TI 2024-071/VI
Tinbergen Institute Discussion Paper

Corporate Legacy Debt, Inflation, and the Efficacy of Monetary Policy

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October 1, 2024

Abstract

We investigate how corporate legacy debt, through heterogeneous household portfolios, affects monetary policy's ability to control inflation. We find that (1) corporate debt generates an income effect that counters the traditional substitution effect, reducing the effectiveness of rate changes on inflation; (2) higher corporate debt exacerbates the trade-off between output and inflation stabilization. The income is positive on aggregate demand and inflation despite declining output. Local projections using U.S. monetary policy shocks show that over six quarters the cumulative difference in output and inflation for high and low corporate debt-to-household asset ratios is 3 percent and 1.2 percent.[1]

Keywords: Household heterogeneity, Inflation, Monetary policy, Corporate debt, Giffen good **JEL Codes**: E31, E32, E52, G11, G51

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[1] This paper has benefited from valuable discussions with Herakles Polemarchakis and Federico Ravenna, as well as helpful comments from Guido Ascari, Saleem Bahaj, Eric Bartelsman, Yao Chen, John Duca, Konstanin Egorov, Simon Gilchrist, Timo Haber, Anil Kashyap, Christoffer Koch, Cristina Manea, Matthias Meier, Benjamin Moll, Athanasios Orphanides, Marcelo Pedroni, Raghuram Rajan, Gabriel Züllig, and other participants of 2024 AEA Meeting, 2023 Annual SED Conference, 2023 European Winter Meeting of the Econometric Society, 2023 LAMC FE & MP workshop, 2023 Warwick Microeconomic Theory for Macroeconomic Analysis (MIMA) Workshop, 2023 ASSA Meetings IBEFA Session, UIUC, DGMF Seminar of the European Central Bank, 2022 EEA annual congress, 2022 CEBRA Annual Meeting, the 2022 Dutch KVS New Paper Sessions, 49th NES Research Conference, and Oberlin College seminar, for valuable comments, and Franklin Colburn, Zimu Liu, Sijmen Rijks, and Aleksandr Shirobokov for assistance in preparing this paper. Cite as CEPR DP16799, https://cepr.org/active/publications/discussion_papers/dp.php?dpno=16799 .

1 Introduction

Indirect responses to monetary policy shocks through the redistribution of income across heterogeneous households can be substantial (Kaplan, Moll and Violante, 2018). We show that these income effects also depend on firms' capital structure as corporate debt forms a significant part of household liquid assets.[2] The income effect identified through corporate debt links to the Fisher channel in Auclert (2019) and Doepke and Schneider (2006), where inflation redistributes income between debtors and creditors, amplifying responses via heterogeneous consumption propensities. While Auclert (2019) emphasizes demand-side effects, our focus is on the additional supply side response: workers' corporate debt holdings increase the elasticity of labor supply. Overall, this redistribution from workers to equity holders mutes the general equilibrium response of inflation to monetary policy shocks (Figure 2). Local projections using U.S. monetary policy shocks show a cumulative six-quarter difference of 3% in output and 1.2% in inflation between high and low corporate debt-to-household asset ratios.

High corporate debt affects monetary policy transmission through two key channels: it introduces an *income effect* that counteracts the traditional *substitution effect*, reducing the effectiveness of interest rates on inflation, and it exacerbates the trade-off between stabilizing output and inflation. Corporate debt dampens price responses to monetary policy changes and increases labor supply elasticity, leading to a prolonged inflationary response and lower, more muted output. Our model differentiates between two household types: lender-worker households, who save by holding safe corporate debt and supply labor, and owner households, who own firms that issue corporate debt. This distinction aligns with Fisher (1910)'s framework of "borrowers" and "creditors" and is supported by empirical work from Mankiw and Zeldes (1991), Toda and Walsh (2020), and Doerr, Drechsel and Lee (2022), which highlights the heterogeneity in asset ownership across wealth and income distributions. Lender-worker households hold significant portions of corporate debt, directly or indirectly, through instruments such as bank deposits, mutual funds, ETFs, and pension funds (Koijen and Yogo, 2023). Firms in our model borrow short-term nominal credit to finance labor costs and owe long-term debt to these lender households. We demonstrate how legacy debt shapes monetary shock transmission through a static general equilibrium model and extend this to a dynamic model to study

[2] Non-financial corporate liabilities grew significantly after the Great Financial Crisis (GFC), doubling by the COVID-19 pandemic. Unlike governments or financial intermediaries, non-financial firms cannot monetize debt or create liquidity, complicating monetary policy transmission.

the propagation of shocks and policy trade-offs. While recent papers show that corporate debt levels influence business cycles (for example, Giroud and Mueller, 2021; Jordà, Kornejew, Schularick and Taylor, 2020; Müller and Verner, 2023; Ivashina, Kalemli-Özcan, Laeven and Müller, 2024), our focus is on how corporate debt level affects the efficacy of monetary policy on inflation control.

The transmission of monetary policy to aggregate demand and supply is influenced by the stock of corporate debt via an income effect that alters the IS curve's slope and potentially makes it positive. A rise in the policy rate reduces the equilibrium real wage rate, and the corporate debt owned by workers flattens their labor supply curve, lowering firms' overall wage bills. This shift redistributes firm income toward owners of firms through profits and away from workers through labor income, causing upward pressure on aggregate demand that intensifies with higher corporate debt. The income effect of monetary policy through corporate legacy debt we identify reveals the potential Giffen good property in aggregate demand, leading to an upward-sloping IS curve.[3] In the static case, when corporate debt is sufficiently low, raising the policy rate lowers inflation. However, higher debt levels lead to smaller price drops, making monetary policy less effective. With substantial corporate debt, the income effect causes a rise in demand and prices, potentially inverting the Taylor principle, whereby raising the policy rate increases inflation. This connects to classic literature on upward-sloping IS curves and provides new microfoundations for this phenomenon, explaining why prices may respond less than output to monetary disturbances.

We then transition into a more realistic and policy-relevant dynamic setting. We embed the static model in a calibrated dynamic general equilibrium with sticky prices and compare the responses of the economy when the steady-state corporate debt-to-output ratio is low (benchmark) and when it is moderately high, describing the increase in the stock of corporate debt in the US over the last 15 years. We show that as the steady-state corporate debt-to-output ratio increases, the coefficient of monetary policy rate on the dynamic path of inflation declines, i.e., a weaker effect of monetary contractions in lowering inflation. The output gap reflects two distortions in the economy: the first arising from price rigidities and the second from the distribution of wealth and how it affects aggregate demand and supply. The latter inefficiency means that inflation targeting should

[3]While the upward-sloping IS curve has long been recognized, our work provides a micro-foundation for it. Previous studies from at least Meiselman (1969) onwards discuss this possibility. We model money and credit in general equilibrium, showing how an upward-sloping IS curve can emerge endogenously based on the magnitude of the income effect through corporate legacy debt.

also account for the levels of corporate debt outstanding. After a monetary contraction, inflation falls on impact in both the high and low corporate debt cases before rising to positive values. The subsequent rise in inflation is higher in the high debt case than in the benchmark case, suggesting that when corporate indebtedness is higher, inflation becomes more challenging to rein in. On the real side, output falls in both the high debt and the benchmark cases, but it falls more aggressively in the high debt case. Real wages and corporate bond prices decrease, but bond prices fall less in high-debt scenarios, leading to smaller wealth deterioration for lender households. Consequently, the effective elasticity of labor supply increases with legacy debt, even with fixed coupon corporate bonds. The overall takeaway from this experiment is that the trade-off between inflation and output stabilization becomes acute when corporate debt is large. The higher corporate debt is, the greater the trade-off becomes, and inflationary pressures increase despite keeping the cost of working capital the same.[4]

Our empirical analysis corroborates our theoretical results by showing through local projections that higher levels of corporate debt are associated with sharper relative declines in investment compared to consumption after a monetary policy shock. When corporate debt is low, output grows for 10 quarters before contracting. However, when corporate debt is high, output experiences a sustained contraction. Additionally, inflation rises more sharply and significantly when corporate debt is high, potentially reflecting a *Giffen good* effect contingent on the level of corporate debt. Harding and Klein (2022) demonstrate how household net worth acts as a state variable, affecting the impulse response of economic variables. Wealthier households enhance liquidity during negative monetary shocks, while poorer households reduce it (Luetticke, 2021), and wealth shifts toward wealthier households, increasing consumption and equity gains as wages fall (Coibion, Gorodnichenko, Kueng and Silvia, 2017). Luetticke (2021) focuses on how the household portfolio composition response to monetary shocks works through static propensities for liquidity, while we focus on how household response to monetary shocks is affected by the effective labor supply elasticity, which, in turn, is influenced by the level of corporate debt in their portfolio.

The rest of the paper is structured as follows. Section 2 presents a static model. Section 3 characterizes the equilibrium and obtains closed-form solutions for equilibrium

[4] Ravenna and Walsh (2006) show that in the presence of the cost channel, the interest rate changes necessary to stabilize the output gap lead to inflation rate fluctuations. While building on the cost channel, our model shows that the intensity of the trade-off between output stabilization and inflation stabilization depends on the level of corporate debt and goes beyond the cost channel of monetary policy.

analysis. Section 4 extends the static model to a dynamic setting while Section 5 presents a quantitative example to illustrate the analytic result. Section 6 provides empirical evidence of our mechanism using US data. Section 7 concludes.

2 Static Model

In this section, we present a stylized general equilibrium with money to fix ideas on how the stock of corporate debt generates an additional income effect of monetary policy. In Section 4, we extend the static model to a calibrated dynamic model with sticky prices to show the implications of this income effect on the trade-off between output and inflation stabilization. Our thesis is that the accretion of corporate debt makes models that assume no such historical legacy inappropriate for assessing current conditions. We assume that there are two types of households. The first are "owner households" that own firms, which is in accord with the usual assumptions, or the "enterpriser-borrower" à la Fisher (1910). The second type are "lender and worker households" who own the historical debt issued by firms and are essentially Fisher's "creditor, the salaried man, or the laborer". These funds pay out a proportion of their accumulated returns ψ from corporate legacy debt D, and ψ is the debt servicing cost for the borrower. Because it is a one-period static model, we assume that both owner and lender households seek to use all their available funds in this period for consumption. In the subsequent dynamic setting, we relax this assumption and model the saving decision of the lenders, where both the quantity and the price of debt are endogenous. For the sake of analytic clarity, all corporate debt is owned by the worker-lender households though this is not critical for our main results.[5] Instead, what is critical is that some quantity of outstanding corporate debt is owned by workers. In the Appendix we show how our results readily extend to more general distributions of corporate debt holdings.

For the rest, the underlying assumptions are more standard. The static model illustrates a one-period production economy with morning and evening sub-periods. A unit measure of firms produce different consumption goods. Although our firms possess market power in final goods, our results do not rely on this and is included for comparability with the dynamic model that follows in a subsequent section. A central bank exists to issue inside money as its liabilities against offsetting credits and sets the policy rate i,

[5] Though consistent with the benchmark setup in macro-finance models such as Bernanke, Gertler and Gilchrist (1999).

which we take as the short-term borrowing cost in money markets. Owner households also have some initial monetary balance, and all private agents can borrow inside money against an offsetting credit from the money market should they wish. Lender households supply labor endogenously. There are two transaction moments in the period, which we term "morning" and "evening". In the morning, firms borrow money via working capital credit to pay wages, and the associated borrowing cost is i; this liquidity-in-advance constraint follows a long tradition in the literature on the cost channel of the monetary transmission mechanism (see, for example, Christiano, Eichenbaum and Evans, 2005). Production then takes place. In the evening, firms sell all output. Households carry their wealth and income into the evening to purchase goods. Firms repay working capital credit and the debt that comes due in the evening.

2.1 Households

Owner households and lender households are indexed by $h \in \{o, l\}$ respectively, and they demand a consumption bundle C^h, given by $C^h \equiv \left(\int_0^1 (c_j^h)^{1-\frac{1}{\theta}} dj \right)^{\frac{\theta}{\theta-1}}$, with c_j^h representing the quantity of goods variety j consumed by the household, and $\theta > 1$ being the elasticity of substitution between goods varieties. A lower θ leads to a higher markup σ set by the firms. The price index is given by $P \equiv \left(\int_j (p_j)^{1-\theta} dj \right)^{\frac{1}{1-\theta}}$. Owner households are shareholders of the firms, and the rest of the households are lenders to the firms. Each owner household has a monetary (fiat) endowment $m^o \geq 0$. We now outline the maximization program for the owner and lender households.

