WORKING PAPER 2610

The Effect of Corporate Cash Accumulation on Monetary Policy Transmission: A Stock-flow Consistent Growth Model

Nitin Nair

April 2026

POST-KEYNESIAN ECONOMICS SOCIETY

The Effect of Corporate Cash Accumulation on Monetary Policy Transmission: A Stock-flow Consistent Growth Model*

Nitin Nair†

April 25, 2026

Abstract

This paper causally shows that non-financial corporate liquidity dampens monetary policy transmission. While standard analyses of financial heterogeneity rely on exposure-based estimates, I additionally employ Granular Instrumental Variables (GIV) to overcome endogeneity concerns. GIVs exploit idiosyncratic shocks to the largest corporate cash holding firms to identify exogenous variation in the aggregate cash ratio. I then develop a stock-flow consistent growth model to identify the structural conditions under which corporate cash accumulation weakens transmission. These results have direct implications for the effectiveness of monetary policy and motivate the inclusion of corporate liquidity into mechanisms like the financial accelerator and investment functions.

Keywords: Monetary Policy Transmission; Local Projections; Granular Instrument Variables; Corporate Finance; Stock–flow consistent model

JEL Codes: E12, E22, E52, G32, C36

*The author thanks Michalis Nikiforos, Giuliano Toshiro Yajima, Simon Grothe, the Leeds PhD Conference, and the PKES PhD conference for feedback. The author is especially indebted to Annina Kaltenbrunner, Karsten Kohler, and Iván Weigandi for their invaluable guidance and feedback at multiple stages. All mistakes are the authors sole responsibility. R-codes for replication can be requested using the correspondence email.

†PhD Candidate, University of Leeds; bnnn@leeds.ac.uk

1 Introduction

Between 2022 and 2023, the U.S. Federal Reserve raised policy rates from 0.25% to over 5% to combat post-pandemic inflation. Yet real output remained near trend, with recent estimates indicating that monetary policy transmission (MPT) was approximately 25% weaker than historical norms (Barrett and Platzer, 2024). While explanations such as muted forward guidance offer one route, a growing body of econometric research attributes this muted response to financial heterogeneities of non-financial corporations (NFCs) (Jeenas, 2018; Ottonello and Winberry, 2020; Luetticke, 2021; Cloyne et al., 2023).

This paper first contributes by identifying the causal role of NFC cash holdings in MPT, highlighting the macroeconomic relevance of this particular heterogeneity. Existing literature examines heterogeneity by interacting firm-level exposures, like leverage or cash ratios, with identified monetary policy surprises (MPS) to estimate effects on firm-level investment (Jeenas, 2018; Ottonello and Winberry, 2020). This approach suffers from two drawbacks. First, the interaction need not be exogenous, since the exposure term is endogenous, leading to competing hypotheses like age and leverage (Ottonello and Winberry, 2020; Cloyne et al., 2023). While existing studies address this with controls and firm grouping, this paper employs the granular instrumental variable (GIV) approach to identify exogenous variation in the aggregate cash ratio, stemming from idiosyncratic changes in cash holding of the largest cash holders (Gabaix and Koijen, 2024). Second, effects at the firm level need not translate to aggregate investment, due to general equilibrium and network effects (Grob and Züllig, 2024). An emphasis on aggregate outcomes, confirms the macroeconomic relevance of cash holdings, motivating inclusion in mechanisms such as the financial accelerator and investment functions. To explore the conditions under which cash holdings dampen monetary policy transmission, the paper then employs comparative statics, stability analysis, and simulations from a stock–flow-consistent (SFC) growth model that explicitly incorporates the role of NFC cash holdings into an investment function.

In line with Jeenas (2018), local projections (LPs) interacting MPS with firm-level cash ratios reveal that firm cash holdings dampen MPT to firm investment. A 1 percentage point (pp) rise in the firm-level cash ratio cushions investment by almost 2%[1] at peak following a one-standard deviation MPS. Literature attributes this dampening effect of cash reserves to providing the alternate of internal financing, generate interest income to offset rising debt-service costs, and preserve borrowing

[1] Note that we assume that log and percentage points are equal.

capacity amid tightening (Sharpe and Suarez, 2021; Lu et al., 2024; Ahn, 2024; Joseph et al., 2026). Endogenity concerns and competing hypotheses motivate the use of a novel instrument to identify aggregate shifts in NFC cash holdings. At the aggregate level, results confirm that cash ratios dampen MPT. A 1 pp increase in the NFC cash ratio cushions aggregate investment contraction by 7% at peak. In the aggregate case while the peak is larger, effects are relatively short lived.

To examine the macroeconomic conditions which dampen MPT in the presence of cash ratios, we develop an SFC model. The model highlights the macroeconomic relevance of corporate finance, incorporating NFC liquidity and liability structure into investment decisions alongside macroeconomically driven expectations (Myers and Majluf, 1984; Fazzari et al., 1987; Ferrando et al., 2025). The model features lower hurdle rates[2] for highly liquid/low-leverage firms (Graham, 2022) and demand expansion via adaptive macroeconomic expectations and interest income on liquid assets (Tauheed and Wray, 2006; Ahn, 2024; Ferrando et al., 2025). Comparative statics and simulations reveal the conditions under which liquidity buffers offset contractionary effects of rate hikes. In conclusion, contractionary policy is less potent when NFCs hold substantial liquidity or accumulate cash post-hike.

The paper is organized as follows. Section 2 surveys related literature. Section 3 empirically motivates macroeconomic relevance of NFC cash holdings. Section 4 discusses model structure and behavioral assumptions. Section 5 derives the conditions that dampen MPT formally though comparative statics and numerically with simulations. Section 6 concludes.

2 Related Literature

This paper contributes to at least two strands of literature. First, it pushes the frontiers of empirical research investigating the relevance of NFC heterogeneities in MPT while motivating firm cash holdings as a key dimension. I move beyond the typical exposure (interaction) approach to a GIV approach which allows for causal inference. Second, I develop a SFC model to examine MPT when NFCs accumulate deposits, connecting macroeconomic determinants with corporate finance.

Canonical theory posits an inverse spending-rate relationship via higher financing costs, weaker balance sheets, reduced credit supply, and collateral effects (Kuttner and Mosser, 2002; Bernanke and Gertler, 1995). Yet recent literature challenges this inverse relationship; suggesting weak investment sensitivity to interest rates (Fazzari et al., 1987), bank profitability (Borio and Zhu, 2012;

[2] Henceforth defined as the minimum rate of return required to justify financing an investment project (Meier and Tarhan, 2007; Graham, 2022).

Bauer et al., 2023), endogenous money (Disyatat, 2011), and interest income effects (Tauheed and Wray, 2006; Ahn, 2024). The most relevant studies to this paper use local projections (Jordà, 2005) and interactions with MPS to examine the implications of NFC heterogeneity for MPT. (Gertler and Gilchrist, 1994) show small firms' contract most after monetary tightening. Cloyne et al. (2023) argue the relevance of firm age and dividend status, finding that young non-dividend payers contract most. Ottonello and Winberry (2020) emphasize leverage and default risk, suggesting that low leveraged/ low default risk firms contract investment most sharply. This happens because high default and leveraged firms are least likely to use external finance for investment. Grob and Züllig (2024) find that at the aggregate level, leverage amplifies investments' response but mutes at the firm-level. This is because when all firms are highly leveraged, investment falls by less meaning the price of capital falls by less, stimulating less investment as opposed to a low leverage state (Grob and Züllig, 2024). Ferrando et al. (2025), using ECB SAFE survey, find that strong fundamentals and easy funding availability muted investment's response. Jeenas (2018), like this paper, shows that firms with larger cash ratios contract less following a rate hike. Each study typically isolates its preferred channel by controlling (or grouping with) for firm-specific characteristics suggested by the others. We update Jeenas (2018)'s estimates confirming the cushioning effects of firm level cash ratios for firm level investment, post pandemic which saw large rises in firm cash holding (Singer and Yang, 2025).

Although MPS are plausibly exogenous, interacting them with raw firm level cash ratios may introduce endogeneity, limiting causal inference. This paper advances this discussion by arguing that NFC liquidity causally cushions the aggregate investment response to monetary tightening. To establish causality, we exploit exogenous variation in the aggregate NFC cash ratio using a granular instrument variable (GIV) approach (Gabaix and Koijen, 2024). This identification strategy isolates idiosyncratic cash ratio shifts of large firms on the aggregate NFC cash ratio. This does not rule out other characteristics but strongly motivates the incorporation of firms' asset-side liquidity alongside net present values, interest rates and liabilities structure to important macroeconomic mechanisms like the financial accelerator and investment function. GIVs present an alternate avenue, to firm level exposures, to incorporate the macroeconomic effects of more granular firm level heterogeneity while preserving causal inference. It accurately identifies the drivers of aggregate outcomes as large participants through size weights. The use of aggregate investment as an outcome confirms that other general equilibrium or network related effects do not alter results as we move up a level of aggregation. To the authors knowledge, this is only the second paper to interact two instrumented shocks. Holm-Hadulla and Thürwächter (2024) apply the GIV to identify the effects of firm leverage shocks on the price level and GDP, to find aggregate NFC leverage to be an amplifier during monetary tightening.

Building on empirical evidence that rate hikes have muted effects on NFC capital expenditure for firms with large cash holdings (Jeenas, 2023; Bräuning et al., 2023; Han and Wang, 2023), Jeenas (2023) present a heterogeneous-agent New Keynesian model most closely related to ours. There, liquid assets cushion the contractionary effects of rate hikes through two financial frictions: (i) debt-issuance (redemption) costs, and (ii) an interest rate differential between borrowing costs and returns on liquid assets. Firms manage corporate liquidity discontinuously through discrete debt issuances (redemptions) and continuously by (de)accumulating liquid assets. Borrowing incurs debt issuance costs, while holding liquid assets incurs negative carry costs[3]. These frictions motivate cash holdings and distinguish cash from leverage. Cash-rich firms avoid costly debt issuance, insulating investment from rising borrowing costs. During monetary tightening, rate hikes are assumed to decrease spending (investment and consumption) through conventional intertemporal substitution and rising discount rates - leading to falling prices. Falling prices (of investment goods) then stimulates investment among cash-rich firms who are insulated from rising borrowing costs due to the above assumed financial frictions.

However, the insulation of cash-rich firms from rising borrowing costs relies on the assumption that they are unlikely to borrow due to debt-related fixed costs. Yet Boyarchenko and Elias (2024) document that firms frequently issue and prepay debt to manage cash outflow schedules, questioning the significance of transaction costs in debt management. The study further finds that macroeconomic factors are as important, if not more so, than the firm-level factors considered by Jeenas (2023) to model debt issuance (redemption) decisions. Holm-Hadulla and Thürwächter (2024) also find that aggregate leverage rises in response to positive MPS. Additionally, investment stimulation in (Jeenas, 2023) relies on the assumption that monetary tightening successfully reduces demand and prices, thus making investment attractive for liquid firms. As pointed out by Grob and Züllig (2024), even within a New-Keynesian framework, a fall in the price of capital could be conditional. Additionally, monetary tightening may not reduce prices if inflation is driven by supply constraints, bottlenecks (Wildauer et al., 2023), or profit margins (Konczal and Lusiani, 2022; Weber and Wasner, 2023; Nikiforos et al., 2024). Nor does it necessarily decrease demand if rate hikes increase disposable income through increased interest receipts (Tauheed and Wray, 2006; Schasfoort et al.,

[3]The interest rate on liquid assets is lower than the debt service rate.

2017; Luetticke, 2021; Papadimitriou and Wray, 2024; Ahn, 2024). These limitations question the generalizability of Jeenas's mechanism to contexts like post-pandemic inflation - when it was unclear if inflation was demand driven and when NFCs were cash rich.

This paper's SFC model accommodates empirical results without these particular financial frictions. The dampening effect of deposits on investment contractions is driven by two empirically grounded phenomena. First, firms with larger liquid reserves and smaller leverage face lower hurdle rates (Graham, 2022). This builds on corporate finance literature which stresses the interdependence between investment and the source of investment financing (Myers and Majluf, 1984; Fazzari et al., 1987; Minsky, 2008). Second, investment stimulation could arise from income expansions for deposit holders (firms and households), rather than from falling prices driven by intertemporal substitution and discount rate effects (Tauheed and Wray, 2006; Schasfoort et al., 2017; Luetticke, 2021; Papadimitriou and Wray, 2024; Ahn, 2024). This allows and endogenizes the general equilibrium effects discussed by (Grob and Züllig, 2024). With administered prices, demand dynamics are separated from prices. This shifts focus to whether monetary policy can control demand, rather than prices. This represents a stricter test as New Keynesian models assume monetary policy tames prices by taming demand. Moreover, SFC models explicitly enforce quadruple-entry accounting consistency, rigorously tracking dynamic firm cash accumulation, leverage, and macroeconomic consequences of financial flows (Godley and Lavoie, 2016; Nikiforos and Zezza, 2018; Lu, 2025). SFC models are therefore a useful complement to understand the muted contractionary effects of post-pandemic rate hikes on NFC investment dynamics.

To the knowledge of the author, only two SFC studies explicitly examine monetary policy: Zezza and Dos Santos (2004) and Le Heron and Mouakil (2008). Both find that rate hikes may be expansionary in the long run but are necessarily contractionary in the short run. Notably, neither allows NFCs to accumulate financial or cash assets, leaving the implications of rising corporate deposits unexplored, despite empirical evidence showing firms hold financial assets beyond their operational needs (Davis, 2018). While a handful of SFC models allow firms to accumulate financial assets, most of them emphasize speculative accumulation which relies mostly on returns (Duwicquet and Mazier, 2010; Mazier, 2020; Caverzasi and Godin, 2015; Miess and Schmelzer, 2015). In contrast, we model deposit accumulation closely aligned with empirical observations and the transactions motive. Evidence shows that firms accumulate cash under uncertainty (Acharya et al., 2007; Singer and Yang, 2025), while in more certain environments cash is used to repay debt. High leverage is associated with precautionary accumulation to mitigate bankruptcy risk (Guney et al., 2007; Minsky, 2008). Gao et al. (2021) finds precautionary demand dominates in low-interest environments, while high rates discourage accumulation due to negative carry. This would suggest that precautionary accumulation is particularly relevant for the COVID-19-related spike in corporate deposits (Tawiah et al., 2024; Singer and Yang, 2025). We minimize our engagement with debates over the motives and instruments underlying corporate financial accumulation (Davis, 2017; Rabinovich, 2019; Darmouni and Mota, 2024). Our focus is on how the existence and scale of liquid assets shape monetary policy transmission. By allowing firms to borrow to acquire both capital and deposits, the model avoids assuming that the acquisition of financial assets necessarily crowd out investment, providing a more realistic framework for analyzing liquidity-driven investment dynamics (Skott and Ryoo, 2008; Dögüs, 2018). Finally, the paper exploits the dynamic structure of SFC models to conduct comparative statics and stability analysis. We also show that SFC models are dynamic systems with positive traces, highlighting how the inclusion of accounting consistency makes stability conditions, shedding light on the inherent instability of real-world economic systems.

3 Heterogeneity in Firm Liquidity and Monetary Policy Transmission

3.1 Data, Key Stylized Facts, and Identification

3.1.1 Data and Key Stylized Facts

This section discusses data and descriptive statistics. Consistent with prior work, we identify rate hikes employing monetary policy surprises (Jordà, 2005; Ottonello and Winberry, 2020; Jeenas, 2023; Cloyne et al., 2023). Following the literature, we directly use the surprises as the shock. We use an updated version of the monthly monetary policy suprises (MPS) dataset from Bauer and Swanson (2023), provided by the Federal Reserve Bank of San Francisco, spanning February 1988 to December 2023 (Jeenas, 2018; Ottonello and Winberry, 2020; Holm-Hadulla and Thürwächter, 2024). Firm-level financial data are drawn from quarterly COMPUSTAT North America (Ottonello and Winberry, 2020; Jeenas, 2023; Cloyne et al., 2023). We use macroeconomic data from FRED (Federal Reserve Economic Data) and BEA (Bureau of Economic Analysis). The analysis is confined to the United States.

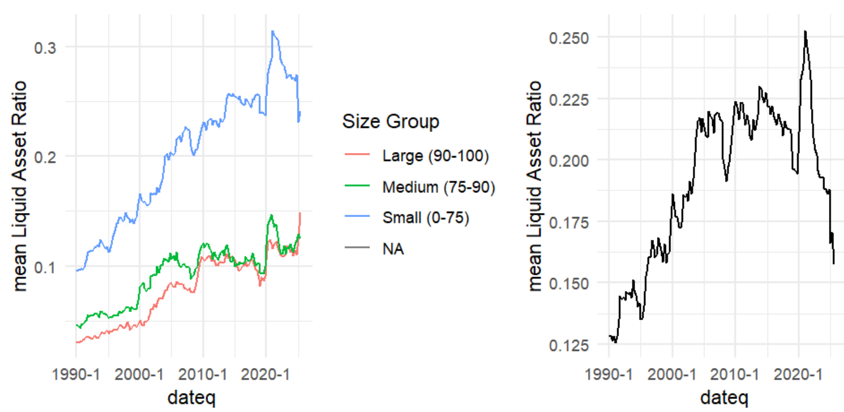
Figure 1 illustrates the empirical relevance of examining rising deposit accumulation. The average ratio of cash and cash equivalents to total assets has risen from 12.5% before 1990 to 25% during the COVID pandemic. In line with Jeenas (2023), we also see the largest liquid ratios and

Variable	N	Mean	SD	P25	Median	P75
$\Delta \log k_{i,t}$	450,300	0.012	0.229	−0.022	−0.004	0.024
$\text{Liq}_{i,t}$	469,512	0.188	0.227	0.026	0.092	0.267
log Assets	469,512	5.253	2.565	3.438	5.283	7.080
Inflation rate	144	0.664	0.545	0.451	0.703	0.871
GDP growth	144	0.622	1.101	0.354	0.678	0.987
MPS	135	−0.006	0.095	−0.027	0.012	0.044
$\Delta \log I_t$	134	0.011	0.020	0.004	0.015	0.024
Liq_t	135	0.028	0.008	0.020	0.026	0.030

Notes: Firm-level data from COMPUSTAT North America 1988–2024. We use *cheq* and *atq* for $liq_{i,t}$ and log Assets, *ppegtq*, *ppentq*, and BEA-NIPA *T*10304 as a deflationary measure. Monetary policy surprises from Bauer and Swanson (2023). The inflation rate, federal funds rate, GDP growth rate, aggregate investment, and aggregate cash ratio are from FRED series CPIAUCSL, FEDFUNDS, GDPC1, PNFI, and A008RD3Q086SBEA respectively.

