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

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Abstract

We posit that corporate legacy debt limits monetary policy's effect on inflation because households are heterogeneous: some hold that debt and supply labor to firms, while others own corporate equity. When policy is contractionary, the debt creates an income effect for the households, which dampens the decline in aggregate demand and flattens the aggregate supply curve. This weakens the disinflationary effect of policy and reduces output, worsening the inflation-output trade-off. We provide empirical evidence consistent with the model's predictions.¹

Keywords: Household heterogeneity, Inflation, Monetary policy, Corporate debt, Giffen good

JEL Codes: E31, E32, E52, G11, G51

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1 Introduction

The U.S. experienced a resurgence of inflation in recent years, despite rapid and sustained increases in the federal funds rate. Understanding why contractionary monetary policy did not stop inflation is key to understanding the inflation-output trade-off. We offer an explanation: the rise in households' holdings of corporate debt can offset the disinflationary effects of contractionary policy. This occurs through an income effect that dampens the decline in aggregate demand and flattens the aggregate supply curve and amplifies the trade-off between inflation and output stabilization.

The inflation-output trade-off is a well-known concern in the monetary policy literature. One explanation is the working-capital cost channel (Barth and Ramey, 2001; Ravenna and Walsh, 2006), which generates a trade-off between stabilizing inflation and stabilizing output. Our model introduces a new mechanism that amplifies this tradeoff: an income effect arising from heterogeneity in household corporate debt holdings. In our model, households are either lender-worker households, who save by holding safe corporate debt and supply labor, or owner households, who own the firms that issue the debt. This distinction aligns with Fisher's (1910) framework "enterpriser-borrowers" and "laborer-creditors" and is supported by empirical work by Mankiw and Zeldes (1991), Toda and Walsh (2020), and Doerr, Drechsel and Lee (2022), which highlights the heterogeneity in asset ownership across the 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).

An increase in the interest rate reduces firms' wage bill for two reasons. A higher interest rate reduces the wage rate by increasing the working capital cost of labor (firms in our model borrow short term to finance labor costs) and thus reduces firms' demand for labor. And the higher level of income from debt compared to labor increases lenderworker households' debt income and overall wealth, which allows them to afford more leisure by supplying less labor (income effect). This income effect is captured by an increase in their labor supply elasticity, which rises with corporate debt holdings and flattens the aggregate supply curve.

This income effect also influences aggregate demand. When firms issue more corporate debt, higher interest rates have a less negative effect on their profits because they have a lower wage bill. As a result, income shifts toward equity-holding households. Monetary

contractions therefore redistribute income away from lender-worker households toward equity-holding households. Monetary policy shocks are known to affect aggregate demand by redistributing income across heterogeneous households (Kaplan, Moll and Violante, 2018; Auclert, 2019). In our setting, however, this redistribution does not operate through the traditional Fisher channel (Auclert, 2019; Doepke and Schneider, 2006). Instead, it arises because corporate debt holdings by lender-worker households reduce the negative impact of higher interest rates on firm profits. This reinforces the income shift toward equity holders and amplifies the resulting increase in aggregate demand.

By affecting both aggregate supply and demand, this income effect worsens the inflation-output trade-off faced by central banks. Higher corporate debt holdings weaken the contractionary impact of monetary tightening on aggregate demand. At the same time, the resulting increase in labor supply elasticity flattens the aggregate supply curve. In general equilibrium, this leads to a smaller decline in prices but a larger drop in output. Controlling inflation thus requires greater output losses. This trade-off is illustrated in Figure 1, where the left panel shows the low-debt case and the right panel the high-debt case. Both face the same monetary tightening. In the low-debt case, output and prices fall. In the high-debt case, aggregate demand falls less and the supply curve is flatter, leading to a smaller drop in prices but a sharper decline in output.



Figure 1: AS-AD Diagram: A Rise in the Policy Rate The blue line shows aggregate supply (AS), and the red shows aggregate demand (AD). The left-hand diagram (a) illustrates the low corporate debt case. The right-hand diagram (b) illustrates the high corporate debt case. 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. All curves are derived in the model section.

This mechanism provides a micro-foundation for an upward-sloping IS curve, long

noted in the literature since Meiselman (1969). The income effect we identify makes the IS curve less negative or even positive, helping explain why prices may respond less than output to monetary shocks. In our model, money and credit interact in general equilibrium, and the slope of the IS curve emerges endogenously from corporate legacy debt.

Others have shown 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). We show that they also affect the efficacy of monetary policy at controlling inflation. Our empirical analysis supports our theoretical results: using local projections, we find that when the corporate debt-to-household assets ratio is high, output is cumulatively 3 percent lower and inflation is cumulatively 1.2 percent higher over six quarters, compared to when the ratio is low.

