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

Charles A.E. Goodhart † M. Udara Peiris‡ Dimitrios P. Tsomocos§ Xuan Wang ¶

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Abstract

We show analytically that the presence of an income effect via the stock of corporate debt affects the monetary policy transmission mechanism by weakening its effect on inflation but strengthening its effect on output. Monetary policy becomes less effective in controlling inflation as the stock of corporate debt rises. Above a threshold, the income effect generated by corporate debt causes the final consumption good to become a Giffen Good, whereby lower real wages caused by an increase in the policy rate *increases* aggregate demand, and *raises* the price level. This is despite equilibrium output declining because of the higher policy rates. In a calibrated dynamic setting this mechanism exacerbates the trade-off in monetary policy between inflation and output stabilization.

Keywords: Corporate debt, inflation, working capital, monetary transmission mechanism, income effect, Taylor principle, Giffen good

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†Financial Markets Group, London School of Economics and CEPR. Houghton Street, London, UK, WC2A 2AE. Email: caegoodhart@aol.com.

‡Oberlin College. Email: upeiris@oberlin.edu.

§Saïd Business School and St Edmund Hall, University of Oxford. Park End Street, Oxford, UK. OX1 1HP. Email: dimitrios.tsomocos@sbs.ox.ac.uk.

¶Vrije Universiteit Amsterdam and Tinbergen Institute. De Boelelaan 1105, NL-1081HV, Amsterdam, Netherlands. Email: xuan.wang@vu.nl .

1 Introduction

The 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%.[1] The COVID-19 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. Meanwhile, the post-pandemic inflation surge has prompted major central banks to raise interest rates to contain inflation, with the labor market being tight.

We ask, how does the stock of non-financial corporate debt affect the ability of monetary policy to control inflation? Our results show that the impact of corporate debt on monetary policy is twofold. First, it introduces an *income effect* that counters the traditional *substitution effect*, reducing the overall effectiveness of interest rates on inflation. Second, it exacerbates the trade-off between output and inflation stabilization. The stock of corporate debt causes demand to offset the usual response of prices to monetary policy, and increases the elasticity of labor with respect to the policy rate. In response to monetary contractions, these two effects make labor more scarce in equilibrium, amplifying the response of output and muting that of inflation.

Non-financial firms neither have the ability to monetize their debt (unlike the government), nor create liquidity via credit extension (unlike financial intermediaries). Despite the extensive research on corporate debt, the majority of studies have focused on its implications for the monetary policy effect on quantities, such as investment (see e.g., Gomes, Jermann and Schmid, 2016; Abraham, Cortina Lorente and Schmukler, 2020; Bräuning and Wang, 2020; Brunnermeier and Krishnamurthy, 2020; Jordà, Kornejew, Schularick and Taylor, 2020; Ottonello and Winberry, 2020), rather than on prices or inflation control. We address this gap in the literature by examining the effects of the stock of corporate debt on monetary policy controlling inflation. While our model does not suggest that corporate debt causes inflation, it does show that corporate debt complicates the effectiveness of monetary policy in controlling inflation, potentially to the point of reversing the Taylor principle and causing the final consumption good to behave as a Giffen good.[2]

We first set out a static general equilibrium model that includes money and credit, with

[1] This has also occurred in emerging economies: China, Chile, Brazil, and Turkey have all seen more than a 50% rise during this period. Hong Kong's non-financial corporate debt-to-GDP ratio soared by over 77% to more than 200%. Throughout the paper, the term 'corporate debt' is used to refer to the debt of non-financial corporations, so it includes debt held by financial intermediaries.

[2] This results from the income effect of corporate debt, and it is distinct from the money-financing channel of public debt (see for example English, Erceg and Lopez-Salido, 2017; Galí, 2020; Reis and Tenreyro, 2022 on money-financed fiscal stimulus).

the nominal rigidity via a liquidity-in-advance constraint. Money is inside because it is issued against an offsetting credit at the cost of the short-term policy rate. The repayment of this credit guarantees money's departure from the economy. We solve for output and the price level in closed form and demonstrate how legacy corporate debt affects monetary contractions. We then extend the static model to a dynamic setting and conduct a simple calibration to study shock propagation and monetary policy trade-offs both in the steady state and on dynamic paths.

The presence of debt necessitates the distinction between key savers and lenders of the macroeconomy. Our economy features two types of households, lender households, i.e., the bondholders, that accumulate safe corporate debt to save, and owner households, the equity holders that own firms that, in turn, issue the corporate debt. The differentiation between these two types of households dates back to Fisher's (1910) narrative on the "enterpriser-borrower" and the "creditor, the salaried man, or the laborer". Empirical evidence by Mankiw and Zeldes (1991), Toda and Walsh (2020), and Doerr, Drechsel and Lee (2022) among others further supports this heterogeneity in asset ownership along the wealth or income distribution. Our central results depend only that a sufficient quantity of corporate debt is held by workers (some, but not all) and in the Appendix we show how our results readily extend to more general distributions of corporate debt holdings. Firms in our model require financing for the purchase of labor in advance of receiving income from production, which they obtain by borrowing money through short-term nominal credit. This timing asymmetry between wage expenditures and income received from output sales justifies the introduction of liquidity-in-advance constraints. The cost of obtaining such credit is the policy rate set by the monetary authority. This liquidity-in-advance nominal friction captures working capital financing along the lines of Christiano, Eichenbaum and Evans (2005) and Ravenna and Walsh (2006). In addition to short-term working capital credit, firms owe longer-term corporate debt to the lender households.

We show that the transmission of monetary policy to both aggregate demand and supply depends on the stock of corporate debt through an income effect that it generates. Typically, with liquidity-in-advance in the spirit of Shapley and Shubik (1977) and Lucas and Stokey (1987), the monetary policy rate drives a wedge in the marginal rate of substitution between consumption and leisure, and so monetary policy changes affect aggregate demand and is the source of money non-neutrality. This mechanism is studied in Ravenna and Walsh (2006) and it also holds in our setup: monetary contractions increase the cost of financing wage bills, leading to a decrease in aggregate demand, and the usual substitution effect that pushes down prices. Ravenna and Walsh (2006) highlight the trade-off between inflation and output, and their result does not depend on the quantity of outstanding intertemporal corporate debt of the firm (the steady state level of corporate debt to be precise). Our contribution to this literature is the identification of an income effect on aggregate demand due to the stock of corporate debt, which changes the slope of the IS curve and may even render it's slope positive. While a rise in the policy rate reduces the equilibrium real wage rate, the ownership of corporate debt by workers flattens their labor supply curve causing the overall wage bill for firms to decline. Given the holdings of corporate legacy debt, this, in turn, shifts the distribution of firm income toward owners through their receipt of profits and away from workers and their labor income. This effect is sufficiently strong to cause upward pressure on aggregate demand, with this upward pressure increasing with the quantity of outstanding corporate debt.