Table 1: Descriptive Statistics

largest rises in liquid ratios were among the smallest firms[4].



Notes: The liquid asset ratio is calculated using the cheq (cash & cash equivalents quarterly) and atq (total assets quarterly) variables from the COMPUSTAT NORTH AMERICA database. The left panel shows the evolution of average liquid ratios of firms grouped by size. The right panel shows the average liquidity ratio for all firms. Firm size is grouped by arranging firms into 0-75, 75-90, and 90-100 percentile groups based on total assets. Size groups are updated quarterly.

Figure 1: Time series of firm level corporate liquid asset ratio

3.1.2 Identification through Granular Instruments

An interaction between raw firm cash ratios and a monetary policy surprise need not be exogenous. As discussed in the literature, the higher cash ratios could be a feature shared by older dividend

[4] Further details on data sources, cleaning, variable construction, descriptive statistics, and robustness checks are available in Appendix A.

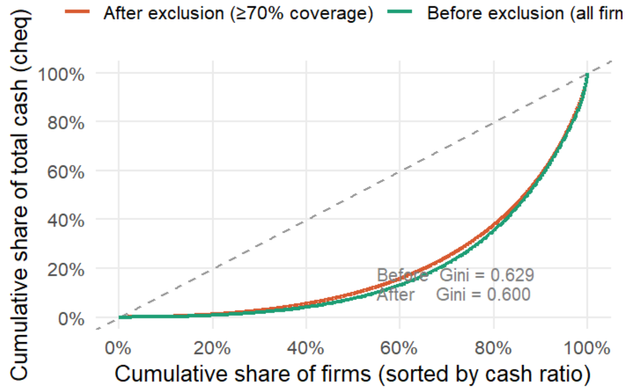


Figure 2: Lorenz Curve

paying firms which do not contract investment as much for reasons other than liquidity (Cloyne et al., 2023). Or as Ottonello and Winberry (2020) suggests the relation through changes in cash ratios could be confounded by distance to default or leverage. Additionally, higher future investment plans could motivate increased cash holding, thus jeopardizing results to simultaneity even with lags. This would be because firms may start hoarding liquidity well before they actually invest. In order to establish that cash holding influences the investment decision such that the impact of rate hikes are mitigated, this paper identifies exogenous shocks to the cash ratio using the GIV approach (Gabaix and Koijen, 2024).

The GIV approach isolates a size weighted average of idiosyncratic shocks to firm level cash ratios to identify aggregate cash ratio changes. In other words, the GIV uses the movements to the aggregate cash ratio that originate from idiosyncratic movements of highest cash holding firms. The key requirement for this method is the existence of concentrated cash holdings among few firms. The top 10 firms hold 13.4% of total cash holdings while the top 50 hold almost 50%, suggesting significant concentration of cash holdings [5]. Figure 2 shows a Lorenz curve (and Gini coefficient) illustrating high concentration of cash and cash equivalent holdings within (orange) and outside (green) the sample (see footnote 5).

The first step involves a multi-factor regression (orthogonalization) on firm level cash ratios to exclude time invariant firm characteristics and time characteristics common to all firms[6].

$$liq_{i,t} = \alpha_i + \delta_t + e_{i,t} \tag{1}$$

[5]In our sample there are 1502 distinct firms. The original data had 17,031 firms but we only use firms with at least 70 percent non-missing coverage of the cash ratio, so that only 12% of our data are missing. This makes up 9% of total firms and captures around 60% of total yearly cash holdings.

[6]We also include industry fixed effects in a robustness check (see figure 12).

Where α_i and δ_t are firm and time fixed effects. $e_{i,t}$ are the residuals that are extracted. Following the GIV approach, the residuals are then fed into a principle component analysis, to isolate idiosyncratic movements from the multi-factor residuals. Fitted residuals are assumed to have the following structure, $\hat{e_{i,t}} = \lambda_{i,t}\eta_t + u_{i,t}$, where $\lambda_{i,t}\eta_t$ are the common variations and $u_{i,t}$ is the truly idiosyncratic component. The non-parametric principle component analysis is used to identify common variations and arrive at the idiosyncratic shocks[7]. This ensures that common shocks are filtered out. We employ the Bai-Ng criterion for factor selection (Bai and Ng, 2002). Finally we multiply the matrix of $u_{i,t}$ with a matrix of lagged time varying shares of cash holdings of each firm relative to total cash holdings in the quarter.

$$Z_t = \sum_i s_{i,t-1} u_{i,t} \tag{2}$$

The instrument Z_t contains the share weighted average of idiosyncratic shocks to firm cash ratios. The share-weight ensures that variations from large participants, which actually effect aggregate variables, are give appropriate importance. The exclusion criteria is that idiosyncratic cash holding shocks to large cash holding firms only effects aggregate investment through changing the aggregate cash ratio. There is no obvious reason to think that idiosyncratic changes in cash holding of large cash holders feed into a mechanism like a financial accelerator. In order to test relevance and transform the instrument into units of the aggregate cash ratio, we run a first stage.

$$liq_t = \alpha_0 + \beta Z_t \tag{3}$$

Where liq_t is ratio of total currency and deposits held by the NFC sector relative to their total assets, from FRED [8]. The F-stat is over 25 which passes the threshold of 16 to 19 suggested by Gabaix and Koijen (2024), confirming relevance. The strongest threat to GIVs is the inability to pick up common shocks (Gabaix and Koijen, 2024). In figure 12, we show that results are immune to changing factor selection and the sample of firms by changing coverage, demonstrating loading stability. A standardized transformation of $\hat{liq_t}$ is then fed into the second-stage in equation (5).

[7] We use the NIPALS PCA from the PCA methods package which imputes missing values. With firm level data some form of imputation is necessary because there would be no unique firms with complete cases.

[8] We also examine the first stage aggregating the liquidity ratio across firms using the Compustat data and we find an F-stat of 21.

3.2 Baseline Specifications

3.2.1 Firm-level Specification

Our firm level empirical strategy is summarized by the following regression equation:

$$\begin{aligned}\log k_{i,t+h} - \log k_{i,t-1} = \alpha_i + \delta_{s,y} + \beta_{1,h}(MPS_t \times liq_{i,t-1}) + \beta_{2,h}MPS_t \\ + \beta_{3,h}liq_{i,t-1} + \gamma_h X_{i,t-1} + \varepsilon_{i,t+h}\end{aligned} \tag{4}$$

Here, subscripts denote firm i, time t, horizon h, sector s, and year y. The dependent variable is the logged cumulative change in the firm's real capital stock, k across h horizons[9]. Following the literature, we calculate firm capital stock using the perpetual inventory method (Ottonello and Winberry, 2020; Jeenas, 2023). Long differences of capital stock allow us to obtain cumulative impulse responses, telling us the total change in investment over horizons (Jordà and Taylor, 2025)[10]. Firm fixed effects α_i capture time invariant firm heterogeneity, and sector-year fixed effects account for common time shocks by one digit industry codes. MPS denotes the monetary policy surprise[11]. While *cashratio* is the cash and cash equivalents to lagged total assets ratio. Baseline control variables $X_{i,t-1}$ include logged firm assets (proxy for firm size), GDP growth, the CPI inflation rate, and four lags of the change in capital stock. Standard errors are clustered by firm. Robustness checks can be found in appendix A.3.

3.2.2 Aggregate Specification

The aggregate specification which uses the granular instrument variable is below.

$$\begin{aligned}\log I_{t+h} - \log I_{t-1} = \alpha_0 + \beta_{1,h}(MPS_t \times \hat{liq_t}) + \beta_{2,h}MPS_t \\ + \beta_{3,h}\hat{liq_t} + \gamma_h X_{t-1} + \varepsilon_{t+h}\end{aligned} \tag{5}$$

Similar to the firm-level specification, we use logged long differences to infer dynamic causal effects on cumulative investment. $\hat{liq_t}$ is the predicted first stage of the cash ratio. Baseline controls (X_{t-1}) include four lags of the dependent variable, GDP growth, and the inflation rate. HC1 standard errors are used for inference. Robustness checks can be found in figure 12.

[9]We multiply this by 100 to get percentage interpretations.
[10]Long differences are multiplied by 100.
[11]We normalize the surprise so that we can interpret results in terms of standard deviations

3.3 Results

3.3.1 Firm-level Results

Figure 3 illustrates the baseline cumulative impulse response of total changes in capital stock (left), and marginal effects of a firm's capital stock with and without liquid assets. Regression table 2, for select horizons, report coefficients of the surprise and interaction. The blue line depicts the effect of the identified monetary policy shock ($\beta_{2,h}$) on capital stock: as expected, unexpected rate hikes negatively impact capital stock. A one standard deviation surprise tightening produces approximately a 0.1% decline in capital stock after a year. Negative effects peak at 0.7% around towards the 8^{th} quarter.

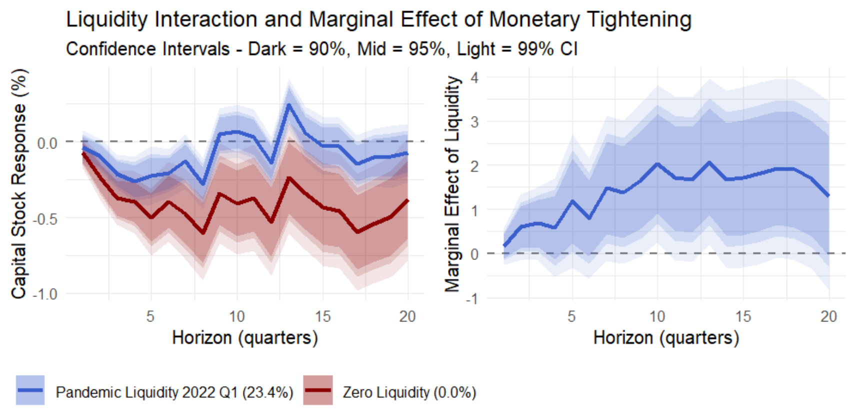
	$h = 1$	$h = 4$	$h = 8$	$h = 12$	$h = 20$
MPS_t ($\beta_{2,h}$)	-0.089^{**}	-0.468^{***}	-0.668^{***}	-0.590^{***}	-0.428^{***}
	(0.040)	(0.079)	(0.119)	(0.135)	(0.153)
$MPS_t \times cashratio_{i,t-1}$ ($\beta_{1,h}$)	0.215	0.946^{**}	1.742^{***}	1.924^{***}	1.533^{*}
	(0.158)	(0.424)	(0.616)	(0.702)	(0.800)
Fixed Effects	Firm, Industry × Year				
Standard Errors	Clustered (firm)				

Notes: Local projections of $\log k_{i,t+h} - \log k_{i,t}$ on monetary policy surprises MPS_t and their interaction with the lagged firm cash ratio $cashratio_{i,t-1}$, estimated via equation (4). Controls $X_{i,t-1}$ include two lags of GDP growth, inflation, and log assets, plus two lags of the dependent variable. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$.

Table 2: Dynamic Response of Capital Stock to Monetary Tightening

The right graph illustrates the heterogeneous response captured by the interaction between shocks and cash holdings. Firms with larger internal liquidity exhibit a muted contraction following a monetary tightening, due to the positive sign of the coefficient. The heterogeneity in exposure to liquid assets has statistically and economically significant effects on firm investment. A one percentage point higher liquid asset ratio offsets the effects of the rate hike by over 2% at peak after a year. The effect of heterogeneous cash exposure becomes less statistically significant over time. These magnitudes and the non-persistent nature of the effect of cash holding are extremely similar to Jeenas (2018). These magnitudes are also comparable to the estimates of the effects of leverage and distance to default by Ottonello and Winberry (2020). Our estimates imply that a liquidity ratio of around 27% would be sufficient to completely offset the negative effects of rate hikes, one year on.

The left graph in figure 3 shows the total effects of holding the average cash ratio (around 23%)



Notes: Local projection estimates of equation 4. (LEFT) Total response of log capital to a one standard deviation monetary tightening shock ($\hat{\beta}_{s,h} + \hat{\beta}_{int,h} \cdot L$) at zero liquidity (red) and mean pandemic-era liquidity of 24.4% (blue). (RIGHT) Dynamics of the interaction coefficient $\hat{\beta}_{int,h}$, capturing how firm liquidity moderates the investment response to monetary tightening. Shaded bands denote 90%, 95%, and 99% confidence intervals. Standard errors clustered at the firm level. Firm and industry-year fixed effects included.

Figure 3: Impulse response of capital stock to unanticipated rate hikes

at the time of the first post pandemic rate hike in comparison to the theoretical firm which does not hold cash at all. Six quarters in, the average firm's investment is significantly above that of the theoretical firm. Except for horizon 12, no other horizon has a positive and significant coefficient. This means that the average cash ratio was sufficiently high to completely offset the contractionary effects of monetary policy, yet cushions its impact nonetheless. Cash holdings not only make firms oblivious to conditions in the market for external finance but also supplement their incomes through interest receipts when there are rate hikes (Sharpe and Suarez, 2021; Jeenas, 2023; Ahn, 2024). The cushioning effects of liquid assets fade out after the 16^{th} quarter.

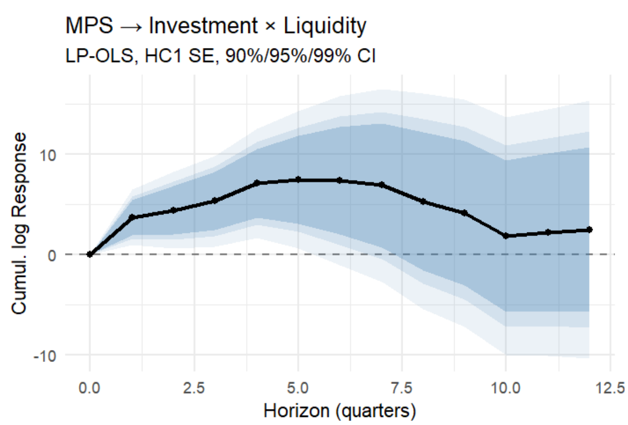
3.3.2 Aggregate Results and Causal Inference

The previous section, using a firm-level exposure based approach confirmed that firms with larger liquidity ratios contract their investment by less. However, the interaction of raw and potentially endogenous liquidity ratios with exogenous monetary policy shocks could hinder causal inference. Moreover, the previous section only confirmed that liquidity mutes monetary policy transmission to an individual firm, not macroeconomically. As Grob and Züllig (2024) finds, that leverage is an amplifier at the aggregate level but not the firm level, there is no reason to believe that firm level outcomes are generalizable to the aggregate. For these reasons, we examine the response of aggregate investment to an identified 1 pp increase in the aggregate NFC liquidity ratio when the monetary policy surprise is raised one standard deviation. Changes to the aggregate NFC liquidity ratio are identified using idiosyncratic changes to the liquidity ratios of large cash holding firms, as discussed in section 3.1.2 (Gabaix and Koijen, 2024).

	$h = 1$	$h = 4$	$h = 6$	$h = 8$
$MPS_t \times \widehat{\text{cash}}_t$ $(\beta_{int,h})$	3.705***	7.105***	7.353**	5.292
	(1.071)	(2.101)	(3.265)	(4.188)
Standard Errors	HC1 heteroskedasticity-robust			

Notes: Local projections of $\log \text{Inv}_{t+h} - \log \text{Inv}_{t-1}$ on the interaction between MPS_t and the GIV-fitted NFC aggregate cash ratio $\widehat{\text{liq}}_t$. Controls include 4 lags of the dependent variable, GDP growth, and CPI inflation. $\hat{\beta}_{int,h}$ is rescaled to reflect the response per 1 percentage point of the cash ratio. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$.

Table 3: Dynamic Response of Aggregate Investment to Monetary Tightening



Notes: Local projection estimates of the interaction coefficient $\hat{\beta}_{int,h}$ from equation (5), measuring the cumulative log response of aggregate non-residential fixed investment (PNFI) per one percentage point of the GIV-fitted NFC cash ratio $\widehat{\text{liq}}_t$, following a one standard deviation monetary policy surprise MPS_t. Controls include 4 lags of the dependent variable, GDP growth, and CPI inflation. Shaded bands denote 90%, 95%, and 99% confidence intervals. Standard errors are HC1 heteroskedasticity-robust.