Owner Households

Owner households have a monetary endowment of m^0 and profits of Π from all firms as income. They spend the income on consumption c^o and have a linear utility function $U = c^o$. The linear function is not crucial but used to facilitate analytic characterization. In the subsequent dynamic model where we rely on numerical solutions we use more standard preferences. Initial cash balances are carried over till the evening without earning interest in the morning. In the evening, the owner household receives the firm's profits and spends total money on goods. Their flow constraint is (1),

$$Pc^o = \Pi + m^o. \tag{1}$$

Lender Households

Lender households have nominal wage income of wL^l, and they receive net repayment ψD on holding corporate debt, where w denotes the nominal wage, L^l is the labor supply, ψ is the corporate debt servicing cost, D is the total stock of debt firms owe to the lender households. We refer to D as the legacy debt. Both corporate debt D and its debt servicing cost ψ will be made endogenous later. For now, we assume that the debt level is bounded as in (2) where i is the policy rate, σ is the markup, m denotes the aggregate monetary endowment of households. As it will become clear shortly, this assumption ensures no bankruptcy of the firm sector.

$$D \leq (\sigma - 1)(1 + \frac{1}{i})\frac{m}{\psi}. \tag{2}$$

Lender households' preferences are represented below,[6] and they choose consumption and the supply of labor, $U = log(c^l) - L$. In the morning, the lender households obtain their labor income wL^l and carry the money till the evening. In the evening, they purchase goods from their income from corporate bonds and their income from labor. Their effective flow budget constraint is thus (3),

$$Pc^l = wL^l + \psi D. \tag{3}$$

2.2 Firms

Owner households own a unit measure of firms. Firm j produces good j according to a linear production function $y_j = Al_j$, where y_j is firm j's output, l_j is the labor it demands, and A denotes technology. Let b_j be the amount of liquidity the firm obtains from the money market by borrowing, and i be the monetary policy rate. Firm j maximizes profits π_j from the perspective of owner households by choosing labor l_j and money market liquidity b_j and by setting the price of its variety of goods p_j monopolistically. The morning constraint is

$$wl_j = b_j, \tag{4}$$

[6] This specification is simple enough to incorporate meaningful substitution between consumption and leisure and still permit analytic results. Nevertheless, in the dynamic model in the next section, we use more standard preferences.

the evening constraint is

$$\pi_j + \psi D + b_j(1+i) = p_j y_j, \tag{5}$$

and combining (4) and (5), the effective flow budget constraint is:

$$\pi_j + (1+i)wl_j + \psi D = p_j y_j. \tag{6}$$

Equation (4) is the liquidity constraint firm j faces in the morning. It states that firm j uses the money b_j borrowed in the money market to pay for wages - the working capital financing constraint.[7] Equation (5) states that at the end of the period, the firm uses the sales proceeds to pay back money market credit $b_j(1+i)$, repay the debt servicing cost on corporate legacy debt ψD, and distribute profits π_j. As we assume $i > 0$, each constraint binds.

2.3 Equilibrium

We define equilibrium as an allocation of resources and positive prices, given a positive monetary policy rate, monetary endowment, and legacy debt such that (i) firms set prices while taking into account the price impact on demand, (ii) agents maximize subject to their budget and liquidity constraints, and (iii) goods market, labor market, and money market clear, and expectations are rational. We now characterize the equilibrium to show that the combination of legacy debt and working capital can provide clear monetary transmission mechanisms, even when allowing prices to adjust. To start with, Lemma 1 below summarizes how real wage and the labor supply elasticity to real wages ϵ_L respond to a contractionary monetary policy shock (see Appendix A for the proof).

Lemma 1.

1. *Contractionary monetary policy reduces real wages, i.e.,* $\tilde{w} = \dfrac{A}{\sigma(1+i)}$.
2. *Real marginal cost remains invariant to short-term policy rate changes, and* $\tilde{mc}_j = \dfrac{1}{\sigma}$
3. *In equilibrium,* $\epsilon_L = \dfrac{\psi D}{b}$*, the labor supply elasticity with respect to real wages is increasing on corporate debt and decreasing on working capital credit.*

[7] Our results depend on corporate debt level and remain robust to firms holding cash; that is, we can allocate some of owner households' initial money balances to firms, and our results still go through.

The above lemma shows that real wages fall in response to a contractionary monetary policy shock. Furthermore, the markup, σ interacts with the policy rate positively. Through the working capital channel alone, the fall in real wages is unambiguous, in contrast to canonical sticky wage models. Interestingly, in this model context, firm j's real marginal cost is equal to the inverse of the markup, so it remains invariant to short-term policy rate changes. This is because although a direct effect of an increase in i increases the marginal cost via the financing cost of working capital, the increase in i decreases real wages, leading to an indirect effect pushing down the real marginal cost. In equilibrium, these two effects on the marginal cost cancel out. As we shall shortly prove, even in this case, when monetary policy does not affect real marginal cost, prices can respond much less than output to monetary disturbances. This has the advantage of highlighting that the mechanism in the present model depends mainly on the income effect of corporate debt, rather than the increase in the marginal cost, whereby monetary contractions lead to weaker responses in prices. Furthermore, Lemma 1 implies that the labor supply elasticity in our model depends not only on preferences but also on the state of the economy through legacy debt (fixed income securities in workers' portfolio).

3 Equilibrium Characterization

3.1 Income Effect, IS curve, and Giffen Good Behavior

Before moving on to the supply of output goods, we first derive the IS curve to examine how the demand for output goods changes with the policy rate. We sum up the households' consumption demand and firm profits. Aggregate profits Π of the firm sector can be derived from (6) as

$$\frac{\Pi}{P} = \int_j y_j dj - (1+i)\tilde{w}L - \frac{\psi D}{P}. \tag{7}$$

We obtain the income, and hence demand, from the owner household by substituting (22) and (21) into owner households' budget constraint. The equilibrium expression for their real income, $\frac{m^o}{P} + \frac{\Pi}{P}$, can be represented as

$$\frac{m^o}{P} + \int_j y_j dj - \frac{A}{\sigma} + i\frac{\psi D}{P}. \tag{8}$$

In (8) raising interest rates increases demand from owner households because raising interest rates lowers the demand for labor. As a result, the wage bill for the firm decreases, which puts upward pressure on profits. We can combine the owner and lender households' budget constraints ($\frac{1}{P}(\psi D + wL + \Pi + m)$) to obtain the expression (9) which is the locus, given a price level, for output (Y) as a function of the policy rate i, in which the labor market clears,

$$Y = \frac{m}{P} + \int_j y_j dj + i \left\{ \frac{\psi D}{P} - \frac{A}{\sigma(1+i)} \right\}. \tag{9}$$

Given P, the above equation summarizes the IS curve. We can observe that when $D = 0$ in (9), the IS curve is unambiguously downward sloping $\partial Y / \partial i < 0$. With $D \neq 0$, the slope of the IS curve is ambiguous. The presence of debt through its income effect changes the slope of the IS curve.

To obtain the micro-founded LM curve, we equate the endogenous supply of inside money M_s with the transaction demand for money $b = wL$. Combine this money market clearing condition with the solution for real wage $\tilde{w} = \frac{A}{\sigma(1+i)}$ and the production function for (10).

$$i = \frac{P}{\sigma M_s} Y - 1. \tag{10}$$

This is the locus of points in which, given the price level, the demand for money equals the supply of money and is the upward-sloping LM curve. Note that along the IS locus the labor market clears but not necessarily the money market, while along the LM locus the money market clears but not necessarily the labor market. The intersection of (9) and (10) gives us the locus of points for output as a function of the policy rate at which both the labor market and the money market clears, for a given price level, and will characterize aggregate demand. The intersection of aggregate demand and supply will give us the equilibrium nominal price level.

Figure 1 puts the IS curve (9) and the LM curve (10) together, with the horizontal axis being the output demand and the vertical axis being the policy rate. The left diagram (a) illustrates IS_0 as the IS curve without corporate debt, LM_0 as the LM curve before the monetary contraction, and the intersection between IS_0 and LM_0 is point A_0. A monetary contraction moves the LM to the left to LM_1, so point A_0 moves to A_1, corresponding to a higher policy rate but a lower output demand. Once corporate debt is introduced, the IS curve becomes steeper and rotates close-wise, as we can observe in eq(9). Thus, IS_0

rotates to IS_1 and point A_1 is moved to A_2. Comparing A_1 and A_2, the drop in demand for output after the monetary contraction is less in A_2 than in A_1: the income effect via debt reduces the decrease in output demand. When corporate debt is sufficiently high, the IS curve becomes upward sloping. This is illustrated in the right diagram (b). Before the monetary contraction, the intersection between the upward-sloping IS and the LM is point B_0, and after the monetary contraction, it becomes B_1, corresponding to a higher policy rate and a *higher* demand for output, compared with B_0.

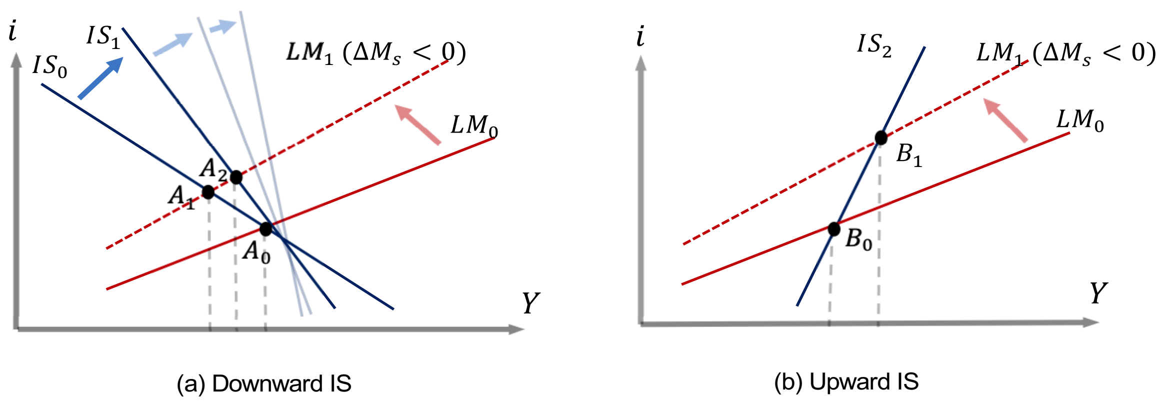


Figure 1: IS-LM: Debt and Monetary Contraction

The left diagram (a) illustrates downward sloping IS curves. The right diagram (b) illustrates an upward sloping IS curve. The horizontal axis is demand for output Y, and the vertical axis is the policy rate i. LM_0 is the money-market clearing before the monetary contraction, and LM_1 is after the monetary contraction, so it is moved to the left of LM_0. IS_0 is the IS curve without corporate debt, IS_1 is introduced with corporate debt, and as debt increases, IS moves close-wise, until when the debt is sufficiently high, such that the IS curve becomes upward sloping, as is IS_2 in the right diagram.

Normally, when the central bank increases the policy rate i, the higher transaction cost induces working households to substitute away from the output good to leisure, so the demand for output goes down (Figure 1a); here we identify a novel channel via corporate debt such that the increase in the policy rate can increase the demand for output (Figure 1b). This is because the increase in i reduces the total wage bills for firms, increasing the owner households' demand for output, as can be seen in (8). We formally define when consumption becomes a Giffen good next.

Definition 1. The consumption good is a *Giffen good* if, given that the labor market clears, debt is repaid, and dividends are paid, a decrease in the real wage caused by an increase in the policy rate increases Aggregate Demand

Labor market clearing means that Aggregate Demand depends on the equilibrium real wage and labor employed, while debt being repaid and dividends being paid means that

Aggregate Demand depends on the value of real profits in terms of the firm's planned revenue and actual costs.

Proposition 1. *When the real value of corporate debt is sufficiently high, the final consumption good is a Giffen Good.*

Proof: see Appendix B.

This shows that when the price of the final consumption good relative to labor (or leisure) increases, then Aggregate Demand actually *increases.* This Giffen property arises from how dividend payments respond to interest rate changes. The following corollary shows this.

