TÜRKİYE CUMHURİYET MERKEZ BANKASI

# Corporate Debt Maturity, Repayment Structure and Monetary Policy Transmission

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May 2020

Working Paper No: 20/09

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# Corporate Debt Maturity, Repayment Structure and Monetary Policy Transmission

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**Abstract**

Taking a theoretical stand, this paper studies the role of corporate debt maturity and its repayment structure in monetary policy transmission mechanism. It builds on a stylized New Keynesian dynamic stochastic general equilibrium (NK-DSGE) model and discusses the transmission under various corporate debt structures. The results show that a given contractionary monetary policy is less effective in terms of stabilizing inflation when debt contracts are written on a floating rate basis. Moreover, increased corporate debt burden amplifies the real effects of the credit channel. Extending the maturity of floating rate debt aggravates these effects and makes firms even more vulnerable to adverse shocks.

**Keywords:** Floating rate debt, Debt maturity, Monetary policy transmission, Credit channel

**JEL Classification:** E43, E44, E52, E58, G30

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# Non-technical Summary

This paper is about balance sheet channels of monetary policy transmission. Specifically it identifies two additional sub-channels: floating rate debt and maturity channel. These channels work through the value of outstanding debt and expected cash flows. Building an otherwise standard NK-DSGE model, the paper focuses on the corporate debt structure and shows the repayment structure (floating or fixed rate debt) and the maturity of the debt significantly effects the transmission after a policy decision.

After a policy rate hike, expected future interest rates increases as the yield curve shifts up. If the corporate debt is issued on a floating rate repayment structure, the hike causes an increase in the total debt burden and in turn expected cash outflow raises. This implies credit channel to entail a stronger adverse real effect compared to the fixed rate debt case. Maturity is an important dimension of transmission mechanism as well. The model shows that extending the maturity of floating rate debt amplifies the real effects due to longer exposure to higher interest rates.

Moreover, the comparison across floating rate and fixed rate debt economies show that monetary policy less effective in steering inflation. The reason is, in the model with floating rate debt, the outstanding repayments are adjusted with the realized change in interest rates each period. Producers' prices do not fall as much as in the fixed rate model, because of the fact that their costs have mounted.

All in all, this paper develops a theoretical ground for corporate debt structure in a standard macroeconomic model. The model shows that the macroeconomic effect of aggregate shocks depend on the structure of debt contracts.

# 1 Introduction

Monetary policy is transmitted through real economy by various channels. There has been continuous effort to explore these channels, in order to examine their empirical relevance by both academics and policy makers. Theoretical models with financial frictions have put forward the balance sheet channel and proposed to explain long-lasting effects of monetary policy through this. A contractionary monetary policy shock affects balance sheet of firms in two ways. First, it typically weakens the net worth of firms and firms' borrowing capacity. Second, it affects the value of outstanding debts and assets, and in turn total cash flow becomes lower (Bernanke and Gertler, 1995).

This paper focuses on the second dimension and investigates the role of repayment structure and debt maturity through their effect on the value of outstanding debt. Building an otherwise standard NK-DSGE model, I focus on the corporate debt structure and show that monetary policy becomes less effective in stabilizing inflation in the floating rate debt economy. Moreover, credit channel entails stronger adverse real effects after a policy rate hike. The models built in this paper also highlight the role of debt maturity. I show that maturity is an important dimension of corporate debt structure and has significant aggregate effects. Namely, extending the maturity of floating rate debt aggravates the real effects since it causes an increase in the total debt burden after a contractionary policy.

The global financial crisis in 2008 has triggered substantial research on the balance sheet channel of monetary policy transmission. Various mechanisms have been studied to understand Bernanke and Gertler's (1995) "black box". An influential branch of the literature has focused on various sub-channels and transmission to better understand the macro-economic effects of monetary policy. Some of this research focus on debt maturity. For example, Almeida et al. (2012) analyze the crisis period and find that firms whose long-term debt was mostly maturing right after the third quarter of 2007 cut down investment significantly more than otherwise similar firms whose debt was scheduled to mature after 2008. Foley-Fisher et al. (2016) focus on the Fed's maturity extension program (MEP)[1], and show that stock prices rose much more for firms with longer maturity debt. Moreover, firms which increased the level of their long-term debts during the MEP also expanded their employment and investment. These papers present evidence on the importance of debt maturity over business cycles.

Repayment structure matters as much as the maturity in the transmission mechanism. If long-term debt is issued at the floating rate basis, aggregate shocks change the outstanding amount to repay which results to cash inflow or outflow. This, in turn makes the effect of the shock even stronger. For instance, Calza et al. (2013) estimate vector auto-regressive regressions (VARs) for a set of countries and find that the economies which finance long-term mortgage debts with floating rate debt are more sensitive to monetary policy shocks.

Ippolito et al. (2017) point out that firms with higher floating rate debt leverage get affected more from monetary policy surprises in terms of stock market reaction and real variables reaction like investment or sales. Recently, Gurkaynak et al. (2019) find that firms that have more cash flow exposure, which is defined as longer floating rate debt exposure, see their stock prices and investment affected more after a forward guidance surprise provided by the Fed. They document that maturity and repayment (fixed or floating) structure of corporate debt obligations is important in understanding the transmission mechanism of monetary policy. Motivated by these empirical evidences, this paper builds an otherwise standard New Keynesian DSGE model and experiments the business cycle implications of different maturity and repayment structures of corporate debt.

