DISCUSSION PAPER SERIES

51666-1753192161

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MONETARY ECONOMICS AND FLUCTUATIONS AND MACROECONOMICS AND GROWTH



ISSN 0265-8003

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Discussion Paper 51666-1753192161
Published N/A
Submitted 22 July 2025

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- Monetary Economics and Fluctuations
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MONOPSONY, INCOME RISK AND R∗ MULTIPLICITY

Abstract

We develop a model where labor market monopsony and income risk generate multiple equilibria for the equilibrium real interest rate, R∗. Firms' debt issuance amplifies labor income risk, making household asset demand non-monotonic. One equilibrium features higher R∗ and lower risk; another, lower R∗, higher debt, and higher risk. Policy affects equilibrium selection: central bank asset purchases lower R∗, while government debt raises it. Empirical evidence supports our prediction that asset supply changes have differing effects on interest rates before and after the Global Financial Crisis.

JEL Classification: E43, E21, J42

Keywords: Natural interest rate, Monopsony, Income risk

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Monopsony, Income Risk and R^* Multiplicity[†]

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This version: July 22, 2025

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Keywords: Natural rate of interest, monopsony, income risk.

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[†]The views expressed in this paper are solely those of the authors and should not be taken to represent those of the Bank of England or any of its Committees, nor the Irish Fiscal Advisory Council. For helpful comments and discussions, we thank participants at the ECB Forum on Central Banking on July 1-3, 2024 at Sintra and at other conferences and seminars.
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"Even if asset purchases have clearly quantifiable benefits, they also come with side effects. These may be difficult to assess, as they can materialise with considerable delay." (Schnabel, 2024)

1. Introduction

The equilibrium real interest rate is generally considered a key reference point for monetary policy. The concept, originally formalized by Wicksell (1898, 1907), corresponds to the real interest rate that equates savings and investment and clears the goods market with output at its potential level. We will refer to this rate as R^*.[1] This long-run notion of the equilibrium real interest rate serves as a fundamental anchor for the lower-frequency movements in its shorter-run counterpart (r^*), which is typically thought of as responding to transitory shocks (Woodford, 2011).

A major concern among Federal Reserve policymakers in their 2020 revision of US monetary policy strategy was to deal with the secular decline in R^* that increased the "*likelihood that a central bank's policy rate will reach its effective lower bound (ELB) in future economic downturns*" and "*make it more difficult during downturns for monetary policy to support spending and employment, and keep inflation from falling too low*" (Clarida, 2019, 2022).

In New Keynesian models, such as Clarida et al. (1999), the stance of monetary policy depends on the gap between the real rate and its equilibrium value. In such workhorse models, R^* is unique and monetary policy plays no role in its determination.[2] In this paper, we challenge this view. While the gradual decline in the equilibrium real rate is well-documented, our focus is on the much steeper decline that many measures suggest took place around and after the Global Financial Crisis (GFC).[3] Such a decline is difficult to explain relying on slow-moving low frequency real factors. Instead, our main contribution is to develop a model that admits multiple equilibrium real interest rates. In the model, the total level of private debt determines in which equilibrium the economy is. As a result, policy actions that affect the net demand or supply of private assets, such as quantitative easing or fiscal policy, can select which equilibrium real interest rate prevails—and thus, ultimately, influence the interest rate stance of monetary policy.

We start by presenting a number of motivating empirical facts that help discipline and frame our theoretical framework. We first document that popular estimates of R^* declined smoothly around a trend until the onset of the Great Financial Crises (GFC), after which all measures fell rapidly. The overall decline from 2009-2011 was around 1pp, though some estimates show a decline closer to 2pp. Crucially, after staying low, or even falling further, for a decade or so, the level of R^* is estimated to have increased somewhat after the 2020 Covid pandemic.

[1] Reis (2025) discusses four versions of "R Star"; our paper aligns most closely with his return on saving (y) and return on bonds (ρ) measures.

[2] More specifically, in those models, the classical dichotomy holds and the equilibrium real rate is determined exclusively by real factors, such as productivity, as well as other factors driving demand and supply in the market for savings such as aging populations and changes in risk-taking behavior.

[3] King and Low (2014) and Rachel and Smith (2017) document the decline across different measures of real interest rates in the past decades.

Next, we discuss five empirical regularities that motivate our theoretical analysis using micro-level data on firms and households. The first two relate to firms. We document that (i) firms increased their leverage around the same time as (ii) their labor market monopsony power is estimated to have increased (Chan et al., 2024). The next two facts, in contrast, relate to workers and households. We show that (iii) wages became more volatile for workers, and (iv) household savings increased markedly before gradually settling back at a level about 2pp higher than before the GFC. Finally, we link the two sets of facts by exploiting firm-level data, demonstrating that, since the late nineties, (v) firms with higher leverage have paid systematically lower wages.

To explain this combination of evidence, we develop a macroeconomic model with two types of households-workers and entrepreneurs. Workers supply labor to firms, while entrepreneurs own firms and receive their profits but do not work. Workers are heterogeneous and supply differentiated labor to firms. Their income fluctuates because of idiosyncratic shocks to their labor supply. Two central frictions interact in the model. First, incomplete financial markets prevent workers from fully insuring themselves against idiosyncratic income risk. Second, firms hold monopsony power vis-à-vis workers. However, this monopsony power does not apply to all worker types in the economy—tying labor market power to fluctuations in workers' labor income. Consistent with our empirical evidence, we assume that a firm's monopsony power increases with its financial leverage, such that debt issuance can amplify workers' income fluctuations. In particular, a higher leverage through debt issuance allows firms to markdown wages more, which, in turn, creates a more risky environment for workers who must increase their savings to self-insure.

Our framework delivers two key results. First, we rationalize the observed decline and subsequent increase in R^* as arising from shifts across multiple equilibria in the model economy. The model admits both multiple steady state and multiple dynamic equilibria for a given state of the economy. Hence, non-fundamental (sunspot) shocks can determine in which equilibrium the economy operates. In one equilibrium, the interest rate is relatively high, while household savings and corporate debt issuance are relatively low. In another equilibrium, the opposite is true. The possibility of multiple equilibria arises from the interaction between incomplete financial markets, as binding borrowing constraints prevent low-income households from smoothing consumption, and the linkage between firms' debt issuance and their monopsony power in the labor market, which in turn magnifies household income fluctuations. Through the lens of the model, we can thus account for the sharp decline in R^* observed at the time of the GFC as being driven by a pessimistic and persistent realization of a sunspot shock in an environment of high corporate indebtedness that has increased firms' monopsony power.

The second key result is the possibility that both monetary and fiscal policies may influence R^*. Specifically, we show that purchases of securities issued by firms can significantly lower R^*. By subsidizing corporate debt issuance, these asset purchases can amplify fluctuations in household income, which in turn raises households' precautionary savings. As a result, high-interest-rate equilibria disappear, and the economy converges to a new equilibrium characterized by high corporate debt and low interest rates. Thus, an unintended consequence of an unconventional monetary policy meant to

stabilize the economy in the presence of a lower bound on nominal interest rates is to paradoxically reduce R^*.

On the other hand, issuance of government debt increases the supply of public assets, allowing households to save without relying on firm-issued assets. This higher asset supply generates two positive effects on the interest rate. The first is improved consumption smoothing across time and states of the world, as resources are transferred from high-consumption to low-consumption households. The second (and more novel) effect is a reduction in the amount of debt issued by firms for a given level of household savings. When a linkage between corporate leverage, labor market monopsony power, and household income fluctuations is present, this lower demand for firm-issued assets reduces the adverse implications of household savings and puts upward pressure on interest rates. Through this mechanism, we can rationalize the rise in R^* observed in recent years as driven by the increase in government debt associated with pandemic-related stimulus policies.

Our paper contributes to the literature on the decline and dynamics of the equilibrium real interest rate. Much of the existing literature attributes the decline of R^* to four slow-moving structural forces: demographic effects of an aging population, growing wealth and income inequality, global savings glut, and productivity slowdown.[4]

Demographic trends represent one of the leading explanations for the secular decline of R^*. Due to lower birth rates and longer life expectancy, aging populations increase aggregate savings relative to investment, thus exerting downward pressure on R^* (Carvalho et al., 2016, 2024; Auclert et al., 2021; Gagnon et al., 2016). Inequality represents a second potential low-frequency driver. An increase in the share of income and wealth held by rich households, who are likely to have a higher propensity to save, would also boost aggregate savings and lower the equilibrium real rate (Mian et al., 2021; Straub, 2020, 2023). A third popular explanation is the *global savings glut* hypothesis, first advanced by Bernanke (2005) in the context of the debate on global imbalances. According to this view, a rise in savings by emerging market economies—particularly China and oil exporters—relative to their investment led to large capital flows into advanced economies, pushing down real interest rates. The fourth main explanation comes from a persistent slowdown in productivity growth across advanced economies. Standard theory implies that lower productivity growth reduces the marginal product of capital and thus the incentive to invest, while a decline in trend output growth increases the incentive to save—both forces leading to a lower equilibrium real interest rate.[5] Related to the slowdown in economic activity, Benigno and Fornaro (2018) show that persistent *demand* shortfalls can themselves reduce trend growth, potentially giving rise to multiple equilibria. In their model, insufficient demand lowers growth and real interest rates, with the zero lower bound playing a key role in sustaining the

[4]Some studies attempt to quantify the relative importance of these forces. For instance, Rachel and Smith (2017), Rachel and Summers (2019), Eggertsson et al. (2019), Cesa-Bianchi et al. (2022), and Peruffo and Platzer (2022) find that demographics, productivity, inequality, and global savings trends all contribute materially to the observed decline in R^*.

[5]Laubach and Williams (2003); Holston et al. (2017) find a close relationship between trend output growth and R^*. However, Hamilton et al. (2016) challenge this view, emphasizing the large uncertainty surrounding R^* estimates and casting doubt on the strength of its empirical relationship with trend growth.

low-R^* equilibrium. Our contribution differs from theirs in that we obtain multiple R^* equilibria even in the absence of nominal rigidities or binding monetary policy constraints.

While we see these factors as important in shaping the long-run trend of R^*, our paper complements this literature by focusing on a mechanism that can generate sharp, sudden shifts in R^*. Specifically, we emphasize the role of trends in household income risk and firm monopsony power in explaining some large fluctuations in R^*. Our model does not explicitly consider demographics or the global savings glut. Conversely, household inequality does play a crucial role in our framework, albeit through a novel channel relative to the existing literature that highlights how household income fluctuations can play an important role in shifting their demand for assets.

Our paper is most closely related the few papers that discuss multiplicity of R^*. In addition to the aforementioned Benigno and Fornaro (2018), multiple R^* equilibria also arise in Beaudry et al. (2023), due to a non-standard downward-sloping household asset demand curve. In that framework, household demand may slope downwards due to a saving-for-retirement motive in an overlapping-generations model. That force is complementary to the interaction between the severity of household income fluctuations and the trends in firms' market power and leverage. Rungcharoenkitkul and Winkler (2022) introduce a framework where two-sided learning between the private sector and monetary authorities can give rise to fluctuations in R^* in the absence of changes in fundamentals.[6] Campos et al. (2024) show that in a HANK model, public debt influences R^* and highlight novel monetary-fiscal interactions. Like us, these authors argue that equilibrium real rates can themselves be policy-driven.

On a different dimension, we also add to the growing literature that points to potential effects of monetary policy on R^*. Moran and Queralto (2018) and Ma and Zimmermann (2023) link monetary policy movements to firm-level innovation. Jordá et al. (2024) show that, contrary to standard thinking, monetary policy has real effects that last for for over a decade. Elfsbacka-Schmöller et al. (2024) use firm-level data to document an effect of ECB monetary policy on innovation expenditure.

Finally, our paper is additionally motivated by the growing literature on monopsony power in labor markets. While the theoretical roots trace back to Robinson (1933), renewed interest began with Manning (2003). Recent empirical work (e.g., Yeh et al., 2022) shows that monopsony power in U.S. manufacturing has risen significantly in the past two decades. Channels include search frictions, job-specific amenities, and labor market concentration (Langella and Manning, 2021; Schubert et al., 2024). Our reduced-form empirical work links rising firm monopsony power to corporate leverage and the amplification of wage risk, which in turn interacts with household asset demand and contributes to sudden movements in R^*.

[6] Castelnuovo et al. (2025) find a positive and persistent effect of monetary policy information shocks on R^*.

2. Motivating Evidence

In this section, we first discuss the recent behavior of R^*, showing that after many decades of gradual decline, likely driven by well-documented factors such as demographic trends and slowing productivity growth, R^* fell sharply around and after the Global Financial Crisis, before gradually increasing albeit in a volatile way. We then present the five empirical regularities that motivate our theoretical analysis.

2.1 The Evolution of R^*: Smooth or Jumpy?

Since R^* is unobservable, a large literature has sought to measure it using various methods, ranging from statistical filtering to estimated DSGE models. These different approaches produce estimates of R^* with varying degrees of smoothness. To try and see the underlying movements in R^*, we focus on three measures:

1. **?** use a state-space model that links observed real interest rates with economic activity measures, such as real GDP and inflation, to extract the underlying trend in the unobservable natural rate. The methodology specifies a simple theoretical relationship and then employs a filter to dynamically estimate R^* from the data. The measure availability stretches back to January 1961. We refer to this measure as LW hereafter.

2. Lubik and Matthes (2015) employ a VAR with time-varying parameters (TVP-VAR) to estimate the natural rate of interest. The empirical model contains three variables—the growth rate of real GDP, the PCE inflation rate, and the real interest rate (as in LW)—from 1961 through the second quarter of 2015. Their method defines the natural rate as the conditional five-year forecast of the observed real rate, computed at each data point from 1967 onward. Because the TVP-VAR's coefficients follow random walks, the forecasts do not revert to the sample mean, effectively capturing both long-term secular trends and business-cycle dynamics. We refer to this measure as LM hereafter.

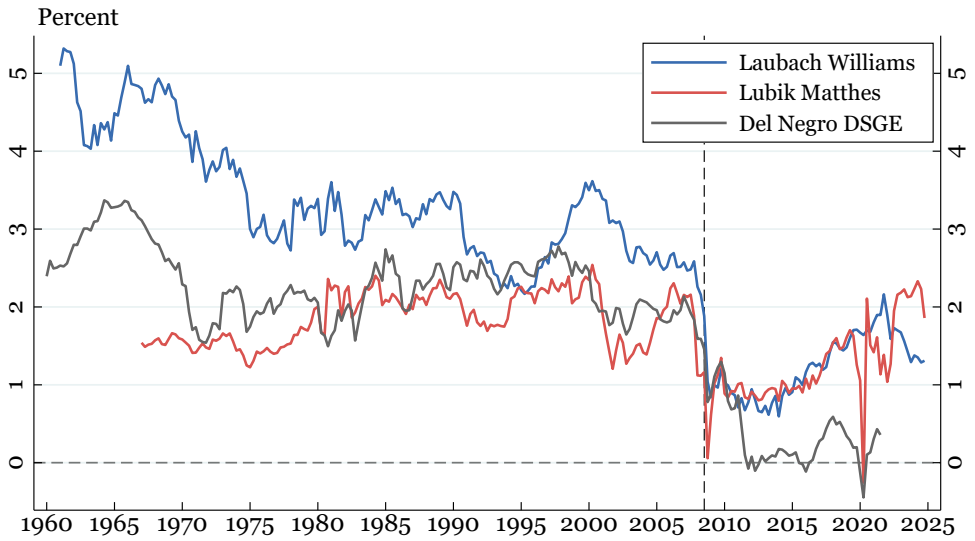
3. Del Negro et al. (2017) derive their measure of R^* from a medium-scale DSGE model with nominal and financial frictions, estimated using yield data along with a broad set of macroeconomic variables. The model equilibrium conditions generate a complete historical trajectory of the natural rate of interest. We refer to this measure as DN-DSGE hereafter.

The estimates of R^* obtained from these three approaches start as far back as 1960:Q1 (DN-DSGE), with the last sample starting in 1967 (LM). The DN-DSGE measures is available until 2019:Q4, while the other two until 2024:Q4.[7]

Figure 1 plots the estimated R^* for each of the three measures discussed above. Two main facts stand out. First, the level is somewhat different across the three measures, in particular the LW

[7]Including the 10-year forward real rate would yield similar results. We opt to exclude this measure because liquidity effects might distort its behavior.

Figure 1 : R^* Over Time.



Note. The figure plots estimated level of R^* from **?**, Lubik and Matthes (2015), Del Negro et al. (2017). The full sample period (which varies across the three measures) is 1960:Q1 to 2024:Q4.

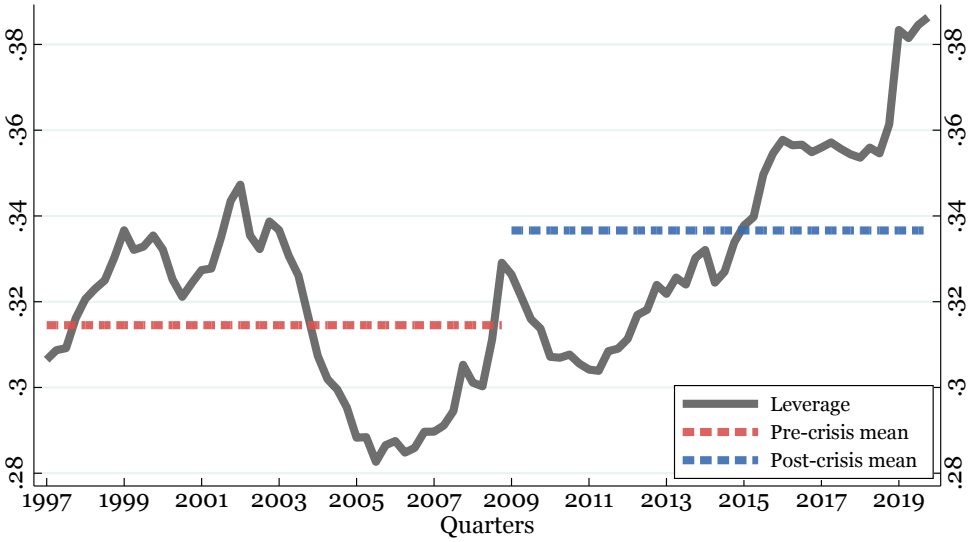
before the GFC and the DN-DSGE afterwards. In addition, the LW measure displays a clear low-frequency downward trend until the financial crisis, which is instead much less apparent in the LM and DN-DSGE measures. Second, despite these differences, estimates generally drop quickly and, in the case of the DN-DSGE measure, repeatedly over the period 2007 to 2012. While the existing literature has mostly focused on the first fact, our paper seeks to explain the sharp decline following the GFC, which is at odds with the usual low-frequency explanations for movements in R^*. In particular, the large drop of R^* post-GFC could be a symptom of multiple regimes or equilibria.

2.2 Four Facts on Firms and Households' Behavior

While the evidence discussed in the previous section raises the possibility of multiple R^* equilibria, the different measures per se do not offer any guidance regarding the reasons for multiplicity. To shed light on the mechanism that might give rise to such an outcome, Section 3 develops a theory based on the interaction of individual income risk and firms' monopsony power. In this section, we bring together four empirical observations that directly motivate the modeling choices that we make—two related to firms and two to households. In the next section, we present evidence linking these firms and households' facts.

Fact 1: Corporate debt has increased. We measure leverage as the average ratio of total debt to total assets using firm-level data from Compustat Fundamental Quarterly (WRDS), which covers

Figure 2 : The Evolution of Corporate Leverage.



Note. The figure plots the evolution of average leverage (see the text for details). The sample period is 1997:Q1 to 2019:Q4.