Following a monetary contraction, both the real wage and the price of corporate bonds decrease, leading to a deterioration of the lender households' wealth. However, the bond price decreases less relative to real wages in a high-debt case than in a low-debt case. This is because the monetary contraction in our model does not lead to a parallel shift in the term structure of the interest rate (indeed, recent monetary contractions in the US are associated with flattening or even inversion in the yield curve). Even though both the short rate for liquidity and the long rate for bonds go up, the long rate increases less, and the term structure becomes flatter. Therefore, the negative impact on wealth in the high-debt scenario is less severe than in the low-debt scenario. Thus the effective elasticity of labor supply increases when legacy debt increases and holds even when we include a fixed coupon corporate bond in our robustness checks, consistent with empirical evidence in Ziliak and Kniesner (1999) and Cesarini, Lindqvist, Notowidigdo and Östling (2017).[3]

In equilibrium, when the stock of corporate debt is below a certain threshold, the traditional Taylor principle holds: raising the policy rate lowers current inflation. However, higher debt levels lead to smaller falls in prices, meaning that monetary policy becomes less effective in controlling inflation. Traditionally, raising the policy rate lowers aggregate demand and causes prices to fall, i.e., the substitution effect that puts downward pressure on aggregate demand and inflation. However, via the income effect through corporate debt as explained above, the aggregate demand curve shifts less to the left, and the aggregate supply curve becomes more elastic due to a higher effective labor supply elasticity, and it moves in the same direction as the aggregate demand curve. This income effect offsets the effect of the usual substitution effect, and, in equilibrium, although output falls markedly, prices and inflation only respond mildly. When the stock of corporate debt is above the aforementioned threshold, its income effect causes the final consumption good to behave as a Giffen good.[4] This occurs since our microfounded IS curve depends positively on the corporate debt level. The increase in the corporate debt level rotates the usual downward sloping IS curve clockwise, and when the debt level is sufficiently

[3]According to Ziliak and Kniesner (1999), their estimated labor supply elasticities rise with saving wealth so that the hours response to wage changes is about 40 percent larger for the wealthiest 25% men than for the poorest 25%. Cesarini et al. (2017) find winning a lottery prize reduces earnings with effects roughly constant over time.

[4]Giffen goods and the income effect are well studied in microeconomics but less so in monetary settings. For example, Facchini, Hammond and Nakata (2001) show when the income effects overturn the usual demand response to a price change, the deadweight loss from a distortionary tax or subsidy has the wrong sign, leading to a spurious deadweight gain. Ben-Ami and Geanakoplos (2019) introduce debt as negative endowments and default in an Edgeworth box and demonstrate the fragility and multiplicity of equilibria.

high, the IS curve becomes upward sloping; thus, a monetary contraction raises the policy rate as well as the demand for output. This positive effect on demand leads to the rise in the price level after the monetary contraction. In this extreme high debt scenario, the income effect dominates the substitution effect, and the Taylor principle becomes inverted: raising the policy rate increases current inflation. These results connect with the classic literature on the possibility of an upward sloping IS curve (see Silber, 1971; Puckett, 1973; Burrows, 1974 and Cherneff, 1976), and we contribute to this literature by offering microfoundations that result in an upward sloping IS curve.

The model also allows us to uncover a novel interaction between firm markups and the stock of corporate debt. In equilibrium, the price level monotonically increases with markup. The increase in firm markup increases the parameter range of Taylor principle inversion. This is because higher markup leads to higher profits and would reduce firms' bankruptcy concern due to higher debt. Evidently, both corporate debt and aggregate markup in the US have recently increased. In particular, De Loecker, Eeckhout and Unger (2020) find that the results hold across industries and sizes though higher in smaller firms. Moreover, Díez, Fan and Villegas-Sánchez (2021) provide comprehensive empirical evidence suggesting the decline in competition at the global level. Our result suggests that the high markup interacting with high corporate debt adds further challenges when monetary policy attempts to control inflation.

To study the dynamic properties, we embed the static model in a calibrated dynamic general equilibrium with sticky prices. 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 also account for the corporate debt dynamics. In a numerical exercise, we 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. This quantitative example considers a contractionary monetary shock and a positive consumption demand shock with a standard benchmark Taylor rule. Model simulations shed light on the cyclicality of the consumption expenditure of wealthy stockholding households and those who do not hold stocks. We find that the consumption expenditure of owner households, the 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. As the level of debt increases, the more owner households' consumption becomes pro-cyclical, and lender households' consumption more acyclical.

After a monetary contraction, inflation falls on impact in both 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. Following a positive consumption demand shock inflation rises and output increases on impact. Notably, inflation is much higher in the high debt case than in the benchmark case, and the subsequent drop in output and employment is also more severe in the high debt case. We conduct a counterfactual experiment where we consider a monetary authority that cares more about output stabilization than our benchmark Taylor rule.[5] In this experiment, an output stabilization Taylor rule could bring output back up to the steady-state rather quickly, whereas our benchmark Taylor rule leads to greater and more persistent output and employment loss. Nevertheless, the output stabilization Taylor rule leads to a much higher inflationary profile. Thus, the path of interest rates that stabilizes the path of inflation may cause instability in output directly through working capital which, in turn, causes instability in the path of intertemporal debt. 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.[6]

Related literature. The income effect of monetary policy through corporate legacy debt allows us to uncover the Giffen good property in the demand for output and hence an upward sloping IS curve. While the possibility that the IS curve slopes upwards has long been recognised, our work provides a micro-foundation for it. For instance, Meiselman (1969) writes "My own judgment is that under a wide range of circumstances, the IS curve is best taken to have a positive slope", and see Silber (1971), Puckett (1973), Burrows (1974), and Cherneff (1976) for further early work on an upward sloping IS curve.

There is a flourishing macro literature that focuses on corporate debt and its implications for monetary policy (see, for example, Farhi and Tirole, 2009; Bhamra, Fisher and Kuehn, 2011; Occhino and Pescatori, 2014, 2015; Gomes, Jermann and Schmid, 2016; Mian, Sufi and Verner, 2017; Greenwald, 2019; Darmouni, Giesecke and Rodnyansky, 2020; Jordà, Kornejew, Schularick and Taylor, 2020; Lakdawala and Moreland, 2021; Ottonello and Winberry, 2020).[7] Previous studies have explored the impact of unexpected inflation on corporate debt and investment, whereas our study addresses the reverse: the effect of corporate debt on inflation control. For instance, Gomes, Jermann and Schmid (2016) investigate how lower-than-expected infla-

[5]For example, the FOMC's "balanced approach" of accommodative policy is more consistent with a Taylor rule that includes a much higher output coefficient (see Bernanke, 2015; Yellen, 2012).