This paper contributes to the theoretical literature on the transmission mechanisms of monetary policy. When there is an interest rate hike, the cash flow effect of monetary policy

[1]It was announced on Sept. 21, 2011, with the intention of lowering long-term rates

does not work only through the total value of debt or leverage. Instead, maturity and the repayment structure matters as well. Monetary policy shock affects the future repayments of debt through i) changes in the present value of debt and ii) changes in expected interest rates in the future periods. Specifically, if the debt is written down on a floating rate basis, changes in expected interest rates directly affect cash (out)flows, whereas the present value of the debt changes slightly or does not change at all. I study the role of debt maturity and repayment structure of constrained entrepreneurs in a general equilibrium framework, where endogenous borrowing constraints serve as an amplification mechanism. The paper aims to provide a theoretical ground to understand the importance of debt maturity and repayment structure over business cycles and monetary policy transmission.

The difficulty in modeling and analyzing maturity choice of a single agent when different types of financial instruments are available in a general equilibrium setting is well-known. Short and long-term bonds are perfect substitutes in the absence of stochastic shocks or endogenous frictions. Therefore, instead of trying to model both long term and short term or floating and fixed rate debt in a single model, I manipulate a single standard model to have longer corporate debt structure or have floating rate debt and provide comparative statistics.

The model presented here provides a set of results with monetary policy implications. After a tightening monetary policy shock, floating rate debt amplifies credit channel and investment and output falls more due to increase in the debt burden. Moreover in the floating rate debt world, inflation and interest rates become more persistent which implies that monetary policy is less effective on stabilizing inflation. This result is in accordance with the literature which compares floating rate and fixed rate mortgage debt structures as in Garriga et al. (2017). As the empirical evidence provided in Gurkaynak et al. (2019) points out maturity of floating rate debt is a significant component, I also provide comparison across two models which differs only in this dimension. The impulse response analyses show that extending the maturity of floating rate debt amplifies the mechanism even further. Longer maturity means increased cost of finance after a interest rate hike, and this causes investment and output to fall even more. It also also weakens the effectiveness of monetary policy rate in steering inflation. Inflation and interest rates become more persistent.

These findings demonstrate that the balance sheet channel of monetary policy is not limited to net worth effect. One of the channels I emphasize is the maturity and repayment structure of corporate debt which are directly linked to future cash flow prospects.

The outline of the paper is as follows: Section 2 takes a tour in the literature. In section 3, I present the baseline model. Section 4 shows calibration. Section 5 displays comparison across impulse responses for short term and long term debt cases. Section 6 introduces floating rate debt and comparisons. Finally Section 7 summarizes the findings and concludes.

## 2 Relevant Literature

Modigliani and Miller (1958) theorem on capital structure is a milestone in corporate finance. The theory shows that under perfect capital markets without any friction, the choice of capital structure and financial instruments are inconsequential to the value of the firm. Stiglitz (1974) extends this theorem and shows that the maturity structure of debt is inconsequential as well. Since then, researchers in corporate finance literature have studied a number of frictions such as tax, agency costs, asymmetric information to point out under what conditions the maturity of debt is relevant, and whether long-term debt is optimal or not.

This paper is related to various strands of the literature which rejects the irrelevance of debt and maturity structure, with a special focus on aggregate economic implications.

The relevance of debt maturity and repayment structure in a general equilibrium setting has been analyzed by the literature that focuses on three different questions. The first strand is government debt and international borrowings that have been popular since the international financial crises of the 1990s, which put many emerging markets into a vulnerable position of debt roll-over crises. Most of these papers lack the endogenous choice between long-term and short-term debt, but instead compare the two extreme cases. [2]

The other two issues have been put on the spotlight by both the policy makers and academics, especially after the recent financial crisis. The second branch is financial institutions' maturity mismatch in their assets and liabilities as in the canonical model of Diamond and Dybvig (1983). The maturity mismatch argument, which suggests that highly levered financial institutions holding too much short-term liabilities to fund their long-term assets, can trigger the crisis (Brunnermeier, 2009). The consequences and relevant policy actions have been studied extensively.[3] The third branch is concerned with housing finance and mortgage credits, which is not completely independent from the second branch. The researchers in this field pay special attention to the structure of debt repayments. They investigate the implications of fixed rate and floating rate multi-period debt comprehensively.

Benes and Lees (2010) investigate business and housing cycle dynamics in response to finance shocks. They find that multi-period fixed rate debt contracts can help smoothing out adverse effects of particular shocks. Calza et al. (2013) study housing finance and the transmission of monetary policy shocks. In accordance with the findings of this paper, they show that consumption is affected more from monetary policy if mortgage debts are preva-

[2] Alfaro and Kanczuk (2009) compare short-term and long-term government debt in a general equilibrium model with uncertainty. Solving an optimal maturity problem for the calibrated Brazilian economy, they conclude that short-term debt implies higher welfare levels because of the higher premium required for the long-term debt due to default risk. Some other examples that deal with government debt include Hatchondo and Martinez (2009), Jeanne (2009), Preston and Eusepi (2011) and Arellano and Ramanarayanan (2008), and Bhattarai et al. (2015)

[3] See for example Farhi and Tirole (2012), Stein (2012), and Segura and Suarez (2016).

lent in the floating-rate type. Similarly, Brzoza-Brzezina et al. (2014) study monetary and macro prudential policy transmission with multi-period loans to housing. They have similar results when they compare fixed rate and floating rate debt multi-period loans. Garriga et al. (2017) study transmission channels additionally and show that monetary policy effects the economy through the cost of new borrowings and the value of outstanding debt with long-term nominal debt.[4]

The results presented in this paper are in line with the findings of these papers. In my model the endogenous borrowing constraints on corporate debt amplify the effect of fundamental shocks. The comparisons across floating rate and fixed rate verify that monetary policy is less effective in terms of stabilizing inflation when debt contracts are written with floating rate repayment structure. On the other hand, floating rate debt contracts aggravate the real effects of credit channel. In addition to this, the analysis of maturity for the floating rate debt shows that extending its maturity cause firms to be more vulnerable to adverse shocks.