Corollary 1. *The Giffen good property of Aggregate Demand is caused by the positive response of Owner households' demand to declines in the real wage caused by a higher policy rate. Furthermore, the response of Owner household's demand is caused by the response of the real value of dividends paid by firms to declines in the real wage caused by a higher policy rate.*

Proof: see Appendix C.

The corollary above shows that it is the heterogeneous response of demand by the two household types to changes in the wage rate caused by changes in the policy rate that drives the result at an aggregate level. Importantly, higher policy rates result in higher real dividends paid to the owner. This effect is driven by the flattening labor supply curve causing total lower labor costs to the firm when policy rates increase.

3.2 Distribution of Income, Aggregate Demand, and Aggregate Supply

Now we bring in the supply of output goods to clear the output markets and obtain the price level, and we show how the distribution of income corresponding to firms' capital structure matters for prices and quantities. For a given policy rate i, the aggregate demand that relates demand for output goods and the price level has already been derived as follows:

$$Y_d = \frac{m}{P} + \int_j y_j dj + i\left\{\frac{\psi D}{P} - \frac{A}{\sigma(1+i)}\right\}. \tag{11}$$

From (11) we can see two effects of monetary policy. Contractionary monetary policy that increases i may increase or decrease aggregate demand depending on how large legacy debt is. On the one hand, higher interest rates increase the financing cost of labor, and the firm demands less labor. As a result, real wages decrease, causing downward pressure on aggregate demand. This is the usual substitution effect. On the other hand, legacy debt renders labor supply more elastic (see Lemma 1) so that the increase in i causes the decrease in wage expenditure to dominate the increase in financing costs. Thus, faced with the fixed cost of the legacy debt, firms need to spread the fixed cost over a larger production scale and the demand for labor drops less after monetary contractions, leading to an upward pressure on aggregate demand, relative to the case without legacy debt. This is the income effect through legacy debt. We collect the insights so far in the following proposition.

Corollary 2. *In equilibrium, the response of aggregate demand to contractionary monetary policy (increasing i) depends positively on legacy debt.*

The income effect of monetary policy crucially depends on legacy debt and heterogeneous households. This can also be seen through the supply of labor which depends on the distribution of income (and hence demand) through legacy debt ($L = 1 - \frac{\frac{\psi D}{P}}{\frac{1}{\sigma}\frac{1}{1+i}A}$). With a representative household, the income effect disappears even when legacy debt is present, and contractionary monetary policy always decreases aggregate demand. To see this, we compare the model with the outcome if we had a representative agent combining owner and lender households. Aggregate income would become $\tilde{w}L + \psi\frac{D}{P} + \frac{m}{P} + \frac{\Pi}{P}$, and substituting in aggregate profits, aggregate demand becomes

$$Y_d = \frac{m}{P} + \int_j y_j dj - i\frac{A}{\sigma(1+i)}. \tag{12}$$

Comparing (11) and (12), given a price level, raising interest rates has the sole effect of reducing aggregate demand in the representative agent case. This is because in the representative agent case, as income distribution does not matter, the increase in financing costs exactly offsets the upward pressure on profits from lower wage expenditure, and hence, the income effect is no longer present. Note that monetary policy is non-neutral because of the nominal friction of the working capital "liquidity-in-advance" constraint that results in a transaction demand for money and the distributional effect on equity holders and debt holders. Building on the above analysis, we derive the closed-form solution for the price level and allocation in Appendix D. The steps to obtain the closed-form solution show that condition (2) ensures no negative profits and they also lead to the following corollary.

Corollary 3. *In equilibrium, nominal and real profits fall when nominal interest rates rise.*

Even though the rise of nominal interest rates reduces wage expenditure, it also causes revenue to go down due to the drop in labor supply. In equilibrium, firm profits unambiguously fall when nominal interest rates rise, and vice versa, which is consistent with the empirical facts documented in Christiano, Eichenbaum and Evans (2005). We now characterize the transmission mechanism of monetary policy onto current inflation and state the central result in the following proposition (see the proof in Appendix E).

Proposition 2. *Under condition (2), in equilibrium,*

1. *when legacy debt is sufficiently low ($\psi D < \frac{b}{i}$),*
   - *(a) the standard Taylor principle applies,*
   - *(b) the higher debt is, the less effective is raising interest rates in lowering current inflation;*
2. *when legacy debt is sufficiently high ($\psi D > \frac{b}{i}$),*
   - *(a) the Taylor principle is inverted - raising interest rates increases current inflation,*
   - *(b) as debt increases, inflation responds increasingly positively to raising interest rates.*

Proposition 2 states that the transmission of monetary policy depends on the debt servicing cost of corporate legacy debt relative to working capital credit. The standard Taylor principle holds, that is, the elasticity of price level P to changes in i is less than zero ($\epsilon_{Pi} < 0$), *iff* $\psi D < \frac{b}{i}$. Loosely interpreted through a timeless perspective, the left-hand side of this condition would be the per-period debt servicing cost of the corporate debt, and the right-hand side would approximate the present value of working capital credit. When the latter is larger than the former, the income effect via corporate debt does not dominate the substitution effect via the transaction demand for money, and hence, the standard Taylor principle holds. However, within this case, higher corporate debt implies higher labor supply elasticity and a flatter aggregate supply curve and when nominal rates rise, current inflation falls less but output falls more. In other words, prices become less responsive and output becomes more responsive following a monetary disturbance because the associated fall in wages creates a large reduction in labor supplied. When $\psi D > \frac{b}{i}$ the Taylor principle is inverted and $\epsilon_{Pi} > 0$. That is, if corporate debt is extremely high relative to working capital liquidity, its income effect dominates, and raising interest rates *raises* the rate of inflation.[8]

To reinforce this intuition, we use an aggregate supply AS and aggregate demand AD diagram for the goods market to illustrate a low debt scenario and a high debt scenario with a rise in the policy rate. For this AS-AD diagram, we have factored in the clearing of the labor market and money market, but not the goods market (P, y); therefore, we can express the AS and AD as functions of output and the price of output, and exogenous parameters m, i, D, σ, A, ψ. The aggregate demand is expressed in (11). As can be seen in (11), with the rise in i, the substitution effect shifts the AD curve to the left, but the income effect through debt offsets the shift; thus, the high debt scenario sees the AD shift less to the left than the low debt case. To obtain the AS curve, we combine the producer's optimality condition for labor demand (21), the labor supply curve (22), and the production function, and we get the supply of output Y_s as

$$Y_s = A - \sigma(1+i)\frac{\psi D}{P}, \tag{13}$$

which shows that an increase in i reduces aggregate supply, and a higher debt renders the AS curve more elastic. Note that the nominal interest rate directly interacts with the stock of outstanding debt to affect the slope of the aggregate supply curve. It is in this sense that our income effect is different from the Fisher channel found in Auclert (2019): 1) monetary policy directly affects the stock of debt, and 2) it affects it through aggregate supply. Figure 2 displays the AS-AD diagram to qualitatively show the equilibrium changes when the central bank raises interest rates.

The left diagram (a) illustrates a low debt case, and the right (b) shows a high debt case. In the low debt case, the rise in the policy rate significantly reduces inflation, whereas, in the high debt case, the rise in the policy rate only moderately reduces inflation, but output falls more responsively. This is because the high debt case shifts the

[8]This is an extreme case because, in reality, ψ in each period is extremely low. Indeed, when we calibrate our dynamic model with the US data, this condition does not hold.

AD to the left less, and the AS curve also becomes more elastic due to the income effect through debt. Indeed, if the debt level is exceptionally high, the rise in the policy rate would even increase inflation, as proved in the second case in Proposition 2.The working capital cost channel (Barth and Ramey, 2001; Ravenna and Walsh, 2006) shows that interest rate changes necessary to stabilize output lead to inflation rate fluctuations. We identify another mechanism, demonstrating that the trade-off intensity between output and inflation stabilization depends on wealth distribution among heterogeneous households and the level of corporate indebtedness.

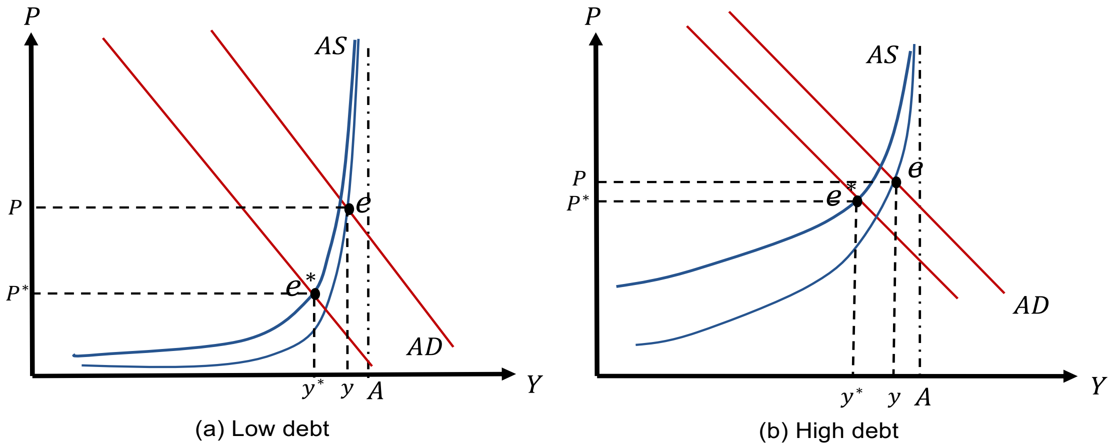


Figure 2: AS-AD diagram: a rise in policy rate

The left diagram (a) illustrates a low debt scenario. The right diagram (b) illustrates a high debt scenario. Equilibrium e is the equilibrium before the rise in the policy rate, and equilibrium e^* is the equilibrium after the rise in the policy rate. The vertical line at A is the output when there is no debt in the economy.

So far, we have assumed the corporate legacy debt servicing cost ψ to be exogenous to the short-term policy rate i changes. In practice, via the yield curve or the term structure of the interest rates, the short-term i changes are likely to affect the debt servicing cost ψ of longer-term corporate bonds. Assuming corporate legacy debt servicing cost is a function of the gross short-term policy rate, i.e., $\psi = \Psi(1+i)$ and denoting $\epsilon_{\psi i}$ as the elasticity of corporate debt servicing cost to the gross short-term policy rate, we find the following results with the proof in Appendix F.

Proposition 3. *In equilibrium,*

1. *when $\epsilon_{\psi i} > -1$, corporate debt makes monetary contractions less effective in controlling inflation. In particular, if $\epsilon_{\psi i} > 0$, the condition for Taylor principle inversion is relaxed.*

2. *when $\epsilon_{\psi i} < -1$, corporate debt makes monetary contractions more effective in controlling inflation.*

In the dynamic model which we shortly introduce, the corporate debt servicing cost ψ is endogenized via the price of corporate bonds and the inter-temporal interest rates of the lender households' Euler equation.[9]

4 Dynamic Model

We now show that the main results and mechanisms illustrated in the static model also hold in the dynamic environment with capital accumulation, nominal rigidities via Calvo pricing, and an endogenous monetary policy rule (Taylor rule). Like the static model, the dynamic model has an owner household that owns firm sectors and holds equities, and it also has a lender-worker household who supplies labor and holds corporate bonds as the inter-temporal saving device. The intermediate goods firms can access short-term financing from the money market to finance their working capital, and they also owe corporate legacy debt to the lender-worker household. We assume a steady-state stock of legacy debt which intermediate goods firms choose to roll over at prevailing inter-temporal interest rates. Physical capital is held by the owner household who makes inter-temporal capital accumulation decisions. Moreover, we replace the monetary endowment of households with central bank open market operations in the bond market. The rest is similar to a canonical New Keynesian model where intermediate goods firms are price-setters with market power and for probability ϕ that they do not change prices. Final goods firms are competitive and produce the final consumption goods by combining a continuum of intermediate goods. All the equilibrium equations and linearized versions are in the Online Appendix.

[9] Based on our calibration, the dynamic model falls into the case of $\epsilon_{\psi}(i) > -1$. But when would $\epsilon_{\psi}(i) < -1$ ever be likely? It would be possible if the economy has a large presence of fixed-coupon long-term corporate debt and the yield curve is steepening, under which case, $\epsilon_{\psi}(i) < -1$ is interpreted as the yield of fixed-coupon bonds rising more than the short-term policy rate. This is because if the yield curve is steepening, the increase in i increases the long-term yield of the corporate debt more for one-to-one, pushing down its prices significantly, and if these bonds have fixed coupon rates, then the wealth of the lender working households (those that hold corporate bonds for saving) will take a larger hit, and labor supply becomes less elastic to the fall in real wages. However, recent monetary contractions in the US are associated with a flattening or sometimes even inversion of the yield curve, and the firms corporate debt maturity has been decreasing.

