The Financial Channel of Wage Rigidity

Benjamin Schoefer

UC Berkeley

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Abstract

I propose a financial channel of wage rigidity. In recessions, rigid average wages squeeze cash flows, forcing firms to cut hiring due to financial constraints. Indeed, empirical cash flows and profits would turn acyclical if wages were only moderately more procyclical. I study this channel in a search and matching model with financial constraints and wage rigidity among incumbent workers (but flexible new hires' wages). While neither feature generates amplification individually, their interaction can account for much of the empirical labor market fluctuations—breaking the neutrality of incumbents' wages for hiring, and showing that financial amplification of business cycles requires wage rigidity.

1 Introduction

Wage rigidity is a core friction in macroeconomists' modeling toolkit to match the volatile behavior of labor demand in the data (Erceg, Henderson, and Levin, 2000; Shimer, 2004; Hall, 2005; Blanchard and Galí, 2007; Elsby, 2009; Gertler and Trigari, 2009; Michaillat, 2012; Christiano, Eichenbaum, and Trabandt, 2016; Schmitt-Grohé and Uribe, 2016). Its conventional amplification channel works through marginal labor costs: wage rigidity props up new hires' wages during recessions, further depressing firms' incentives to hire. However, new hires' wage rigidity remains elusive empirically due to, e.g., composition bias in job and worker quality. By contrast, the rigid wages of incumbent workers—a robust empirical fact—are considered an inframarginal fixed cost, irrelevant for hiring.

I propose a financial channel of wage rigidity. In my model, rigid wages amplify fluctuations of firms' cash flow, and thereby, due to financial constraints, firms' capacity to hire and invest. This channel is driven by average—i.e., largely incumbent workers'—wages. By contrast, the standard amplification channel is driven by marginal labor costs, i.e., new hires' wages.

This channel has empirical power because small changes in wages have large effects on firms' financial resources, on which the wage bill is the largest drain. As a result, a simple counterfactual— backing out the hypothetical wage time series required to perfectly smooth cash flows and profits— requires only a moderate increase in the procyclicality of wages. On average, incumbents' real wages would need to fall by an additional 1.5ppt when the unemployment rate increases by 1ppt (from a baseline wage cyclicality of 1.25% in the micro data, see, e.g., Pissarides, 2009). The resulting wage cyclicality is moderate in that it, e.g., would still remain below the measured actual cyclicality of new hires' wages (3%). Wages are unique as other financial outflows, such as dividends or interest payments, are just 3–11 percent as large as the wage bill, and hence would need to turn strongly *negative* during recessions to stabilize cash flow.

Quantitatively, the effect of this counterfactual of stable firm finances on the real economy— and hence the power of the financial channel of wage rigidity—naturally depends on the scope of firm-side financial amplification in business cycles—a key focus of the macro-finance literature (reviewed in, e.g., Quadrini, 2011). My paper points out that without wage rigidity, such amplification would be moot. I do show new evidence that, consistent with real effects of the channel, industries with smaller labor shares, where it looms smaller, have both smoother cash flow, and also smoother investment and employment.

I assess the equilibrium consequences of the financial channel of wage rigidity in a calibrated Diamond-Mortensen-Pissarides (DMP) model. I consider variants with and without wage rigidity, and with and without financial constraints. Incumbent workers' wages are imperfectly indexed to new hires' entry wages, which, in turn, are bargained flexibly. The underlying incumbents' wage rigidity parameter is calibrated targeting the relative cyclicalities of incumbents' and new hires' wages reviewed in Pissarides (2009). Firms' investment expenditures, which in the model are DMP hiring costs, are subject to financial constraints, and hence potentially sensitive to firms' cash flow. Concretely, firms face a borrowing constraint and dividend adjustment costs, similar to

the financial frictions in Jermann and Quadrini (2012). The other features are standard, and their calibration and the driving force, productivity, follow the canonical calibration in Shimer (2005).

Without financial constraints, the Nash-bargained wages are endogenously procyclical, absorbing productivity shocks, leaving recruitment incentives and hence hiring and unemployment smooth, replicating the puzzle pointed out by Shimer (2005) for the standard calibrated DMP model with flexible (Nash) wages. Even when incumbents' wages are sticky (after having been set flexibly at the hiring stage), the flexible bargaining of entry wages leads them to perfectly adjust to deliver the same present value of wages in new jobs as without incumbents' wage rigidity—echoing the neutrality of incumbent-only wage rigidity shown in Shimer (2004). In this standard DMP model without financial constraints, amplification of hiring fluctuations requires new hires' wage rigidity, which has hence been the focus of the literature (e.g., Pissarides, 2009).

Incumbents' wage rigidity does amplify cash flow fluctuations, which are otherwise unrealistically smooth as *both* new hires' and incumbents' wages absorb productivity shocks. This model property mirrors the aforementioned empirical counterfactual, that average wages can easily stabilize cash flow fluctuations. Yet, without financial constraints, firms finance hiring externally even when incumbents' wage rigidity squeezes cash flow during recessions—a mere accounting side show. Here, incumbents' wages are an inframarginal fixed cost irrelevant for hiring.[1]

With financial constraints, firms spend uncommitted cash flow on hiring, as access to external finance is limited. Hence, incumbents' wages affect firms' *capacity* to hire—whereas standard, marginal wage rigidity (of new hires) affects their *willingness* to hire (as in, e.g., Shimer, 2004; Hall, 2005). Qualitatively, financial constraints therefore break the canonical neutrality of incumbents' wage rigidity. Moreover, the distortion they bring about manifests itself as firms' countercyclical discount rates (consistent with Hall, 2017; Kehoe, Midrigan, and Pastorino, 2019). Quantitatively, the interaction of incumbents' wage rigidity and financial constraints lets the model (in the illustrative benchmark calibration of financial constraints) explain more than half the hiring fluctuations in the U.S. data, compared to less than a tenth without financial constraints. Conversely, financial constraints are cyclically unimportant without incumbents' wage rigidity (i.e., when incumbents' wages move in lockstep with new hires), explaining less than a tenth of the empirical fluctuations. This complementary result highlights the other side of the coin, namely the dependence of financial amplification on wage rigidity.

Finally, I sketch implications for stabilization policy in the context of payroll taxes and wage subsidies. Standard prescriptions (e.g., Bils and Klenow, 2009) implicitly assume away financial constraints and hence limit wage subsidies to new hires only (making incumbent workers ineligible). This view reflects the macro-labor paradigm that only new hires' (net-of-tax) wages matter for hiring. When firms are financially constrained, wage subsidies covering incumbent workers offset the cash flow fluctuations their rigid wages induce, and thereby stabilize hiring—undoing the financial channel of wage rigidity.

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[1]This finding is consistent with recent and in part parallel research on the asset pricing effects of operating leverage from labor costs (Danthine and Donaldson, 2002; Favilukis and Lin, 2016; Favilukis, Lin, and Zhao, 2020), but has not drawn implications for the real effects on employment and investment fluctuations under financial constraints.

The financial channel is not the only way by which incumbent workers might affect hiring. Recent work by Bils, Chang, and Kim (forthcoming) explores how incumbents' being employed in contracts with sticky wages leads firms to demand higher effort in recessions, at the expense of hiring. Fukui (2020) studies effects of incumbents' wage rigidity on hiring in wage posting models. Incumbent workers' wage rigidity likely affects separations (see, e.g., Jäger, Schoefer, and Zweimüller, forthcoming).

Outline I formalize the financial channel of wage rigidity in a simple model in Section 2. In Section 3, I show that it has empirical power. In Section 4, I integrate it into an equilibrium model with financial constraints and wage rigidity. I quantitatively evaluate the model in Section 5. Section 6 presents implications for labor market stabilization through payroll taxes. In the conclusion, Section 7, I discuss limitations of my paper and questions it leaves open.

2 The Basic Mechanism

I convey the mechanism in a simple model. The bottom line is that when firms are financially constrained, firms act as if they face a higher cost on investment and, here, on hiring; the burden of precommitted spending on specifically incumbent workers' wages raises those implied costs, depressing hiring.

In period t, the firm chooses hires h_{t+1}, who start producing (linearly with productivity p_{t+1}) and earning wages in period $t + 1$. Fraction δ of jobs end each period after production and wage payments. Wages w_c are taken as given, differentiated between hiring cohorts denoted by their first period of production c, and constant while the cohort members remain on that job. The firm inherits factor β from the households, which receive dividends equal to flow profits. The firm's period-t problem is:

$$\max_{h_{t+1}} \mathbb{E}_t \sum_{s \geq t} \beta^{s-t} \left(p_s n_s - \Phi_s - C(h_{s+1}) \right) \tag{1}$$

$$\text{s.t.} \quad n_{s+1} = h_{s+1} + (1 - \delta) n_s \quad \forall s \geq t \tag{2}$$

$$\Phi_{s+1} = w_{c=s+1} h_{s+1} + (1 - \delta) \Phi_s \quad \forall s \geq t, \tag{3}$$

where Φ is the total wage bill. Upfront hiring costs $C(h)$ may reflect training or recruitment costs, or arise from complementary capital (here then implicitly with Leontieff production); in the full model, the relevant hiring costs will be pre-bargaining DMP recruitment costs.

Without financial constraints, firms hire until the present value of the cash flow stream from the marginal hire equals her upfront hiring cost, or, equivalently, until her present value of productivity

equals her total (wage plus hiring) costs:

$$C'(h_{t+1}^*) = \mathbb{E}_t \sum_{s>t} \beta^{s-t}(1-\delta)^{s-(t+1)}(p_s - w_{c=t+1}) \qquad (4)$$

$$\Leftrightarrow C'(h_{t+1}^*) + \mathbb{E}_t \sum_{s>t} \beta^{s-t}(1-\delta)^{s-(t+1)} w_{c=t+1} = \mathbb{E}_t \sum_{s>t} \beta^{s-t}(1-\delta)^{s-(t+1)} p_s. \qquad (5)$$

Out of steady state, the first-period hiring response dh_{t+1}^* to a permanent productivity shift dp is, in logs:

$$\frac{d \ln h_{t+1}^*}{d \ln p} = \frac{1}{\frac{hC''}{C'}} \cdot \frac{p}{p - w_{c=t+1}} \cdot \left(1 - \frac{dw_{c=t+1}}{dp}\right). \qquad (6)$$

Standard amplification of hiring depends on the sensitivity of *new hires'* wages, $\frac{dw_{c=t+1}}{dp}$. Incumbent workers' wages $w_c = \overline{w}_{c \leq t} \forall c \leq t$ do not show up, but are an inframarginal fixed cost. This intuition underlies the paradigm that only new hires' wages can distort hiring, which guides both the theory and empirics of wage rigidity (see, e.g., Shimer, 2004; Hall, 2005; Mortensen and Nagypal, 2007; Hall and Milgrom, 2008; Elsby, 2009; Pissarides, 2009; Michaillat, 2012; Haefke, Sonntag, and Van Rens, 2013; Kudlyak, 2014; Christiano, Eichenbaum, and Trabandt, 2016; Hazell and Taska, 2020; Grigsby, Hurst, and Yildirmaz, 2021).[2]

Implicitly, standard labor demand as laid out above assumes that firms have sufficient internal funds or can raise enough external financing (e.g., debt at interest rate $r = 1/\beta - 1$) to cover the hiring costs. Consider the opposite, extreme case: firms cannot access any external finance (or build savings internally), but must finance investment entirely out of internal funds: current cash flow. This feature adds the following financial constraint to the firm's problem:

$$C(h_{t+1}) \leq \underbrace{p_t n_t - \Phi_t}_{\text{Cash Flow}}. \qquad (7)$$

Constraint (7) conveys that in case the company can comfortably cover costs $c(h_t)$ out of pocket, it complies with conventional labor demand condition (4). When constraint (7) binds (e.g., out of steady state, following shocks, or over the lifecycle of a firm), upfront cost $C'(h_{t+1}^*)$ in optimality condition (4) is marked up with Lagrange multiplier τ_t on financial constraint (7):

$$(1 + \tau_t) \cdot C'(h_{t+1}^*) = \mathbb{E}_t \sum_{s>t} \beta^{s-t}(1 + \tau_s)(1-\delta)^{s-(t+1)}(p_s - w_{c=t+1}). \qquad (8)$$

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[2]In important caveat to measuring new hires' wage rigidity in a model-consistent way, developed in Hall and Milgrom (2008), is that the relevant wage cyclicality concerns the gap between (marginal) labor productivity and the new hires' wage, which is spent on recruitment costs and hence determines labor market tightness and unemployment. In the canonical calibrations of the DMP model (Shimer, 2005; Ljungqvist and Sargent, 2017) as well as in the data (Silva and Toledo, 2009), this gap is small. Hence, the difference between flexible and rigid new hires' wages would be hard to detect in the data, with small decreases in the cyclicality of wages implying large amplifications of this gap and hence of unemployment fluctuations.

More insightfully, I take the comparative static of constraint (7) directly, highlighting that recruitment expenditures simply track cash flow in this simple model (when the constraint binds):

$$C(h_{t+1}^*) = p_t n_t - \Phi_t \tag{9}$$

$$= (p_t - \overline{w}_{c \leq t}) \cdot n_t \tag{10}$$

$$\Rightarrow \frac{d \ln h_{t+1}^*}{d \ln p} = \frac{1}{\frac{hC'}{C}} \cdot \frac{p}{p - \overline{w}_{c \leq t}} \cdot \left(1 - \frac{d\overline{w}_{c \leq t}}{dp}\right). \tag{11}$$

The response of financially constrained labor demand given by comparative static (11) mirrors the standard, unconstrained response in Equation (6), except that now, the response of *incumbents'* wages determines hiring by determining financial resources in financial constraint (7). In this extreme example, incumbents' wages and recruitment expenditures per worker move one to one as per condition (10). New hires' wages no longer show up *at all*. Pointing out and exploring this financial link between labor demand and wages are the two contributions of my paper.

The full model in Section 4 will generalize this model, e.g., featuring intermediate degrees of wage rigidity, some but potentially frictional access to external finance, and an equilibrium context.

3 Empirical Evidence

I provide empirical evidence for the quantitative relevance of the financial channel of wage rigidity in two steps. First, I show that a moderate increase in incumbents' wage procyclicality could smooth the empirical fluctuations in aggregate cash flows as well as profits. To do the job, incumbents' wages would move only towards the measured procyclicality of new hires' wages, a realistic benchmark. Second, I confirm the financial consequences of wage rigidity at the industry level, where I exploit cross sectional, as well as panel, variation in industry labor shares as a mediating factor. Cash flow is more procyclical (i.e., sensitive to aggregate unemployment and industry shocks) in industries with higher labor shares, consistent with wage rigidity amplifying cash flow fluctuations by more in those industries. Lastly, I confirm that, consistent with financial constraints, industries with higher labor shares also have more procyclical employment and investment.

3.1 Aggregate Time Series

I show that a moderate increase in the procyclicality of wages would stabilize cash flow and profits, and hence has the potential to neutralize a large class of financial amplification channels. My main data is quarterly U.S. Flow of Funds data from 1951q4 to 2019q4. All quarterly time series in this section are detrended with an HP-filter with a smoothing parameter of 1,600.

The Aggregate Income Statement over the Business Cycle   Figure 1 presents a cash flow statement of the U.S. non-financial corporate sector for 2019 (in 2019 dollars), which I construct from Federal Reserve Flow of Funds data. Appendix Figure A.1 Panel (a) plots the time series of each component (normalized by the trend of value added) from 1951q4 to 2019q4, confirming the

Figure 1: Aggregate Cash Flow Statement (2019) for the United States
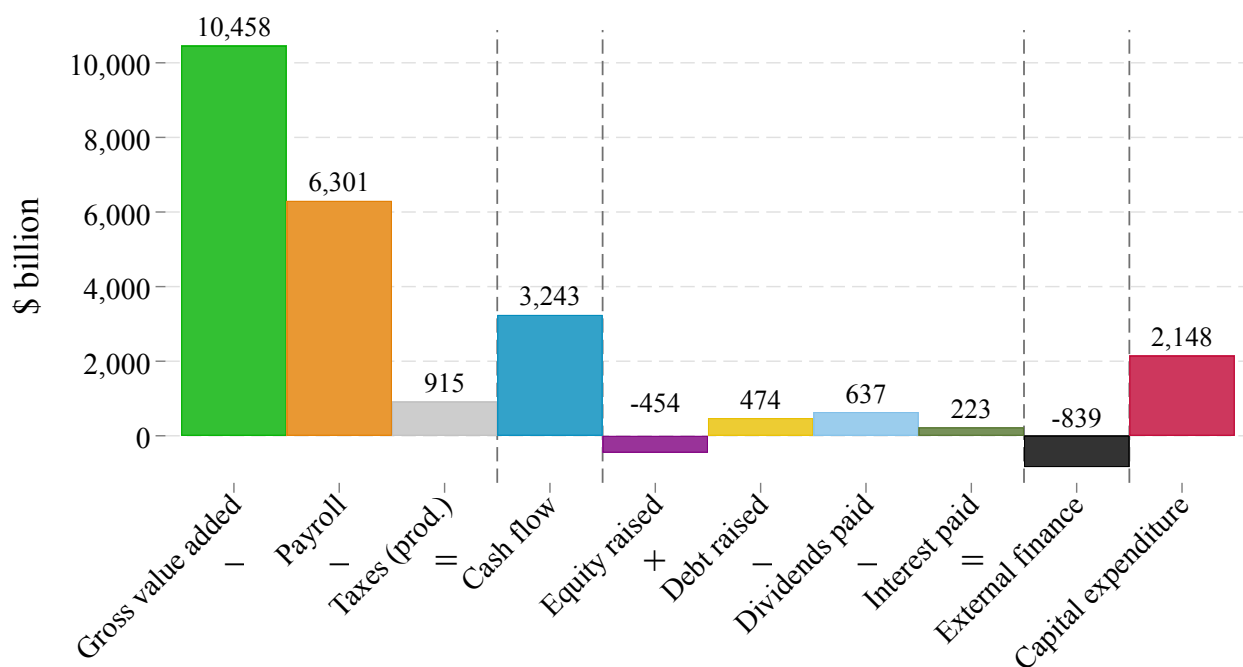
Note: The figure draws on 2019 annual Flow of Funds (Z.1 Financial Accounts) data (1951-2019) for the U.S. nonfinancial corporate sector, in 2019 dollars. Cash flow is net operating surplus plus consumption of fixed capital or, equivalently, gross value added minus compensation of employees and taxes on production and imports less subsidies. Debt raised is flow in debt securities and loans liabilities; equity raised is flow in corporate equities liabilities.

stability of the relative levels; Appendix Figure A.1 Panel (b) presents sample period averages of the 2019 bar chart in Figure 1.

In essence, cash flow is value added minus compensation (and some taxes). Cash flow plus external finance (equity and debt raised, minus interest and dividends) sum to the net inflow of total liquidity. Out of total liquidity, firms finance investment activities, such as capital expenditure.

Cash Flow, External Finance, and Total Liquidity   Figure 2 Panel (a) plots the time series of cash flow, external finance, and total liquidity (each normalized by trend value added). Cash flow is the dominant source of finance at the aggregate level; its average share in total liquidity is 117% (exceeding 100% due to external finance turning negative starting 2000 due to an increase in share repurchases and dividends, see the time series in Appendix Figure A.1 Panel (b)). As suggestive evidence from time series comovement, Figure 2 Panel (a) shows that when cash flow falls, external finance does not make up for that shortfall. Panel (b) scatterplots these (detrended) time series in total liquidity against cash flow, so that the slope traces out a dollar-for-dollar sensitivity. It shows that total liquidity comoves more than one to one with cash flow, by $1.47 on the dollar. The regression coefficient of external finance on cash flow is 0.47. While not identifying causal evidence, the time series comovement is consistent with a large class of corporate finance and

macro-finance models in which firms are financially constrained, i.e., have restricted access to external finance.[3]

Cash Flow and Capital Investment   Under such financial constraints, firms' resort to financing much of their investment internally, using cash flow. Indeed, cash flow exceeds capital expenditure *every* quarter in the period depicted in Figure 2 Panel (a), hovering on average at 165% of capital expenditure. Some of this buffer of course is due to heterogeneity. Appendix Figure A.2 draws on firm micro data (U.S. Compustat as well as a unique German firm survey) to show that this aggregate pattern is attenuated once accounting for firm-level heterogeneity and financial intermediation, such that a little less than 100% of aggregate capital expenditure is financed internally, reflecting or leaving room for (but not definitively due to) financial constraints and the resulting importance of cash flow for investment.[4]

Moreover, under financial constraints, investment is *sensitive* to cash flow and firms' net worth (for canonical macro models with these features, see, e.g., Bernanke and Gertler, 1989; Bernanke, Gertler, and Gilchrist, 1999; Jermann and Quadrini, 2012); in Section 4, I discuss those models. This prediction is consistent with empirical firm-level panel evidence on the comovement of capital expenditure with cash flow even after controlling for investment opportunities (e.g., Fazzari, Hubbard, and Petersen, 1988) and a large body of more recent empirical work aiming to establish causal effects from cash flow windfall shocks and other financial shocks on investment. Similarly, in the aggregate time series data, aggregate capital expenditure moves by $0.84 on the cash flow dollar (SE 0.054), as depicted additionally in Figure 2 Panel (b), consistent with, but not causally identifying, this effect.

Capital Investment and Hiring   While the mechanism this paper explores would apply to capital expenditure too, the model presented in Section 4 and onward will focus on firms' hiring behavior and investment in recruitment. Time series proxies for recruitment expenditures comove almost perfectly with capital investment; Figure 3 plots the log deviations from trend of capital expenditure and the standard proxy for recruitment expenditures, the Help-Wanted Index (drawing on the updated web version of Barnichon, 2010, which ends in 2016). Appendix Figure A.3 shows similar patterns for job opening and hiring time series from JOLTS data, available from 2000 onward. The strong correlation demonstrates that any financial forces that contribute to capital expenditure fluctuations plausibly affect the hiring side as well, as is the case in my model in Section 4.

Counterfactual: Stabilizing Cash Flow With Wages   I now ask what degree of additional wage cyclicality would be needed to smooth aggregate cash flow and hence firms' financial resources

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[3]The figure also points to the rise in cash flow starting in the 2000s (compared to outflows including investment), consistent with the rise in corporate savings (Chen, Karabarbounis, and Neiman, 2017); it is possible that the pockets of the corporate sector driving this trend are hence shielded from financial amplification.

[4]Specifically, I draw on U.S. Compustat firm data in Appendix Figure A.2 Panel (a) (all nonfinacial/non-utility sectors) and Panel (b) (manufacturing only, i.e., investment-intensive industries). I find that nearly all capital investment appears to be funded internally without any financial intermediation. In Appendix Figure A.2 Panel (c), I additionally show more direct, new micro evidence by drawing on unique firm-level survey data (the CESifo Investment Test, 1990–2000) on the sources of investment finance where firms directly report on the fraction of investment financed internally rather than with external finance for the manufacturing sector in Germany, finding very similar results.
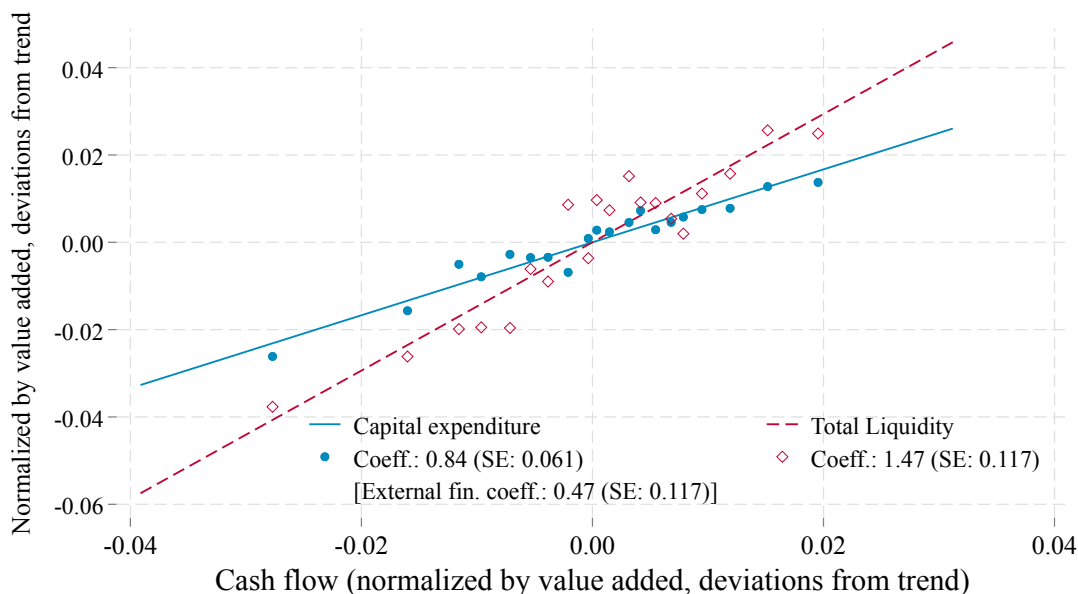
Figure 2: Cash Flow, Liquidity, and Capital Expenditure
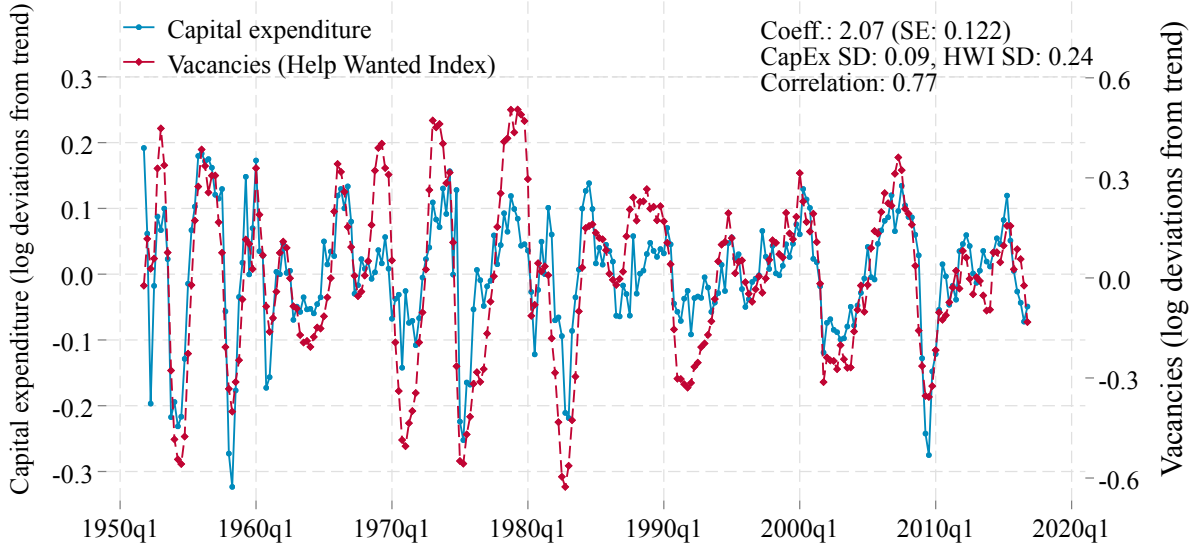
(a) Time Series
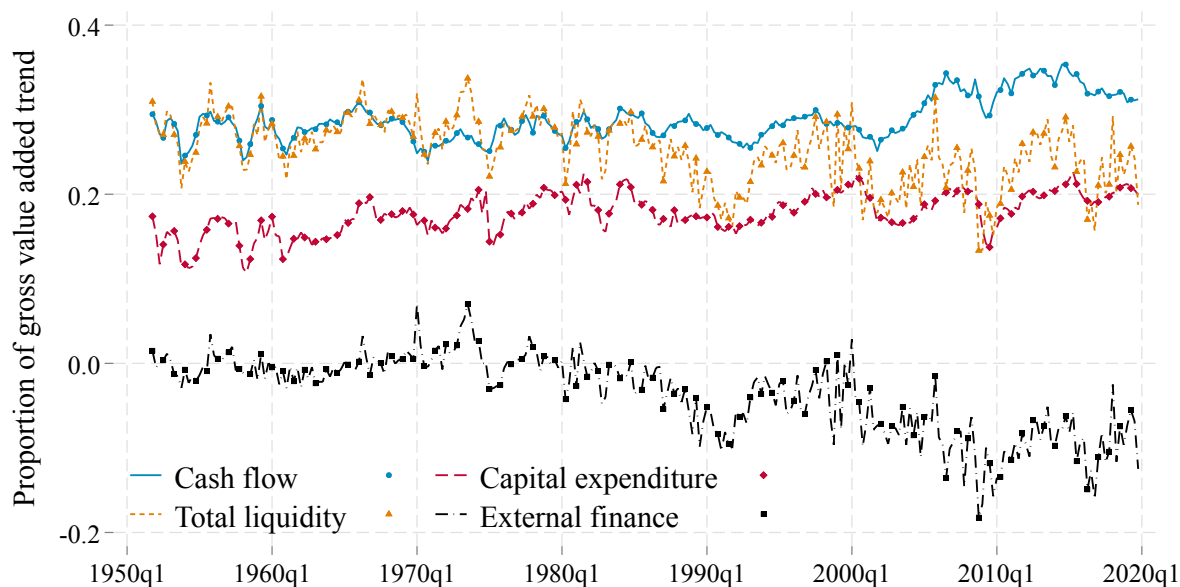
(b) Capital Expenditure and Liquidity Against Cash Flow

Note: The figure draws on seasonally adjusted quarterly Flow of Funds data (1951q4-2019q4, Z.1 Financial Accounts) for the U.S. nonfinancial corporate sector. In Panel (a), cash flow, external finance (i.e., debt and equity raised minus net dividends and net interest paid) and total liquidity (i.e., cash flow plus external finance), are divided by trend gross value added. Panel (b) bin-scatterplots capital expenditure and total liquidity against cash flow, all defined as in Panel (a) but detrended. Detrending of quarterly data uses an HP-filter with a smoothing parameter of 1,600. SEs are robust.