While the literature is rich in terms of pointing out the significance of maturity structure of government debt, financial institutions' maturity mismatch or mortgage debts and the relevant policy implications, it has not sufficiently explored the implications of corporate debt maturity in standard dynamic general equilibrium models in response to macroeconomic shocks. Among the recent studies, Bengui (2011) analyzes private debt maturity choices in a Kiyotaki-Moore (1997) type environment, with endogenous collateral constraints. In his model, long-term debt provides insurance against negative shocks, but at the expense of an extra cost over short-term debt. Borrowers choose their debt maturity by trading off the insurance benefits of long-term debt with its costs. He concludes that macro prudential policy in the form of a tax on short-term debt can lead to Pareto improvements. Converse (2017) focuses on emerging markets and investigates the relationship between international capital

[4]Other studies on mortgage debts and its implications include Kydland et al. (2014), Gelain et al. (2015).

flows and maturity mismatch of investment projects. He shows that shocks to capital flow volatility are more destructive when maturity mismatch is prevalent. Shen (2016) studies the role of debt maturity in the context of financial amplification effect and sudden stop crises from emerging countries perspective. She finds that increasing the debt maturity can be beneficial in terms of welfare. Unlike Shen (2016) and Converse (2017), the motivation of this paper is not debt finance in emerging markets and capital flow crisis. Instead, my focus is transmission of monetary policy with corporate debt. This paper shows that longer maturity increases cost of finance and repayments that's why amplifies the real effects of a monetary policy decision.

Finally, this paper is related to the literature on financial frictions. Bernanke and Gertler (1989) and Kiyotaki and Moore (1997) illustrate that in the presence of financial frictions, endogenous variations in borrowers' net worth can lead to amplification of fundamental shocks. When modeling borrowing constraints, I use the structure proposed by Kiyotaki and Moore (1997). In particular, I follow Iacoviello (2005) and Bengui (2011) who embed the mechanism into New Keynesian dynamic stochastic general equilibrium models. To augment the model with price stickiness and monetary policy, I borrow Bernanke et al.'s (1999) model structure and impose price stickiness to retailers.

# 3 Model

I construct a simple NK-DSGE model with corporate debt and nominal rigidities, which is inspired by Iacoviello (2005). The model has five types of agents. These are households who are savers, entrepreneurs who are debtors, a retailer, a capital producer and the monetary policy authority.

The representative entrepreneur borrows from the household to invest in their capital, produce their output which they sell to retailers who are monopolistically competitive and is subject to Calvo price stickiness. The entrepreneur is limited in terms of borrowing: they are subject to collateral constraints á la Kiyotaki and Moore (1997). The retailer will differentiate the output, turn it into a consumption good and sell it back to consumers. The debts are written in nominal terms. So, future payments will be affected by inflation.

The representative household enjoys consumption and leisure. S/he behaves like a banker; receives returns from financial instruments and lends to entrepreneurs each period. S/he supplies labor to the production provided by entrepreneurs.

## Long-term and Short-term Debt Structure

To examine the effects of long-term debt, I choose to model it as perpetuity whose repayments decrease geometrically. This enables us to investigate the role of maturity in a tractable manner. As explained in Benes and Lees (2010), it is easy to specify the "average" time until maturity of such a geometric loan by Macaulay's duration, that is, the weighted term to maturity of the cash flows from a loan.[5]

The structure of this instrument is explained as follows. Assume that an agent borrows $B_t^L$ amount for long-term debt (in nominal terms). Repayment is done with a rate which declines at $\phi$, with a fixed rate $r_t^L$.

- repayment due at t+1 $r_t^L B_t^L$

[5]Benes and Lees (2010) discusses that Macaulay's duration of an asset, or a stream of payments in general, can be computed as $d = \frac{\sum_{k=1}^{\infty} kPV_{t+k}}{\sum_{k=1}^{\infty} PV_{t+k}}$, where PV is the present value of a payment receivable at time t. Then, the duration at steady state is given by:

$$d = \frac{\sum_{k=1}^{\infty} k \frac{\phi^{k-1}}{R^k}}{\sum_{k=1}^{\infty} \frac{\phi^k}{R^k}} = \frac{\frac{R}{(R-\phi)^2}}{\frac{1}{R-\phi}} = \frac{R}{R-\phi} \tag{1}$$

which is a function of short-term interest rate R, and the parameter $\phi$.

- at t+2 $\phi r_t^L B_t^L$
- .....
- at t+k $\phi^k r_t^L B_t^L$

I call $j_t^L$ sum of real outstanding payments due in time t and $b_t^L$ real amount of debt. Then, I can write sum of real outstanding payments as a state variable, whose law of evolution is,

$$j_t = \frac{1}{\pi_t^S}(\phi j_{t-1} + r_{t-1}^L b_{t-1}^L). \tag{2}$$

From modeling perspective, introducing long-term debt with this structure costs adding only one more state variable, and for this reason the average maturity can be calibrated with a single parameter. If I choose to use a finite long-term maturity, that would cause many complications such as the curse of dimensionality.

Short-term debt is a standard non-state-contingent instrument which bears an interest rate of $\frac{1}{\pi_t^S} r_{t-1}^S$.

## Households

Households are the bankers in the economy: they are more patient than the entrepreneurs. They also supply labor for them.

The infinitely-lived representative household maximizes his lifetime discounted utility:

$$E_0 \sum_{t=0}^{\infty} \beta^t \left\{ logC_t - \frac{L_t^{1+\eta}}{1+\eta} \right\} \tag{3}$$

where $E_0$ is the expectations operator, $\beta$ is the discount factor, and $C_t$ is the consumption by the representative household. $L_t$ is the amount of labor she supplies for the production and $\eta$ is the inverse of the Frisch elasticity.