[6]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.

[7]Earlier works such as Bernanke, Campbell, Friedman and Summers (1988) and Bernanke, Campbell, Whited and Warshawsky (1990) investigate the default risks of excessive corporate debt and potential debt deflation, while Benjamin Friedman believed the more likely outcome due to corporate America's post-1982 borrowing binge was inflation.

tion creates a debt overhang by affecting the corporate debt real value and in turn investment. Jungherr, Meier, Reinelt and Schott (2022) show that firms' investment is more responsive to monetary policy with more maturing debt. In Ottonello and Winberry (2020), the authors show that the investment of low debt firms or those with a high distance to default is more responsive to expansionary monetary shocks, while the investment of high debt firms with high default risks is less so; again, the concern there is not with contractionary monetary policy controlling inflation. In sum, existing work focuses on the debt impediment on firm investment or aggregate demand, while less attention has been paid to how nominal debt could affect the efficacy of monetary policy in controlling inflation. Our work on controlling inflation serves to fill this gap.

Our paper connects with the literature on the interaction between corporate capital structure and household portfolios and contributes to this literature by highlighting the macro and monetary implications of this interaction. Previous studies such as Gomes, Haliassos and Ramadorai (2020) emphasize the skewed cross-sectional distribution of stock ownership, while Becker and Ivashina (2014), and Adrian, Colla and Song Shin (2013) among others, document the strong cyclicality of bank versus bond financing of corporate liabilities. This result suggests that the cyclicality of aggregate savings is crucial to understanding corporate indebtedness implications. Furthermore, we argue that the distinction between households that own equity and the lender/worker households that save, either through the banking system or through non-bank financial intermediaries, is important. First, empirical evidence suggests that the top rich invest relatively more in stocks (see Mankiw and Zeldes, 1991; Haliassos and Bertaut, 1995; Parker, 2001; Carroll, 2002; Vissing-Jorgensen, 2002; Campbell, 2006; Wachter and Yogo, 2010; Bucciol and Miniaci, 2011; Calvet and Sodini, 2014; Gârleanu and Panageas, 2015), and a significant proportion of safe corporate debt are held either by households directly, or through bank deposits, or in mutual funds, ETFs, life insurance, pension funds, which the 'salaried creditors' indirectly hold (see Koijen and Yogo, 2023). As Campbell (2006) shows, low-wealth households hold large amounts of liquid or safe assets and do not participate in the risky stock markets. Second, Toda and Walsh (2020) also differentiate households as equity holders or bondholders. Based on their model, Toda and Walsh (2020) provide empirical evidence that suggests that the portfolio share of the 1% income earners in the United States concentrates in stocks and that when the income share of the top 1% rises, the subsequent 1-year excess stock market return falls on average. They also show that this finding is not specific to the US. Third, the fact that the lender households supply labor and do not participate in the equity market is also consistent with Benzoni, Collin-Dufresne and Goldstein, 2007, who shows that zero equity allocations arise where labor income risks are highly correlated with stocks and produce results consistent with empirical observation. To the best of our knowledge, our paper is among the first to study the household heterogeneity that specifically corresponds to firms' capital structure in a monetary model, it offers a novel addition to the existing macro literature on household heterogeneity (see Kaplan, Moll and Violante, 2018; Auclert, 2019; Bayer, Lütticke, Pham-Dao and Tjaden, 2019; Hagedorn and Mitman, 2020, non-exhaustive non-exhaustive).

In addition, our paper complements the cost channel of monetary policy literature.[8] The working capital cost channel provides important implications for the monetary transmission mechanism. For example, Ravenna and Walsh (2006) show that the interest rate changes necessary to stabilize the output gap leads to inflation rate fluctuations due to the working capital cost channel. Our paper identifies another mechanism that interacts with working capital by showing that the intensity of the trade-off between output stabilization and inflation stabilization depends on the wealth distribution between heterogeneous households and the level of longer-term corporate indebtedness on top of working capital loans. In the macro-finance literature, Jermann and Quadrini (2012), Bianchi (2016), and Bianchi and Mendoza (2018) model working capital-in-advance financing constraints. However, the cost channel in these papers is not operational as zero interest is assumed on working capital loans. Thus, the working capital loan in these papers is a storage technology, whereas in ours, it is the transaction demand for money at the cost of short-term interest rates (essentially the borrowing cost of working capital), which is consistent with the empirical evidence by Drechsler, Savov and Schnabl (2022) on the endogenous supply side effect of monetary policy via the policy rate changing affecting the borrowing cost of working capital.

More broadly, our paper connects with the long list of classic literature on inside money in general equilibrium that dates back at least to Grandmont and Younes (1972, 1973); Shapley and Shubik (1977). In this literature, money is inside because it enters the economy issued against an offsetting loan, and the repayment of the loan guarantees money's departure. The presence of non-Ricardian seigniorage transfers determines the equilibrium price level, as in the Fiscal Theory of the Price Level (See Drèze and Polemarchakis, 2000, Buiter, 2002, and Dubey and Geanakoplos, 2003 among others). As a result, money is non-neutral, even with flexible prices, as in Dubey and Geanakoplos (2003); Tsomocos (2003); Bloise and Polemarchakis (2006); Goodhart, Sunirand and Tsomocos (2006), non-exhaustive.

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 results. Section 6 concludes.

[8] See, e.g., Kashyap, Stein and Wilcox, 1993; Kashyap, Lamont and Stein, 1994; Gertler and Gilchrist, 1994; Barth and Ramey, 2001; Christiano, Eichenbaum and Evans, 2005; Ravenna and Walsh, 2006, and more recently Phaneuf, Sims and Victor, 2018; Ascari, Phaneuf and Sims, 2018; Grosse-Rueschkamp, Steffen and Streitz, 2019; Zanetti, 2019; Gomez, Landier, Sraer and Thesmar, 2021; Beaudry, Hou and Portier, 2022, among others.

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. That said, however, the introduction of history and time makes it more complicated to apply static models. In particular, we assume that there are two types of households: the first is "owner households" that own firms, which is in accord with the usual assumptions, or the "enterpriser-borrower" à la Fisher (1910). We assume that funds which "lender and worker households" were required to contribute from previous periods own the historical debt issued by firms. This type of household is 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 we impose that all corporate debt is owned by the worker households, in line with the benchmark setup in macro-finance theory models such as Kiyotaki and Moore (1997), Bernanke, Gertler and Gilchrist (1999), and Brunnermeier and Sannikov (2014). Nevertheless, this is not critical for our main results. 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 produces different consumption goods, so firms possess market power. A central bank exists to issue inside money as its liabilities against offsetting credits and sets the policy rate i, 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 Blinder, 1987; Farmer, 1984, 1988*a*,*b*; Fuerst, 1992; Christiano et al., 2005, 2015, non-exhaustive). 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.