4.1 Households

Owner Households: Owner households own firm sectors, and they maximize their expected inter-temporal utility $U^o = \sum_t \mathbb{E}_t \beta^t exp(\epsilon_t^d) log(c_t^o)$, where ϵ_t^d is a normally distributed demand shock[10]. Preferences are subject to their flow budget constraint written in real terms as follows: $c^o + k' = \tilde{\pi}_I + \tilde{r}_k k$, where $\tilde{\pi}_I$ are aggregate profits from intermediate goods firms. Optimality with respect to capital gives $\frac{1}{c^o} = \beta \mathbb{E} \frac{1}{c^{o'}}(\tilde{r}_k')$.

Lender Households: Lender households maximize $U^l = \sum_t \mathbb{E}\beta^t \left\{ exp(\epsilon_t^d) log(c_t^l) - \frac{\kappa}{2} l^2 \right\}$. and are subject to the budget constraint written in real terms $\tilde{q}\tilde{d}' + \frac{\phi_d}{2}\tilde{q}(\tilde{d}' - \bar{d})^2 + c^l = \tilde{w}l + \frac{\tilde{d}}{1+\eta}$, where $\bar{d}$ is the steady-state value of debt and $\frac{\phi_d}{2}\tilde{q}(\tilde{d}' - \bar{d})^2$ is a quadratic adjustment cost for debt, and η is the net rate of inflation.[11] The optimality condition with respect to labor is $\frac{\tilde{w}}{c^l} = \kappa l$, while the optimality condition with respect to debt is $\frac{\tilde{q}}{c^l}(1 + \phi_d(\tilde{d}' - \bar{d})) = \beta \mathbb{E} \frac{1}{c^{l'}} \frac{1}{1+\eta'}$.

4.2 Intermediate Goods Firms

Intermediate goods firms have a selling unit and a wholesale unit. Wholesale units produce wholesale goods, and the selling units internally purchase wholesale goods from the wholesale units and have a simple linear production function. Selling units each have differentiated goods and sell that to the consumer, setting the price of the goods they sell. The selling unit and the wholesale unit operate independently but in the end share profits via the intermediate goods firm. Wholesale units maximize the present discounted value of real value profits valued at the owner's marginal utility by choosing working capital credit, labor and capital, $\sum_t \beta^t \mathbb{E} \frac{1}{c_t^o} \tilde{\pi}_{W,t}$. They have a production function with capital k and labor l being the inputs and A being productivity: $y_W = A k^\alpha l^{1-\alpha}$. Capital is rented from the owner households, while labor is rented from the lenders. As in the static model, wholesale units face a morning budget constraint and an evening one. In equilibrium, these can be represented as the working capital and the flow budget constraints,

[10] We suppress notation for this as we have removed it from our analysis. We have explored the endogenous response of monetary policy to demand shocks in previous versions of this paper.

[11] In the robustness check section, we also include a fixed coupon corporate bond to generate a deterioration in lenders' non-labor income wealth after a monetary contraction, and our key results also go through.

respectively. The nominal working capital constraint is represented by $wl = b$, and the end-period nominal constraint is represented by $\pi_W + r_k k + d_W + b(1+i) = p_W y_W + q d'_W$, where p_W is the nominal value of a unit of wholesale goods, and its real value $\tilde{p}_W$ is the marginal cost of the intermediate goods firms. And b is the money wholesale units borrow from the short-term money market at a nominal interest rate i. d'_W is the nominal value of inter-temporal bonds sold at a price q, and which is repaid one period in the future. Define the real value of short-term borrowing as $\tilde{b} = \frac{b}{P}$, the real value of inter-temporal bonds as $\tilde{d}'_W = \frac{d'_W}{P}$, and recall that inflation is given by $1 + \eta = \frac{P}{P_{-1}}$. With this, we obtain the real flow budget constraints as follows: $\tilde{w}l = \tilde{b}$, and $\tilde{\pi}_W + \tilde{r}_k k + \frac{1}{1+\eta}\tilde{d}_W + \tilde{b}(1+i) = \tilde{p}_W y_W + \tilde{q}\tilde{d}'_W$.

Selling units purchase wholesale goods from the wholesale units to produce differentiated good according to a linear function. Thus, the marginal cost of each selling unit is $\tilde{p}_W$, and they set prices monopolistically subject to Calvo-style nominal rigidity. The nominal flow budget constraint for its profits $\tilde{\pi}_j$ summarizes these constraints : $\tilde{\pi}_j = \frac{1}{P}\{p_j y_j - p_W y_j\}$, and substituting in the demand function $y_j = \left(\frac{p_j}{p}\right)^{-\theta} y$, $\tilde{\pi}_j = \left(\frac{p_j}{p}\right)^{1-\theta} y - \tilde{p}_W \left(\frac{p_j}{p}\right)^{-\theta} y$. Let ϕ be the probability that an intermediate goods firm does not change its price each period. Using the above, we obtain the following expression for the price of the firms that re-set their price each period as $p_j^{\#} = \sigma \frac{X_1}{X_2}$, where $X_1 = \frac{1}{c^o}\tilde{p}_W P^{\theta} y + \phi\beta\mathbb{E}X'_1$ and $X_2 = \frac{1}{c^o}P^{\theta-1}y + \phi\beta\mathbb{E}X'_2$. We can observe that if prices are flexible, it follows that $p_j^{\#} = \sigma P \tilde{p}_W$. And finally, aggregate profits of the selling units are $\tilde{\pi} = \int_0^1 \tilde{\pi}_j dj = y \int_0^1 \left\{\left(\frac{p_j}{p}\right)^{1-\theta} - \tilde{p}_W \left(\frac{p_j}{p}\right)^{-\theta}\right\} dj = y - \tilde{p}_W \nu y$, where ν is price dispersion. Aggregate profits of the intermediate goods firms are $\tilde{\pi}_I = \tilde{\pi}_W + \tilde{\pi}$.

4.3 Final Goods Firm

The final goods firm's problem is the same as in the standard literature. Each period a perfectly competitive, representative final goods firm produces the final consumption good, y. The firm produces the final good by combining a continuum of intermediate goods, indexed by $j \in (0,1)$, using the technology $y = \left(\int_0^1 y_j^{1-\frac{1}{\theta}}\right)^{\frac{\theta}{\theta-1}} dj$. Optimality implies $y_j = \left(\frac{p_j}{p}\right)^{-\theta} y$, and $P = \left[\int_0^1 p_j^{1-\theta} dj\right]^{\frac{1}{1-\theta}}$. Note that integration of individual firm supply using the production function of the intermediate goods firm gives $y_W = \nu y = \int_0^1 \left(\frac{p_j}{p}\right)^{-\theta} y dj$.

4.4 Monetary Policy

The monetary authority sets the short-term interest rate of the money market according to a Taylor rule. It also trades inter-temporal bonds in its regular open market operation. Let the *overline* symbol denote the steady state real value, let $\rho_y, \rho_i, \rho_\eta$ be the Taylor rule coefficients, and the Taylor rule is specified as follows:

$$\frac{1+i}{1+\bar{i}} = (\frac{y}{\bar{y}})^{\rho_y} (\frac{1+i_{-1}}{1+\bar{i}})^{\rho_i} (\frac{1+\eta}{1+\bar{\eta}})^{\rho_\eta} e^{\epsilon_i}, \tag{14}$$

where ϵ_i is a Normally distributed shock.

A meaningful trade-off between inflation and output stabilization requires a real rigidity in the canonical New Keynesian model (Blanchard and Galí, 2007 call this the absence of the "divine coincidence").[12] We include the log deviation of output from its trend in the Taylor rule. We do this because the nominal interest rate enters as a direct working capital financing cost and because of the additional transmission mechanism we obtain through corporate debt. These reasons imply that monetary policy can meaningfully target overall output fluctuations and not only its deviation from the flexible price equilibrium. Given the nominal interest rate specified by the Taylor rule, the monetary authority supplies money on demand in the money market, $\tilde{M}$. We interpret these activities as discount window actions. In addition, the monetary authority commits to trade a constant real amount of inter-temporal bonds $\tilde{\mu}$, and we interpret the trading of inter-temporal bonds as open market operations. These actions result in a public flow balance equation,

$$\tilde{M}i + \frac{\tilde{\mu}}{1+\eta} - \tilde{q}\tilde{\mu}' = 0. \tag{15}$$

The monetary policy rule gives the interest rate i, and the central bank supplies $\tilde{M}$

[12] Ravenna and Walsh (2006) show that the cost channel via working capital loans alters the trade-off between inflation and output stabilization. We show that the intensity of this trade-off depends on the quantity of corporate debt in the economy and that the mechanism hinges on the income effect through corporate debt, which reinforces the cost channel via working capital loans. The higher the level of corporate debt is, the more difficult this trade-off becomes.

on demand to clear the money market.[13]

4.5 Market Clearing and Equilibrium

The market clearing condition for final goods is $Y = C^o + C^l + K' + \frac{\phi_d}{2}\tilde{q}(\tilde{D}' - \bar{D})^2$. The money market clearing condition is $\tilde{B} = \tilde{M}$. The inter-temporal bond market clearing condition is $\tilde{D}'_W = \tilde{D}' + \tilde{\mu}'$. Note that the upper case variables coincide with the aggregate value of the population share. In the quantitative simulations, we calibrate our economy such that the population share of the owner households is smaller than that of the workers. We assume each household type is of unit measure and use the lowercase variables to denote aggregate quantities.

In addition, the labor market, capital rental market, and the wholesale goods market clears. For the sake of brevity, we have assumed markets clear in the problem description in the previous sections. Equilibrium is defined as a sequence of quantities and prices, given the monetary policy rule, and the real quantity of inter-temporal bonds traded by the monetary authority ($\tilde{\mu}$), such that (i) the monetary authority supplies real money balances on demand, (ii) intermediate goods firms set prices while taking into account the price impact on demand, (iii) agents maximize subject to their budget and liquidity constraints, (iv) goods market, labor market, capital market, corporate bond market, and money market clear, and expectations are rational.

Summing up the flow of funds constraint of the economy, we note that the interest payment of the monetary market equals the trading cost in the open market operation, i.e., $i\tilde{b} = q\tilde{\mu}' - \frac{\tilde{\mu}}{1+\eta}$. Let $m \equiv q\tilde{\mu}' - \frac{\tilde{\mu}}{1+\eta}$, it follows that $\tilde{M} = \frac{\tilde{m}}{i}$, and variable $\tilde{M}$ refers to the real value of money balance. The Online Appendix presents the system of equations that summarize equilibrium together with the closed-form solution for the steady-state and linearised dynamic equations. Proposition 4 characterizes the real effects of money and legacy debt in the steady state equilibrium.

Proposition 4. *In the steady state,*

a More legacy debt decreases real money balance and output;

[13] In this framework, money is issued against an offsetting loan, and its repayment guarantees money's departure, influencing the equilibrium price level. Our setup, where the central bank maintains credibility without discretionary seigniorage changes, ensures money's non-neutrality even with flexible prices, as in, for example, Tsomocos (2003), Bloise and Polemarchakis (2006), and Goodhart et al. (2006).

b An increase in the nominal interest rate reduces real money balance, but the reduction is weaker the higher legacy debt is;

c Changing the nominal interest rate exerts real effects in the steady state when debt $\bar{d} \neq 0$, but is neutral when debt $\bar{d} = 0$.

This result arises because corporate debt affects both aggregate demand (through the distribution of household income) *and* aggregate supply (through the level of inputs of the firm). The nominal interest rate is neutral when corporate debt is zero because we allow for a Ricardian seigniorage transfer m each period. A non-Ricardian seigniorage transfer, on the other hand, determines the price level and makes monetary policy non-neutral in the steady state even with zero debt (see Nakajima and Polemarchakis, 2005).

