

Firms' precautionary savings and employment during a credit crisis - Online Appendix *

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A Data

The primary data source used in this paper is FAME dataset, gathered by Bureau van Dijk. It contains information on over 9 million companies in UK and Ireland, 2 million of which are in detailed format, over the period 2004-2013.¹ I restrict the dataset to UK only. A standard company report includes a balance sheet, profit and loss account, turnover, employees and industry codes.² In contrast to other datasets such as US Compustat, 93.7% of the firms contained in the FAME sample are non-publicly traded.³ This implies that there is a large number of small and medium-sized companies.⁴ Since the model does not feature life cycle dynamics, I restrict the sample to a balanced panel; firms that have weakly positive observations for employment, cash and total assets are kept in the sample. Following the standard procedure employed in similar studies, I exclude from the sample firms with UK SIC code referring to "Financial and insurance activities". The final sample consists of 17,762 firms each year. Cash is recorded in firm's balance sheets as *Bank Deposits*, which is the British format for cash & equivalent. Hence, this definition should already account for a potential substitution among cash securities. Moreover, the average share of short-term investments to total assets stays constant between 2009 and 2010 and even rises in the following year. This further excludes that the increase in cash is driven by a reduction in other liquid assets. Net job creation is defined as the difference in number of employees for a given firm from one year to the other. I define employment growth for a firm j at year t as $\Delta n_{j,t} = \frac{n_{j,t} - n_{j,t-1}}{\alpha n_{j,t} + (1-\alpha)n_{j,t-1}}$, with $\alpha = 0.5$.

*The views expressed in this paper are entirely those of the author. They do not necessarily represent the views of the Federal Reserve Bank of New York or the Federal Reserve System.

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¹A maximum of 10 years data history can be downloaded at once. Companies are registered at Companies House in the UK.

²Some firms report also the Cash Flow statement. Moreover, the data includes detailed ownership and subsidiary information.

³This share is comparable to recent studies that use the FAME database, as Brav (2009) and Michaely and Roberts (2011).

⁴Unlike in the US, UK firms have to disclose their accounts even when not traded on the stock market. Following the UK Companies Act 1985, large firms have to report detailed accounts, whereas medium-size companies do not have to disclose turnover details and small firms are required to submit only an abridged balance sheet.

Table A.1: Descriptive Statistics

	Employment	Total Assets	Cash ratio	Employment growth rate	Investment rate
Mean	448	95,511	0.19	0.01	0.02
Std. Dev.	2,340	635,232	0.23	0.21	0.41
25th	29	3,009	0.02	-0.04	-0.11
Median	78	7,664	0.10	0	-0.01
75th	191	22,590	0.28	0.08	0.10
N Obs	177,620	177,620	177,620	159,858	134,123

Notes: Moments computed over the entire sample period 2004-2013. Total assets in Thousands GBP.

Moscarini and Postel-Vinay (2012) explain the advantages of this symmetric approach, which bounds employment growth between -2 and 2. Finally, I define investment ratio using the same strategy as for employment growth. Investment ratio for a firm j at time t is defined as $\frac{k_{j,t} - k_{j,t-1}}{\alpha k_{j,t} + (1-\alpha)k_{j,t-1}}$, with $\alpha = 0.5$, where k is the book value of fixed assets as recorded at balance sheet. All base variables are winsorized at the 99.75 percentile. Table A.1 reports descriptive statistics for the sample. Although the reporting requirements slightly bias the sample towards large firms, the size distribution is much closer to the UK universe than a dataset with only publicly quoted firms. For instance, the median firm in the sample has 78 employees. The sample is representative also in terms of aggregate dynamics. The evolution of aggregate employment, for instance, closely resembles the one for Non-financial corporations published by the UK Office for National Statistics.