2.1.1 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 characterisation. 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),

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

2.1.2 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,[9] and they choose consumption and the supply of labor, $U = log(c^l) - L$. In the morning, the lender households obtain their labor income and carry the money till the evening$\hat{m}^l = wL^l$. 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

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

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.[10] 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 and 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

[9] 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.

[10] 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.

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

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 which leads 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 a 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), and this is consistent with the empirical evidence in Ziliak and Kniesner (1999); Cesarini, Lindqvist, Notowidigdo and Östling (2017). In contrast, in Christiano, Eichenbaum and Evans (1997), the labor supply elasticity only depends on the parameter for leisure in preferences, and their model's empirical performance depends sensitively on this parameter.

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 (21) and (20) 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 equilibirum 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.

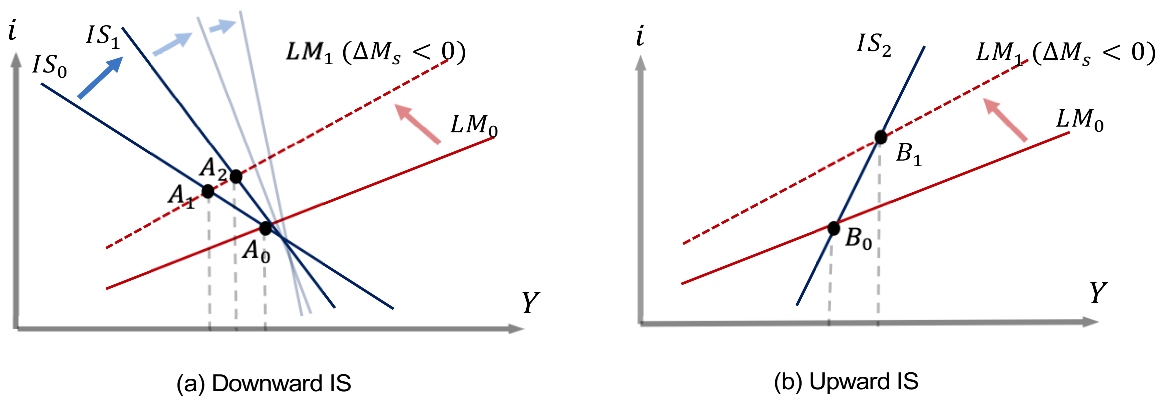


Figure 1: IS-LM: Debt and Monetary Contraction

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 heterogenous 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 which leads 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 labour 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 even though in this simple setup there is no price dispersion, monetary policy is non-neutral because of the nominal friction of 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) and Christiano, Eichenbaum and Evans (1997).

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 ($\epsilon_{Pi} < 0$), that is, the elasticity of price level P to changes in i is less than zero, *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.[11]

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 (20), the labor supply curve (21), 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.

[11] 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.

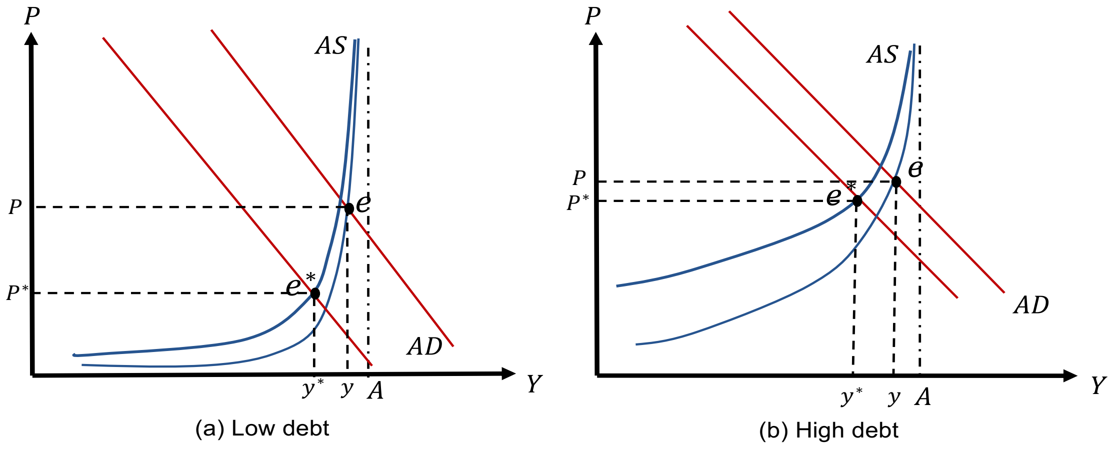


Figure 2: AS-AD diagram: a rise in policy rate

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.

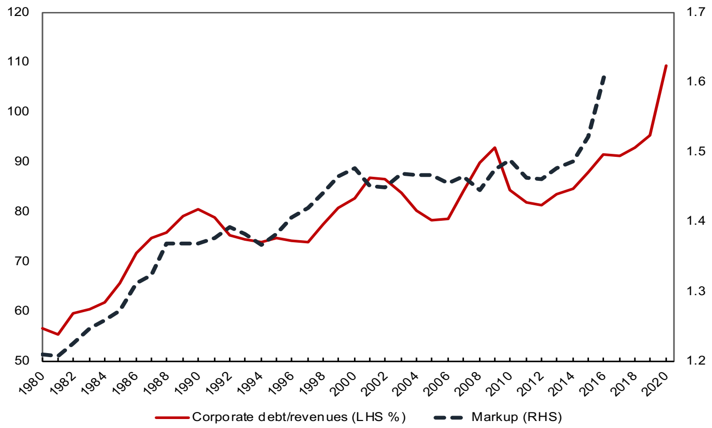
Figure 2 displays the AS-AD diagram to qualitatively show the equilibrium changes when the central bank raises interest rates. The left diagram (a) illustrates a low debt case, and the right (b) shows a high debt case. In the low debt case, the rise in the policy rate significantly reduces inflation, 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 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.[12]

3.3 Markup and Debt Servicing Cost

From the above analysis, we can observe that firm markup interacting with corporate debt level changes the slope of the IS and LM curves (eqs 9, 10), which naturally connects with the recent empirical literature on the rising firm markups (see De Loecker, Eeckhout and Unger, 2020; Díez, Fan and Villegas-Sánchez, 2021), and we contribute to this literature by uncovering a novel interaction between corporate debt and firm markup. To bring to the fore the empirical relevance of this interaction, Figure 3 plots US corporate indebtedness and firm markups. The former is proxied by the ratio of non-financial corporate debt to annual revenue of non-financial corporate businesses, and the latter is estimated in De Loecker et al. (2020).