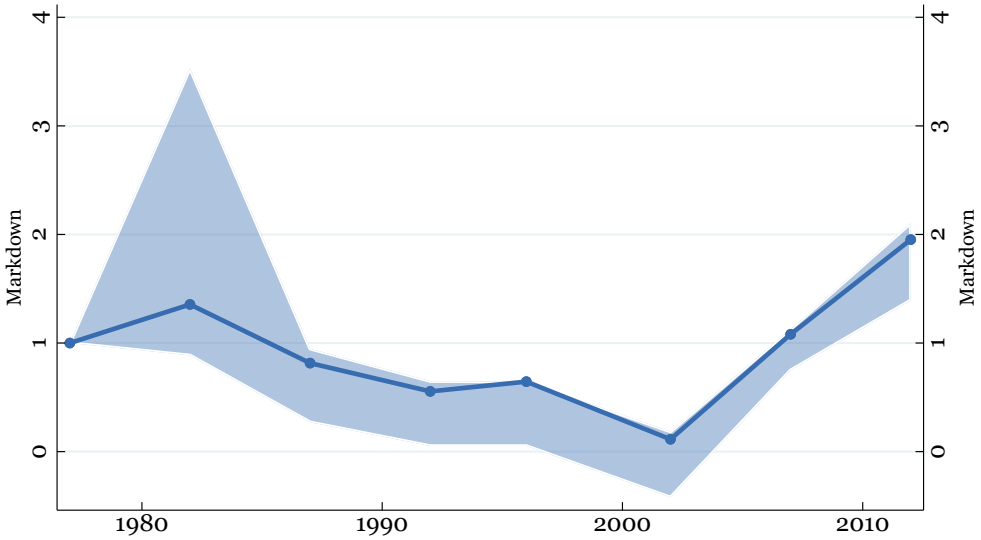
publicly listed firms in the United States from 1997:Q1 to 2019:Q4.[8] For each corporation, leverage corresponds to the ratio of total debt (the sum of variables `dlcq` and `dlttq`) to total assets (variable `atq`). We then calculate the aggregate measure by taking the cross-sectional average, weighted by total assets.

Figure 2 shows the evolution of the resulting measure between 1997 and 2019. Corporate leverage remained relatively stable in the years leading up to the GFC. The most significant development in the first part of the sample is the dip that starts in 2003 and lasts until 2005. Post-crisis, however, leverage has increased from about 0.3 to almost 0.4.

Fact 2: Firms' monopsony power has increased. Langella and Manning (2021) underscore that monopsony power is widespread in modern economies, and not merely a feature of niche or rural labor markets. Their work argues that monopsony arises naturally from job search frictions, labor mobility constraints, and firm-specific wage-setting power, even in otherwise competitive industries. For our purposes, the most important observation is that monopsony power has intensified after the GFC, as labor market concentration has increased, workers have faced fewer outside options, and non-compete agreements and other restrictive employment practices have proliferated. At the same time, the declining elasticity of labor supply to individual firms has made workers are becoming less responsive to wage changes, further strengthening firms' ability to set wages below competitive levels.

[8] We follow standard practice (e.g., as in Ottonello and Winberry, 2020) to clean the data. Appendix A discusses the details, which include dropping duplicates, removing non-US and financial firms (SIC code $\in$ [6000, 6799]), and excluding observations with negative assets. To mitigate the influence of extreme observations, we exclude the top and bottom 0.5% of the observations for these variables.

Figure 3 : Wage Markdowns.



Note. The figure replicates the wage markdown across US firms estimated in Yeh et al. (2022). The shaded area represents bootstrapped standard errors.

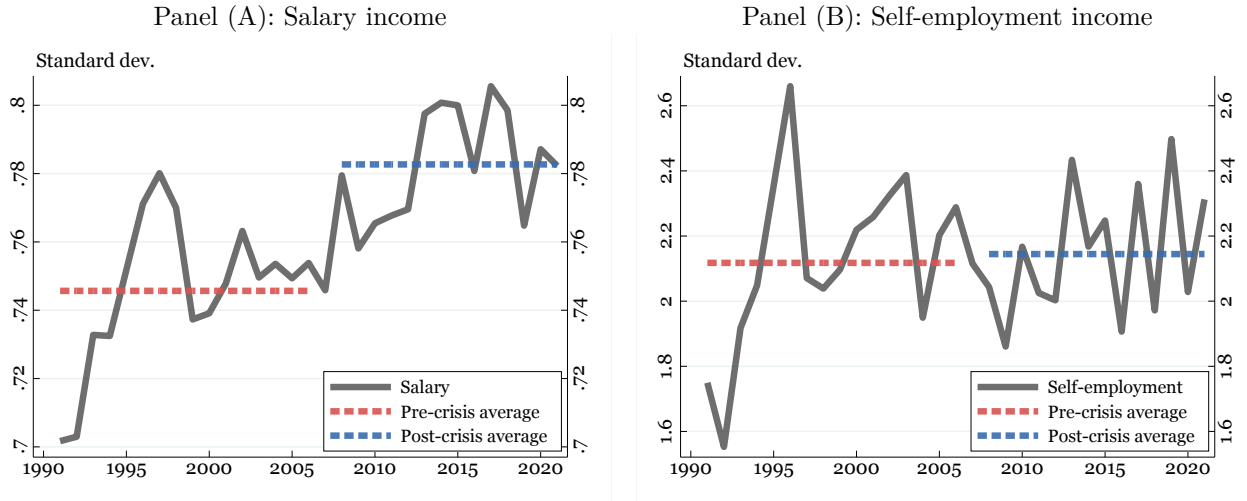
Yeh et al. (2022) present empirical estimates of the growing wage-setting power of firms. These authors construct wage markdowns using administrative data for U.S. manufacturers via the Census and Annual Surveys of Manufactures from the U.S. Census Bureau. These data allow for the estimation of plant-level markdowns which is then aggregated and normalized such that the initial value is 1. Their evidence runs from 1977 to 2012. We replicate their aggregate findings in Figure 3, which shows that wage markdowns—an indicator of firms monopsony power—have been increasing sharply in the U.S. since just before the GFC.

Khan and Metaxoglou (2021) use the same procedure to estimate the aggregate U.S. wage markdown but applied to KLEMS data, which cover a different sample period (1987 to 2018). Like Yeh et al. (2022), their key finding is that the markdown has increased post-GFC and was especially elevated between 2006 and 2015. The higher frequency of their estimates also highlights the strong procyclical nature of markdowns.

Fact 3: Employed workers' income risk has increased. Figure 4 plots the standard deviation of income constructed from the CPS microdata for the period from 1990 to 2021. Panel (A) refers to employees, while Panel (B) to self-employed individuals. Both time series rose substantially in the mid-1990s before stabilizing. However, income risk for employed workers increased by about 5 percentage points right around the GFC. Conversely, income risk for the self-employed, who are not subject to monopsony power, remained stable.

Our findings align well with existing evidence documenting a rise in earnings inequality around the GFC. For instance, Abowd et al. (2018) show that post-2008 earnings inequality increased, particularly among workers at the lower end of the earnings distribution.

Figure 4 : The Evolution of Income Risk.



Note. Evolution of income risk for employed workers (panel A) and self-employed (panel B) workers. Source: CPS, 1990-2021.

Fact 4: The personal saving rate has increased. At the individual level, a natural response to greater income risk is to increase savings. Figure 5 plots the aggregate US personal savings, expressed as a percent of disposable income, from the Bureau of Economic Analysis. The figure shows that savings started to increase significantly during 2008 and continued to rise until 2012. Obviously, many possible factors may drive the behavior of savings around a financial crisis episode. Yet, even from 2013 until the Covid pandemic, personal savings remained well above the average in the run up to the GFC.

2.3 The Relation Between Debt and Wages

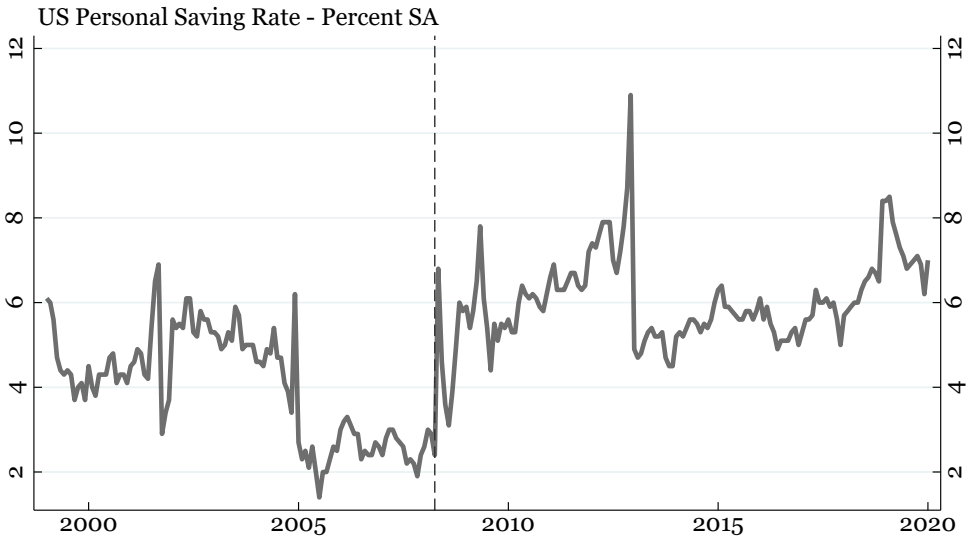
The four facts presented in the previous section show that the ability of the corporate sector to suppress wages has grown alongside broader trends of rising corporate leverage, growing income risk for employees and higher personal savings.[9]

To investigate more directly the relationship between wages and firms' leverage, we use again the firm-level data from Compustat data described in the previous section. We proxy for salary costs per worker (wages) using 'Selling, General, and Administrative Expenses' (code `xsga`) divided by the number of employees (code `emp`). This proxy increases the number of observations that we can employ as the 'Salary' variable (code `xlr`) is available only at a yearly frequency and for a limited subset of firms (about 3,000 out of 15,000 firms with `xsga` data).[10]

[9]The parallels between rising monopsony power and corporate leverage raise essential questions about whether financial pressures, such as the need to service higher levels of debt, have reinforced firms' incentives to suppress wages. This connection may be particularly relevant for understanding post-2008 labor market dynamics—an important issue that we do not address in this paper.

[10]Figure B.6 in Appendix A shows that `xsga` and `xlr` are closely related for the firms in which both variables are

Figure 5 : Personal Saving Rate.



Note. US personal savings in percent of disposable income. Source: U.S. Bureau of Economic Analysis, Personal Saving Rate, retrieved from FRED (`PSAVERT`), Federal Reserve Bank of St. Louis.

Ideally, we would compare firms that are identical in all their characteristics, including size and industry, but differ in their debt levels. In practice, this *ceteris paribus* comparison is challenging since larger firms are typically more productive, pay higher wages, and also tend to borrow more. A naïve regression of wages on debt could therefore confound the impact of debt with productivity effects.

To address this problem, we estimate the regression

$$Wages_{it} = \alpha_{sct,t} + \beta Assets_{it} + \gamma \left(Assets_{it} \times Leverage_{it}\right) + \Gamma Z_{it} + u_{it} \tag{1}$$

where $Wages_{it}$ is the log of salary costs per worker for firm i in quarter t, $\alpha_{sct,t}$ represents sector-time fixed effects (based on the first two digits of the SIC classification), $Assets_{it}$ is the log of total assets (a standard proxy for firm size), $Leverage_{i,t}$ is the log of leverage, and $Z_{i,t}$ is a vector of firm-level controls, including the log number of employees.

The key coefficient of interest in (1) is γ, on the interaction between assets and leverage, which captures the relationship between wages and debt while controlling for firm size. By incorporating fixed effects at the sector level, our empirical model exploits the variation within each sector, helping to mitigate biases from both observed and unobserved factors that might otherwise drive the observed correlation between wages and debt. The inclusion of firm fixed effects further controls for time-invariant characteristics of the firm, both observed and unobserved.

available. Hence not surprisingly, our main results hold when using `xlr` for the smaller subset (see Table D.1 and D.2 in Appendix D).

Table I : Wages and Leverage.

	(1)	(2)	(3)	(4)
Assets	0.49***	0.47***	0.36***	0.36***
	(0.02)	(0.02)	(0.01)	(0.01)
Assets × Leverage		-0.03***		-0.01***
		(0.00)		(0.00)
Sector × Time FE	yes	yes	yes	yes
Firm FE	no	no	yes	yes
Observations	285,075	285,075	284,606	284,606
R-squared	0.64	0.65	0.93	0.93

Note. Robust standard errors (clustered two-way, at the year and firm level) are reported in parentheses, with (0.00) indicating a value lower than 0.005. *** = p<0.01, ** = p<0.05, * = p<0.1. Coefficients corresponding to the constant, fixed effects, and controls (log number of employees and log leverage) are not reported.

Fact 5: Higher leverage is associated with greater monopsony power. Table I presents the estimation results. The regressions reveal a strong positive relationship between wages and firm size. The coefficient on assets is positive and statistically significant in all specifications. For our purposes, however, the key result is that firms with higher leverage pay lower wages, even after controlling for firm size. The comparison of column (1) and column (2) confirms that the introduction of the interaction term does not alter the fundamental relation between wages and size. Larger firms tend to pay higher wages. However, conditional on firm size, higher leverage is associated with lower wages. This negative relationship persists even after including firm fixed effects, as the comparison of columns (3) and (4) highlights.

Taken together, these results suggest that the corporate financial structure plays a significant role in the determination of wages. In the next section, we propose a novel theory that embeds a link between firm debt levels and monopsony power in labor markets. This model provides a unified explanation for the comovement between corporate leverage, monopsony power in labor markets, income risk for workers and their need to increase savings.

3. The Model

We study a closed economy with two types of households: workers and entrepreneurs. Workers are heterogeneous and their labor supply to firms changes over time. Entrepreneurs own the firms and receive their profits but do not work. Two key frictions interact. First, incomplete financial markets prevent workers from fully insuring themselves against idiosyncratic income risk. Second, firms hold *monopsony power* vis-à-vis workers, which increases with leverage, so that debt issuance amplifies workers' income fluctuation. However, the monopsony power does not apply to all worker types,

tying labor market power to fluctuations in workers' labor income. The only source of uncertainty in the model is a sunspot shock that coordinates expectations. We next describe the problem of workers and entrepreneurs, then characterize the equilibrium of the economy.

3.1 Workers

A continuum of worker-households populates the economy. Households can be of two types, high (H) or low (L), each of constant unit mass. In each period, a household switches type deterministically. The $L-$type is potentially subject to monopsony power in the labor market, while the $H-$type is not. Fluctuations in types may give rise to a motive for borrowing or lending, as in Townsend (1980).

Each household type, in turn, comprises a continuum of members, providing a differentiated labor input (task) to firms. All members pool their labor income within the household. The preferences of a household of type $j \in \{H, L\}$ are

$$\mathcal{U}_{j,0} = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[\log(C_{j,t}) - \int_0^1 \frac{L_{j,t}(i)^{1+\varphi}}{1+\varphi} di \right], \tag{2}$$

where $\mathbb{E}_t(\cdot)$ is the expectation operator conditional on information available at time t, $\beta \in (0,1)$ is the household's subjective discount factor, $\varphi > 0$ is the inverse Frisch elasticity of labor supply, $C_{j,t}$ represents household consumption at time t, and $L_{j,t}(i)$ the amount of hours supplied by the member of household j that provides the differentiated labor input $i \in [0,1]$.

Households can save in risk-free bonds $B_{j,t+1}$, which pay the gross interest rate R_{t+1}. Each member receives the wage $W_{j,t}(i)$ per unit of differentiated labor input i supplied. The per-period budget constraint for a worker-household of type j is

$$C_{j,t} + B_{j,t+1} = R_t B_{j,t} + \int_0^1 W_{j,t}(i) L_{j,t}(i) di - T_{j,t}, \tag{3}$$

where $T_{j,t}$ are lump-sum taxes. Finally, households are subject to the borrowing constraint

$$B_{j,t+1} \geq 0. \tag{4}$$

The problem of the worker-household j is to maximize the utility (2) subject to the budget constraint (3) and the borrowing constraint (4).

The optimal consumption-saving decision obeys the modified Euler equation

$$1 - \mu_{j,t} = \beta R_{t+1} \mathbb{E}_t \frac{C_{j,t}}{C_{j,t+1}}, \tag{5}$$

where $\mu_{j,t}$ is the (normalized) Lagrange multiplier on the borrowing constraint. The optimal labor

supply for each task i must respect

$$W_{j,t}(i) = L_{j,t}(i)^{\varphi} C_{j,t}. \tag{6}$$

The budget constraint and the borrowing constraint, with the associated non-negativity constraint on the Lagrange multiplier ($\mu_{j,t} \geq 0$), complete the set of first-order conditions for worker-households.

3.2 Entrepreneurs

A representative entrepreneur owns a firm, which produces output Y_t of a homogeneous good using a technology that combines labor from households of both types according to

$$Y_t = L_{H,t}^{\alpha} L_{L,t}^{1-\alpha}, \tag{7}$$

where $\alpha \in (0,1)$ represents the output elasticity with respect to labor input from households of type H. For each household type j, total labor input $L_{j,t}$ aggregates individual labor across all tasks according to

$$\log L_{j,t} = \int_0^1 \log L_{j,t}(i)\, di.$$

Firms can fund their time-t operations by issuing one-period debt, D_{t+1}, which pays a gross interest rate R_{t+1} at maturity. The representative firm operates competitively in the goods market but may be able to exert some market power when employing labor. Crucially, the extent of this labor market power is endogenous and depends on the firm's issuance of debt. Specifically, the firm acts as a monopsonist in a fraction χ of the tasks performed by type-L workers. This fraction increases with the amount of debt issued by the firm in each period, according to

$$\chi = \chi(D_{t+1}), \tag{8}$$

with $\chi(0) = 0$, $\chi'(0) = 0$, and $\chi'(D) > 0 \; \forall D > 0$. The positive relationship between labor market power and firm leverage aligns with the empirical evidence discussed in Section 2.3.[11]

Bond issuance entails a cost to the firm, over and above interest payments on debt. We denote this issuance cost with $\psi\left(D_{t+1}, \overline{Y}_t\right)$, where $\overline{Y}_t$ corresponds to aggregate output, which an individual firm takes as given. The function $\psi(\cdot,\cdot)$ is convex in its first argument (debt issuance), capturing, in reduced form, the financial frictions faced by firms, whose severity increases non-linearly with the level of debt issued.[12]

Entrepreneurs are risk-neutral and discount the future at rate $\widetilde{\beta} \in (0,1)$. Per-period profits

[11] Greater debt issuance can, for example, increase monopsony power because firms can allocate some borrowed resources toward lobbying efforts aimed at shaping labor regulations in their favor. Chan et al. (2024) discuss an alternative mechanism involving adjustment costs, through which larger firms achieve greater wage markdowns. The rise of private equity provides a further rationale for the link between debt and monopsony power (Davis et al., 2021).

[12] We detail the specific functional form of ψ in Section 4.3.

correspond to the difference between revenues and total wages paid across all tasks, adjusted for resources raised through borrowing and net of debt issuance costs

$$\mathcal{P}_t = Y_t - \int_0^1 W_{H,t}(i)L_{H,t}(i), di - \int_0^1 W_{L,t}(i)L_{L,t}(i), di + D_{t+1} - R_t D_t - \psi\left(D_{t+1}, \overline{Y}_t\right). \tag{9}$$

The entrepreneur's problem is to maximize the present discounted value of per-period profits (9), subject to the technological constraint (7) and the labor supply constraint (6) for all tasks where the firm exercises monopsony power-specifically, that is, the tasks of type L with $i \in [0, \chi]$. Additionally, entrepreneurs internalize how their debt issuance choice influences the fraction of tasks affected by monopsonistic power, as described by (8).

The entrepreneur's optimal demand for each differentiated labor input (task) is the solution to a static problem. Labor demand for tasks supplied by type H is

$$W_{H,t}(i) = \alpha \frac{Y_t}{L_{H,t}(i)}. \tag{10}$$

Similarly, labor demand for tasks supplied by type L in competitive conditions (indexed by c) is

$$W^c_{L,t}(i) = (1-\alpha)\frac{Y_t}{L^c_{L,t}(i)}, \tag{11}$$

for $i \in (\chi, 1]$. Finally, the optimal labor input for tasks supplied by type L in monopsonistic conditions (indexed by m) satisfies

$$(1+\varphi)W^m_{L,t}(i) = (1-\alpha)\frac{Y_t}{L^m_{L,t}(i)}, \tag{12}$$

for $i \in [0, \chi]$.