Figure 4: Response of Aggregate Investment to Monetary Tightening

Figure 4 and table 3 report the coefficient of interest, the interaction between the monetary policy surprise and identified changes in aggregate NFC cash ratios. Results suggest that a 1 pp increase in the liquid ratio of NFCs investment by over 7 pp under a one standard deviation MPS. These magnitudes are larger than the firm-level estimates from section 3.3.1. Yet they are still not much larger than the point estimates reported by Jeenas (2023). The difference from section 3.3.1 could also be explained by aggregate NFC liquidity ratios being substantially lower in levels and variance than firm level ones, with a range of 1% to a maximum of 5%[12]. Additionally, aggregate investment may contain general equilibrium and network effects not included in firm-level investment. If multiple firms investment are less effected by rate hikes due to cash holdings, then macroeconomic spending by firms (to households and other firms) would decrease less, therefore indirectly propping up investment through growth and profit expectations (Ferrando et al., 2025). Another key qualitative difference between the aggregate and firm level CIRFs are that the former shows that the aggregate effects of NFC cash ratio are relatively short-term. Significance fades beyond the 8^{th} horizon and estimates converge back to zero on and by the 10^{th} horizon. This, however, does not threaten the argument because monetary tightening attempts to slow down the economy in the short-term. Therefore short-term dampening effects are most relevant to this paper.

4 Setting-up a Stock-flow Consistent Economy

4.1 Matricies and Accounting Equations

This model assumes a single-good closed economy. The economy consists of households, firms, and banks. There are two assets and one liability; i.e., fixed capital, bank deposits, and bank loans. Households hold deposits accumulated only through savings from income. Firms accumulate capital stock and deposits, financed both internally and externally. Allowing firms to accumulate deposits is crucial to our question of how cash hoards effect monetary policy. For the formal analysis, we assume banks have a static zero net-worth and distribute their profits to households which are directly credited to their deposit accounts. In the numerical simulation, we lift this assumption and allow banks to accumulate profits, and have a dynamic non-zero net-worth. The aggregated household sector consumes, earns wages and interest on deposits. Firms spend on wages, investments in fixed capital, interest on loans, and bank deposits. They earn through consumption income, investment in fixed capital (which is a within-sector expenditure), and interest on bank deposits. Banks only create loans and deposits. Their entire income and expenditures constitute interest payments on deposits and interest receipts on loans.

In tables 4 and 5, we choose firm loans and household deposits to be the residual variables which adjust to satisfy accounting constraints. We can capture these two variables using two budget

[12] A robustness check which fits the first stage using aggregated values of cash ratios from COMPUSTAT instead of the aggregate cash ratio from FRED shows extremely similar magnitudes to firm-level results (see figure 12).

	Banks	Firms	Households	Total
Fixed Capital	0	+K	0	+K
Deposits	-D	$+D^f$	$+D^h$	0
Loans	+L	-L	0	0
Net Wealth	0	NV^f	NV^h	K

Table 4: Balance Sheet Matrix

	Households	Firms		Banks		Total
		Current	Capital	Current	Capital	
Consumption	-C	+C	0	0	0	0
Investment	0	+I	-I	0	0	0
Wages	+W	-W	0	0	0	0
Interest on Loans	0	$-r^l_{t-1}L_{t-1}$	0	$+r^l_{t-1}L_{t-1}$	0	0
Interest on Deposits	$+r^d_{t-1}D^h_{t-1}$	$+r^d_{t-1}D^f_{t-1}$	0	$-r^d_{t-1}D_{t-1}$	0	0
Profits	$+\Pi_B$	$-\Pi_F$	$+\Pi_F$	$-\Pi_B$	0	0
Δ Loans	0	0	$+\Delta L$	0	$-\Delta L$	0
Δ Deposits	$-\Delta D^h$	0	$-\Delta D^f$	0	$+\Delta D$	0
Total	0	0	$-\Delta K$	0	0	ΔK

Table 5: Transactions Flow Matrix

constraints which are derived by adding up the vertical columns from table 5. These two equations ensure stock-flow consistency, and govern the dynamics of our system. The first one belongs to households, for whom the accumulation of deposits equals the sum of unspent incomes and past deposits [13];

$$D^h_t = D^h_{t-1} + W_t + r^d_{t-1} \cdot D^f_{t-1} + \Pi_B - C_t \tag{6}$$

The second budget constraints belong to firms, whose loans adjust to accommodate uses of funds in excess of sources of funds;

$$L_t = L_{t-1} + I + (D^f_t - D^f_{t-1}) - (C_t + I_t + r^d_{t-1} \cdot D^f_{t-1} - W_t - r^l_{t-1} \cdot L_{t-1}) \tag{7}$$

4.2 Behavioral Equations

The behavior of the capacity utilization rate (u_t), i.e. the ratio of actual output to potential output, follows other Kaleckian growth models (Dos Santos and Zezza, 2008; Hein, 2012). The goods market equilibrium holds when consumption and investment demand are met, with capacity utilization adjusting to clear demand.(normalized by the capital stock).

[13]Variable definitions can be found in table 4, 5, and C.2

$$u_t = v \cdot (c_t + g_t) \qquad (8)$$

u_t : rate of capacity utilization

v : capital-potential output ratio

c_t : consumption to capital stock ratio

g_t : rate of capital accumulation

We follow benchmark stock–flow consistent models to formalize our consumption function (c_t), normalized by the capital stock, as a function of current income and wealth. To be conservative about spending from non-wage income, we model separate propensities to consume from wages and from wealth, with interest and other non-wage income credited directly to household deposits and affecting consumption only through the propensity to consume from wealth.

$$c_t = c_1 \cdot ws_t \left(\frac{u_t}{v}\right) + a \cdot d^h_{t-1} \qquad (9)$$

c_1 : propensity to consume - wages

ws_t : wage share

a : propensity to consume - wealth

d^h_t : household deposits to capital

The gross (operational) profit rate (r_t) follows Kaleckian theory. It is demand-led, determined by firms' pricing and sales, and excludes interest payments and receipts.

$$r_t = (1 - ws_t)\left(\frac{u_t}{v}\right) \qquad (10)$$

Where $ws_t = \frac{1}{1+m_t}$ and m_t is the mark-up over costs charged by firms Hein (2014). Within the confines of a model in which prices and distribution are constant, the reaction of the rate of profit depends wholly on the reaction of the utilization rate (or sales).

We do not model a central bank explicitly. Consistent with U.S. data, deposit and loan rates are set as constant mark-down (μ) and mark-up (η) of the policy rate (r^p_t), allowing for clearer analytical derivations.

$$r^d_t = r^p_t - \mu \qquad (11)$$

$$r^l_t = r^p_t + \eta \qquad (12)$$

Examining these equations will tell us that we need to define two more variables to close the model. The rate of capital accumulation (g_t) and the stock of firm's deposits normalized by capital stock (d_t^f).

4.3 Behavioral Novelties

4.3.1 Modeling Capital Accumulation

Benchmark Kaleckian models formalize capital accumulation as a function of the utilization rate, profit rate (share), leverage, and so on. We follow Taylor and O'Connell (1985) and Charles (2008) who formalize capital accumulation as a function of an autonomous component and excess returns - defined here as the difference between the profit rate (r_t) and an endogenously determined hurdle rate (b_t). In this manner we are able to contrast distributional forces, income effects, and financial forces against each other in the capital accumulation function.

$$g_t = g_0 + g_1 \cdot (r_t - b_t) \qquad \begin{array}{ll} g_0 & \text{: autonomous capital accumulation} \\ g_1 & \text{: sensitivity to returns} \\ r_t & \text{: profit rate} \\ b_t & \text{: hurdle rate} \end{array} \tag{13}$$

The model endogenously determines the hurdle rate, in a simplified form, based on interest payments, leverage, liquid assets, and financial returns (bank deposits)[14]. Following Keynes (1936), Minsky (2008), and section 3, liquidity, cash flows and balance sheet conditions shape hurdle rates and influence investment. The hurdle rate emphasizes firm and sector balance sheets, cash flow structures, and the policy rate, rather than inherent capital stock productivity.

$$b_t = b_0 + b_1 \cdot (1 + r_{t-1}^l) \cdot l_{t-1} - b_2 \cdot (1 + r_{t-1}^d) \cdot d_{t-1}^f \tag{14}$$

b_0 is the exogenous, convention-based part of the hurdle rate. b_1 captures the relationship between leverage, borrowing costs and hurdle rates. Higher leverage reduces liquidity, raising the required return to stimulate capital accumulation— referred to in the literature as borrower's risk or debt overhang (Kalecki, 1937; Minsky, 2008; Kalemli-Özcan et al., 2022). Graham (2022) finds that firms with higher leverage face a larger hurdle rate premium. High debt service, from leverage or interest rates, also reduces retained earnings, discouraging investment and raising the hurdle rate (Fazzari et al., 1987; Clévenot et al., 2010). $(1 + r_{t-1}^l) \cdot l_{t-1}$ captures how leverage and interest

[14] Unlike Taylor and O'Connell (1985) and Charles (2008), which rely on interest or exogenous profit expectations

payments affect the hurdle rate, ensuring it rises with leverage and accelerates with higher interest rates, highlighting the importance of stock size alongside flows. b_2 captures how deposits and interest on deposits affect the hurdle rate. Larger deposits boost liquidity and provide margins of safety (Minsky, 2008), and can finance investment (Sharpe and Suarez, 2021). Graham (2022) finds firms with more cash face smaller hurdle rate premiums. This aligns with pecking order theory, as internal funds promote investment (Myers and Majluf, 1984; Fazzari et al., 1987). Joseph et al. (2026) find that cash rich small and medium enterprises invested much more in capital stock that their cash poor counter-parts in the aftermath of the global financial crisis. Interest on deposits also increases retained earnings, thus lowering the hurdle rate. We assume $b_2 > b_1$, meaning the liquidity benefits of deposit hoarding outweigh the illiquidity costs of leverage. Otherwise, it would be hard to justify why leveraged firms accumulate deposits instead of simply deleveraging.

4.3.2 Modeling Deposit Accumulation

Only a handful of models allow firms to hold financial assets. An even smaller subset use accounting closures which facilitate internally and externally financed financial accumulation. A behavioral deposit accumulation function implies no necessary trade-off between capital and financial accumulation, with loans adjusting to accommodate both (Stockhammer, 2004; Skott and Ryoo, 2008; Dallery, 2009; Dögüs, 2018). Unlike most SFC literature, which emphasizes the substitution aspects of financial and capital accumulation, we emphasize the liquidity dimension of cash holding. We follow the empirical work of Acharya et al. (2007) discussed in the literature review to model deposit accumulation.

$$d_t^f = \lambda \cdot (ws_t \cdot (u_t/v)) \pm d_1 \cdot (l_t^T - l_{t-1}) \tag{15}$$

λ : sensitivity to wage bill

d_1 : sensitivity to leverage

l_t^T : leverage target

d_t^f : firm deposits to capital stock

Following Michell (2014), the transactions motive is captured by the sensitivity of deposits to changes in wage payments to workers normalized by capital stock $(\lambda \cdot (ws_t \cdot (u_t/v))$. We assume that firms have a target leverage ratio so that we have a reference of what over-leveraged means. If d_1 is negative firms will accumulate deposits to compensate for financial distress and bankruptcy costs when they are over-leveraged $(l_t^T > l_t)$ (Guney et al., 2007). This situation demonstrates a pessimistic scenario where firms do not feel they can access funds later (Acharya et al., 2007). If firms are under-leveraged ($l_t^T < l_t$), they will not accumulate deposits and would rather put their liquid resources to some other use. However, d_1 could also be positive. In this case, if the firm sector is over-leveraged, deposits will be used to repay debt or as a source of marginally financing investment. This case would correspond to a case of relative macroeconomic certainty, since firms would prefer to invest or repay debt in these cases (Acharya et al., 2007). In our model, deposits could be either a use or source of funds depending on the relationship between actual and target leverage. Precautionary accumulation ($d_1 < 0$) is assumed in main simulation. This approach is consistent with recent empirical findings that suggest that increased perception of risk and the pandemic induced firm cash accumulation, especially among financially constrained firms (Ren, 2025; Singer and Yang, 2025). We also examine how using deposits as a source of funds for capital accumulation ($d_1 > 0$) alters results.

The corporate leverage target is modeled as a function of firm earnings capacity present value calculations and liquidity (Watanabe, 2020, 2023). As explained in Bernanke and Gertler (1995), a rate hike is expected to have a negative effect on the borrowing capacity of firms since it decreases their net present value (balance sheet channel). However, this need not be true if the profit rate rises sufficiently or the firm is sufficiently liquid (Lu et al., 2024). While firms have a leverage target, they do not face binding financial constraints, i.e. they need not sacrifice investment if they have exceeded their leverage target. Larger leverage would only discourage future investment.

$$l_t^T = \frac{r_t}{r_t^l + \sigma} + \chi_1 d_{t-1}^f \qquad (16)$$

l^T : leverage target

σ : risk premium

χ : sensitivity to liquidity

d_{t-1}^f : Firm deposits to capital-stock

5 The Stock-Flow Consistent Economy

This section begins by analytically examining the short-period and long-period responses of demand and growth to a policy rate hike. We also discuss properties of the model like demand, growth, and debt regimes, comparative statics, and stability. We then use a numerical simulation to illustrate the reaction of the economy to a rate hike under reasonable parameter values.

5.1 Monetary Policy Transmission in the Short-period

The short-period analysis assumes all stocks (normalized by capital stock) to be constant, providing insight on the contemporaneous relationship between the models variables.

Equations (8) to (14) are used to derive the equilibrium rate of capacity utilization in the short-run [15];

$$u^* = v \cdot \left(\frac{g_0 - g_1 \cdot b_0 + a \cdot d^h - g_1 \cdot b_1 \cdot (1 + r^p + \eta) \cdot l + g_1 \cdot b_2 \cdot (1 + r^p - \mu) \cdot d^f}{1 - ws \cdot (c_1 - g_1) - g_1} \right) \tag{17}$$

The short-period equilibrium suggests that interest rates (r^p) and leverage (l) negatively affect demand (u) by raising the hurdle rate (b) via the principle of increasing risk. Household deposits (d^h) boost demand through consumption from wealth, while firm deposits (d^f) enhance liquidity, increasing demand through accelerated capital accumulation. The Keynesian stability condition, a necessary but not sufficient stability condition, holds if the sensitivity of capital accumulation to excess returns (g_1) is below unity (see section B.1). Appendix B discusses the general properties of the model that are not immediately relevant to interest rate shocks.

Proposition 1. *Firm deposits can render the impact effect of monetary tightening expansionary if*

$$\frac{d^f}{l} > \frac{b_1}{b_2}$$

A positive reaction of demand to a rate hike occurs when the liquidity provided by firm deposits (b_2) sufficiently outweighs the illiquidity costs of leverage (b_1). In other words, for a given b_1 and b_2, the larger the relative magnitude of firm deposits are compared to firm leverage, the more insulated firms are from external financing constraints. Here, b_2 reflects the liquidity buffer from deposit holdings, which allows firms to finance expenditures internally, while b_1 reflects the sensitivity of firm investment to leverage - both via the hurdle rate.

Income distribution, wealth distribution, and balance sheet structure matter for the response of demand to monetary policy. The larger firm deposits become relative to the deposits of other spending sectors, the less effective monetary policy would be – since $l = d^h + d^f$. If firms did not accumulate deposits ($d^f_{t-1} = 0$), the effect would necessarily be negative, underscoring the role of deposit hoards. Rising deposit holdings thus mitigate the effects of rate hikes on demand. The proof to this proposition can be found in B.2.1.

[15] We do not include subscripts because in the short-period the model is static or a single period model where stock ratios are exogenous.

Proposition 2. *Investment reacts positively to a rate hike in the short-period if*

$$\frac{d^f}{d^h} > \frac{b_1}{(b_2 - b_1)}$$

The reaction of firm investment to monetary tightening also depends on b_1 and b_2. Household deposits accumulate when firms borrow to pay other sectors. Thus household deposits lead to a more leveraged balance sheet, discouraging investment by a factor of b_1. Firm deposits serve as internal funds, encouraging investment by a factor of b_2. However, internal funds could also increase balance sheet liquidity if used to repay debt. The opportunity cost of cash holding in terms of balance sheet liquidity is thus $b_2 - b_1$. The larger the latter relative to the former the less contractionary a rate hike becomes. Assuming a fixed b_1 and b_2, a larger stock of firm deposits reduces the contractionary effects of a rate hike – in line with section 3 and other relevant literature (Sharpe and Suarez, 2021; Ahn, 2024; Jeenas, 2023; Bräuning et al., 2023).

If we assume firms do not hold deposits ($d^f_{t-1} = 0$), in which case the partial of a rate hike is always negative. An expansion of investment is harder to achieve than an expansion of output because of the direct negative effects of leverage on investment (b_2), which offsets the positive liquidity effects of hoarding deposits (b_1).This model reflects insulation from rate hikes without assuming that debt issue is discontinuous, infrequent, transaction-cost ridden, or issued only if cash reserves are low. The proof to this proposition can be found in B.2.2.

This section contributes to the literature by showing the macroeconomic relevance of firm deposits without assuming financial frictions. It allows rate hikes to have immediate expansionary effects, highlighting an important conditionality in the expected functioning of monetary policy. Other models only allow monetary policy to be expansionary over time (Zezza and Dos Santos, 2004; Le Heron and Mouakil, 2008)[16].

5.2 Monetary Policy Transmission in the Long-period

In the long-period, unlike the short-period, stocks are endogenous and have their own laws of motions given by equations (6), (7), and (15). We can choose any two of these three variables to be the state variables of our system since the sum of household and firm deposits equal firm leverage. Due to the complex nature of accounting residuals, and the large number of parameters in our model we

[16]For example, with a canonical capital accumulation function like $g_t = g_0 + g_1 \cdot r_t - g_2 r^l_{t-1} - g_3 \cdot l_{t-1}$, the short-run reaction of demand to a rate hike is $\frac{-g_2}{1 - ws \cdot (c_1 - g_1) - g_1}$, which is necessarily negative. Even adding a liquidity term for firm deposits ($g_4 \cdot d^f_{t-1}$) makes the reaction depend on sensitivity parameters, not the size of the deposit stock[17].

do not present the long-period steady-state solutions of our state variables in a closed-form.