Harding and Klein (2022) demonstrate how household net worth acts as a state variable, affecting the impulse response of economic variables. Wealthier households enhance their 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). While Luetticke (2021) focuses on how the household portfolio composition response to monetary shocks works through static propensities for liquidity, we focus on how the household response is shaped 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 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 model with money to fix ideas on how the stock of corporate debt generates an income effect via 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 for the trade-off between inflation control and output. Our conjecture is that the accretion of corporate legacy debt makes models that assume no such debt inappropriate for assessing current conditions.² We assume there are two types of households. The first, which own firms, are owner households, which align with the idea of the "enterpriser-borrower" in Fisher (1910). The second type is lenderworker households, who own the debt issued by firms and represent Fisher's "creditor, the salaried man, or the laborer." These funds pay out a proportion of their accumulated returns ψ from legacy debt D, and ψ is the debt-servicing cost to 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 dynamic setting, we relax this assumption and consider the saving decision of the lenders in a model in which both the quantity and price of debt are endogenous.) For the sake of analytic clarity, we assume all corporate debt is owned by the worker-lender households, though this is not critical for our main results.³ What is critical is that some outstanding corporate debt is owned by workers. In the Online Appendix we show how our results readily extend to more general distributions of corporate debt holdings.

Our other assumptions are standard. The static model illustrates a one-period production economy with morning and evening subperiods. 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 assumption, which we include only for ease of comparison with the dynamic model. A central bank issues inside money as its liabilities against offsetting credits and sets the policy rate i, which is also the short-term borrowing cost in money markets. Owner households have an initial monetary balance, and all private agents can opt to borrow inside money against an offsetting credit from the money market. Lender households supply labor endogenously. There are two transaction moments in the period (morning and evening). In the morning, firms borrow money via working-capital credit to pay wages, and the associated borrowing cost is i; this assumption of a liquidity-inadvance 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 use

²The stock of debt of non-financial firms (i.e., firms that exclude financial intermediaries) has risen globally since 2007. In the Euro Area, non-financial corporate debt-to-GDP ratio rose by almost 14% from an already high 93.3% in 2007. Sweden saw an increase of 26.8% from 125.2%, while in Canada the increase was almost 40%. The pandemic crisis has further intensified the buildup of corporate debt. US corporate debt-to-GDP rose by 12.5% between December 2018 and December 2020, far surpassing its total increase in the decade before the pandemic. Emerging economies have also seen large increases in corporate indebtedness.

³This is consistent with the benchmark setup in macro-financial models such as Bernanke, Gertler and Gilchrist (1999).

their wealth and income to purchase goods in the evening. In the evening, firms repay the working-capital credit and the debt that comes due.

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 of variety j consumed by the household; $\theta > 1$ is 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 $m^o \ge 0$. We now outline the maximization problem 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 assumption of a linear function is not crucial but is adopted to facilitate analytic characterization. In the dynamic model, in which we rely on numerical solutions, we assume more standard preferences. Initial cash balances are carried over till the evening without earning interest in the morning. In the evening, owner households receive the firms' profits and spend all their money on goods. Their flow constraint is

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

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 the labor supply, ψ the corporate-debt servicing cost, and D 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 are endogenized in Section 4. For now, we assume that the debt level is bounded as in (2), in which i is the policy rate, σ is the markup, and m denotes

the aggregate monetary endowment of households. As will become clear shortly, this assumption ensures there is no bankruptcy among firms.

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

Lender households' preferences are represented below,⁴ and they choose their consumption and supply of labor in accordance with the function $U = log(c^l) - L$. 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

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

2.2 Firms

Owner households own a unit measure of firms. Firm j produces good j according to a linear production function $y_j = Al_j$, in which 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 the monetary policy rate. Firm j maximizes profits π_j accruing to owner households by choosing labor l_j and money market liquidity b_j and by setting the price of its goods p_j monopolistically. The morning constraint is

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

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

$$\pi_{i} + (1+i)wl_{i} + \psi D = p_{i}y_{i}.$$
(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

⁴This 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.

financing constraint).⁵ 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 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) the goods market, labor market, and money market clear in a context of rational expectations. 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 summarizes how the real wage and the labor supply elasticity with respect 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 $(\tilde{w} = \frac{A}{\sigma(1+i)})$.
- 2. Real marginal cost remains invariant to short-term policy rate changes, and $\tilde{m}c_j = \frac{1}{\sigma}$.
- 3. In equilibrium, $\epsilon_L = \frac{\psi D}{b}$, the labor supply elasticity with respect to real wages, is increasing in corporate debt and decreasing in working-capital credit.

The 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. In this model, 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* is to increase the marginal cost via

⁵Our results depend on the 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 hold.

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 cancel out. As we shall see shortly, even in this case, when monetary policy does not affect real marginal cost, prices can respond to monetary disturbances much less than output does. This has highlights that the mechanism in this model depends mainly on the income effect of corporate debt, rather than the increase in the marginal cost, such that 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 on the state of the economy through legacy debt (fixed-income securities in workers' portfolios).

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 both households' consumption demand and firms' profits. Aggregate profits Π of firms can be derived from (6) as

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

We obtain owner households' income, and hence demand, 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

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

In (8) raising interest rates increases demand from owner households because raising interest rates lowers the demand for labor. As a result of the lower demand, 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 expression (9), which is the locus, given a price level, for output (Y) as a function of the policy rate *i*,

at which the labor market clears:

$$Y = \frac{m}{P} + \int_{j} y_{j} dj + i \left\{ \frac{\psi D}{P} - \frac{A}{\sigma(1+i)} \right\}$$
(9)

Given P, the above equation summarizes the IS curve. We 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 along with the associated 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-marketclearing condition with the solution for real wage $\tilde{w} = \frac{A}{\sigma(1+i)}$ and the production function to obtain (10):

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

This is the locus of points at which, given the price level, the demand for money equals the supply of money and is represented as the upward-sloping LM curve. Along the IS locus, the labor market, but not necessarily the money market, clears, while along the LM locus the money market, but not necessarily the labor market, clears. 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 clear, for a given price level, and characterizes aggregate demand. The intersection of aggregate demand and supply gives us the equilibrium nominal price level.