Figure 3: Capital Expenditure and Vacancies (Help-Wanted Index)

Note: The figure plots detrended log capital expenditure (CPI-deflated) and log vacancies. The regression estimates are of log vacancies on log capital expenditure. Capital expenditure is based on seasonally adjusted quarterly Flow of Funds data (1951q4-2019q4, Z.1 Financial Accounts) for the U.S. nonfinancial corporate sector. Vacancies are the Help-Wanted Index (HWI), obtained from Barnichon (2010), specifically the updated web version, which ends in 2016. Detrending of quarterly data uses an HP-filter with a smoothing parameter of 1,600. SEs are robust.

over the business cycle. I find that it would suffice for incumbent workers' wages to turn only moderately more procyclical. Figure 4 Panel (a) plots the time series of the detrended log deviations of real cash flow. (All nominal variables are CPI deflated, since the wage cyclicality benchmark will reference CPI-deflated wages; all results are robust to using the business sector gross value added deflator.) The time series is very volatile (a standard deviation of 0.045). It is also very procyclical; the "Okun's law" has cash flow fall by $\frac{dCF/CF}{du} = 3.28$ percent for a percentage point change in unemployment. Figure 4 Panel (b) plots the associated binned scatter plot of detrended log cash flow against detrended unemployment rate (in levels, not logs).

As a first counterfactual, I back out the additional wage changes required to perfectly stabilize *all* fluctuations in cash flow, including those unrelated to business cycle indicators such as the unemployment rate. Consider the total derivative of cash flow CF and its components value added y and payroll $\Phi = wn$ (product of average wage w and employment n)—where the differences are to be understood as deviations from trend and where I denote empirical values of x as $\widehat{x}$:

$$\widehat{\left(\frac{dCF}{CF}\right)} = \widehat{\left(\frac{dy}{y}\right)} \cdot \widehat{\left(\frac{y}{CF}\right)} - \widehat{\left(\frac{d\Phi}{\Phi}\right)} \cdot \widehat{\left(\frac{\Phi}{CF}\right)}. \tag{12}$$

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Now consider a counterfactual cash flow movement that equals the empirical movement but additionally incorporates a counterfactual, incremental wage change (i.e., a wage change on top of the empirical one that is already encoded in the empirical cash flow change)—conservatively assuming that employment n and value added y keep their empirical values so that the incremental wage change only mechanically affects cash flow:

$$\widetilde{\left(\frac{dCF}{CF}\right)} = \widehat{\left(\frac{dCF}{CF}\right)} - \widetilde{\left(\Delta\frac{dw}{w}\right)} \cdot \widehat{\left(\frac{\Phi}{CF}\right)}, \tag{13}$$

where I denote counterfactual values of x by $\tilde{x}$ and the incremental differences by Δ. Here, the wage change is amplified by the ratio of payroll to cash flow. Hence, any given empirical percent change in cash flow could be zeroed out by an incremental percent change in wages given by the empirical percent change in cash flow times the ratio of cash flow to payroll:

$$\Rightarrow \widetilde{\left(\Delta\frac{dw}{w}\right)}\Bigg|_{\widetilde{\left(\frac{dCF}{CF}\right)}=0} = \widehat{\left(\frac{dCF}{CF}\right)} \cdot \widehat{\left(\frac{CF}{\Phi}\right)}. \tag{14}$$

In the U.S. data, the long-run (1951q4–2019q4) average of the ratios of trend cash flow to trend payroll is 0.463; Appendix Figure A.4 Panel (a) depicts the time series of this ratio (which has gone up since the 2000s).

Results: Moderate Required Incremental Wage Fluctuations   A core insight of this paper is that these incremental wage fluctuations required to perfectly stabilize cash flow are small. Figure 4 Panel (a) plots the time series of those cash-flow-stabilizing incremental wage fluctuations constructed following Equation (14) (feeding in the detrended log cash flow times trend of the cash flow to payroll ratio); Appendix Figure A.4 Panel (c) plots their histogram.[5] The range of those required additional wage changes is moderate: their standard deviation is just 0.020, and their p90, p75, p25 and p10 values are 0.024, 0.013, -0.012 and -0.025.

Results: Zeroing Out the Okun's Law of Cash Flow   Additionally, as a more parametric statement, I ask what it takes for wages to zero out the aforementioned Okun's law of cash flow. The scatter plot in Figure 4 Panel (b) traces out the Okun's law of the additional wage movements. The estimated coefficient indicates that wages would need to fall by an extra 1.49 percentage points to stabilize cash flow with regards to the business cycle. Intuitively, this is because a given percent change in cash flow can be offset by a percent change in payroll equal to the ratio of cash flow to

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[5]The ratio of cash flow to payroll has shifted up since around 2000 (see Appendix Figure A.4 Panel (a)), explaining the larger relative amplitude of the cash-flow stabilizing wage movements in that time period.

Figure 4: Financial Fluctuations and Wages in the United States

(a) Cash Flow and Cash-Flow-Stabilizing Additional Wage Fluctuations
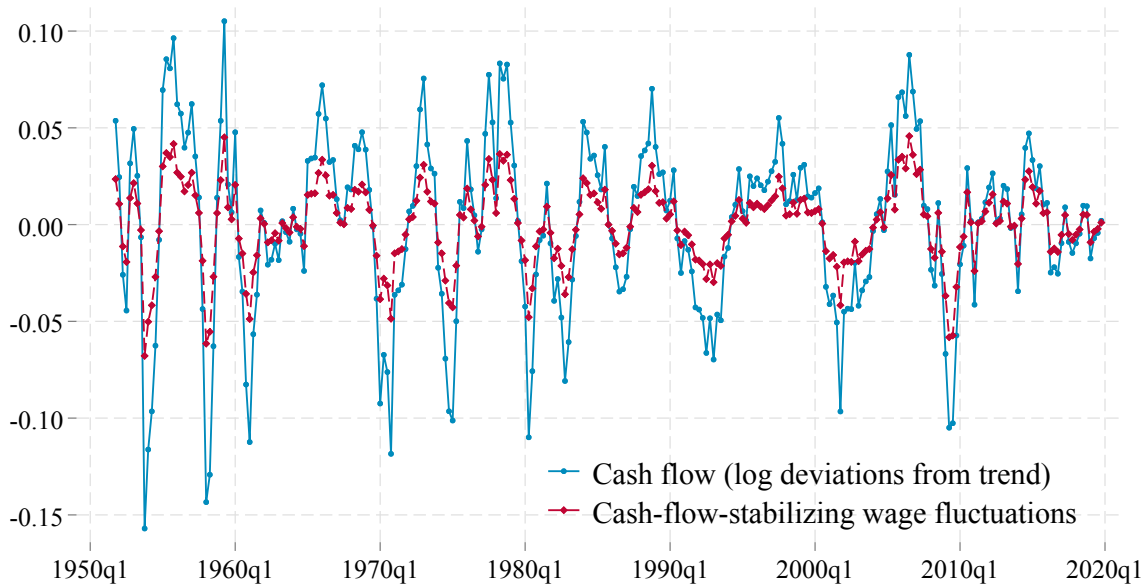
(b) Okun's Laws: Cash Flow and Cash-Flow-Stabilizing Additional Wage Fluctuations
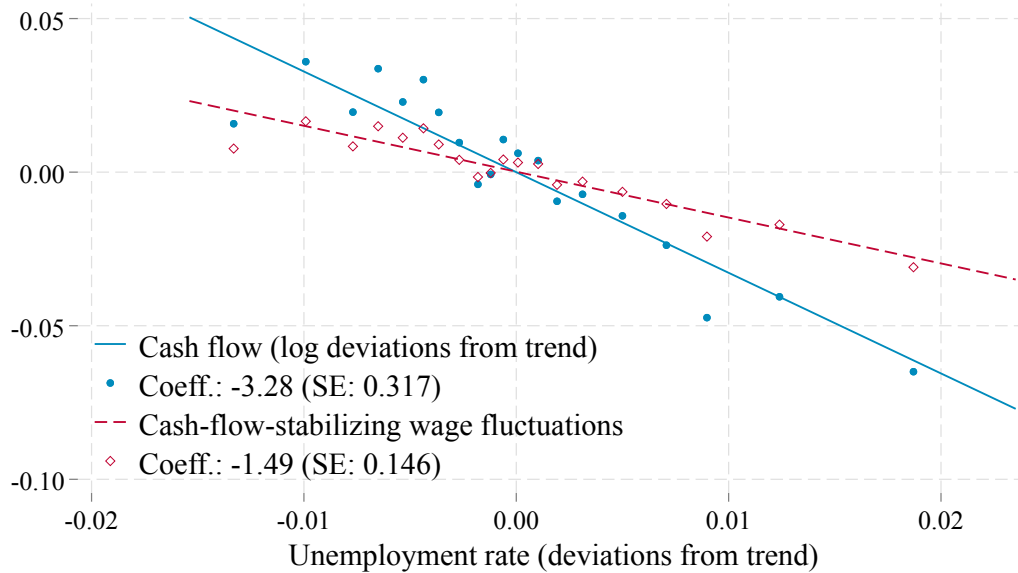
Note: Panel (a) plots detrended log aggregate cash flow and incremental wage movements necessary to offset these fluctuations and stabilize cash flow, as described in Section 3.1. Panel (b) bin-scatterplots these two variables against the detrended unemployment rate, reporting semi-elasticities/Okun's laws. Cash flow is based on seasonally adjusted quarterly Flow of Funds data (1951q4-2019q4, Z.1 Financial Accounts) for the U.S. nonfinancial corporate sector as computed and depicted in Figure 1. Detrending of quarterly data uses an HP-filter with a smoothing parameter of 1,600. SEs are robust.

payroll, and thus approximately:[6]

$$\Rightarrow \left.\widetilde{\left(\frac{\Delta\frac{dw}{w}}{du}\right)}\right|_{\widetilde{\left(\frac{dCF}{CF}\right)}=0} = \underbrace{\widetilde{\left(\frac{\frac{dCF}{CF}}{du}\right)}}_{-3.28}\underbrace{\widetilde{\left(\frac{CF}{\Phi}\right)}}_{0.463} \tag{15}$$

$$= -1.52.$$

Empirical Benchmark: Micro Evidence of Wage Cyclicalities The additional wage fluctuations required can be considered moderate by a variety of benchmarks. First, they are small compared to idiosyncratic wage and earnings changes found in the micro data at similar frequencies (Guvenen, Karahan, Ozkan, and Song, 2020). Second, at an aggregate business cycle perspective, the additional wage procyclicality corresponds to the empirical wage cyclicality differential estimated between new hires and incumbent workers. Pissarides (2009) conducts a comprehensive meta analysis of existing micro evidence that adjusts for composition bias (e.g., going back to Bils, 1985; Solon, Barsky, and Parker, 1994), which puts the semi-elasticities of wages with respect to the unemployment rate at about -1.25 for average and incumbent workers' wages, compared to about -3.00 for new hires—giving a differential of about -1.75.[7] That is, average (largely incumbents') wages would need to turn as procyclical as a strand of the literature indicates new hires' wages are in the data already, and thereby would stabilize cash flow fluctuations. In the theoretical model, my counterfactual case will also raise incumbent workers' wage cyclicality to that of new hires. In the calibrated model too, when incumbent workers' wages move as procyclically as new hires' wages, cash flow will turn acyclical.

Importantly, there is an ongoing debate as to whether these wage cyclicality differentials may reflect composition bias (Solon, Barsky, and Parker, 1994; Hagedorn and Manovskii, 2013) and whether new hires' wages too may actually be rigid (Galuscak, Keeney, Nicolitsas, Smets, Strzelecki, and Vodopivec, 2012; Gertler, Huckfeldt, and Trigari, 2020; Hazell and Taska, 2020). Yet, for my accounting exercise, I merely cite that potential estimate for new hires' wages as a tangible benchmark for the percentage point number required to smooth cash flow. If new hires wages are rigid too, then the counterfactual simply refers to all workers' wages raising their semi-elasticity by about -1.5. (Similarly, in my model, if new hires wages were rigid too, both the standard marginal channel, from new hires' wages, and the financial channel from incumbents would be active.) The counterfactual holds even if incumbents' wages are differentially cyclical but for reasons unrelated to rigidity but due to, e.g., differential aggregate productivity shifts (Mercan, Schoefer, and Sedláček, 2021). Similarly, baseline cyclicality of incumbents' wages (e.g., Elsby and

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[6]The small gap to the estimate of -1.49 discussed above and reported in Figure 4 Panel (b) reflects rounding and feeding in the long-run average cash flow/payroll ratio rather than its point in time trend.

[7]The micro-empirical literature on wage cyclicality features regressions of log wages of individual i in job j on detrended unemployment and controls (to reduce composition bias) as the cyclical indicator: $\ln w_{ikt} = \beta_0 + \beta_u u_t + \beta_X X_{ijt} + \varepsilon_{ijt}$. The wage cyclicality measure is the coefficient on unemployment: $e_{w,u} = \beta_{UR} = dlog(w_t)/du_t$. The meta analysis by Pissarides (2009) puts new hires at $e_{w,u}^{new} \approx 3$ vs. at most half for incumbents: $e_{w,u}^{inc} \in [1.0, 1.5]$. Pissarides (2009) and Haefke, Sonntag, and Van Rens (2013) also explore productivity as alternative cyclical indicators.

Solon, 2019, argue that downward wage stickiness has been overestimated) does not change the required percentage point increase in their cyclicality. In any case, the bottom line of the exercise is that stabilizing firms' financial resources does not require a large degree of additional wage procyclicality of incumbent workers.

Robustness: Profit Fluctuations   Besides from cash flow, firms' profitability can generate alternative firm-side financial amplification, e.g., through moral hazard (Bernanke and Gertler, 1989) or collateral values (Shleifer and Vishny, 1992). Appendix Figure A.5 replicates the results for cash flow (i.e., Figure 4 and Appendix Figure A.4) with pre-tax profits. The semi-elasticity of profits with respect to the unemployment rate is -6.87. Yet, the much lower profit-payroll ratio, on average 0.206 rather than 0.463 for cash flow, further leverages the wage pass-through into profits. As a result, profit-stabilizing incremental wage fluctuations remain very similar to the cash flow counterfactual; the additional semi-elasticity to unemployment is only -1.40. Appendix Figure A.6 shows similar results considering post-tax profits, which are smoother and hence require even smaller wage movements.

Robustness: Frequencies and Detrending   Appendix Figure A.7 replicates the figures for cash flow at annual rather than quarterly frequency, and detrends using an HP-filter with a smoothing parameter of 100. Appendix Figure A.8 replicates the quarterly analysis but applies a smoothing parameter of 10^5, as in Shimer (2005), to whose moments I will quantitatively benchmark my model in Section 5.

Robustness: Alternative Sources of Financial Stabilization?   Wages are unique in that no other single outflow in the aggregate cash flow statement in Figure 1 could realistically stabilize financial resources. To show this, I define total liquidity as cash flow plus external finance (in turn, net debt raised plus net equity raised minus dividends minus interest payments), and construct the additional fluctuations that would stabilize total liquidity, separately for wages, dividends, and interest expenditures. The method otherwise follows the counterfactual for cash flow. Appendix Figure A.9 plots these incremental total-liquidity-stabilizing fluctuations, which for dividends and interest expenditure are dramatically larger than those for wages. Dividends and interest expenditures would need to regularly turn dramatically *negative* during recessions. An even more striking illustration of the implausibility is the Okun's laws for the additional dividend and interest movements that would stabilize total liquidity, also depicted in Appendix Figure A.9. The semi-elasticity would need to become steeper by an incremental -49.41 for dividends and -97.50 for interest expenditures—nearly 30 and 50 times the magnitude of the corresponding incremental wage movements (also depicted), respectively. By contrast, the wage movements remain in a realistic ballpark (although slightly increasing because total liquidity is more procyclical than cash flow, see also Figure 2).

Take-away   The aggregate perspective reveals that wage rigidity plays a crucial role in cash flow fluctuations. If average wages—hence, largely those of incumbent workers—were only moderately more procyclical, aggregate cash flow and profits would turn perfectly acyclical—thereby shutting

off this class of financial amplification. The next section provides suggestive evidence for the real effects of this financial stabilization at the industry level. Then, in the rest of the paper, I formalize and quantitatively explore this aggregate counterfactual in a calibrated model.

3.2 Industry-level Evidence

I provide suggestive industry-level evidence for amplification of cash flow, employment and investment fluctuations from the (rigid) wage bill by using cross-sectional and panel variation in the labor share.

Strategy I start by leveraging cross-sectional variation in industry labor shares. The labor share mediates the financial channel of wage rigidity on cash flow, defined as value added y minus payroll (average wage w times employment n), i.e., $CF = y - wn$ (and thence on input demand under financial constraints), e.g., letting labor productivity $p = \frac{y}{n}$ and wages w vary (but again, holding n constant):

$$\frac{d \ln CF}{d \ln p} = \frac{1 - \frac{dw}{dp}}{1 - \frac{\Phi}{y}}. \tag{16}$$

To conduct this test, I draw on the NBER-CES Manufacturing Industry Database (described in Becker, Gray, and Marvakov, 2013), annual data covering 473 U.S. manufacturing industries at the 6-digit NAICS level, with complete data from 1958 to 2016 for 457 of those industries, the longest and most granular industry panel data set for the U.S. Where applicable, I detrend the annual data with an HP filter using a smoothing parameter of 100. I construct cash flow as value added minus payroll. The labor share is payroll divided by value added by year. I average the year-specific labor shares across the sample period within each industry. There is substantial cross-sectional variation in this average labor share, with a mean of 0.40, a standard deviation of 0.10ppt, and 10th and 90th percentile values of 0.25 and 0.52. Appendix Figure A.11 Panel (a) depicts the histogram of these industry-level sample-period labor share averages.

Of course, the labor share may affect outcomes through other channels, or may be correlated with other cyclically relevant factors (such as wage rigidity, financial constraints, cyclicality of demand, the DMP "fundamental surplus" discussed below). Hence, this exercise is not definitive, but to alleviate those concerns, I present a series of robustness checks at the end of the section.

Cash Flow Fluctuations The (binned) scatter plot in Figure 5 Panel (a) plots the cross-sectional relationship between industry-level labor shares (averaged in an industry across the sample period) and industry-level cash flow cyclicalities, defined as the industry-level Okun's laws, i.e., industry-specific semi-elasticities of detrended (log) cash flow (CPI-deflated) to the detrended unemployment rate. Indeed, industries with higher labor shares exhibit more procyclical cash flow, consistent with wages being the dominant drain on cash flow and wages not becoming more procyclical in those industries to offset this effect. Cash flow is nearly acyclical with low labor shares. As a nonparametric complement, Figure 6 Panel (a) plots the percent (log) cash flow de-

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Figure 5: Industry-Level Evidence: Okun's Laws of Cash Flow and Inputs, by Industry Labor Share
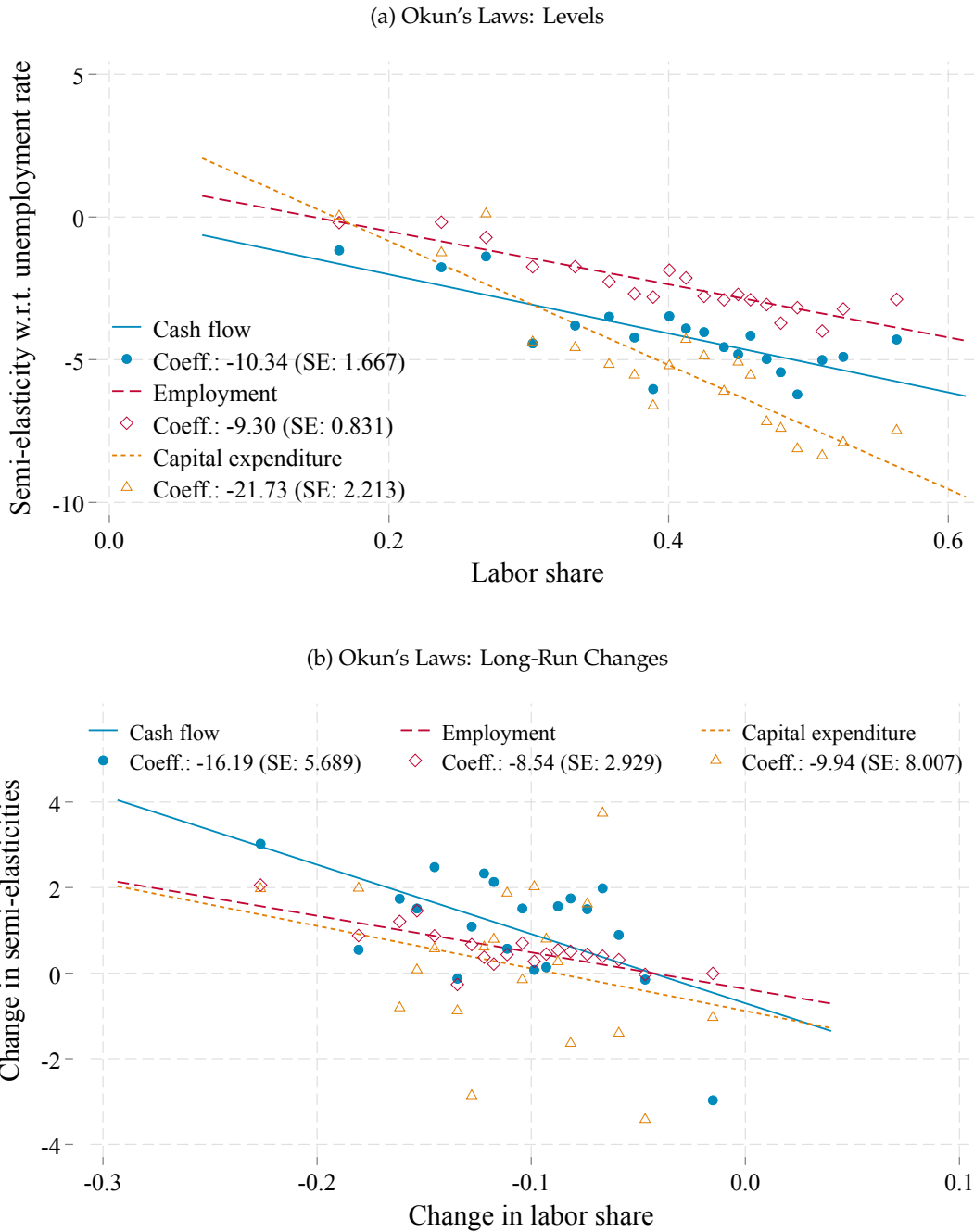
(a) Okun's Laws: Levels

(b) Okun's Laws: Long-Run Changes

Note: The figure draws on the annual NBER CES Manufacturing Industry Database (1958-2016). Panels are binned scatter plots; SEs are robust; nominal variables are CPI-deflated; detrending uses an HP-filter (smoothing parameter of 100). Panel (a) relates industry-level semi-elasticities of cash flow, employment and capital expenditure to the unemployment rate (all detrended), to industry labor shares, both calculated/averaged over the full sample period. Panel (b) replicates Panel (a) by half sample period (1958-82, 1983-2016), and scatterplots the difference, i.e., long-run *changes*, on both axes.