B Numerical Method

The firm's problem is solved with value function iteration. The AR(1) process for the the log of idiosyncratic productivity is discretized using Tauchen and Hussey (1991) method over 7 grid points. The aggregate credit shock ϕ can take on two values, as described in Section 4.1. In the spirit of Khan and Thomas (2013), I specify the value function over $\left(n_{t-1}, \frac{m_t}{k_t}, k_t, z_t, \phi_t\right)$. Using $\frac{m}{k}$ allows me to restrict the knot points to the feasible set. I set 20 grid points for the grid on $\frac{m}{k}$ and 27 points for the state grid for capital. The choice grid for capital contains twice as many points as it always comprises the inaction decision $k_{t+1} = (1 - \delta_k)k_t$; this is quantitatively important given the capital adjustment costs. The choice grid for labour exploits the features of the financial constraint and thus has 22 points for each $(k, \frac{m}{k}, \phi)$ triplet, therefore effectively consisting of 23,760 points. As such, the binding financial constraint can be identified precisely. Alternative models with $\chi = 0$ have a reduced state space, since labour is not a state variable. In those models, the solution can computationally accommodate 80 grid points for the state grid for capital and 55 for $\frac{m}{k}$. Having defined the value function, I iterate on the Bellman equation until convergence. At each round of iteration, the value function is interpolated using linear interpolation, to accommodate the discrepancy in the number of grid points between states and choices. Linear interpolation has the advantage of preserving the shape of the policy functions and the kinks arising from the constraints that characterize

the model.

The internal calibration is implemented as follows. For each set of parameters, I solve the dynamic program allowing for aggregate uncertainty. I then fix the policy functions to the steady state aggregate credit tightness ϕ_H , and simulate 20,000 firms – which is roughly the same number of firms in the FAME dataset – for 400 quarters. I repeat this simulation for 25 economies with a different draw of the simulated panel of idiosyncratic productivity. In each economy, I compute the moments discarding the first 300 quarters, and then average out the moments across the economies. In the simulations, the transition back from fine choices to coarser states is implemented using a nearest neighbour approach; the simulation keeps track of sequential inaction choices and adjusts the policy functions accordingly. As a first approach to the joint calibration, I compute several moments across a large multi-dimensional grid of parameters. This allows me to identify the strongest relationships between parameters and moments and get closer to the global minimum. I then minimize the sum of squared differences between model and data moments, using a Nelder-Mead minimization routine.

The quantitative exploration and the impulse responses shown in Section III.C, III.D and IV are obtained with a similar approach, but implement 5 quarters of ϕ_L after 400 quarters of ϕ_H and then ϕ_H thereafter. I repeat the simulation for 100 economies, which does not affect the moments but improves the precision of the aggregate impulse responses.

The time period in the model is a quarter, and the results shown in the paper follow this frequency. Little information on the frequency of the decision making at firm level is known (Bloom (2009)). Thus, I decide to strike a balance between monthly frequency of board meetings in public firms and the annual balance sheet data. When required, model-generated quarterly data is converted into annual figures using standard accounting techniques. Flow figures from the Income Statement are added across the quarters of the year, stock figures from the Balance sheet are taken from the year end values. As reported in FAME company reports, the number of employees is the average over the accounting year.

C The firm’s problem

As mentioned in Section II.E, non-smooth labour and capital adjustment costs raise potential concerns with respect to the differentiability of the value function. As shown by Cui (2017), the value function $V(m_t, k_t, n_{t-1}, z_t; \phi_t)$ is differentiable at $k_t > 0$ and satisfies the envelope condition.⁵

The first order conditions that pin down the optimal decisions for dividends, labour, capital and cash respectively, of a firm with idiosyncratic productivity z_t , are shown below. With a slight abuse of notation, V' is a compact form for $V(m_{t+1}, k_{t+1}, n_t, z_{t+1}; \phi_{t+1})$.

⁵The differentiability of $V(m_t, k_t, n_{t-1}, z_t; \phi_t)$ when $k_{t+1} \neq (1 - \delta_k)k_t$ and $n_t \neq (1 - \delta_n)n_{t-1}$ is standard, as proved by Benveniste and Scheinkman (1979). The differentiability at $k_{t+1} = (1 - \delta_k)k_t$ and $n_t = (1 - \delta_n)n_{t-1}$ can be proved using methods from Clausen and Strub (2012), as shown by Cui (2017). The intuition is that the value function is super-differentiable, but also sub-differentiable, given the potential downward kink stemming from the adjustment costs. Being both super-differentiable and sub-differentiable implies the differentiability of the value function.