To convert equations (6) and (7) into rates; we normalize them by the stock of capital[18] ($d^h_t = \frac{D^h_t}{K_t}; l_t = \frac{L_t}{K_t}$). We may further simply these equations using equations (9) and (10). The following equation defines the law of motion of bank deposits normalized by the previous period's capital stock.

$$d^h_t = \frac{d^h_{t-1} \cdot (1 + r^l_{t-1} - a) + ws_t \cdot \left(\frac{u_t}{v}\right) \cdot (1 - c_1) + d^f_{t-1} \cdot (r^l_{t-1} - r^d_{t-1})}{1 + g_t} \tag{18}$$

$$l_t = \frac{l_{t-1} \cdot (1 + r^l_{t-1} - a) + d^f_t \cdot (1 + g_t) - d^f_{t-1} \cdot (1 + r^d_{t-1} - a) + ws_t \cdot \left(\frac{u_t}{v}\right) \cdot (1 - c_1)}{1 + g_t} \tag{19}$$

Proposition 3. *In the long-run, debt-led demand ($a > g_1 \cdot b_1 \cdot (1 + r^p_{t-1} + \eta)$), low interest rates and mark-ups on interest rates (r^p, η, μ), and larger stocks of deposits make an expansionary reaction to a rate hike more likely.*

The partial derivative of utilization with respect to the policy rate can be decomposed into consumption and liquidity effects.

$$\frac{\partial u^{**}}{\partial r^p} = \psi_1 \cdot v \cdot \left[\overbrace{a \cdot \frac{\partial d^{h*}}{\partial r^p_{t-1}}}^{\text{consumption effect } (+)} \underbrace{- \overbrace{\frac{\partial l^*}{\partial r^p_{t-1}} \cdot (g_1 b_1)(1 + r^p_{t-1} + \eta) - g_1 b_1 l_{t-1}}^{\text{leverage effects (-)}} + \overbrace{\frac{\partial d^{f*}}{\partial r^p_{t-1}} \cdot (g_1 b_2)(1 + r^p_{t-1} - \mu) + g_1 b_2 d^f_{t-1}}^{\text{deposit effects } (+)}}_{\text{liquidity effects}} \right]$$

As in other stock–flow consistent models, a rate hike redistributes income to households through higher interest receipts and bank profits (transferred to households), raising household wealth and stimulating consumption via the multiplier (ψ_1), which we call the *consumption effect* (Zezza and Dos Santos, 2004; Le Heron and Mouakil, 2008). These consumption effects could however be outweighed by valuation effects and capital losses, following a rate hike, which would effect consumption in the opposite direction. We do not include these effects for simplicity.

The *liquidity effect* operates through loans, deposits, and related cash flows. In line with empirical evidence, larger aggregate leverage and interest on loans intensifies the contractionary effects of monetary policy (Holm-Hadulla and Thürwächter, 2024; Grob and Züllig, 2024). Following section 3.3.1 and 3.1.2, NFC deposits (d^f_{t-1}), their accumulation ($\frac{\partial d^{f*}}{\partial r^p_{t-1}}$), and interest receipts cushion

[18] Flows are normalized by the stock of capital in the previous period and stock are normalized by contemporary values of the capital stock (Dos Santos and Zezza, 2008).

the contractionary impact of rate hikes by providing internal finance for investment (Jeenas, 2018; Sharpe and Suarez, 2021; Ahn, 2024). Debt-financed deposit accumulation, higher leverage, and negative carry from larger spreads spreads between loans and deposits can partially offset these gains as they also simultaneously decrease liquidity and retained earnings. Reflecting literature on financial heterogeneities, the intensity of of one unit rate hike on demand is conditional on the prevailing state of leverage, deposit hoards, and interest rates at the time of the rate hike.

If a rate hike has no effect on deposit accumulation ($\frac{\partial d^f_{t-1}}{\partial r^p_{t-1}} = 0$ and $d^f_{t-1} = 0$), the liquidity effect always reduces demand unless firms deleveraged, as no positive terms exist. Including deposits allows firms to buffer monetary tightening independently of consumption or deleveraging.

Using a canonical capital accumulation function ($g_t = g_0 + g_1 \cdot r_t - g_2 r^l_{t-1} - g_3 \cdot l_{t-1}$), the reaction of demand to a rate hike is $\frac{a \cdot \frac{\partial d^h_{t-1}}{\partial r^p_{t-1}} - g_2 - g_3 \cdot \frac{\partial l_{t-1}}{\partial r^p_{t-1}}}{1 - ws \cdot (c_1 - g_1) - g_1}$, which does not account for the principle of increasing risk tied to the pre-shock leverage stock. Even adding a deposit term only captures the effect of the rate of change of deposits, not the role of the stock/hoard as an alternative source of finance (Sharpe and Suarez, 2021), nor does it account for interest payment and receipt effects unless stocks and interest rates are explicitly interacted. Deposits thus affect not only the magnitude but also the direction of demand's response to a rate hike.

5.3 Model Stability

Stock-flow consistent growth models are unlikely to be globally stable for two reasons; non-nonlinearities and the positive traces produced by state variables which are typically stocks [19]. The stability section of the SA examines the stability of the model under four exclusive and exhaustive states, assuming a constant bank net-worth, no interest rate spreads ($r^p = r^l = r^d$), and a unitary capital-output ratio ($v = 1$)

	Precautionary ($d_1 < 0$)	Non-precautionary ($d_1 > 0$)
Debt-led $\left(\frac{\partial u^*}{\partial d^h_{t-1}} > 0\right)$	State 1: Stable	State 2: Numerically Stable
Debt-burdened $\left(\frac{\partial u^*}{\partial d^h_{t-1}} < 0\right)$	State 3: Conditionally Stable	State 4: Conditionally Stable

Note: (1) Stable: Solutions are stable if we exclude economically implausible values. (2) Numerically Stable: Unstable for sufficiently extreme values but stable in simulations that use a realistic subset of parameters. (3) Conditionally stable: Stable only if we impose additional assumptions.

[19] See Lemma 2 in the SA

Proposition 4. *Debt-led demand produces a stable model for realistic parameter choices. If the model is debt-burdened, assuming that* $\frac{\partial d^{h*}}{\partial d^h_{t-1}} < 1$*, the following conditions are sufficient for stability;*

1. *State 3:* $d_1 < \dfrac{\lambda \cdot ws \cdot \frac{\partial u^*}{\partial d^h_{t-1}}}{1 - d_1 \cdot \frac{(1-ws)}{r^p+\sigma} \cdot \frac{\partial u^*}{\partial d^h_{t-1}}}$ *and* $g^* < \dfrac{Z \cdot [(1 - ws \cdot c_1)]}{ws \cdot (1 - c_1)}$
2. *State 4:* $g^* > \dfrac{Z \cdot [(1 - ws \cdot c_1)]}{ws \cdot (1 - c_1)}$

While counter-intuitive, debt-led demand demonstrates stable properties because the borrowing undertaken by firms refluxes back as profits through consumption, thereby facilitating the convergence of firm leverage through avoiding debt explosions. In state one and two, the ceiling growth rate is so large it is irrelevant. Rate hikes increase this already large ceiling, since the subsequent interest payments further increase spending and demand. Figure B.4 in the SA, demonstrates that debt-led demand moderates the magnitude of the feedback loop between contemporaneous household deposits and its lag, keeping $\frac{\partial d^{h*}}{\partial d^h_{t-1}} < 1$ (see proposition 1 in SA).

Under debt-burdened growth, firm borrowing need not raise demand or profits, creating the risk of escalating leverage—particularly at higher interest rates, where rising debt service can induce further borrowing. We can see in figure B.4 in the SA that under debt-burdened growth, $\frac{\partial d^{h*}}{\partial d^h_{t-1}}$ sometimes exceeds one, thus resulting in a larger trace which could induce instability (see lemma 2 and proposition 1 in SA). Especially when coupled with precautionary accumulation of deposits, there could be a feedback loop between firm loans and firm deposits as suggested in equation (15). Thus under the case of precautionary accumulation there is a floor on how negative the intensity of precautionary accumulation is. A larger interest rate makes the violation of the assumption $\frac{\partial d^{h*}}{\partial d^h_{t-1}} < 1$ more likely, creating instability in both state three and four. This simply reflects how larger interest rates allow household deposits and firm to grow faster due to capitalization of interest flows. In state three, larger interest rates impose a tighter floor on the sensitivity of deposits to excess leverage (d_1), reflecting how it accelerates the feedback loop between firm deposits and leverage. In the fourth state, larger interest rates impose a larger floor for growth.

5.4 Numerical Simulations

In the numerical simulation we shock the economy by increasing the policy rate from 4 to 6 percent - in the 20^{th} period. In our simulation, we allow the banking sector to have a non-zero net-worth. This change is reflected in a change of accounting equations which is shown in appendix C.1. Allowing banks to have a net-worth would add robustness to our results since we can remove unrealistic consumption effects from bank profits. In addition, we introduce a realistic demand leakage into our model - since bank profits and wealth are not used for consumption.

5.4.1 Summary of Results

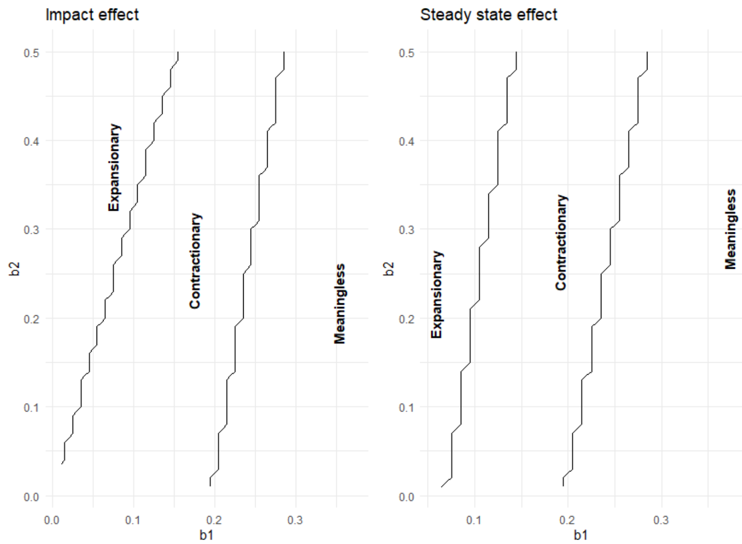
In the presence of NFC deposits, we find that rate hikes may fail to suppress demand in the short period. The left panel of figure 6 is the counterpart to figures 3 and 4. The simulation reflects the short-run cushioning effect of rate hikes on investment, shown by the impulse response functions in section 3. The right panel of figure 6 depicts a representative run where a rate hike fail to contract demand in the short-run. In the case where deposits were not taken into account (red), GDP contracted at impact. This impact and short-period contraction disappears when firm deposits are included in the model.

Since b_1 and b_2 are unobserved, numeric results are evaluated with respect to a range of values. See figure 5 for the combinations of b_1 and b_2 that render rate hikes non-contractionary in the short and long-period. The main scenario we analyze assumes that firms engage in precautionary accumulation, i.e. increase deposit accumulation when they feel over-leveraged. We also run sweep checks which present the results under different propensities to consume from wealth, different sizes of deposit hoards, and different reactions of deposit accumulation to excess leverage.

The stability of the model with respect to three important parameters (b_1, b_2, d_1) is examined by the 3D graph in the supplemental appendix, where we provide 2 different angles. We see that precautionary accumulation beyond some point always renders the system unstable and/or economically meaningless irrespective of the values taken by b_1 and b_2. For several values of d_1 which provide weaker precautionary accumulation or deposit liquidation all examined combinations of b_1 and b_2 produce stable results. As precautionary accumulation of deposits becomes stronger, larger values of b_1 create instability.

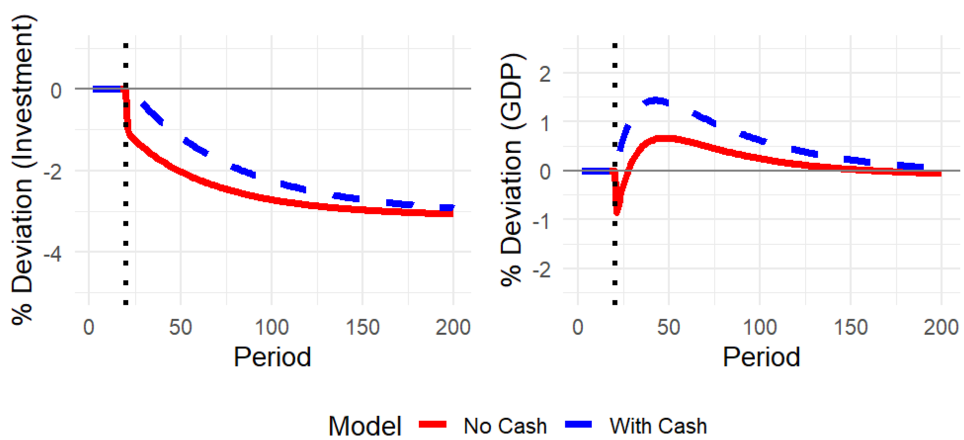
5.4.2 Economic Mechanisms

Allowing NFC deposits, figure 6 shows that the utilization rate increased in response to the rate hike, peaked, and slowly declined to the baseline. This suggests that the rate hike was unable to achieve its intended outcome of suppressing demand in the short-period. An evident force that stimulated demand was a consumption effect driven by a rise in household deposits on account of additional interest receipts (see figure 7). Under more realistic assumptions that include capital



Note. The x-axis (b_1) captures the loan-illiquidity effect and the y-axis (b_2) the deposit-liquidity effect on capital accumulation. The left panel shows the impact response to a rate hike; the right shows the long-run response. Parameter combinations fall into expansionary, contractionary, or non-viable/unstable regions.

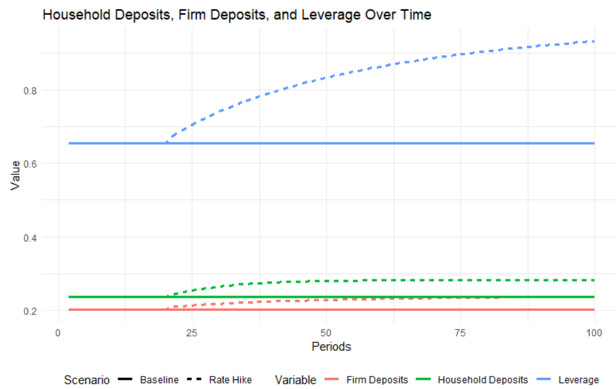
Figure 5: Combinations of b_1 and b_2 and reactions of demand to rate hikes



Note. The x-axis denotes time. The y-axis plots deviation of capital stock (left) and demand (right) relative to the baseline. The policy rate is exogenously shocked from 4% to 6% in period 20. The blue dotted line denotes reaction with NFC deposits and the red solid one shows the reaction without NFC deposits.

Figure 6: Reaction of demand and growth to rate hike

losses following a rate hike, the rise in consumption from increased interest income would be offset. However, because these mechanisms are not central to the argument of this paper we omit them for simplicity. Meanwhile, as explained in propositions 1 to 3, the existence of firm deposit hoards cushions the decline in investment due to its cushioning effect on hurdle rates.



Note. The x-axis shows time, and the y-axis plots firm leverage and household and firm deposits (normalized by capital). Solid lines depict the baseline; dotted lines show the rate-hike scenario. The policy rate increases from 4% to 6% in period 20.

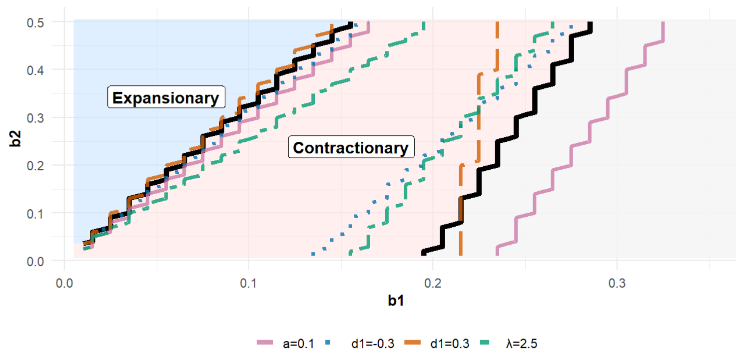
Figure 7: Reaction of stocks to rate hike

Firm deposit accumulation is driven by both the transactions motive and the precautions motive. The rise in capacity utilization meant the wage bill rose, which in turn stimulated transactionary accumulation of deposits. The rise in the interest rate also meant a contraction of the target leverage which stimulated precautionary accumulation of deposits. Over time, the rise in firm leverage due to a rise in debt service and the accumulation of deposits discouraged capital accumulation and thus exerted a downward pressure on the utilization rate (see figure 7)[20]. Note that the rate of change of deposit accumulation approached zero before the rate of change of leverage, thus also exerting a downward pressure on the utilization rate over time. However, the existence of deposits contributed to allowing consumption to rise more than investment fell - thus resulting in a rise in the utilization rate. Thus we can conclude that under these assumptions, a rate hike not only failed to suppress demand but it also sabotaged economic growth - both in the short and long-period. While the empirical realism of an expansion of leverage during a rate hike is questionable, it is plausible especially if the rate hike results in capitalization of interest payments and if it stimulates precautionary accumulation of deposits. Holm-Hadulla and Thürwächter (2024) also finds that aggregate leverage rises with rate hikes. Other things constant, results are not conditional on rising leverage, a decrease in leverage would actually encourage investment further by reducing the hurdle rate, adding further strength to the argument. We also show in the following section that results hold even when firms choose to use deposits to repay debt.

[20]If firms were to use these deposits at some point, instead of just accumulating, this would create yet another mean reverting force. The use and fall in deposits would increase the hurdle rate closer to a no-deposits case.