[12]In this figure, we only conduct comparative statics of the equilibria under different debt levels an policy rates, and we do not seek to model the transition between equilibria. Goodhart, Romanidis, Tsomocos and Shubik (2016) argue that bankruptcy and process models could be employed to describe dynamics and transitions between equilibria.

Figure 3: Aggregate markup and corporate debt in the US



Source: The markup data is from De Loecker et al. (2020). Data on non-financial corporate debt and revenues of non-financial businesses are from Board of Governors of the Federal Reserve System (US) and U.S. Bureau of Economic Analysis, retrieved from FRED, Federal Reserve Bank of St. Louis.

We can see the close positive correlation between the rise in markups and the rise in non-financial corporate indebtedness. In equilibrium, we find a positive markup shock is inflationary and it makes contractionary monetary policy more challenging to control inflation. This result holds without appealing to sticky prices. Formally,

Corollary 4. *A markup shock increases the price level, and it only has an indirect effect on the monetary transmission to inflation: an increase in the markup makes an inversion of the Taylor principle more likely.*

In the proof of this corollary (see Appendix F), we show that $\partial P/\partial\sigma > 0$ and that the rise in markup increases the parameter space of the Taylor principle inversion region. As we have shown in Proposition 2, this parameter region is $1 < \psi D/b < (1+i)(\sigma-1)$; essentially a large markup reduces firms' insolvency concern resulting from holding a large volume of corporate debt. 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 G.

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. 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 labour 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 (see e.g., Harford, Klasa and Maxwell, 2014 and Graham, Leary and Roberts, 2015).

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 hold equities, and it also has a lender-working household who supplies labour 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-working 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 decision. 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.

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[13]. 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 $\frac{1}{c^o} = \beta \mathbb{E} \frac{1}{c^{o\prime}} (\tilde{r}_k')$.

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.[14] The optimality condition with respect to labor is $\frac{\tilde{w}}{c^l} = \kappa l$, while the optimality condition with respect to debt is $\frac{\tilde{q}}{c^l}(1 + \phi_d(\tilde{d}' - \bar{d})) = \beta \mathbb{E} \frac{1}{c^{l\prime}} \frac{1}{1+\eta'}$.

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: $y_W = Ak^\alpha l^{1-\alpha}$. 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 the flow budget constraints, 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 $\tilde{\pi}_W + \tilde{r}_k k + \frac{1}{1+\eta}\tilde{d}_W + \tilde{b}(1+i) = \tilde{p}_W y_W + \tilde{q} d_W'$

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

[13] We suppress notation for this for brevity and reintroduce it in the quantitative simulation. Nevertheless, the shock should appear wherever the marginal utility of households appears, including in the forward-looking equations of the firms.

[14] 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.

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').[15] What should be the appropriate output target is also unclear (Woodford, 2001, Garín, Lester and Sims, 2016). 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

[15] 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.

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 $\tilde{M}$ to clear the money market.

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;*

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. Full equations are in the Online Appendix. Using the linearized equations we obtain the 'naíve' Phillips curve[16]:

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

where the marginal cost is given by[17]

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

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 has 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 that 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

[16] 'Naíve' because we do not present it in terms of the output gap.
[17] The derivation is in Appendix I.

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) can be obtained by combining in the individual Euler and labour supply condition with the marginal product of labor and the definition of firm output (and $\phi = 0$)[18],

$$\hat{q} + (\widehat{1+i}) - \hat{p}_W - \hat{y}(1 - \frac{2}{1-\alpha}) - 2\frac{\hat{A} + \alpha\hat{k}}{1-\alpha}$$

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

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

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 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

[18] See the Online Appendix for the equations.

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 parameterisation in Table 1, below Table 2 displays the model steady-state values with quantity variables normalised 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 two shocks, a positive shock to interest rates and a positive demand shock. We assume the former has no persistence while the latter has a persistence of 0.9. A consumption demand shock gives us an insight into the policy response in a post-pandemic recovery.

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, that is, the 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) finds higher sensitivity of the consumption growth of wealthy stockholders to both the stock market and to 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 Mankiw and Zeldes, 1991; 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 4 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 2.2).

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. As seen in the high debt case, labor decreases more than in the benchmark case. Moreover, corporate profits fall after a monetary contraction.

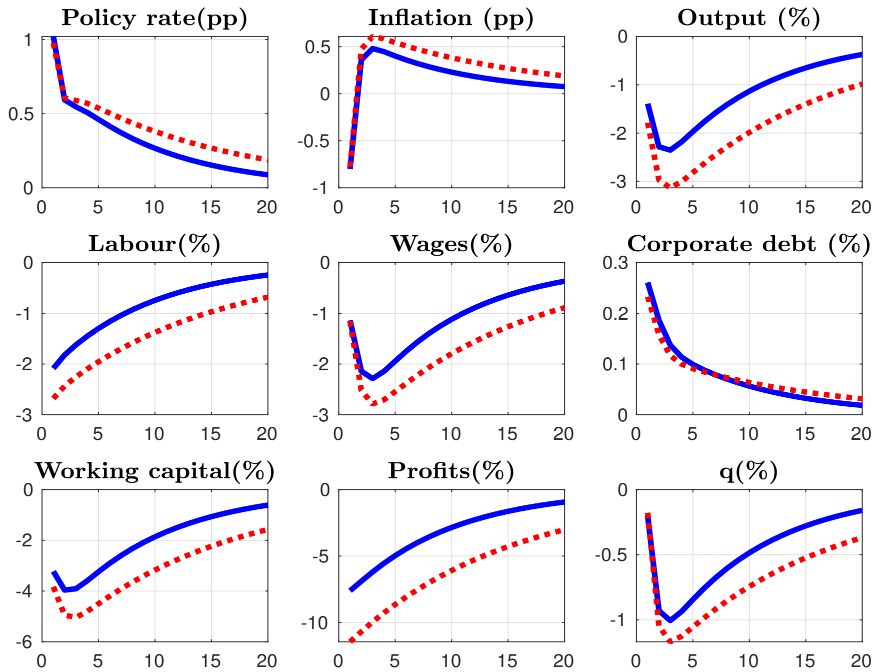


Figure 4: Tightening shock to nominal policy rate i.
Blue line is 75% corporate debt-to-output ratio and red line is 100% corporate debt-to-output ratio. The y-axis is % change and the x-axis is the number of periods. Other than inflation and policy rate, all variables are in real terms

5.2 Output Stabilisation Taylor Rule

We now compare how legacy debt affects output-inflation stabilization trade-offs and show that the trade-off between inflation stabilization and output stabilization becomes more acute with a large volume of corporate debt in the economy. With a large stock of corporate debt, if the monetary authority is more concerned about output and employment stabilization, inflationary pressure is then high; if the monetary authority is strictly sticking to it's price stability mandate, it could bring down inflation on impact but at the cost of hurting output and employment with some persistence.