Household can lend using either short-term or long-term debt to entrepreneurs. They are allowed to hold one period government bonds as well. I aim to compare effects of different debt structures in separate models. This way, the model has two different rates (short and long) when the maturity of corporate debt is higher than one year. Monetary authority always sets one period interest rate. The household maximizes his life time utility subject to the flow budget constraint. If the economy operates with a short term corporate debt the budget constraint would be:

$$P_t^C C_t + B_t^S + D_t^S = r_{t-1}^S B_{t-1}^S + r_{t-1}^S D_{t-1}^S + W_t L_t + T_t \tag{4}$$

which in real terms is

$$C_t + b_t^S + d_t^S = \frac{1}{\pi_t} r_{t-1}^S b_{t-1}^S + \frac{1}{\pi_t} r_{t-1}^S d_{t-1}^S + w_t L_t + t_t. \tag{5}$$

If the economy operates with a long term corporate debt, then the budget constraint and the evolution of long-term debt repayments is given by:

$$C_t + b_t^L + d_t^S = j_t + \frac{1}{\pi_t} r_{t-1}^S d_{t-1}^S + w_t L_t + t_t. \tag{6}$$

$$j_t = \frac{1}{\pi_t^S}(\phi j_{t-1} + r_{t-1}^L b_{t-1}^L). \tag{7}$$

In the budget constraints, $b_t^i$ and $r_t^i$, i=(S,L) denote debt instrument and returns, either short term or long term.$\pi_t$ shows inflation by period t, $w_t$ is for real wages, and $t_t$ is for real transfers from capital producing firms. $d_t^S$ and $r_t^S$ are the amount of government bonds held by the household and policy rate set by the central bank.

Household's behavior will be characterized by the first order conditions from utility maximization subject to the constraints.

At the steady state, short-term rate will be equal to the inverse of the discount factor of the household: $r_t^S = 1/\beta$ and the long-term rate will be $r_t^L = \frac{1-\beta\phi}{\beta}$. So, the long-term interest rate per period equals to the short-term interest rate, corrected by its average maturity.

## Entrepreneurs

Producers enjoy the consumption of the final good as well. They are less patient than the household to ensure flow of funds and they need to borrow to finance their investment. I assume that entrepreneur's utility function is the natural logarithm of their consumption. As explained in Iacoviello (2005), there are two ways to model constrained producers. One way is modeling them as risk neutral agents, who respond heavily to shocks. The other is imposing a constant death probability, which gives more passive responses. Logarithmic utility lies somewhere in the middle, which I follow.

The representative entrepreneur buy capital from capital producing firms from the price of $q_t$. They turn their total capital into production with a Cobb-Douglas function: $Y_t = A_t k_{t-1}^{\alpha} L_t^{1-\alpha}$ where $A_t$ is the total factor productivity that follows a autoregressive process.

There is a retailer in the economy who packs the outputs of entrepreneurs á la Bernanke et al. (1999). The entrepreneur sells his/her output at nominal price of $X_t$. Since these entrepreneurs produce in a market that is perfectly competitive, a single representative agent suffices. His/her problem is as follows:

Maximize the discounted life time utility,

$$E_0 \sum_{t=0}^{\infty} \gamma^t \left\{ log C_t^e \right\} \tag{8}$$

subject to the budget constraint for the short term debt economy

$$C_t^e + r_{t-1}^S b_{t-1}^S \frac{1}{\pi_t} + w_t L_t + q_t[k_t - (1-\delta)k_{t-1}] = b_t^S + x_t^S A_t^S (k_{t-1})^{\alpha} (L_t)^{1-\alpha} \tag{9}$$

and for the long term debt economy:

$$C_t^e + j_t + w_t L_t + q_t[k_t - (1-\delta)k_{t-1}] = b_t^L + x_t^S A_t^S (k_{t-1})^{\alpha} (L_t)^{1-\alpha} \tag{10}$$

where $C_t^e$ is entrepreneur's own consumption. Their investment is limited by a borrowing constraint as in Kiyotaki and Moore (1997) and Iacoviello (2005). As stated above, the entrepreneur needs to borrow to increase his capital stock and so that he can produce more. I assume that his borrowing is constrained by a fraction of worth of his capital next period. The constraints look as follows for short term debt economy and long term debt economy respectively:

$$r_t^S b_t^S \leq \chi_t^S q_{t+1} (1-\delta) \pi_{t+1} k_t \tag{11}$$

$$r_t^L b_t^L \leq \chi_t^L q_{t+1} (1-\delta) \pi_{t+1} k_t \tag{12}$$

I assume that the total factor productivity and the tightness for the borrowing constraints ($i$=$S,L$) follow stochastic processes:

$$log(A_t^S) = (1-\rho) log(\bar{A^S}) + \rho^{A^S} log(A_{t-1}^S) + \epsilon_t^{A^S} \tag{13}$$

$$\chi_t^i = \bar{\chi}^i + \epsilon_t^{\chi^i}. \tag{14}$$

We can interpret $\chi_t^i$ as a bounded random variable. Here $\bar{\chi}^i$ represents steady state value of $\chi_t^i$, i=(S,L). I calibrate this to be lower then 1 so that in equilibrium the entrepreneurs can only borrow a fraction of their investment, when the constraint is binding at equilibrium.

Since entrepreneurs are less patient than the households, the constraint will bind at the steady state equilibrium. Moreover, I assume that it will continue to bind around the steady state equilibrium as in Iacoviello (2005) and Monacelli (2009).

Finally, note that the model does not permit entrepreneurs to hold both kinds of corporate debt. This way, it avoids a portfolio choice problem among different assets. The amount of corporate debt will be determined by the demand of entrepreneurs.