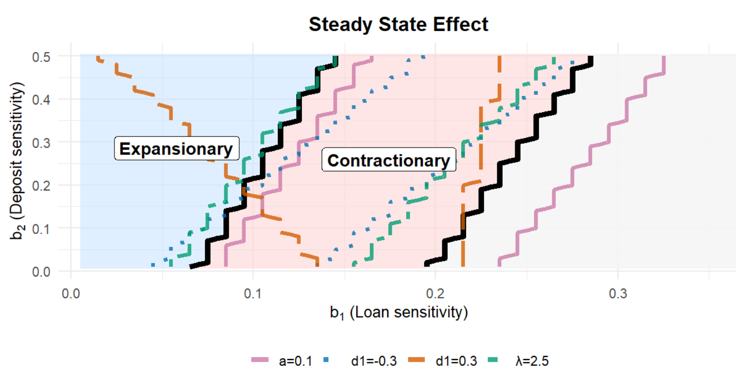
5.5 Additional Simulations

In figures 8 and 9, we examine how changing the propensity to consume (a), size of cash hoards (λ), and the pace and direction of deposit accumulation (d_1) effect the likelihood of monetary tightening being non-contractionary.



Note. The x-axis (b_1) captures the loan-illiquidity effect and the y-axis (b_2) the deposit-liquidity effect on capital accumulation through the hurdle rate. The figure shows the impact response to a rate hike, partitioning the (b_1, b_2) space into expansionary, contractionary, and economically non-viable/unstable regions. Scenario variations shift these boundaries.

Figure 8: Impact effect of rate hike under different scenarios



*Note.*The x-axis (b_1) reflects the loan-illiquidity effect and the y-axis (b_2) the deposit-liquidity effect on capital accumulation. The figure depicts steady-state responses to a rate hike, with regions indicating expansionary, contractionary, or non-viable/unstable outcomes. Scenario changes alter these boundaries.

Figure 9: Steady state effect of rate hikes under different scenarios

As expected, a higher propensity to consume from wealth increases the number of combinations of b_1 and b_2 which produce a non-contractionary outcome. This is clear from the rightward shift of the pink solid curve in figures 8 and 9. Larger disposable incomes from increased interest receipts by households increase the profit rate and thus investment, by enough to offset the effects of a higher interest rate. Larger deposit hoards do the same. The existence of larger liquid asset stocks insulate hurdle rates from rising interest rates as liquid assets serve as an alternate source of finance. Smaller deposit hoards have symmetric effects. In the short-run, rapid (precautionary) deposit accumulation also increases the number of combinations of b_1 and b_2 which produce a non-contractionary outcome while liquidating deposits do the opposite. This is because the resulting larger stock of deposits from precautionary accumulation decrease the hurdle rate in future periods. In the long-run, changing the nature of deposit accumulation completely changes the nature of the expansionary/contractionary boundaries. This is because larger values of b_2 in the presence of small stocks of deposits would result in a higher hurdle rate which eventually results in large hurdle rates that discourage investment. The liquidation of deposits also decreases leverage which suppresses hurdle rates even with larger b_1s. These results show that monetary policy transmission is shaped not only by factors within the firm sector but also the behavior of other sectors and aggregate dynamics.

6 Conclusions

This paper highlights the role of firm cash holdings in monetary policy transmission, contributing to the literature on financial heterogeneity in monetary transmission (Ottonello and Winberry, 2020; Cloyne et al., 2023; Jeenas, 2023). In the context of rising corporate financial accumulation, corporate cash holdings mitigate the contractionary effects of rate hikes (Almeida et al., 2004; Acharya et al., 2007; Yang et al., 2017; Bräuning et al., 2023; Jeenas, 2023).

Using firm-level data and local projections, the analysis shows that liquidity cushions the effects of monetary tightening. The paper extends the estimations of Jeenas (2023) to the post-COVID period. We find evidence that firm cash ratios dampen the response of firm-level investment to a monetary policy surprise. However, as pointed out by the literature, the endogenity created by the interaction of identified monetary policy surprises with raw firm level cash ratios hinder causal inference (Jeenas, 2018; Ottonello and Winberry, 2020; Cloyne et al., 2023). This results in the literature attempting to convince readers controlling for competing heterogeneities directly or through firm grouping. This paper advances that discussion through the creation of a instrument, using the granular instrument variable approach, to identify exogenous changes in aggregate NFC cash ratios (Gabaix and Koijen, 2024). The instrument isolates the contribution of idiosyncratic changes to the cash ratio of large firms to the aggregate NFC cash ratio. Not only does this approach allow causal inference but confirms the macroeconomic relevance of NFC cash ratios as a dampening force. Unlike the case of leverage, in the case of cash holdings general equilibrium and network effects do not alter the relationship between cash holdings and investment at the aggregate level following a monetary policy surprise (Grob and Züllig, 2024). These results confirm the intuition that liquidity mitigates tightening by enabling firms to sustain investment through internal resources and by increasing interest income that partially offsets rising debt-service costs Sharpe and Suarez (2021); Ahn (2024); Lu et al. (2024).

Building on these findings, the paper develops a stock–flow consistent growth model of monetary policy transmission, allowing NFCs to accumulate bank deposits. The model reflects the empirical results through two empirically grounded mechanisms without relying on assumptions like infrequent debt issuance, transaction costs, cash-driven financing constraints, or assumptions about the change in the price of capital—thereby complementing Jeenas (2023), who demonstrates similar effects in a heterogeneous-agent model with such financial frictions. The results are driven by two key observations, cash-rich firms face lower hurdle rates (Graham, 2022), and interest income expands disposable income and internal funds (Tauheed and Wray, 2006; Ahn, 2024). In contrast to existing models (Zezza and Dos Santos, 2004; Le Heron and Mouakil, 2008), the framework captures the impact mitigation effects of liquid assets during rate hikes by extending Taylor and O'Connell (1985)'s capital accumulation function to be conditional on NFC deposits and by introducing an explicit deposit accumulation function.

The key policy insight is that monetary transmission is more effective when firms hold low cash reserves, precautionary motives are weak, and household consumption propensities are limited. Conversely, high corporate liquidity can neutralize or even reverse contractionary effects, particularly when combined with rising interest income or rapid deposit accumulation. Finally, a skewed distribution of wealth (liquidity) in favor of producing sectors over spending sectors is likely to further dampen transmission. As a result, rate hikes may fail to constrain demand in both the short and long run while simultaneously depressing long-term growth. These findings challenge conventional views on the reliability of interest rate adjustments as a stabilization tool and underscore the importance of incorporating non-financial corporate financial assets into macroeconomic mechanisms.

References

Acharya, V. V., H. Almeida, and M. Campello (2007). Is cash negative debt? a hedging perspective on corporate financial policies. *Journal of financial intermediation 16*(4), 515–554.

Ahn, J. (2024, 11). The Role of Corporate Cash Holdings in the Transmission of Monetary Policy Tightening. *IMF Working Papers 2024*(245), 1.

Almeida, H., M. Campello, and M. S. Weisbach (2004). The cash flow sensitivity of cash. *The journal of finance 59*(4), 1777–1804.

Bai, J. and S. Ng (2002). Determining the number of factors in approximate factor models. *Econometrica 70*(1), 191–221.

Barrett, M. P. and J. Platzer (2024). *Has the Transmission of US Monetary Policy Changed Since 2022?* International Monetary Fund.

Bauer, M. D., B. S. Bernanke, and E. Milstein (2023). Risk appetite and the risk-taking channel of monetary policy. *Journal of Economic Perspectives 37*(1), 77–100.

Bauer, M. D. and E. T. Swanson (2023). A reassessment of monetary policy surprises and high-frequency identification. *NBER Macroeconomics Annual 37*(1), 87–155.

Bernanke, B. S. and M. Gertler (1995). Inside the black box: the credit channel of monetary policy transmission. *Journal of Economic perspectives 9*(4), 27–48.

Borio, C. and H. Zhu (2012). Capital regulation, risk-taking and monetary policy: a missing link in the transmission mechanism? *Journal of Financial stability 8*(4), 236–251.

Boyarchenko, N. and L. Elias (2024). Corporate debt structure over the global credit cycle. Technical Report 1139, FRB of New York Staff Report.

Bräuning, F., J. L. Fillat, and G. Joaquim (2023). Firms' cash holdings and monetary policy transmission. Technical Report 97115, Federal Reserve Bank of Boston.

Caverzasi, E. and A. Godin (2015). financialization and the sub-prime crisis: a stock-flow consistent model. *European Journal of Economics and Economic Policies 12*(1), 73–92.

Charles, S. (2008). Corporate debt, variable retention rate and the appearance of financial fragility. *Cambridge Journal of Economics 32*(5), 781–795.

Clévenot, M., Y. Guy, and J. Mazier (2010). Investment and the rate of profit in a financial context: the french case. *International Review of Applied Economics 24*(6), 693–714.

Cloyne, J., C. Ferreira, M. Froemel, and P. Surico (2023). Monetary policy, corporate finance, and investment. *Journal of the European Economic Association 21*(6), 2586–2634.

Dallery, T. (2009). Post-keynesian theories of the firm under financialization. *Review of Radical Political Economics 41*(4), 492–515.

Darmouni, O. and L. Mota (2024). The savings of corporate giants. *The Review of Financial Studies 37*(10), 3024–3049.

Davis, L. E. (2017). Financialization and investment: A survey of the empirical literature. *Journal of Economic Surveys 31*(5), 1332–1358.

Davis, L. E. (2018). Financialization and the non-financial corporation: An investigation of firm-level investment behavior in the united states. *Metroeconomica 69*(1), 270–307.

Disyatat, P. (2011). The bank lending channel revisited. *Journal of Money, Credit and Banking 43*(4), 711–734.

Dögüs, I. (2018). A minskyan critique of the financial constraint approach to financialization. *Review of Keynesian Economics 6*(2), 202–220.

Dos Santos, C. H. and G. Zezza (2008). A simplified, 'benchmark', stock-flow consistent post-keynesian growth model. *Metroeconomica 59*(3), 441–478.

Duwicquet, V. and J. Mazier (2010). Financial integration and macroeconomic adjustments in a monetary union. *Journal of Post Keynesian Economics 33*(2), 333–370.

Fazzari, S., R. G. Hubbard, and B. C. Petersen (1987). Financing constraints and corporate investment. Technical report, National Bureau of Economic Research Cambridge, Mass., USA.

Ferrando, A., S. Lamboglia, and E. Offner (2025). Monetary policy transmission to investment: Evidence from a survey on enterprise finance. Technical report, European Central Bank.

Gabaix, X. and R. S. Koijen (2024). Granular instrumental variables. *Journal of Political Economy 132*(7), 2274–2303.

Gandolfo, G. (1997). *Economic Dynamics: Study Edition*. Economic Dynamics. Springer.

Gao, X., T. M. Whited, and N. Zhang (2021). Corporate money demand. *The Review of Financial Studies 34*(4), 1834–1866.

Gertler, M. and S. Gilchrist (1994). Monetary policy, business cycles, and the behavior of small manufacturing firms. *The quarterly journal of economics 109*(2), 309–340.

Godley, W. and M. Lavoie (2016). *Monetary Economics: An Integrated Approach to Credit, Money, Income, Production and Wealth*. Palgrave Macmillan UK.

Graham, J. R. (2022). Presidential address: Corporate finance and reality. *The Journal of Finance 77*(4), 1975–2049.

Grob, V. and G. Züllig (2024). Corporate leverage and the effects of monetary policy on investment: a reconciliation of micro and macro elasticities. Technical report, Swiss National Bank Working Paper.

Guney, Y., A. Ozkan, and N. Ozkan (2007). International evidence on the non-linear impact of leverage on corporate cash holdings. *Journal of Multinational financial management 17*(1), 45–60.

Han, H. and X. Wang (2023). Monetary policy uncertainty and corporate cash holdings: Evidence from china. *Journal of Financial Stability 67*, 101138.

Hein, E. (2012). *The Macroeconomics of Finance-Dominated Capitalism – and its Crisis*. Cheltenham, UK: Edward Elgar Publishing.

Hein, E. (2014). *Distribution and Growth After Keynes: A Post-Keynesian Guide*. Edward Elgar.

Holm-Hadulla, F. and C. Thürwächter (2024). Granular shocks to corporate leverage and the macroeconomic transmission of monetary policy. Technical report, European Central Bank.

Jeenas, P. (2018). Monetary policy shocks, financial structure, and firm activity: A panel approach.

Jeenas, P. (2023). Firm balance sheet liquidity, monetary policy shocks, and investment dynamics. Technical report, Universitat Pompeu Fabra, Department of Economics and Business.

Jordà, Ò. (2005). Estimation and inference of impulse responses by local projections. *American economic review 95*(1), 161–182.

Jordà, Ò. and A. M. Taylor (2025). Local projections. *Journal of Economic Literature 63*(1), 59–110.

Joseph, A., C. Kneer, and N. Van Horen (2026). All you need is cash: Corporate cash holdings and investment after the global financial crisis. *Review of Finance NA*(NA), rfag005.

Kalecki, M. (1937). The principle of increasing risk. *Economica 4*(16), 440–447.

Kalemli-Özcan, Ş., L. Laeven, and D. Moreno (2022). Debt overhang, rollover risk, and corporate investment: Evidence from the european crisis. *Journal of the European Economic Association 20*(6), 2353–2395.

Keynes, J. (1936). *The General Theory of Employment, Interest and Money.* Papermac (London, England). Macmillan.

Konczal, M. and N. Lusiani (2022). *Prices, profits, and power: an analysis of 2021 firm-level markups.* Roosevelt Institute New York.

Kuttner, K. N. and P. C. Mosser (2002). The monetary transmission mechanism: some answers and further questions. *Economic Policy Review 8*(1), n/a.

Le Heron, E. and T. Mouakil (2008). A post-keynesian stock-flow consistent model for dynamic analysis of monetary policy shock on banking behaviour. *Metroeconomica 59*(3), 405–440.

Lu, C.-L., H.-C. Chen, R. K. Chou, and C.-Y. Lin (2024). Debt capacity, cash holdings and financial constraints. *Journal of Business Finance & Accounting 51*(7-8), 2020–2054.

Lu, S. (2025). Household debt, financial balance, and macroeconomic stability: An empirical stock-flow consistent model of the uk economy. *Review of Income and Wealth 71*(1), e12725.

Luetticke, R. (2021). Transmission of monetary policy with heterogeneity in household portfolios. *American Economic Journal: Macroeconomics 13*(2), 1–25.

Mazier, J. (2020). *Global Imbalances and Financial Capitalism.* Routledge.

Meier, I. and V. Tarhan (2007). Corporate investment decision practices and the hurdle rate premium puzzle.

Michell, J. (2014, November). A Steindlian account of the distribution of corporate profits and leverage: A stock-flow consistent macroeconomic model with agent-based microfoundations. Working Papers PKWP1412, Post Keynesian Economics Society (PKES).

Miess, M. G. and S. Schmelzer (2015). A stock-flow consistent model of financialization and shadow banking: Financial fragility in a modern capitalist economy. Technical report, FMM Conference 2015,.

Minsky, H. P. (2008). *Stabilizing an unstable economy.* McGraw-Hill New York.

Myers, S. C. and N. S. Majluf (1984). Corporate financing and investment decisions when firms have information that investors do not have. *Journal of financial economics 13*(2), 187–221.

Nikiforos, M., S. Grothe, and J. D. Weber (2024). Markups, profit shares, and cost-push-profit-led inflation. *Industrial and Corporate Change 33*(2), 342–362.

Nikiforos, M. and G. Zezza (2018). Stock-flow consistent macroeconomic models: A survey. *Analytical Political Economy 0*, 63–102.

Nishi, H. (2012). A dynamic analysis of debt-led and debt-burdened growth regimes with minskian financial structure. *Metroeconomica 63*(4), 634–660.

Ottonello, P. and T. Winberry (2020). Financial heterogeneity and the investment channel of monetary policy. *Econometrica 88*(6), 2473–2502.

Papadimitriou, D. B. and L. R. Wray (2024). Still flying blind after all these years: The federal reserve's continuing experiments with unobservables. *Society and Economy 46*(3), 219–235.

Rabinovich, J. (2019). The financialization of the non-financial corporation. a critique to the financial turn of accumulation hypothesis. *Metroeconomica 70*(4), 738–775.

Ren, Z. (2025). Real effects of bernanke–kuttner: The risk channel of monetary policy on corporate investment.

Schasfoort, J., A. Godin, D. Bezemer, A. Caiani, and S. Kinsella (2017). Monetary policy transmission in a macroeconomic agent-based model. *Advances in Complex Systems 20*(08), 1850003.

Sharpe, S. A. and G. A. Suarez (2021). Why isn't business investment more sensitive to interest rates? evidence from surveys. *Management Science 67*(2), 720–741.

Singer, E. and J. Yang (2025, August 22). Corporate cash accumulation during the covid-19 pandemic. Technical report, Board of Governors of the Federal Reserve System, Washington.

Skott, P. and S. Ryoo (2008). Macroeconomic implications of financialisation. *Cambridge Journal of Economics 32*(6), 827–862.

Stockhammer, E. (2004). financialization and the slowdown of accumulation. *Cambridge Journal of Economics 28*(5), 719–741.

Tauheed, L. and L. R. Wray (2006). System dynamics of interest rate effects on aggregate demand. In *Money, Financial Instability, and Stabilization Policy*, pp. 37–57. Edward Elgar Publishing Cheltenham, UK and Northampton, MA.

Tawiah, B., O. Keefe, et al. (2024). Cash holdings and corporate investment: Evidence from covid-19. *Review of Corporate Finance 4*(3-4), 10–1561.