4.6 Dynamic Properties

In this section, we study the effects of legacy debt on the dynamic properties of the model and on the monetary transmission mechanism away from the steady state. We obtain the 'naíve' Phillips curve[14]:

$$(1 \hat{+} \eta) = \frac{(1-\phi)(1-\phi\beta)}{\phi}\hat{p}_W + \beta(1 \hat{+} \eta'). \tag{16}$$

where the marginal cost is given by[15]

$$\begin{aligned} \hat{p}_W = &- \frac{(1 \hat{+} \eta) + \bar{q}\hat{q}}{1-\bar{q}} - \frac{(1 \hat{+} i)}{((1 \bar{+} i) - 1)} \left\{ 1 - \frac{(1 \bar{+} i)(1-\alpha)\bar{d}(1-\bar{q})}{2(\bar{w}\bar{l} + \bar{d}(1-\bar{q}))} \right\} \\ &- \hat{A} - \alpha\hat{k} - \frac{(1-\alpha)\bar{d}\left\{\bar{q}\hat{d}' - \hat{d}\right\}}{2(\bar{w}\bar{l} + \bar{d}(1-\bar{q}))}. \end{aligned} \tag{17}$$

As the steady state stock of legacy debt increases, the absolute value of the coefficient of interest rates on the path of inflation declines, i.e., changes in interest rates have a smaller negative effect on inflation. The following proposition summarizes this result

Proposition 5. *Given monetary policy, as the steady state debt level increases, the effectiveness of interest rates on the path of inflation declines.*

[14]'Naíve' because we do not present it in terms of the output gap. See Online Appendix for full model equations.

[15]The derivation is in Appendix H.

We can observe from the "naíve" Phillips curve (16) and the expression of the marginal cost (17) that lack of "divine coincidence" depends, in part, on the level of legacy debt. The expression in (16) is identical to the standard expression in the presence of a cost channel with the standard real marginal cost supplemented with the liquidity cost. However, in Ravenna and Walsh (2006), the real marginal cost can be expressed in terms of output because the labor supply decision of households depends only on wages and aggregate output. With heterogeneous households, the real marginal cost also depends on the wealth distribution (i.e., corporate debt holdings), as seen in Equation (17).

Our 'naíve' dynamic IS curve (18)[16] can be obtained by combining in the individual Euler and labor supply condition with the marginal product of labor and the definition of firm output (and $\phi = 0$),

$$\hat{q} + (1 \hat{+} i) - \hat{p}_W - \hat{y}(1 - \frac{2}{1-\alpha}) - 2\frac{\hat{A} + \alpha\hat{k}}{1-\alpha}$$
$$= (1 \hat{+} i)' - \hat{p}_W' - \hat{y}'(1 - \frac{2}{1-\alpha}) - 2\frac{\hat{A}' + \alpha\hat{k}'}{1-\alpha} - (1 \hat{+} \eta)'. \quad (18)$$

Here we can see that both the steady-state stock and the dynamics of corporate debt affect aggregate demand through the real marginal cost, $\hat{p}_W$.[17]

5 Quantitative Example

We now present our simulation, calibrated to the US. We take the population share of the owners to be 10% (and the worker-lenders to be 90%) to match known distributions in financial asset holdings, in particular, equity (see Toda and Walsh, 2020 and Campbell, 2006, for example). Other than the corporate debt-to-output ratio, we appeal to standard calibrated parameters from recent literature (see Table 1). The model period is one quarter, and we set the discount factor β to 0.99, the same as in Ottonello and Winberry (2020). We set the markup parameter to 1.25, which is at the low end of the estimated

[16]See Online Appendix.

[17]Note that a standard IS or Phillips curve using a measure of the output gap, i.e., the difference between a flexible price economy and a sticky price one, would not affect our core result. The dynamics of debt affect both aggregate demand *and* price-setting behavior, meaning that the output gap would reflect two distortions in the economy: the first arising from pricing rigidities and the second from distribution of wealth and hence aggregate demand and supply. The latter inefficiency means that inflation targeting should also account for debt dynamics. Putting this together, the path of interest rates that stabilizes the path of inflation may cause instability in output directly through instability in working capital which indirectly causes instability in the path of inter-temporal debt.

markup in De Loecker, Eeckhout and Unger (2020) but at the high end of the value conventionally used in the New Keynesian literature. In the monetary policy rule, we set the response to inflation to 1.5 and the smoothing parameter to 0.5 (similar to Gomes, Jermann and Schmid, 2016). Following Christiano, Trabandt and Walentin (2010), we set the output coefficient to 0.2 as our benchmark.

A crucial calibration in this economy is the value of the corporate debt-to-output ratio at the steady-state, i.e., the steady state corporate debt-to-output ratio. This parameter matters for the wealth distribution of the "enterpriser-borrower" and the "salaried creditor". We set the benchmark corporate debt-to-output ratio to a 75% corporate debt-to-output ratio at the steady-state and high corporate debt-to-output ratio as 100%. In our numerical illustrations, we compare the macroeconomic responses between the benchmark and high debt cases. We base our choice of corporate indebtedness on the ratio of corporate debt to quarterly revenue of non-financial corporate businesses from 2001 to 2022. We find it fluctuates between 3 and 4 (or 75% and 100% on an annualized basis) and has been trending up in the recent decade, consistent with corporate debt-to-output ratios in various economies documented in Section 2.1. Furthermore, the total stock of non-financial business debt in the US stands at a historically high level of around 130% of GDP in 2020 (see Jordà, Kornejew, Schularick and Taylor, 2020 and Federal Reserve Board Financial Accounts of the United States 2020).

Table 1: Calibration

Parameter	A	α	β	i	σ	κ	ϕ	ϕ_d	ρ_y	ρ_η	ρ_i
Value	100	0.33	0.99	0.01	1.25	0.1	0.7	0.001	0.2	1.5	0.5

Given our parameterization in Table 1, below Table 2 displays the model steady-state values with quantity variables normalized by output.

Table 2: steady-state values

	$\bar{c}^0/\bar{y}$	$\bar{c}^l/\bar{y}$	$\bar{k}/\bar{y}$	$\bar{b}/\bar{y}$	$\bar{\pi}/\bar{y}$	$\bar{d}/\bar{y}$	$\bar{q}$	$\bar{r}_k$
BMK lev	0.178	0.558	0.264	0.587	0.175	3	0.990	1.01
High lev	0.168	0.568	0.264	0.587	0.165	4	0.990	1.01

BMK lev refers to the benchmark corporate debt-to-output ratio of 75% (annual), or $\bar{b}/\bar{y} = 3$. High lev refers to the high debt corporate debt-to-output of 100% (annual), or $\bar{b}/\bar{y} = 4$.

We simulate the model with a positive shock to interest rates with no persistence[18]. The model simulation sheds light on the cyclicality of the consumption expenditure of the

[18]The demand shock has a persistence of 0.9.

households that own large shares of equity and those that do not. Table 3 presents the correlation matrix of key variables with output. The consumption expenditure of owner households (equity owners) tends to be highly pro-cyclical, whereas the expenditure of the lender households, those who do not own shares, is much less cyclical. Moreover, both working capital and labor income appear highly pro-cyclical. As the stock of debt increases, the more pro-cyclical owner households' consumption appears, and the more acyclical lender households' consumption expenditure becomes. This result connects with the literature on the high sensitivity of consumption growth of wealthy stockholders to the stock market and aggregate fluctuations. For example, Malloy, Moskowitz and Vissing-Jørgensen (2009) find higher sensitivity of the consumption growth of wealthy stockholders to both the stock market and aggregate consumption growth, and Parker and Vissing-Jorgensen (2009) show that consumption growth of high-consumption and high-income households are significantly more exposed to aggregate fluctuations, among others (see Parker, 2001).

Table 3: Cyclical properties: correlations with output

	c^o	c^l	b	l	d
y (BMK lev)	0.73	0.38	0.96	0.93	-0.76
y (High lev)	0.88	0.20	0.99	0.97	-0.86

BMK lev refers to the benchmark corporate debt-to-output ratio of 75% (annual), or $\bar{b}/\bar{y} = 3$. High lev refers to the high corporate debt-to-output ratio of 100% (annual), or $\bar{b}/\bar{y} = 4$. c^o is the consumption of owner households, c^l is the consumption of lender households, b is working capital in real terms, l is labor, d is debt in real terms, and y is real output.

5.1 The Effect of Monetary Contractions

The tightening monetary policy shock we introduce is 0.025 standard deviations of the nominal policy rate, which leads to an endogenous increase in the policy rate of around one percentage point. Figure 3 shows the dynamic responses to the monetary contraction shock, where the blue line represents benchmark corporate indebtedness, or corporate debt-to-output ratio, of 75%, while the red line represents high indebtedness of 100%. In both cases, inflation falls on impact after a monetary contraction before rising to the positive realm. The subsequent rise in inflation is higher in the high debt case than in the benchmark case, suggesting that the higher corporate indebtedness is, the more challenging it is to rein in inflation. On the real side, output falls in both the high debt and benchmark cases. However, output responds much more aggressively in the high debt case because corporate debt triggers the income effect of rising interest rates, causing the labor supply to become more elastic. Consequently, the AS curve is more elastic in the high debt case than in the low debt case. The positive shock to the nominal interest rates dampens both aggregate demand and aggregate supply, and with a more elastic AS curve, inflation, although it falls on impact, can even increase slightly after a monetary contraction (see Proposition 2.).

Our impulse responses for real wages and labor confirm that Lemma 1 also holds on the dynamic path (that the effective elasticity of labor supply depends on legacy debt). A monetary contraction increases the borrowing cost of financing the working capital, driving down real wages. Although the price of corporate bonds also falls, it falls less than the real wages. With a high effective labor supply elasticity, wage decreases drive down labor supply significantly. Corporate profits also fall after a monetary contraction. Moreover, as seen in the high debt case, labor decreases more than in the benchmark case. Wages decrease more in the high debt case than in the low debt case after two quarters. This is consistent with our real wage equation $\tilde{w} = \dfrac{A}{\sigma(1+i)}$ derived from the model, which says real wages have an inverse relationship with the policy rate and that wages do not directly depend on corporate indebtedness; since the rise in the endogenous policy rate in the high debt case is more significant than that in the low debt case after two quarters (first subplot of Figure 3), real wages decline more in the high debt case.

Worker-lender households derive most of their income from wages, and therefore are the household wealth group to experience the greatest loss to income from wages. As in Luetticke (2021) they decrease portfolio liquidity, thereby decreasing the size of their portfolio in aggregate, to smooth consumption. Wages fall further when corporate debt is higher and therefore must liquidate a greater share of their portfolio in order to smooth consumption, causing the liquidity premium to drop to a level where wealthier households increase their share of portfolio liquidity.

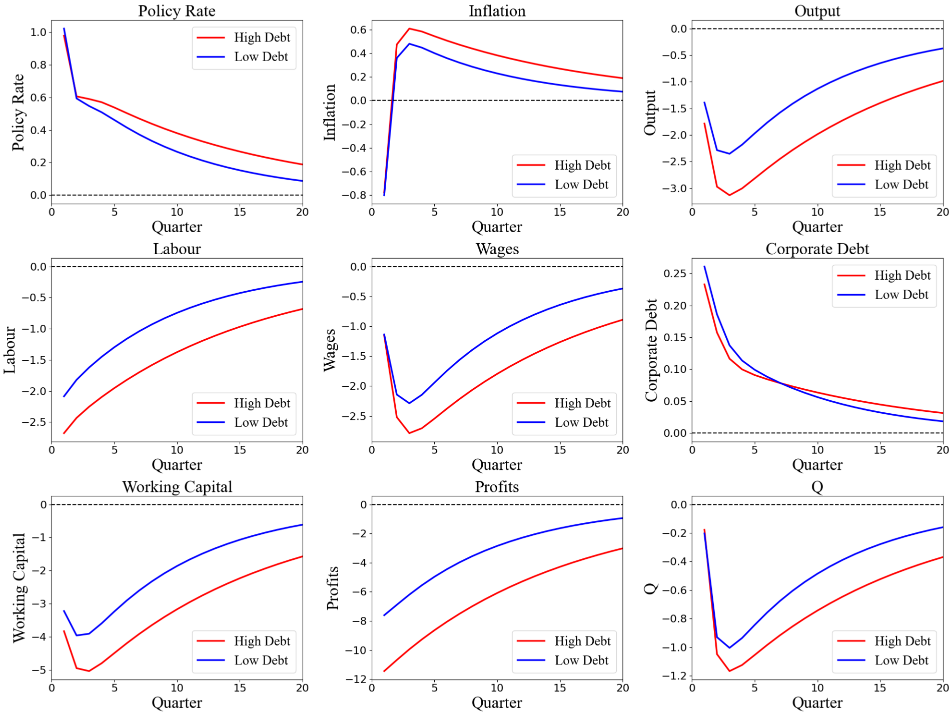


Figure 3: Tightening shock to nominal policy rate i.