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clines separately for each of the five post-war recessions sufficiently long enough to study in the annual data.

Employment and Investment Fluctuations Under financial constraints, the industries in which higher labor shares increase the financial burden from rigid wages during recessions should also exhibit more volatility in employment and investment. Figure 5 Panel (a) shows evidence strikingly consistent with this prediction, additionally plotting industry-specific Okun's laws for investment (CPI-deflated) and employment against industry labor shares. These gradients trace out a negative slope, such that industries with high labor shares have not only more volatile cash flow, but also employment and investment. Similarly, Figure 6 Panels (b) and (c) show that in each of the recessions considered, employment and investment, respectively, dropped the most in the industries with higher labor shares.

Robustness: Long-Run Panel Variation in the Labor Share Besides cross-sectional variation, I exploit the long-run panel variation in the labor share in the manufacturing sector (see Elsby, Hobijn, and Şahin, 2013a; Karabarbounis and Neiman, 2014, for broader evidence on the decline of the labor share). I split the sample period into two, and construct average industry-level labor shares for each semi-period (1958-1982 and 1983-2016). Appendix Figure A.11 Panel (b) plots the histogram of these long-run changes; Panel (c) juxtaposes an industry's change against its average level in the first semi-period. Using this panel variation, I re-estimate industry-level semi-elasticities to the unemployment rate separately in each sample semi-period. Figure 5 Panel (b) plots each industry's ppt long-run change in its semi-elasticity against the ppt long-run change in its labor share—essentially giving a panel version of Figure 5 Panel (a). Again, there is a negative relationship between now panel variation in the labor share and amplification of cash flow, employment, and investment fluctuations. The negative panel gradients rule out the concern that the cross-sectional gradients reflected (stable) omitted variables at the industry level, such as differential cyclicality in product demand, for instance.

Robustness: Industry-Specific Productivity Shifts To rule out confounding factors such as more procyclical product demand, I additionally estimate industry-specific elasticities of cash flow, employment, and investment to industry-specific productivity shifts, estimating those industry-specific elasticities in a pooled panel regression of each outcome on the industry productivity shift and controlling for a common year fixed effect. I do so for industry-specific value added, labor productivity (value added per worker), and TFP (the dataset's 5-factor series). Figure 7 plots the resulting industry elasticities against the labor share. The slopes again indicate larger cyclical sensitivities for high labor share industries, suggesting that the link between the labor share and the industry sensitivities to the aggregate business cycle did not capture a correlation between an industry's productivity or product demand with the aggregate business cycle, but plausibly instead heterogeneity in amplification from the labor share.

Figure 6: Industry-Level Evidence: Cash Flow and Input Declines During Specific Recessions, by Industry Labor Share
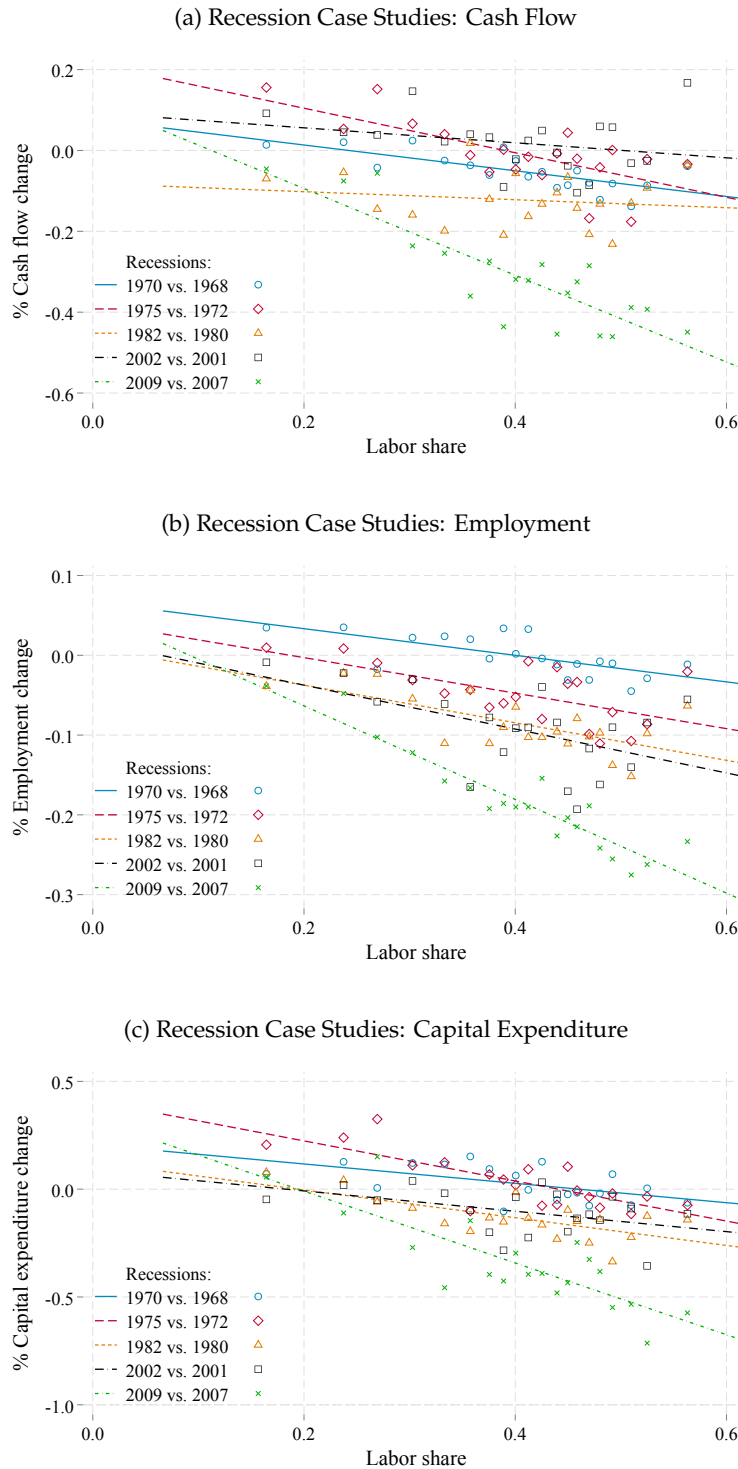
(a) Recession Case Studies: Cash Flow

(b) Recession Case Studies: Employment

(c) Recession Case Studies: Capital Expenditure

Note: The figure draws on the annual NBER CES Manufacturing Industry Database (1958-2016). Panels are binned scatter plots; nominal variables are CPI-deflated. The panels plot the relationship between the industry-level percent (log) changes of cash flow, employment and capital expenditure during specific recessions, and the industry labor share computed over the full sample period.

Figure 7: Industry-Level Evidence: Elasticity of Cash Flow and Inputs to Industry Productivity Shifts, by Industry Labor Share
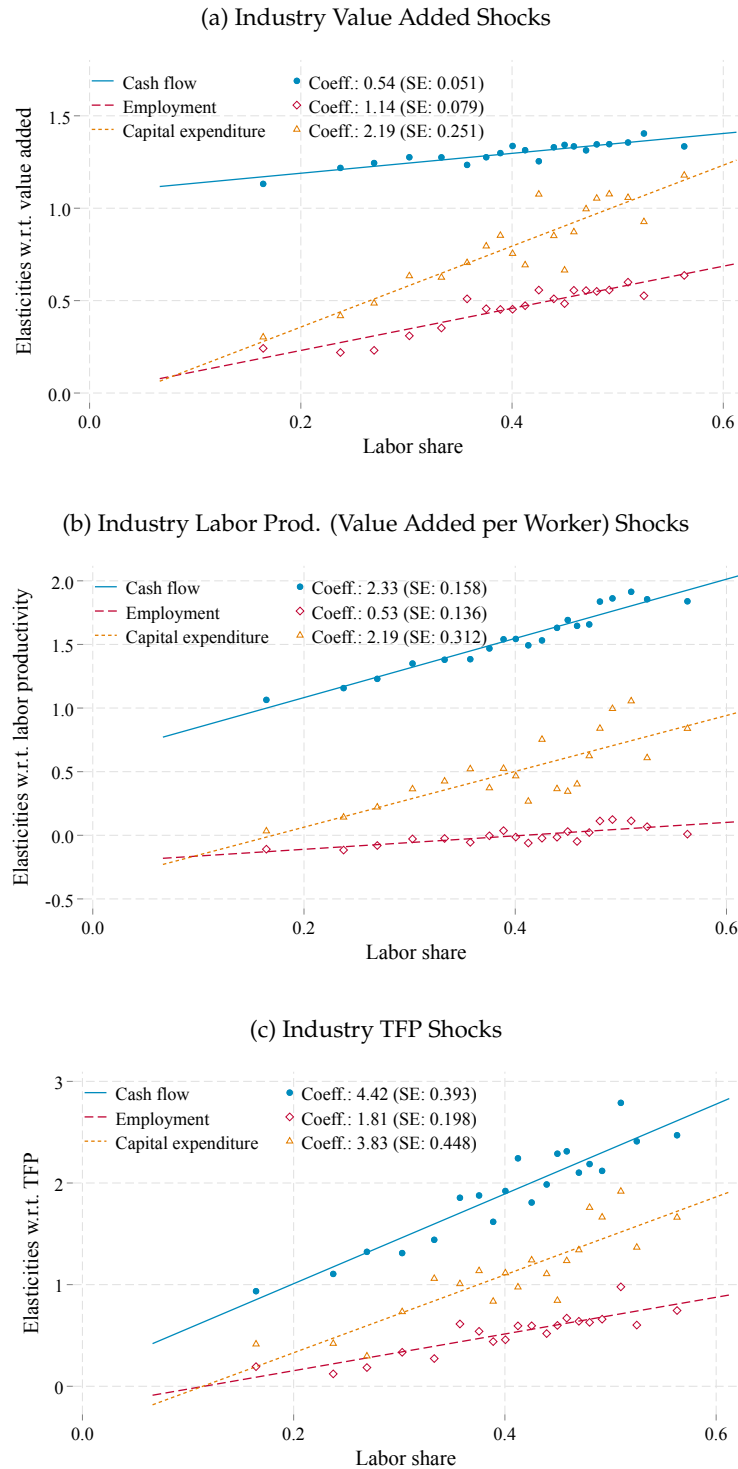
(a) Industry Value Added Shocks

(b) Industry Labor Prod. (Value Added per Worker) Shocks

(c) Industry TFP Shocks

Note: The figure draws on the annual NBER CES Manufacturing Industry Database (1958-2016). Panels are binned scatter plots; SEs are robust; nominal variables are CPI-deflated; detrending uses an HP-filter (smoothing parameter of 100). The panels replicate Figure 5 Panel (a) for industry elasticities to various industry shock proxies (value added, value added per worker, TFP) from panel regressions with year fixed effects.

The representative firms and households are large in that they have a continuum of jobs and members of measure one, but are small enough to take aggregate variables as given, as in, e.g., Shimer (2010).

Robustness: Revenue Shares   To check that the labor share captures payroll as a drain on cash flow rather than intermediate-input intensity, Appendix Figure A.11 Panel (d) replicates Figure 5 Panel (a) but constructs the labor share using revenue (value of shipments) instead of value added.

Robustness: Orthogonality to the "Fundamental Surplus" (Ljungqvist and Sargent, 2017)   My final robustness check addresses a concern specific to the literature on the Diamond-Mortensen-Pissarides (DMP) search and matching model (foreshadowing a model framework below): whether the standard labor share may correlate with the "fundamental surplus" in the DMP model.

First, the labor share and the DMP fundamental surplus are unrelated a priori and conceptually. The DMP concept of the fundamental surplus is the gap between the *marginal* product of labor and the wage (or the worker's instantaneous payoff from nonemployment)—which in the DMP model would amplify the elasticity of labor market tightness to shocks (Ljungqvist and Sargent, 2017, 2021).[8] Due to free entry in recruitment, the DMP fundamental surplus describes a gap that is tiny and finances the upfront (tiny) recruitment costs per worker.[9] Instead of one minus the labor share, the relevant cost share for the fundamental surplus concerns those upfront costs that are sensitive to labor market tightness. This is because due to free entry, the hiring cost equals the present value of cash flow $(p - w)$ from a job, as in Equation (4).

Second, in terms of measurement and accounting, recruitment costs are likely contained in labor costs (as in the model of, e.g. Shimer, 2010) or in intermediate services if outsourced (hence not in the (manufacturing industry) value added labor share either), but not in capital income.

Third, the labor share and the fundamental surplus appear also unrelated empirically. While the fundamental surplus (or, equivalently in the DMP model, the share of recruitment costs that are sensitive to labor market tightness) is notoriously difficult to measure in the data, I attempt a simple strategy to gauge the correlation between the fundamental surplus and the industry labor share empirically. In Appendix Figure A.10, I scatterplot a proxy for the fundamental surplus against the labor share. The proxy is the inverse of the industry-level payroll share of workers with recruitment-related occupations, multiplied by the industry labor share drawing on 3-digit manufacturing and census data. The details of the construction and derivation are in the figure

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[8]Using symbols defined in the later DMP model sections, the elasticity of labor market tightness (the ratio of vacancies to unemployment, which guides the job finding rate) to productivity is given by:

$$\frac{d\theta/\theta}{dp/p} = \left(1 - \frac{dw}{dp}\right)\frac{1}{1-v}\frac{p}{p-w}, \tag{17}$$

where the third term (the "fundamental surplus" term) may appear to be related to the labor share, comparable to the *marginal* hiring condition in Equation (6). While the version above and the one I dissect here uses wages (and assumes that the wage sensitivity $\frac{dw}{dp}$ does not systematically vary across industries), the perhaps most central version discussed in Ljungqvist and Sargent (2017, 2021) is the expression with Nash bargaining, where the denominator includes the nonemployment payoff rather than the wage. Of course, it is implausible that industry variation in that property drives the labor share differences.

[9]I thank Marcus Hagedorn, Claudio Michelacci, and Yusuf Mercan for insightful discussions on this topic.

note.[10] There, the linear slope is essentially zero (where I put the more noisily measured variable, the fundamental surplus proxy, on the left-hand side to avoid attenuation bias of the slope estimate from potential measurement error). Hence, at least this proxy that is plausibly related to the DMP fundamental surplus appears unrelated to standard labor income share in the data.

Taken together, the potential amplification I document across industries is unlikely to reflect the standard DMP fundamental surplus channel dissected in Ljungqvist and Sargent (2017, 2021).

Take-away The cross-industry perspective suggests that the financial channel of wage rigidity amplifies cash flow fluctuations, which, consistent with financial constraints, transmit into input fluctuations. Wages insufficiently adjust to shocks and hence affect firms' financial resources, a channel that looms the largest in industries with high labor shares. The aggregate model below explores the consequences of changing the cyclical behavior of (average, or incumbents') wages, i.e., $\frac{dw}{dp}$ in Equation (16), and hence the severity of this channel. Just as industries with low labor shares, an aggregate economy with more procyclical wages would have stable financial resources, and, hence, in the presence of financial constraints, smoother business cycles.

4 A DMP Model With Wage Rigidity and Financial Constraints

To formally explore the financial channel of wage rigidity, I build a Diamond-Mortensen-Pissarides (DMP) search and matching model with wage rigidity among incumbent workers and financial constraints on firms' (hiring) investment.

The DMP Labor Market Aggregate hiring (worker flows from unemployment into employment) is given by a matching function $\mathcal{M}(u, v)$, which takes as inputs vacancies v and unemployed job seekers u. The labor force has a constant unit mass, so employment is $n = 1 - u$. Constant returns to scale in the matching function (later specified to Cobb Douglas) and random search imply that labor market tightness $\theta = v/u$ determines the vacancy filling rate $q(\theta) = \mathcal{M}(u, v)/v = \mathcal{M}(1/\theta, 1)$ and job finding rate $f(\theta) = \mathcal{M}(u, v)/u = \mathcal{M}(1, \theta) = \theta q(\theta)$. Separations occur exogenously with constant probability δ. Unemployment evolves as inflows $\delta(1 - u)$, minus outflows $f(\theta)u$:

$$u_{t+1} = u_t + \delta(1 - u_t) - f(\theta_t)u_t. \tag{18}$$

The representative firms and households are large in that they have a continuum of jobs and members of measure one, but are small enough to take aggregate variables as given, as in, e.g., Shimer (2010).

Incumbent-Only Wage Rigidity I present a tractable, ad-hoc wage structure that permits me to have flexible wages for new hires yet, at a degree I can control with one parameter ρ, ex-post rigid wages for incumbents. The period-t wage of an incumbent worker that started employment in period $c < t$ equals the geometric mean of the current period's entry wage of new hires $w_{t,t}$ (and

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hence the wage the incumbent would obtain if she fully rebargained the wage), and her hiring cohort's initial wage $w_{t=c,t=c}$, weighted by rigidity parameter ρ:

$$w_{t,c} = w_{c,c}^{\rho} \cdot w_{t,t}^{1-\rho},$$ (19)

which I expand with commentary as follows:

$$\underbrace{\overbrace{w_{t,c}}^{\substack{\text{Cohort } c\text{'s wage}\\ \text{in period } t > c}}}_{} = \underbrace{\overbrace{w_{c,c}}^{\substack{\text{Cohort } c\text{'s original, ex-ante}\\ \text{flexible entry wage set in period } c}}\overbrace{\rho}^{\substack{\text{Rigidity}\\\text{parameter}}}}_{\substack{\text{Ex-post rigid}\\\text{cohort effect}}} \cdot \underbrace{\overbrace{w_{t,t}}^{\substack{\text{Entry wage of}\\\text{current new hires}}}{}^{1-\rho}}_{\substack{\text{Cyclical wage}\\\text{component}}}.$$ (20)

Incumbents' wage rigidity parameter $\rho \in [0,1]$ puts weight on the cohort's entry wage $w_{c,c}$, controlling the relative wage cyclicality (comovement) of incumbents vis-à-vis new hires (as $\frac{d \ln w_{t,c}}{d \ln w_{t,t}} = 1 - \rho$ $\forall \, c < t$). Throughout, I assume that incumbents' wages are indexed to new hires' wage in the external market, thereby precluding a specific bargaining pair from internalizing the effects of their wage bargain in a new match on incumbents' wages even in a large-firm setting.

Importantly, as discussed in Section 3.1, the results in this paper do *not* rely on new hires' wages actually being more flexible than incumbents' wages; if both wages were rigid, the model would simply feature both the standard channel of amplification, from new hires, and the financial one, from incumbent workers. I therefore sidestep the important and ongoing empirical debate about the degree of new hires' wage rigidity (Pissarides, 2009; Galuscak, Keeney, Nicolitsas, Smets, Strzelecki, and Vodopivec, 2012; Kudlyak, 2014; Hazell and Taska, 2020; Gertler, Huckfeldt, and Trigari, 2020; Grigsby, Hurst, and Yildirmaz, 2021). For instance, in the presence of pay equity constraints (Bewley, 1999; Snell and Thomas, 2010; Saez, Schoefer, and Seim, 2019; Drenik, Jäger, Plotkin, and Schoefer, forthcoming), differential wage cyclicality of new hires may be curbed, and hence amplification would be even larger.

The wage specification in Equation (19) renders the law of motion for payroll Φ recursive (where $n_{t,c} = (1-\delta)^{t-c} h_c$ is the count of workers of cohort c remaining in that job through period t and $h_c = n_{c,c}$ is the initial cohort size):

$$\Phi_t = \sum_{c \leq t} w_{t,c} n_{t,c}$$ (21)

$$= \sum_{c \leq t} w_{t,t}^{1-\rho} w_{c,c}^{\rho} \cdot (1-\delta)^{t-c} h_c$$ (22)

$$= w_{t,t} h_t + (1-\delta) \left(\frac{w_{t,t}}{w_{t-1,t-1}} \right)^{1-\rho} \Phi_{t-1}.$$ (23)

Recursive Notation Going forward, I present the model recursively, with notation x^-, x, x^+ and x^{++} for x_{t-1}, x_t, x_{t+1} and x_{t+2}, respectively. New hires' entry wages are denoted by $w = w_{t,t}$, and are flexibly bargained over at match formation in a way that renders their subsequent rigidity as

incumbent workers neutral in the absence of financial constraints, as discussed below. Incumbents' wage evolution will be captured by the law of motion of payroll in Equation (23).

Firm's Problem Firms maximize the expected present value of dividends d by posting vacancies v at per-period cost k to recruit next period's new hires h^+ at vacancy filling rate $q(\theta)$. They also choose dividends d (broadly interpreted to be all nondebt, e.g., equity finance), and one-period debt B (or, if negative, savings in an interest-bearing asset):

$$V\left(n^-, \Phi^-, h, B^-; \mathbf{s}\right) = \max_{v, d, B, h^+, n^+} \left\{ d - \frac{\kappa^d}{2}(d - d^{ss})^2 - \frac{\kappa^B}{2}(B - B^{ss})^2 + \mathbb{E}\,\beta V\left(n, \Phi, h^+, B; \mathbf{s}^+\right) \right\} \quad (24)$$

$$\text{s.t.:} \quad \Phi = wh + (1 - \delta)\left(\frac{w}{w^-}\right)^{1-\rho} \Phi^- \quad (25)$$

$$n = (1 - \delta)\,n^- + h \quad (26)$$

$$h^+ = v\,q\,(\theta) \quad (27)$$

$$kv = pn - \Phi - d + \left(\Delta B - r(1 - t^B)B^- - rt^B\widetilde{B}^-\right) \quad (28)$$

$$B \leq \overline{B}, \quad (29)$$

where β is the discount factor the managers inherit from the households, which own the firms, where $\mathbf{s}$ denotes the aggregate state (suppressed in the variables except for value V, and going forward, suppressed throughout), and where superscript ss denotes a variable's steady state level.

The firm's net financial resource flow consists of cash flow $pn - \Phi$ and external finance, i.e., net borrowing ΔB, minus net-of-subsidy interest expenditure $(1 - t^B)rB^-$ and dividends d. t^B is a tax subsidy on interest payments. The subsidy will encourage the firm to raise debt to the borrowing limit $\overline{B}$ in steady state, such that the borrowing constraint (29) binds in steady state; to neutralize its cash flow effects, the subsidy is financed by lump-sum tax $rt^B\widetilde{B}^-$, where the debt level $\widetilde{B}^-$ is taken as given by the firm and is equal to the (stochastic) equilibrium debt level.

Reflection: Financing DMP Hiring Investment To highlight the relationship between hiring investment and internal and external finance, it is instructive to rewrite constraint (28) as follows:

$$\underbrace{\overbrace{\underbrace{kv}_{\substack{\text{Investment} \\ \text{(Rec. Exp.)}}} - \underbrace{(pn - \Phi)}_{\text{Cash flow}}}^{\text{Financing gap}}} = -d + \underbrace{\left(\Delta B - r(1 - t)B^- - rt\widetilde{B}^-\right)}_{\text{External finance}}. \quad (30)$$

Hence, whenever investment (here: recruitment) expenditures exceed cash flow, i.e., the financing gap is positive, the firm must raise external finance; by contrast, if cash flow exceeds investment expenditures, the firms can pay out dividends (analogously, repurchase equity, see below), or save (reduce debt). The simple model in Section 2 assumed away external finance entirely.

Literally interpreted, the hiring cost consists of DMP vacancy posting costs (as in, e.g., Petrosky-Nadeau, 2014) paid for by the firm before matching and bargaining, and those costs are likely small in the data (Silva and Toledo, 2009), but control labor market tightness fluctuations in the DMP

model (see also the discussion in Hall and Milgrom, 2008). Hiring costs may also include post-bargaining costs such as training and other costs (e.g., working capital), and the effect of financial shocks on employment may also reflect complementarity with capital. The main result of the DMP setup evoked here is that employment is directly sensitive to financial resources—consistent with empirical findings such as in Sharpe (1994); Chodorow-Reich (2014); Benmelech, Bergman, and Seru (2015); Melcangi (2020). I further discuss the interpretation of financial constraints on hiring in Sections 5.4 and 7.

Financial Frictions   Three features shape the financial frictions in the model—while keeping the steady state size of the representative firm and hence the unemployment rate unaffected across specifications. The borrowing limit $\overline{B}$ could be rationalized with a collateral constraint (as in, e.g, Jermann and Quadrini, 2012, appealing to an enforcement friction that marks down creditors' valuation of the firm's collateral, which here would be the value of the filled jobs).[11]

When the borrowing constraint (29) binds, cash flow matters for input (here: vacancy) choices if the second source of external finance, dividends, does not adjust to achieve the unconstrained liquidity level. In other words, the firm then must either adjust dividends d, or cut recruitment expenditures kv (for $B^- = B = \overline{B}$). In this case, constraint (28) becomes:

$$kv + d = pn - \Phi. \tag{31}$$

The choice of dividends is subject to a quadratic adjustment cost from their steady-state value and scaled by κ^d (akin to Jermann and Quadrini, 2012), which here, without loss of generality, shows up as a "virtual" iceberg cost (similarly for the debt adjustment cost below), but for simplicity will not show up on the household side.[12] Conversely, if the model did not have a borrowing constraint, debt could provide the unconstrained financing even if $\kappa^d > 0$. As in Jermann and Quadrini (2012), the "dividend" captures equity broadly defined including repurchasing/issuing, or even, most broadly, the marginal non-debt external finance source. Potential rationalizations of the dividend adjustment cost include free-cash-flow agency problems and asymmetric information (Jensen and Meckling, 1976; Myers and Majluf, 1984; Jensen, 1986; Stein, 1989, 2003), and any sources leading to dividend smoothing (a phenomenon going back to the work of Lintner, 1956).

Here, while the model taken literally features DMP recruitment costs as the only investment activity subject to financial constraints, a fuller model would feature capital investment, training costs and/or working capital that would directly or indirectly render labor sensitive to financial factors.

As an auxiliary feature, I add a quadratic cost of deviating from the steady state debt level, scaled by parameter κ^B. Together with the size of the tax subsidy, this parameter permits me

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[11]See Merz and Yashiv (2007) for a derivation of the asset value of the firm's workers. To isolate the cash flow channel, the debt limit is acyclical (otherwise, if it were cyclical and micro-founded, it too would be related to cash flow, and hence incumbents' wages). Lian and Ma (2021) show that for U.S. firms, debt capacity is largely based on current cash flow rather than asset value or projected future capacity to repay the debt.