Taylor, L. and S. A. O'Connell (1985). A minsky crisis. *The Quarterly Journal of Economics 100*(Supplement), 871–885.

Watanabe, T. (2020). Financial instability and effects of monetary policy. *Bulletin of Political Economy 14*(1), 117–145.

Watanabe, T. (2023). Financial dynamics in the medium run. *Metroeconomica 74*(3), 632–656.

Weber, I. M. and E. Wasner (2023). Sellers' inflation, profits and conflict: why can large firms hike prices in an emergency? *Review of Keynesian Economics 11*(2), 183–213.

Wildauer, R., K. Kohler, A. Aboobaker, and A. Guschanski (2023). Energy price shocks, conflict inflation, and income distribution in a three-sector model. *Energy Economics 127*, 106982.

Yang, X., L. Han, W. Li, X. Yin, and L. Tian (2017). Monetary policy, cash holding and corporate investment: Evidence from china. *China Economic Review 46*, 110–122.

Zezza, G. and C. H. Dos Santos (2004). The role of monetary policy in post-keynesian stock-flow consistent macroeconomic growth models. In *Central banking in the modern world: alternative perspectives*, Volume 183. Edward Elgar Cheltenham.

A Empirical Appendix

A.1 Data Appendix

A.1.1 Macroeconomic Data

Quarterly macroeconomic data are obtained from publicly available sources:

- **Federal Funds Rate (FEDFUNDS):** Federal Reserve Economic Data (FRED), series ID `FEDFUNDS`. The monthly observation is averaged to quarterly frequency.
- **Real GDP (GDPC1):** FRED series `GDPC1`, expressed in chained 2017 dollars. Quarterly growth rates are computed as $100 \times (GDP_t/GDP_{t-1} - 1)$.
- **Consumer Price Index (CPIAUCSL):** FRED series `CPIAUCSL`. Inflation is computed as the quarterly rate of change in the price index.
- **U.S. Recession Indicator (USREC):** FRED series `USREC`. The quarterly dummy, R_t, equals 1 if any month within the quarter is classified as recessionary.
- **Monetary Policy Surprises:** High-frequency (monthly) monetary policy surprises from the dataset of Bauer and Swanson (2023) are aggregated to quarterly sums:

$$MPS_t = \sum_{m \in Q_t} MPS_m, \qquad MPS_t^{\perp} = \sum_{m \in Q_t} MPS_m^{\perp}.$$

- **Gross Value Added Deflator:** Downloaded via BEA's NIPA Table T10304 (Nonfarm Business Sector). Quarterly deflators are computed as $P_t^{GVA} = \text{DataValue}_t/100$.
- **Non-residential Fixed Investment (PNFI):** FRED series `PNFI`, nominal private nonresidential fixed investment.
- **Implicit Price Deflator for PNFI:** FRED series `A008RD3Q086SBEA`, used to deflate nominal investment.
- **NFC Currency and Deposits:** FRED series `NCBCDTQ027S`, nonfinancial corporate business; total currency and deposits (asset side).
- **NFC Total Assets:** FRED series `TABSNNCB`, total assets of the nonfinancial corporate business sector.

All macroeconomic series are merged on a common quarterly index $t = 1989Q1–2025Q4$.

A.1.2 Firm-Level Micro Data

Firm-level data are retrieved from the *Compustat Quarterly Fundamentals* file (via the Wharton Research Data Services (WRDS) PostgreSQL interface). The raw extract includes identifiers and key flow and stock variables (`atq`, `cheq`, `dlttq`, `dlcq`, `nopiq`, `ppentq`, `ppegtq`, `saleq`, `oibdpq`, etc.), joined with industry classification from `comp.co_industry`.

A.1.3 Sample Criteria

The following filters are applied to ensure data consistency and economic relevance:

1. Exclude financial (SIC 6000–6999) and utility (SIC 4900–4999) firms.
2. Exclude WRDS special codes (`sich = 9995, 9997`).
3. Keep only U.S.-domiciled firms (`fic = 'USA'`).
4. Restrict to consolidated industrial format records (`consol='C', indfmt='INDL', popsrc='D'`).
5. Remove firms with fewer than 40 quarterly observations.
6. Drop non-positive total assets (`atq`) or negative plant, property, equipment (`ppentq`).
7. Exclude observations before the first nonmissing gross capital stock (`ppegtq`).

After cleaning, the data are expanded to a balanced panel across the full sample horizon by merging each firm's timeline with the universe of quarterly dates, ensuring explicit missingness for quarters without firm reports.

A.1.4 Construction of Key Firm Variables

Capital Stock and Investment. Capital dynamics are reconstructed using the accounting identity:

$$K_{it} = K_{i0} + \sum_{\tau \le t} \Delta PPE_{i\tau}, \quad \Delta PPE_{i\tau} = PPE^{\text{net}}_{i\tau} - PPE^{\text{net}}_{i,\tau-1},$$

where PPE^{net} (`ppentq`) is linearly interpolated within one-quarter gaps. The initial value K_{i0} is the earliest nonmissing observation of `ppegtq`. Real capital and real investment are obtained by deflating nominal series with the BEA gross value added deflator:

$$K_{it}^{\text{real}} = \frac{K_{it}}{P_t^{GVA}}, \quad I_{it}^{\text{real}} = K_{i,t+1}^{\text{real}} - K_{it}^{\text{real}}.$$

Balance Sheet Ratios. Liquidity and leverage are constructed as:

$$\text{liq}_{it} = \frac{\texttt{cheq}_{it}}{\texttt{atq}_{it}}, \quad \text{lev}_{it} = \frac{\texttt{dlttq}_{it} + \texttt{dlcq}_{it}}{\texttt{atq}_{it}}.$$

Outliers in leverage (`lev < 0 or > 10`) and liquidity (`cheq > atq`) are removed. Sales growth is defined as $(\texttt{saleq}_t/\texttt{saleq}_{t-1}) - 1$ when denominator is positive.

A.1.5 Winsorization and Data Treatment

To mitigate the influence of outliers, continuous variables are winsorized at the 1st and 99th percentiles within firm using:

$$x_{it}^{\text{win}} = \begin{cases} q_{0.01}(x_i) & \text{if } x_{it} < q_{0.01}(x_i), \\ q_{0.99}(x_i) & \text{if } x_{it} > q_{0.99}(x_i), \\ x_{it} & \text{otherwise.} \end{cases}$$

Winsorized variables include total assets (deflated), leverage, liquidity ratios, log capital, investment rates, and sales growth.

A.1.6 Industry Classification

Industry affiliation follows the four-digit SIC code in Compustat. A major industry indicator (`maj_ind`) is assigned by the first two digits of SIC:

Code	SIC range	Industry description
1	0–9	Agriculture, forestry, fishing
2	10–14	Mining and quarrying
3	15–17	Construction
4	20–39	Manufacturing
5	40–49	Transportation, utilities (non-financial)
6	50–51	Wholesale trade
7	52–59	Retail trade
8	70–89	Services

Firm-industry codes are forward-filled, if NA.

A.2 Granular Instrument Appendix

For the GIV, the same Compustat data is used. Entries with negative cash and cash equivalents (cheq <0) and total assets (atq) are excluded. The top 0.5% of both variables are windsorized. The liquidity ratio is computed as $\frac{cheq_{i,t}}{atq_{i,t}}$. Top and bottom 1% of this ratio are windsorized. Only firms (gvkey) with more than 70% non missing coverage of the liquidity ratio are retained to create the instrument.

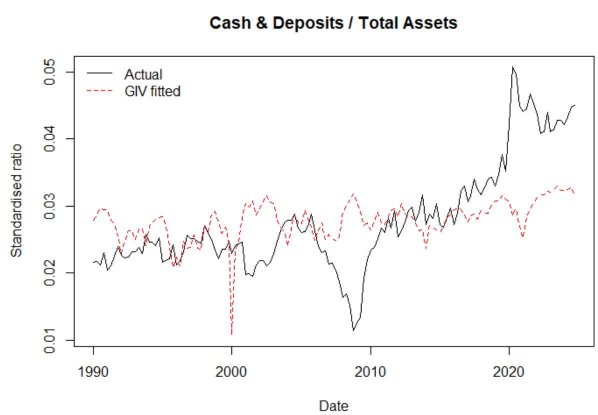
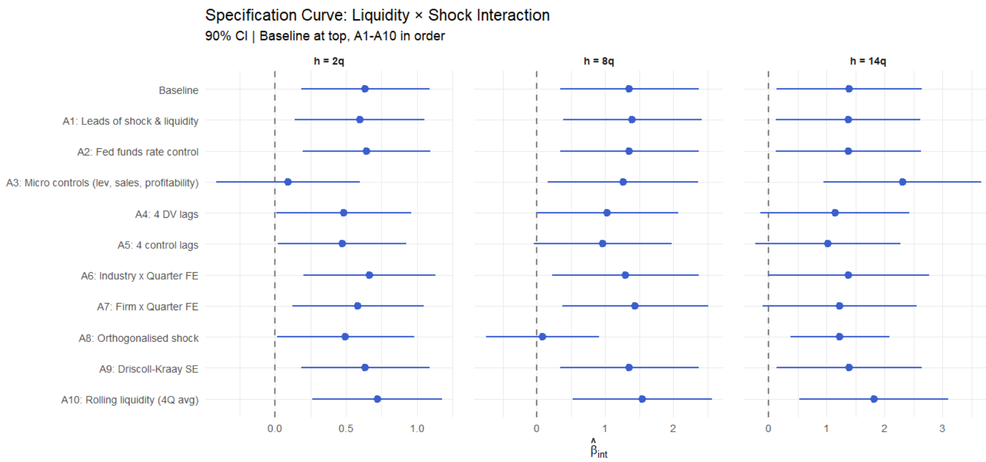


Figure 10: Fitted versus actual aggregate cash ratio

A.3 Robustness checks

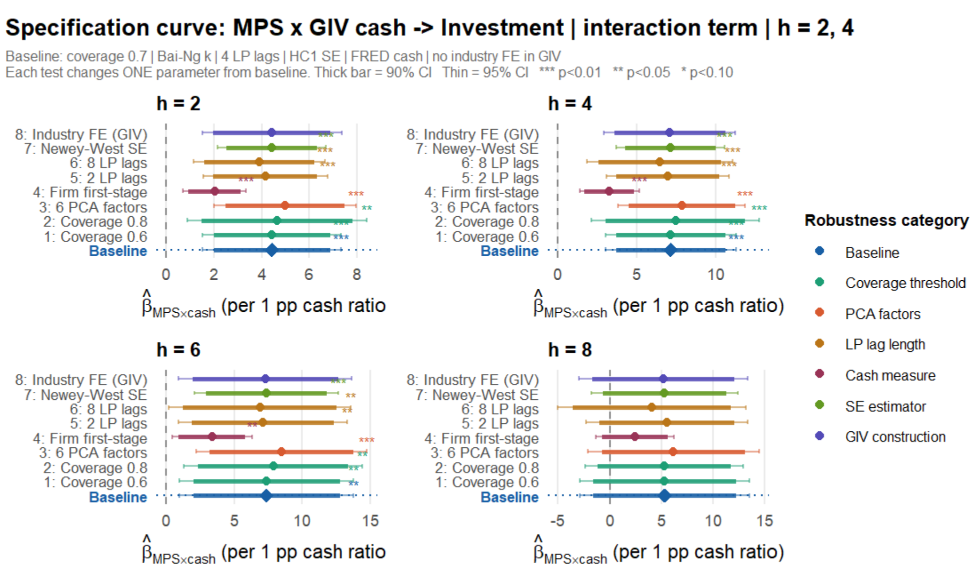
A.3.1 Firm-level Specification Curve

A.3.2 Aggregate Specification Curve



Notes: The specification curve plots the coefficient $\beta_{1,h}$ (black point) and standard errors at 90% (line) for each robustness check. The number above each plot indicates the horizon for which the coefficient was computed.

Figure 11: Specification Curve



Notes: The specification curve plots the coefficient $\beta_{1,h}$ and standard errors at 90, 95, and 99% for each robustness check. The number above each plot indicates the horizon for which the coefficient was computed.

Figure 12: Aggregate Specification Curve

B Mathematical Appendix

B.1 Short-period properties

Keynesian Stability Condition

The Keynesian stability condition, a necessary but not sufficient requirement, holds if

$$\frac{1 - c_1 \cdot ws}{1 + ws} > g_1.$$

Since $0 < c_1 \cdot ws < 1$, the numerator exceeds the denominator, implying the LHS is greater than one. Thus, as long as the sensitivity of capital accumulation to excess returns (g_1) is below unity, the stability condition is satisfied.

Equilibrium capacity utilization rate

Equilibrium growth rate

$$g^* = \left[g_0 - g_1 \cdot b_0 + g_1 \cdot d^f_{t-1} \cdot ((b_2 - b_1) \cdot (1 + r^p) - b_2 \cdot \mu - b_1 \cdot \eta)\right] \cdot \left[1 + g_1 \cdot (1 - ws) \cdot \psi_1\right] + g_1 \cdot d^h_{t-1} \cdot \left[\psi_1 \cdot (1 - ws) \cdot (a - g_1 \cdot b_1 \cdot (1 + r^p_{t-1} + \eta)) - b_1 \cdot (1 + r^p_{t-1} + \eta)\right] \tag{20}$$

Where ψ_1 is the multiplier ($\frac{1}{1 - c_1 \cdot ws - g_1 \cdot (1 - ws)}$). As proved in lemma 1, growth can only be debt-burdened for reasonable parameter ranges and growth co-moves with firm deposits assuming that $b_2 > b_1$.

Paradox of Thrift

$$\frac{\partial u^*}{\partial c_1} = \frac{ws}{\left[1 - ws \cdot (c_1 - g_1) - g_1\right]^2} \Bigg[g_0 - g_1 b_0 + l_{t-1}\left(a - g_1 b_1 (1 + r^p_{t-1} + \eta)\right) + d^f \left(g_1 b_2 (1 + r^p_{t-1} - \mu) - a\right) \Bigg]$$

Distribution regime

$$\frac{\partial u^*}{\partial ws} = \frac{(c_1 - g_1)}{[1 - ws \cdot (c_1 - g_1) - g_1]^2} \Bigg[g_0 - g_1 b_0 + l_{t-1}\left(a - g_1 b_1 (1 + r^p_{t-1} + \eta)\right) + d^f \left(g_1 b_2 (1 + r^p_{t-1} - \mu) - a\right) \Bigg]$$

Debt-regime

$$\frac{\partial u^*}{\partial l_{t-1}} = \frac{a - g_1 \cdot b_1 \cdot (1 + r^p_{t-1} + \eta)}{1 - ws \cdot (c_1 - g_1) - g_1}$$

Discussion of Model Properties

The model displays wage-led demand if; (1) $c_1 > g_1$, and (2) short-run autonomous components produce a net positive value. The paradox of thrift holds as long as short-run autonomous components are net positive. For practical purposes, we can rule out profit-led demand and a violation of the paradox of thrift as these would require a negative utilization rate which is a consequence of net negative autonomous components or would require an unrealistically low propensity to consume or unrealistically high investment sensitivity. Demand in the model is debt-led ($\frac{\partial u^*}{\partial d^f_{t-1}}$) if the propensity to consume from wealth is larger than the illiquidity effects of firm leverage on investment ($a > g_1 \cdot b_1 \cdot (1 + r^p + \eta)$)[21]. Computations supporting these claims can be found in appendix B and lemma 1. Demand can only co-move with firm deposits, as illustrated in lemma 1.

B.2 Proof to Propositions

B.2.1 Proposition 1

We can examine the effect of a rate hike by finding the partial of the rate of capacity utilization with respect to the policy rate;

$$\frac{\partial u^*}{\partial r^p} = v \cdot \left(\frac{g_1 \cdot d^f_{t-1} \cdot b_2 - l_{t-1} \cdot g_1 \cdot b_1}{1 - ws \cdot (c_1 - g_1) - g_1}\right)$$

If a rate hike has a positive effect on demand then $\frac{\partial u^*}{\partial r^p} > 0$ and $\frac{\partial u^*}{\partial r^p} < 0$ would imply that

[21]Debt-led demand is used as defined by Nishi (2012), where the rate of capacity utilization co-moves with NFC borrowing. This simply means that balance sheet expansion is expansionary.

demand reacts negatively. To work out when a rate hike would have a positive effect we need to examine when;

$$v \cdot (\frac{g_1 \cdot d^f_{t-1} \cdot b_2 - l_{t-1} \cdot g_1 \cdot b_1}{1 - ws \cdot (c_1 - g_1) - g_1}) > 0$$

This can be reduced to;

$$d^f_{t-1} \cdot b_2 - l_{t-1} \cdot b_1 > 0$$

and can be rearranged to;

$$\frac{d^f_{t-1}}{l_{t-1}} > \frac{b_1}{b_2}$$

Thus if $\frac{d^f_{t-1}}{l_{t-1}} > \frac{b_1}{b_2}$, then demand responds positively to a rate hike. If $\frac{d^f_{t-1}}{l_{t-1}} < \frac{b_1}{b_2}$ demand reacts negatively and if $\frac{d^f_{t-1}}{l_{t-1}} = \frac{b_1}{b_2}$, positive and negative forces offset each other.