In equilibrium, all firms employ the same amount of labor and wages are equal across all tasks within type H, reflecting their symmetric role in both the production function and household preferences

$$W_{H,t}(i) = W_{H,t} \qquad \text{and} \qquad L_{H,t}(i) = L_{H,t}$$

$\forall i \in [0, 1]$. Similarly, within type L, equilibrium wages and employment levels are identical. For the monopsonistic sets of tasks we have

$$W^m_{L,t}(i) = W^m_{L,t} \qquad \text{and} \qquad L^m_{L,t}(i) = L^m_{L,t}$$

$\forall i \in [0, \chi]$, while for the competitive set of task we have

$$W^c_{L,t}(i) = W^c_{L,t} \qquad \text{and} \qquad L^c_{L,t}(i) = L^c_{L,t}$$

$\forall i \in (\chi, 1]$, where m and c denote the monopsonistic and competitive market, respectively.

The optimal choice of debt D_{t+1} is instead dynamic and can be written recursively incorporating the static results for labor demand above

$$\begin{aligned} V(R_t D_t) = \max_{D_{t+1}} \quad & (L_{H,t})^{\alpha} (L^m_{L,t})^{(1-\alpha)\chi(D_{t+1})} (L^c_{L,t})^{(1-\alpha)[1-\chi(D_{t+1})]} \\ & - W_{H,t} L_{H,t} - \chi(D_{t+1}) W^m_{L,t} L^m_{L,t} - [1-\chi(D_{t+1})] W^c_{L,t} L^c_{L,t} \\ & + D_{t+1} - R_t D_t - \psi(D_{t+1}, \overline{Y}_t) \\ & + \widetilde{\beta}\, \mathbb{E}_t V(R_{t+1} D_{t+1}). \end{aligned} \tag{13}$$

The borrowing decision influences the level of production (and, thus, revenues) by altering the relative contribution of workers subject to monopsony power, as measured by $\chi(D_{t+1})$, given labor inputs across worker types and tasks $L_{H,t}$, $L^c_{L,t}$, and $L^m_{L,t}$. The second and third terms in the second line capture how borrowing impacts the firm's total wage bill, again through changes in the share of workers subject to monopsony power. The third line represents the direct effect of borrowing on the firm's available resources and the associated borrowing costs. Finally, the fourth line captures the effect of debt on the firm's continuation value in the subsequent period.

The first-order condition associated with this problem is

$$1 + (1-\alpha) Y_t \left[\frac{\varphi}{1+\varphi} + \ln\left(\frac{L^m_{L,t}}{L^c_{L,t}} \right) \right] \chi'(D_{t+1}) = \psi_D \left(D_{t+1}, \overline{Y}_t \right) + \widetilde{\beta} R_{t+1}. \tag{14}$$

The left-hand side shows the benefit to the firm of issuing an extra unit of debt, which corresponds to one extra unit of resources in the current period plus the gain in terms of monopsonistic power. The right-hand side measures the cost of issuing one additional unit of debt, which is the direct cost related to financial frictions plus the interest rate that the firm pays at maturity, where $\psi_D(\cdot)$ denotes the derivative of the borrowing-cost function with respect to the quantity of debt issued. Since entrepreneurs are risk-neutral, their marginal utility of consumption is constant.

We can derive the firm's debt supply curve by replacing the ratio of the labor-market equilibrium conditions across the two subsets of type-L tasks in the expression above. The result is an equilibrium relationship between the firm's optimally chosen debt level and the interest rate

$$1 + \left(\frac{1-\alpha}{1+\varphi} \right) Y_t \left[\varphi - \ln(1+\varphi) \right] \chi'(D_{t+1}) = \psi_D \left(D_{t+1}, \overline{Y}_t \right) + \widetilde{\beta} R_{t+1}. \tag{15}$$

In Section 4.3, we discuss in detail the key properties of this debt supply curve.

3.3 Government

The government levies type-specific lump-sum taxes on households and issues debt D^g_{t+1} subject to the budget constraint

$$D^g_{t+1} = R_t D^g_t - (T_{H,t} + T_{L,t}). \tag{16}$$

In our baseline specification, we assume that the government does not levy any taxes ($T_{H,t} = T_{L,t} = 0\ \forall t$), the initial debt level is zero ($D_0^g = 0$) and thus government debt remains zero throughout ($D_t^g = 0\ \forall t$).

3.4 Market Clearing and Equilibrium

In equilibrium, aggregate output is equal to output produced by the representative firm ($\overline{Y}_t = Y_t$). The market-clearing condition for the goods market is that output produced must equal the sum of consumption of the two types of worker-households and of the entrepreneurs

$$Y_t = C_{H,t} + C_{L,t} + C_{E,t}, \tag{17}$$

where, for the entrepreneurs, consumption equals per-period firm profits ($C_{E,t} = \mathcal{P}_t$).

Wages for the high-type workers and for the competitive segment of low-type workers equate the marginal product of labor with the marginal rate of substitution between consumption and leisure, that is

$$(L_{H,t})^{1+\varphi} = \alpha \frac{Y_t}{C_{H,t}} \qquad \text{and} \qquad (L_{L,t}^c)^{1+\varphi} = (1-\alpha)\frac{Y_t}{C_{L,t}}. \tag{18}$$

For the monopsonistic segment of low-type workers wages equate the marginal rate of substitution with the marginal product of labor adjusted by a markdown that depends the elasticity of labor supply

$$(L_{L,t}^m)^{1+\varphi} = \left(\frac{1-\alpha}{1+\varphi}\right)\frac{Y_t}{C_{L,t}}. \tag{19}$$

Throughout the analysis we focus on the case in which the labor-income share accruing to high-type workers is weakly higher than the share of those workers in the population, that is, $\alpha \geq 0.5$. Thus, low-type households have a desire to borrow, which the presence of monopsony power further exacerbates. A binding borrowing constraint, nevertheless, prevents low-type households from doing so. As a result, in any equilibrium in which the borrowing constraint binds for low-type workers, high-type workers save and accumulate assets, while workers of low type hold wealth and receive interest income. Thus, the bond market clearing condition is

$$B_{H,t+1} = D_{t+1} + D_{t+1}^g. \tag{20}$$

In equilibrium, the amount of assets purchase by high-type households equals the sum of the assets issued by the government and the corporate sector. Since households alternate between types, the assets acquired while of type H provide self-insurance for the next period when a household becomes of type L.

Given initial conditions for the state variables $\{D_0, D_0^g, B_0, R_0\}$ and a sequence of government policies $\{T_{H,t}, T_{L,t}, D_{t+1}^g\}_{t=0}^{\infty}$, an equilibrium is a sequence of quantities $\{C_{H,t}, C_{L,t}, C_{E,t}, L_{H,t}, L_{L,t}^c, L_{L,t}^m, Y_t,$

$D_{t+1}, B_{t+1}, T_t\}_{t=0}^{\infty}$ and prices $\{W_{H,t}, W_{L,t}^c, W_{L,t}^m, R_{t+1}\}_{t=0}^{\infty}$ such that households maximize utility subject to their budget constraint (i.e., equation 2–3), entrepreneurs maximize profits subject to their technology and the labor supply of workers (i.e., equation 13), the government budget constraint holds (i.e., equation 16), and all markets clear (i.e., 17–20).

4. Steady State and Multiple Equilibria

This section starts by characterizing the steady state of the model, highlighting the possibility of multiple equilibria. We then calibrate the model parameters and explore the quantitative properties of the multiple steady-state equilibria. We further analyze how shifts of the debt supply curve affect the equilibrium interest rates, providing empirical evidence in support of the theoretical predictions. Finally, we investigate the effects of asset purchase programs on equilibrium interest rates in the model.

4.1 The Steady State

A deterministic steady state of the economy presented in the previous section is an equilibrium with no shocks in which all variables are constant over time. Therefore, in the remainder of this section, we omit time subscript below to simplify notation.

We focus on an equilibrium in which the borrowing constraint of the $L-$type household always binds, so that their Euler equation pins down the multiplier $\mu_L > 0$. Conversely, type-H workers' Euler equation holds with equality

$$1 = \beta R \frac{C_H}{C_L}, \tag{21}$$

and their borrowing constraint is slack ($\mu_H = 0$).

The type-L workers' budget constraint implies that their consumption level is equal to their labor income plus the wealth and interest income accrued from savings accumulated in the previous period while being type-H workers

$$C_L = (1-\alpha)\left[1 - \frac{\varphi}{1+\varphi}\chi(D)\right] Y + RD. \tag{22}$$

Similarly, consumption of type-H workers equals their labor income net of savings

$$C_H = \alpha Y - D. \tag{23}$$

The labor income of type-H workers is proportional to their contribution to total output, determined by the share α. In contrast, type-L workers earn less than the competitive benchmark share of output $(1-\alpha)$. The reason is that a fraction χ of type-L workers is subject to firms' monopsonistic power in the labor market. The term $\varphi\chi(D)/(1+\varphi)$ captures the extent of the wage markdown resulting from monopsony.

The household demand for bonds follows from substituting the consumption levels of type-L workers, given by (22), and type-H workers, given by (23), into the Euler equation of type-H workers

$$\beta R = \frac{(1-\alpha)\left[1-\frac{\varphi}{1+\varphi}\chi(D)\right]Y + RD}{\alpha Y - D}. \tag{24}$$

The steady-state firms' asset supply curve follows directly from the supply curve in (15)

$$1+\left(\frac{1-\alpha}{1+\varphi}\right)\left[\varphi-\ln(1+\varphi)\right]\chi'(D)Y = \psi_D(D,Y)+\widetilde{\beta}R. \tag{25}$$

Entrepreneurs' consumption is equal to monopsony profits net of interest payments on debt and of borrowing costs

$$C_E = (1-\alpha)\left[\frac{\varphi}{1+\varphi}\chi(D)\right]Y-(R-1)D-\psi(D,Y). \tag{26}$$

Substituting the consumption levels obtained above for type L and H into the labor-market clearing conditions (18) and (19) determines hours worked by each type

$$L_H = \left(\frac{\alpha Y}{\alpha Y - D}\right)^{\frac{1}{1+\varphi}}, \quad L_L^c = \left[\frac{(1-\alpha)Y}{(1-\alpha)Y+RD}\right]^{\frac{1}{1+\varphi}}, \quad \text{and} \quad L_L^m = \left(\frac{1}{1+\varphi}\right)^{\frac{1}{1+\varphi}} L_L^c. \tag{27}$$

In the next subsection, we explain how the properties of workers' asset demand may give rise to multiple steady-state equilibria.

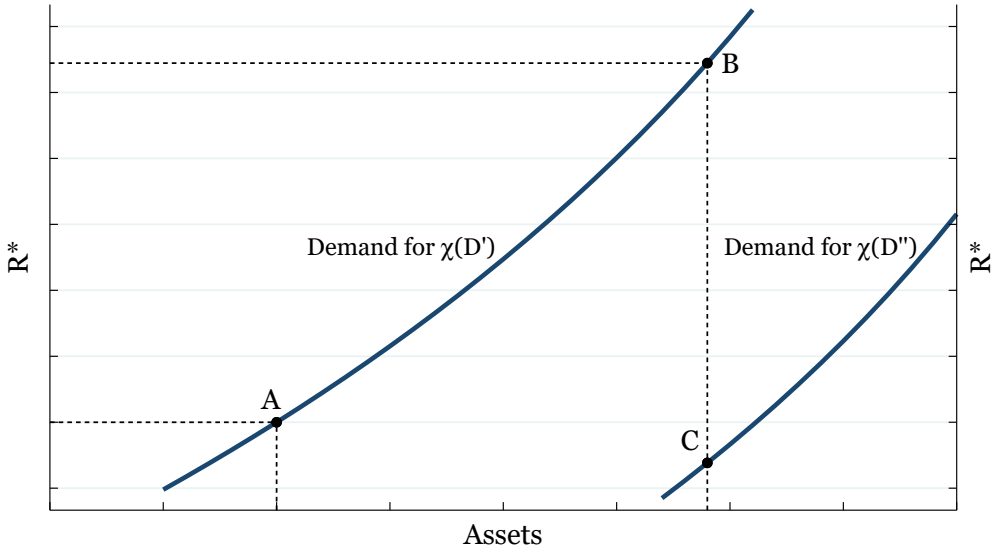
4.2 Steady-State Multiplicity, Monopsony, and Asset Demand

Households' asset demand (24) is crucial in generating the possibility of multiple steady-state equilibria. The impact of higher corporate debt on the interest rate along this demand for bonds is, in general, ambiguous.[13] On the one hand, higher debt allows workers to better smooth consumption over time, exerting upward pressure on the interest rate. On the other hand, higher corporate debt increases firms' monopsonistic power in the labor market, depressing the labor income of type-L workers. This second effect amplifies workers' income fluctuations, raises their demand for insurance, and exerts downward pressure on the interest rate.

Figure 6 illustrates workers' asset demand for two different levels of monopsony power, $\chi(D')$ and $\chi(D'')$. Point A corresponds to a feasible combination of assets and interest rate on the demand curve for a given degree of monopsony power $\chi(D')$. As the degree of monopsony power remains constant, the demand curve exhibits a positive slope. Along this demand curve, more assets held by type-H households correspond to more resources for type-L households, supporting a higher level of consumption in the low state and causing the equilibrium interest rate R to rise. Therefore, if firms issue more debt without increasing their monopsony power, the economy transitions from point A to

[13] Throughout this analysis, we refer to corporate debt simply as "debt," since we abstract for the moment from government liabilities and households face a non-negativity constraint on their asset position.

Figure 6 : Steady State Demand for Debt.



Note. The figure plots the steady state asset demand (24) for two different values of the degree of monopsony power, $\chi(D')$ and $\chi(D'')$.

point B, characterized by higher debt and a higher interest rate. We refer to this mechanism as the *insurance effect*.

However, in our framework, higher debt issuance increases firms' labor market power, reducing the compensation for the fraction of tasks subject to monopsony. The associated reduction in consumption shifts workers' asset demand downward—an effect we label the *monopsonistic effect*. Hence, rather than moving from point A to point B, the economy shifts from point A to point C.

Consequently, the impact of corporate debt on the interest rate is, generically, ambiguous. If the insurance effect dominates, the asset demand curve remains positively sloped in the $(R, D)-$space. Conversely, if the monopsonistic effect prevails, the asset demand curve becomes negatively sloped. The monopsonistic effect dominates when the increase in monopsony power due to higher corporate debt issuance is sufficiently large.

A necessary condition for multiple equilibria to exist is that, at some debt-interest rate combination, the monopsonistic effect outweighs the insurance effect, causing the asset demand curve to be negatively sloped. When both debt demand and supply curves are negatively sloped, multiple equilibria can arise. Conversely, if debt demand is upward-sloping and debt supply in downward-sloping, as standard, a unique equilibrium exists.

In the next subsection, we present a simple parametrization of the model under which multiple equilibria emerge. Importantly, however, the existence of multiple equilibria does not rely on this specific calibration. Rather, what matters is that monopsony power $\chi(D)$ increases strongly enough with debt issuance D over a certain range of debt levels.

4.3 Calibration and Quantitative Properties of Steady States

We calibrate the model to match the quantitative properties of the equilibrium to standard empirical targets. In particular, we impose functional forms and parameters for the functions $\chi(D)$ and $\psi(D)$, which govern how debt affects monopsony power and the cost of bond issuance, respectively.

Two opposing forces operate on the demand for debt, the monopsonistic and the insurance effect. The function $\chi(D)$ plays a key role in shaping the magnitude of the monopsonistic effect, and thus the shape of the demand function (24). We postulate a flexible formulation for the way in which debt affects the monopsonistic power of firms, given by

$$\chi(D) = \frac{\gamma_1 D^{\gamma_2}(1+D)}{1+\gamma_1 D^{\gamma_2}(1+D)}, \tag{28}$$

where γ_1 and γ_2 are positive parameters. This function allows for a non-linear relationship between debt and monopsony power, which, in turn, implies a non-monotonic household asset demand.

The shape of the supply curve (25) further depends on the functional form for the cost of issuing debt

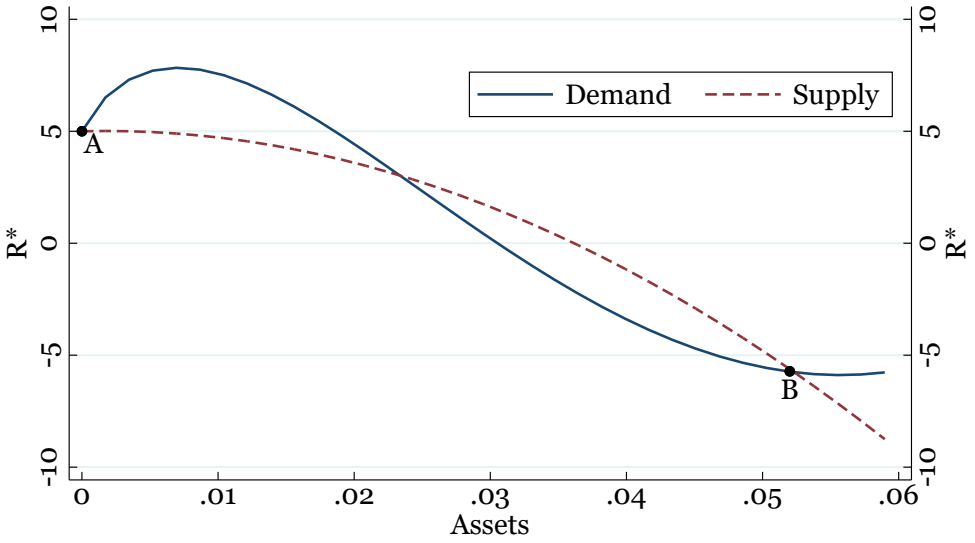
$$\psi(D, \overline{Y}) = [\delta_1 \chi(D) + \delta_2 D^2 + \delta_3 D^3]\overline{Y}. \tag{29}$$

The first term "undoes" the effects of $\chi(D)$ on the supply of bonds. The remaining terms amount to a convex adjustment cost. We parametrize δ_1, δ_2 and δ_3 to set the shape of the supply curve.

We calibrate the model at quarterly frequency. The discount factor of entrepreneurs ($\widetilde{\beta} = 0.9877$) implies an annualized real interest rate equal to 5% when debt is zero. We then impose that households are more impatient than entrepreneurs ($\beta < \widetilde{\beta}$) to ensure that workers of type-L are always against the borrowing constraint. Assuming a 8% annualized discount rate gives $\beta = 0.9804$. Replacing (22) and (23) with $D = 0$ into the Euler equation for type-H workers (21) pins down an implied value for α, which turns out to be equal to 0.5018. We further choose an inverse Frisch elasticity of labor supply (φ) equal to 3, which corresponds to an intermediate value between micro and macro estimates. Given these parameter values, output equals one in the equilibrium with zero debt and zero monopsony power.[14] We set the parameter δ_1 of the bond issuance cost function to equal $\left(\frac{1-\alpha}{1+\varphi}\right)[\varphi - \ln(1+\varphi)]$, to ensure that firms' marginal cost of issuing debt remains strictly positive, even after accounting for the marginal benefit firms obtain from increased monopsony power when issuing debt. We set the parameters that govern the function $\chi(\cdot)$, γ_1 and γ_2, equal to 26 and 1.4, respectively. These parameters ensure that households' income risk is mildly increasing in debt for low levels of firm-issued debt, and increasing more sharply as the level of debt increases, until plateauing when most L-type workers are subject to monopsony power. These properties of monopsony power give rise to a household asset demand that is initially increasing, then decreasing, and finally increasing again in the D, R space. Specifically, these parameters imply that the asset demand crosses the low-debt steady state interest rate of 5% for a level of debt of 2% and that the

[14] The level of output also depends on the relative weight of labor disutility in (2), which we have assumed to be one.

Figure 7 : Steady State Equilibria in the Debt Market.



Note. The figure plots R^* as a function of assets (D). The solid blue line is the demand for bonds. The dashed red line is the supply of bonds. The points A and B denote two stable steady state equilibria in the debt market. A third, unstable equilibrium is also possible.

minimum of the asset demand is in correspondence of a level of debt of 5.5% and an interest rate of -6%. Finally, we set the remaining parameters of the bond issuance cost function $\psi(\cdot,\cdot)$, δ_2 and δ_3, equal to 0.04 and -10.8, respectively, to ensure that the slope of the debt supply is negative and concave in the D, R space and to pin down the location of the high-debt steady state.