[12]The costs could alternatively show up as resource costs in the firm's budget constraint as in Jermann and Quadrini (2012).

to control the degree to which the firm may deleverage in response to persistent productivity shocks, and hence guides the share of the periods the firm's constraint binds. Otherwise, a high κ^d (guiding the hiring effect of cash flow conditional on the constraint binding, as discussed in Section 5) would induce the firm to amass large internal savings.

Firm's Optimality Conditions   The firm's first-order and envelope conditions are:

$$V_d = 0: \qquad \tau = 1 - \kappa^d(d^* - d^{ss}) \tag{32}$$

$$V_B = 0: \qquad \tau = (1 + r(1 - t^B))\, \mathbb{E}\left[\beta \tau^+\right] + \kappa^B(B^* - B^{ss}) + \nu \tag{33}$$

$$V_\Phi = 0: \qquad \lambda = -\tau + \mathbb{E}\left[\beta\,(1 - \delta)\left(\frac{w^+}{w}\right)^{1-\rho} \lambda^+\right] \tag{34}$$

$$V_n = 0: \qquad \mu = p\tau + \mathbb{E}\left[\beta\,(1 - \delta)\,\mu^+\right] \tag{35}$$

$$V_{h^+} = 0: \qquad \eta = \mathbb{E}\left[\beta\left(\mu^+ + \lambda^+ w^+\right)\right] \tag{36}$$

$$V_v = 0: \qquad \eta = \tau\frac{k}{q\,(\theta)}. \tag{37}$$

Condition (32) equalizes the outside value of the dividend net of the adjustment cost, to the shadow value of cash inside the firm, τ. That shadow value is always equal to one in the absence of dividend adjustment costs $\kappa^d = 0$. Condition (33) is the firm's Euler equation with respect to debt, which takes into account the tax subsidy, adjustment cost, and a potential distortion in the form of borrowing constraint multiplier ν.

Envelope condition (34) pins down the shadow value of adding another dollar in payroll, λ, capturing its present value due to the long-term nature of jobs and wage rigidity over the course of a job. Condition (35) defines μ analogously as the present value of the productivity stream of another worker. Condition (36) gives the optimality condition of the marginal hire, requiring that her shadow value η equal the present values of the productivity stream, given by μ^+, and of the wage stream, given by λ^+ multiplied with the cohort's wage w^+ (which is set next period).

Finally, condition (37) gives the vacancy optimality condition, equalizing the cost of the marginal hire—marked up by the shadow value of cash, τ—with her value to the firm, given by η. Plugging in for η using Equation (36), gives the analog of the standard DMP zero (here: potentially positive, if financial constraints bind) profit condition:

$$\tau\frac{k}{q\,(\theta)} = \mathbb{E}\left[\beta\left(\mu^+ + \lambda^+ w^+\right)\right], \tag{38}$$

where the equilibrating variables include the aggregate labor market tightness θ (not a choice variable of the individual firm). This condition can be further made similar to the standard DMP condition by reformulating the right-hand side present value terms as one-period cash flow plus

the continuation value, in turn expressed in terms of the equilibrium hiring cost:[13]

$$\Leftrightarrow \frac{k}{q(\theta)} = \mathbb{E}\left[\beta\frac{\tau^+}{\tau}\left((p^+ - w^+) + (1-\delta)\frac{k}{q(\theta^+)} + \beta(1-\delta)\frac{\lambda^{++}}{\tau^+}(w^{+\rho}w^{++1-\rho} - w^{++})\right)\right], \qquad (39)$$

where the rightmost term captures the present value difference in the continuation value of wages across adjacent cohorts (an adjustment required to express the job's continuation value in the form of next period's hiring costs).

In words, the firm seeks to hire until the present value of cash flow from another hire equals her upfront recruitment cost, both discounted at the firm's stochastic discount factor $\beta\frac{\tau^+}{\tau}$.

When borrowing constraint (29) is (always) slack, or when $\kappa^d = 0$, a standard DMP zero-profit condition emerges—augmented with a term that takes into account the degree to which the entry wage set at match formation will persist over the course of the match. For $\rho = 0$, this wage term is zero, and so condition (39) then fully collapses to the standard DMP zero profit condition.

For $\kappa^d > 0$, this condition is distorted from the standard one whenever the borrowing constraint binds (at some point), leading the firm to apply a stochastic discount factor that diverges from β.[14]

The Financial Channel of Wage Rigidity Specifically, when the borrowing constraint binds and if $\kappa^d > 0$, shifts in cash flow will affect hiring by shifting the firm's internal cash and hence cash valuation τ. This property gives rise to the financial channel of wage rigidity, whereby incumbent workers' wages being propped up during recessions squeeze liquidity, raise τ, and hence distort hiring downward in recessions.[15] As in the simple model in Section 2, incumbents' wages—and the degree of their rigidity, ρ—are financially linked with equilibrium recruitment expenditures.

Household's Problem With linear consumption utility, households maximize the present value of income: payroll Φ (which evolves identically to that of firms in Equation (25)) plus dividends d plus interest rB^- minus net lending ΔB, minus labor disutility z. I recycle the firm's symbols, but differentiate them with superscripts F and H once they appear together, as in wage bargaining

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[13]The hiring condition can alternatively be expressed non-recursively:

$$\frac{k}{q(\theta_t)} = \mathbb{E}_t \sum_{s>t} \beta^{s-t}\frac{\tau_s}{\tau_t}(1-\delta)^{s-(t+1)}(p_s - w_{s,t+1})$$

$$= \mathbb{E}_t \beta\frac{\tau_{t+1}}{\tau_t}(p_s - w_{t+1,t+1}) + \mathbb{E}_t \beta\frac{\tau_{t+1}}{\tau_t}(1-\delta)\frac{k}{q(\theta_{t+1})} + \mathbb{E}_t \sum_{s>t+1} \beta^{s-t}\frac{\tau_s}{\tau_t}(1-\delta)^{s-(t+1)} \underbrace{(w_{s,t+2} - w_{s,t+1})}_{=w_{s,s}^{1-\rho}(w_{t+2,t+2}^\rho - w_{t+1,t+1}^\rho)}.$$

[14]Hence, the model features a distortion of hiring that manifests itself as a procyclical discount factor, consistent with the finding in Hall (2017) that discount factor fluctuations can rationalize DMP hiring fluctuations; Clymo (2020) and Yashiv (2016) develop models in which hiring as well as investment fluctuations may track discount factor fluctuations; Kehoe, Midrigan, and Pastorino (2019) develop a DMP model with human capital accumulation in which credit constraints lead to countercyclical discount rates.

[15]This feature would not be present in one-job-one-firm DMP models with frictions in external finance and hence no inframarginal cash flow and no incumbent workers, where firms would entirely finance their investment from external finance (Petrosky-Nadeau and Wasmer, 2013; Petrosky-Nadeau, 2014).

below. The household's problem is:

$$V^H\left(n^-, \Phi^-, h, B^-; \mathbf{s}\right) = \max_B \left\{\Phi + d - zn + rB^- - \Delta B + \mathbb{E}\beta V^H(n, \Phi, h^+, B; \mathbf{s}^+)\right\} \quad (40)$$

$$\text{s.t.:} \quad \Phi = wh + (1-\delta)\left(\frac{w}{w^-}\right)^{1-\rho}\Phi^- \quad (41)$$

$$n = (1-\delta)n^- + h \quad (42)$$

$$h^+ = f(\theta)(1-n). \quad (43)$$

The household has an Euler equation that (absent shocks to β) pins down the equilibrium interest rate as $r = \frac{1}{\beta} - 1$.[16] The household's envelope conditions also pin down two auxiliary shadow values analogous to the firm's, namely, for the value of the marginal hire, which consists of her present value of wages (the effect of another wage dollar entering payroll and anticipating its evolution) and the labor disutility stream (which will come in at the wage bargaining stage below):

$$V_B^H = 0: \quad 1 = \mathbb{E}\left[\beta\left(1+r\right)\right] \quad (44)$$

$$V_\Phi^H = 0: \quad \lambda^H = 1 + \mathbb{E}\left[\beta(1-\delta)\left(\frac{w^+}{w}\right)^{1-\rho}\lambda^{H+}\right] \quad (45)$$

$$V_n^H = 0: \quad \mu^H = -z - f(\theta)\eta^H + \mathbb{E}\left[\beta\left(1-\delta\right)\mu^{H+}\right]. \quad (46)$$

$$V_{h^+}^H = 0: \quad \eta^H = \mathbb{E}\left[\beta\left(\lambda^{H+}w^+ + \mu^{H+}\right)\right] \quad (47)$$

Wage Bargaining The parties bargain, hire-by-hire, over the cohort-specific entry wage w anticipating the potentially rigid evolution of the hire's flow wages given by the wage rule in Equation (19).[17] Following steps as in Shimer (2010) for the Nash wage with large representative agents, I define the value of a new worker—hired at an arbitrary entry wage $\widetilde{w}$—for the firm and for the household as, respectively:[18]

$$V_n^F(\widetilde{w}) = \lambda^F\widetilde{w} + \mu^F \quad (48)$$

$$V_n^H(\widetilde{w}) = \lambda^H\widetilde{w} + \mu^H. \quad (49)$$

Generalized Nash bargaining sets the entry wage w to maximize the geometric average of these

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[16]Debt constraints or risk aversion on the household side have been explored in, e.g., Guiso, Pistaferri, and Schivardi (2005, 2013); Matsa (2018).

[17]The bargaining parties do not internalize the feedback effect of their wage bargain on incumbents' wages and hence liquidity because, reiterating the discussion of the wage expression in Equation (19), incumbents' wages are indexed to new hires' wage in the external market.

[18]I preserve Nash bargaining along with the Shimer (2005) calibration to showcase the quantitative potential of the amplification channel. As a caveat, for discussions of the theoretical and empirical problems with period-by-period Nash bargaining in the context of wage determination, see, e.g., Hall (2005), Hall and Milgrom (2008) and Jäger, Schoefer, Young, and Zweimüller (2020), and the original discussions in Shimer (2005); Hagedorn and Manovskii (2008).

values weighted by household bargaining power ϕ:

$$w = \underset{\widetilde{w}}{\text{argmax}}\{V_n^H(\widetilde{w})^\phi V_n^F(\widetilde{w})^{1-\phi}\}. \tag{50}$$

The equilibrium condition for the wage bargain, $\phi \frac{V_n^{H\prime}(w)}{V_n^H(w)} + (1 - \phi)\frac{V_n^{F\prime}(w)}{V_n^F(w)} = 0$, requires that the present value of wages (entry wage times the household's present value multiplier λ^H) equal the weighted average of the disutility of labor stream μ^H and the productivity stream μ^F:

$$\lambda^H w = (1 - \phi)(-\mu^H) + \phi\psi\mu^F, \tag{51}$$

where $\psi = V_n^{H\prime}(\widetilde{w})/V_n^{F\prime}(\widetilde{w}) = \lambda^H/-\lambda^F$ represents the relative marginal (present) value from a dollar in wages.

Present-Value Neutrality of Incumbents' Wage Rigidity ρ   The wage bargain in Equation (51) also makes clear that if the firm is never constrained, when $\tau = 1$ in all periods (and therefore both parties value and discount wage streams the same), then the bargain determines the present value of wages, $\lambda^H w$, as a function of standard factors captured by the multipliers on the right-hand side. Since those non-wage terms on the right-hand side are invariant in ρ, the Nash bargain on the left-hand side gives a present value that is independent of ρ. This present-value neutrality slightly generalizes the result in Shimer (2004) to intermediate degrees of incumbents' wage rigidity (see also the results in Pissarides, 2009).

Further Characterization of the Wage Bargain   For further intuitions, Equation (51) can be solved into an explicit entry wage highlighting the flow payoffs to contrast with the standard DMP wage:

$$w = (1 - \widetilde{\phi})z + \widetilde{\phi}(p + k\theta) - \mathbb{E}\left\{\beta(1 - \delta)w^{+(1-\rho)}(w^\rho - w^{+\rho})[(1 - \widetilde{\phi})\lambda^{+H} + \widetilde{\phi}(-\lambda^{+F})]\right\} + \gamma, \tag{52}$$

where

$$\widetilde{\phi} = \frac{\tau\psi\phi}{\tau\psi\phi + (1 - \phi)} \tag{53}$$

$$\psi = \frac{\lambda^H}{-\lambda^F} \tag{54}$$

$$\gamma = \mathbb{E}\left\{\widetilde{\phi}(1 - \frac{\psi^+}{\psi})(1 - \delta)\beta V_n^F(\widetilde{w})^+\right\}. \tag{55}$$

When $\tau = 1$, the wage bargain gives the standard DMP wage $w_{DMP} = w_{\rho=0} = \phi(p + \theta k) + (1 - \phi)z$ plus an amortization term that reflects the difference between next period's going wage w^+ and the next-period wage of the match at hand. If additionally $\rho = 0$ ($\rho = 1$), it fully collapses to the standard DMP Nash wage of flexible period-by-period rebargaining (perfectly rigid incumbent wages considered in Shimer, 2004).

The relative marginal value from a dollar in wages settled on today ψ equals one if $\tau = 1$ in all periods. When the firm is constrained and $\tau > 1$, the firm values cash more than the

worker. The firm's financial condition then enters the wage bargain through $\tau\psi$, effectively giving liquidity-dependent bargaining weights $\tilde{\phi}$, entailing concessions in the form of lower wages.[19]

But the firm cannot sufficiently borrow from (new) workers due to incomplete contracts, even if $\rho = 0$ ("flexible" period-by-period bargaining). Workers are even less willing to make concessions when liquidity tightens temporarily if $\rho > 0$, as then wage rigidity renders persistent any cyclical wage concessions. This consideration is reflected in the term in curly brackets, which captures the expected present value differential between the current match persisting tomorrow and a new match at next period's going wage (priced by the weighted average of the relative cash valuations of the bargaining parties, which would be equal without financial constraints).

γ adjusts for the evolution of ψ (a cosmetic consequence of this additional characterization following the DMP literature in using the value of a new match next period as reference for the continuation value, which complicates things if ψ and ψ^+ diverge).

Stochastic Equilibrium   The model's stochastic equilibrium is defined as follows. For the aggregate variables, labor market tightness θ solves the firms' vacancy posting condition (38), unemployment evolves according to law of motion (18) (and employment is $n = 1 - u$), vacancies are $v = \theta u$, the constant interest rate r solves the household's Euler Equation (44), and the evolution of the exogenous aggregate shocks are introduced in the next section (productivity p). New hires' entry wage w follows Nash wage solution (51); payroll evolves according to Equation (25). The firm's optimality condition for debt B is given by the firm's Euler Equation (33) with occasionally binding borrowing constraint Equation (29) giving multiplier ν, and dividends d are given by Equation (32) and budget constraint (28). The firm's and household's other multipliers are defined in Equations (34), (35), (36) and (37), and respectively (45), (46) and (47).

Informal Discussion: Fluctuations With and Without the Financial Channel of Wage Rigidity
I sketch some intuitions that informally characterize the stochastic equilibrium over the business cycle before moving to the quantitative analysis. In the absence of financial constraints, incumbents' wage rigidity ρ is perfectly neutral for DMP quantities for two reasons. *Ex ante*, as discussed surrounding Nash wage (51) above, flexible bargaining over the entry wage offsets subsequent wage rigidity to leave the present value of the wage stream in a match stable; that present value, rather than flow wages, in turn matters for hiring (as in the hiring condition (38)). This present value neutrality underlies the macro-labor paradigm that only new hires' wage rigidity can amplify hiring fluctuations, which guides both the theory and empirics of wage rigidity, (Shimer, 2004; Hall, 2005; Mortensen and Nagypal, 2007; Hall and Milgrom, 2008; Elsby, 2009; Pissarides, 2009; Shimer, 2010; Michaillat, 2012; Christiano, Eichenbaum, and Trabandt, 2016). It can be seen by plugging in the alternative wage expression (52) into the zero profit condition (39) and imposing $\tau = 1$ and $\lambda^F = \lambda^H$—yielding a zero profit condition in terms of non-wage fundamentals only, for

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[19]Similar mechanisms in wage setting are active in Michelacci and Quadrini (2005); Monacelli, Quadrini, and Trigari (2011); Guiso, Pistaferri, and Schivardi (2013); Petrosky-Nadeau (2014); Quadrini and Sun (2018).

any value of ρ, given by:

$$\frac{k}{q(\theta)} = \mathbb{E}\left[\beta\left((p^+ - z) + (1 - \delta)\frac{k}{q(\theta^+)}\right)\right],\tag{56}$$

where the ρ-dependent wage terms have cancelled out. *Ex post*, e.g., in a recession, without financial constraints, the fact that incumbent workers' wages are rigid and hence propped up does not distort hiring in this setting because their wages act as a mere, inframarginal fixed cost. Firms can flexibly use external finance to make up for inframarginal cash flow shortfalls to still cover the hiring costs that give the unconstrained equilibrium.

Financial constraints break the neutrality of incumbents' wage rigidity by amplifying fluctuations in cash flow and thence firms' financial resources. In the model, this mechanism manifests itself through τ, the firm's value of cash, which increases if cash flow is low due to, e.g., incumbents' wages propping up the wage bill during recessions. This amplification occurs even if new hires' present values of wages move one to one with productivity shocks. But if incumbents' wages too move one to one with productivity, total cash flow is smooth, thus limiting financial amplification—implying, conversely, that financial amplification requires (incumbents') wage rigidity, as in the simple model in Section 2.

5 Quantitative Evaluation: Business Cycle Behavior

To quantify the effects of the financial channel of wage rigidity, I calibrate the model, simulate its cyclical behavior, and compare it to the data, revisiting the exercises in Shimer (2005) and the follow-up literature. Table 1 Panel A reports key moments for the U.S. labor market from 1951q2 to 2016q4 (where the end point is constrained by the availability of vacancy time series from the updated web version of the Help-Wanted Index provided by Barnichon, 2010). I detrend the quarterly log time series using an HP-filter with a smoothing parameter of 10^5 following Shimer (2005); Appendix Table A.1 reports the full correlation matrix. Labor market tightness θ has a standard deviation of 0.40 (slightly larger than in Shimer, 2005, due to the extra years of data); the SD of labor productivity is around 0.02. Shimer (2005) showed that at least for productivity shocks, a calibrated DMP model generates standard deviation of labor market tightness an order of magnitude below the empirical value, and the follow-up literature (summarized in Ljungqvist and Sargent, 2017, 2021) has studied potential amplification mechanisms or alternative driving forces (with, e.g., Hall, 2017, having pointed to the limited correlation between productivity and unemployment particularly in the recent US data). The remaining panels of Table 1 report the corresponding moments for the model-generated time series, produced and discussed in this section.

Table 1: Business Cycle Moments: Data and Models

	$\log u$	$\log v$	$\log \theta$	$\log f$	$\log p$	$\log w$	$\log \overline{w}$
Panel A: Data							
Standard deviation	0.203	0.206	0.400	0.139	0.020		
Autocorrelation	0.946	0.941	0.947	0.928	0.892		
Correlation with u	0.977	-0.904	0.960	-0.956	-0.239		
Panel B: Neither Financial Constraints Nor Incumbents' Wage Rigidity							
Standard deviation	0.009	0.025	0.033	0.009	0.020	0.020	0.020
Autocorrelation	0.924	0.860	0.895	0.894	0.894	0.894	0.894
Correlation with u	1.000	-0.926	-0.958	-0.958	-0.958	-0.958	-0.958
Panel C: No Financial Constraints but Incumbents' Wage Rigidity							
Standard deviation	0.009	0.025	0.033	0.009	0.020	0.013	0.006
Autocorrelation	0.924	0.860	0.895	0.894	0.894	0.894	0.967
Correlation with u	1.000	-0.926	-0.958	-0.958	-0.958	-0.958	-0.822
Panel D: Both Financial Constraints and Incumbents' Wage Rigidity							
Standard deviation	0.052	0.159	0.225	0.056	0.020	0.013	0.007
Autocorrelation	0.915	0.847	0.880	0.885	0.894	0.893	0.966
Correlation with u	0.999	-0.906	-0.925	-0.953	-0.954	-0.955	-0.718
Panel E: Financial Constraints, but no Incumbents' Wage Rigidity							
Standard deviation	0.009	0.027	0.035	0.010	0.020	0.020	0.020
Autocorrelation	0.925	0.865	0.898	0.897	0.894	0.894	0.894
Correlation with u	1.000	-0.927	-0.959	-0.959	-0.956	-0.956	-0.956

Note: The table reports business cycle summary statistics (standard deviation, autocorrelation, and correlation with the detrended (level/not logged) unemployment rate), for a series of key quarterly time series variables, which have been logged and detrended using an HP-filter (with a smoothing parameter of 10^5 following Shimer, 2005). p, f, u, θ, w and $\overline{w}$ denote, respectively, the unemployment rate, vacancies, labor market tightness (vacancy-unemployment ratio), job finding rate, (average) labor productivity, new hires' entry wages, and average wages (which are identical without incumbents' wage rigidity). Panel A reports these moments for the U.S. labor market from 1951q2 to 2016q4 using quarterly data (where the end point is constrained by the availability of vacancy time series from the updated web version of the Help-Wanted Index provided by Barnichon, 2010). The other panels report on the simulated time series from four model variants with and without financial constraints and with and without incumbents' wage rigidity. Appendix Tables A.1–A.4 report the full correlation matrices for each panel.

5.1 Calibration

Table 2 presents the parameters of the model. The model period is a month, and I then average the monthly model output into quarterly time series, to compare to the quarterly data in Table 1 Panel A.

For the standard DMP features, I preserve the parameters provided by Shimer (2005) and the follow-up literature, except for monthly frequencies. I specify the matching function to a standard Cobb Douglas function, $\mathcal{M}(u, v) = mu^{\zeta}v^{1-\zeta}$. I set the matching function elasticity parameter v to 0.72. I set matching efficiency $m = 0.45$ to deliver monthly job finding probability of 0.45 in steady state, given that the calibration normalizes the steady state labor market tightness to $\theta^{ss} = 1$. I

set the household's extensive-margin disutilty of labor $z = 0.4$, roughly equalling the replacement rate. I set the household bargaining power $\phi = v$ for the Hosios condition of constrained efficiency to hold in the financially unconstrained model (and in the constrained model in steady state). I set the separation probability $\delta = 0.0227$ to deliver a steady state unemployment rate of 0.05 given the job finding rate above.[20] If unconstrained, firms discount cash flows given by the household discount factor $\beta = 0.996$, set to imply an annual discount factor of 0.953.

I calibrate incumbents' wage rigidity ρ to the comovement of incumbents' wages with new hires' wages, for which the meta study of wage cyclicality estimates in Pissarides (2009) suggest 1–1.5% and 3% per unemployment percentage point, respectively. For small changes, ρ maps directly into the relative elasticities, since $\rho = 1 - \frac{d \ln w_{t,c<t}}{d \ln w_{t,t}} = 1 - \frac{d \ln w_t^{\text{inc}}}{du_t} / \frac{d \ln w_t^{\text{new}}}{du_t}$. I calibrate ρ internally, such that the model's relative semi-elasticity of incumbents' and new hires' wages to the unemployment rate matches about 2.5 times the semi-elasticity for new hires' wages. I present details on this choice and a sensitivity analysis below in Section 5.3.[21]

For the financial side, I set the borrowing limit $\overline{B}$ to 0.03. (Note that the debt level in the model is difficult to compare to leverage in the data due, e.g., the absence of capital sources of asset values or profits.) I set the subsidy t^B to 0.3 (somewhat higher than the U.S. marginal corporate tax rate), and the cost of borrowing deviations to $\kappa^B = 100$, such that the constraint binds in around half of the periods in the financial model with the benchmark $\kappa^d > 0$ discussed now (there is no clear target for this moment); below, I focus on κ^d as guiding the the relevant marginal source of external finance, on which I will focus below (see also the discussion in Footnote 23). Finally, I set $\kappa^d = 0$ in the model in which firms are not financial constrained (as they can then costlessly adjust dividends/equity); I then consider a range of values for κ^d to have the model exhibit appreciable financial constraints with a benchmark calibration of $\kappa^d = 20$. An empirically tangible assessment by which to gauge the constraints is the hiring/recruitment expenditure sensitivity to cash flow; I detail the calibration of κ^d and its effects below in Section 5.4, along with an extensive sensitivity analysis.

The exogenous aggregate shock that drives the simulated business cycle is aggregate productivity, as in Shimer (2005). I normalize steady state productivity $p^{ss} = 1$. Productivity p follows an AR(1) process in logs, with autocorrelation $\rho^p = 0.98$. The i.i.d. innovation to productivity ε_t^p has a standard deviation of $\sigma^{\varepsilon^p} = 0.0064$ at the monthly frequency (such that $\ln p_t = (1 - \rho^p) \ln p^{ss} + \rho^p \ln p_{t-1} + \varepsilon_t^p$). This process delivers quarterly analogs of productivity $\ln p_t$ after detrending with an autocorrelation of 0.901 and a standard deviation of 0.020, consistent with the empirical productivity time series in Panel A of Table 1.

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[20]Hence, the calibration might overstate tenure due to separations only entering unemployment and the empirical object of wages of new hires would, in the model, refer to hires out of unemployment. As discussed before, the model features flexible wages of new hires to isolate the purely financial channel of wage rigidity. Integrating job-to-job transitions would detach job switchers' wage from their cohort's wage, a feature this paper abstracts from.

[21]While the specific wage process I posit and specifically the choice of ρ have richer implications for wage dynamics, the financial channel of wage rigidity works through the cyclicality of average wages, which in the model is guided by ρ.

Table 2: Parameter Values: Monthly Model Frequency

	Parameter	Value		Source/Strategy	Target	Model
β	Discount factor	0.996		Annual interest rate	0.04	0.04
ζ	Matching elasticity	0.72		Shimer (2005)	0.72	0.72
m	Matching efficiency	0.45		Job finding probability (s.s.)	0.45	0.45
δ	Separation rate	0.0237		Unemployment rate (s.s.)	0.05	0.05
ϕ	Bargaining power	0.72		Hosios condition	0.72	0.72
z	Unemployment flow payoff	0.4		Avg. replacement rate	0.40	0.40
k	Vacancy posting cost	0.2149		Normalization $\theta^{ss} = 1$	−	1.00
$\bar{z}$	Productivity, mean	1		Normalization	−	1.00
σ^{ε^p}	Productivity innovation, SD	0.0064		SD of ALP (quarterly)	0.020	0.020
ρ^p	Productivity, autocorrelation	0.98		Persistence of ALP (quarterly)	0.892	0.901
		No Wage Rigidity	Wage Rigidity for Incumbent Workers			
ρ	(One minus) indexation of incumbents' wages to new hires' entry wages	0	0.8	Relative cyclicality of new to average wages (Figure 8)	2.5	2.5
t^B	Tax benefit of debt	0.3		Fraction of periods constraint binding (Figure A.15)		
$\bar{B}$	Borrowing limit	0.03		"		
κ^B	Debt adjustment cost	100		"		
		No Constraints	Financial Constraints			
κ^d	Dividend adjustment cost	0	20	Judge by hiring-cash flow sensitivity (Figure A.12)		

Note: Parameter values and targets are the same across all model variants, except for κ^d and ρ.