The blue line is 75% corporate debt-to-output ratio and the red line is 100% corporate debt-to-output ratio. The y-axis is % change and the x-axis is the number of periods. Other than inflation and policy rate, all variables are in real terms

5.2 Robustness Check

Monetary contractions lead to a reduction in both real wages and corporate bond prices. One may be concerned that if lenders hold fixed coupon bonds whose market value is negatively affected by the rate hike but not compensated by the rising interest payment, lenders' wealth may be more adversely affected in the high debt case than in the low debt case. In that scenario, would the effective labor elasticity still turn out higher in the high debt case, and our results go through? In the Online Appendix we introduce a two-period fixed coupon bond and show that our results still go through reflecting that our results work through the redistribution of income rather than state-contingent value of wealth.

6 Empirical Results

We now present our empirical results that support our theoretical predictions on the state-contingent effects of monetary policy shocks, particularly on prices, labor supply, and investment demand. We find that economic activity is more depressed but prices are significantly and uniformly higher following a monetary policy shock for the high ratio of corporate debt to household financial assets ("corporate debt ratio" henceforth) states than in low corporate debt ratio states. We employ a state-contingent local projection (Jordà, 2005) of monetary policy shocks estimated by Wieland and Yang (2020) ("Romer shocks" henceforth) incorporating a binary interaction term that represents the cyclical level of corporate debt (along the lines of Auerbach and Gorodnichenko (2012)). Our estimation equation is:

$$\boldsymbol{\gamma}_{t+j} = \beta_{j,0}\tau + \beta_{j,1} + \beta_{j,2}\bar{\epsilon}_t^R \mathbb{I}_{t-1} + \beta_{j,3}\bar{\epsilon}_t^R \left(1 - \mathbb{I}_{t-1}\right) + \beta_{j,4}\mathbf{X}_{t-1} + \upsilon_{t+j} \tag{19}$$

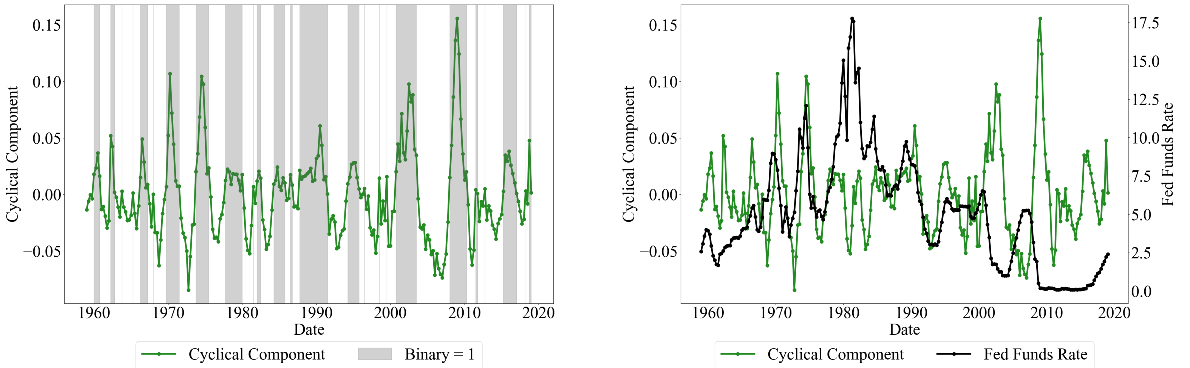
Where $\boldsymbol{\gamma}_{t+j}$ is a collection of relevant macro-variables, τ is a linear time trend, $\beta_{j,1}$ is the intercept, $\bar{\epsilon}_t^R$ is the contemporaneous monetary policy shock interacted with a binary variable, $\mathbb{I}$, by one period so as to avoid the endogenous response of corporate leverage or household wealth to the shock. The vector of control variables is $\mathbf{X}_{t-1}$.[19]

The binary variable is derived from our measure of the level of corporate debt: the Federal Reserve Flow of Funds accounts - "Non-financial Corporate Business; Debt Securities and Loans; Liability, Level." We take the log ratio of this variable and "Households and Nonprofit Organizations; Total Financial Assets" so as to capture the proportion of household wealth in corporate debt. Since we are interested in the cyclical state-contingent response of household demand, we apply a Hodrick-Prescott filter to extract its cyclical component and convert it to a binary variable with a value of 1 when it is above the mean and 0 otherwise. In this we follow Harding and Klein (2022) who apply this methodology to household net worth.

Figure 4a plots the cyclical component of corporate debt to net household assets (green) and periods in which it is above its mean. This is the binary variable that has a value of 1 (shaded in grey) when the cyclical component is above its mean. We also provide the list of NBER recession dates to compare the periods when the binary variable is 1, out of potential concern that our measure proxies for the business cycle. While some periods seem to intuitively coincide with monetary events, like the steep drop in the real level of debt following the 2008 financial crisis, we observe elevated levels of debt during and after the savings and loan crisis of 1987. Moreover, in Figure 4b we observe no clear relationship between the cyclical component of our corporate debt to household assets variable and the level of the Federal Funds rate. As such, we are not simply measuring an endogenous

[19] The log of Real GDP, log of Real Personal Consumption Expenditures, log of Real Gross Private Domestic Investment, Effective Fed Funds Rate, log of the Implicit GDP Deflator, the Romer shock at $t-1$, and the Romer shock at $t-2$.

Cyclical Component of Corporate Debt to Household Wealth Ratio Vs Binary Variable (Left) and vs Fed Funds Effective Rate (Right)



(a) Cyclical Component of Corporate Debt to Household Wealth and Binary Variable

(b) Cyclical Component of Corporate Debt to Household Wealth and Fed Funds Rate

Figure 4: *Notes:* Left panel is the filtered series is the log ratio of quarterly level of corporate debt and household assets from Q1 1952 to Q1 2019. We set the HP-filter smoothing parameter is to 1600 to obtain the cyclical trend. The value of the binary variable is 1 when the cyclical trend is above its mean, and is 0 when the cyclical trend is below its mean. The shaded grey areas correspond to when the cyclical variable, in green, is above its mean. Right panel is the cyclical component of the binary variable (Green) plotted against the Fed Funds Effective Rate (Black). NBER Recession dates are: April 1960 to February 1961, December 1969 to November 1970, November 1973 to March 1975, January 1980 to July 1980, July 1981 to November 1982, July 1990 to March 1991, March 2001 to November 2001, December 2007 to June 2009, February 2020 to April 2020.

response of corporate leverage or household wealth in response to either the business or monetary policy cycle. We use a set of macroeconomic variables as proxies for household responses to monetary shocks. These include the log of Real Average Private Hourly Earnings (wages), the Average Weekly Hours Worked by Private Employees (hours), the Implicit GDP Deflator (deflator), the liquidity premium, the housing premium, and the capital premium. These premia are obtained from the replication files of Luetticke (2021) and represent the ratio of liquid assets to illiquid assets held by households (where corporate debt is considered a liquid asset and equities an illiquid asset) and the housing premia is the excess return on housing (price appreciation plus rents).[20]

Figure 5 presents the results of the estimation where impulse responses in red (blue) denote states when corporate debt is high (low). We find that the level of the corporate debt ratio has a significant effect on the response of output to a monetary shock. When corporate debt is low, output expands for 10 quarters until contracting. When corporate

[20]The Flow of Funds (FoF), Table Z1, provides the aggregate balance sheet of the U.S. household sector, including nonprofits, from 1952-2016. Net liquid assets include currency, deposits, money market funds, various debt securities, loans (as assets), and miscellaneous assets minus consumer credit and certain loans. Net illiquid wealth comprises real estate, life insurance reserves, pension entitlements, business equity, corporate equities, and mutual funds minus mortgages. The housing premium is constructed from house prices (Case-Shiller Index), CPI for rents, and federal funds rate, measuring the excess return on housing. See online appendix and replication files of Luetticke (2021) for details on constructed variables.

Full Sample Period (1983-01-01 - 2007-10-01)
Binary Variable: (Corporate Debt / Household Total Financial Assets)

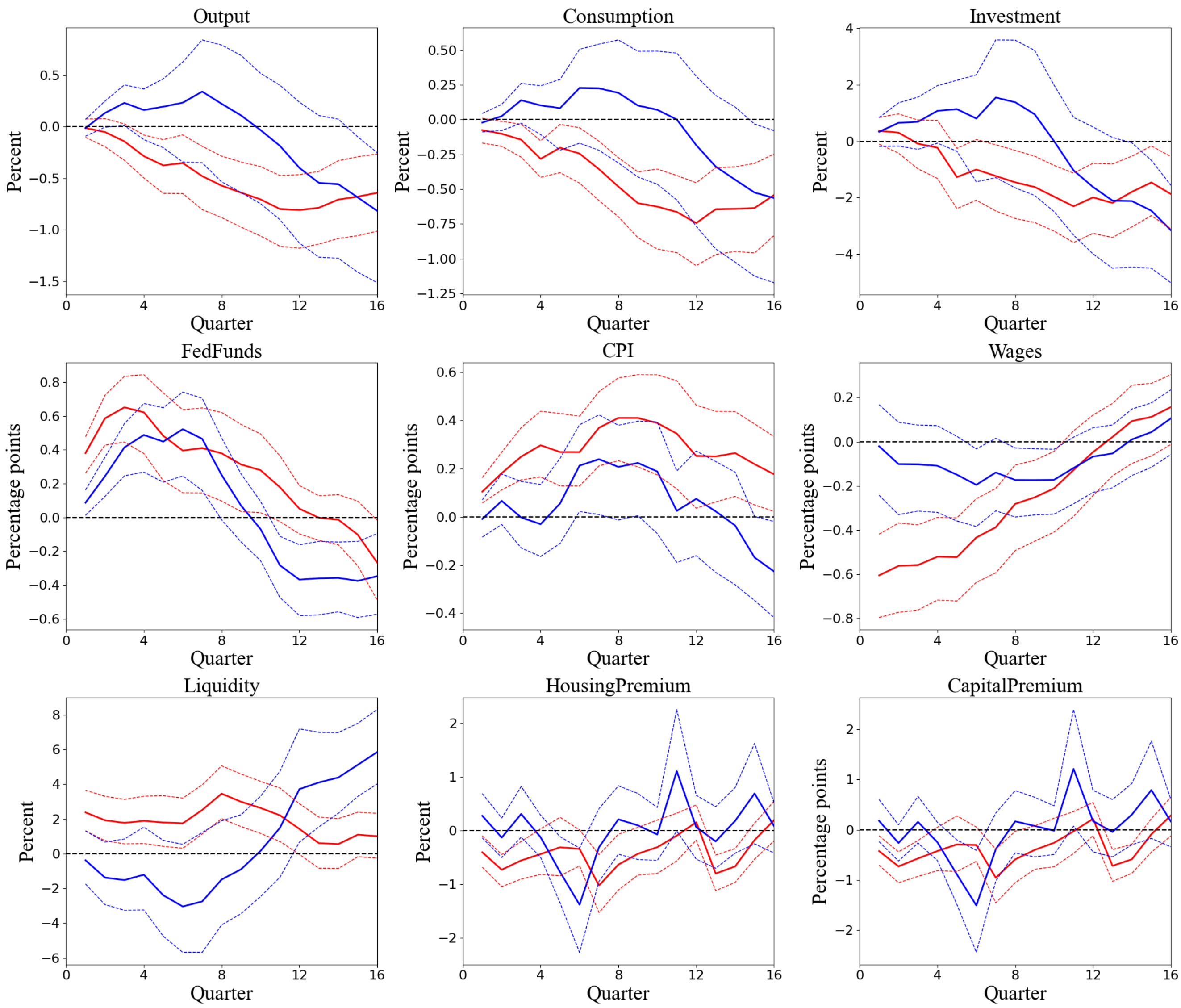


Figure 5: Aggregate Response to Monetary Shock

Notes: Estimated response of all dependent variables through 16 quarters, $t+h, h = 1, ..., 16$, post a contemporaneous monetary policy shock, ϵ_t^R, when the ratio of corporate debt to household financial assets (we call this the corporate debt ratio henceforth) is high (Red) and low (blue). Bootstrapped confidence intervals at the 90 % level are the dashed lines with the color corresponding to the state of the interaction variable. Newey-West correction is used for errors. t corresponds to the sample period of the 100 quarters from Q1 1983 to Q4 2007. The results are conditioned upon the observed values of the state variables at $t-1$, $\mathbf{X}_{t-1} = \left[Y_{t-1}, C_{t-1}, I_{t-1}, R^B_{t-1}, \epsilon^R_{t-1}, \epsilon^R_{t-2}\right]$.

debt is high, output persistently contracts. In our dynamic model (Figure 3) output falls in both high and low debt cases but more so in the high debt case.