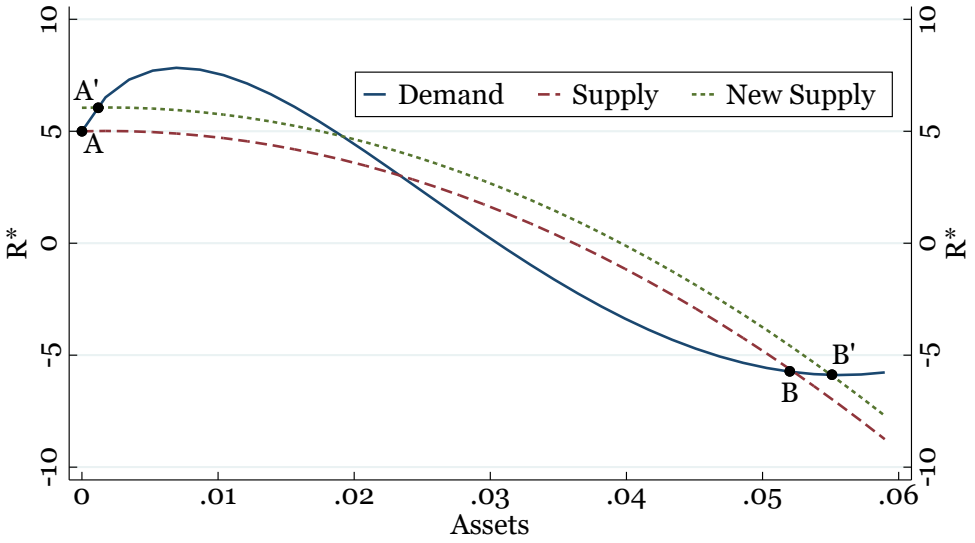
Multiple steady-state equilibria emerge in this economy, as the parametrization above implies a strong effect of firms' bond issuance on their monopsony power, leading to a steep downward-sloping segment of the bond demand curve. Consequently, bond demand and supply intersect at three interest rate-debt pairs, corresponding to three steady-state equilibria. Two of these equilibria are stable, while one is unstable. Figure 7 illustrates the intersection of steady-state bond demand and supply, with A and B denoting the two stable equilibria. We discuss the properties of these stable equilibria below.

The two stable equilibria differ markedly in several respects. In equilibrium A, debt is low (normalized to zero) and the real interest rate is relatively high (5%), corresponding to the inverse of the discount factor of the entrepreneurs. At zero debt, firms have no monopsony power, and wages are equal to the marginal product of labor for all households. As a result, the only source of household income risk arises from the difference in labor income shares. Evaluating consumption of the two worker types, (22) and (23), when $D = 0$ yields

$$C_L = (1-\alpha)Y \qquad \text{and} \qquad C_H = \alpha Y.$$

Since firms' monopsony power does not rise sharply with debt issuance when the level of debt is close

Figure 8 : A Debt Supply Shock.



Note. The figure plots a shift in the supply of debt (from the red dashed to the green dotted line). The new stable equilibria are points A' and B'.

to zero, the households' bond demand curve exhibits a conventional positive slope in the vicinity of this equilibrium.

In contrast, in equilibrium B, debt is positive and the real interest rate is relatively low. Firms issue a positive amount of debt, which households of type H purchase, while households of type L hold maturing claims against firms acquired in the previous period. Under our calibration, the steady-state debt level in this equilibrium equals 0.05. When debt is sufficiently high, its issuance significantly increases firms' monopsony power. As a result, asset purchases by type-H workers exacerbate income and consumption fluctuations rather than smoothing consumption through self-insurance. In this region, the monopsonistic effect dominates over the insurance effect. Consequently, the real interest rate in this equilibrium is low (-5.7%), with type-H households enjoying higher income and consumption than type-L households, whose average wage is 23% below their marginal product of labor due to firms' labor market power.

4.4 Shifts to the Supply of Debt

Although proving the existence of multiple equilibria is challenging, the steady state analysis offers a testable implication: the slope of the households' bond demand varies as a function of debt, with a positive slope for low debt levels and a negative slope for higher debt levels. Hence, our model allows the relationship between bond demand and interest rates to differ across the two steady-state equilibria.

Figure 8 illustrates the implications of an increase in the supply of bonds in the model. We obtain

the shift in the supply curve by lowering the discount factor of entrepreneurs $\widetilde{\beta}$.[15]

Starting from point A (high interest rate), if the economy remains in the vicinity of this equilibrium following a shift in debt supply, the interest rate rises. For low levels of debt, the standard insurance effect dominates. Higher debt issuance by firms enables workers to better smooth consumption fluctuations, leading to a higher interest rate. However, for sufficiently high debt levels, the demand curve slopes downward. As a result, near the low-interest-rate equilibrium (point B), an increase in bond supply reduces the real interest rate. While the model does not inherently select between the two equilibria, Figure 8 highlights a testable implication: the effect of increased debt issuance on the real interest rate differs across the two steady-state equilibria.

We validate the model by testing this prediction against the data. Using data from the non-financial corporate sector, we study how shocks to firms' debt issuance affect the equilibrium real interest rate R_t^*, which allows us to estimate the slope of the bond demand function. For this purpose, we create an instrumental variable that exploits the large degree of heterogeneity in leverage across COMPUSTAT firms, enabling us to identify an exogenous increase in firm debt. The sample covers the period 1997:Q1-2019:Q4. Following Gabaix and Koijen (2024), we construct a Granular Instrumental Variable (GIV) by using the cross-sectional variation in outstanding debt for large firms over time. Specifically, we first extract firm-level idiosyncratic debt innovations from our large panel of US corporations. Second, we construct the GIV by computing the difference between a size-weighted and an equal-weighted average of these firm-level innovations. Third, after checking that the GIV satisfies the appropriate requirements, we run local projections to estimate how R_t^* responds to exogenous shifts in firms' debt issuance over different periods.

The first step of our approach consists in isolating idiosyncratic changes in firm-level debt by estimating the regression

$$\Delta D_{i,t} = \alpha_i + \alpha_{sct,t} + \epsilon_{i,t}, \tag{30}$$

where $D_{i,t}$ is debt of firm i at time t, α_i is a firm fixed effect controlling for time-invariant firm characteristics and $\alpha_{sct,t}$ is a sector-time fixed effect based on the first two digits of the SIC classification. The estimated residuals $\hat{\epsilon}_{i,t}$ capture movements in firm-level debt that cannot be explained by sector-specific common factors or individual fixed effects.[16]

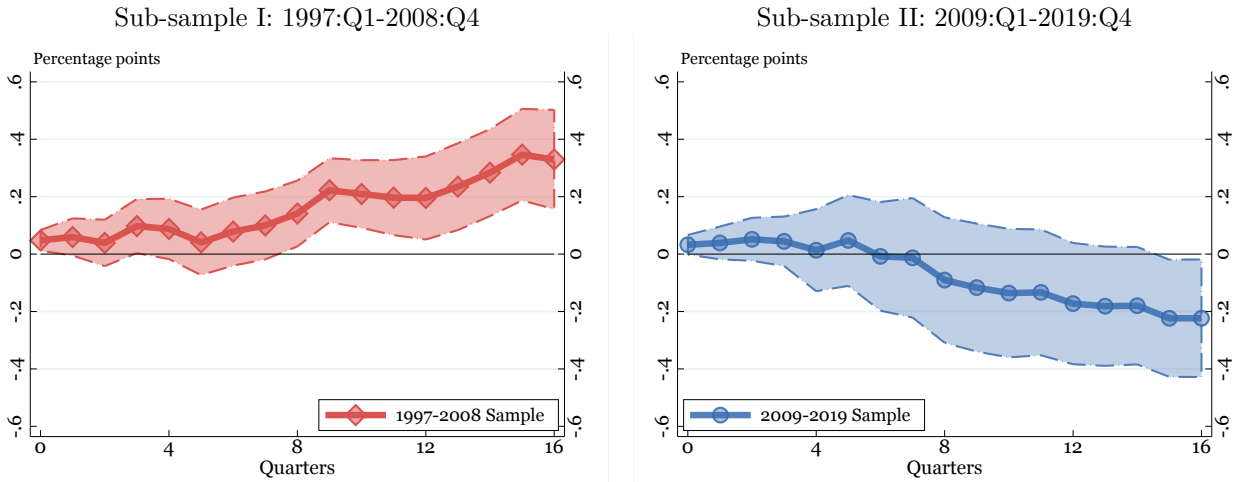
In the second step, we construct the granular instrument by taking the difference between the size-weighted average and the equal-weighted average of the firm-level debt innovations $\hat{\epsilon}_{i,t}$

$$\mathrm{z}_t = \sum_{i=1}^{N_t} w_{i,t-1}\hat{\epsilon}_{i,t} - \frac{1}{N_t}\sum_{i=1}^{N_t}\hat{\epsilon}_{i,t}, \tag{31}$$

[15] Specifically, we decrease $\widetilde{\beta}$ from 0.9877 to 0.9851. Alternatively, an equivalent shift in the supply curve could be achieved by introducing a proportional subsidy on debt interest rate payments—to capture a favorable tax treatment—financed by a lump-sum tax on entrepreneurs, so that the policy is budget-neutral for the government.

[16] An alternative approach would be to run a principal component analysis on the panel of firms and use the variation not explained by the first few components as a proxy for idiosyncratic firm-level variation. Given the unbalanced nature of our panel, we favor the fixed-effect approach.

Figure 9 : The Response of R^* to a Debt Issuance Shock.



Note. Dynamic response of R_t^* to an exogenous increase in firm debt identified using a granular instrumental variable approach (Gabaix and Koijen, 2024) in a local projection specification (Jorda, 2005). The weights are computed with total assets. The local projection specification controls for one lag of the instrument, one lag of the dependent variable, and one lag of GDP growth. The sample period is 1997:Q1-2008:Q4 for the left panel, and 2009:Q1-2019:Q4 for the right panel.

where N_t is the total number of firms in each period and $w_{i,t}$ is the weight of firm i at time t, so that both weights add up to one in all periods (i.e., $\sum_i w_{it} = \sum_i (1/N_t) = 1 \ \forall t$). In our baseline specification, we use weights based on firms' total assets, which satisfy standard granularity assumptions (see Appendix C for details).

Finally, the third step is to estimate the effects of a shock to firms' debt issuance on the equilibrium real interest rate by means of a local projection specification

$$R^*_{t+h} - R^*_{t-1} = \alpha^h + \alpha^h_q + \beta^h z_t + \sum_{\ell=1}^{P} \gamma^h X_{t-\ell} + \nu_{t+h}, \tag{32}$$

where R_t^* is the estimated 30-year-forward short-run interest rate from Del Negro et al. (2017), α^h is a constant, α^h_q is a quarterly dummy to capture seasonality effects, $X_{t-\ell}$ is a vector of controls that includes real GDP growth, lags of R_t^*, and lags of the granular instrument, and ν_{t+h} is a residual.[17]

The two panels of Figure 9 show the impact of an exogenous increase in firms' debt issuance on the equilibrium real interest rate up to 16 quarters (that is, the coefficient β^h with $h = 0, ..., 16$), for two sub-samples of roughly equal length.[18] For the first sub-sample (left panel), which covers the period from 1997 until the financial crisis of 2008, higher corporate debt issuance raises the equilibrium real interest rate. This response aligns well with the standard intuition of the effects of

[17] In robustness exercises, we consider alternative 'macro' measures of R_t^*, including those by Laubach and Williams (2003) and Lubik and Matthes (2015), as well as a measure derived from term structure models (a 10-year real forward rate).

[18] Appendix D shows that in the full sample (1997-2019), an asset supply shock leads to a mild increase of R_t^*.

an increase in supply. As firms issue more debt, its price should fall and the return should increase. This adjustment is consistent with a positively sloped households' demand for assets, as depicted in Figure 8 when the equilibrium moves from A to A'.

The right panel of Figure 9 shows the response of the equilibrium real interest rate to an exogenous increase in firms' debt issuance in the second sub-sample, which runs from 2009 to 2019. In this case, the sign of the response flips compared to the pre-crisis sub-sample. An increase in firms' debt issuance now leads to a drop in R_t^*. This response to an outward shift of the supply schedule is inconsistent with a positively-sloped demand for assets. Instead, the demand curve must be negatively sloped, at least locally, as in Figure 8 when the equilibrium moves from B to B'.

Interpreted through the lens of the model, the empirical results suggest a structural shift in the relationship between debt issuance and the equilibrium real interest rate after the Global Financial Crisis. Before 2008, the economy fluctuated around a high-interest-rate equilibrium, such as point A in Figure 8, where higher debt issuance raises the real interest rate, consistent with an upward-sloping asset demand curve. After 2008, the economy transitioned to a low-interest-rate equilibrium, similar to point B, where increased debt supply lowers the real interest rate due to a downward-sloping asset demand curve. The next section explores potential drivers of this shift.

4.5 Steady-State Effects of Asset Purchase Programs

This section examines the model implications of shifts in government policy. Our focus is on the impact of large-scale asset purchases on equilibrium outcomes. We proceed in two steps. The first is to outline how asset purchases operates within our framework. The second is to highlight the potential of negative impact of asset purchases on the equilibrium real interest rate.

With a slight abuse of terminology, we refer to asset purchases of private assets as quantitative easing (QE).[19] Relative to actual asset purchase programs since the GFC, the experiment that we consider features two main differences. The first is that we focus on permanent purchases, although the next section extends the analysis to temporary purchases and the dynamics of the equilibrium real interest rate. The second is that, differently from most of the existing literature on QE, we abstract from the effects on liquidity and safety premia and instead zoom in on the consequences for risk sharing.[20]

We amend the model by letting B^G denote the amount of corporate debt purchased by the

[19] In practice, purchases of private-sector issued assets accounted for a relatively small fraction of official asset purchases. However, this exercise may also capture in a stylized way the QE-induced rise in the demand for corporate debt, as investors seek higher yields in response to lower returns caused by central bank purchases of government securities, and through the reduction in corporate risk that such programs generate (Krishnamurthy and Vissing-Jorgensen, 2011).

[20] An additional minor difference is that, in our exercise, the authority that purchases assets is the government, not the central bank. This aspect is not crucial, since we can interpret the government budget constraint as consolidating fiscal and monetary policy in a model with two separate authorities.

government. In equilibrium, the steady-state consumption of type-L workers becomes

$$C_L = (1-\alpha)\left[1 - \frac{\varphi}{1+\varphi}\chi(D)\right]Y + RB^P - T_L, \tag{33}$$

where now B^P represents private asset holdings and T_L denotes taxes for type-L workers. Similarly, for type-H workers, consumption is

$$C_H = \alpha Y - B^P - T_H, \tag{34}$$

where T_H denotes the taxes that type-H pays. The government's steady-state budget constraint is

$$(R-1)B^G = -T, \tag{35}$$

where total tax revenue is $T = T_L + T_H$. For simplicity, we assume that the government only taxes type-H households to finance its purchases and transfers the returns on its asset holdings to type-L workers, so that

$$T_H = B^G \qquad \text{and} \qquad T_L = -RB^G. \tag{36}$$

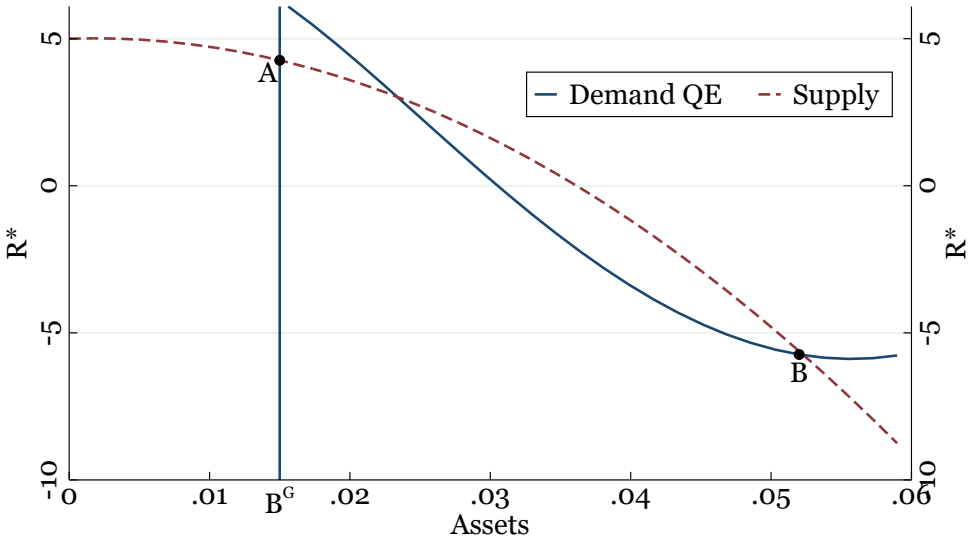
Under these tax rules, the private demand for corporate debt remains unchanged relative to the baseline scenario. Notably, the fiscal rules in (36) are equivalent to a specification in which the government issues public debt to purchase corporate debt, provided that type-H households fully absorb the new issuance.

Figure 10 illustrates the impact of the asset purchase program. In our model, type-H households indirectly hold at least B^G in corporate debt through government intervention. Consequently, asset holdings below B^G are no longer feasible, and the lowest-debt equilibrium shifts to the new point A. In this equilibrium, firm-issued debt is positive and equal to B^G, while the interest rate is lower than in the low-debt equilibrium of the baseline model. The key mechanism is that increased government demand prompts firms to issue more debt, which in turn strengthens their monopsony power in the labor market. Greater monopsony power increases wage markdowns for low-type workers, amplifying their income fluctuations. Ultimately, government asset purchases impose a negative externality on workers by lowering their labor income and increasing its volatility.

A sufficiently large government purchase of corporate debt can eliminate the high-interest-rate/low-debt equilibrium. In Figure 10, if B^G exceeds the debt level of the unstable equilibrium, the intersection of asset demand and supply at point A vanishes, leaving only the low-interest-rate, high-debt equilibrium at point B.

This experiment highlights a possible unintended consequence of asset purchase programs, as suggested in Schnabel (2024). Clearly, the caveat is that by abstracting from both their positive effects and other potential costs, our model does not provide a comprehensive evaluation of QE. Instead, our objective is to demonstrate that unconventional monetary policy can interact with structural features

Figure 10 : Asset Purchase Program.



Note. The figure plots the effects of a fiscal authority that permanently purchases an amount B^G of corporate debt. The dashed red line is the bond supply curve, while the solid blue line is the bond demand curve inclusive of government purchases, where B^G is the minimum amount of corporate debt H households must hold. If B^G moves beyond the unstable equilibrium, point A disappears, and the economy converges to point B.

of the economy in ways that lead to unintended and persistent changes in equilibrium outcomes.

While the model admits multiple steady states, one limitation of the analysis so far is that we have not characterized how the transition from one equilibrium to another can occur, either as a consequence of asset purchase programs or of other factors. The next section extends the analysis to equilibrium dynamics, showing that even smaller asset purchases—insufficient to eliminate the high-interest-rate steady-state equilibrium—can still push the economy toward the low-interest-rate steady state. In addition, we discuss two other possible reasons for a switch from a high to a low-interest-rate equilibrium.

5. Equilibrium Interest Rate Dynamics

In this section, we characterize the dynamic equilibria of the model. First, we discuss the properties of the model that give rise to dynamic multiplicity, and thus to a role for sunspot shocks in determining the level of debt and the equilibrium real interest rate. Second, we analyze a range of scenarios for sunspot shocks and government policies that can rationalize the shift from a high to a low-R^* equilibrium around the 2008 GFC.

5.1 Dynamic Equilibria, Multiplicity, and Sunspots

Our economy allows for dynamic equilibria that differ from the steady states. In these dynamic equilibria, households' expectations about their next-period consumption play a crucial role in determining the households' bond demand and, therefore, the equilibrium real interest rate. Just as multiple steady-state equilibria are present, multiplicity of equilibria can also arise over time. As a result, the realization of a sunspot shock that coordinates households' expectations about next-period consumption can potentially determine consumption and the interest rate in each period. In what follows, we first describe an algorithm that allows us to characterize dynamic equilibria in the model economy. Next, we show that multiple dynamic equilibria are possible if the economy is expected to be in steady state from the subsequent period onward, giving rise to the potential for sunspot shocks to select among such multiple equilibria. Then, we introduce a process for sunspot shocks and characterize the sunspot equilibrium. In the next section, we analyze the quantitative predictions of this economy with sunspot equilibria.