5.2 Simulated Business Cycle Moments

For each model variant, I simulate the calibrated model for 900 monthly periods (after throwing away the initial 100 monthly periods), averaging them into 300 quarters, 50 times (for 50 productivity shock paths). To accommodate the occasionally binding borrowing constraint of the firm, I use the OccBin toolkit (Guerrieri and Iacoviello, 2015).[22] I detrend the simulated time series again using an HP filter with a smoothing parameter of 10^5 described above, as with the data in Panel A. I report the mean moments across those 50 simulations for each model across Panels B–E of Table 1, there focusing on the standard deviation of detrended log time series, their autocorrelation, and their correlation with the detrended unemployment rate (in levels rather than logs). Appendix Tables A.1–A.4 report the full correlation matrices for each panel in Table 1.

Neither Financial Constraints Nor Incumbents' Wage Rigidity   Table 1 Panel B is the model analog of Panel A for the simulated time series without financial constraints ($\kappa^d = 0$) and without incumbents' wage rigidity ($\rho = 0$)—essentially replicating the standard DMP model explored in Shimer (2005). Here, all (new hires' and incumbents') wages are continuously renegotiated, absorbing much of the productivity shocks. Hence, incentives to hire—embodied in the present value of cash flow from new hires—are smooth, such that labor market tightness θ and hence unemployment u are unrealistically smooth too. This tension is the Shimer (2005) volatility puzzle.

No Financial Constraints but Incumbents' Wage Rigidity   In Table 1 Panel C, I report on the model variant that switches on incumbents' wage rigidity ($\rho = 0.8$), but does not yet feature financial constraints ($\kappa^d = 0$). Besides incumbents' wages being rigid, new hires' entry wages are smoother, endogenously frontloading compensation during recessions—however in a way that leaves their present value unchanged, as discussed in Section 4. As a result, the cyclical behavior of labor market quantities remains unchanged compared to the previous model without incumbents' wage rigidity ($\rho = 0$). Hence, in the standard model, incumbent workers' wage rigidity is irrelevant for quantities as long as new hires' entry wages can initially be bargained flexibly.

Both Financial Constraints and Incumbents' Wage Rigidity   Panel D of Table 1 reports on the model with financial constraints ($\kappa^d = 20$ in the benchmark calibration, discussed in Section 5.4 below) and with incumbents' wage rigidity ($\rho = 0.8$, discussed in Section 5.3). When incumbents' wages are rigid, cash flow is more procyclical. But unlike in the model without financial constraints, this model variant now features a link between firms' capacity to hire (financial resources, comprising internal cash flow and external finance) and inframarginal cash flow. As a result, the model features substantially more volatile hiring. Indeed, the amplification is quantitatively significant: for $\rho = 0.8$, the standard deviation of labor market tightness provides more than half of the empirical target of the standard deviation of labor market tightness. Financial constraints have broken the neutrality of incumbent workers' wage rigidity, generating the financial channel

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[22]The original 2015 version of the paper considered either a never binding or a permanently binding constraint, thereby obtaining larger amplification. I now include a parameter κ^B and tax subsidy t^B that guide the fraction of periods the borrowing constraint binds along with κ^d (see Appendix Figure A.15).

of wage rigidity this paper proposes and explores.

Financial Constraints, but no Incumbents' Wage Rigidity   A final comparison further eluci-
dates the financial channel of wage rigidity. Table 1 Panel E reports on the model with financial
constraints ($\kappa^d = 20$), but without incumbents' wage rigidity ($\rho = 0$). Strikingly, the financially
constrained economy without incumbents' wage rigidity exhibits negligible fluctuations. This is
because here, when productivity changes, both new hires' *and* incumbent workers' wages absorb
much of the shock, leaving liquidity smooth, in line with the empirical evidence on aggregate
and industry-level dynamics in Section 3. Hence, financial constraints on their own do not trigger
quantitatively significant financial amplification. Financial amplification requires wage rigidity,
specifically among incumbent workers.

Discussion   The financial model with the benchmark calibration of financial constraints does
not fully account for the empirical labor market fluctuations. Of course, the remainder could be
matched by simply raising κ^d to around 30—see Figure 9, with a small increase in the hiring-cash
flow sensitivity. Alternatively and perhaps more plausibly, the remainder could be obtained by
drawing on other driving forces, or structural changes to the model, e.g., by raising the "funda-
mental surplus" $p - z$, as discussed in Ljungqvist and Sargent (2017, 2021) and a property of the
solution to the Shimer (2005) puzzle in Hagedorn and Manovskii (2008). Since Shimer (2005), in
whose calibration the $z = 0.4$ was interpreted more narrowly to match the replacement rate of
unemployment insurance, additional factors comprising the opportunity cost of employment such
as leisure (see Chodorow-Reich and Karabarbounis, 2016) have led the literature to favor values of
z around 0.7. Moreover, while the job finding rate accounts for the majority of the unemployment
rate fluctuations in the U.S. economy (Shimer, 2012), the remainder of the SD of unemployment
will be accounted for the separation rate fluctuations (for a discussion, see, e.g. Shimer, 2005; Coles
and Moghaddasi Kelishomi, 2018; Mercan, Schoefer, and Sedláček, 2021). Lowering the matching
function elasticity parameter v from the relatively high calibration of 0.72 in (Shimer, 2005) may
further increase the elasticity of labor market tightness on job finding rates. Lastly, invoking wage
rigidity at the margin (Shimer, 2004; Hall, 2005) or wage bargaining protocols that endogenously
render wages less sensitive to incipient unemployment increases (Hall and Milgrom, 2008) would
provide additional amplification. In this paper, I intentionally focus on the original Shimer (2005)
calibration to highlight the large increase in labor market tightness fluctuations that already emerge
from that baseline.

5.3   Inspecting the Mechanism: The Role of Wage Rigidity

To inspect the mechanisms of the financial channel of wage rigidity, I complement the tables
with sensitivity analyses of the key parameters. I start with wage rigidity, and move to financial
constraints in Section 5.4.

Calibration Choice of ρ   To clarify the calibration strategy and to trace the role of incumbents'
wage rigidity, Figure 8 Panel (a) plots the ratio of the semi-elasiticties of new hires' wages to that of

Figure 8: The Interaction of Financial Constraints and Wage Rigidity: Calibration of Incumbent Workers' Wage Rigidity ρ and Sensitivity Analysis

(a) Calibration: Effect of ρ on the Relative Semi-Elasticity of Wages (New Hires' vs. Average Wages)
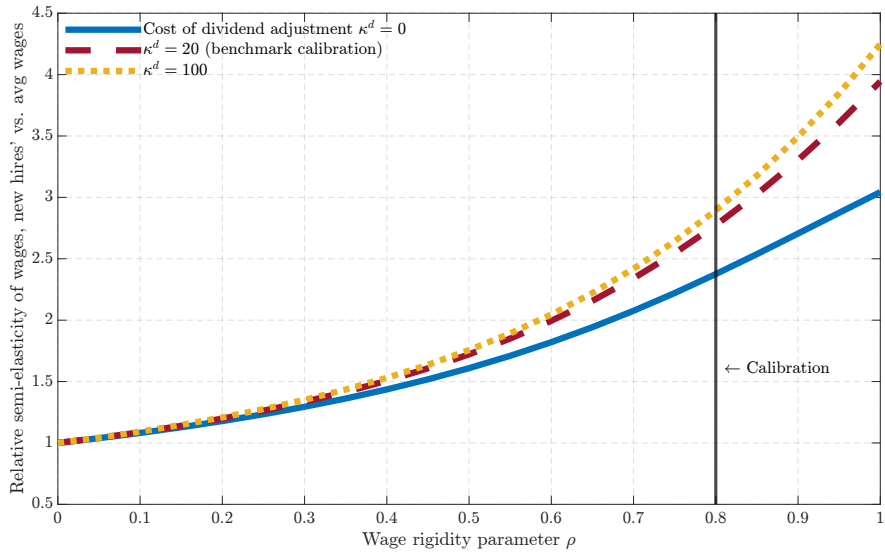
(b) Sensitivity: Effect of ρ on the Standard Deviation of Labor Market Tightness
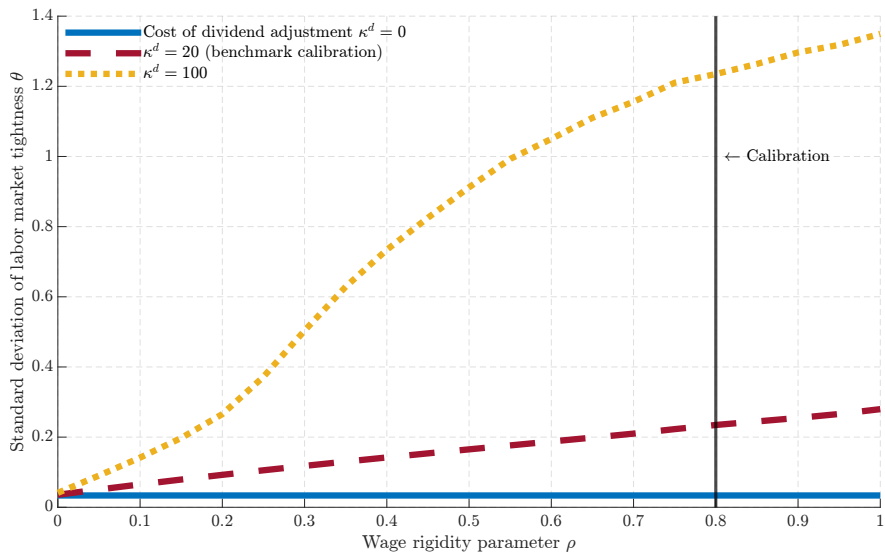
Note: Panel (a) plots the relative wage cyclicalities of new hires and the average worker (the ratio of the semi-elasticity of wages to the unemployment rate). Panel (b) illustrates the sensitivity of the standard deviation of detrended log labor market tightness to the incumbents' wage rigidity parameter ρ. Both panels do so for three different degrees of financial constraints including the intermediate value $\kappa^d = 20$ of the benchmark calibration. Both panels highlight the calibration of $\rho = 0.8$ with the vertical line. Appendix Figure A.16 plots the underlying individual semi-elasticities rather than their ratio, again against ρ, for the models with and without financial constraints, as well as using a synthetic semi-elasticity that accounts for the change in the volatility of the unemployment rate, concluding that the absolute wage moments are also realistic (rather than merely their relative ones).

average wages. In each model, I calculate the semi-elasticity of wages to the unemployment rate, both detrended; Appendix Figure A.16 plots the underlying individual semi-elasticities rather than their ratio. As ρ increases, average wages become more acyclical, and hence the ratio of the semi-elasticities of new hires' wages to that of average wages increases. I set $\rho = 0.8$, targeting a semi-elasticity (in the financial model) of about 2.5, consistent with the estimates in the meta-analysis in Pissarides (2009) discussed above in Section 5.1. (By considering average wages rather than incumbents' wages that Pissarides (2009) studies in some studies, this target is an underestimate of the true relative wage rigidity as a target for ρ.)

As stated before, the paper does not rely on new hires' wages actually being more procyclical than those of incumbent workers; I instead draw on this empirical view put forth by Pissarides (2009) as a benchmark in which new hires' wages follow the Shimer (2005) properties and isolate the purely financial channel of wage rigidity. If new hires' wages were just as rigid as incumbents' wages, the model would simply feature both margins of amplification; if incumbents' wage cyclicality were underestimated, the counterfactual would still just require a moderate increase in wage movements, as discussed in Section 3.1.

Sensitivity Analysis: Incumbents' Wage Rigidity   To gauge effects on amplification, Panel (b) of Figure 8 plots the SD of labor market tightness as a function of wage rigidity parameter ρ. It does so separately for the model with zero ($\kappa^d = 0$), intermediate ($\kappa^d = 20$) and, as an extreme benchmark, very large financial constraints ($\kappa^d = 100$).

In the model without financial constraints ($\kappa^d = 0$), the degree of incumbents' wage rigidity is neutral: as described in Section 4, the bargaining parties anticipate and offset this rigidity by adjusting the entry wage, leaving the expected present value of the wage stream invariant in ρ. The fact that incumbent workers' wages are propped up in recessions is a mere fixed cost that does not distort marginal investment (hiring) decisions.

In the model with financial constraints ($\kappa^d > 0$), the rigidity of incumbents' wages amplifies not only cash flow fluctuations, but also fluctuations in the total financial resources firms have available to invest. The more rigid incumbents' wages are, the more volatile are cash flow and, consequently, hiring. Quantitatively, this financial amplification depends on the ease with which firms can raise external funds in recessions when incumbents' wage rigidity forces cash flow to drop. The ease of accessing external finance is guided by κ^d, which thereby mediates the financial effects of wage rigidity on hiring. Hence, when ρ is high, at the realistic value of 0.8, the model exhibits substantial amplification, considering the benchmark value of $\kappa^d = 20$ I discuss below.

However, in the left corner, for $\rho = 0$, even severe financial constraints do not enable the model to generate volatility above and beyond the calibration in Shimer (2005), as cash flow is smooth. That is, financial constraints on their own are irrelevant without incumbents' wage rigidity; conversely, wage rigidity among incumbent workers is neutral without financial constraints but it does provide considerable amplification with financial constraints.

5.4 Inspecting the Mechanism: The Role of Financial Constraints

I now assess the role of financial constraints, focusing on parameter κ^d, which guides the ease of adjusting dividends (or, of the marginal source of external finance more broadly and less literally).

Figure 9: The Interaction of Financial Constraints and Wage Rigidity: Sensitivity Analysis and Benchmark Calibration of Dividend Adjustment Cost Parameter κ^d
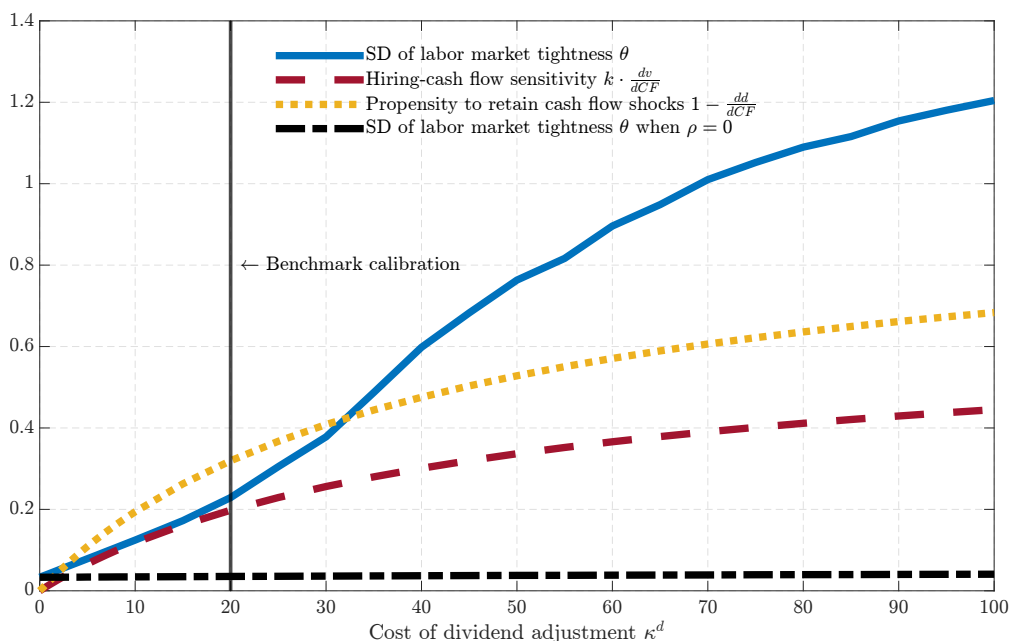
Note: The figure illustrates the role of the degree of financial constraints κ^d (the adjustment cost of dividends) for the cyclical behavior of the model. It plots moments for incumbent workers' wage rigidity $\rho = 0.8$ by κ^d, specifically the standard deviation of detrended log labor market tightness, the hiring-cash flow sensitivity, and the propensity to retain cash flow shocks. It highlights the benchmark calibration of $\kappa^d = 20$ with the vertical line. Finally, it plots the SD of labor market tightness for $\rho = 0$ (no wage rigidity among incumbent workers), which is essentially flat in κ^d.

Sensitivity Analysis: Financial Constraints   Figure 9 plots the SD of labor market tightness against the parameter primarily guiding the relevant transmission channel of incumbents' wage rigidity into labor demand fluctuations: the dividend adjustment cost κ^d. For $\kappa^d = 0$, external finance flexibly adjusts to obtain the financially unconstrained hiring level, and so the Shimer (2005) puzzle emerges in the form of low volatility. This occurs, importantly, whether incumbents' wages are flexible ($\rho = 0$) or rigid ($\rho > 0$), since the expected present value of the wage stream is unaffected by ρ thanks to adjustments in the entry wage of new hires, as discussed in Section 4.

When κ^d turns positive, the models with and without wage rigidity start diverging. Both models obtain amplification, as the SD of labor market tightness increases. However, in the model in which incumbents' wages track those of new hires ($\rho = 0$), the amplification from financial constraints is tiny, and visually absent. The reason is that in this model, an inframarginal, financial version of the intuition underlying the Shimer (2005) puzzle emerges: the standard model features

weak marginal amplification, as new hires' wages absorb the shock to productivity and hence leave the present value of cash flow from new hires' stable. In the financial model, incumbent workers' wages similarly soak up the productivity shocks, and therefore leave firms' total cash flow and financial resources stable. Financial constraints are moot when incumbent workers' wages are flexible in that sense. Appendix Figure A.12 replicates this curve for additional values of ρ besides the 0 and 0.8 cases depicted here.

By contrast, when incumbent workers' wages are rigid ($\rho > 0$), the aggregate shocks do appreciably transmit into firms' cash flow, and thence into firms' capacity to hire. When the borrowing constraint binds and dividends only partially adjust, amplification emerges.

The Propensity to Retain Cash Flow   I next provide some tangible ways to assess the quantitative implications from different values of κ^d. The direct incipient channel through which κ^d affects labor demand is by controlling the propensity to retain (not pay out as dividends) an inframarginal cash flow shift dCF, i.e., $1 - \frac{dd}{dCF}$. Figure 9 additionally plots that propensity as a function of κ^d. (The underlying experiment is described below.) For $\kappa^d = 0$, dividends immediately adjust to leave the alternative uses of cash—hiring or dissaving—unaffected. The reason is that the firm optimally stays borrowing constrained due to the tax subsidy (making dividend payouts preferable), but also seeks to avoid distorting its hiring level. Hence, inframarginal cash flow fluctuations are passed into dividends one to one, with no effect on hiring. As κ^d increases, firms trade off costs from dividend fluctuations with the opportunity costs of dissaving (due to the tax subsidy) and, ultimately, hiring distortions. Hence, for higher κ^d, financial amplification of labor market quantities emerges, as evidenced by the increase in the SD of labor market tightness also depicted in Figure 9.

The Hiring-Cash Flow Sensitivity   The choice of κ^d for the financial constraints model is best understood not by taking it literally, but by judging it by its effect most germane to the paper: the resulting sensitivity of hiring to cash flow. This is because the financial channel of wage rigidity in the model amplifies the fluctuations in cash flow from incumbent workers, which transmit into hiring depending on the ease with which firms can raise external finance to make up for that shortfall. To provide a quantitative symptom of this ultimate transmission mechanism, I construct the hiring-cash flow sensitivity $k \cdot \frac{dv}{dCF}$ for each calibration, as an analog of the (capital) investment-cash flow sensitivity estimated in corporate finance (started with the seminal work of Fazzari, Hubbard, and Petersen, 1988), but rather than capital expenditure, I consider investment in hiring, which in the model is recruitment expenditure kv. As the main benchmark plotted in the figures, I do so for a 1% positive, perfectly transitory shock to cash flow corresponding to 1% of GDP in the model, to trace out realistic business cycle fluctuations in aggregate cash flow. To gauge its dependency on κ^d, Figure 9 additionally plots the hiring-cash flow sensitivity as a function of κ^d. It does so for the preferred choice of $\rho = 0.8$; Appendix Figure A.14 reports the additional lines for a wider range of ρ values, finding relatively similar sensitivities away from $\rho = 0$. Appendix Figure A.17 supplements this analysis of the hiring-cash flow sensitivity by plotting a fuller range of cash flow shocks, spanning to -3% to $+3$ of model GDP. The hiring sensitivity is very stable across those shock sizes, but exhibits a small decline for positive shocks, which push the firms out of

their borrowing constraint and hence partially feed the shock into saving (change in *B*) rather than hiring (which retains a stable sensitivity of about 0.20 rather than 0.23 in those positive regions).

Benchmark Calibration Choice of κ^d   The benchmark model selects $\kappa^d = 20$, which yields an appreciable standard deviation of labor market tightness (depicted on the left y-axis of Figure 9), chosen as a benchmark matching around half of the empirical labor market tightness fluctuations. This level of κ^d can be judged by the hiring-cash flow sensitivity of about 0.2.[23]

Financial Constraints Required to Explain all Fluctuations   Figure 9 clarifies that the κ^d required to match 100% of labor market tightness fluctuations is around 30. This parameter level can be made tangible by considering the corresponding hiring-cash flow sensitivity, which increases only slightly, to about 0.25, with a propensity to retain increase towards 0.4.

Caveats: Limitations of this Benchmark Calibration   A limitation that leaves this calibration as a tentative benchmark is that the model's only investment activity is recruitment, which makes this sensitivity difficult to empirically interpret, and no estimates of this sensitivity exist. Other direct investment channels on labor demand include training and other hiring costs (and job creation costs, as in Mercan and Schoefer, 2020, and references cited therein), or working capital (Jermann and Quadrini, 2012); Gavazza, Mongey, and Violante (2018) provide a rich view of a variety of costly recruitment cost activities. Moreover, rather than direct effects only as in the model, a fuller model with, e.g., capital would also feature indirect effects through the capital-labor ratio's effect on the marginal product of labor. Lastly, this simulated effect is an aggregate, equilibrium effect, which may not correspond to any potentially emerging firm-level, partial equilibrium empirical estimates of this sensitivity; if available, benchmarking it to firm-level estimates may feature an upward bias (e.g., due to labor market adjustment in wages and recruitment costs) or a downward bias (as in equilibrium models of financial frictions, e.g., Bernanke, Gertler, and Gilchrist, 1999). The standard DMP model is poorly suited for firm-level experiments without inclusion of, e.g., imperfect competition in the product market or decreasing returns at the firm level.[24]

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[23] While κ^d guides the sensitivity of external resources to cash flow fluctuations, a second, albeit subtler dimension of the severity of financial constraints is the fraction of periods the borrowing constraint binds. Appendix Figure A.15 shows the relationship between κ^d and the fraction of model periods the borrowing constraint binds. In the models with financial constraints, the constraint binds, for the relevant κ^d region, around half of the periods. Moreover, the model features an effect of κ^d on this frequency, because when dividends are difficult to adjust, the firm must divide excess cash flow (say, from productivity increases) between hiring more or saving more (lowering debt *B*), leading to a buffer stock that makes borrowing constraints less likely to bind. This corporate saving also explains why in Figure 9, the propensity to retain the cash flow shock is somewhat larger than the hiring sensitivity; the difference goes into saving (reduction of debt). Of course, the fraction is 100% for $\kappa_d = 0$, where the firm always takes full advantage of the tax subsidy of debt and only uses dividends to adjust external finance. Besides κ^d, the debt adjustment cost κ^B (and those of the tax subsidy t^B and of borrowing constraint level $\overline{B}$) of course guide the fraction of periods the constraint binds; to economize on additional parameters with similar ultimate effects (the hiring-cash flow sensitivity), I set κ^B to a high value that turns out to deliver that fraction of periods the constraint binds (and a relatively flat effect of κ^d in the relevant region), and do not vary it across calibrations. However, in principle, the model as such features a two-dimensional menu of external finance and frictions therein (the two adjustment costs, borrowing limit, tax subsidy); I conjecture that the hiring-cash flow sensitivity likely remains the relevant sufficient statistic capturing the relevant transmission mechanism of the financial channel of wage rigidity.

[24] The previous, original 2015 version of this paper reported on a meta analysis of existing investment cash flow sensitivity estimates, and extended those paper-by-paper to employment-cash flow sensitivities; it also showed that during

Instead, the robust and qualitatively credible message of the paper is to take as a point of departure a model in which financial constraints drive a significant portion of business cycles in the presence of realistic wage rigidity, and then study the attenuation from counterfactual fluctuations with more procyclical wages. For instance, for this benchmark calibration of $\kappa^d = 20$, more than half the labor market tightness fluctuations are matched, which drops to less then a tenth *for the same degree of financial constraints* once wage rigidity is shut off. Of course, if financial factors do not play a role in real-world business cycles ($\kappa^d = 0$), the financial channel of wage rigidity is irrelevant. The actual share of business cycle fluctuations driven by financial factors is an active object of research in the macro-finance literature; whatever their importance, this paper points out and dissects the crucial role of wage rigidity therein. I will saliently reiterate these limitations of my paper in the conclusion, Section 7.

5.5 The Interaction between Financial Constraints and Wage Rigidity

Table 1 and the sensitivity analyses above clarify that *both* financial constraints and wage rigidity are needed to generate amplification in the model. On their own, financial constraints do not generate amplification because cash flow is not volatile, and hence recessions are not times when financial constraints tighten. On its own, wage rigidity among incumbents is perfectly neutral, as firms can simply take out loans or raise equity to externally finance hiring when wage rigidity squeezes cash flow during recessions. The *interaction* between the two frictions generates amplification—the financial channel of wage rigidity.