B.2.2 Proposition 2

On differentiating the equilibrium growth rate (equation (20)) with respect to the policy rate we can examine the effect of monetary policy on the rate of capital accumulation;

$$\frac{\partial g^*}{\partial r^p} = [d^f_{t-1} \cdot (b_2 - b_1) - b_1 \cdot d^h_{t-1}] \cdot [g_1 + g_1^2 \cdot (1 - ws) \cdot \psi_1]$$

Similar to above, the growth rate reacts positively to a rate hike if $\frac{\partial g^*}{\partial r^p} > 0$ and negatively otherwise. So for a positive reaction, we require that;

$$[d^f_{t-1} \cdot (b_2 - b_1) - b_1 \cdot d^h_{t-1}] \cdot [g_1 + g_1^2 \cdot (1 - ws) \cdot \psi_1] > 0$$

Which can be reduced to;

$$\frac{d^h_{t-1}}{d^f_{t-1}} > \frac{(b_2 - b_1)}{b_1}$$

Thus if $\frac{d^h_{t-1}}{d^f_{t-1}} > \frac{(b_2 - b_1)}{b_1}$, then growth responds positively to a rate hike. If $\frac{d^h_{t-1}}{d^f_{t-1}} < \frac{(b_2 - b_1)}{b_1}$

demand reacts negatively and if $\frac{d^h_{t-1}}{d^f_{t-1}} = \frac{(b_2 - b_1)}{b_1}$, positive and negative forces offset each other.

B.3 Stability analysis and related propositions

To proceed with the stability analysis we make two simplifying complementary assumptions. We assume that mark-ups on loans and mark-downs on deposits are zero ($\eta, \mu = 0$), i.e. banks lend and borrow at a rate equal to the policy rate ($r^p = r^d = r^l$). Secondly, in line with the rest of the formal analysis, unlike the simulations, we assume that banks have a zero net-worth. The formal 2 dimensional difference equation system then boils down to;

$$d^h_t = \frac{d^h_{t-1} \cdot A_1 + B \cdot u^*}{1 + g^*} \tag{21}$$

$$d^f_t = \frac{u^*}{v} \cdot A_2 + d_1 \cdot [(\chi_1 - 1) \cdot d^f_{t-1} - d^h_{t-1}] \tag{22}$$

Where u^*, g^* are expanded in equations (17) and (20) respectively. We leave them as placeholders for easier algebraic manipulations. Note however that they are functions of the state variables and will thus be dealt as partials when differentiating. For the purpose of the stability analysis we will assume that A_1 and A_2 are positive exogenous parameters. $A_1 = (1 + r^p - a)$ indicates the direct effects of stylized expenditures and receipts on household deposits, like consumption from deposits and interest on deposits. $A_2 = \lambda \cdot ws + \frac{d_1 \cdot (1 - ws)}{r^p + \sigma}$ - which indicates the net effect of the rate of capacity utilization on deposit accumulation. Recall from equation (15) that larger rates of capacity utilization increase the demand for deposits for transactionary reasons but can also decrease the demand for deposits for precautionary reasons by increasing borrowing capacity though an increase in the profit rate, i.e. if $d_1 < 0$. $A_2 > 0$ if there is no precautionary motive for deposit accumulation ($d_1 > 0$) or if the magnitude of precautionary accumulation is sufficiently small ($d_1 > -\frac{\lambda ws \cdot (r^p + \sigma)}{(1 - ws)}$)[22]. On the other hand $A_1 > 0$ because it is unrealistic to have propensities to consume from wealth which are even remotely close to 100%. Similarly $B = \frac{ws_t \cdot (1 - c_1)}{v}$ which indicates saving from the wage share. B is positive by definition. In addition, for $d^h > 0$ we must assume that $g^* > r^p - a$. This is because the steady state solution of (21) is $d^{h*} = \frac{B \cdot u^*}{g^* - r^p + a}$. To examine stability, we must now compute the Jacobian of the 2D system and engage with stability conditions.

[22] In the baseline case this gives us a pretty large maneuvering space since this constraint implies $d_1 < -0.315$ which is considerably large.

The Jacobian is a matrix where each element is the partial of each of the state variables (d^h, d^f) with respect to itself and other state variables in the dynamic system. Since our system is 2D our matrix reduces to a 2 by 2 matrix, as visible below;

$$J = \begin{bmatrix} \frac{\partial d_t^f}{\partial d_{t-1}^f} & \frac{\partial d_t^f}{\partial d_{t-1}^h} \\ \frac{\partial d_t^h}{\partial d_{t-1}^f} & \frac{\partial d_t^h}{\partial d_{t-1}^h} \end{bmatrix}$$

Below we expand each of the partials, using the short-period equilibrium and partials of the utilization rate (u^*), and the growth rate (g^*)

$$\frac{\partial d_t^f}{\partial d_{t-1}^f} = \frac{A_2}{v} \cdot \frac{\partial u^*}{\partial d_{t-1}^f} - d_1 \cdot (1 - \chi_1)$$

$$\frac{\partial d_t^f}{\partial d_{t-1}^h} = \frac{A_2}{v} \cdot \frac{\partial u^*}{\partial d_{t-1}^h} - d_1$$

$$\frac{\partial d_t^h}{\partial d_{t-1}^f} = \frac{(1+g^*) \cdot B \cdot (\frac{\partial u^*}{\partial d_{t-1}^f}) - \frac{\partial g^*}{\partial d_{t-1}^f} Z}{(1+g^*)^2}$$

$$\frac{\partial d_t^h}{\partial d_{t-1}^h} = \frac{(1+g^*) \cdot (A_1 + B \cdot (\frac{\partial u^*}{\partial d_{t-1}^h})) - \frac{\partial g^*}{\partial d_{t-1}^h} Z}{(1+g^*)^2}$$

Where $Z = [d_{t-1}^h \cdot A_1 + B \cdot u^*]$, which we can call the initial conditions component. $Z > 0$ since all its components must be positive to preserve economic meaning.

Lemma 1. *Demand can be debt-led or debt burdened but growth is debt-burdened for realistic parameter values. Demand and growth co-move with firm deposits.*

Proof to lemma 1

Where the following partials explain the reaction of the utilization rate to a change in firm and household deposits respectively.

$$\frac{\partial u^*}{\partial d_{t-1}^f} = \psi_1 \cdot g_1 \cdot [(b_2 - b_1) \cdot (1 + r^p)]$$

$$\frac{\partial u^*}{\partial d_{t-1}^h} = \psi_1 \cdot [a - g_1 \cdot b_1 \cdot (1 + r^p)]$$

Consistent with our assumption that $b_2 > b_1$ the utilization rate can only move in the same direction as firm deposits ($\frac{\partial u^*}{\partial d^f_{t-1}} > 0$). The only instance when a rise in firm deposits coincides with a decline in the utilization rate would be when one unit of deposits provide less liquidity than one unit of loans ($b_1 > b_2$). We ignore this possibility since it would call into question the motive of accumulating deposits in the first place. On the other hand, the utilization rate could move with or against household deposits ($\frac{\partial u^*}{\partial d^h_{t-1}} \lesseqgtr 0$). If the condition of debt-led demand holds, i.e. $a > g_1 \cdot b_1 \cdot (1 + r^p)$, then the utilization rate rises with a rise in household wealth. This is because the propensity to consume from wealth (a) is sufficiently large to induce an expansion of demand (GDP) via consumption on account of a rise in household wealth. However, if the illiquidity effects ($g_1 \cdot b_1 \cdot (1 + r^p)$) of household wealth, which is the counterpart of firm loans, is large enough ($a < g_1 \cdot b_1 \cdot (1 + r^p)$), then a rise in household wealth does not result in a rise in consumption that is sufficient to offset the fall in investment expenditure by firms, therefore resulting in a contraction of GDP and the utilization rate.

Below are the reactions of the rate of capital accumulation to a change in firm and household deposits;

$$\frac{\partial g^*}{\partial d^f_{t-1}} = g_1 \cdot (b_2 - b_1) \cdot (1 + r^p)[\frac{g_1 \cdot (1 - ws)}{v} \cdot \psi_1 + 1]$$

$$\frac{\partial g^*}{\partial d^h_{t-1}} = \frac{g_1 \cdot (1 - ws)}{v} \cdot \psi_1 \cdot a - g_1 \cdot b_1 \cdot (1 + r^p) \cdot [(\frac{g_1 \cdot (1 - ws)}{v}) \cdot \psi_1 + 1]$$

We see once again that the only way that capital accumulation can decline in the face of a rise in firm deposits is if $b_2 < b_1$ - which is a scenario we discard for this analysis. Thus capital accumulation always moves with firm deposits ($\frac{\partial g^*}{\partial d^f_{t-1}} > 0$). However capital accumulation could move with or against household deposits. For capital accumulation to rise with a rise in household deposits, it is necessary but not sufficient for the utilization rate to be demand-led. We require that the stimulation from a rise in profits on account of a rise in consumption is larger than the negative effects of a rise in firm loans which discourages capital accumulation. This requires not only that $a > g_1 \cdot b_1 \cdot (1 + r^p)$ but that the margin between a and $g_1 \cdot b_1 \cdot (1 + r^p)$ is $g_1 \cdot b_1 \cdot (1 + r^p) \cdot \frac{v}{g_1 \cdot (1 - ws)}$. However, because the aforementioned margin is large, the propensity to consume would have to be unrealistically large for capital accumulation to be debt-led especially as the value of v gets larger and closer to realistic values. If demand is debt-burdened then capital accumulation falls even more rapidly than the utilization rate with an equivalent increase of household deposits. Thus debt-led growth is unrealistic in the model. We can now proceed to use this information to make informed conclusions about the Jacobian.

To conclude, we proved that **demand can be debt-led or debt burdened but that growth can only be debt-burdened for reasonable parameter values. We also showed that demand and growth co-move with firm deposits.**

Lemma 2. $1 - tr(J) + det(J) > 0$ *is the binding constraint of our 2D system.*

Proof to lemma 2

To prove lemma 2 we use both numeric and symbolic analysis. In the numeric analysis, we find clear evidence that condition two is the only binding condition without a close second across these parameter ranges; $a \in [0.01, 0.3], b_1 \in [0.05, 0.5], b_2 \in [0.15, 0.7], d_1 \in [-0.8, 0.3], d^f \in [0.2, 1.5], d^h \in [0.5, 2]$[23].

The relevant necessary and sufficient stability conditions we need to examine are (Gandolfo, 1997);

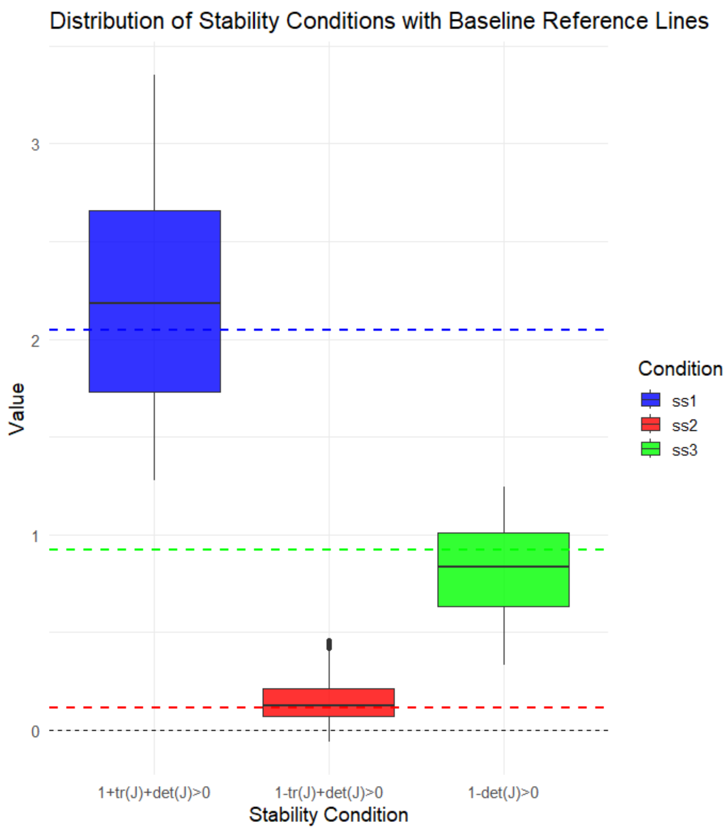
$$1 + tr(J) + det(J) > 0$$
$$1 - tr(J) + det(J) > 0$$
$$1 - det(J) > 0$$

From our numerical exercise we produce this graph to prove the lemma;

If we can establish that the determinant is less than one then we can relegate the last stability condition. To establish this, $\frac{\partial d_t^h}{\partial d_{t-1}^h} \cdot \frac{\partial d_t^f}{\partial d_{t-1}^f} < 1 - \frac{\partial d_t^h}{\partial d_{t-1}^f} \cdot \frac{\partial d_t^f}{\partial d_{t-1}^h}$. To justify this would be the case we can show that the product of the diagonal elements of the Jacobian is less than 1 [24]. For $\frac{\partial d_t^f}{\partial d_{t-1}^f} > 1$, $\frac{\partial u^*}{\partial d_{t-1}^f} > \frac{v \cdot (1 + d_1 \cdot (1 - \chi_1))}{A_2}$ which would require $g_1 \cdot (b_2 - b_1) \cdot (1 + r^p)$ to be unrealistically large. This is because realistic values of v are typically larger than 1 or 2 while A_2 would typically be less than 1, meaning that $\frac{\partial d_t^f}{\partial d_{t-1}^f} > 1$ would tend to be closer to zero than 1. This would mean that for the determinant to be larger than 1, $\frac{\partial d_t^h}{\partial d_{t-1}^f}$ would not just have to be larger than 1 but significantly

[23] R code for this can be requested.

[24] We are content with this because $\frac{\partial d_t^h}{\partial d_{t-1}^f}$ takes a maximum value of 0.002 in our simulations thus allowing us to approximate that $\frac{\partial d_t^h}{\partial d_{t-1}^f} \cdot \frac{\partial d_t^f}{\partial d_{t-1}^h}$ is close to zero.



Note. The graph illustrates that the first and the third stability conditions are not close to being violated as they sit comfortably above zero. On the other hand, the second stability condition is closest to zero and even below it in some cases. The colored doted lines denotes the values at baseline parameters.

Figure 13: Binding Stability Condition

larger than 1. For $\frac{\partial d_t^h}{\partial d_{t-1}^h} > 1$, we would require that $g^* < -1 - \frac{\frac{\partial g^*}{\partial d_{t-1}^h} \cdot Z}{g^* - r^p + a + B \cdot \frac{\partial u^*}{\partial d_{t-1}^h}}$. While this is possible because growth is debt-burdened $\frac{\partial g^*}{\partial d_{t-1}^h} < 0$, this partial and initial conditions (Z) would have to be sufficiently large. The maximum value that this partial took in out numerical exercise was 1.05.

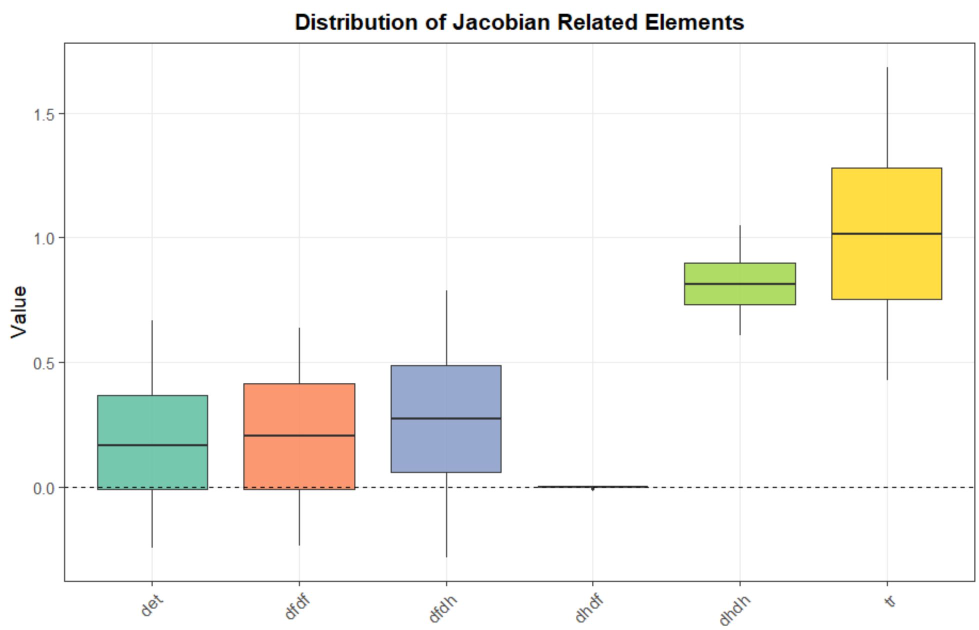
Further, If we can show that the trace is always positive then we can also rule out the first stability conditions because we already claimed that the determinant is less than 1. We can establish that $\frac{\partial d_t^h}{\partial d_{t-1}^h} > 0$. The only component that could be negative is $\frac{\partial u^*}{\partial d_{t-1}^h}$ and even if demand is debt-burdened $B \cdot \frac{\partial u^*}{\partial d_{t-1}^h}$ would have to be unrealistically large to even offset A_1 which is close to one, let alone the debt-burdened growth ($\frac{\partial u^*}{\partial d_{t-1}^h} < 0$) and initial value components (Z). $\frac{\partial d_t^f}{\partial d_{t-1}^f} \lesseqgtr 0$, and is only positive if $d_1 < 0$ or $d_1 < \frac{\frac{A_2}{v} \cdot \frac{\partial u^*}{\partial d^f_{t-1}}}{1-\chi_1}$ - in which case the trace is always positive. Thus we can easily eliminate the first condition if deposit accumulation is driven by a precautionary motive. Even if deposit accumulation is not precautionary, the condition for a positive trace boils down to;

$$(1+g^*) \cdot [A_1 + B \cdot \frac{\partial u^*}{\partial d^h_{t-1}} + (1+g^*) \cdot (\frac{A_2}{v} \cdot \frac{\partial u^*}{\partial d^f_{t-1}} - d_1 \cdot (1-\chi_1))] - \frac{\partial g^*}{\partial d^h_{t-1}} \cdot Z > 0$$

All components are positive except $d_1 \cdot (1-\chi_1)$ if there is precautionary deposit accumulation and $B \cdot \frac{\partial u^*}{\partial d^h_{t-1}}$ id demand is debt burdened. However, the other positive components are of a much larger magnitude and cannot be offset by these negative elements for reasonable parameter choices. As figure 14 demonstrates, the trace is significantly positive.