5.1.1 Dynamic Equilibria

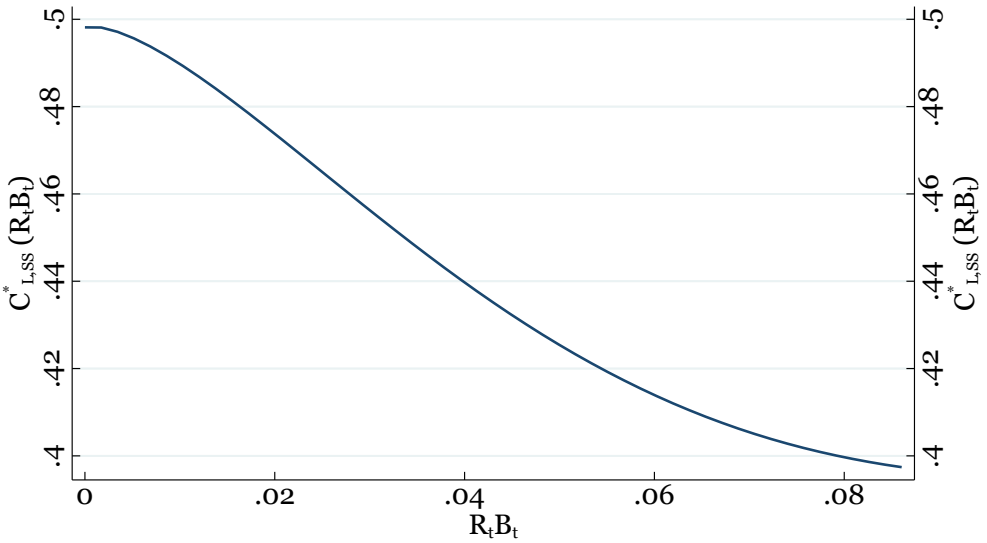
In order to fully characterize the dynamic equilibria, we first determine output, consumption, employment, and wage levels consistent with households' and firms' optimality given households' wealth, for all possible choices of assets to be carried to the next period. Second, we explain how households' expectations pin down the households' bond demand—i.e., the real interest rate associated with households' optimality for any choice of household savings, given household wealth. Third, we derive firms' bond supply, which is a constant function in every period, closely related to its steady-state counterpart. Finally, we construct dynamic equilibria as the intersection of bond demand and supply. We show that for any level of initial wealth that households hold, multiple equilibria may arise, depending on the realization of the sunspot shock that coordinates households' expectations about next-period consumption.

Output and Consumption: The amount of output produced in the economy is a function of households' initial wealth $R_t B_t$ and of the choice of next-period asset holdings B_{t+1}, which we obtain from the solution of a static system of equations comprising the production function, the two households' budget constraints, their labor supply, and the firms' labor demand. We denote this relationship between output, wealth, and saving as $Y_t = Y(B_{t+1}, R_t B_t)$. Given the households' budget constraint and the equilibrium in the labor market, we can also determine a similar function for consumption of the high-type household, that is, $C_{H,t} = C_H(B_{t+1}, R_t B_t)$.[21]

Household Bond Demand: We denote the expectation about the next-period policy function for the consumption of the L-type household $C_L^*(R_{t+1}B_{t+1})$, which is a function of next-period wealth $R_{t+1}B_{t+1}$. Using the consumption functions of the high and low-type household into the high-type

[21] Appendix F.2 fully outlines the derivation of these two functions.

Figure 11 : Initial Guess for Consumption Policy Function.



Note. The figure plots an initial guess for the low-type consumption policy function $C^*_{L,ss}(R_{t+1}B_{t+1})$ based on the steady-state solution.

household Euler equation at time t (5), we obtain

$$\frac{1}{C_H(B_{t+1}, R_tB_t)} = \beta R_{t+1}\mathbb{E}_t\left[\frac{1}{C^*_L(R_{t+1}B_{t+1})}\right]. \tag{37}$$

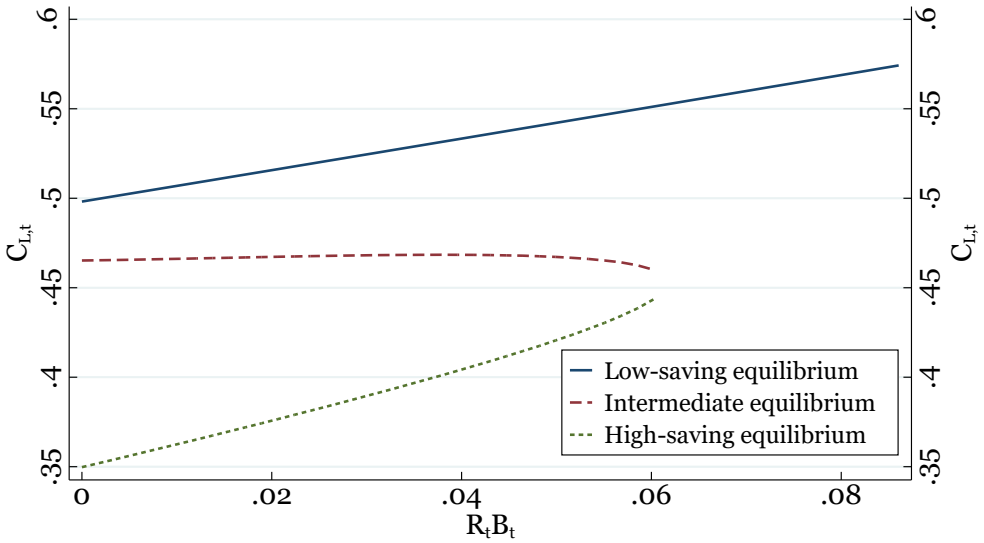
The solution of this non-linear equation determines R_{t+1} as a function of R_tB_t and B_{t+1}, which corresponds to the bond demand $R^d(B_{t+1}, R_tB_t)$.

Bond Market Equilibrium: The supply of bonds corresponds to (15), except for the dependence of output $\overline{Y}_t = Y_t$ on wealth and savings. The equilibrium interest rate and bond issuance are the values for R_{t+1} and B_{t+1} that jointly satisfy bond demand and supply, (37) and (15), imposing the bond market-clearing condition (20) and that output and consumption of the high-type households are determined by $Y(B_{t+1}, R_tB_t)$ and $C_H(B_{t+1}, R_tB_t)$. The intersection pins down the equilibrium choice for bonds as function of initial wealth, $B_{t+1} = B^*(R_tB_t)$.

5.1.2 Equilibrium Multiplicity

Multiple equilibria are possible for any given level of initial wealth R_tB_t. We illustrate the logic whereby this result occurs by considering first the case in which households expect savers in the following period to behave identically to savers in the current period (that is, the equilibrium choice of bonds in the following period is expected to satisfy $B_{t+2} = B_{t+1}$). This guess is correct if, in the following period, the economy is in one of the multiple steady states equilibria. The guess for the bond policy functions implies a guess for the consumption policy function of the low-type household, which we denote as $C^*_{L,ss}(R_tB_t)$ and plot in Figure 11.

Figure 12 : Consumption Policy Function(s) Given Initial Guess.



Note. The figure plots the policy functions for consumption of the low-type household that correspond to each of the multiple equilibria in the market for bonds, given the initial guess for next-period consumption of the low-type household itself.

A non-monotonic bond demand emerges in this economy if households' expect next-period consumption to follow the steady-state policy function $C^*_{L,ss}(R_{t+1}B_{t+1})$. Hence, multiple intersections between the bond demand and supply may occur for some levels of initial wealth, and multiple equilibria may thus arise. Figure 12 displays the policy functions for bonds and low-type household consumption corresponding to each of the multiple equilibria, as a function of initial wealth. The presence of multiple equilibria in the above example highlights the possibility that the unique policy function $B_{t+2} = B_{t+1}$ is not, in general, correct.

5.1.3 Sunspot Shocks

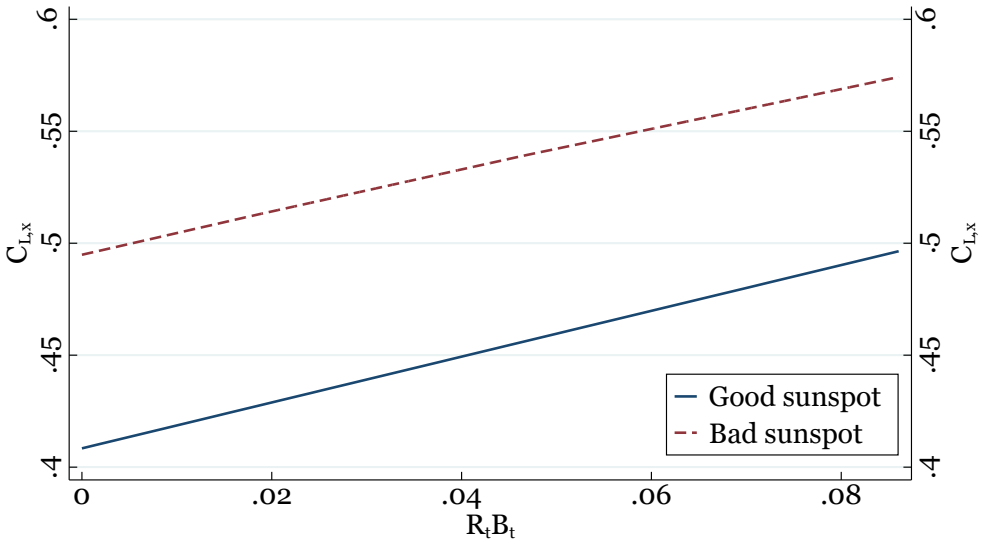
Given the presence of multiple equilibria, we assume that a sunspot shock coordinates household expectations about next-period policy functions. Specifically, the sunspot shock x_t takes two possible realizations $\{x_G, x_B\}$, where the subscript G refers to a "good" equilibrium and B to a "bad" equilibrium. The sunspot shock follows a Markov process whose transition matrix is

$$\begin{bmatrix} \pi & 1-\pi \\ 1-\pi & \pi \end{bmatrix},$$

with $\pi \in [0, 1]$, where the diagonal entries correspond to the probability of remaining in the same state over two periods.

If the good realization occurs, the sunspot selects the equilibrium in which consumption of the L-type household is the highest, and vice versa with the bad realization. The sunspot shock thus co-

Figure 13 : Consumption Policy Function(s) in the Sunspot Equilibrium.



Note. The figure plots the policy functions for consumption of the low-type household associated to the good and bad realization of the sunspot shock, respectively.

ordinates households' expectations about next-period policy functions, and its realization determines the equilibrium choice for bonds. We set the persistence of this sunspot process π to 0.9725.

We define two couples of policy functions, for consumption of the low and high-type households, conditionally on the two possible realizations of the sunspot shock, $C_{H,x_j}(R_tB_t)$ and $C_{L,x_j}(R_tB_t)$, for $j = \{G, B\}$. Formally, we solve for the fixed point of the functional equation in the policy functions

$$\frac{1}{C_{H,x_G}} = \beta R_{x_G,t+1}\left[\pi\frac{1}{C_{L,x_G}} + (1-\pi)\frac{1}{C_{L,x_B}}\right] \tag{38}$$

and

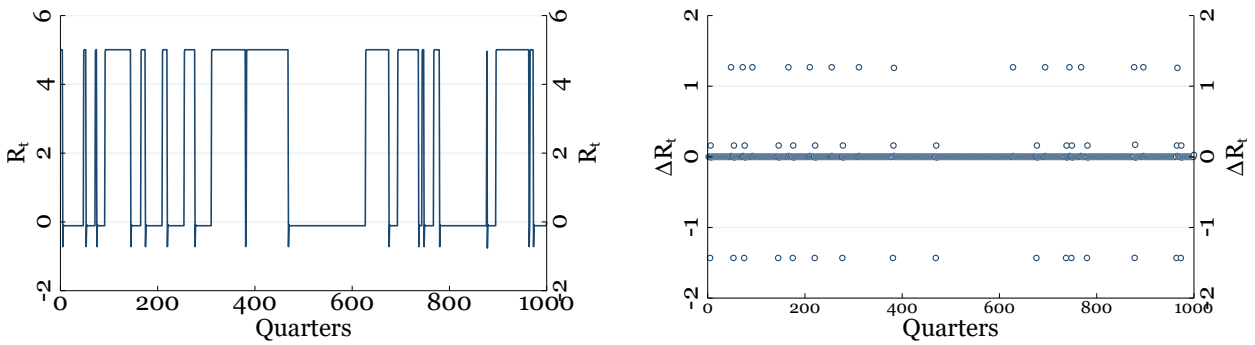
$$\frac{1}{C_{H,x_B}} = \beta R_{x_B,t+1}\left[\pi\frac{1}{C_{L,x_B}} + (1-\pi)\frac{1}{C_{L,x_G}}\right], \tag{39}$$

where $R_{x_j,t+1}$ denotes the interest rate between period t and $t+1$ when the realization of the sunspot shock at t is given by x_j. Conditional on the sunspot realization, the two Euler equations above define a couple of policy functions for next-period assets also conditional on the sunspot. Figure 13 plots the policy functions for consumption from the sunspot equilibrium.[22]

Figure 14 presents the level of the equilibrium real interest rate (left panel) and its changes (right panel) from a simulation with sunspot shocks. The figure highlights the potential for sunspot shocks to give rise to sharp movements in interest rates.

[22] A full characterization of the equilibrium requires that the policy functions for consumption and asset accumulation are consistent with goods and labor market clearing in each period and for each sunspot shock realization. Appendix F.3 outlines the solution method for the dynamic equilibrium with sunspot shocks.

Figure 14 : Simulation of the Sunspot Equilibrium.



Note: The figure plots the simulated values of the real interest rate and of its changes from the solution of the model economy with sunspots.

5.2 Multiple Equilibria and R^* Regimes

In this section, we discuss three scenarios that can rationalize the reduction in the level of R^* post-GFC and its recent rise, in line with the empirical evidence documented in Section 2. The first scenario considers a fall in interest rates generated by an adverse sunspot shock that coordinates households' expectations around the low-interest-rate, high-debt equilibrium. In addition, we study two changes in government policy that may have been partly responsible for the observed interest rate dynamics.

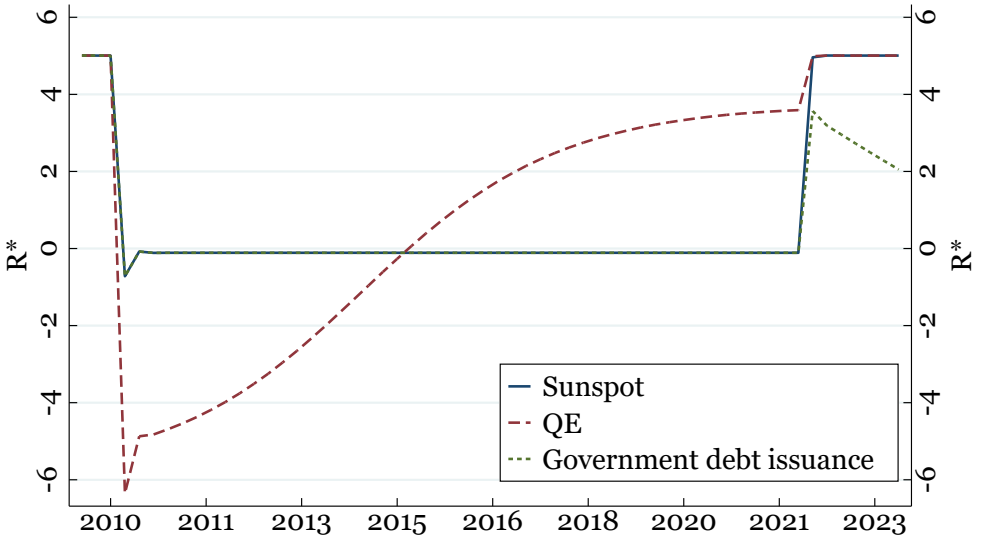
The first change in policy is an increased issuance of government debt. In this scenario, consumption risk-sharing across households improves, leading to a rise in the interest rate. The second is an asset purchase program. We show that this scenario is compatible with a reduction in the equilibrium real interest rate and an increase in monopsony power by firms, in line with our steady-state results. Figure 15 jointly displays the three simulated economies.

5.2.1 A GFC Sunspot

In our model, a negative realization of the sunspot shock process can account for a decline of the equilibrium real interest rate similar to the one observed after the Global Financial Crisis. When the sunspot shock realization is negative, the annualized equilibrium interest rate is five percentage points lower than under the optimistic realization. If this adverse realization persists for 48 periods, our model can rationalize the twelve years of exceptionally low interest rates that followed the Global Financial Crisis. In our calibration, the probability that the pessimistic sunspot shock persists for twelve years is 26%.[23]

[23]The persistence of the sunspot process is 97.25%, so the probability of observing the pessimistic realization for at least 48 quarters equals $0.9725^{48} = 26\%$.

Figure 15 : R^*-Dynamics Post-GFC.



Note. The figure plots the simulated path of R^* post-GFC under three scenarios. The sunspot scenario (solid blue line) represents a fall in interest rates generated by an adverse sunspot shock. The second (dotted green line) represents a setting where after the adverse realization of the sunspot shock, the government issues debt and redistributes receipts from borrowing to households. The third scenario (dashed red line) is an asset purchase program, whereby the public sector purchases a given amount of bonds issued by firms, funding these asset purchases through taxation on households.

5.2.2 Government Debt

After the COVID pandemic, government debt rose substantially worldwide, driven both by the direct effects of the recession on fiscal deficits and by the stimulus policies implemented to counter the pandemic's adverse consequences. In this section, we consider the possibility that expansionary fiscal policy—rather than a positive realization of the sunspot shock—may have contributed to the recent rise in R^*.

In the experiment that we study, the government issues a positive amount of debt, denoted by D^G_{t+1}, rebates the receipts from debt issuance to H-households, and keeps the level of government debt constant thereafter, setting taxes on H households to finance interest payments on debt. The issuance of government debt allows H-households to save through a financial instrument that is different from corporate debt, and thus to smooth out their income fluctuations without increasing the severity of firms' monopsony power. Hence, the increase in public debt facilitates the redistribution of consumption across high and low-type households, which in turn can drive an increase in R^*.

We consider a scenario in which fiscal expansion is introduced after the economy has been subject to a prolonged sequence of adverse sunspot shock realizations. Specifically, we assume that the bad sunspot shock persists for 16 years—rather than reverting after 12 years as in the baseline scenario—but that government debt rises starting in year 13 and remains elevated for four years. The dotted green line in Figure 15 depicts the interest rate dynamics under this scenario, in which

fiscal expansion overlaps with continued pessimistic expectations.

The announcement of higher government debt leads to an immediate rise in the interest rate. Given the issuance of government debt, H-households can now save by purchasing government debt instead of corporate debt. As a result of the lower issuance of corporate debt, firms' labor market power diminishes, increasing income of type$-L$ households. Anticipating higher future incomes, type$-H$ households reduce their current savings, further reinforcing the upward impact on R^*.

The length of the period for which public debt remains elevated is crucial in determining the quantitative impact of fiscal policy on the equilibrium interest rate. A permanent increase in public debt could eliminate the low-interest-rate equilibrium. The reason is that a rise in public debt effectively shifts the household demand for debt upward. If public debt reaches a sufficiently high level, the demand for debt lies above its supply by firms, preventing the existence of an equilibrium in which firms issue a positive amount of corporate debt. However, also for a temporary increase in government debt, the longer is the fiscal expansion projected to last, the greater is the initial rise in R^*.