Figure 2 puts the IS curve (9) and the LM curve (10) together, with the horizontal axis being output demand and the vertical axis being the policy rate. The left-hand 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 at point A_0 . A monetary contraction moves the LM curve to the left to LM_1 , so the intersection moves from point A_0 to A_1 , corresponding to a higher policy rate but lower output demand. Once corporate debt is introduced, the IS curve becomes steeper and rotates clockwise, as we can observe in (9). Thus, IS_0 rotates to IS_1 , and point A_1 the intersection moves 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-hand diagram (b). Before the monetary contraction, the intersection between the upward-sloping IS curve and the LM curve 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 2: IS-LM: Debt and Monetary Contraction

The left-hand diagram (a) illustrates downward-sloping IS curves. The right-hand 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 represents the money market clearing before the monetary contraction, and LM_1 is the clearing after the monetary contraction, so it is to the left of LM_0 . IS_0 is the IS curve without corporate debt, IS_1 is that with corporate debt; as debt increases, IS moves close-wise until the debt is sufficiently high such that the IS curve becomes upward sloping, as in IS_2 in the right-hand 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 2a); here we identify a novel channel via corporate debt such that the increase in the policy rate can increase the demand for output (Figure 2b). This is because the increase in i reduces the total wage bill for firms, increasing the owner households' demand for output, as can be seen in (8). We now formally define when consumption becomes a Giffen good.

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, aggregate demand *increases*. This Giffen-good 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 households' 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.

Corollary C shows that it is the heterogeneous response of the two household types' demand to changes in the wage rate caused by changes in the policy rate that drives the result at the 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 labor costs to the firm to fall 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 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:

$$Y_d = \frac{m}{P} + \int_j y_j dj + i \left\{ \frac{\psi D}{P} - \frac{A}{\sigma(1+i)} \right\}$$
(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, putting downward pressure on aggregate demand. This is the standard 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. Firms need to spread the fixed cost of the legacy debt over a larger production scale, and the demand for labor drops less after a monetary contraction, leading to upward pressure on aggregate demand, relative to the case without legacy debt. This is the income effect through legacy debt. We unite 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 household heterogeneity. 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 would become

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

Comparing (11) and (12), for a given 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 disappears. Monetary policy is non-neutral because of the nominal friction of the working-capital liquidity-in-advance constraint, which results in higher transaction demand for money and a 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 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 fall because of 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 from monetary policy to 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, and
 - (b) the higher debt is, the less effective is raising interest rates at 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) and
 - (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 legacy debt relative to working-capital credit. The standard Taylor principle holds (that is, the elasticity of the price level P with respect 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 is the per-period debt servicing cost of the corporate debt, and the right-hand side approximates 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, in 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.⁶

⁶This 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.

To reinforce this intuition, we use a diagram of aggregate supply AS and aggregate demand AD for the goods market to illustrate a low-debt scenario and a high-debt scenario with a rise in the policy rate. For this diagram, we factor in clearing in the labor market and money market but not the goods market (P, y); therefore, we can express ASand AD as functions of output and the price of output, as well as exogenous parameters m, i, D, σ, A, ψ . 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. The nominal interest rate directly interacts with the stock of outstanding debt to affect the slope of the aggregate supply curve. In this sense, our income effect is different from the Fisher channel found in Auclert (2019): (i) monetary policy directly affects the stock of debt, and (ii) it affects it through aggregate supply. Figure 1 displays the AS-AD diagram to qualitatively show the equilibrium changes when the central bank raises interest rates.

The left-hand diagram (a) illustrates the low-debt case, and the right-hand diagram (b) shows the 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. This is because in the high-debt case the AD shifts to the left less, and the AS curve also becomes more elastic because of the income effect through debt. Indeed, if the debt level was 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 intensity of the trade-off between inflation control and output depends on the wealth distribution among heterogeneous households and the level of corporate indebtedness.

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

Proposition 3. In equilibrium,

- 1. when $\epsilon_{\psi i} > -1$, corporate debt makes monetary contractions less effective at 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 at controlling inflation.

In the dynamic model, the corporate-debt servicing cost ψ is endogenized via the price of corporate bonds and the intertemporal interest rates of the lender households' Euler equation.⁷

4 Dynamic Model

We now show that the main results and mechanisms illustrated in the static model also hold in a dynamic environment with capital accumulation, nominal rigidities via Calvo pricing, and an endogenous monetary policy rule (a Taylor rule). Like the static model, the dynamic model has an owner household, who owns firms and holds equities, and a lender-worker household, who supplies labor and holds corporate bonds for saving. Intermediate-goods firms can access short-term financing from the money market to finance their working capital, and they also owe legacy debt to the lender-worker household. We assume a steady-state stock of legacy debt that intermediate-goods firms roll over at prevailing intertemporal interest rates. Physical capital is held by the owner household,

⁷Based on our calibration, the dynamic model falls into the case of $\epsilon_{\psi}(i) > -1$. But when would $\epsilon_{\psi}(i) < -1$ be likely? It would be possible if the economy had a large amount of fixed-coupon long-term corporate debt and the yield curve was steepening, in which case $\epsilon_{\psi}(i) < -1$ would be 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 than one-to-one, pushing down its prices significantly, and if these bonds have fixed coupon rates, then the wealth of the lender-worker households will take a larger hit and labor supply will become less responsive 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 firms' corporate-debt maturity has been decreasing.

who makes intertemporal 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 in which intermediategoods firms are price setters with market power and keep prices steady at probability ϕ . 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.