## Capital Producing Firms

Capital producer firms are perfectly competitive and owned by households. At the end of each period t, they buy the depreciated capital from entrepreneurs, combine it with investment goods to produce new installed capital, which is then resold to entrepreneurs at the price of $q_t$. Let $I_t$ denote the investment, capital dynamics are given by:

$$k_t = (1-\delta)k_{t-1} + (1 - S(.))I_t \tag{15}$$

As in Christiano et al. (2005), capital accumulation is subject to investment adjustment cost represented by a function S(.). The optimization problem of a representative capital producer is to maximize the present discounted value of future profits:

$$\max_{I_t} E_t \sum_{k=0}^{\infty} \Lambda_{t,t+k}[q_{t+k}(1-S(.))I_{t+k} - I_{t+k}] \tag{16}$$

I assume the adjustment cost function, $S(.)$ is given by $\frac{\phi_k}{2}(\frac{I_{t+k}}{I_{t+k-1}} - 1)^2$. Then optimization problem of capital producers becomes:

$$\max_{I_t} E_t \sum_{k=0}^{\infty} \Lambda_{t,t+k}[q_{t+k}I_{t+k} - \frac{\phi_k}{2}q_{t+k}I_{t+k}(\frac{I_{t+k}}{I_{t+k-1}} - 1)^2 - I_{t+k}] \tag{17}$$

## Retailers and Price Stickiness

I assume monopolistically competitive retailers buy intermediate goods from entrepreneurs, differentiate them, and turn these into a consumption good á la Bernanke et al. (1999) and Iacoviello (2005). This structure enables us to impose price stickiness easily and allows the pricing decision to be separate from borrowing decision.

There are continuum of retailers, indexed by $z$. They buy intermediate goods $Y_t$ paying $X_t$ and sell at $P_t$ to the household.

The final good ready to consume is,

$$Y_t = (\int_0^1 (Y_{z,t})^{\frac{\epsilon-1}{\epsilon}} dz)^{\frac{\epsilon}{\epsilon-1}}. \tag{18}$$

With this aggregate output index, the price index is,

$$P_t = (\int_0^1 (P_{z,t})^{1-\epsilon} dz)^{\frac{1}{1-\epsilon}}. \tag{19}$$

Then, the demand for each retail good variety is,

$$Y_{z,t} = (\frac{P_{z,t}}{P_t})^{-\epsilon} Y_t. \tag{20}$$

Firms in the retail sector are able to change their prices with $1-\psi$ probability. Then, firm's profit maximization problem takes the form:

$$max\ E_t \sum_{k=0}^{\infty} (\psi\beta)^k \Lambda_{t,t+k} \left\{ \frac{P_{z,t}^{j*}}{P_{t+k}} (\frac{P_{z,t}^*}{P_{t+k}})^{-\epsilon} Y_{t+k} - x_{t+k} (\frac{P_{z,t}^*}{P_{t+k}})^{-\epsilon} Y_{t+k} \right\} \tag{21}$$

Here, $\Lambda_{t,t+k}$ is the stochastic discount factor of the household. Notably, the demand equation for each variety is also substituted. The first order condition is

$$E_t \sum_{k=0}^{\infty} (\psi\beta)^k \Lambda_{t,t+k} \left\{ (1-\epsilon) \frac{(P^*_{z,t})^{-\epsilon}}{P^{1-\epsilon}_{t+k}} Y_{t+k} + \epsilon w_{t+k} \frac{(P^*_{z,t})^{-\epsilon-1}}{P^{-\epsilon}_{t+k}} Y_{t+k} \right\} = 0. \tag{22}$$

If I integrate $Y_{z,t} = (\frac{P_{z,t}}{P_t})^{-\epsilon} Y_t$, the aggregate output ready for consumption will be net of price dispersion costs. So, define price dispersion as,

$$v^p_t = \int_0^1 (\frac{P_{z,t}}{P_t})^{-\epsilon} dz \tag{23}$$

$$Y^f_t = Y_t / v^p_t. \tag{24}$$

Because of the price dispersion costs, not all output will reach the final consumption stage.

## Monetary Policy and Market Clearing

The monetary authority chooses one period risk free interest rate, $r^S_t$. As in Iacoviello (2005), it follows a Taylor Rule, which takes the form

$$r^S_t = (r^S_{t-1})^{r_R} \left[ \Pi^{1+r_\pi}_{t-1} (\frac{Y_{t-1}}{Y_{SS}})^{r_y} \bar{rr} \right]^{1-r_R} e_{R,t}. \tag{25}$$

Here, $\bar{rr}$ and $Y_{SS}$ show steady state levels for real interest rate and output. The natural logarithm of $e_{R,t}$ follows a white noise shock process with a mean 0 and variance, $\sigma^2_{e_R}$.

Equilibrium in goods market entail total consumption and investment should equal to total available output.

$$C_t + C^e_t + I_t = Y^f_t \tag{26}$$

# 4 Calibration

For calibration, I mostly borrow from the business cycle literature on U.S. economy. The saver's (household's) discount rate, $\beta$, is calibrated to 0.99 to match the annual real rate of return of 4 percent, and borrower's (entrepreneur's) discount rate, $\gamma$ is calibrated to 0.97 as in Iacoviello (2005) and Monacelli (2009).

For price stickiness, I set $\psi$ to 0.75, which is the standard value in the literature as in Iacoviello (2005). For the Taylor rule, I borrow the parameter values from various studies on US economy and calibrate $r_R$ to 0.73, $r_\pi$ to 1 and $r_y$ to 0.1. $\phi_k$ is calibrated to 5 and $\epsilon$ is calibrated to 10. I normalize steady state exogenous productivity factors, $\bar{A}$ to 1. To calibrate $\bar{\chi}^S$ and $\bar{\chi}^L$, I choose 0.2. I calibrate inverse of Frisch elasticity with setting $\eta$ to 0.01.