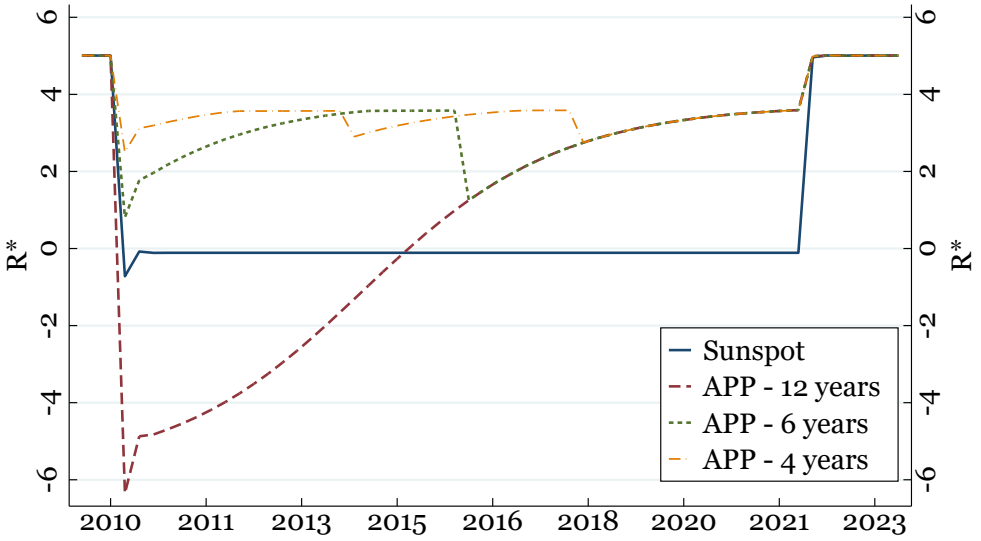
The impact of government debt on the equilibrium interest rate in our framework depends crucially on the adverse effect of corporate debt on household income fluctuations. Higher government debt raises interest rates by allowing households to save more without relying on firm-issued debt. This shift in households' portfolios prevents the unintended consequence associated with corporate debt purchases of lowering the income of some workers, thus increasing households' income fluctuations.

5.2.3 Asset Purchase Programs

Asset Purchase Programs can influence the dynamics of R^*. In Section 4.5, we discussed how permanent government purchases of firm-issued assets can eliminate the high-interest-rate steady-state equilibrium. Here, we show that temporary asset purchases can rationalize the sharp decline in the equilibrium interest rate observed in the context of the Global Financial Crisis.

First, we assume that the government announces an expansion in corporate asset purchases in the first quarter of 2010. The program follows the structure outlined in Section 4.5 but is set to conclude in the last quarter of 2021. During this period, the economy operates under the optimistic sunspot equilibrium. Hence, absent the asset purchase program, the interest rate would remain at 5%. Figure 15 displays the path of interest rates associated with this scenario. Asset purchases lead to an immediate and sharp decline in the equilibrium interest rate. By taxing households to finance the purchase of firm-issued assets, the government indirectly induces households to save. This effect, in turn, strengthens firms' monopsony power in the labor market, increases income risk, and further lowers interest rates. If the asset purchase program is expected to be persistent, the resulting decline in interest rates is substantial. Anticipating an extended period of low consumption due to low labor income and high firms' monopsony power associated with high corporate debt issuance, households increase their demand for assets, further driving the interest rate decline. Effectively, the

Figure 16 : Asset Purchase Programs and R^*-Dynamics.



Note. The figure plots the simulated path of R^* under different assumptions regarding the duration of the asset purchase program. The dotted green and dashed yellow lines represent scenarios where the government initially announces an asset purchase program of length N, later extended for another N periods until the total duration reaches 12 years, with N corresponding to 6 and 4 years, respectively. The dashed red line depicts the case in which the government commits upfront to a 12-year program and adheres to this commitment. The solid blue line represents the path of interest rates under a pessimistic sunspot shock.

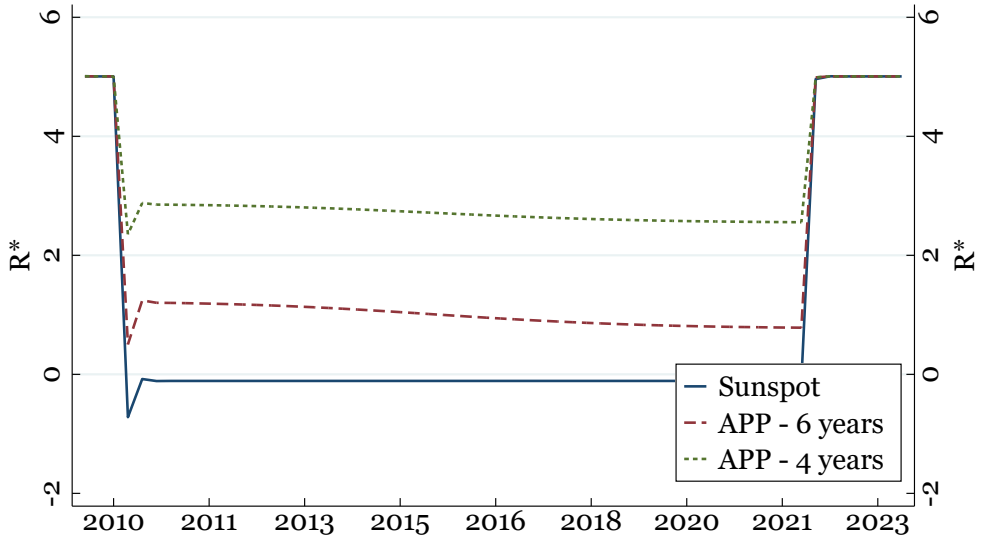
government eliminates the high-interest-rate equilibrium and forces the economy to converge toward the low-interest-rate steady state (point B in Figure 7). Over time, as the asset purchase program unwinds, the equilibrium interest rate gradually rises toward the high-interest-rate equilibrium.

We analyze two additional scenarios that differ in their assumptions about the duration of the asset purchase program. These scenarios are motivated by the fact that, at the inception of such programs, market participants did not necessarily expect them to last more than a decade. In the first scenario, the government initially announces a program lasting N periods. When this period ends, however, the program is extended by another N periods, resulting in a total duration of 12 years. Figure 16 illustrates this scenario for $N = 6$ and $N = 4$ years, respectively, alongside the previously discussed 12-year program.

When the government commits to corporate debt purchases for an initial period and later extends the program, the initial decline in the equilibrium interest rate is more moderate than when the full duration is announced upfront. The interest rate falls following the initial announcement, reverts toward the high-interest-rate equilibrium, and then declines again when the extension is announced. Qualitatively similar dynamics occur for both the 6- and 4-year announcements, with longer initial durations producing larger initial declines.

Figure 17 illustrates the interest rate dynamics in a scenario in which the government initially commits to either a six (dashed red line) or a four-year (dotted green line) asset purchase program.

Figure 17 : Recurrently Extended Asset Purchase Programs and R^*-Dynamics.



Note. The figure plots the simulated path of R^* in a scenario where the government repeatedly extends the asset purchase program unexpectedly. The dashed red (dotted green) line represents the case where the government initially commits to a six-year (four-year) program, which is subsequently renewed each quarter, each time announcing an additional six-year (four-year) duration. The solid blue line represents the path of interest rates under a pessimistic sunspot shock.

After the initial announcement, the program is unexpectedly renewed in each quarter, each time with an announcement that the program would last for six (or four) years. After 12 years from the initial announcement, the program unexpectedly ends.

In this scenario, households are consistently surprised by the actual length of the asset purchase program. This uncertainty captures, in a stylized way, the ambiguity surrounding the duration of similar programs following the GFC. As the figure shows, the interest rate declines upon the initial announcement, remaining low throughout the entire 12-year period. The six-year asset purchase program implies a fall of R^* to about 1%, while the four-year program to about 2.75%.

Regardless of the specific level of R^*, a key takeaway is that even a short-term policy can significantly influence the steady-state interest rate. In particular, a corporate asset purchase program can eliminate the high-interest-rate equilibrium and shift the economy toward a low-interest-rate regime. Thus, in our model, unconventional monetary policy can have long-lasting consequences.

Taking stock, our framework points to two possible explanations for the sharp decline in the equilibrium real interest rate following the Global Financial Crisis: a negative sunspot shock that shifted savers' expectations, the implementation of asset purchase programs, or a combination of the two. Moreover, the framework allows for the possibility that the subsequent reversion to a high interest rate was driven by an optimistic sunspot realization or by an expansionary fiscal policy.

6. Concluding Remarks

The equilibrium real interest rate, commonly known as R^*, is generally considered as a key reference point for monetary policy. On average, the policy rate should be equal to the equilibrium real interest rate plus the inflation target. Conventional wisdom maintains that real factors determine a unique equilibrium real interest rate which the monetary authority should target. We develop a model with multiple equilibrium real interest rates. In our framework, government purchases of private assets can select the equilibrium real interest rate.

We believe that our model can help rationalize the recent experience of equilibrium interest rates after the Global Financial Crisis. While other long-term forces—such as demographics, inequality, capital flows, and slowing productivity growth—are likely to have continued to influence R^*, our analysis focuses on the short-run fluctuations. Our mechanism helps explain the sudden drops in R^* that are not fully accounted for by long-term trends. We attribute the decline in R^* around the GFC to shifts in expectations and the deployment of large-scale asset purchase programs. Through the lens of our model, fiscal policy and, again, expectation shifts can account for the recent increase in R^*.

While we do not explicitly consider monetary policy stabilization here, our framework casts doubts on the usefulness of R^* as a guiding variable in a liquidity trap. A central bank that is guided by R^* in an attempt to set monetary policy through asset purchases may, in turn, influence R^* itself. This mechanism creates a policy endogeneity, whereby policymakers who attempt to react to fluctuations in R^* can modify its trajectory and further depress its level.

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Appendix for

"Monopsony, Income Risk and R^* Multiplicity"

by Ambrogio Cesa-Bianchi, Sergio de Ferra, Andrea Ferrero, Alex Kohlhas, Michael McMahon, Federica Romei, Giovanni Rosso

A. Data Sources

A.1 Firm-level data

The baseline dataset is derived from Compustat, focusing on US firms for 1997 to 2019. Our main variables of interest are

1. 'Selling, General, and Administrative Expenses' (`xsga`), divided by the number of employees (`emp`) to obtain a proxy for salary costs per worker (wages)
2. 'Staff Expenses - Total' (`xlr`), divided by the number of employees (`emp`) to obtain an alternative proxy for salary costs per worker (wages)
3. Total assets (`atq`) to proxy for firm size
4. Total debt (`dlcq+dlttq`)
5. Leverage, defined as the ratio of total debt to total assets.

Following standard practices in the literature (Ottonello and Winberry, 2020), we perform the following cleaning steps:

1. Drop duplicates (proper duplicates, that is same id and value)
2. Only keep firms incorporated in the US
3. Drop COVID period (i.e. post 2019q4)
4. Drop financial firms (SIC code $\in$ [6000, 6799])
5. Drop observations with negative assets
6. Drop observations that fall above/below the top/bottom 0.5 percent of observations for each variable.

A.2 Macro data

We obtain macroeconomic data from Federal Reserve Economic Data (FRED). Specifically, we download:

1. Real GDP (`GDPC1`)
2. PCE Price Index (`PCEPI`)
3. Vix index (`VIXCLS`)

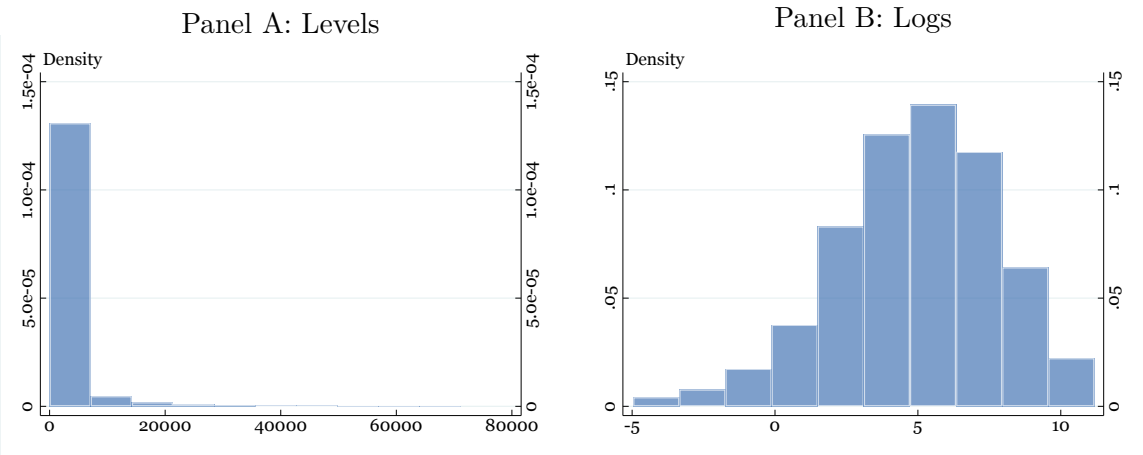
B. Stylized Facts

This section reports additional information about the data.

Figures B.1, B.2, B.3, and B.4 report the empirical distributions of our main variables of interest, namely *Total Assets*, *Total Debt*, *Selling, General, and Administrative Expenses*, and *Leverage* in Compustat quarterly.

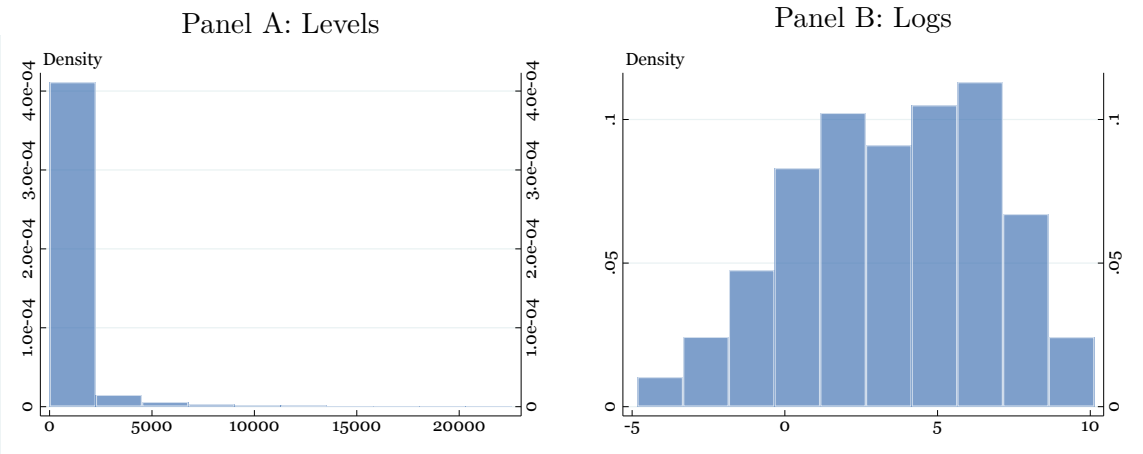
Figures B.5 and B.6 report a comparison between Compustat's `xsga` (Selling, General, and Administrative Expenses) and `xlr` (Staff Expenses). The figures show a strong similarity between the two measures. The distribution of firm-year observations is very similar, both when considering "between" and "within" firm information. The chart suggests that using `xsga` is suitable for the analysis, especially given the advantage that `xsga` is available for a much larger sample of firms (15,000 vs. 3,000) and at a quarterly frequency.

Figure B.1 Total Assets



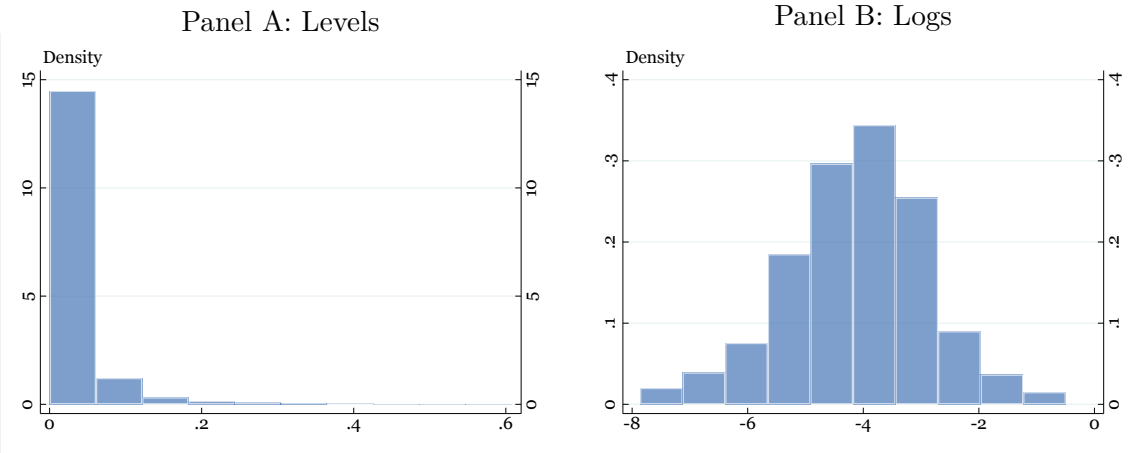
Note. This figure plots the distribution of total assets in our sample, in levels (Panel A) and in logs (Panel B). Sample period 1997q1 to 2019q4.

Figure B.2 Total Debt



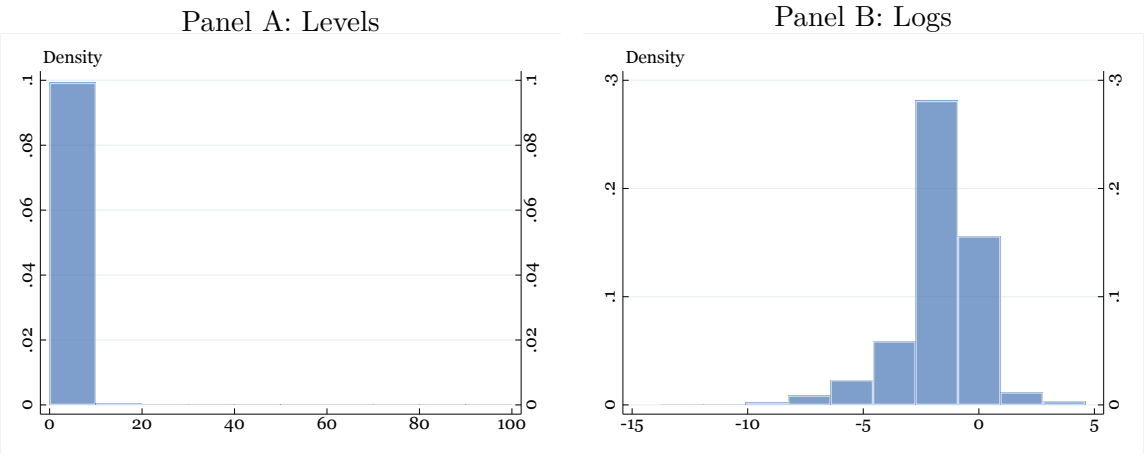
Note. This figure plots the distribution of debt in our sample, in levels (Panel A) and in logs (Panel B). Sample period 1997q1 to 2019q4.

Figure B.3 Salary Costs



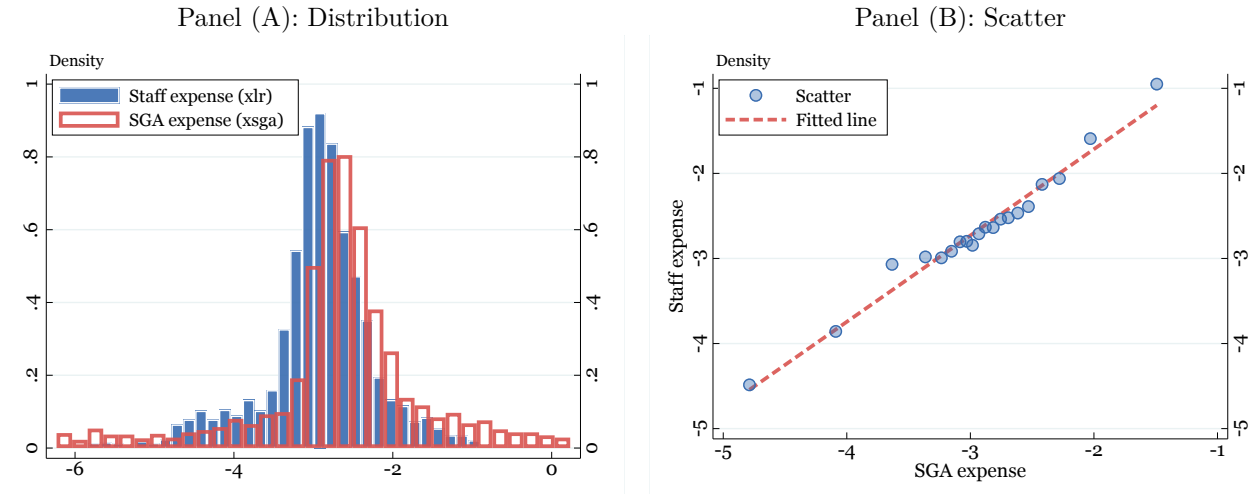
Note. This figure plots the distribution of debt in our sample, in levels (Panel A) and in logs (Panel B). Sample period 1997q1 to 2019q4.

