early and late consumer is weakly increasing in the cost γ the late consumer pays to find out the second and third period surpluses.*

A safe asset is characterized by the difficulty consumers have in researching its backing. The higher the difficulty in finding out the true return, the safer it is. Safe assets allow consumers to insure against bad states of the world.

A higher cost to find out surpluses means R_1^* is higher, hence the early consumer will be able to sell more bonds $B_2^l(R_l^*)$ to the late consumer in the event the early consumer is hit by the liquidity shock. Since the early consumer can sell more bonds to the late consumer without triggering revelation, the early consumer will be willing to buy more bonds (at any given price). Since consumers choose to buy more bonds, purchasing more bonds must result in higher expected welfare than purchasing fewer.

Example 2 To illustrate the effects of Claim 5 consider a case where both $d(S_2, R_2), d(S_3)$ have support near 0, and the liquidity penalty α is very close to ∞. I contrast two polar cases for the cost γ of learning S_2, S_3.

If an asset is entirely unsafe, $\gamma = 0$, the late consumer will always learn the surpluses in the second and third period. Hence $R_1^* \approx 0$. Because the early consumer believes there is a chance that both surpluses are minuscule, he won't purchase any bonds because he knows he will be unable to resell them to the late consumer if the liquidity shock hits. Thus $B_2 \approx 0$ and neither consumer benefits can smooth or save.

If an asset is perfectly safe, $\gamma \approx \infty$, the late consumer will never know the surpluses in the second and third period. Hence $R_1^* \approx \infty$. The early consumer knows he will be able to resell any amount of bonds he buys if the liquidity shock hits. Thus the early consumer will buy bonds and sell some to the late consumer. The bonds will insure the early consumer against the liquidity shock and allow both consumers to smooth and save.

5 Conclusion

Treating government bonds as a safe asset leads to a new theory of the price level: the monetary-fiscal theory of the price level. Nominal government bonds are bonds, and should be priced as such. Furthermore, government bonds are a safe asset. Holmstrom (2015) and Gorton (2017) provide a method of valuing safe assets, and explain how they provide liquidity in the economy. Applying those methods to valuing nominal government debt results in a theory of the price level that matches the intuition that the monetary authority controls the price level in normal times and the fiscal authority's choices matter in unusual times.

Bond valuation is different from stock valuation because a bond will only ever pay out a maximum of its face value. A consumer wants to know if his bond will be repaid. If he's confident it will be repaid, he won't bother to learn the exact surplus that backs the bond. A safe asset is defined by that learning being very expensive for the consumer to do. Translated to government bonds, a consumer will buy and hold government bonds without knowing the government's true future surplus because he believes the bonds will be repaid, and it's too costly to learn the truth.

The more bonds the consumer holds, the more important the information about the government's future surplus becomes. Eventually it's worthwhile for the consumer to learn the future surplus to guarantee he'll be repaid. Equivalently, the monetary authority is constrained in its ability to raise revenue by selling bonds at a high interest rate without the consumer investigating future surpluses. Once the consumer knows future surpluses, he won't purchase bonds he knows won't be repaid. Since revenue helps determine the price level, the monetary authority doesn't exert perfect control – it needs the backing of the fiscal authority.

References

Andolfatto, David, "On the Social Cost of Transparency in Monetary Economics," *Federal Reserve Bank of St. Louis*, 2010, (001A).

Bassetto, Marco, "A Game–Theoretic View of the Fiscal Theory of the Price Level," *Econometrica*, 2002, *70* (6), 2167–2195.

Benmelech, Efraim and Nittai K Bergman, "Credit Market Freezes," Working Paper 23512, National Bureau of Economic Research June 2017.

_ **and** _ , "Debt, Information, and Illiquidity," *mimeo*, 2017.

Cochrane, John, "Money as stock," *Journal of Monetary Economics*, 2005, *52* (3), 501–528.

Dang, Tri Vi, Gary Gorton, Bengt Holmström, and Guillermo Ordoñez, "Banks as Secret Keepers," *American Economic Review*, April 2017, *107* (4), 1005–29.

Gorton, Gary, "The History and Economics of Safe Assets," *Annual Review of Economics*, 2017, *9* (1), 547–586.

Holmstrom, Bengt, "Understanding the Role of Debt in the Financial System," *BIS Working Papers*, Jan. 2015, (479).

Leeper, Eric M., "Equilibria under 'active' and 'passive' monetary and fiscal policies," *Journal of Monetary Economics*, 1991, *27* (1), 129 – 147.

Sargent, N. Wallace T.J., "Some Unpleasant Monetarist Arithmetic," *Federal Reserve Bank of Minneapolis Quarterly Review*, 1985, *9.*

Sims, Christopher A., "A simple model for study of the determination of the price level and the interaction of monetary and fiscal policy," *Economic Theory*, May 1994, *4* (3), 381–399.

Woodford, Michael, "Fiscal Requirements for Price Stability," *Journal of Money, Credit and Banking*, 11 2000, *33.*