I calibrate $\delta^L$ to 0.03 following the standard value in the literature (Monacelli, 2009). I calibrate the capital share in the production function $\alpha$ to 0.3. $\rho^A$ is calibrated to 0.9, which correspond to highly persistent path for productivity factor. Finally, the value, $\bar{\phi}$ which reflects the average maturity of repayment of the long-term debt at steady state, is calibrated to 0.5, which means in each period agents pay half of their remaining debt. So, the duration of the long-term debt is twice that of the short-term debt. Since the model presented in ths paper aims to embed main features of an otherwise standard DSGE model, I do not calibrate the maturity parameter to a particular data. With this calibration, the model has a stable steady state in the long term debt economy.

# 5 Impulse Responses of Macroeconomic Variables to Selected Shocks

In this section, by solving the model around steady state, I examine responses of macroeconomic variables to various shocks: a tightening monetary policy shock and a shock to borrowing limits which worsen financial conditions. Then I provide various comparisons among fixed rate and floating rate debt and maturity. The monetary policy shock size is 12.5 basis points (in annual terms 50 basis points) For quantity variables, I present impulse responses as percentage deviations from steady state. These are total output of the economy, $Y_t$; consumption of household and entrepreneurs, $C_t$, $C_t^e$; capital stock and investment, $k_t$, $I_t$; wages and labor supply,$w_t$ and $L_t$. For the inflation and interest rates, $\pi_t$, $r_t^p$, $r_t^S$ and $r_t^L$; I present these in levels.

## Comparison of Short Term and Long Term Debt Economies

I first present the impulse responses to a positive monetary policy surprise for short term debt and long term debt economies. The impulse responses are presented in Figure 1 and Figure 2 in Appendix. The red lines exhibit the economy that uses solely short term debt, the blue lines stand for the economy in which corporate debts are written in longer maturity (on average 2 years). I refer the first one as short-term debt economy and the latter as long-term debt economy.

As expected, the rise in the short-term policy rate causes an increase in the corporate lending rate as well. The rise is lower in the long-term debt economy since the interest rate represent one period repayment rate. Accompanying the policy rate, the corporate debt rate and the inflation are more persistent in the long-term debt economy. The persistence is more apparent for the inflation.

The increase in the interest rates leads entrepreneurs to take less debt and in the end invest less. The fall in entrepreneurial consumption and investment is much more obvious in the long-term debt economy. This leads a stronger fall in output. For the households, in the initial periods, long-term debt economy has higher amounts of consumption. The reason for this is twofold. First, due to the fact that entrepreneurs demand less debt, the household can spend more on consumption. Second is the fall in prices and inflation. Because the fall in inflation level increases real returns from financial instruments, this income effect mitigates the adverse affects of tightening policy shock on consumers. Later due to the fall in output, household consumption falls as well.

The model presented in this paper lacks insurance properties of long term debt as in Bengui (2011). The representative firm takes all available debt as the constraint binds at all times. In reality firms may opt not to borrow any more after a interest rate hike and benefit from long term debt that they took before. In other words long term debt might provide an advantage over rolling over short term debt against macroeconomic shocks. Here, since the main purpose is comparing repayment structure and maturity of floating rate debt, I did not consider such properties of long term debt.

# 6 Floating Rate Long-term Debt

In reality, firms borrow long-term debt, most of which are written on the floating rate basis, documented as in Ippolito et al. (2017) and Gurkaynak et al. (2019). In this section, I will modify the long-term perpetuity debt to have the property of floating rate repayment structure.

For example, consider that an agent borrows $b_t^L$ amounts of long-term debt. Repayment is done at a decaying rate of $\phi$ with a floating rate $r_t^L$, determined one period in advance.

- repayment due at t+1 $r_t^L b_t^L$
- at t+2 $\phi r_{t+1}^L b_t^L$
- .....
- at t+k $\phi^k r_{t+k-1}^L b_t^L$

Call $j_t^L$ sum of payments due in time t. Then, I can rewrite it as a state variable, whose law of evolution with floating rate debt is

$$j_t = \phi j_{t-1} \frac{r_{t-1}^L}{r_{t-2}^L} + r_{t-1}^L b_{t-1}^L. \tag{27}$$

Now, in each period, outstanding amount of repayment is restructured with the realized change in interest rate.

The floating rate long-term debt will not alter the steady state of the model since the ratio $\frac{r_{t-1}^L}{r_{t-2}^L}$ is equal to 1 in the steady state. The change in the long-term interest rate will alter the optimality conditions.

## Comparison of Fixed and Floating Rate Debt Economies

The main purpose of this paper is to investigate the transmission through floating rate debt and its interaction with maturity. This section compares the impulse responses of the two models to a positive monetary policy shock: one with fixed rate long-term debt, and the other with floating rate long-term debt. Both of them has the same average maturity of 2 years. The impulse responses are presented in Figure 3 and Figure 4 in Appendix.

Even though the impulse response of policy rates are quite similar, we observe a stronger increase in the corporate debt rate in floating rate economy due to higher expected path of interest rates. Inflation is more persistent. After an interest rate hike the cost of existing debt increases more in the floating rate case. Since firms finance their investment with debt, this increases cost of production as well. In the end prices and inflation become more persistent. So we verify the literature that documents monetary policy is less effective in terms of stabilizing inflation with the floating rate debt case (as documented in Brzoza-Brzezina et al. (2014)). Most of this literature investigate mortgage debt models in comparing fixed and floating rate debt. In my case, I show this is also valid with a corporate debt via credit channel.

When the payments are in floating rate, the cost of debt is much higher compared to the fixed rate case after a positive tightening shock. That cost amplifies the effects of credit channel and makes the differences across real variables noteworthy. Entrepreneurial consumption and investment suffers more with the floating rate debt model. Labor demand and output remain lower as a result. The story for household consumption resembles the one in the short term and long term debt comparison.