Thus we only need to show that;

$$1 - tr(J) + det(J) > 0$$



Note. The graph illustrates the range of values that each element of the Jacobian matrix, its determinant, and trace take for the parameter domains outlined above. This further reinforces our symbolic proof.

Figure 14: Binding Stability Condition

We can divide our examination into four scenarios based on two outcomes; the reaction of the utilization rate to household deposits and the nature of deposit accumulation. Demand can be either debt-led ($\frac{\partial u^*}{\partial d^h_{t-1}} > 0$) or debt burdened ($\frac{\partial u^*}{\partial d^h_{t-1}} < 0$). Deposit accumulation could be driven by a precautionary motive ($d_1 < 0$) or not ($d_1 > 0$).

Proposition 5. *The stability claims for each of these cases are as follows;*

	Precautionary ($d_1 < 0$)	Non-precautionary ($d_1 > 0$)
Debt-led $\left(\frac{\partial u^*}{\partial d^h_{t-1}} > 0\right)$	State 1: Stable	State 2: Numerically Stable
Debt-burdened $\left(\frac{\partial u^*}{\partial d^h_{t-1}} < 0\right)$	State 3: Conditionally Stable	State 4: Conditionally Stable

Proof to proposition 5

On substituting the trace and determinant with respective partials, we can condense this condition to;

$$(1 - \frac{\partial d^h_t}{\partial d^h_{t-1}}) \cdot (1 - \frac{\partial d^f_t}{\partial d^f_{t-1}}) > (\frac{\partial d^f_t}{\partial d^h_{t-1}}) \cdot (\frac{\partial d^h_t}{\partial d^f_{t-1}}) \tag{23}$$

A sufficient condition for stability, if the diagonal elements are less than 1, would be that the off-diagonal elements take alternate signs. As we have already discussed $\frac{\partial d^f_t}{\partial d^f_{t-1}} < 1$ for reasonable parameter choices. While $\frac{\partial d^h_t}{\partial d^h_{t-1}}$ could be larger than 1, it would require extreme parameter choices as discussed above. Thus we can establish as factors that would make the off-diagonal elements take the same signs as possible signs of instability.

Case 1: Debt-led demand and precautionary deposit accumulation

In this case, we know that $\frac{\partial d^f_t}{\partial d^f_{t-1}} > 0$ and that $\frac{\partial d^f_t}{\partial d^h_{t-1}} > 0$. We already know that $\frac{\partial d^h_t}{\partial d^h_{t-1}} > 0$. Thus we need to examine the conditions under which $\frac{\partial d^h_t}{\partial d^f_{t-1}} < 0$. The sign structure of our Jacobian is the following;

$$\begin{bmatrix} + & + \\ ? & + \end{bmatrix}$$

We can derive a sufficient condition for stability by simplifying this inequality;

$$\frac{\partial d^h_t}{\partial d^f_{t-1}} = \frac{(1+g^*) \cdot B \cdot (\frac{\partial u^*}{\partial d^f_{t-1}}) - \frac{\partial g^*}{\partial d^f_{t-1}} Z}{(1+g^*)^2} < 0$$

On simplification, a sufficient condition of stability would be;

$$g^* < \frac{Z \cdot [(g_1 - ws \cdot g_1) \cdot (1 - v) + v \cdot (1 - ws \cdot c_1)]}{ws \cdot (1 - c_1)}$$

If we assume that $v = 1$; this reduces to[25];

$$g^* < \frac{Z \cdot [(1 - ws \cdot c_1)]}{ws \cdot (1 - c_1)}$$

This gives the steady state growth rate a lot of space, in fact close to a 100%. The upper limit on growth would be 100% if $Z > \frac{ws \cdot (1 - c_1)}{1 - ws \cdot c_1}$ which is highly likely since Z is the placeholder for the sum of initial conditions of household deposits and the utilization rate. Thus we can conclude that this case of precautionary accumulation and debt-led demand would produce stable results. Z, i.e. initial deposit hoards and the utilization rate, would have to be sufficiently small for this to be untrue. Z $(= d^h_{t-1} \cdot A_1 + B \cdot u^*])$ increases if interest rates rise since demand is debt-led and u^* rises with a rate hike, meaning a larger ceiling growth rate. We can further support this result numerically with figure 15 which shows that the combination of debt-led demand and precautionary deposit accumulation do not violate any of our stability conditions under the domain of explored parameters. Thus we can label this case stable.

Case 2: Debt-led demand and non-precautionary deposit accumulation

In this case, $\frac{\partial d^h_t}{\partial d^h_{t-1}} > 0$ but $\frac{\partial d^f_t}{\partial d^f_{t-1}} < 0$. This is because d_1 has to be larger than $\frac{\lambda \cdot ws \cdot \frac{\partial u^*}{\partial d^f_{t-1}}}{v - \frac{(1 - ws)}{r^p + \sigma} \cdot \frac{\partial u^*}{\partial d^f_{t-1}}}$. This would be very easy since the numerator is close to zero and the denominator can be much higher than one, close to the assumed value of v which means a d_1 would just need to be a small positive value close to 0 for $\frac{\partial d^f_t}{\partial d^f_{t-1}} < 0$[26]. This can also be confirmed numerically by examining figure 16 - which also tells us that $\frac{\partial d^h_t}{\partial d^h_{t-1}}$ is smaller in the debt-led cases. This would mean that the LHS of equation (23) is larger thus increasing the chances of stability. Unlike case 1, however, we cannot make any definite claims about the sign of the off-diagonal elements.

$\frac{\partial d^f_t}{\partial d^h_{t-1}} < 0$ if $d_1 > \frac{\partial u^*}{\partial d^h_{t-1}} \cdot \frac{A_2}{v}$. This would be true for larger values of d_1. The condition remains the same for $\frac{\partial d^h_t}{\partial d^f_{t-1}} < 0$. Thus in this case, to ensure stability we would require that

$$g^* < \frac{Z \cdot [(1 - ws \cdot c_1)]}{ws \cdot (1 - c_1)}$$

[25] Even if $v > 1$ because $g_1 < ws \cdot g_1$ there would be no effect on the sign of the numerator. Therefore justifying our assumption of $v = 1$.

[26] We made a simplifying assumption that $\chi_1 = 0$ which is actually the strictest case so this would also be true for $\chi_1 \in [0, 1]$.

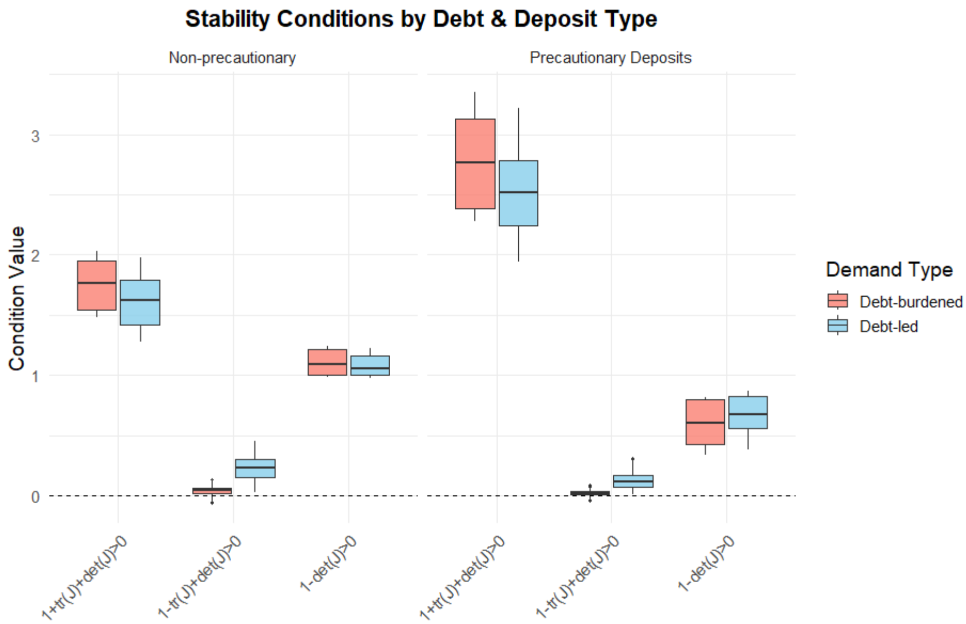
and $d_1 > \frac{\partial u^*}{\partial d^h_{t-1}} \cdot \frac{A_2}{v}$ or the opposite. However numerical analysis from figures 15 and 16 show that this sufficient condition for stability is not necessary. This is likely because of the factors discussed above which suggest that the LHS of equation 23 is likely to be larger in this case and $\frac{\partial d^h_t}{\partial d^f_{t-1}}$ is very close to zero.

Case 3: Debt-burdened demand and precautionary deposit accumulation

In this case, the diagonal elements remain positive. $\frac{\partial d^f_t}{\partial d^h_{t-1}} > 0$ since this would only require that $d_1 < \frac{\lambda \cdot ws \cdot \frac{\partial u^*}{\partial d^h_{t-1}}}{1 - d_1 \cdot \frac{(1-ws)}{r^p + \sigma} \cdot \frac{\partial u^*}{\partial d^h_{t-1}}}$ which would be a small negative number close to zero. This is because the numerator is negative but small while the denominator would be positive but large (er than 1). This claim has further numerical evidence in graph 16. Thus for stability, we need to ensure that $\frac{\partial d^h_t}{\partial d^f_{t-1}} < 0$, which would boil down to the same condition discussed in the above two cases. However, due to the small size of this element and its proximity to zero this is not a necessary stability condition and just a sufficient one. However figure 16 illustrates that this case does experience some instability. In the debt-burdened cases it is also possible that $\frac{\partial d^h_t}{\partial d^h_{t-1}} > 0$ which is an additional source of instability that needs to be addressed as it would turn the LHS negative. Thus requiring off diagonal elements to both be the same sign.

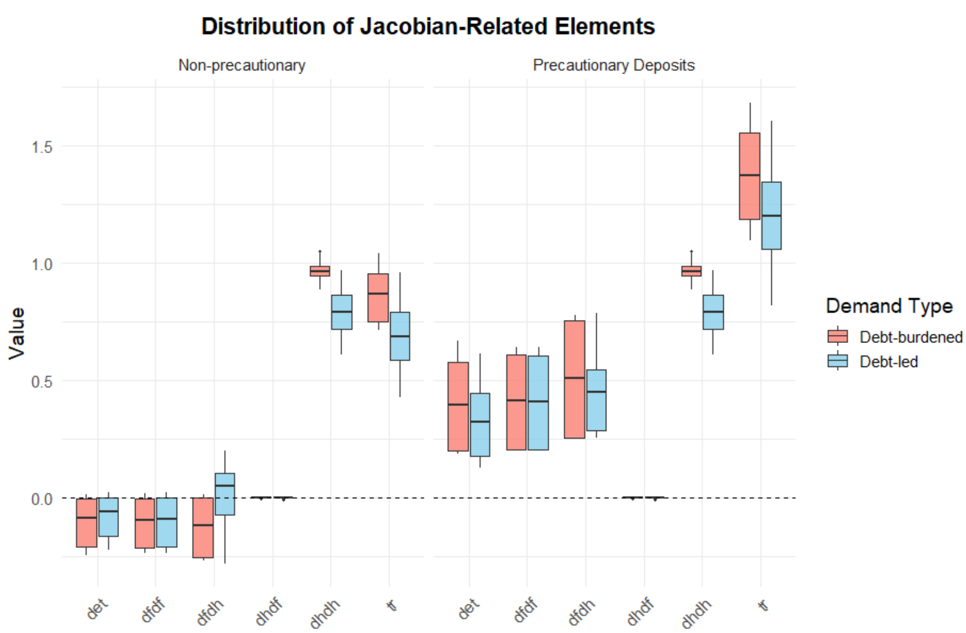
Case 4: Debt-burdened demand and non-precautionary deposit accumulation

In this case $\frac{\partial d^f_t}{\partial d^h_{t-1}} < 0$ if $d_1 < \frac{A_2}{v} \cdot \frac{\partial u^*}{\partial d^h_{t-1}}$, which would be true by definition because $\frac{A_2}{v} \cdot \frac{\partial u^*}{\partial d^h_{t-1}}$ would be negative and d_1 is positive by definition. This however would mean that $\frac{\partial d^h_t}{\partial d^f_{t-1}} > 0$ which is possible but unlikely as explained in the previous cases. However this is not a necessary condition of stability as explained above. In any case from figure 16 we see that this case is by far the most unstable.



Note. The graph illustrates how close to violating the stability conditions each case of our model is.

Figure 15: Binding Stability Condition



Note. The graph illustrates the range of values that each element of the Jacobian matrix, its determinant, and trace take for the parameter domains outlined above with respect to our classification of the system. This further reinforces our symbolic proof.

Figure 16: Binding Stability Condition

C Simulation Appendix

C.1 Residual equation for simulation

As explained previously, the simulation relaxed the assumption that bank profits are transferred to households. Bank profits are instead assumed to be added to the net-worth of the bank. Thus we have to change our residual equations which ensure stock flow consistency. The modified equations are below.

$$d^h_t = \frac{d^h_{t-1} \cdot (1 + r^d_{t-1} - a) + ws_t \cdot \left(\frac{u_t}{v}\right) \cdot (1 - c_1)}{1 + g_t} \tag{24}$$

$$l_t = \frac{l_{t-1} \cdot (1 + r^l_{t-1}) + d^f_t \cdot (1 + g_t) - d^f_{t-1} \cdot (1 + r^d_{t-1}) + ws_t \cdot \left(\frac{u_t}{v}\right) \cdot (1 - c_1)}{1 + g_t} \tag{25}$$

$$nw^b_t = \frac{nw^b_{t-1} + r^l_{t-1} \cdot l_{t-1} - r^d_{t-1} \cdot d^f_{t-1} - r^d_{t-1} \cdot d^h_{t-1}}{1 + g_t} \tag{26}$$

C.2 Parameters Values for Simulations

Category	Variable	Value	Source
Exogenous Parameters			
Propensity to Consume (wealth)	a	0.064	G & L (2012)
Propensity to Consume (wage)	c_1	0.75	G & L (2012)
Capital-Output Ratio	v	3	FRED & CEPR (2023)
Wage Share	ws_t	0.6	FRED
Fraction of wage bill as deposits	λ	1.5	N/A
Sensitivity to excess leverage	d_1	-0.1	N/A
b_t sensitivity to risk-free rate	b_0	0.04	N/A
b_t sensitivity to leverage	b_1	0.08	N/A
b_t sensitivity to deposits	b_2	0.28	N/A
l_t sensitivity to liquidity	χ	0.2	N/A
Autonomous capital accumulation	g_0	0.1	Self
Sensitivity to excess returns	g_1	0.1	Self
Mark-down on deposit rate	μ	0.01	Self
Mark-up on loan rate	η	0.015	Self
Firm risk premium	σ	0.04	Self

C.3 No Deposit and Canonical Capital Accumulation Case

Capital Accumulation Function

$g_t = g_0 + g_1 \cdot r_t - g_2 r^l_{t-1} - g_3 \cdot l_{t-1}$

Short-period utilization equilibrium

$u^* = \frac{g_0 + a \cdot d^h_{t-1} - g_2 r^l_{t-1} - g_3 \cdot l_{t-1}}{1 - ws \cdot (c_1 - g_1) - g_1}$

Short-period reaction of demand to a rate hike

$\frac{\partial u^*}{\partial r^p_{t-1}} = \frac{-g_2}{1 - ws \cdot (c_1 - g_1) - g_1}$

Long-period reaction of demand to a rate hike

$$\frac{\partial u^{**}}{\partial r^p_{t-1}} = \frac{a \cdot \frac{\partial d^h_{t-1}}{\partial r^p_{t-1}} - g_2 - g_3 \cdot \frac{\partial l_{t-1}}{\partial r^p_{t-1}}}{1 - ws \cdot (c_1 - g_1) - g_1}$$

D Numerical Stability

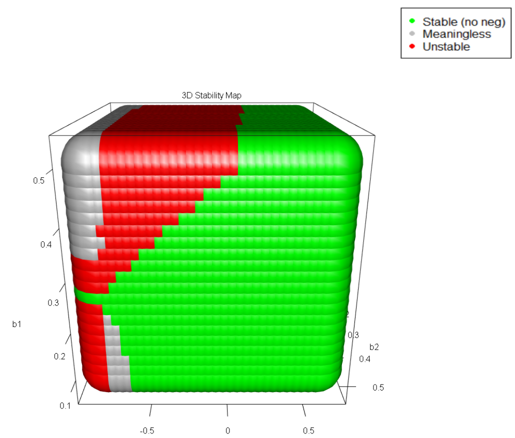


Figure 17

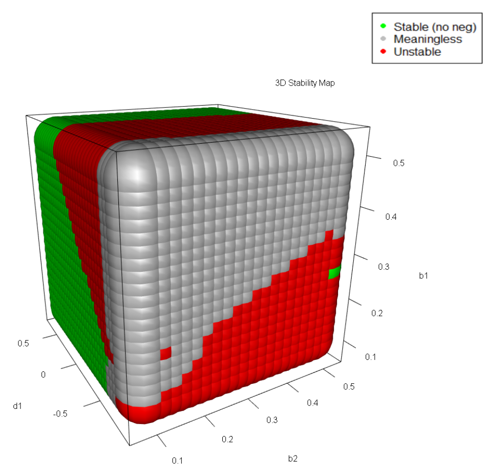


Figure 18