4.1 Households

Owner Households: Owner households own firms, and they maximize their expected intertemporal 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.⁸ Preferences are subject to a flow budget constraint written in real terms as follows: $c^o + k' = \tilde{\pi}_I + \tilde{r}_k k$. Here, $\tilde{\pi}_I$ 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: $\tilde{q}\tilde{d}' + \frac{\phi_d}{2}\tilde{q}(\tilde{d}' - \bar{d})^2 + c^l = \tilde{w}l + \frac{\tilde{d}}{1+\eta}$. Here, \bar{d} is the steady-state value of debt, $\frac{\phi_d}{2}\tilde{q}(\tilde{d}' - \bar{d})^2$ is a quadratic adjustment cost for debt, and η is the net rate of inflation.⁹ The optimality condition with respect to labor is $\frac{\tilde{w}}{c^l} = \kappa l$, while the optimality condition with respect to debt is $\frac{\tilde{q}}{c'}(1 + \phi_d(\tilde{d}' - \bar{d})) = \beta \mathbb{E} \frac{1}{c''} \frac{1}{1+\eta'}$.

4.2 Intermediate-Goods Firms

Intermediate-goods firms have a selling unit and a wholesale unit. Wholesale units produce wholesale goods, and 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 them to consumers, setting the price of the goods they sell. Selling units and wholesale units operate independently but share profits via the

 $^{^{8}}$ We suppress notation for this, as we have removed it from our analysis. We explored the endogenous response of monetary policy to demand shocks in previous versions of this paper.

⁹In Section 5.2, 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 still hold.

intermediate-goods firms. Wholesale units maximize the present discounted value of realvalue 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: $y_W = Ak^{\alpha}l^{1-\alpha}$. 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 flow budget constraints, respectively. The nominal working-capital constraint is represented by wl = b, and the end-of-period nominal constraint is represented by $\pi_W + r_k k + d_W + b(1+i) = p_W y_W + qd'_W$, 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. b is the money the wholesale units borrow in the short-term money market at nominal interest rate i. d'_W is the nominal value of intertemporal bonds sold at price q and is repaid one period in the future. Define the real value of short-term borrowing as $\tilde{b} = \frac{b}{P}$, define the real value of intertemporal 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: $\tilde{w}l = \tilde{b}$ and $\tilde{\pi}_W + \tilde{r}_k k + \frac{1}{1+\eta}\tilde{d}_W + \tilde{b}(1+i) = \tilde{p}_W y_W + \tilde{q}d'_W$.

Selling units purchase wholesale goods from wholesale units to produce differentiated goods 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: $\tilde{\pi}_j = \frac{1}{P} \{p_j y_j - p_W y_j\}$. Substituting in the demand function $y_j = \left(\frac{p_j}{p}\right)^{-\theta} y$, we get $\tilde{\pi}_j = \left(\frac{p_j}{p}\right)^{1-\theta} y - \tilde{p}_W \left(\frac{p_j}{p}\right)^{-\theta} y$. 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 reset 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 $X_2 = \frac{1}{c^o} P^{\theta-1} y + \phi \beta \mathbb{E} X_2'$. Observe that if prices are flexible, $p_j^{\#} = \sigma P \tilde{p}_W$. 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 $P = \left[\int_{0}^{1} p_{j}^{1-\theta} dj\right]^{\frac{1}{1-\theta}}$. 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 in the money market according to a Taylor rule. It also trades intertemporal bonds in its regular open market operations. Let the overline symbol denote the steady-state real value, let $\rho_y, \rho_i, \rho_\eta$ be the Taylor-rule coefficients, and specify the Taylor rule as follows:

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

where ϵ_i is a normally distributed shock.

A meaningful trade-off between inflation and output stabilization requires real rigidity in the canonical New Keynesian model (Blanchard and Galí, 2007 call this the absence of the "divine coincidence").¹⁰ We include the log deviation of output from its trend in the Taylor rule 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 trading a constant real amount of intertemporal bonds $\tilde{\mu}$, and we interpret the trading of intertemporal bonds

¹⁰Ravenna and Walsh (2006) show that the cost channel via working-capital loans alters the trade-off between inflation stabilization 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 intense this trade-off becomes.

as open market operations. These actions result in a public flow balance equation,

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

The monetary policy rule gives the interest rate i, and the central bank supplies \tilde{M} on demand to clear the money market.¹¹

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 market-clearing condition in the intertemporal bond market is $\tilde{D}'_W = \tilde{D}' + \tilde{\mu}'$. The uppercase 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 worker households. 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 wholesale-goods market clear. 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 intertemporal 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 impact of price on demand, (iii) agents maximize subject to their budget and liquidity constraints, (iv) and the goods market, labor market, capital market, corporate bond market, and money market clear in a rational-expectations setting.