Figure 5 shows different Taylor rule coefficients (in which we set the output coefficient to 0.2 or 0.9 and the inflation coefficient remains at 1.5) in a high debt regime (100% corporate debt-to-output ratio). We consider the counterfactual experiment between a monetary authority who cares more about output stabilization than our benchmark Taylor rule. To model this, we increase the Taylor rule output coefficient to 0.9, which is among the high range estimated in the literature (see, e.g., Clarida, Gali and Gertler, 2000) and suggested by policymakers (see Bernanke, 2015; Yellen, 2012).[19]

[19] As Bernanke (2015) pointed out that 'in principle, the relative weights on the output gap and inflation should depend on, among other things, the extent to which policymakers are willing to accept greater variability in inflation in exchange for greater stability in output'. Moreover, according to Bernanke (2015), the FOMC pays

In Figure 5 the solid line corresponds to the benchmark Taylor rule $\rho_y = 0.2$ and the dashed line corresponds to the output stabilisation Taylor rule $\rho_y = 0.9$. Compared with the benchmark Taylor rule, the output stabilization Taylor rule ($\rho_y = 0.9$) brings output back up to the steady-state within seven quarters, whereas with the benchmark Taylor rule, the loss of output is greater and much more persistent. Furthermore, the benchmark Taylor rule also sees more persistent loss in employment and business profits than the output stabilization Taylor rule. Nevertheless, the output stabilization Taylor rule leads to a much higher inflationary profile.

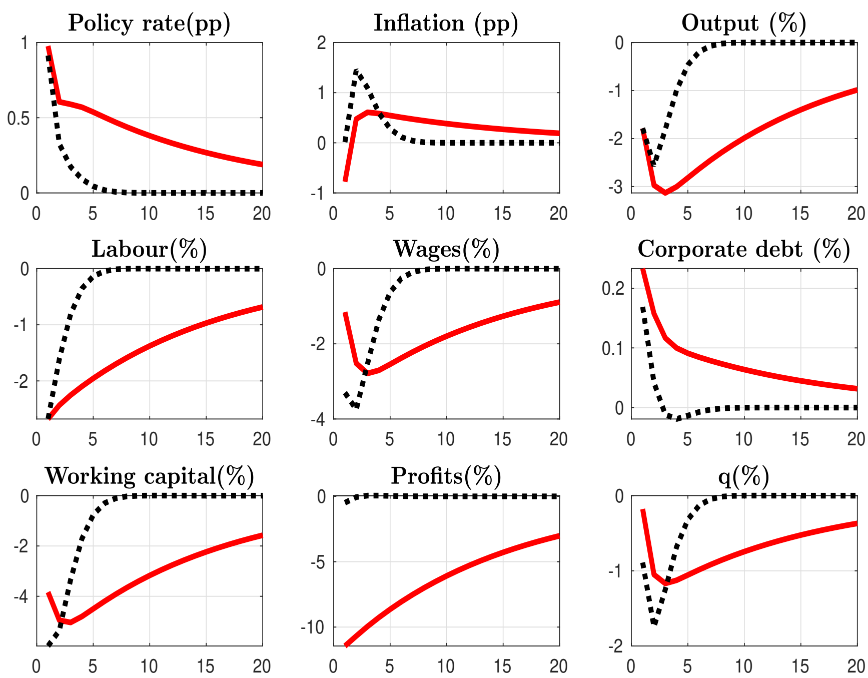


Figure 5: Tightening shock to nominal policy rate i with or without output stabilisation.
Red solid line is the benchmark Taylor rule ($\rho_y = 0.2$) and the dashed black line is the output stabilisation Taylor rule ($\rho_y = 0.9$). y-axis is % change and x-axis is the number of periods. Other than inflation and policy rate, all variables are in real terms

5.3 The Effect of a Positive Demand Shock

We now study a positive demand shock of 0.05 standard deviation and an autoregressive coefficient of 0.9. Figure 6 demonstrates the dynamic responses with the positive demand shock and our benchmark Taylor rule. Unsurprisingly, inflation rises when demand picks up, and output increases on impact. The monetary authority responds by tightening monetary policy and increasing the policy rate. As the policy rate increases, the cost channel of monetary policy starts to dampen aggregate supply, and with the income effect of debt, the aggregate supply curve shifts inward and becomes more elastic, leading to a subsequent drop in output. Notably,

closer attention to variants of the Taylor rule that include the higher output coefficient, and Janet Yellen has also suggested that the FOMC's 'balanced approach is more consistent with an output coefficient of 1.

inflation is much higher in the high debt case than in the benchmark case, and the subsequent drop in output is more severe in the high debt case than in the benchmark case, for reasons already explained. Relatedly, employment in the high debt case falls, but it holds well in the benchmark case, suggesting that a high level of corporate debt increases the effective labor supply elasticity.

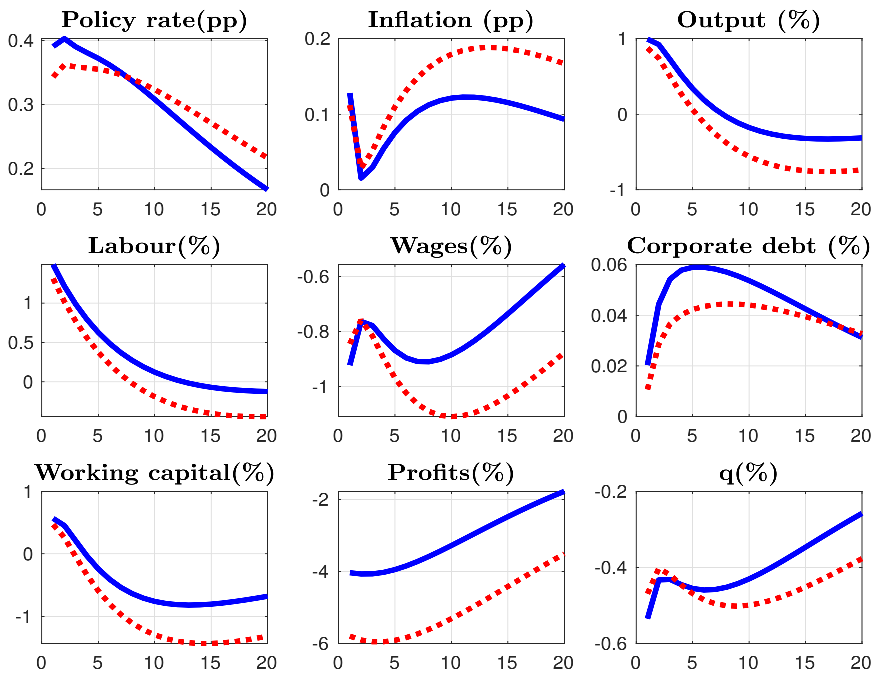


Figure 6: A positive consumption demand shock.
Blue line is 75% corporate debt-to-output ratio and red line is 100% corporate debt-to-output ratio. y-axis is % change and x-axis is the number of periods. Other than inflation and policy rate, all variables are in real terms

5.4 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 this robustness check, we added a two-period fixed coupon bond whose steady-state quantity is four times as much as the floating rate bond. This scenario captures a noticeable potential decrease in lender working households' non-labor income wealth after monetary contractions.