Figure B.4 Leverage



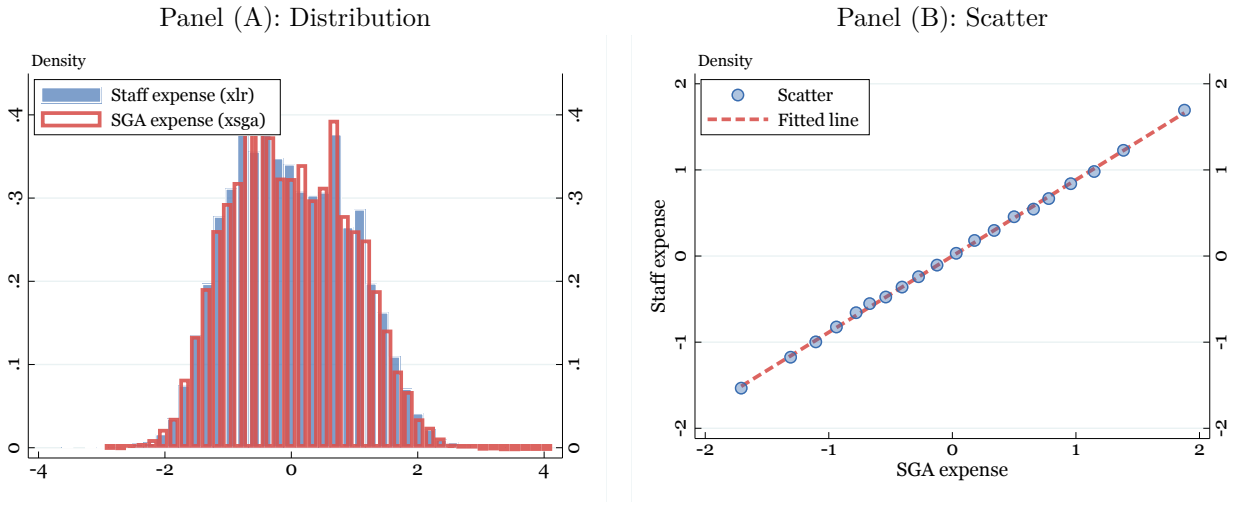
Note. This figure plots the distribution of debt in our sample, in levels (Panel A) and in logs (Panel B). Sample period 1997q1 to 2019q4.

Figure B.5 SGA Expenses vs. Staff Expenses: Between



Note. Comparison between Compustat's `xsga` (Selling, General, and Administrative Expenses) and `xlr` (Staff Expenses) in the cross-section of firms. Each observation represents the average values of `xsga` and `xlr` for a firm over time.

Figure B.6 SGA Expenses vs. Staff Expenses: Within



Note. Comparison between Compustat's `xsga` (Selling, General, and Administrative Expenses) and `xlr` (Staff Expenses) in the cross-section of firms. Each observation represents the yearly values of `xsga` and `xlr` standardized at the firm level (i.e. $(x - \mu_x)/\sigma_x$, where μ_x and σ_x are the firm-level average and standard deviation of x).

C. Granular Instruments

To explain the methodology, we employ the simple example used by Gabaix and Koijen (2024). Think of the following system, where to keep consistency with Gabaix and Koijen (2024), we write in terms of households' capital supply and firms capital demand:

$$R_t = \psi D_{St} + \varepsilon_t \tag{C.1}$$

$$D_{it} = \phi^d R_t + \eta_t + u_{it} \tag{C.2}$$

where $D_{St} = \sum_i S_i D_{it}$ with S_i representing the weight of firm $i \in \{1, ..., N\}$ and with $\sum_i S_i = 1$. Each firm's log demand D_{it} depends on the real interest rate R_t as in (C.2), with demand elasticity ϕ^d, and some shocks. The real interest rate, in turn, depends on aggregate demand D_{St}, which is the size-weighted demand, with a sensitivity ψ that is the inverse of the supply elasticity. We impose that $\psi\phi^d \neq 1$, which ensures the existence of a unique solution of our system (C.1) – (C.2). The econometrician observes S_i, R_t, and D_{it}.

Our object of interest is ψ, the slope of households' capital supply curve, which tells us how the interest rate R_t is responding to an exogenous increase to firms' debt issuance. We cannot estimate ψ (and ϕ^d for that matter) by OLS as ε_t and η_t are typically correlated, implying that D_{St} is correlated with ε_t in (C.1) and R_t with η_t in (C.2).

Following Gabaix and Koijen (2024), we construct the GIV as the size-weighted average outcome, $D_{st} = \sum_i S_i D_{it}$, minus the equal-weighted average outcome, $D_{Et} = (1/N) \sum_{i=1}^N D_{it}$:

$$z_t := D_{\Gamma t} = D_{St} - D_{Et}. \tag{C.3}$$

Given that

$$D_{st} = \phi^d R_t + \eta_t + u_{St}, \qquad D_{Et} = \phi^d R_t + \eta_t + u_{Et} \tag{C.4}$$

the GIV is also

$$z_t = u_{\Gamma t} = u_{St} - u_{Et} \tag{C.5}$$

and it is made only of idiosyncratic shocks. Given the exogeneity condition

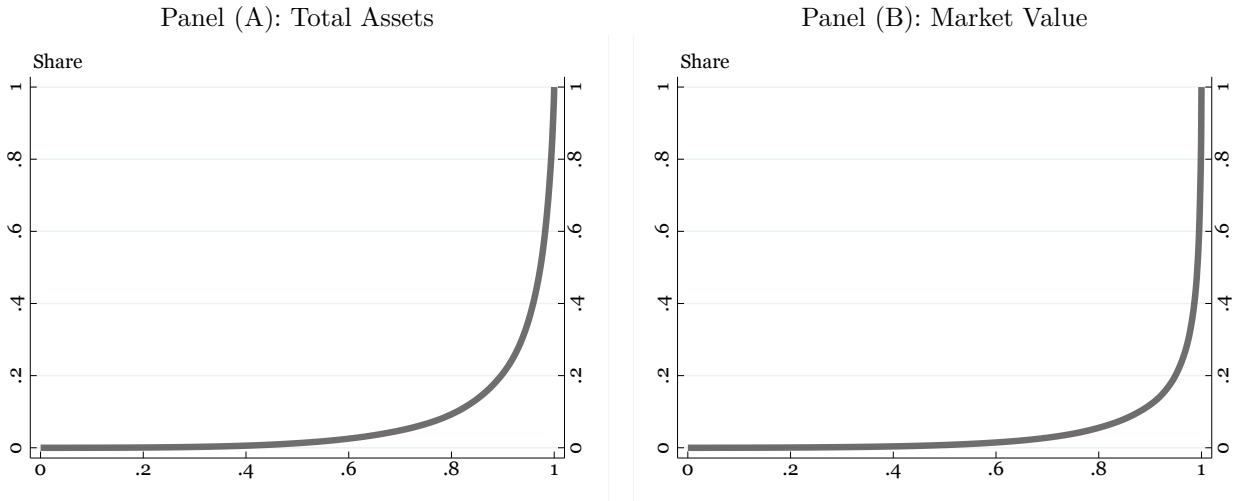
$$u_t \perp \eta_t, \varepsilon_t \tag{C.6}$$

we have $\mathbb{E}[u_t \varepsilon_t] = 0$, and hence $\mathbb{E}[z_t \varepsilon_t] = 0$. Using (C.1), this gives $\mathbb{E}[(R_t - \psi D_{s_t}) z_t] = 0$, and thus $\psi = \mathbb{E}[R_t z_t] / \mathbb{E}[B_{st} z_t]$. Its empirical counterpart is the estimator $\psi_T^e = \sum_{t=1}^T R_t z_t / \sum_{t=1}^T D_{st} z_t$.[24]

[24] Remember that, for a simple model with one endogenous variable $R = a + bD_{St} + e$, this is the formula of the 2SLS estimator. To see that, take the covariance of all terms with the instrument z, which gives $Cov(R, z) = Cov(a, z) + bCov(D_S, z) + Cov(e, z) = bCov(D_S, z)$. Then, you get $b^{IV} = Cov(R, z)/Cov(D_S, z)$. This is the same expression as you have in matrix notation, i.e. $b^{IV} = (z'D_S)^{-1}(z'R)$, where remember that, for example, $(z'D_S) = \sum_1^T z_t D_{St}$, is the sum of cross products for D_S and z from which the mean is subtracted given that the regression has an intercept.

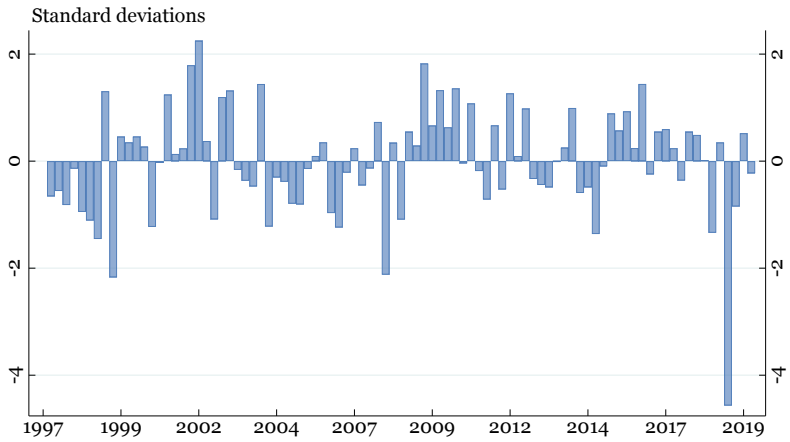
For the instrument to be relevant, there has to be heterogeneity in the share/size distribution. Trivially, if there were no difference between share-weighted and equally weighted firm-level shocks, z_t would display no variation and the would likely be poor. Figure C.1 reports the Lorentz curves for firms' total assets and market value. With such a skewed distribution, idiosyncratic shocks can become 'granular' and have aggregate effects (Gabaix, 2011), making our data a natural application of the GIV methodology. The series of granular shocks is reported in Figure C.2.

Figure C.1 Lorentz Curves



Note. This figure plots the Lorentz curves for assets (left) and market value (right).

Figure C.2 The Granular Instrument



Note. This figure plots the evolution of the granular instrument. Sample period 1997q1 to 2019q4.

D. Robustness

This section reports the robustness of our main empirical results. We conduct several exercises to ensure the reliability of our findings, including using different sample selection criteria, varying the time periods analyzed, and employing alternative measures of R^*.

Tables D.1 and D.2 demonstrate that our results on the relationship between wages and leverage are robust to using Compustat's `xlr` (Staff Expenses) instead of `xsga` (Selling, General, and Administrative Expenses). To verify this, we first check whether our results using `xsga` hold in the smaller (and at annual frequency) sample of firms for which `xlr` is available, as shown in Table D.1. We then re-run our specification using `xlr` instead of `xsga`, with the results presented in Table D.2. The findings are very similar to those reported in our baseline analysis.

Tables D.3 and D.4 report the relationship between wages and leverage in a sample of firms that includes those in the financial sector and only includes safe firms (proxied by firms above the median firm size in the cross-section of firms). The tables show that the strong positive relationship between wages and firm size documented in the main text is robust to different sample selection choices.

Figure D.1 reports the estimates from the baseline local projections specification employing alternative measures of R^*, namely the 'macro' measures by **?** and Lubik and Matthes (2015); as well as a measure of R^* derived from term structure models, i.e. a 10-year real forward rate. In each panel, the left chart reports the dynamic response of R^* over the full sample (i.e. 1997q1 to 2019q4, in gray); and the right chart reports the dynamic response of R^* over the two sub-samples as in the main text, namely 1997q1 to 2008q4 (in orange) and 2009q1 to 2019q4 (in blue).

Figure D.2 reports the estimates from the baseline local projections specification (XX) employing alternative sample selection criteria and different econometric specifications. Specifically, Panel A *No Seasonal Dummies* excludes seasonal dummies from the estimation; Panel B *Market Value Weights* employs firms' market value instead of total assets to compute the granular instrument; Panel C *Including Financials* uses a sample of firms that includes those in the financial sector; Panel D *Safe Firms* uses a sample of safe firms, proxied by firms above the median firm size in the cross-section of firms.

Table D.1 Wages and Leverage (Annual, `xsga`)

	(1)	(2)	(3)	(4)
Total Assets	0.48***	0.46***	0.36***	0.37***
	(0.02)	(0.02)	(0.01)	(0.01)
Total Assets × Leverage		-0.03***		-0.01***
		(0.00)		(0.00)
Sector × Time FE	yes	yes	yes	yes
Firm FE	no	no	yes	yes
Observations	81,152	81,152	79,595	79,595
R-squared	0.65	0.66	0.94	0.94

Note. Robust standard errors (clustered two-way, at the year and firm level) are reported in parentheses, with (0.00) indicating a value lower than 0.005. *** p<0.01, ** p<0.05, * p<0.1. Coefficients corresponding to the constant, fixed effects, and controls (log number of employees and log leverage) are not reported.

Table D.2 Wages and Leverage (Annual, `xlr`)

	(1)	(2)	(3)	(4)
Total Assets	0.32***	0.32***	0.25***	0.26***
	(0.02)	(0.02)	(0.03)	(0.03)
Total Assets × Leverage		-0.03***		-0.01*
		(0.00)		(0.00)
Sector × Time FE	yes	yes	yes	yes
Firm FE	no	no	yes	yes
Observations	6,809	6,809	6,575	6,575
R-squared	0.58	0.59	0.92	0.92

Note. Robust standard errors (clustered two-way, at the year and firm level) are reported in parentheses, with (0.00) indicating a value lower than 0.005. *** p<0.01, ** p<0.05, * p<0.1. Coefficients corresponding to the constant, fixed effects, and controls (log number of employees and log leverage) are not reported.

Table D.3 Wages and Leverage: Including Financials

	(1)	(2)	(3)	(4)
Assets	0.47***	0.45***	0.35***	0.35***
	(0.03)	(0.02)	(0.01)	(0.01)
Assets × Leverage		-0.03***		-0.01***
		(0.00)		(0.00)
Sector × Time FE	yes	yes	yes	yes
Firm FE	no	no	yes	yes
Observations	345,454	345,454	344,915	344,915
R-squared	0.62	0.63	0.92	0.92

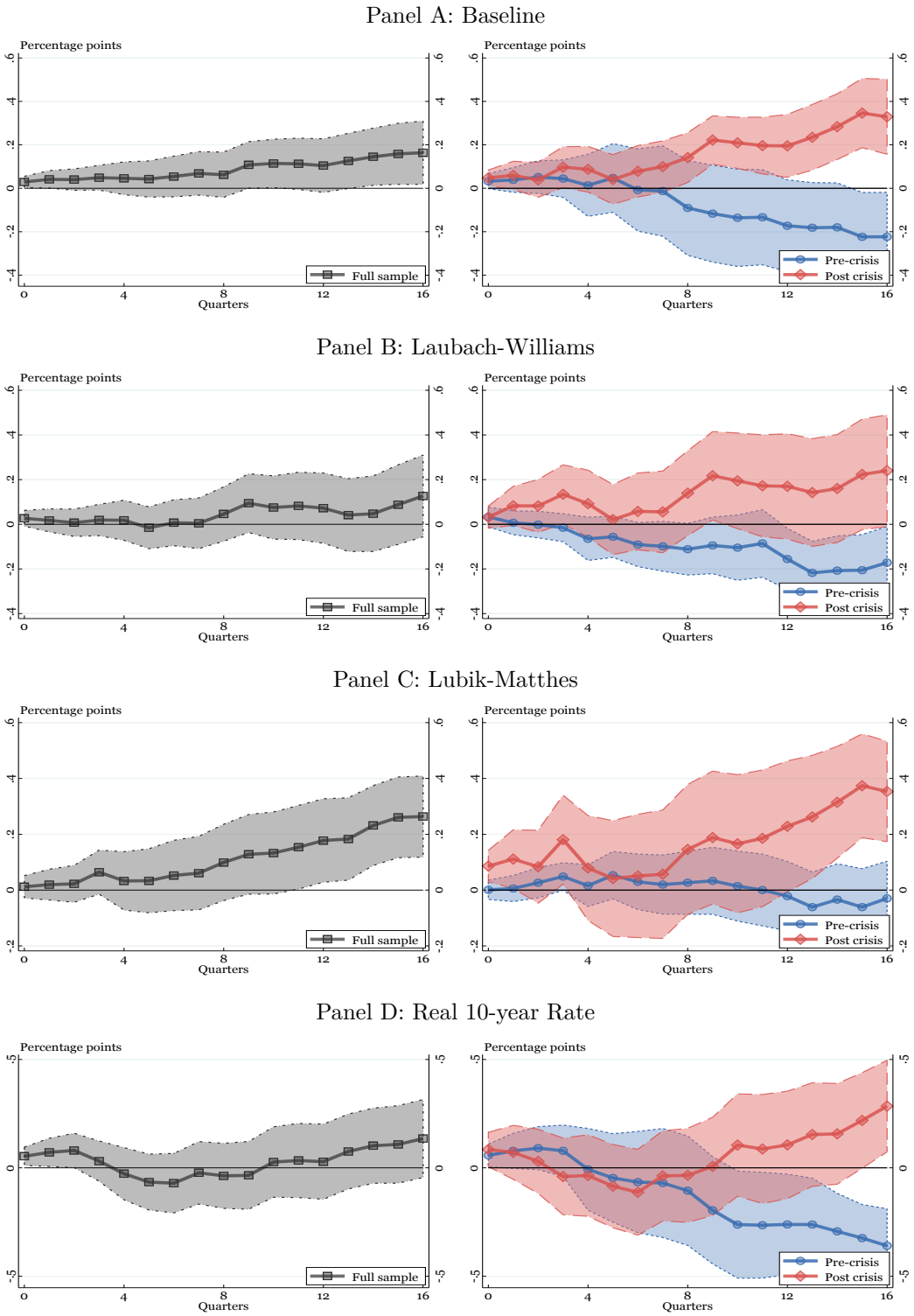
Note. Robust standard errors (clustered two-way, at the year and firm level) are reported in parentheses, with (0.00) indicating a value lower than 0.005. *** p<0.01, ** p<0.05, * p<0.1. Coefficients corresponding to the constant, fixed effects, and controls (log number of employees and log leverage) are not reported.