Summing up the flow-of-funds constraint of the economy, the interest payment in the monetary market equals the trading cost in the open market operations $(i\tilde{b} = q\tilde{\mu}' - \frac{\tilde{\mu}}{1+\eta})$. Let $m \equiv q\tilde{\mu}' - \frac{\tilde{\mu}}{1+\eta}$. It follows that $\tilde{M} = \frac{\tilde{m}}{i}$, where \tilde{M} refers to the real value of money balances. The Online Appendix presents the system of equations that summarize

¹¹In this framework, money is issued against an offsetting loan, and its repayment guarantees money's departure, influencing the equilibrium price level. Our setup, in which the central bank maintains credibility without discretionary seigniorage changes, ensures money's non-neutrality even with flexible prices, as in Tsomocos (2003), Bloise and Polemarchakis (2006), and Goodhart, Sunirand and Tsomocos (2006).

equilibrium together with the closed-form solution for the steady-state and linearized 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 balances and output;
- b an increase in the nominal interest rate reduces real money balances, 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

We now 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 naive Phillips curve:¹²

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

Here, the marginal cost is given by 13

$$\hat{p}_{W} = -\frac{(\hat{1}+\eta) + \bar{q}\hat{q}}{1-\bar{q}} - \frac{(\hat{1}+i)}{((\hat{1}+i)-1)} \left\{ 1 - \frac{(\hat{1}+i)(1-\alpha)\bar{d}(1-\bar{q})}{2(\bar{w}\bar{l}+\bar{d}(1-\bar{q}))} \right\} - \hat{A} - \alpha\hat{k} - \frac{(1-\alpha)\bar{d}\left\{\bar{q}\hat{d}'-\hat{d}\right\}}{2(\bar{w}\bar{l}+\bar{d}(1-\bar{q}))}.$$
(17)

 $^{^{12}}$ "Naive" because we do not present it in terms of the output gap. See Online Appendix for full model equations.

¹³The derivation is in Appendix \mathbf{H} .

As the steady-state stock of legacy debt increases, the absolute value of the coefficient of interest rates on the path of inflation declines. That is, 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.

We can observe from the naive Phillips curve (16) and the expression of 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 (that is, corporate debt holdings), as seen in equation (17).

Our naive dynamic IS curve $(18)^{14}$ can be obtained by combining the individual Euler and labor supply condition with the marginal product of labor and the definition of firm output (and $\phi = 0$),

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

Observe that both the steady-state stock and the dynamics of corporate debt affect aggregate demand through the real marginal cost, \hat{p}_W .¹⁵

¹⁴See Online Appendix.

¹⁵A standard IS or Phillips curve using a measure of the output gap (the difference between a flexibleprice 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 the 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 intertemporal debt.

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 ratio of to corporate debt to output, we appeal to standard calibrated parameters from recent works (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, at the low end of the estimated markup in De Loecker, Eeckhout and Unger (2020) but the high end of the range conventionally used in the New Keynesian literature. For 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 ratio of corporate debt to output at the steady state. This parameter matters for the wealth distribution of owner households and lender-worker households. We set the benchmark ratio to 75% at the steady state and the high ratio to 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 nonfinancial corporate businesses from 2001 to 2022. We find it fluctuates between three and four (or 75% and 100% on an annualized basis) and has been trending up in the last decade, consistent with the ratios of corporate debt to output in various economies as documented in Section 2.1. Furthermore, the total stock of nonfinancial business debt in the US stood at a historically high level of around 130% of GDP as of 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	$ ho_y$	$ ho_\eta$	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, Table 2 displays the model steady-state values with quantity variables normalized by output.

Table 2: Steady-State Values

	\bar{c}^0/\bar{y}	$\bar{c}^l/ar{y}$	\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 ratio of corporate debt to output (75% annual), or $\bar{b}/\bar{y} = 3$. "High lev" refers to the high-debt ratio of 100% (annual), or $\bar{b}/\bar{y} = 4$.

We simulate the model with a positive shock to interest rates with no persistence.¹⁶ The model simulation sheds light on the cyclicality of the consumption expenditure of the 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 tends to be highly pro-cyclical, whereas the expenditure of the lender households 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 wealthy stockholders' consumption growth to the stock market and to aggregate fluctuations. For example, Malloy, Moskowitz and Vissing-Jørgensen (2009) find higher sensitivity of such consumption growth to both the stock market and aggregate consumption growth, and Parker and Vissing-Jørgensen (2009) show that consumption growth of high-consumption and high-income households is significantly more exposed to aggregate fluctuations, among others (see Parker, 2001).

	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

Table 3: Cyclical Properties: Correlations with Output

5.1 The Effect of Monetary Contractions

The contractionary 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 1 percentage point. Figure 3 shows the dynamic responses to the monetary

[&]quot;BMK lev" refers to the benchmark ratio of corporate debt to output (75% annual), or $\bar{b}/\bar{y} = 3$. "High lev" refers to the high ratio of 100% (annual), or $\bar{b}/\bar{y} = 4$. c° 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.

¹⁶The demand shock has persistence of 0.9.

contraction shock, where the blue line represents benchmark corporate indebtedness of 75%, while the red line represents high indebtedness of 100%. In both cases, inflation falls on impact after a monetary contraction before becoming positive. 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 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 is, 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 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 $\tilde{w} = \frac{A}{\sigma(1+i)}$ derived from the model, which says that 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 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 to smooth consumption, causing the liquidity premium to drop to a level at which wealthier households increase their share of portfolio liquidity.