Our results still go through. Take the policy experiment of a positive consumption demand shock as an example (we leave the numerical results of a contractionary monetary policy shock and output stabilization Taylor rule in the appendix to save space). As the economy experiences a positive consumption demand shock - again, we have the post-pandemic economy rebound in mind as the context - the monetary policy rate increases as an endogenous response. Both real wages and bond prices go down after the monetary contraction. However, the bond price-to-wage ratio increases, and in particular, it increases more in the high debt case than in the low debt case. In a high-debt scenario, the bond price decreases less relative to the real wage than in a low-debt scenario. This result suggests that even though the short and long rates increase after the monetary contraction, the long rate increases to a lesser degree, and the term structure becomes flatter. This suggests that the condition $\epsilon_{\psi}(i) < -1$ in Proposition 3 is not reached. Therefore, the negative impact on wealth in the high-debt scenario is less severe than in the low-debt scenario, resulting in the effective labor elasticity increasing on legacy debt. Hence, when the corporate debt level is high, monetary contraction is less effective in controlling inflation.

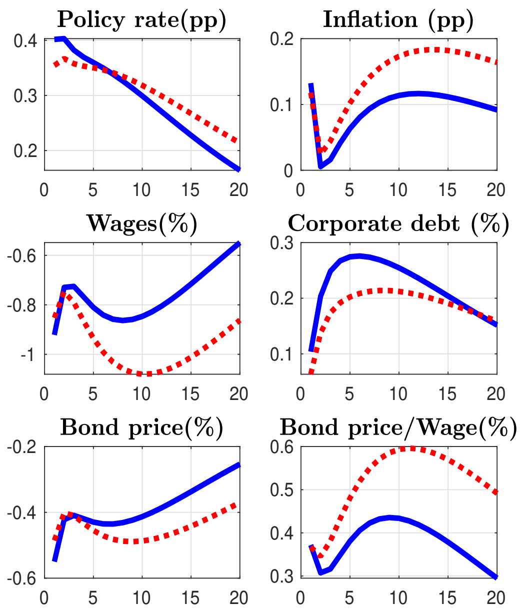


Figure 7: A positive consumption demand shock (with fixed coupon bonds).
Blue line is 75% corporate debt-to-output ratio and red line is 100% corporate debt-to-output ratio. y-axis is % change and x-axis is the number of periods. Other than inflation and policy rate, all variables are in real terms

6 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 addition, we find that higher markups interacting with higher levels of the stock of corporate debt add further hurdles to monetary contractions in reining in inflation.

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., Blanchard, 2016; Gilchrist, Schoenle, Sim and Zakrajšek, 2017; Hazell, Herreno, Nakamura and Steinsson, 2022, non-exhaustive). 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 Curdia and Woodford (2010), Schularick and Taylor (2012), Jordà, Schularick and Taylor (2013), 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 and a new interaction between firm markups and corporate debt levels. Thus, our result contributes to the literature on the cost channel of monetary policy by showing how corporate debt may intermediate the transmission mechanism from monetary policy to economic activity in additional to the cost channel via the transaction demand for money. In stark 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 much more intricate trade-off between inflation stabilization and output stabilization when there is a large volume of corporate debt in the economy.

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Appendix

A Proof of Lemma 1

First, we derive the demand function for goods varieties. Households' optimisation for goods variety 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): $\pi_j = (p_j)^{1-\theta}P^{\theta}Y - \psi D - (1+i)(wp_j^{-\theta}P^{\theta}\frac{Y}{A})$. We now break the firm's problem into one, minimizing cost and setting the price, which will help us illustrate the working capital channel. **Cost Minimisation:** From 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

$$\tilde{mc}_j = \frac{(1+i)}{A}\tilde{w}, \tag{19}$$

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 19: $0 = (1-\theta)(p_j)^{-\theta}P^{\theta}Y - (1+i)(-\theta w(p_j)^{-1-\theta}P^{\theta}l_j) = (1-\theta)A - (1+i)(-\theta w(p_j)^{-1})$ 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

$$\tilde{w} = \frac{A}{\sigma(1+i)}. \tag{20}$$

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

$$\tilde{w}L = \tilde{w} - \psi\frac{D}{P}. \tag{21}$$

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.[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 $\epsilon_L = \frac{\frac{\partial L}{\partial \tilde{w}}}{\frac{L}{\tilde{w}}} = \frac{\psi D}{P\tilde{w}L} = \frac{\psi}{b}\frac{D}{P}$. □

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. □

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

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 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 (22):

$$P = \frac{m + i\psi D}{\frac{1}{\sigma}\frac{i}{1+i}A}. \tag{22}$$

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 (23), 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 monetary authority's seigniorage profits.

$$bi = m. \tag{23}$$

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 (20) into (23), we obtain $L = \frac{m}{iP}\left(\frac{A}{\sigma(1+i)}\right)^{-1}$. Combine the above equation with (22) 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 (22), 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 (22) 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 direct liquidity cost incurred through higher policy rates, while the second term is the direct 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 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 Corollary 4

From (22), we differentiate P with respect to σ, $\partial P/\partial \sigma = (m + i\psi D)(1+i)i^{-1}A^{-1} > 0$. As we have also shown, the parameter space of the Taylor principle inversion is $1 < \psi D/b < (1+i)(\sigma - 1)$, it is straightforward to see that a larger σ increases this parameter space. □

G Proof of Proposition 3

Suppose ψ is a function of gross interest rate $1+i$, i.e., $\psi = \Psi(1+i)$, and from eq (22), 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. □