### Comparison of Maturity for Floating Rate Debt Economies

Next, I investigate the effect of floating rate debt maturity by comparing the two models' in responses to monetary policy shocks, which are presented in Figure 5 and Figure 6. The average maturity, $\phi$, is calibrated to 0.33 and 0.50 respectively for the short maturity (1.5 years) and long maturity models (2 years). All other parameters stay the same.

The impulse responses show that extending the maturity of the floating rate debt amplifies credit channel even further. The higher the maturity of floating rate debt, the more persistent inflation is. With a higher maturity floating rate debt, inflation in response to positive monetary policy falls less compared to the model with the lower maturity. The interpretation is similar to above. After central bank raises interest rates the yield curve typically shifts up. The expectations for the future rates increase. This adds further burden to the floating rate debt.

The comparison across real variables resembles above as well. Capital stock and investment falls more for the higher maturity calibration because of higher cost of finance. Extending the maturity of corporate debt leads to less output and labor demand. So this exercise verifies empirical findings of Gurkaynak et al. (2019). After a couple of periods household consumption falls more similar to the case in the short and long debt comparison.

# 7 Conclusion

In this paper, I study the role repayment structure and debt maturity in a new Keynesian dynamic stochastic general equilibrium model. It employs an otherwise standard DSGE model and extends it to include corporate debt with different structures such as short term, long term, fixed repayments and floating repayments. By focusing on monetary policy shocks and its implications, I assess policy effectiveness and transmission mechanism under different structures.

Briefly, the results show the following: First, the comparison of floating rate long-term debt and fixed rate long-term debt show that floating rate debt hurts the output and investment more compared to fixed rate debt, and it also makes monetary policy less effective in steering inflation. The reason is, in the model with floating rate debt, the outstanding repayments are adjusted with the realized change in interest rates each period. Producers' prices do not fall as much as in the fixed rate model, because of the fact that their costs have mounted. This finding is in line with results of Calza et al. (2013) and Brzoza-Brzezina et al. (2014). In the end, floating rate debt aggravates the credit channel.

Second, the increase in the floating rate debt maturity leaves firms financed by long-term debt in a more vulnerable position when there is an interest rate hike. So extending the maturity of floating rate debt strengthens the credit channel even more. More persistent inflation and lower investment and output are observed in the longer maturity case resulting from higher debt burden.

This paper develops a theoretical ground for corporate debt structure in a standard macroeconomic model. The model shows that the macroeconomic effect of aggregate shocks depend on the structure of debt contracts. To quantify these effects, calibrating the share of long-term debt in total corporate debt, the relevant maturity and borrowing constraint parameters would shed more light on this issue. In this sense, the model could even be extended to include both fixed rate and floating rate debt used by the entrepreneur at the same time. The speed and magnitude of credit channel and the transmission to real economy depends to debt structure as well. A continuing work will accompany with a Vector Autoregression (VAR) type study to test the arguments built here.

The model is open to further extensions such as incorporating equity finance, endogenous debt choice to address further questions on the transmission channels of monetary policy. For example, a micro-founded mechanism such as search and matching frictions could help model a single entrepreneur who can invest in both types with an endogenous decision between short and long-term debt. Investigating the optimal monetary policy within this environment would also be very interesting. I leave these points as future research agenda.

# Appendix

## Comparison of Short Term and Long Term Debt Economies

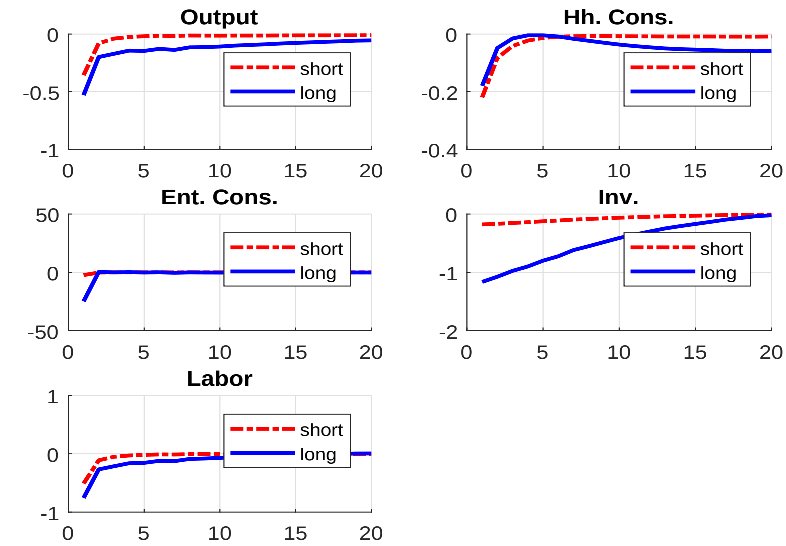


Figure 1: Comparison of Short and Long: A Positive Monetary Policy Shock (1)

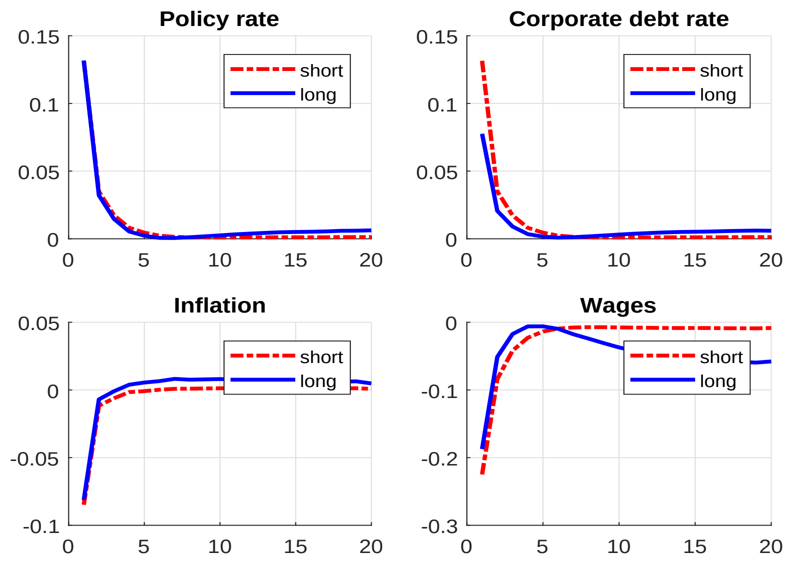


Figure 2: Comparison of Short and Long: A Positive Monetary Policy Shock (2)