Figure 3: Tightening Shock to Nominal Policy Rate i. The blue line is a 75% ratio of corporate debt to output, and the red line is a 100% 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 might be concerned that if lenders hold fixed-coupon bonds whose market value is reduced by the rate hike but not compensated for 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 would our results hold? In the Online Appendix we introduce a two-period fixed-coupon bond and show that our results still hold, as our results work through the redistribution of income rather than the state-contingent value of wealth.

6 Empirical Results

We now present our empirical results to support our theoretical predictions on monetary policy shocks' state-contingent effects, particularly 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 in the states with a high ratio of corporate debt to household financial assets ("corporate-debt ratio" henceforth) 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 as follows:

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

Here, γ_{t+j} is a collection of macroeconomic 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, I, lagged by one period to avoid the endogenous response of corporate leverage or household wealth to the shock. The vector of control variables is \mathbf{X}_{t-1} .¹⁷

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" 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 one when it is above the mean and zero otherwise. In this we follow Harding and Klein (2022), who apply this methodology to household net worth.

Figure 4a plots the cyclical component of the ratio of corporate debt to net household assets (green) and indicates the periods in which it is above its mean. This binary variable has a value of one (shaded in gray) when the cyclical component is above its mean. We also provide a list of National Bureau of Economic Research recession dates to compare the periods when the binary variable is one, out of concern that our measure might proxy for the business cycle. While some periods seem to intuitively coincide with monetary events, such as the period following the 2008 financial crisis, when the real level of debt dropped steeply, we observe elevated levels of debt during and after the savings-andloan crisis of 1987. Moreover, in Figure 4b we observe no clear relationship between the cyclical component of the corporate-debt ratio and the level of the federal funds rate. Accordingly, we are not simply measuring an endogenous response of corporate leverage

¹⁷The log of real GDP, log of real personal consumption expenditures, log of real gross private domestic investment, effective federal funds rate, log of the implicit GDP deflator, Romer shock at t-1, and Romer shock at t-2.



(a) Cyclical Component of Ratio of Corporate Debt to (b) Cyclical Component of Ratio of Corporate Debt to Household Wealth, and Binary Variable Household Wealth, and Federal Funds Rate

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), 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 premium is the excess return on housing (price appreciation plus rents).¹⁸

Figure 5 presents the results of the estimation in which 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

Figure 4: Notes: The left-hand panel is the filtered series of the log ratio of quarterly level of corporate debt to household assets from Q1 1952 to Q1 2019. We set the HP-filter smoothing parameter to 1,600 to obtain the cyclical trend. The value of the binary variable is one when the cyclical trend is above its mean, and zero when the cyclical trend is below its mean. The shaded gray areas correspond to when the cyclical variable, in green, is above its mean. The right-hand panel is the cyclical component of the binary variable (green) plotted against the effective federal funds rate (black). National Bureau of Economic Research 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, and February 2020 to April 2020.

¹⁸The Flow of Funds, in Table Z1, provides the aggregate balance sheet of the US household sector, including nonprofits, from 1952 to 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 the 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 with 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, after a contemporaneous monetary policy shock, ϵ_t^R , when the ratio of corporate debt to household financial assets 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, $\mathbf{X}_{t-1} = \begin{bmatrix} Y_{t-1}, C_{t-1}, I_{t-1}, R_{t-1}^B, \epsilon_{t-1}^R, \epsilon_{t-2}^R \end{bmatrix}$.

corporate debt is low, output expands for 10 quarters until contracting. When corporate debt is high, output persistently contracts. In our dynamic model (Figure 3), output falls in both high- and low-debt cases but more 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 toward 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, since worker-lender households have a lower propensity to invest and a higher propensity to consume, after four 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 ones. In their paper, poorer households, which derive most of their income from labor, are able to trade off labor and leisure and, in line with our findings, thereby evoke a response in the supply of labor. Wealthier households, who are predominantly older, not only discount the future much more and do not trade off labor and leisure, but are much more sensitive to shocks in the short-term rate of interest. In our model, the relative pro-cyclicality of owner demand is represented in Table 3, and there is evidence of the Giffen-good property (Corollary 1).

The federal funds rate responds more to monetary policy shocks in high corporatedebt states. Luetticke (2021) finds that distributional changes to portfolio liquidity drive investment after a monetary policy shock. Our result is complementary, as it shows that 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, in which 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 corporate-debt ratio has an initially strong effect on real wages, as corporations are limited in their ability to borrow funds to expand (the effect on real wages in our model works through 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 five quarters.¹⁹

¹⁹Similar results are obtained with a replication of Ramey (2016), as detailed in the Online Appendix.

7 Conclusion

We presented a general equilibrium model to study the effect of corporate indebtedness on the monetary policy transmission mechanism. We showed that an unequal wealth distribution in the presence of a large stock of corporate debt renders monetary policy less effective in controlling inflation. When that stock is above a threshold, raising the policy rate may even raise current inflation because corporate debt causes an income effect and leads aggregate demand to behave as a Giffen good.