H 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 condition for

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

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

$$\bar{w}\bar{l} = \frac{\bar{m}}{\bar{i}} = \bar{M}. \tag{24}$$

From the marginal cost of the firm we get that $\bar{p}_W = \frac{1}{\sigma}$ in 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 (24) 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 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 $\bar{l} = \frac{\bar{w}}{\kappa(\frac{\bar{m}}{\bar{i}}+\bar{d}(1-\bar{q}))}$. Now we use the steady-state equations to prove Proposition 4. The capital-labor ratio can be expressed as: $\frac{\bar{k}}{\bar{l}} = \beta\frac{\alpha}{1-\alpha}(1+\bar{i})\bar{\tilde{w}} = \frac{\beta\alpha}{1-\alpha}\left\{\frac{A(\beta\alpha)^{\alpha}(1-\alpha)^{1-\alpha}}{\sigma}\right\}^{\frac{1}{1-\alpha}} = \left\{\frac{A\beta\alpha}{\sigma}\right\}^{\frac{1}{1-\alpha}}$ and so the steady-state level of output is $\bar{y} = A(\frac{\bar{k}}{\bar{l}})^{\alpha}\bar{l} = A\left\{\frac{A\beta\alpha}{\sigma}\right\}^{\frac{\alpha}{1-\alpha}}\bar{l} = A\left\{\frac{A\beta\alpha}{\sigma}\right\}^{\frac{\alpha}{1-\alpha}}\frac{\bar{M}(1+\bar{i})}{\left\{\frac{A(\beta\alpha)^{\alpha}(1-\alpha)^{1-\alpha}}{\sigma}\right\}^{\frac{1}{1-\alpha}}} = \frac{\sigma}{1-\alpha}\bar{M}(1+\bar{i}) = \frac{\sigma}{1-\alpha}\frac{\bar{m}}{1-\frac{1}{1+\bar{i}}}$. 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: $\kappa\bar{M}(\bar{M} + \bar{d}(1-\bar{q})) = (\bar{w})^2 = \frac{1}{(1+\bar{i})^2}\left\{\frac{A(\beta\alpha)^{\alpha}(1-\alpha)^{1-\alpha}}{\sigma}\right\}^{\frac{2}{1-\alpha}} = \kappa\bar{M}(\bar{M} + \bar{d}(1-\bar{q}))$

Suppose that $\bar{d} = 0$. In this case, $\bar{M} = \kappa^{-.5}\frac{1}{1+\bar{i}}\left\{\frac{A(\beta\alpha)^{\alpha}(1-\alpha)^{1-\alpha}}{\sigma}\right\}^{\frac{1}{1-\alpha}}$ 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, due to the legacy debt, money balances decrease to a lesser degree. Note that 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 corporate debt-to-output ratio: $lev = \frac{\bar{d}}{\bar{y}}$. From $\frac{1}{(1+\bar{i})^2}\left\{\frac{A(\beta\alpha)^{\alpha}(1-\alpha)^{1-\alpha}}{\sigma}\right\}^{\frac{2}{1-\alpha}} = \kappa\frac{\bar{M}}{1+\bar{i}}(\frac{\bar{M}}{1+\bar{i}} + \bar{y}lev(1-\bar{q}))$ 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. □

I 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 $\bar{\mu}(\bar{q}\hat{q} + (\hat{1+\eta})) = \bar{w}\bar{l}((1+\bar{i})-1)(\hat{w}+\hat{l}) + \bar{w}\bar{l}(1+\bar{i})(\hat{1+i})$. Simplifying $\hat{w}+\hat{l} = \frac{\bar{\mu}(\bar{q}\hat{q}+(\hat{1+\eta})) - \bar{w}\bar{l}(1+\bar{i})(\hat{1+i})}{\bar{w}\bar{l}((1+\bar{i})-1)}$, where $\bar{w}\bar{l} = \bar{\mu}\frac{\bar{q}-1}{\bar{i}}$. We can now solve for labour supply from the budget constraint and labour supply FOC $\hat{l} = \frac{1}{2\bar{c}^l}\left\{\bar{q}\bar{d}(\hat{q} + \hat{d}') + \phi_d\bar{q}\bar{d}\hat{d}' + (\bar{c}^l - \bar{w}\bar{l})(\hat{w} + \hat{l}) - \bar{d}(\hat{d} - (\hat{1+\eta}))\right\}$

With this in hand, we can obtain an expression for output:

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

From the linearized labor marginal cost condition, and for analytical convenience set $\phi_d = 0$, $\hat{p}_W = (\hat{l} + \hat{w})\left\{1 - (1-\alpha)\frac{1}{2\bar{c}^l}(\bar{c}^l - \bar{w}\bar{l})\right\} + (1 \hat{+} i) - \hat{A} - \alpha\hat{k} - (1-\alpha)\frac{\bar{d}}{2\bar{c}^l}\left\{\bar{q}(\hat{q} + \hat{d}') - \hat{d}\right\} - (1-\alpha)\frac{\bar{d}}{2\bar{c}^l}(1 \hat{+} \eta)$ which simplifies to $\hat{p}_W = (1 \hat{+} \eta)\left\{\frac{\bar{\mu}\left\{1-(1-\alpha)\frac{1}{2\bar{c}^l}\bar{d}(1-\bar{q})\right\}}{\bar{w}\bar{l}((1 \bar{+} i)-1)} - (1-\alpha)\frac{\bar{d}}{2\bar{c}^l}\right\} + \bar{q}\hat{q}\left\{\frac{\bar{\mu}\left\{1-(1-\alpha)\frac{1}{2\bar{c}^l}\bar{d}(1-\bar{q})\right\}}{\bar{w}\bar{l}((1 \bar{+} i)-1)} - (1-\alpha)\frac{\bar{d}}{2\bar{c}^l}\right\} + (1 \hat{+} i)\left\{1 - (1 \bar{+} i)\frac{\left\{1-(1-\alpha)\frac{1}{2\bar{c}^l}\bar{d}(1-\bar{q})\right\}}{((1 \bar{+} i)-1)}\right\} - \hat{A} - \alpha\hat{k} - (1-\alpha)\frac{\bar{d}}{2\bar{c}^l}\left\{\bar{q}\hat{d}' - \hat{d}\right\}$ where $\bar{c}^l = \bar{w}\bar{l} + \bar{d}(1-\bar{q})$. Consider the coefficient in front of $(1 \hat{+} i)$, $\left\{1 - (1 \bar{+} i)\frac{\left\{1-(1-\alpha)\frac{1}{2\bar{c}^l}\bar{d}(1-\bar{q})\right\}}{((1 \bar{+} i)-1)}\right\} = \frac{-1}{((1 \bar{+} i)-1)}\left\{1 - (1 \bar{+} i)(1-\alpha)\frac{1}{2\bar{c}^l}\bar{d}(1-\bar{q})\right\}$. 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 $\bar{q}\hat{q}$, $\frac{\bar{\mu}\left\{1-(1-\alpha)\frac{1}{2\bar{c}^l}\bar{d}(1-\bar{q})\right\}}{\bar{w}\bar{l}((1 \bar{+} i)-1)} - (1-\alpha)\frac{\bar{d}}{2\bar{c}^l} = \frac{\left\{1-(1-\alpha)\frac{1}{2\bar{c}^l}\bar{d}(1-\bar{q})\right\}}{\bar{q}-1} - (1-\alpha)\frac{\bar{d}}{2\bar{c}^l} = -\frac{1}{1-\bar{q}}$. 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. □