6 Fiscal Policy Application: Wage Subsidies and Payroll Taxes As Stabilization Tools

The financial channel of wage rigidity raises similar perspectives also on wage subsidies aimed to stabilize labor demand in recessions. Oftentimes, these subsidies are applied to new hires only (e.g., Cahuc, Carcillo, and Le Barbanchon, 2019), consistent with the standard paradigm this paper revisits, and with the fact that declines in hiring and in the job finding rate account for the majority of unemployment increases during recessions (Shimer, 2012). For instance, Bils and Klenow (2009); Correia, Farhi, Nicolini, and Teles (2013); Farhi, Gopinath, and Itskhoki (2014) discuss such policies, where the received wisdom is that such policies work by lowering the cost of labor at the margin. Some countries do implement such policies as cyclical stabilization tools; for instance, Singapore regularly implements discretionary procyclical adjustments to employer-side payroll taxes on all workers (the taxes funding the Central Provident Fund retirement savings program) for purposes

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U.S. recessions, Compustat firms with high liquidity buffers exhibited less of a recessionary declines in employment and investment. Since the model considered here is not suitable to provide a credible extrapolation of those micro effects to the aggregate economy and since employment (stock) changes depend on the duration of the shock and the period measured, such an analysis is beyond the scope of this paper. For micro, firm-level evidence linking financial shocks with employment, see, e.g. Sharpe (1994); Chodorow-Reich (2014); Benmelech, Bergman, and Seru (2015); Melcangi (2020). See also my discussion in the conclusion, in Section 7.

of macroeconomic stabilization, e.g., cutting payroll taxes from 20% to 10% in the 1999 and 2003 downturns and restored rates in between. Most recently, the COVID crisis has led to a global surge in wage subsidies.

I show that analogous lessons from the above analysis of amplification apply to such fiscal policies. In a model with financial constraints, broad-based subsidies applied to incumbent workers too would increase hiring; in the model without financial constraints, only the marginal channel is active, so only only subsidizing new hires' wages is effective.

To show this, I simulate the model with financial constraints ($\kappa^d = 20$) and without ($\kappa^d = 0$), both times with incumbents wage rigidity ($\rho = 0.8$), while imposing an additional payroll tax on firms. The payroll tax $x(\mathbf{s})$, which will be indexed to the aggregate state $\mathbf{s}$ as described below, affects the firm's problem by entering its budget constraint (28):

$$kv = zn - (1 + x(\mathbf{s}))\Phi - T^x(\mathbf{s}) - d + \left(\Delta B - r(1 - t^B)B^- - rt^B\widetilde{B}^-\right), \tag{57}$$

where $T^x(s)$ is an offsetting tax taken as given, described below, differing between three cases I consider. Accordingly, firms take the tax into account when hiring as seen in a modified version of the standard equilibrium condition for θ, Equation (38), but in which the shadow value of a dollar in payroll λ now takes into account the payroll tax, leading to a tax-augmented version of Equation (34):

$$\lambda = -\tau(1 + x(\mathbf{s})) + \mathbb{E}\left[\beta(1 - \delta)\left(\frac{w^+}{w}\right)^{1-\rho}\lambda^+\right]. \tag{58}$$

To model the tax as a cyclical stabilization tool, I index it to labor market tightness as the business cycle indicator, as follows:

$$x(\mathbf{s}) = \left(\frac{\theta_t}{\theta^{ss}}\right)^\alpha - 1. \tag{59}$$

Here, α captures the elasticity of the net-of-tax rate $1 + x(\mathbf{s})$ to a percent deviation in labor market tightness from steady state. Hence, for $\alpha > 0$, the tax is a countercyclical subsidy, lowering wage costs to firms in recessions.

I then generate simulated time series with and without the tax, for the financial and nonfinancial model (throughout with $\rho = 0.8$).[25] Moreover, for both models, I consider three cases: I let the payroll tax work through the marginal (new hires') channel only, through only the cash flow inframarginal channel from incumbent workers' wage bill, and through both channels. I engineer the tax system as follows to induce these diagnostics.

Case I: Cash Flow and Marginal Channels First, I activate both channels. Here, firms hire

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[25]To facilitate interpretation of the consequences of the payroll tax, for comparability with the baseline specifications, and consistent with empirical evidence against pass-through of such taxes (Saez, Schoefer, and Seim, 2019, 2021), wage setting ignores the direct effects of payroll taxes on the wage bargain in the previous sections, by using the λ from the no-tax scenario, in Equation (34), for wage bargaining in all models.

according to condition (38) taking into account the tax subsidy for new hires in λ as per Equation (58). In addition, the payroll tax looms in budget constraint (57), thereby affecting cash flow. This is achieved by setting the reimbursement of the payroll tax (which the household takes as given) constant at the steady state value (where it is zero) so that out of steady state, the payroll tax affects cash flow on top of hiring:

$$T_{\text{Both}}^x(\mathbf{s}) = x^{ss}\Phi^{ss}. \tag{60}$$

Case II: Marginal Channel Only   Second, I isolate the standard marginal channel, for new hires, which is emphasized in the policy discourse mentioned above. To do so, I let the payroll taxes apply only at the margin, i.e., when considering new hires. This is achieved by neutralizing the other, cash flow, channel, specifically through specifying the tax reimbursement T^x to equal to the contemporaneous equilibrium tax benefit, where $\widetilde{\Phi}$ is the contemporaneous, stochastic-equilibrium value of payroll that is however taken as given by the individual agents, hence denoted by a $\sim$ (as before the debt level determining the tax refund $rt^B\widetilde{B}^-$ of the interest subsidy t^B):

$$T_{\text{Marginal}}^x(\mathbf{s}) = x(\mathbf{s})\widetilde{\Phi}. \tag{61}$$

Case III: Inframarginal, Financial Channel Only   Finally, I isolate the inframarginal, financial channel, whereby the subsidy does not affect firms' hiring decisions as per Equation (38), but instead only looms in firms' budget constraint (57) with the tax refund given by the time-invariant specification (60), so that cash flow effects of cyclical deviations full pass through into firms' financial resources. However, to shut off the marginal channel, firms' hiring ignores the marginal cost channel, which I engineer by ad-hoc letting hiring condition (38) use the *no-tax* wage bill multiplier λ from the baseline model in Equation (34) (rather than the λ that takes into account the taxes, defined above in Equation (58) that would have brought about the marginal channel).

Results   Figure 10 reports the standard deviations of θ, for a series of degrees of cyclical stabilization α and for the three tax specifications, separately for the model with financial constraints (left y-axis) and the model without (right y-axis). Appendix Tables A.6 and A.7 report the full business cycle moments (for the highest value depicted in the figure, $\alpha = 0.3$).

In the nonfinancial model, the countercyclical payroll subsidy with both channels switched on lowers the volatilies considerably. By contrast, the inframarginal subsidy has precisely a zero effect; all of the effect is driven by the marginal-only channel. As a result, combining both channels does not yield any larger stabilization than the marginal subsidy on its own, exactly reflecting the paradigm that only new hires (net-of-tax) wages matter for hiring fluctuations in the standard DMP model. Subsidies to incumbent workers are a lump-sum transfer to firm owners. (Of course, while the current model does not feature endogenous separations, wage subsidies for incumbents may stabilize employment through that margin, see, e.g., Giupponi, Landais, and Lapeyre, 2021).

In the financial model, the stabilization in the variant with both channels active leads to dramatic

Figure 10: Policy Application: Standard Deviation of Labor Market Tightness by Countercyclicality of Wage Subsidy α for Models With Financial Constraints (Left Axis) and Without (Right Axis), for Marginal Cost, Cash Flow, and Both Channels
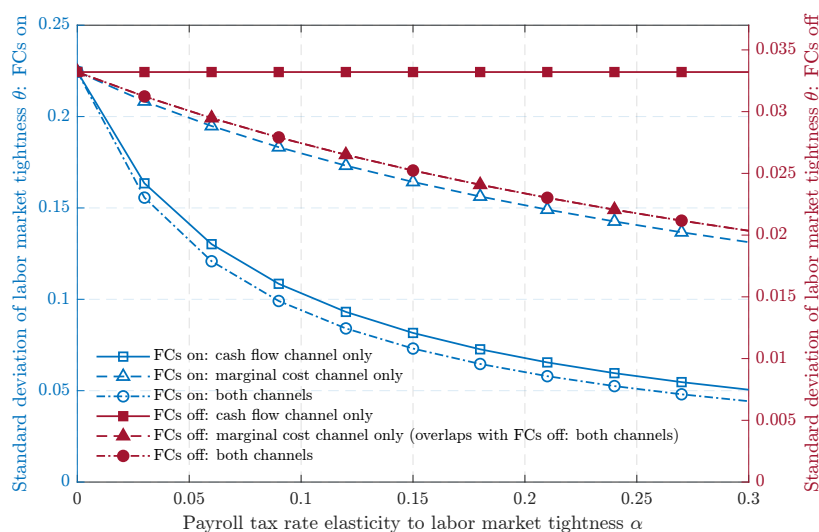
Note: The figure reports the stabilization effect of countercyclical wage subsidies (equivalently, procyclical payroll taxes) on the standard deviation of detrended log labor market tightness θ, for a series of degrees of stabilization parameters α, where α is the elasticity of the tax rate to labor market tightness, such that a larger α indicates more cyclical stabilization. The figure plots results for the models with financial constraints (left y-axis) and without financial constraints (right y-axis), both with incumbents' wage rigidity $\rho = 0.8$, as well as for three tax specifications that surgically switch on the marginal channel only, the inframarginal cash flow channel only, and both channels combined. The two y-axes are scaled such that the model with and without financial constraints align at $\alpha = 0$ (no cyclicality in the tax). Appendix Tables A.6 and A.7 detail the business cycle moments for these models, separately for each payroll tax specification (throughout for $\alpha = 0.3$).

stabilization. Here however, a large share of this stabilization reflects the cash flow channel—in stark contrast to the idea that encompassing payroll tax cuts are pure giveaways to firm owners without stabilization effects. Accordingly, the marginal channel on its own provides considerably weaker stabilization.

Related Empirical Evidence   Since the original 2015 draft of this paper, evidence has emerged supporting this prediction. Saez, Schoefer, and Seim (2019) study employer payroll tax cuts for young workers (new hires and incumbent) and find that financially constrained firms increase employment the most. Giupponi and Landais (2020) find that employment effects from short-term work subsidies in Italy (which applied to incumbent workers only) are concentrated in financially constrained firms. Ku, Schönberg, and Schreiner (2020) find suggestive evidence that the employment effects of regional hiring subsidies are larger among plausibly financially constrained firms. Lastly, the recent wide-spread adoption of employment subsidies responding to the COVID recession may provide further empirical assessments of their interaction with financial constraints.

7 Open Questions and Limitations

I conclude by highlighting some questions the paper leaves open, and by reiterating caveats and limitations.

First, while I explore the financial channel of wage rigidity in a DMP model with hiring as the only explicit investment activity, the channel would apply to capital investment too.[26]

Second, as made precise in Section 5.4, this paper sheds little new light on the quantitative importance of financial factors in empirical business cycles; instead, the paper points out that whatever their importance, wage rigidity is crucial in generating the cash flow and profit fluctuations that often get financial amplification off the ground.[27]

Third, while I focused on financial constraints on the firm side, wage rigidity may stabilize continuously employed workers' income during recessions, and hence have aggregate demand effects not considered here.[28]

Fourth, an interesting question is which compensation structures can attenuate the financial channel of wage rigidity. Profit sharing policies, performance pay, or equity compensation may do so, suggesting a new interpretation of the potential stabilization from such arrangements besides the standard ones (Weitzman, 1986; Baker, 1992; Lemieux, MacLeod, and Parent, 2012). A similar consideration emerges for pension payments, e.g., comparing rigid commitments from defined benefit plans vs. defined contribution plans, where the same, marginal paradigm dominates the analysis.[29]

Fifth, while this paper focuses on the hiring margin (which drives the lion's share of U.S. unemployment fluctuations and is important across the OECD, see Shimer, 2012; Elsby, Hobijn,

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[26]Garin (2015) merges the DMP model with a financial block and capital as in Jermann and Quadrini (2012), but includes flexible Nash wage bargaining. Petrosky-Nadeau and Wasmer (2013) and Petrosky-Nadeau (2014) explore the effects of credit market frictions and labor market frictions in a model with one job per firm, so that firms do not have internal finance/cash flow, precluding the mechanism of this paper. Kehoe, Midrigan, and Pastorino (2019) generate financial amplification in a DMP model with jobs with longer-duration, backloaded cash flows from human capital accumulation on the job; Kehoe, Lopez, Midrigan, and Pastorino (forthcoming) and Di Tella and Hall (forthcoming) study the role of countercyclical price of risk and the resulting countercylical cost of investment in risky projects (such as job creation), and business cycles.

[27]There is a growing body of work on the micro effects of financial shocks on individual firms' real input levels, but pass-through from micro effects to the aggregate economy is an open question. Catherine, Chaney, Huang, Sraer, and Thesmar (2017) investigate the micro-macro nexus.

[28]To add to my treatment of payroll taxes in Section 6, the aggregate demand channel also guided the statutory incidence of the 2011–12 payroll tax cuts to fall on the worker portion in the U.S. following the Great Recession (Graziani, Van Der Klaauw, and Zafar, 2016), rather than the firm-side cuts considered in this paper or the policy advice guided by the standard search and matching models with wage rigidity (Bils and Klenow, 2009).

[29]For instance, a Chicago Fed's Economic Perspectives brief (Aaronson, Rissman, and Sullivan, 2004) reasons that "increased requirements to fund pensions for retired workers impose an increased burden on firms that is restraining hiring. However, retiree pension obligations are fixed costs that do not depend on current employment or production levels. Thus, basic economic theory predicts they should have no effect on firms' decisions." By contrast and instead in line with the financial channel of rigid labor costs, employers (American Benefits Council, 2009) have called for reforms towards procyclical funding requirements of DB plans, to alleviate the financial burden during recessions: "These extraordinary pension funding requirements [...] could derail the [2009] economic recovery by forcing these employers to either severely curtail their capital investments or make further reductions in their workforces." See Rauh (2006); Bakke and Whited (2012) for empirical analyses of the firm-level effects of DB funding requirements in publicly traded U.S. firms.

and Şahin, 2013b), wage rigidity of incumbent workers can amplify (endogenous) separations and render them inefficient, which may interact with financial constraints (Giupponi and Landais, 2020; Jäger, Schoefer, and Zweimüller, forthcoming). For instance, stabilization policies responding to the COVID recession appear to indeed have been motivated by the interaction of rigid labor costs and labor demand that this paper explores, with an added focus on preventing separations. Indeed, the firing margin may be a way for firms to relax cash flow constraints in recessions (and even hire, if new hires' are relatively cheap). Overall therefore, permitting endogenous separations would therefore likely attenuate the hiring effects from financial channel of wage rigidity while opening the door for it to amplify separation fluctuations.[30]

Sixth, an open question is whether heterogeneity in wage cyclicality and financial constraints across firms may amplify or attenuate the effects considered here. On the modeling side, this paper focused on aggregates (in essence, homogeneous firms and workers). Moreover, with heterogeneity in firms' exposure to business cycles, the incremental wage movements to stabilize cash flow would be more dispersed; but this implication of heterogeneity would extend to the marginal channel of wage rigidity as well. Relatedly, the paper does not provide a direct empirical test of the interaction of financial constraints and (inframarginal) wage rigidity. An ideal experiment would exploit empirical heterogeneity, and investigate the cyclical properties, or sensitivities to shocks, of firms with and without financial constraints, and with and without wage rigidity.

Seventh, an avenue for additional investigation is alternative driving forces besides the amplification of productivity shocks explored here. For instance, Hall (2017) argues that the limited correlation between unemployment and productivity in the recent U.S. data makes this approach unattractive, in favor of, e.g., discount factor shocks as driving forces. However, since cash flow in the data is procyclical, I speculate that the counterfactual this paper raises would go through even for other shocks as long as hiring is sensitive to the cash flow injection from counterfactually lower wages in recessions. Moreover, the model also raises the possibility of asymmetric fluctuations and path-dependent unemployment dynamics as a series of positive shocks raises incumbents' wages and the probability of the constraint binding following a subsequent negative shock, and perhaps more generally slowing down convergence to steady state.

I close by highlighting that beyond wage rigidity, the financial channel of wages may play a role in labor demand more generally. Corporate finance economists may see cash flow shocks where labor economists see marginal labor costs change. Liquidity-constrained labor demand, which depends on (marginal) wages w and liquidity (into which payroll $\Phi = wn$ enters negatively) features standard marginal effects and a liquidity effect of wages—the latter akin to the income effect in standard consumer theory. Hence, I can define a "Slutsky identity" of liquidity-constrained

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[30]Even more broadly, the paper leaves aside richer ways to smooth cash flow such as from real earnings manipulation ranging to even price setting among constrained firms in recessions (Gilchrist, Schoenle, Sim, and Zakrajšek, 2017); this paper's focus is on the residual, realized cash flow fluctuations net of those activities.

labor demand:

$$\varepsilon_{n,w}^{\text{Total}} = \varepsilon_{n,w}^{\text{Marginal}}\Big|_{d\text{Liquidity}=0} - \frac{wdn}{dCF},$$ (62)

where the second, new term is the wage-adjusted employment-cash flow sensitivity akin to the standard capital investment-cash flow sensitivity (e.g. Fazzari, Hubbard, and Petersen, 1988). A testable prediction is that financially constrained firms' labor demand elasticities are higher due to the cash flow effect, and that encompassing wage changes, for all workers, have larger effects than marginal wage changes. Saez, Schoefer, and Seim (2019) provide some evidence for this prediction, studying net-of-payroll-tax wage changes from a payroll tax change that targeted young workers (but ended up boosting employment for all, even ineligible, worker groups, especially in financially constrained firms).

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Online Appendix:
The Financial Channel of Wage Rigidity

Benjamin Schoefer

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(b) Long-Run Averages
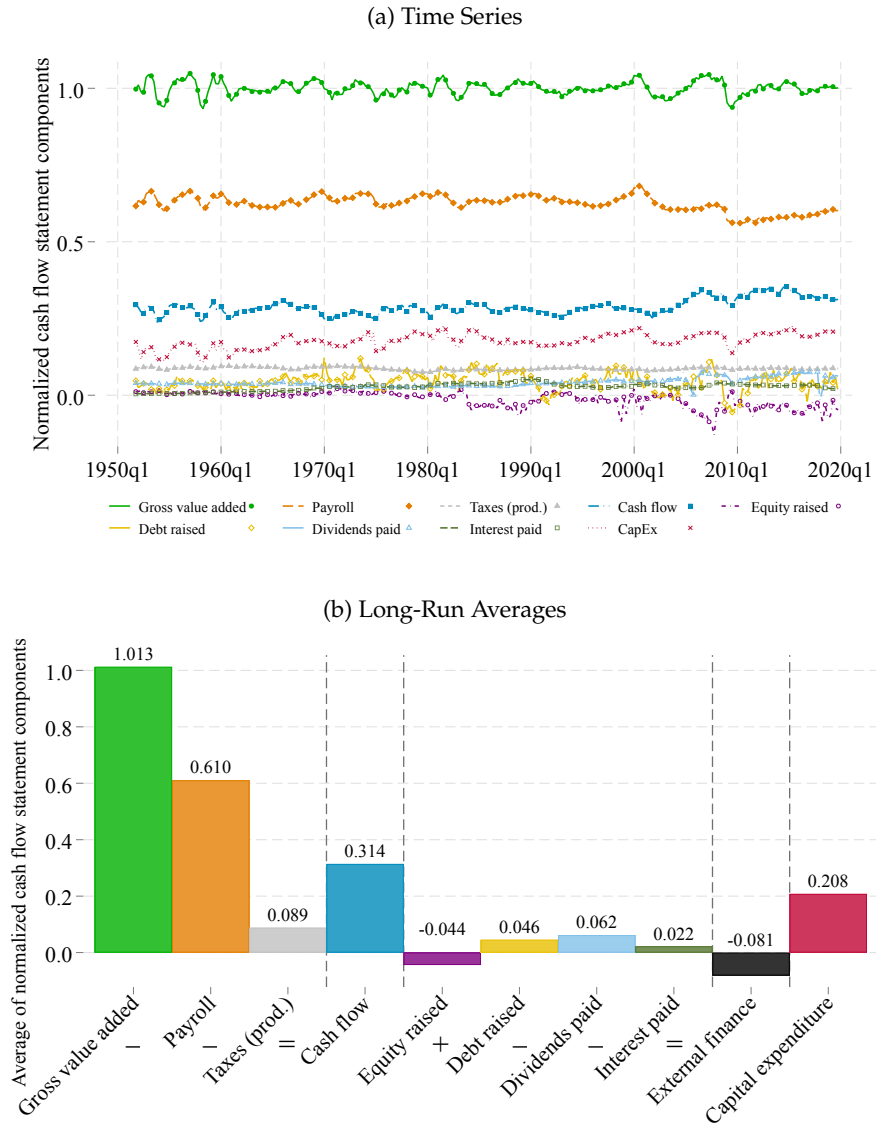
Note: The panels draw on seasonally adjusted quarterly U.S. Flow of Funds data (1951q4-2019q4, Z.1 Financial Accounts) for the non-financial corporate sector. Panel (a) plots the time series for each of the cash flow statement components divided by the trend of gross value added (HP-filter with a smoothing parameter of 1,600). Panel (b) plots the time series average for these normalized variables over the sample period.

Figure A.2: The Importance of Cash Flow/Internal Finance: Accounting for Heterogeneity and Financial Intermediation

(a) Compustat: All Firms (Minus Utilities/Finance)
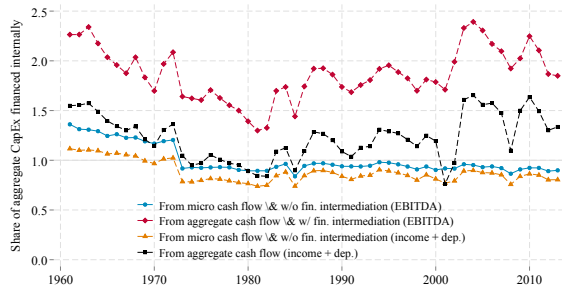
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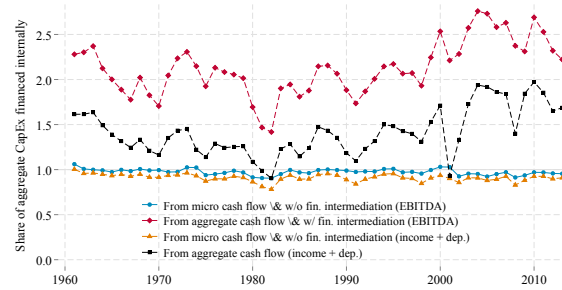
(c) CESifo Investment Test: German Manufacturing Firms
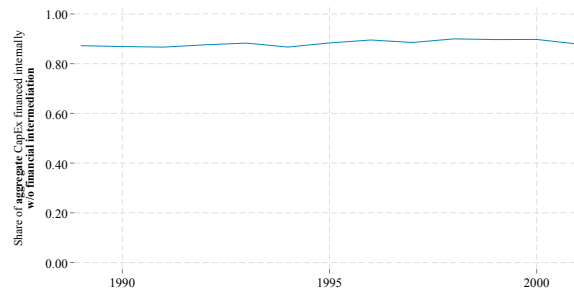
Note: The figure plots the share of aggregate capital expenditures that could in principle be financed internally, i.e., from cash flow at firm level without financial intermediation. At the firm level, I generate internally financed capital expenditure as the minimum of the firm's cash flow and actual capital expenditure in that year t and each firm f, $\text{IntFinCapEx}_{ft} = \min\{\text{CapEx}_{ft}, \text{CashFlow}_{ft}\}$. In each year t, I then sum both IntFinCapEx_{ft} and CapEx_{ft}, and plot the ratio $\frac{\sum_f \text{IntFinCapEx}_{ft}}{\sum_f \text{CapEx}_{ft}}$. Panels (a) and (b) do so for U.S. Compustat firm data of publicly traded firms, for all firms outside of utilities and finance, and for manufacturing only, respectively. It considers as cash flow measures the sum of income before extraordinary items and depreciation, as well as EBITDA. Panel (c) draws on the German survey of manufacturing firms in the CESifo Investment Test, 1990–2000 (same sample period to which the author had restricted access in 2014), where firms report directly on the internal/external sources of funds covering their capital expenditures; shares are weighted by capital expenditure to obtain the aggregate share financed internally.

Figure A.3: The Cyclical Comovement of U.S. Capital Expenditure, Hiring, Job Openings, and the Help-Wanted Index
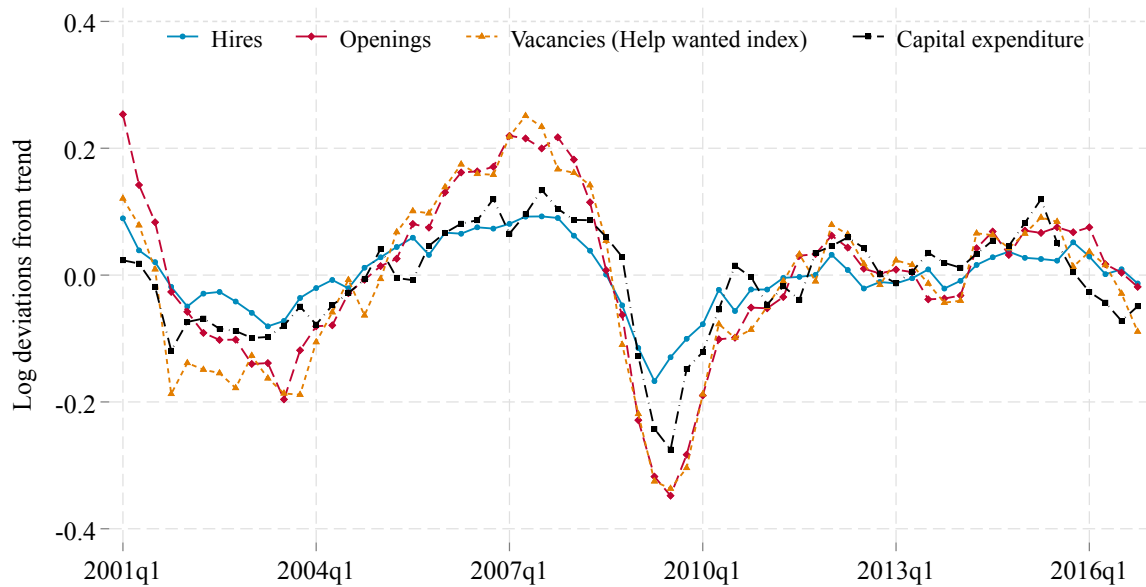
Note: This figure plots the quarterly (2001q1-2019q4) time series of log deviations from trend for capital expenditures, hires, job openings, and the Help-Wanted Index (HWI), all detrended using an HP-filter with a smoothing parameter of 1,600. Capital expenditure is from seasonally adjusted quarterly U.S. Flow of Funds (Z.1 Financial Accounts) data for the non-financial corporate sector. HWI is from the web update of the extended Help-Wanted index provided by Barnichon (2010), which ends in 2016 and hence limits the cross-validation to that end point. Hires are quarterly total non-farm hires and openings are quarterly total non-farm job openings from the Bureau of Labor Statistics Job Openings and Labor Turnover Survey.