In our dynamic model, we derived the Phillips curve augmented with corporate debt and showed that the effectiveness of interest rate hikes declines as the steady-state debt level increases. This debt mechanism explains changes in the slope of the Phillips curve over time (on the insensitivity of inflation to unemployment, see, e.g., Hazell, Herreno, Nakamura and Steinsson, 2022). We provided a quantitative example to illustrate that the key results hold on the dynamic path away from the steady state. That monetary policy's effectiveness depends on the stock of corporate debt supports the argument (Schularick and Taylor, 2012 and Jungherr, Meier, Reinelt and Schott, 2022) that monetary policy should take into account financial market conditions and credit conditions in particular.

Our findings show how corporate debt may intermediate the transmission of monetary policy to economic activity via the cost channel and the transaction demand for money. Unlike in representative-agent frameworks, in our model, because 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 the quantity of outstanding corporate debt is large.

The mechanism we identify matters because household corporate debt holdings have been increasing, while inflation has returned as a major monetary policy issue.

Appendix

A Proof of Lemma 1

We first derive the demand function for goods. Households' optimization for goods gives $\int_{j} c_{j}^{h} = \int_{j} \left(\frac{p_{j}}{P}\right)^{-\theta} C^{h}$, and 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 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): $\pi_{j} = (p_{j})^{1-\theta} P^{\theta} Y - \psi D - (1+i)(wp_{j}^{-\theta}P^{\theta}\frac{Y}{A})$.

We now develop the cost-minimization and price-setting problems.

Cost Minimization: From equation (6), firms solve $min_{l_j}(1+i)wl_j$ s.t. $Al_j \ge \left(\frac{p_j}{P}\right)^{-\theta} Y$. 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, Eichenbaum and Evans (2005). We show below that debt and household heterogeneity affect monetary transmissions beyond the working-capital channel, which goes through 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 $p_j = \sigma P \tilde{m}c_j$,

where $\sigma = \frac{\theta}{\theta - 1}$ is the markup and 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

give $\tilde{w} = c_L = \tilde{w}L + \psi \frac{D}{P}$, or

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

The above equation shows that corporate debt flattens the labor supply curve and supports the high effective labor supply elasticity emphasized in the monetary policy literature on the cost channel.²⁰ 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 $\epsilon_L = \frac{\partial L}{\frac{\partial \tilde{w}}{\tilde{w}}} = \frac{\psi D}{P\tilde{w}L} = \frac{\psi D}{\tilde{b}} \frac{D}{P}$. \Box

B Proof of Proposition 1

Recall that the real wage is given by $\tilde{w} = \frac{A}{\sigma(1+i)}$. From this we obtain $\frac{\partial \tilde{w}}{\partial i} = -\frac{A}{\sigma(1+i)^2}$. 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. \Box

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 means that the consumption of the lender household moves proportionately to 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 $\frac{\partial c^{l}}{\partial \tilde{w}} + \frac{\partial c^{o}}{\partial \tilde{w}} < 0$, a decrease in wages caused by an increase in interest rates increases aggregate demand. In other words, when the amount of legacy debt is sufficiently high, a decline in real

 $^{^{20}}$ See Barth and Ramey (2001) for the aggregate and industry-level evidence on the strength of monetary disturbances as a cost shock.

wages due to an increase in the policy rate increases the demand of owner households more than it decreases the demand of lender households. \Box

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):

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

To obtain the closed-form solution for allocation, we combine all flow-of-funds constraints of households (1) and (3) and of 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 the central bank (the monetary-fiscal authority), which becomes the central bank'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 are 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, and 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. \Box

E Proof of Proposition 2

Let ϵ_{P_i} be the elasticity of the price level with respect to the 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 $\psi D < \frac{b}{i}$.²¹ Otherwise, the Taylor principle is inverted and $\epsilon_{Pi} > 0$. If the corporate-debt servicing cost is extremely high relative to working-capital credit, raising interest rates raises the 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 the gross interest rate 1+i ($\psi = \Psi(1+i)$). From equation (23), we obtain $P = \frac{m+i\Psi(1+1)D}{Ai}\sigma(1+i)$. We can derive the elasticity of P with respect 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 $\Psi(1+i)$ with respect to 1+i, and note that $\Psi'(1+i)Di(1+i)+\Psi(1+i)Di(1+i)+\Psi(1+i)Di(1+i)+\Psi(1+i)Di(\epsilon_{\psi i}+1)$. 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 than without. Whenever $\epsilon_{\psi}(1+i) < -1$, the presence of D decreases the 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. \Box

²¹In terms of primitives, the condition can be written as $i\psi D < \frac{m}{i}$.