Table D.4 Wages and Leverage: Large Firms

	(1)	(2)	(3)	(4)
Assets	0.60***	0.59***	0.42***	0.41***
	(0.03)	(0.03)	(0.01)	(0.01)
Assets × Leverage		-0.01		-0.00
		(0.01)		(0.00)
Sector × Time FE	yes	yes	yes	yes
Firm FE	no	no	yes	yes
Observations	159,102	159,102	158,824	158,824
R-squared	0.65	0.65	0.95	0.95

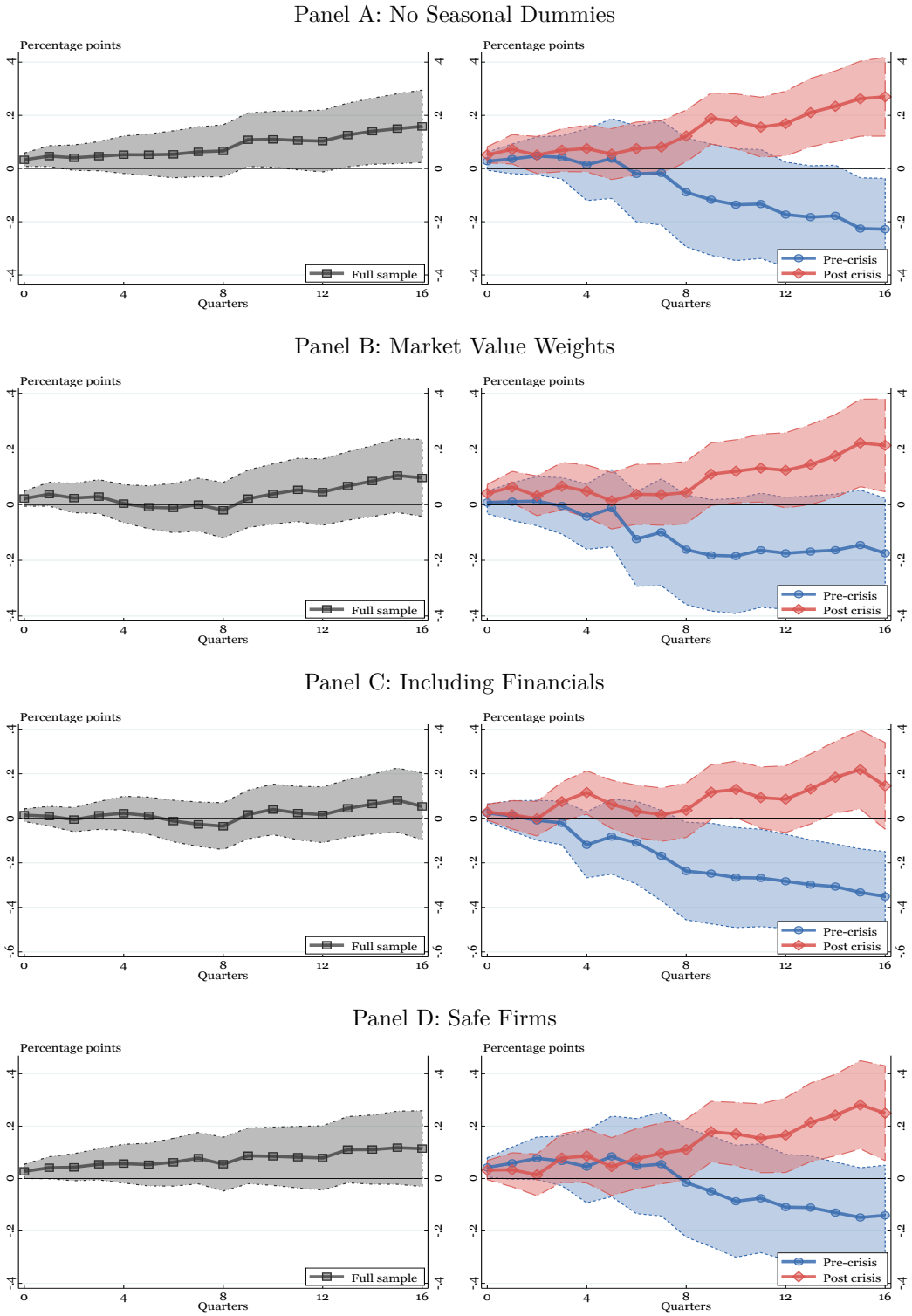
Note. Robust standard errors (clustered two-way, at the year and firm level) are reported in parentheses, with (0.00) indicating a value lower than 0.005. *** p<0.01, ** p<0.05, * p<0.1. Coefficients corresponding to the constant, fixed effects, and controls (log number of employees and log leverage) are not reported.

Figure D.1 GIV LP Robustness: Alternative R^* Measures



Note. This figure plots the evolution of leverage blabla. Sample period 1997q1 to 2019q4.

Figure D.2 GIV LP Robustness: Other Specifications



Note. This figure plots the evolution of leverage blabla. Sample period 1997q1 to 2019q4.

E. Empirical analysis of consumption risk

In this section we explore the dynamic response of consumption risk to an increase in corporate debt.

E.1 Data

The analysis in this section relies on data from the Consumption Expenditure Survey (CEX), administered since 1980 by the Bureau of Labour Statistics (BLS) which uses it as an input to compute CPI weights. The CEX collects quarterly detailed information on a nationally representative sample of households' expenditure using a rotating panel design. The 'interview' component of the CEX consists of a rotating panel where each household is surveyed quarterly over 5 quarters (data on the first interview are not published, as it is preparatory; post 2015 the interviews are only 4). Information provided pertains to expenditure over the previous three months. We follow Blundell, Pistaferri and Saporta-Eksten (2018) in constructing a measure of non-durable consumption as the sum of expenditure on "food at home, food away from home, alcohol and tobacco, utilities, maintenance and repairs, education, housing services, financial services, clothing, health, entertainment, cash contributions, transportation, and other nondurables". We focus on the 1997-2015 sample.

E.2 Construction of consumption risk and dynamic response

Construction of consumption risk measure. We construct a measure of consumption risk as the standard deviation of the quarterly (quarter-on-quarter) change in log consumption at the household level. That is, we generate change in log non-durable consumption as

$$\Delta c_{i,t} = \log c_{i,t} - \log c_{i,t-3} \tag{E.1}$$

where $c_{i,t}$ is the non-durable consumption of household i in the last quarter t in which it appears in the sample and $c_{i,t-3}$ is the consumption in the first quarter in which it appears in the sample. Then, in every quarter t there is a cross-sectional distribution of $\Delta c_{i,t}$, with households entering and exiting the sample. An example of this cross-sectional variation is in Figure E.1, comparing the distribution of changes in log consumption for 2007q1 and 2007q3. We compute an aggregate measure of consumption risk by taking the standard deviation consumption changes over time:

$$\Delta CR_t = \sqrt{\frac{1}{N}\sum_{i=1}^{N}\left(\Delta c_{i,t} - \Delta c_t\right)^2} \tag{E.2}$$

where Δc_t is the cross-sectional average of $\Delta c_{i,t}$ at time t. Figure E.2 plots this quarterly measure from 1997q1 to 2015q4.

Estimation of dynamic response. To estimate the effects of a shock to firms' debt issuance on

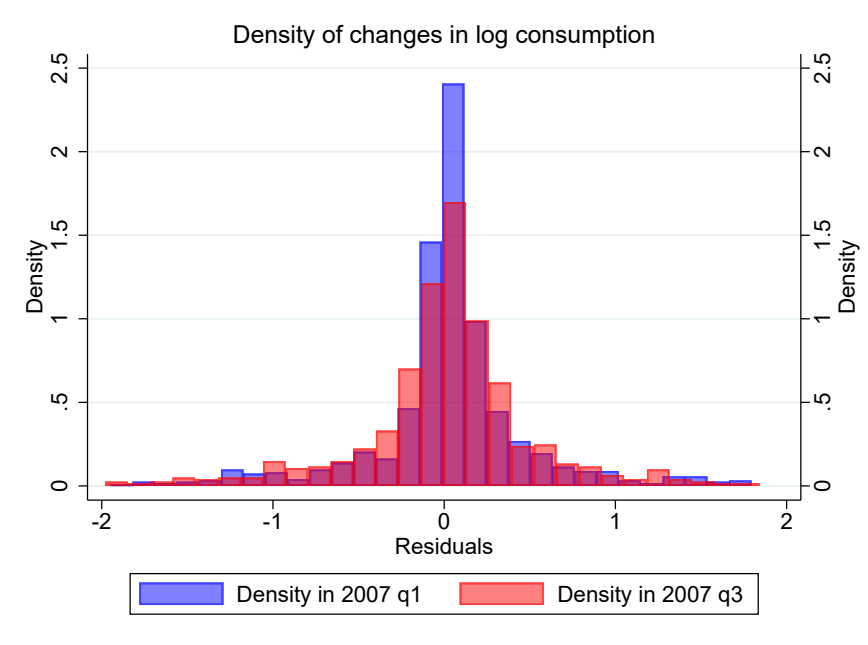
households' consumption risk, we employ the following local projection specification:

$$CR^*_{t+h} - CR^*_{t-1} = \alpha^h + \alpha^h_q + \beta^h \epsilon_t + \sum_{\ell=1}^{P} \gamma^h X_{t-\ell} + \nu_{t+h} \tag{E.3}$$

where α^h is a constant; α^h_q is a quarter-dummy to capture seasonality effects; ϵ_t is the granular instrument; $X_{t-\ell}$ is a vector of controls, including real GDP growth, lags of CR^*, and lags of the granular instrument described in section 2; and ν_{t+h} is a residual, and CR^* is the quarterly measure of consumption risk.

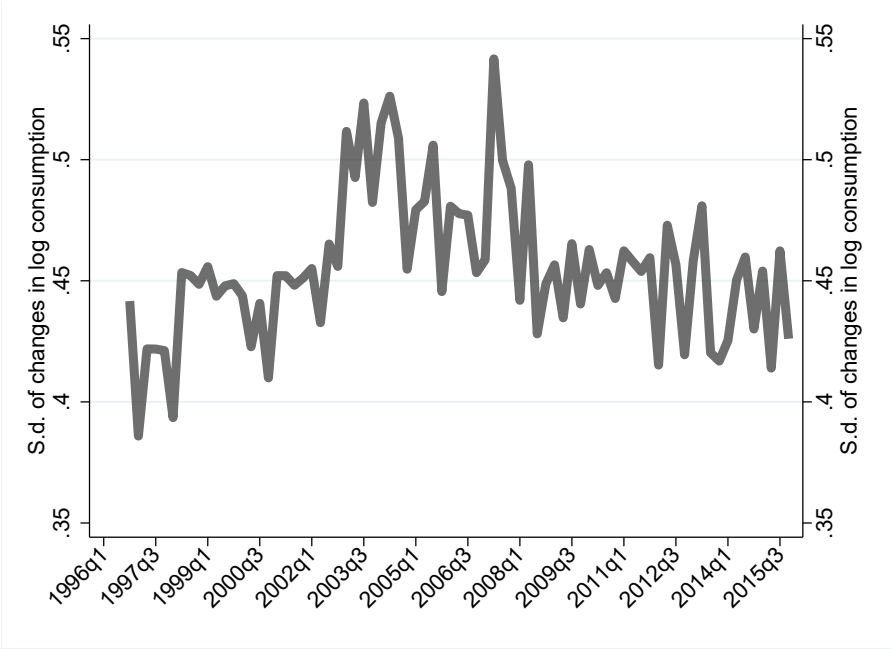
Figure E.3 shows the impact on consumption risk of an exogenous increase in firms' debt issuance, for the period 1997-2015. We observe evidence of an increase in consumption risk in response to an increase in corporate debt, in agreement with the model's central mechanism.

Figure E.1 Changes in household log consumption



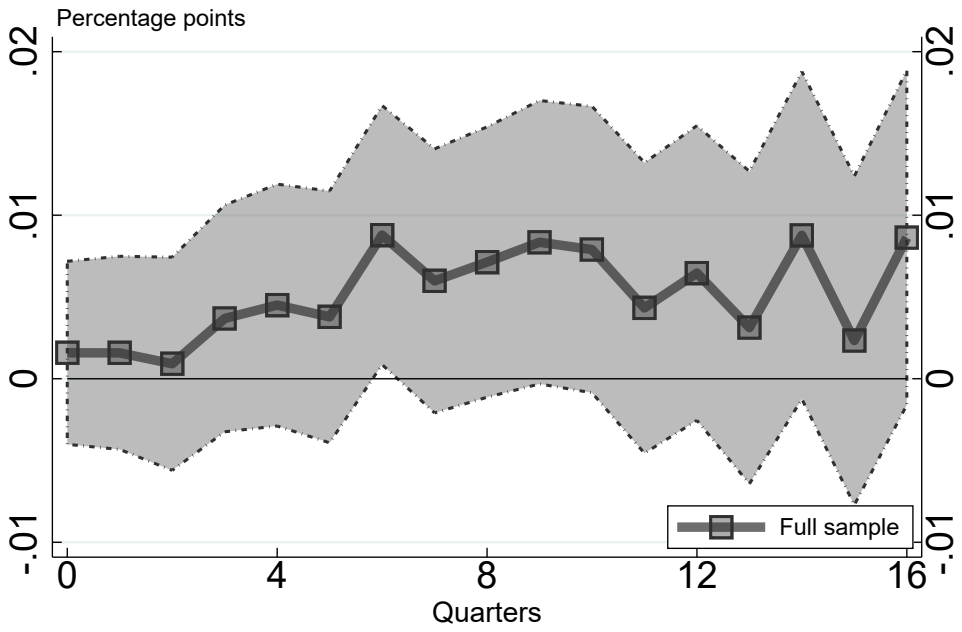
Note. This figure plots the distribution of changes in households nondurable consumption between the last three months they appear in the sample and the first quarter they appear.

Figure E.2 Time series of consumption risk



Note. This figure plots the cross-sectional s.d. of changes in log consumption, as detailed in equation (E.2).

Figure E.3 The response of consumption risk to a debt issuance shock



Note. Dynamic response of consumption risk to an exogenous increase in firm debt identified using a granular instrumental variable approach (Gabaix and Koijen, 2024) in a local projection specification (Jorda, 2005). The weights are computed with total assets. The local projection specification controls for one lag of the instrument, one lag of the dependent variable, and one lag of GDP growth. Sample period is 1997q1 to 2015q2.

F. Derivations

F.1 Firms' Problem

The problem of the firm is to maximize the discounted stream of profits, subject to the (7), and the first-order condition for household labor supply (6) for inputs in whose market the firms is monopsonist, i.e. for $i \in (0, \chi(D_t))$. Formally, this problem is:

$$\begin{aligned}\max_{L_{H,t}(i), L_{L,t}(i), D_{t+1}} \; & Y_t - \int_0^1 W_{H,t}(i) L_{H,t}(i)\, di - \int_0^{\chi} W_{L,t}(i) L_{L,t}(i)\, di \\ & - \int_{\chi}^1 L_{L,t}(i)^{1+\varphi} C_{L,t} + D_{t+1} - D_t R_t - \psi\left(D_{t+1}\right).\end{aligned} \tag{F.1}$$

We can use the labour supply condition (6) for the L households to get the wage ratio as a function of the L labour ratio:

$$\frac{W^m_{L,t}}{W^c_{L,t}} = \left(\frac{L^m_{L,t}}{L^c_{L,t}}\right)^{(\varphi)}. \tag{F.2}$$

From the firms' labour demand, we can also derive the wage ratio as a function of the L labour ratio:

$$\frac{W^m_{L,t}}{W^c_{L,t}} = \left(\frac{L^c_{L,t}}{(1+\varphi) L^m_{L,t}}\right) \tag{F.3}$$

We can use (F.2) and (F.3) to find the L-household labour ratio as a function of the parameters:

$$\left(\frac{L^m_{L,t}}{L^c_{L,t}}\right) = \left(\frac{1}{1+\varphi}\right)^{\frac{1}{1+\varphi}}. \tag{F.4}$$

Therefore we can write equation (F.5) as:

$$1 + (1-\alpha) Y_t \frac{1}{1+\varphi} \left[\varphi - \ln\left(1+\varphi\right)\right] \chi'\left(D_{t+1}\right) = \psi'\left(D_{t+1}\right) + \beta R_{t+1} \tag{F.5}$$

F.2 Combination of Optimality Conditions to derive Output as Function of Wealth and Saving

We outline below how to obtain output Y_t as function of housheold wealth $R_t B_t$ and saving B_{t+1}, i.e. the function $Y_t = Y(B_{t+1}, R_t B_t)$.

First, combine firm's labor demand (10), (12) and (11) with households' budget constraints to

yield households' consumption as function of output, wealth, and saving:

$$C_{H,t} = \alpha Y_t - B_{t+1}, \tag{F.6}$$

$$C_{L,t} = (1-\alpha)\left[1 - \frac{\varphi}{1+\varphi}\chi(D_{t+1})\right] Y_t + R_t B_t. \tag{F.7}$$

Second, combine household labor supply (6) with the labor demands, to yield employment as function of total output and the above-determined consumption:

$$L_{H,t} = \left(\frac{\alpha Y_t}{C_{H,t}}\right), \tag{F.8}$$

$$L^c_{L,t} = \left(\frac{(1-\alpha)Y_t}{C_{L,t}}\right), \tag{F.9}$$

$$L^m_{L,t} = \left(\frac{(1-\alpha)Y_t}{(1+\varphi)C_{L,t}}\right). \tag{F.10}$$

Third, plug these expressions into the production function (7), to yield a non-linear equation for output as function of the bond choices and of the initial household wealth:

$$Y_t = L_{H,t}^{\alpha} {L^m_{L,t}}^{(1-\alpha)\chi} {L^c_{L,t}}^{(1-\alpha)[1-\chi]} \tag{F.11}$$

$$Y_t = \left(\frac{\alpha Y_t}{C_{H,t}}\right)^{\alpha} \left(\frac{(1-\alpha)Y_t}{C_{L,t}}\right)^{(1-\alpha)} \left(\frac{1}{1+\varphi}\right)^{(1-\alpha)\chi} \tag{F.12}$$

$$1 = \frac{\alpha^{\alpha}(1-\alpha)^{(1-\alpha)}\,(1+\varphi)^{-(1-\alpha)\chi}}{C_{H,t}^{\alpha} C_{L,t}^{1-\alpha}}, \tag{F.13}$$

which simplifies to:

$$[\alpha Y_t - B_{t+1}]^{\alpha}\left[(1-\alpha)\left[1 - \frac{\varphi}{1+\varphi}\chi\right] Y_t + R_t B_t\right]^{1-\alpha} = \alpha^{\alpha}(1-\alpha)^{(1-\alpha)}\,(1+\varphi)^{-(1-\alpha)\chi}. \tag{F.14}$$

Finally, solve the above expression non-linearly for Y_t as function of B_{t+1} and $R_t B_t$, which we denote as $Y_t = Y(B_{t+1}, R_t B_t)$.

In turn, this function can be used to determine the consumption levels of the two households, as well as the employment levels of the two types of workers, as function of the bond choices and of the initial wealth of the households: $C_{H,t} = C_H(B_{t+1}, R_t B_t)$, $C_{L,t} = C_L(B_{t+1}, R_t B_t)$, $L_{H,t} = L_H(B_{t+1}, R_t B_t)$, $L^c_{L,t} = L^c_L(B_{t+1}, R_t B_t)$, $L^m_{L,t} = L^m_L(B_{t+1}, R_t B_t)$,

Note that in the above equations we have implicitly imposed that bonds purchased by households equal bonds issued by firms, $B_{t+1} = D_{t+1}$. Hence, choices for asset purchases B_{t+1} affect equilibrium variables also through their impact on monopsony power, via the function $\chi(D_{t+1})$.

F.3 Solution for Dynamic Sunspot Equilibrium

We outline in what follows our solution method for the equilibrium in the dynamic model economy with sunspot. We proceed by backward induction.

First, consider a guess for the households' guess about the next-period policy function for consumption of the low type, and associated marginal utility of consumption. We use as initial guess the policy function associated with the steady-state choice for asset accumulation, $C_{L,ss}$. We initially guess that households expect this policy function to characterize equilibrium in the next period independently of the current period sunspot realization.

Second, solve for the multiple equilibria implied by the above guess for next-period consumption. Specifically, solve the Euler equation

$$\frac{1}{C_H} = \beta R_{t+1} \frac{1}{C_{L,ss}} \tag{F.15}$$

for equilibrium B_{t+1}. As discussed in Section 5, multiple equilibria for B_{t+1} and R_{t+1} may be consistent with the solution to the equation above for given initial wealth $R_t B_t$. We impose that if the good (bad) sunspot realizes, the equilibrium of the model economy is, for each level of initial wealth, the one associated with the maximum (minimum) level for low-type consumption. We thus define new, sunspot conditional guesses for the low-type consumption policy function: $C_{L,x,guess}$.

Third, proceed backwards by one period and, given the stochastic process for the sunspot (**??**) and the guess for the next-period, sunspot conditional, policy functions for low-type consumption, form expectations for the next-period marginal utility of consumption. Given these expectations, solve for a couple of bond demand functions, conditional on the current realization of the sunspot that are each consistent with the Euler equation:

$$\frac{1}{C_{H,x}} = \beta R_{t+1} \mathbb{E}_t \left[\frac{1}{C_L} \right]. \tag{F.16}$$

Find the intersection of the bond demands with the bond supply, and obtain equilibrium asset purchases and interest rate conditional on the sunspot realization. Update the guess for the policy function for low-type consumption conditional on the sunspot.

Fourth, proceed backwards until convergence of the policy functions for consumption.