The results for investment and consumption coincide with output. In Coibion, Gorodnichenko, Kueng and Silvia (2017) monetary policy shocks redistribute wealth towards wealthier households who own virtually the entire share of equities, and thus benefit from the profits generated from falling real wages. Luetticke (2021) finds that wealthier households have a stronger propensity to invest than poorer households, and a weaker propensity to consume than poorer households. Thus, in his model, following a monetary policy shock, investment falls less than consumption. In our estimations, with corporate debt included as a state variable, and since worker-lender households have a lower propensity to invest and a higher propensity to consume, after 4 quarters investment falls more than consumption when the outstanding amount of corporate debt is high. Berg, Curtis, Lugauer and Mark (2021) find that consumption is more sensitive to monetary policy shocks for asset rich households than asset poor. In their paper, poorer households, which derive most of their income from labor, are able to make a trade-off between labor and leisure and, in line with our findings, thereby evoke a response in the supply of labor. Wealthier households, who are predominantly older households, not only discount the future much greater, and make no trade-off between labor and leisure, are also much more sensitive to shocks in the short-term rate of interest. In our model, the relative procyclicality of owner demand is represented in Table 3, and when there is evidence of the *Giffen Good* property, in Corollary 1.

The Fed Funds Rate responds more to monetary policy shocks in high corporate debt states. Luetticke (2021) finds that distributional changes to portfolio liquidity drive investment after a monetary policy shock. Our result is complementary by showing that the level of the corporate debt ratio is a key factor in determining the cyclical level of portfolio liquidity. This aligns with the response of monetary policy on inflation in our static model (Proposition 2)) and the Phillips curve in our model where the level of corporate debt enters into the marginal cost equation (see Equation 16 and Equation 17) of our dynamic model with sticky prices.

Figure 5 shows that the level of the corporate debt ratio has an initially strong effect on real wages as corporations are mitigated in their ability to borrow funds to expand (the effect on real wages in our model works through the working capital cost, see Lemma 1). However, when corporate debt is high, the propensity of households to substitute labor income with interest income rises, demand is sustained, and thus prices rise even as real wages fall. LCPI is significantly higher when corporate debt is high for about 5 quarters. [21]

[21] Similar results are obtained with a replication of Ramey (2016), detailed in the online appendix.

7 Conclusion

We have presented a monetary general equilibrium model to study the effect of corporate indebtedness on the monetary policy transmission mechanism. Household portfolio heterogeneity corresponds to firms' capital structure. While Irving Fisher's narrative is that booms and busts are caused by changes in the relative wealth of the "enterpriser-borrower" and the "creditor, the salaried man, or the laborer", our focal point is on the impact of such wealth distribution on the efficacy of monetary policy in controlling inflation. We highlight that the stock of corporate debt renders monetary policy less effective. When the stock of corporate debt is above a threshold, raising the policy rate may raise current inflation. This is due to the income effect via corporate debt resulting in aggregate demand behaving as a Giffen good.

In the dynamic model we derive the Phillips curve augmented with corporate debt and show that the effectiveness of interest rates declines as the steady state debt level increases. This debt mechanism provides an explanation of the slope dynamics of the Phillips curve (on the insensitivity of inflation to unemployment, see, e.g., Hazell, Herreno, Nakamura and Steinsson, 2022). Then a quantitative example is given to illustrate that the key results hold on the dynamic path away from the steady state. Our result that monetary policy effectiveness depends on the stock of corporate debt adds support to the argument in papers including Schularick and Taylor (2012) and Jungherr, Meier, Reinelt and Schott (2022) that monetary policy should be conducted taking into account financial market conditions and that credit and money deserve to be watched carefully when implementing monetary policy rules.

The mechanism of our central result relies on the income effect of longer-term corporate legacy debt interacting with the transaction demand for money, allowing us to uncover Giffen good behavior. Our result contributes to the literature on the cost channel of monetary policy by showing how corporate debt may intermediate the transmission of monetary policy to economic activity in addition to the cost channel via the transaction demand for money. In contrast to representative agent frameworks, because our real marginal cost depends on the distribution of wealth, the cost channel operates through *both* the IS and Phillips curves. On dynamic paths, the monetary authority faces a larger trade-off between inflation stabilization and output stabilization when there is a large quantity of corporate debt outstanding in the economy.

Appendix

A Proof of Lemma 1

We first derive the demand function for goods. Households' optimization for goods gives $\int_j c_j^h = \int_j \left(\frac{p_j}{P}\right)^{-\theta} C^h$, goods market clearing gives $c_j^o + c_j^l = c_j = y_j$ and hence $\int_j y_j = Y \int_j \left(\frac{p_j}{P}\right)^{-\theta}$ where Y is the aggregate bundle of goods produced. The aggregate goods market clearing is $c^o + c^l = Y$. Substituting in the demand function $y_j = \left(\frac{p_j}{P}\right)^{-\theta} Y$ and $l_j = \frac{1}{A}\left(\frac{p_j}{P}\right)^{-\theta} Y$ into (6): $\pi_j = (p_j)^{1-\theta} P^\theta Y - \psi D - (1+i)(w p_j^{-\theta} P^\theta \frac{Y}{A})$.

We now develop the cost minimization and price setting problems.

Cost Minimization: From Equation 6, Firms solve $min_{l_j}(1+i)wl_j \quad s.t. Al_j \geq \left(\frac{p_j}{P}\right)^{-\theta} Y$. The solution to this satisfies

$$\tilde{mc}_j = \frac{(1+i)}{A}\tilde{w}, \tag{20}$$

where $\tilde{mc}_j$ is the real marginal cost and $\tilde{w}$ is the real wage. This is the expression for the working capital channel of Christiano et al. (2005). We show below that debt and household heterogeneity affect monetary transmissions beyond the working capital channel, which goes through the marginal cost.

Price Setting: Take the first-order condition for optimal profits with respect to price and substitute Equation 20: $0 = (1-\theta)(p_j)^{-\theta} P^\theta Y - (1+i)(-\theta w (p_j)^{-1-\theta} P^\theta l_j) = (1-\theta)A - (1+i)(-\theta w (p_j)^{-1})$ and so $p_j = \sigma P \tilde{mc}_j$

Where $\sigma = \frac{\theta}{\theta - 1}$ is the markup, where a higher value of σ means greater market power. This shows that the real marginal cost is constant and equal to the inverse of σ in this example. **Aggregate prices:** Use $p_j = P$, and substitute $l_j = L$, $0 = (1-\theta)Y + (1+i)(\theta \tilde{w} L)$, equivalent to

$$\tilde{w} = \frac{A}{\sigma(1+i)}. \tag{21}$$

Labor Supply: The optimality conditions for the lender households' labor supply gives $\tilde{w} = c_L = \tilde{w}L + \psi\frac{D}{P}$, or

$$\tilde{w}L = \tilde{w} - \psi\frac{D}{P}. \tag{22}$$

The above equation shows that corporate debt flattens the labor supply curve and supports the high effective labor supply elasticity emphasized in the cost channel of monetary policy literature.[22] This high elasticity may dampen the response of prices in the presence of monetary disturbances, even though output remains responsive. Given the price level, the elasticity of labor supplied ϵ_L is $\epsilon_L = \frac{\frac{\partial L}{\partial \tilde{w}}}{\frac{L}{\tilde{w}}} = \frac{\psi D}{P\tilde{w}L} = \frac{\psi}{\tilde{b}}\frac{D}{P}$. □

B Proof of Proposition 1

Recall that the real wage is given by $\tilde{w} = \frac{A}{\sigma(1+i)}$. From this we obtain that $\frac{\partial \tilde{w}}{\partial i} = -\frac{A}{\sigma(1+i)^2}$. and Aggregate Demand is given by equation (9), $Y_d = \frac{m}{P} + \int_j y_j dj + i\left\{\frac{\psi D}{P} - \tilde{w}\right\}$. Taking the firm's production plan as given, the partial derivative of this with respect to the real wage gives us $\frac{\partial Y_d}{\partial \tilde{w}} = \psi\frac{D}{P}\frac{\partial i}{\partial \tilde{w}} - \frac{\partial i}{\partial \tilde{w}}\tilde{w} - i$, and $\frac{\partial Y_d}{\partial \tilde{w}}$ is negative when $\psi\frac{D}{P} > \tilde{w} + i\frac{\partial \tilde{w}}{\partial i} = \frac{A}{\sigma(1+i)^2}$, because $\frac{\partial i}{\partial \tilde{w}} < 0$. It follows that a decline in the real wage caused by an increase in the policy rate causes Aggregate Demand to increase. □

C Proof of Corollary 1

After substituting in their labor demand, the demand of lender households is given by $c^l = \tilde{w}$. Hence $\frac{\partial c^l}{\partial \tilde{w}} = 1$ which says that the consumption of the lender household moves proportionately (and positively) on real wages. The demand of owner households is given by $c^o = \frac{\Pi}{P} + \frac{m^o}{P} = \int_j y_j dj - (1+i)\tilde{w} + i\frac{\psi D}{P} + \frac{m^o}{P}$ and so $\frac{\partial c^o}{\partial \tilde{w}} = -(1+i) - \frac{\partial i}{\partial \tilde{w}}\tilde{w} + \frac{\partial i}{\partial \tilde{w}}\frac{\psi D}{P} = -(1+i) + \frac{\sigma(1+i)^2}{A}(\tilde{w} - \frac{\psi D}{P}) < -1$, where the last step uses the result that $\psi\frac{D}{P} > \tilde{w} + i\frac{\partial \tilde{w}}{\partial i}$.

As the response of Aggregate Demand to a change in real wages is given by $\frac{\partial c^l}{\partial \tilde{w}} + \frac{\partial c^o}{\partial \tilde{w}} < 0$, an decrease in wages caused by an increase in interest rates increases Aggregate

[22] See Barth and Ramey (2001) for the aggregate and industry-level evidence on the strength of monetary disturbances as a cost shock.