Figure A.4: Additional Facts: Cash-Flow-Stabilizing Incremental Wage Movements

(a) Cash Flow to Payroll Trend Ratios

(b) Distribution of Cash-Flow-Stabilizing Incremental Wage Movements
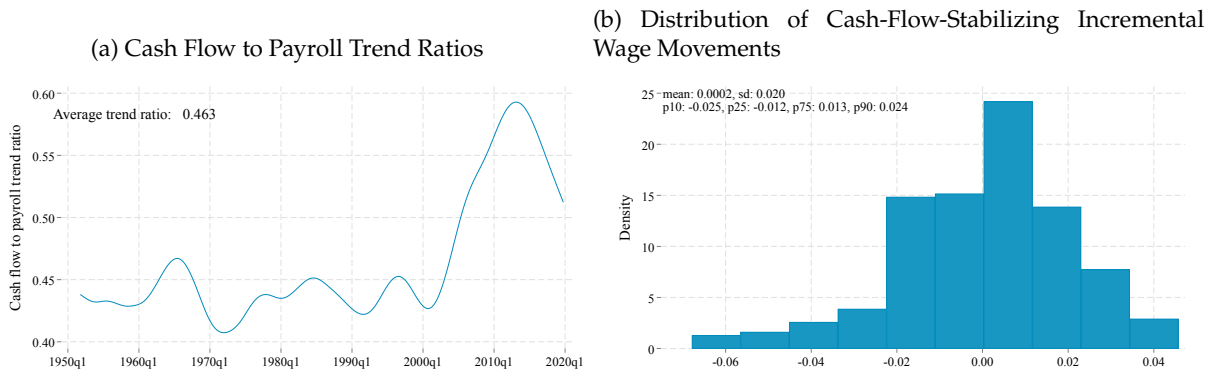
Note: The figure draws on seasonally adjusted quarterly U.S. Flow of Funds data for non-financial corporate businesses spanning 1951q4-2019q4. Panel (a) plots the time series of cash flow trend divided by payroll trend (where the filtering was done on logged data, and the resulting trend of the log time series was re-exponentiated). Panel (b) provides a histogram of the time series of incremental wage movements necessary to offset the empirical fluctuations in cash flow. Throughout, detrending of the quarterly data is done with an HP-filter with a smoothing parameter of 1,600.

Figure A.5: Robustness Check: Pre-tax Profits

(a) Fluctuations of Pre-tax Profits and Pre-tax Profits Stabilizing Incremental Wage Movements
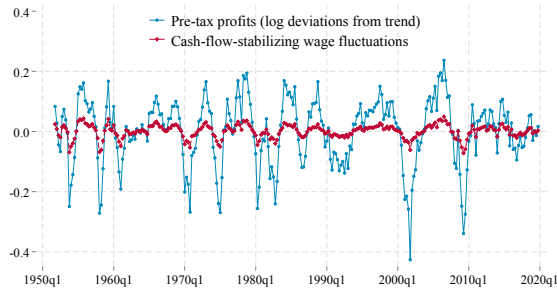
(b) Okun's Laws
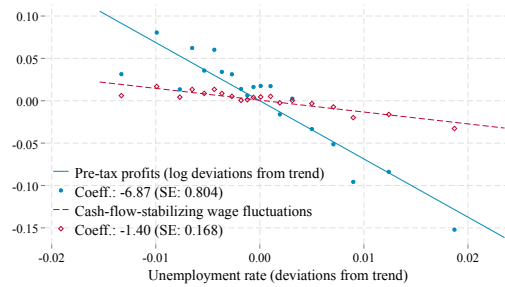
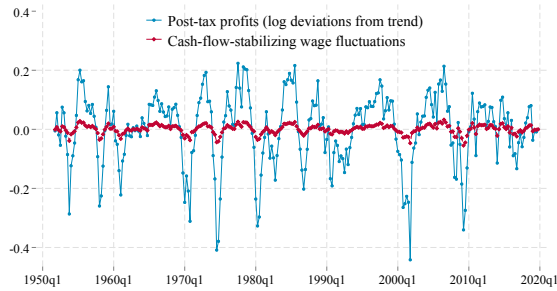(c) Pre-tax Profits to Payroll Trend Ratios
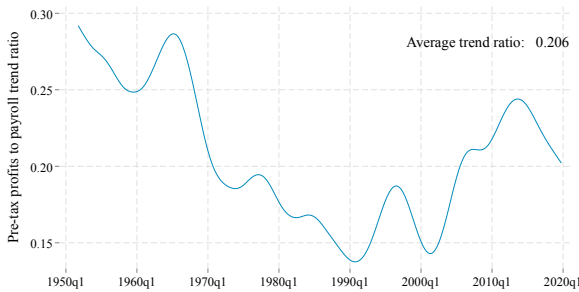
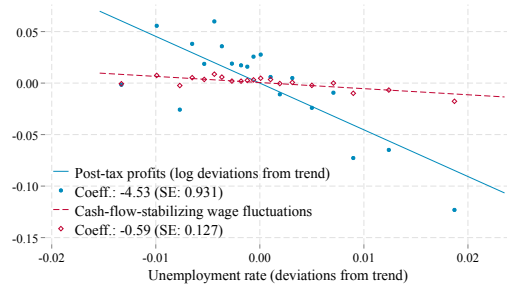(d) Distribution of Pre-tax Profits Stabilizing Incremental Wage Movements
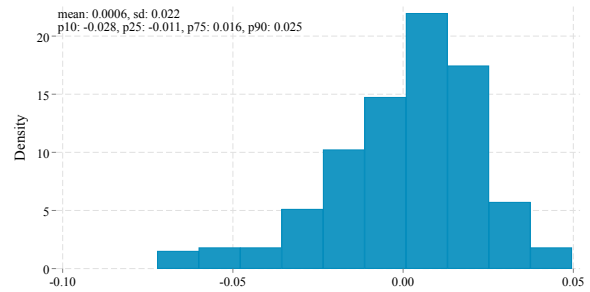
Note: The figure draws on seasonally adjusted quarterly U.S. Flow of Funds (Z.1 Financial Accounts) data for the non-financial corporate sector spanning 1951q4-2019q4. Panel (a) plots the time series for detrended log pre-tax profits and incremental wage movements necessary to offset these profit fluctuations. Panel (b) provides a binscatter plot for the same pre-tax profits log deviations from trend and wage movement variables against the detrended unemployment rate. The estimated regression coefficients and robust standard errors are reported. Panel (c) plots the time series of pre-tax profits trend divided by payroll trend (where the filtering was done on logged data, and the resulting trend of the log time series was re-exponentiated). Panel (d) provides a histogram of incremental wage movements necessary to offset the empirical fluctuations in pre-tax profits. Throughout, detrending of the quarterly data is done with an HP-filter with a smoothing parameter of 1,600.

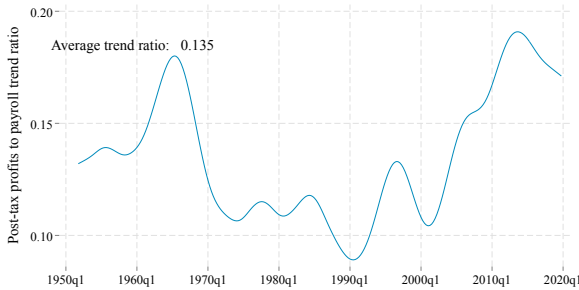# Figure A.6: Robustness Check: Post-tax Profits

(a) Fluctuations of Post-tax Profits and Post-tax Profits Sta-
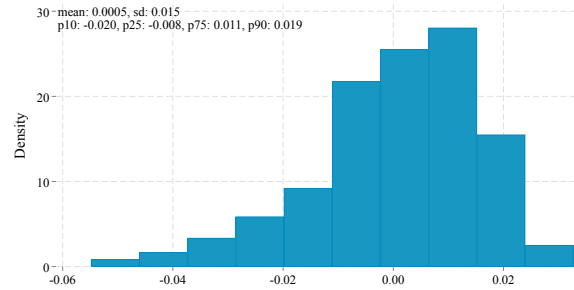bilizing Incremental Wage Movements

(b) Okun's Laws

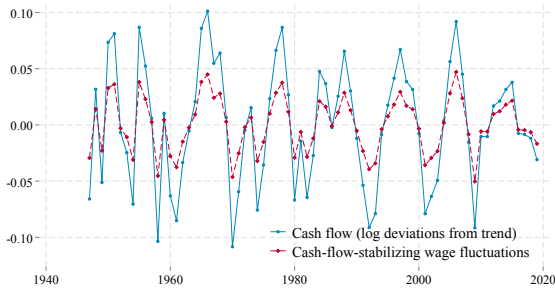(c) Post-tax Profits to Payroll Trend Ratios

(d) Distribution of Post-tax Profits Stabilizing Incremental
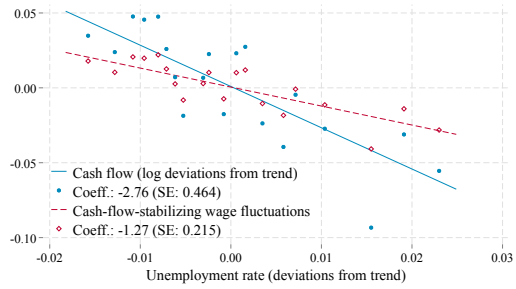Wage Movements

Note: The figure draws on seasonally adjusted quarterly U.S. Flow of Funds (Z.1 Financial Accounts) data for the non-financial corporate sector spanning 1951q4-2019q4. Panel (a) plots the time series for detrended log post-tax profits and incremental wage movements necessary to offset these profit fluctuations. Panel (b) provides a binscatter plot for the same post-tax profits log deviations from trend and wage movement variables against the detrended unemployment rate. The estimated regression coefficients and robust standard errors are reported. Panel (c) plots the time series of post-tax profits trend divided by payroll trend (where the filtering was done on logged data, and the resulting trend of the log time series was re-exponentiated). Panel (d) provides a histogram of incremental wage movements necessary to offset the empirical fluctuations in post-tax profits. Throughout, detrending of the quarterly data is done with an HP-filter with a smoothing parameter of 1,600.
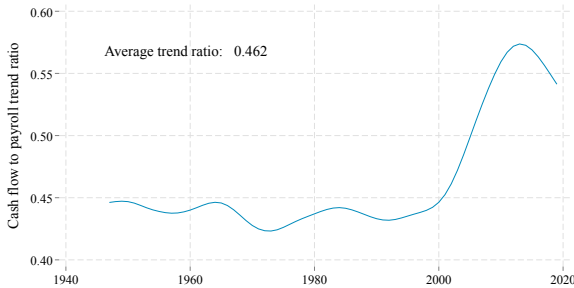
Figure A.7: Robustness Check: Annual Data

(a) Fluctuations of Cash Flow and Cash Flow Stabilizing
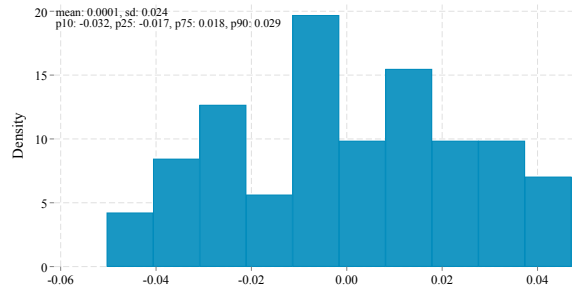Incremental Wage Movements

(b) Okun's Laws
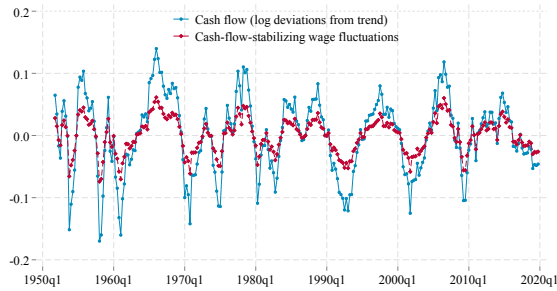

(c) Cash Flow to Payroll Trend Ratios

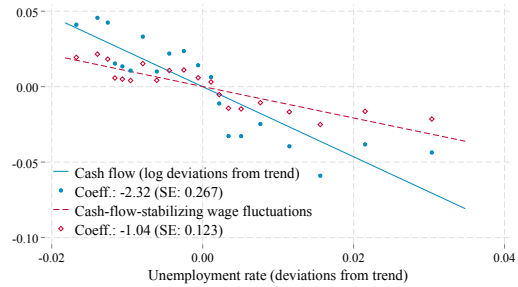(d) Distribution of Cash Flow Stabilizing Incremental Wage
Movements

Note: The figure draws on annual U.S. Flow of Funds (Z.1 Financial Accounts) data for for the non-financial corporate sector spanning 1951-2019. Panel (a) plots the time series for detrended log cash flow and incremental wage movements necessary to offset these cash flow fluctuations. Panel (b) provides a binscatter plot for the same cash flow log deviations from trend and wage movement variables against the detrended unemployment rate. The estimated regression coefficients and robust standard errors are reported. Panel (c) plots the time series of cash flow trend divided by payroll trend (where the filtering was done on logged data, and the resulting trend of the log time series was re-exponentiated). Panel (d) provides a histogram of incremental wage movements necessary to offset the empirical fluctuations in cash flow. Throughout, detrending of the annual data is done with an HP-filter with a smoothing parameter of 100.

Figure A.8: Robustness Check: Detrending with HP-Filter with a Smoothing Parameter 10^5
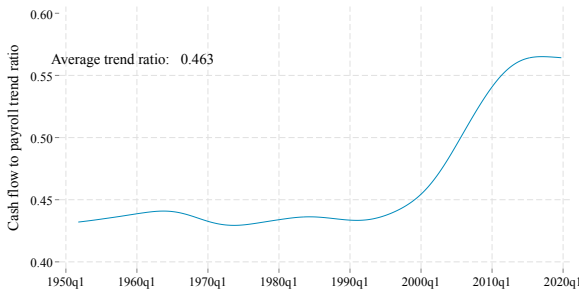
(a) Fluctuations of Cash Flow and Cash Flow Stabilizing
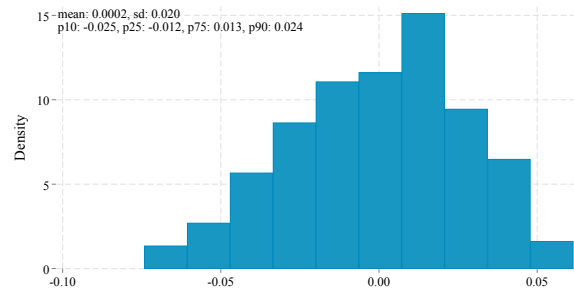Incremental Wage Movements

(b) Okun's Laws

(c) Cash Flow to Payroll Trend Ratios

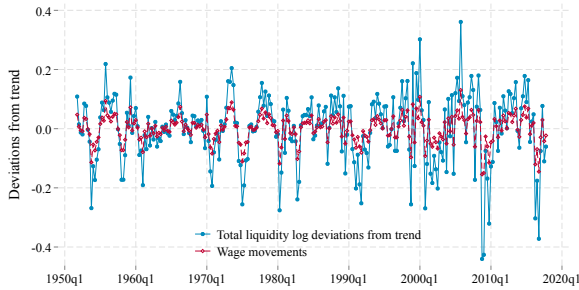(d) Distribution of Cash Flow Stabilizing Incremental Wage
Movements

Note: The figure draws on seasonally adjusted quarterly U.S. Flow of Funds (Z.1 Financial Accounts) data for the non-financial corporate sector spanning 1951q4-2019q4. Panel (a) plots the time series for detrended log cash flow and incremental wage movements necessary to offset these cash flow fluctuations. Panel (b) provides a binscatter plot for the same cash flow log deviations from trend and wage movement variables against the detrended unemployment rate. The estimated regression coefficients and robust standard errors are reported. Panel (c) plots the time series of cash flow trend divided by payroll trend (where the filtering was done on logged data, and the resulting trend of the log time series was re-exponentiated). Panel (d) provides a histogram of incremental wage movements necessary to offset the empirical fluctuations in cash flow. Throughout, detrending of the quarterly data is done with an HP-filter with a smoothing parameter of 10^5 following the detrending procedure in Shimer (2005), rather than 1,600 as in the other figures that used quarterly data.
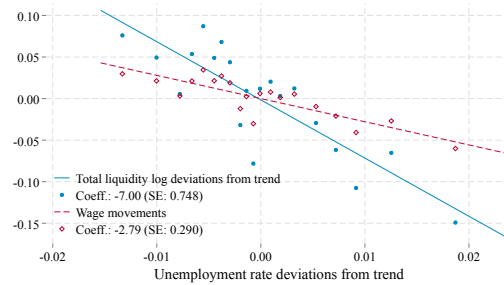
Figure A.9: Robustness Checks: Total Liquidity rather than Cash Flow, and Other Sources of Stabilization than Cash Flow (Dividends and Interest)
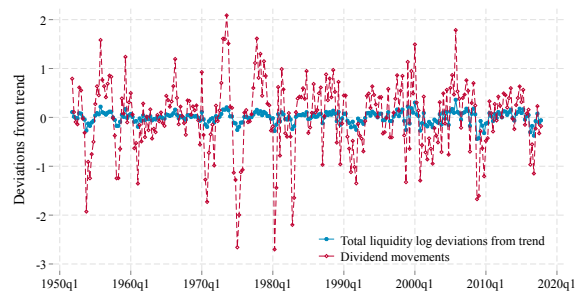
(a) Fluctuations of Total Liquidity and Total-Liquidity-Stabilizing Incremental Wage Movements
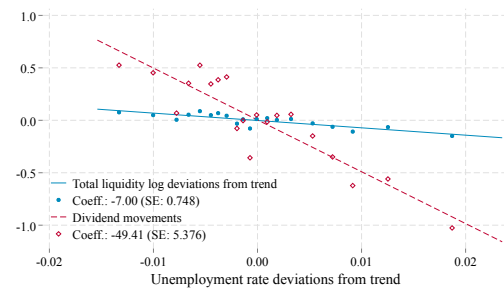
(b) Okun's Laws for Total Liquidity and Total-Liquidity-Stabilizing Incremental Wage Movements

(c) Fluctuations of Total Liquidity and Total-Liquidity-Stabilizing Incremental Dividend Movements

(d) Okun's Laws for Total Liquidity and Total-Liquidity-Stabilizing Incremental Dividend Movements

(e) Fluctuations of Total Liquidity and Total-Liquidity-Stabilizing Incremental Interest Expenditure Movements
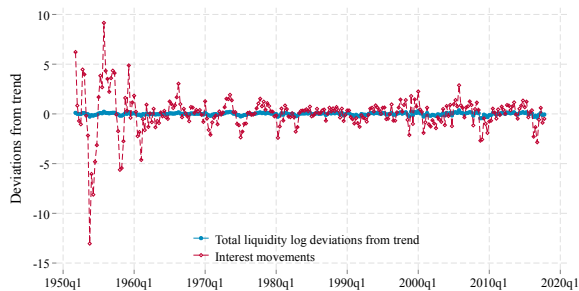
(f) Okun's Laws for Total Liquidity and Total-Liquidity-Stabilizing Incremental Interest Expenditure Movements
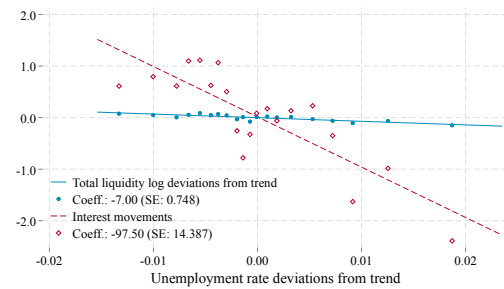
Note: The figure draws on seasonally adjusted quarterly U.S. Flow of Funds (Z.1 Financial Accounts) data for the non-financial corporate sector spanning 1951q4-2019q4. Panels (a), (c), and (e) plot the time series for detrended log total liquidity (cash flow plus external finance) the incremental wage, net dividend, and net interest payment movements necessary to offset these empirical fluctuations in total liquidity, respectively. Panels (b), (d), and (f) provide binscatter plots for these two variables against the detrended unemployment rate. The estimated regression coefficients and robust standard errors are reported. Throughout, detrending of the quarterly data is done with an HP-filter with a smoothing parameter of 1,600.

Figure A.10: The Orthogonality of Fundamental Surplus Proxy vs. Standard Labor Income Share
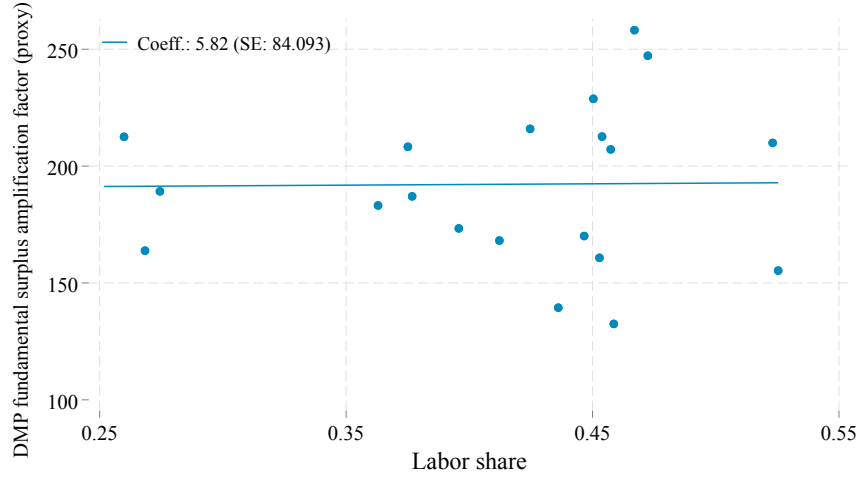
Note: The figure relates a proxy for the DMP fundamental surplus to the standard labor income share at the industry level. The industry level labor share is the average payroll to value added ratio from the NBER CES Manufacturing Industry Database spanning 1958-2016, averaged at the 3-digit NAICS level. It is then merged onto an industry data set (those with standard 3-digit NAICS code) in the Census/ACS, constructed from the compensation share of occupations in recruitment-related occupations across all occupations. Recall from Footnote 8 that the fundamental surplus term $\frac{p}{p-w}$ highlighted in Ljungqvist and Sargent (2017, 2021) scales the the elasticity of labor market tightness to productivity as follows: $\frac{d\theta/\theta}{dp/p} = \left(1 - \frac{dw}{dp}\right)\frac{1}{1-v}\frac{p}{p-w}$. I obtain the DMP-relevant fundamental surplus term for my purposes as follows. First, I note that the free entry condition gives $\frac{k}{q} \approx \frac{p-w}{\delta}$, for a low discount rate compared to the separation rate δ. This gives $\frac{k}{q} \cdot \delta \approx p - w$. Second, I note that the recruitment-related occupation compensation share in total compensation, which I denote by x here, is a proxy for vk, so that $x = \frac{vk}{wn}$, which I further (using the steady state relationship $\delta n = h$) expand to $x = \frac{k}{q}\frac{vq}{n} = \frac{k}{q}\frac{h}{n}\frac{1}{w} = \frac{k}{q}\delta\frac{1}{w}$, and moreover rewrite as $\Leftrightarrow x \cdot w = \frac{k}{q}\delta$— where the right-hand side equals approximately $p - w$ from the first step. Third, both steps combined therefore imply that the fundamental surplus is given by $p - w \approx x \cdot w \Leftrightarrow \frac{p-w}{p} \approx x \cdot \frac{w}{p}$, and hence the fundamental surplus amplification factor is given by the inverse, $\frac{p}{p-w} \approx \frac{1}{x \cdot \frac{w}{p}}$. Under the—naive but for this exercise entertained as correct—assumption that the standard labor income share is $\frac{w}{p}$ (see the main text in Section 3.2 for the discussion), the fundamental surplus is then given by the inverse of the product of the recruitment labor cost share I draw on here and the labor share. The binscatter plot above plots the thusly computed amplification factor $\frac{p}{p-w} \approx \frac{1}{x \cdot \frac{w}{p}}$ against the standard income labor share, and finds a flat and noisy relationship. This pattern speaks against the hypothesis that the amplification provided by the labor share reflects the DMP fundamental surplus mechanism. However, I caveat that this exercise is not definitive, as the fundamental surplus is notoriously difficult to measure (or calibrate). However, the specification does put the plausibly noisily measured variable, the fundamental surplus proxy, on the left-hand side to avoid attenuation bias of the slope estimate. *[Note continues on the next page.]*

[Continuation of Note of Figure A.10.] Finally, the recruitment cost measure uses data from Census/American Community Survey samples for manufacturing industries, averaged between 2000 and 2011. I merge on those with clean 3-digit industry codes in the ACS/Census data. Respondents' earned income, industry and occupation, gives recruitment cost share $\frac{n_i^v w_i^v}{w_i n_i}$ by industry i, where n^v is employment in hiring-related occupations, w^v denotes their average earnings, and the denominator is payroll of all employees in the industry. The following occupations are classified as hiring-related based on use ONET definitions, with the tasks in the footnotes including the hiring-related ones:[31] (i) Human Resources Managers (occ2010 = 0130),[32] (ii) Human Resources Specialists (occ2010 = 0620),[33] and Human Resources Assistants, Except Payroll and Timekeping (occ2010 = 5360).[34] Of course, this exercise is speculative as the occupation shares may be correlated with other omitted factors (such as the separation rate guiding job duration, etc).

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[31]The ONET definitions are available at https://www.onetonline.org.

[32]Tasks of Human Resources Managers (occ2010 = 0130):

- Serve as a link between management and employees by handling questions, interpreting and administering contracts and helping resolve work-related problems.
- Analyze and modify compensation and benefits policies to establish competitive programs and ensure compliance with legal requirements.
- Advise managers on organizational policy matters such as equal employment opportunity and sexual harassment, and recommend needed changes.
- Perform difficult staffing duties, including dealing with understaffing, refereeing disputes, firing employees, and administering disciplinary procedures.
- Plan and conduct new employee orientation to foster positive attitude toward organizational objectives.