## Comparison of Fixed and Floating Rate Debt Economies

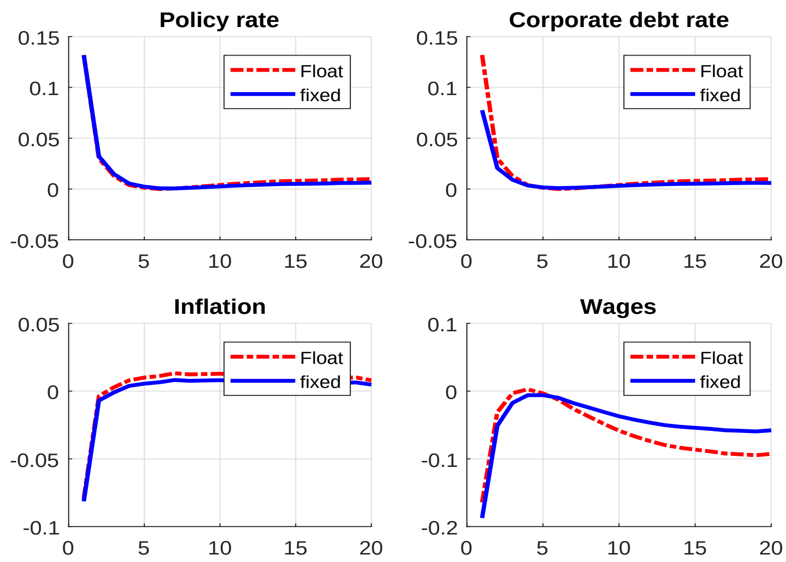


Figure 3: Comparison of Fixed and Floating: A Positive to Monetary Policy Shock (1)

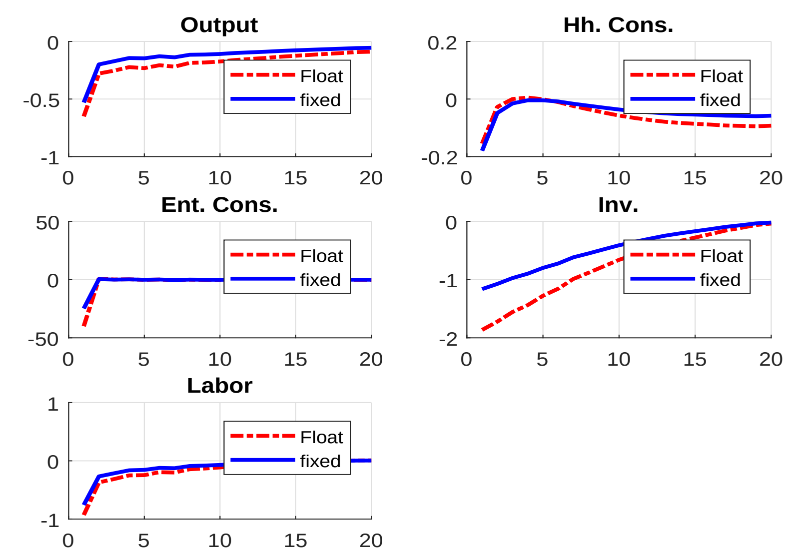


Figure 4: Comparison of Fixed and Floating: A Positive to Monetary Policy Shock (2)

## Comparison of Maturity for Floating Rate Debt Economies


Figure 5: Comparison of Maturity Effect for Floating: A Positive to Monetary Policy Shock (1)

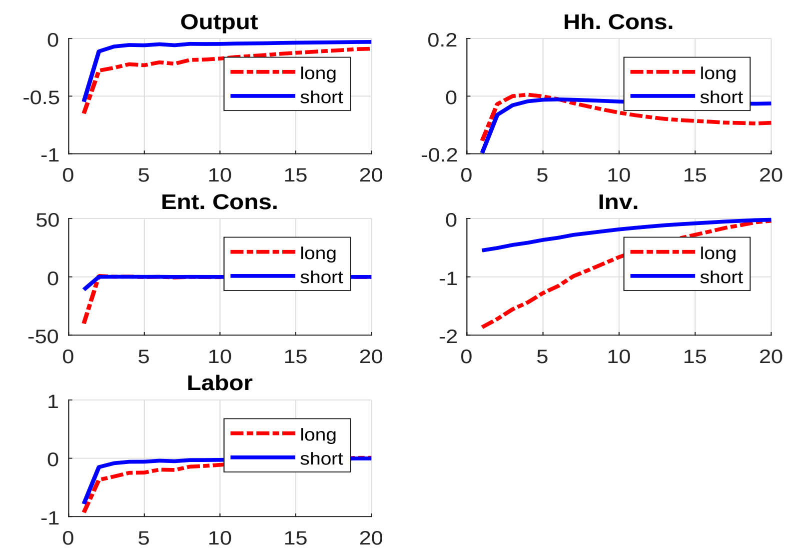


Figure 6: Comparison of Maturity Effect for Floating: A Positive to Monetary Policy Shock (2)

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