Demand. In other words, when the amount of legacy debt is sufficiently high, a decline in real wages due to an increase in the policy rate increases the demand of owner households more than it decreases the demand of lender households. □

D Closed-form Solution and Proof of Corollary 3

To derive the closed-form solution for the price level, we simply equate Aggregate Demand and Supply and obtain (23):

$$P = \frac{m + i\psi D}{\frac{1}{\sigma}\frac{i}{1+i}A}. \tag{23}$$

To obtain the closed-form solution for allocation, we combine all flow of funds constraints of households (1) and (3) and of the firms (6). This leads to (24), showing that when the working capital liquidity that was injected in the morning exits the economy, the net interest payment of the working capital liquidity bi equates the aggregate monetary endowment m - an outstanding liability of central bank (essentially the monetary-fiscal authority), which becomes the monetary authority's seigniorage profits.

$$bi = m. \tag{24}$$

The total endogenous money lent by the central bank (inside money) is given by $M = \frac{m}{i}$. This is because the seigniorage profits of the monetary-fiscal authority is m, and the total money supply is $M + m$, the inside money plus outside money. Substituting $b = wL$ and (21) into (24), we obtain $L = \frac{m}{iP}\left(\frac{A}{\sigma(1+i)}\right)^{-1}$. Combine the above equation with (23) and $Y = AL$, we have the closed-form solution for output: $Y = \frac{A}{1+\frac{i\psi D}{m}}$. We obtain nominal profits from 7 $\Pi = P\frac{A}{1+\frac{i\psi D}{m}} - (1+i)P(\frac{A}{\sigma(1+i)} - \psi\frac{D}{P}) - \psi D = \frac{1+i}{i}m(\sigma - 1) - \psi D$. It follows that $\partial\Pi/\partial i = -i^{-2}m(\sigma-1)$. Since $\sigma > 1$, $\partial\Pi/\partial i < 0$. As can be seen in the above equation, condition (2) rules out negative profits or bankruptcy. Moreover, given that we have obtained the closed form for the price level (23), the expression for real profits $\tilde{\Pi}$ is as follows: $\tilde{\Pi} = \frac{\frac{\sigma-1}{\sigma}mA - \psi D(1-\frac{1}{1+i})\frac{A}{\sigma}}{m+i\psi D}$. It is straightforward that with an appropriate level of m real profits decrease when i increases. □

E Proof of Proposition 2

Let ϵ_{P_i} be the elasticity of the price level with respect to the monetary policy rate. We use (23) to derive ϵ_{P_i}. First, the price level can be rearranged as $P = \frac{m + (1+i)\psi D - \psi D}{\frac{1}{\sigma}A - \frac{1}{\sigma}\frac{1}{1+i}A}$. The direct response of the price level to the policy rate is $\frac{\partial P}{\partial(1+i)} = -\frac{P}{i(1+i)} + \psi D \frac{P}{m + i\psi D}$. Finally, the elasticity is given by $\frac{\frac{\partial P}{\partial(1+i)}}{\frac{P}{1+i}} = \frac{i\psi D - b}{m + i\psi D}$. The first term in the numerator is the liquidity cost incurred through higher policy rates, while the second term is the effect of monetary policy on the repayment of outstanding debt. Therefore, $\epsilon_{Pi} < 0$ (the standard Taylor principle) holds *iff* $\psi D < \frac{b}{i}$[23]. Otherwise, the Taylor principle is inverted and $\epsilon_{Pi} > 0$. If corporate debt servicing cost is extremely high relative to working capital credit, raising interest rates *raises* current inflation rate. It is straightforward that ϵ_{Pi} is higher when D is larger. Hence the negative response of inflation is increasingly muted and eventually becomes positive as the size of legacy debt increases.

F Proof of Proposition 3

Suppose ψ is a function of gross interest rate $1+i$, i.e., $\psi = \Psi(1+i)$, and from eq (23), we obtain $P = \frac{m + i\Psi(1+1)D}{Ai}\sigma(1+i)$. We can derive the elasticity of P to $1+i$, $\epsilon_{Pi} = \frac{\partial P/\partial(1+i)}{P/(1+i)} = \frac{-b + \Psi'(1+i)Di(1+i) + \Psi(1+i)Di}{m + i\Psi(1+i)D}$. Let $\epsilon_{\psi i}$ be the elasticity of $\Psi(1+i)$ to $1+i$, and note that $\Psi'(1+i)Di(1+i) + \Psi(1+i)Di = \Psi(1+i)Di(\Psi'(1+i)(1+i)/\Psi(1+i) + 1) = \Psi(1+i)Di(\epsilon_{\psi i} + 1)$, it follows that $\epsilon_{Pi} = \frac{-b + \Psi(1+i)Di(\epsilon_{\psi i} + 1)}{m + i\Psi(1+i)D}$. Therefore, whenever $\epsilon_{\psi i} > -1$, the presence of corporate legacy debt increases ϵ_{Pi}, so the fall in price level in response to the increase in the policy rate is less with corporate legacy debt than without. Whenever $\epsilon_{\psi}(1+i) < -1$, the presence of D decreases price level even more. Furthermore, the Taylor principle inversion condition becomes $\Psi(1+i)D(\epsilon_{\psi i} + 1) > \frac{b}{i}$. Thus, when $\epsilon_{\psi i} > 0$, the condition for Taylor principle inversion is enlarged. □

G Proof of Proposition 4

Aggregate demand at the steady-state is $\bar{c}^o + \bar{k} + \bar{c}^l$. Substitute in households' and firms' flow of funds constraints into aggregate demand for output, with the market-clearing

[23] In terms of primitives, the condition can be written as $i\psi D < \frac{m}{i}$.

condition for final output $\bar{y} = \bar{c}^o + \bar{c}^l + \bar{k}$, we obtain that $\bar{y} = \bar{c}^o + \bar{k} + \bar{c}^l = -\bar{w}\bar{l}\bar{i} + \bar{y} + \bar{m}$ and hence

$$\bar{w}\bar{l} = \frac{\bar{m}}{\bar{i}} = \bar{M}. \tag{25}$$

From the marginal cost of the firm we get that $\bar{p}_W = \dfrac{1}{\sigma}$ in the steady-state. With $\bar{p}_W = \dfrac{1}{\sigma}$, we obtain the analytic expression for real wage at the steady-state. We can see that contractionary monetary policy reduces real wages in the steady-state from $\bar{w} = \dfrac{1}{1+\bar{i}}\left\{\dfrac{A(\beta\alpha)^{\alpha}(1-\alpha)^{1-\alpha}}{\sigma}\right\}^{\frac{1}{1-\alpha}}$ To obtain the closed-form solution for labor in the steady-state, we combine the previous expression and (25) to obtain: $\bar{l} = \dfrac{\bar{M}(1+\bar{i})}{\left\{\frac{A(\beta\alpha)^{\alpha}(1-\alpha)^{1-\alpha}}{\sigma}\right\}^{\frac{1}{1-\alpha}}}$. Combine the lenders' first order condition for labour and their budget constraint to get the expression for the steady state real wage $\bar{w} = \kappa\bar{l}(\bar{w}\bar{l} + \bar{d}(1-\bar{q}))$, and labor $\bar{l} = \dfrac{\bar{w}}{\kappa(\frac{\bar{m}}{\bar{i}} + \bar{d}(1-\bar{q}))}$. Now we use the steady-state equations to prove Proposition 4. With the steady state real wage $\dfrac{\bar{k}}{\bar{l}} = \left\{\dfrac{A\beta\alpha}{\sigma}\right\}^{\frac{1}{1-\alpha}}$, so the steady-state level of output is $\bar{y} = A(\frac{\bar{k}}{\bar{l}})^{\alpha}\bar{l} = \dfrac{\sigma}{1-\alpha}\bar{M}(1+\bar{i}) = \dfrac{\sigma}{1-\alpha}\dfrac{\bar{m}}{1-\frac{1}{1+\bar{i}}}$. This is independent of household preferences. Keeping $\bar{i}$ unchanged, the ratio of real money balance to output is constant. We can now solve for the steady-state real money balance. Note that the expression for the steady state real wage can be re-expressed as follows: $\kappa\bar{M}(\bar{M} + \bar{d}(1-\bar{q})) = (\bar{w})^2 = \dfrac{1}{(1+\bar{i})^2}\left\{\dfrac{A(\beta\alpha)^{\alpha}(1-\alpha)^{1-\alpha}}{\sigma}\right\}^{\frac{2}{1-\alpha}} = \kappa\bar{M}(\bar{M} + \bar{d}(1-\bar{q}))$.

Suppose that $\bar{d} = 0$. In this case, $\bar{M} = \kappa^{-.5}\dfrac{1}{1+\bar{i}}\left\{\dfrac{A(\beta\alpha)^{\alpha}(1-\alpha)^{1-\alpha}}{\sigma}\right\}^{\frac{1}{1-\alpha}}$ and the nominal interest rate has an inverse relationship with the steady-state level of money balance. As legacy debt $\bar{d}$ increases, the steady-state level of money decreases. Furthermore, as the nominal interest rate increases, due to the legacy debt, money balances decrease to a lesser degree. Note that when $\bar{d} = 0$, $\bar{y} = \dfrac{\sigma}{1-\alpha}\kappa^{-.5}\left\{\dfrac{A(\beta\alpha)^{\alpha}(1-\alpha)^{1-\alpha}}{\sigma}\right\}^{\frac{1}{1-\alpha}}$, so money is neutral in the steady-state. When $\bar{d} \neq 0$, money is non-neutral in the steady-state. It is convenient to denote legacy debt in terms of corporate debt-to-output ratio: $lev = \dfrac{\bar{d}}{\bar{y}}$. From $\dfrac{1}{(1+\bar{i})^2}\left\{\dfrac{A(\beta\alpha)^{\alpha}(1-\alpha)^{1-\alpha}}{\sigma}\right\}^{\frac{2}{1-\alpha}} = \kappa\dfrac{\bar{M}}{1+\bar{i}}(\dfrac{\bar{M}}{1+\bar{i}} + \bar{y}lev(1-\bar{q}))$ we get that $\bar{M} = \frac{\left\{\frac{A(\beta\alpha)^{\alpha}(1-\alpha)^{1-\alpha}}{\sigma}\right\}^{\frac{1}{1-\alpha}}}{\left\{\kappa(1+\frac{\sigma}{1-\alpha}(1+\bar{i})lev(1-\beta))\right\}^{\frac{1}{2}}}$. The expression above implies that as corporate debt-to-output ratio increases, the quantity of real money balance decreases. □

H Proof of Proposition 5

Recall the public balance equation (15). After substituting the working-capital constraint, and the constant purchases of intertemporal bonds, this becomes $\tilde{w}li + \bar{\mu}(\frac{1}{1+\eta} - \tilde{q}) = 0$. When we linearize, this becomes $\bar{\mu}(\bar{q}\hat{q} + (1 \hat{+} \eta)) = \bar{w}\bar{l}((1 \bar{+} i) - 1)(\hat{w} + \hat{l}) + \bar{w}\bar{l}(1 \bar{+} i)(1 \hat{+} i)$. Simplifying the expression for $\hat{w} + \hat{l}$, where $\bar{w}\bar{l} = \bar{\mu}\frac{\bar{q}-1}{\bar{i}}$, we can now solve for labour supply, $\hat{l} = \frac{1}{2\bar{c}^l}\left\{\bar{q}\bar{d}(\hat{q} + \hat{d}') + \phi_d\bar{q}\bar{d}\hat{d}' + (\bar{c}^l - \bar{w}\bar{l})(\hat{w} + \hat{l}) - \bar{d}(\hat{d} - (1 \hat{+} \eta))\right\}$. With this in hand, we can obtain an expression for output:

$$\hat{y}_W = \hat{A} + \alpha\hat{k} + (1-\alpha)\frac{1}{2\bar{c}^l}\left\{\bar{q}\bar{d}(\hat{q} + \hat{d}') + \phi_d\bar{q}\bar{d}\hat{d}' + (\bar{c}^l - \bar{w}\bar{l})(\hat{w} + \hat{l}) - \bar{d}(\hat{d} - (1 \hat{+} \eta))\right\}.$$

For analytical convenience set $\phi_d = 0$, and where $\bar{c}^l = \bar{w}\bar{l} + \bar{d}(1-\bar{q})$. Consider the coefficient in front of $(1 \hat{+} i)$,

$$\left\{1 - (1 \bar{+} i)\frac{\{1 - (1-\alpha)\frac{1}{2\bar{c}^l}\bar{d}(1-\bar{q})\}}{((1 \bar{+} i) - 1)}\right\} = \frac{-1}{((1 \bar{+} i) - 1)}\left\{1 - (1 \bar{+} i)(1-\alpha)\frac{1}{2\bar{c}^l}\bar{d}(1-\bar{q})\right\}.$$

As $(1 \bar{+} i)(1-\alpha)\frac{\bar{d}(1-\bar{q})}{2\bar{c}^l} < 1$ holds, it follows that higher steady-state levels of legacy debt, $\bar{d}$, makes the coefficient of $(1 \hat{+} i)$ closer to 0 in absolute value. Similarly, we can simplify the expression in front of the inflation term, $(1 \hat{+} \eta)$, and bond price term $\bar{q}\hat{q}$. This allows us to obtain the following expression for the marginal cost $\hat{p}_W = -\frac{(1 \hat{+} \eta) + \bar{q}\hat{q}}{1-\bar{q}} - \frac{(1 \hat{+} i)}{((1 \bar{+} i) - 1)}\left\{1 - \frac{(1 \bar{+} i)(1-\alpha)\bar{d}(1-\bar{q})}{2(\bar{w}\bar{l} + \bar{d}(1-\bar{q}))}\right\} - \hat{A} - \alpha\hat{k} - \frac{(1-\alpha)\bar{d}\left\{\bar{q}\hat{d}' - \hat{d}\right\}}{2(\bar{w}\bar{l} + \bar{d}(1-\bar{q}))}$. To summarize, higher steady-state legacy debt reduces the direct effect of interest rates on marginal cost and increases the sensitivity of changes in debt. □

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