[33]Tasks of Human Resources Specialists (occ2010 = 0620):

- Prepare or maintain employment records related to events, such as hiring, termination, leaves, transfers, or promotions, using human resources management system software.
- Interpret and explain human resources policies, procedures, laws, standards, or regulations.
- Hire employees and process hiring-related paperwork.
- Inform job applicants of details such as duties and responsibilities, compensation, benefits, schedules, working conditions, or promotion opportunities.
- Address employee relations issues, such as harassment allegations, work complaints, or other employee concerns.

[34]Tasks of Human Resources Assistants, Except Payroll and Timekeping (occ2010 = 5360):

- Process, verify, and maintain personnel related documentation, including staffing, recruitment, training, grievances, performance evaluations, classifications, and employee leaves of absence.
- Explain company personnel policies, benefits, and procedures to employees or job applicants.
- Record data for each employee, including such information as addresses, weekly earnings, absences, amount of sales or production, supervisory reports on performance, and dates of and reasons for terminations.
- Gather personnel records from other departments or employees.
- Examine employee files to answer inquiries and provide information for personnel actions.

Figure A.11: Additional Facts: Industry Labor Shares

(a) Industry Labor Shares, 1958-2016 Averages

(b) Long-Run Changes in Industry Labor Shares, 1983-2016 vs. 1958-82

mean: 0.4023, sd: 0.100
p10: 0.254, p25: 0.343, p75: 0.474, p90: 0.516

mean: -0.1105, sd: 0.049
p10: -0.170, p25: -0.140, p75: -0.078, p90: -0.055

(c) Changes Labor Shares vs. 1958-82 Labor Shares

(d) Alternative Labor Share Measure: Labor Costs Over Revenue (Value of Shipments)

Coeff.: -7.29, SE: 2.397

Cash flow — Employment — Capital expenditure
Coeff.: -7.29 (SE: 2.397)   Coeff.: -8.32 (SE: 1.205)   Coeff.: -25.34 (SE: 3.028)

Note: The figure reports U.S. industry-level (6-digit NAICS) facts drawing on the annual (1958-2016) NBER CES Manufacturing Industry Database. Panel (a) provides a histogram of industry-level labor shares averaged by industry over the full sample period. Panel (b) is a histogram of labor share changes at the industry level, comparing an industry's average labor share computed over 1983-2016 minus that computed over 1958-82, i.e., dividing the original sample period in half. Panel (c) is a binned scatter plot of the changes depicted in Panel (b) against the first-half labor share during 1958-82. Panel (d) replicates Figure 5 Panel (a) for the labor share computed as labor costs divided by revenue (value of shipments) rather than value added.

B Additional Theoretical Material

B.1 Additional Theoretical Material: Figures

Figure A.12: Sensitivity Analysis: Standard Deviation of Labor Market Tightness by κ^d and for Various Levels of ρ
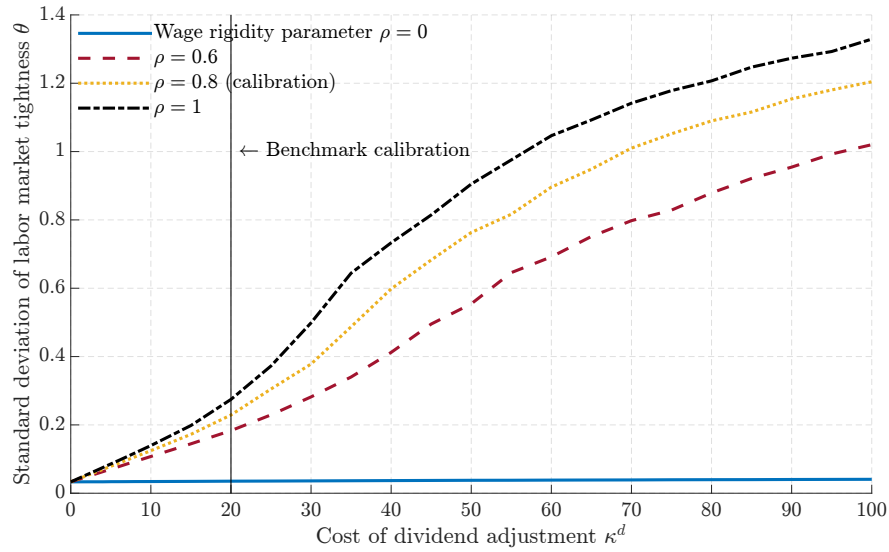
Note: The figure illustrates the sensitivity of the standard deviation of detrended log labor market tightness to the degree of financial constraints κ^d (the adjustment cost of dividends) for four values of incumbent workers' wage rigidity ρ.

Figure A.13: Sensitivity Analysis: Propensity to Retain Cash Flow by κ^d and for Various Levels of ρ
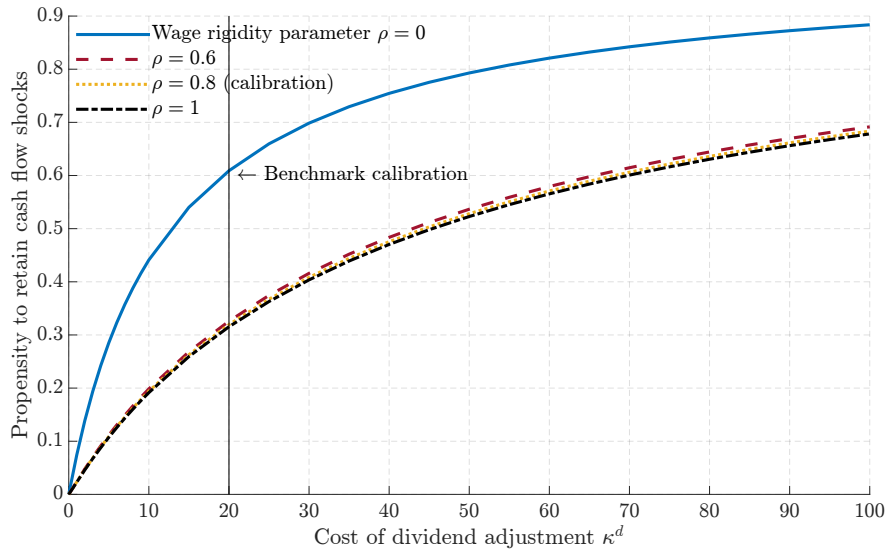
Note: The figure illustrates the sensitivity of the firm's propensity to retain cash flow (shocks) to the degree of financial constraints κ^d (the adjustment cost of dividends) for four values of incumbent workers' wage rigidity ρ.

Figure A.14: Sensitivity Analysis: Hiring Sensitivity to Cash Flow Shocks by κ^d and for Various Levels of ρ
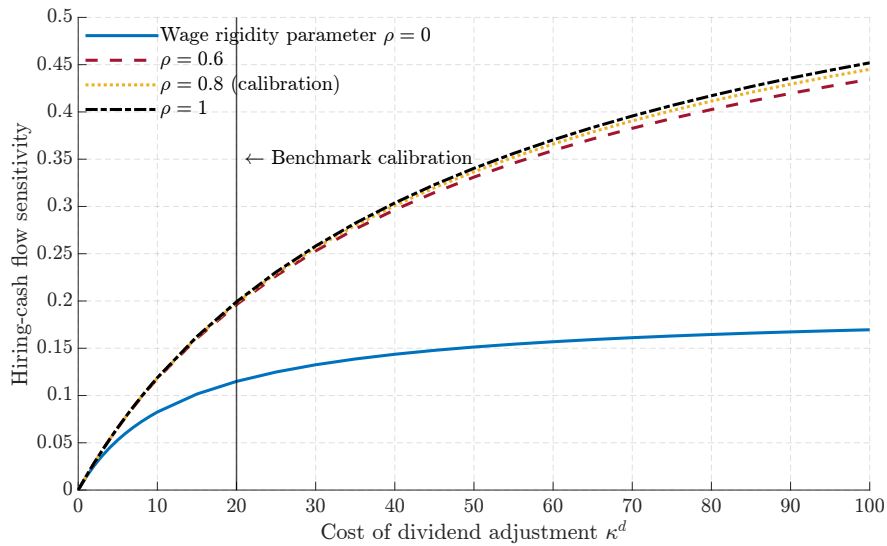
Note: The figure illustrates the sensitivity of the hiring (recruitment expenditure) sensitivity to cash flow (shocks) to the degree of financial constraints κ^d (the adjustment cost of dividends) for four values of incumbent workers' wage rigidity ρ.

Figure A.15: Sensitivity Analysis: Fraction of Periods the Borrowing Constraint Binds by κ^d and for Various Levels of ρ
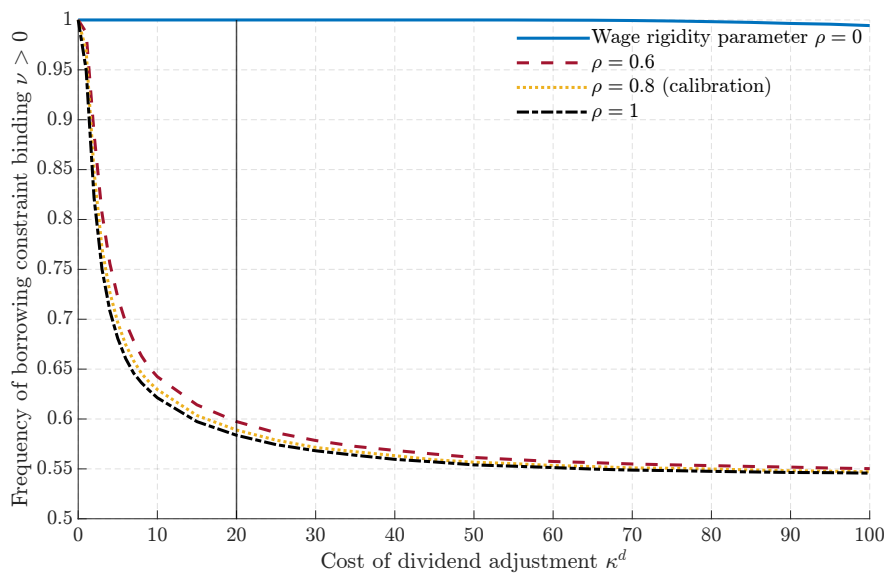
Note: The figure illustrates the sensitivity of the frequency the firm's borrowing constraint binds (its multiplier is positive) to the degree of financial constraints κ^d (the adjustment cost of dividends) for four values of incumbent workers' wage rigidity ρ.

Figure A.16: Sensitivity Analysis: Average and New Hires' Wage Cyclicality (Semi-elasticity w.r.t. the Unemployment Rate) by ρ and for Models with and without Financial Constraints

(a) Average Wages
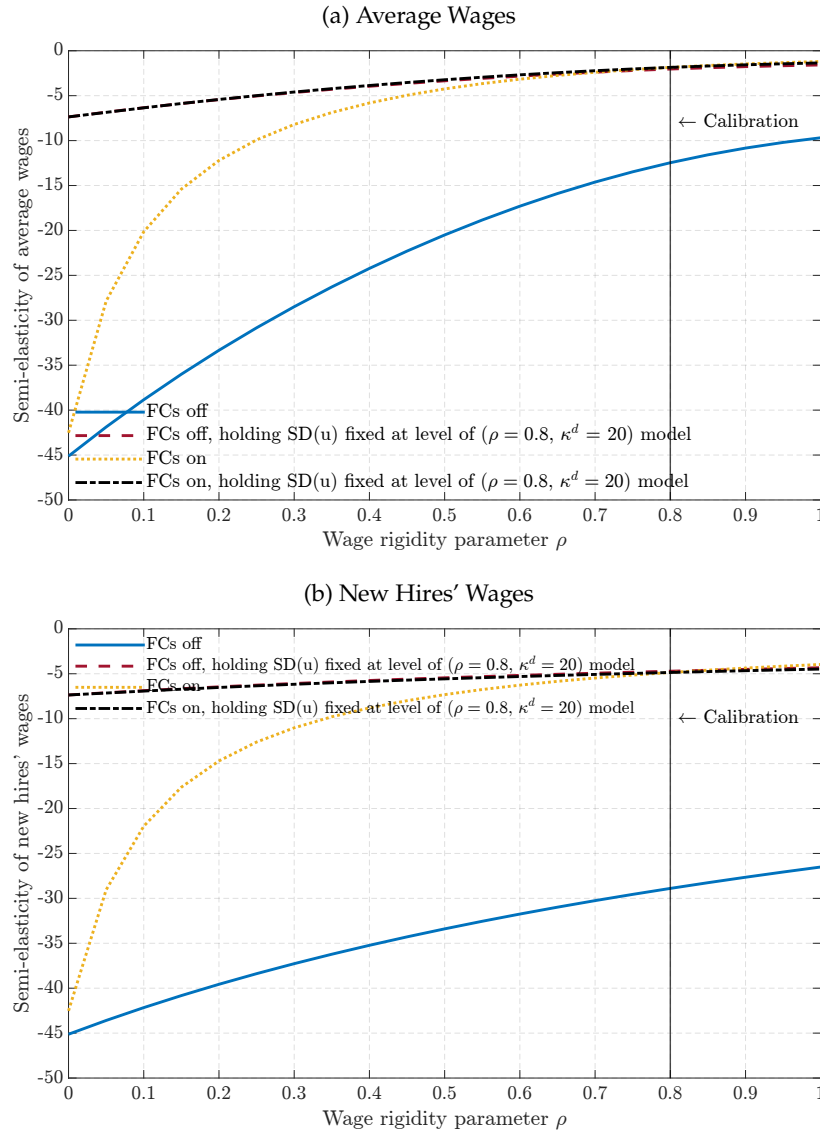
(b) New Hires' Wages

Note: The figure illustrates the sensitivity of the semi-elasticity of average wages (Panel (a)) and of new hires' wages (Panel (b)) with respect to the unemployment rate, to the degree of incumbent workers' wage rigidity ρ. The semi-elasticity is constructed as the coefficient on the unemployment rate in a linear regression of log wages as the dependent variable, drawing on model time series data, i.e., $\text{Corr}(\ln x_t, u_t)\text{SD}(\ln x_t)/\text{SD}(u_t)$ for $x \in \{w_t, \overline{w}_t\}$. Across ρ values in a given model (i.e., $\kappa^d \in \{0, 20\}$) and within a ρ value across models, differences in the semi-elasticity may reflect differences in the unemployment volatility rather than the absolute wage movements. To account for this, the panels additionally report the semi-elasticities that would emerge by feeding in $\text{SD}(u_t)$ from the model with $\rho = 0.8$ and $\kappa^d = 20$ (but letting the correlation and standard deviation of wages vary), i.e., $\text{Corr}\left(\ln x_t^{\rho,\kappa^d}, u_t^{\rho,\kappa^d}\right)\text{SD}\left(\ln x_t^{\rho,\kappa^d}\right)/\text{SD}\left(u_t^{\rho=0.8,\kappa^d=20}\right)$. The simulated time series are detrended. Finally, note that the these patterns imply that for a truly realistic $\text{SD}(u)$, which more than triple that of the ($\rho = 0.8$, $\kappa^d = 20$) model, both semi-elasticities would be even lower (such that any remaining excess semi-elasticity compared to the proposed values from Pissarides (2009) would be eliminated and hence does not reflect exaggerated absolute wage movements).

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Figure A.17: Sensitivity Analysis: On-Impact Responses to Perfectly Transitory Cash Flow Shocks)

(a) Responses as Fraction of the Shock (+1% of Steady State GDP)
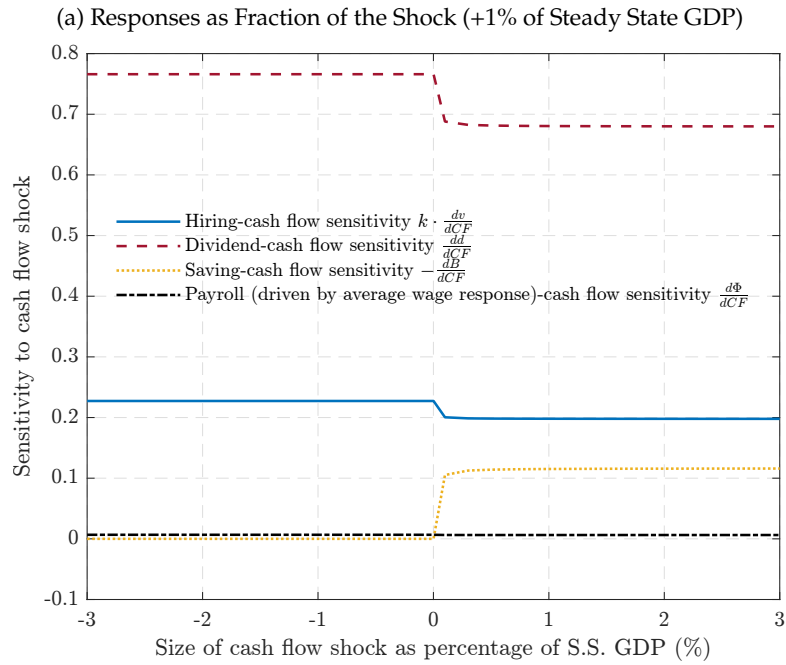
(b) Responses (Normalized by Steady State GDP) to Cash Flow Shocks of Different Sizes (as Fraction of Steady State GDP)
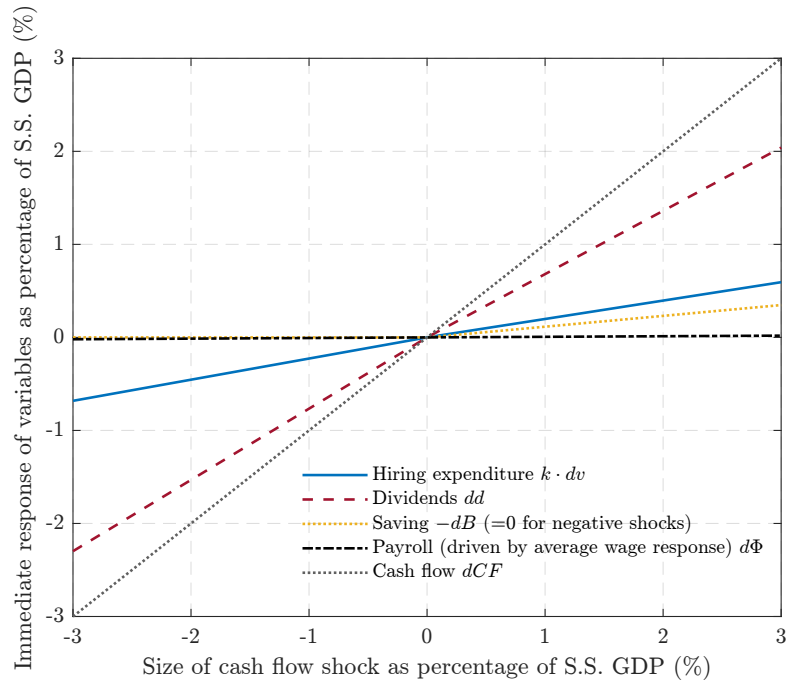
Note: The figure illustrates the sensitivities of core outcome variables to perfectly transitory shocks of different sizes (amounting to various fractions of GDP), namely the first-period (on-impact) responses of hiring (recruitment expenditures), cash flow retained (not paid out as dividends), savings, and payroll (to gauge potential endogenous wage effects). Panel (a) normalizes the first period responses by the size of the shock, giving dollar-for-dollar sensitivities. Panel (b) scales responses by steady state GDP rather than the shock sizes, complementing Panel (a).

B.2 Additional Theoretical Material: Tables

Table A.1: Full Business Cycle Statistics: Data

	$\log u$	$\log v$	$\log \theta$	$\log f$	$\log p$
Standard deviation	0.203	0.206	0.400	0.139	0.020
Autocorrelation	0.946	0.941	0.947	0.928	0.892
$\log u$	0.977	-0.904	0.960	-0.956	-0.239
$\log v$		1	-0.918	0.979	-0.952	-0.261
$\log \theta$			1	-0.980	0.879	0.293
$\log f$				1	-0.935	-0.283
$\log p$					1	0.241
$\log w$						1

Note: The table reports the full business cycle statistics (full correlation matrix) for Table 1 Panel A.

Table A.2: Full Business Cycle Statistics: Model with Neither Financial Constraints Nor Incumbents' Wage Rigidity

	$\log u$	$\log v$	$\log \theta$	$\log f$	$\log p$	$\log w$	$\log \overline{w}$
Standard deviation	0.009	0.025	0.033	0.009	0.020	0.020	0.020
Autocorrelation	0.924	0.860	0.895	0.894	0.894	0.894	0.894
$\log u$	1	-0.925	-0.957	-0.958	-0.958	-0.958	-0.958
$\log v$		1	0.995	0.995	0.995	0.995	0.995
$\log \theta$			1	1.000	1.000	1.000	1.000
$\log f$				1	1.000	1.000	1.000
$\log p$					1	1.000	1.000
$\log w$						1	1.000
$\log \overline{w}$							1

Note: The table reports the full business cycle statistics (full correlation matrix) for Table 1 Panel B.

Table A.3: Full Business Cycle Statistics: Model with No Financial Constraints but Incumbents' Wage Rigidity

	$\log u$	$\log v$	$\log \theta$	$\log f$	$\log p$	$\log w$	$\log \overline{w}$
Standard deviation	0.009	0.025	0.033	0.009	0.020	0.013	0.006
Autocorrelation	0.924	0.860	0.895	0.894	0.894	0.894	0.967
$\log u$	1	-0.925	-0.957	-0.958	-0.958	-0.958	-0.821
$\log v$		1	0.995	0.995	0.995	0.995	0.745
$\log \theta$			1	1.000	1.000	1.000	0.776
$\log f$				1	1.000	1.000	0.775
$\log p$					1	1.000	0.776
$\log w$						1	0.775
$\log \overline{w}$							1

Note: The table reports the full business cycle statistics (full correlation matrix) for Table 1 Panel C.

Table A.4: Full Business Cycle Statistics: Model with Both Financial Constraints and Incumbents' Wage Rigidity

	$\log u$	$\log v$	$\log \theta$	$\log f$	$\log p$	$\log w$	$\log \overline{w}$
Standard deviation	0.052	0.159	0.225	0.056	0.020	0.013	0.007
Autocorrelation	0.915	0.847	0.880	0.885	0.894	0.893	0.966
$\log u$	1	-0.898	-0.914	-0.949	-0.952	-0.953	-0.714
$\log v$		1	0.991	0.989	0.966	0.967	0.627
$\log \theta$			1	0.981	0.961	0.961	0.650
$\log f$				1	0.985	0.986	0.663
$\log p$					1	1.000	0.781
$\log w$						1	0.775
$\log \overline{w}$							1

Note: The table reports the full business cycle statistics (full correlation matrix) for Table 1 Panel D.

Table A.5: Full Business Cycle Statistics: Model with Financial Constraints, but no Incumbents' Wage Rigidity

	$\log u$	$\log v$	$\log \theta$	$\log f$	$\log p$	$\log w$	$\log \overline{w}$
Standard deviation	0.009	0.027	0.035	0.010	0.020	0.020	0.020
Autocorrelation	0.925	0.865	0.898	0.897	0.894	0.894	0.894
$\log u$	1	-0.927	-0.958	-0.959	-0.956	-0.956	-0.956
$\log v$		1	0.995	0.995	0.996	0.996	0.996
$\log \theta$			1	1.000	1.000	1.000	1.000
$\log f$				1	1.000	1.000	1.000
$\log p$					1	1.000	1.000
$\log w$						1	1
$\log \overline{w}$							1

Note: The table reports the full business cycle statistics (full correlation matrix) for Table 1 Panel E.

Table A.6: Business Cycle Statistics: Effects of Payroll Tax Stabilization Without Financial Constraints

	$\log u$	$\log v$	$\log \theta$	$\log f$	$\log p$	$\log w$	$\log \overline{w}$
Panel A: Cash Flow and Marginal Channels							
Standard deviation	0.005	0.015	0.020	0.006	0.020	0.013	0.006
Autocorrelation	0.924	0.860	0.894	0.894	0.894	0.894	0.967
Correlation with u	1.000	-0.926	-0.958	-0.958	-0.958	-0.958	-0.822
Panel B: Marginal Channel Only							
Standard deviation	0.005	0.015	0.020	0.006	0.020	0.013	0.006
Autocorrelation	0.924	0.860	0.894	0.894	0.894	0.894	0.967
Correlation with u	1.000	-0.926	-0.958	-0.958	-0.958	-0.958	-0.822
Panel C: Inframarginal, Financial Channel Only							
Standard deviation	0.009	0.025	0.033	0.009	0.020	0.013	0.006
Autocorrelation	0.924	0.860	0.895	0.894	0.894	0.894	0.967
Correlation with u	1.000	-0.926	-0.958	-0.958	-0.958	-0.958	-0.822

Note: The table reports the full business cycle statistics corresponding to the model with the cyclical payroll tax stabilization and without financial constraints depicted in Figure 10, where $\alpha = 0.3$ (the highest value depicted in the figure).

Table A.7: Business Cycle Statistics: Effects of Payroll Tax Stabilization With Financial Constraints

	$\log u$	$\log v$	$\log \theta$	$\log f$	$\log p$	$\log w$	$\log \overline{w}$
	Panel A: Cash Flow and Marginal Channels						
Standard deviation	0.011	0.033	0.044	0.012	0.020	0.013	0.006
Autocorrelation	0.913	0.840	0.879	0.879	0.894	0.894	0.967
Correlation with u	1.000	-0.914	-0.951	-0.952	-0.955	-0.956	-0.703
	Panel B: Marginal Channel Only						
Standard deviation	0.033	0.097	0.131	0.035	0.020	0.013	0.007
Autocorrelation	0.915	0.847	0.884	0.884	0.894	0.894	0.966
Correlation with u	0.999	-0.914	-0.945	-0.953	-0.955	-0.956	-0.717
	Panel C: Inframarginal, Financial Channel Only						
Standard deviation	0.013	0.038	0.051	0.014	0.020	0.013	0.006
Autocorrelation	0.913	0.840	0.879	0.879	0.894	0.894	0.967
Correlation with u	1.000	-0.914	-0.951	-0.952	-0.955	-0.955	-0.700

Note: The table reports the full business cycle statistics corresponding to the model with the cyclical payroll tax stabilization and with financial constraints depicted in Figure 10, where $\alpha = 0.3$ (the highest value depicted in the figure).