G Proof of Proposition 4

Aggregate demand at the steady state is $\bar{c}^o + \bar{k} + \bar{c}^l$. Substituting in households' and firms' flow-of-funds constraints into aggregate demand for output, with the market-clearing condition for final output $\bar{y} = \bar{c}^o + \bar{c}^l + \bar{k}$, we obtain $\bar{y} = \bar{c}^o + \bar{k} + \bar{c}^l = -\bar{w}\bar{l}\bar{i} + \bar{y} + \bar{m}$ and hence

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

From the marginal cost of the firm we find that $\bar{p}_W = \frac{1}{\sigma}$ in the steady state. With $\bar{p}_W = \frac{1}{\sigma}$, 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 $\bar{w} = \frac{1}{1+\bar{i}} \left\{ \frac{A(\beta\alpha)^{\alpha}(1-\alpha)^{1-\alpha}}{\sigma} \right\}^{\frac{1}{1-\alpha}}$ To obtain the closed-form solution for labor in the steady state, we combine the previous expression and (25) to obtain $\bar{l} = \frac{\bar{M}(1+\bar{i})}{\left\{ \frac{A(\beta\alpha)^{\alpha}(1-\alpha)^{1-\alpha}}{\sigma} \right\}^{\frac{1}{1-\alpha}}}$. Combine the lenders' first-order condition for labor 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 $\bar{l} = \frac{\bar{w}}{\kappa(\frac{\bar{m}}{\bar{i}} + \bar{d}(1-\bar{q}))}$. Now we use the steady-state equations to prove Proposition 4. With the steady-state real wage $\frac{\bar{k}}{\bar{l}} = \left\{ \frac{A\beta\alpha}{\sigma} \right\}^{\frac{1}{1-\alpha}}$, the steady-state level of output is $\bar{y} = A(\frac{\bar{k}}{\bar{l}})^{\alpha}\bar{l} = \frac{\sigma}{1-\alpha}\bar{M}(1+\bar{i}) = \frac{\sigma}{1-\alpha}\frac{\bar{m}}{1-\frac{1+\bar{i}}{1+\bar{i}}}$. 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. The expression for the steady-state real wage can be expressed as follows: $\kappa \bar{M}(\bar{M} + \bar{d}(1-\bar{q})) = (\bar{w})^2 = \frac{1}{(1+\bar{i})^2} \left\{ \frac{A(\beta\alpha)^{\alpha}(1-\alpha)^{1-\alpha}}{\sigma} \right\}^{\frac{2}{1-\alpha}}$

Suppose that $\bar{d} = 0$. In this case, $\bar{M} = \kappa^{-.5} \frac{1}{1+\bar{i}} \left\{ \frac{A(\beta\alpha)^{\alpha}(1-\alpha)^{1-\alpha}}{\sigma} \right\}^{\frac{1}{1-\alpha}}$ 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, money balances decrease to a lesser degree because of the legacy debt. When $\bar{d} = 0$, $\bar{y} = \frac{\sigma}{1-\alpha} \kappa^{-.5} \left\{ \frac{A(\beta\alpha)^{\alpha}(1-\alpha)^{1-\alpha}}{\sigma} \right\}^{\frac{1}{1-\alpha}}$, 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 the ratio of corporate debt to output: $lev = \frac{\bar{d}}{\bar{y}}$. From $\frac{1}{(1+\bar{i})^2} \left\{ \frac{A(\beta\alpha)^{\alpha}(1-\alpha)^{1-\alpha}}{\sigma} \right\}^{\frac{2}{1-\alpha}} = \kappa \frac{\bar{M}}{1+\bar{i}} \left(\frac{\bar{M}}{1+\bar{i}} + \bar{y}lev(1-\bar{q}) \right)$ we get $\bar{M} = \frac{\left\{ \frac{A(\beta\alpha)^{\alpha}(1-\alpha)^{1-\alpha}}{\sigma} \right\}^{\frac{1}{1-\alpha}}}{\left\{ \kappa \left(1 + \frac{\sigma}{1-\alpha}(1+\bar{i})lev(1-\beta)\right) \right\}^{\frac{1}{2}}}$. The expression implies that as the ratio of corporate debt to output increases, the real money balance decreases. \Box

H Proof of Proposition 5

Recall the public-balance equation (15). After substituting in the working-capital constraint and noting 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 $\bar{\mu}(\bar{q}\hat{q} + (1+\eta)) = \bar{w}\bar{l}((1+i)-1)(\hat{w} + \hat{l}) + \bar{w}\bar{l}(1+i)(\hat{1}+i)$. 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 labor supply, $\hat{l} = \frac{1}{2\bar{c}^l} \left\{ \bar{q}\bar{d}(\hat{q} + \hat{d}') + \phi_d\bar{q}\bar{d}\hat{d}' + (\bar{c}^l - \bar{w}\bar{l})(\hat{w} + \hat{l}) - \bar{d}(\hat{d} - (1+\eta)) \right\}$. With this in hand, we can obtain an expression for output:

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

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

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

As $(1 + i)(1 - \alpha)\frac{a(1 - q)}{2\bar{c}^l} < 1$ holds, it follows that higher steady-state levels of legacy debt \bar{d} make the coefficient of (1 + i) closer to zero in absolute value. Similarly, we can simplify the expression in front of the inflation term, $(1 + \eta)$ and the bond-price term $\bar{q}\hat{q}$. This allows us to obtain the following expression for marginal cost $\hat{p}_W = -\frac{(1 + \eta) + \bar{q}\hat{q}}{1 - \bar{q}}$

 $\frac{(1+i)}{((1+i)-1)} \left\{ 1 - \frac{(1+i)(1-\alpha)\bar{d}(1-\bar{q})}{2(\bar{w}\bar{l}+\bar{d}(1-\bar{q}))} \right\} - \hat{A} - \alpha\hat{k} - \frac{(1-\alpha)\bar{d}\left\{\bar{q}\hat{d}'-\hat{d}\right\}}{2(\bar{w}\bar{l}+\bar{d}(1-\bar{q}))}.$ 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. \Box

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