Then:

$$1 - 2\kappa d_t = \lambda_t \quad (\text{A.1})$$

$$\lambda_t \omega \frac{y_t}{n_t} + \beta \frac{\partial \mathbb{E}V'}{\partial n_t} = \bar{w} \mu_t + \lambda_t \left[\bar{w} + AL_{n_t}(n_{t-1}, n_t) + AC_y^F(k_t, k_{t+1}, y_t) \omega \frac{y_t}{n_t} \right] \quad (\text{A.2})$$

$$\beta \frac{\partial \mathbb{E}V'}{\partial k_{t+1}} = \lambda_t [AC_{k_{t+1}}^P(k_t, k_{t+1}) + AC_{k_{t+1}}^F(k_t, k_{t+1}, y_t)] \quad (\text{A.3})$$

$$\beta \frac{\partial \mathbb{E}V'}{\partial m_{t+1}} = \lambda_t - \psi_t \quad (\text{A.4})$$

And the envelope conditions for labour, capital and cash are:

$$V_{n_{t-1}}(m_t, k_t, n_{t-1}, z_t; \phi_t) = -\lambda_t AL_{n_{t-1}}(n_{t-1}, n_t) \quad (\text{A.5})$$

$$V_{k_t}(m_t, k_t, n_{t-1}, z_t; \phi_t) = \lambda_t \left[\nu \frac{y_t}{k_t} - AC_{k_t}^P(k_t, k_{t+1}) - AC_{k_t}^F(k_t, k_{t+1}, y_t) \right] + \phi_t (1 - \vartheta) (1 - \delta_k) \mu_t \quad (\text{A.6})$$

$$V_{m_t}(m_t, k_t, n_{t-1}, z_t; \phi_t) = \lambda_t + \mu_t \quad (\text{A.7})$$

Combining equations (A.1-A.7) gives the first order conditions (10)-(13) shown in Section II.E. Following Cui (2017), it is possible to further decompose the derivatives with respect to labour and capital adjustment costs. For instance, let $q(m_t, k_t, n_{t-1}, z_t; \phi_t)$ be the marginal value of capital that satisfies the envelope condition, which we shall refer to as q_t thereafter. Then, Equation (A.6) can be rewritten as:

$$V_{k_t}(m_t, k_t, n_{t-1}, z_t; \phi_t) = \lambda_t \left[\nu \frac{y_t}{k_t} (AC_y^F(k_t, k_{t+1}, y_t) + 1) + q_t (1 - \delta_k) \right] + \phi_t (1 - \vartheta) (1 - \delta_k) \mu_t \quad (\text{A.8})$$

Intuitively, q_t is the marginal reward of adjusting capital. When it reaches 1, a firm buys capital. The lower bound of q_t is instead $1 - \vartheta$; selling capital is associated to this marginal reward to decrease capital. When the firm is inactive in its capital investment decision, q_t is less than 1 and greater than $1 - \vartheta$. Inside the inaction region, q_t is the option value of remaining inactive.⁶

D Supplemental results on alternative models

D.1 Alternative models matching average liquidity

In this appendix I repeat the analysis of Section IV, recalibrating parameters in the model counterfactuals such that they match the empirically observed average cash ratio.⁷ Indeed, keeping all the other parameters equal, the model with $\chi = 0$ overshoots the average cash ratio relative to the data (22%) while this ratio is only 7% when also $\kappa = 0$. As shown in Figure A.1, the dynamics of aggregate employment remain more short-lived

⁶As in the main text, AC_k^F is the total derivative of the fixed adjustment cost with respect to capital, incorporating the indirect effect via the production function. Similarly, the intuition about q disregards this channel.

⁷There are obviously different ways of performing the recalibration. One purpose of this exercise is to show that, even when the average amount of liquidity is matched, the precautionary channel remains weak when labour adjustment costs are absent.

Table A.2: The precautionary channel in alternative models (with recalibration)

	Contribution to aggregate employment growth (%)		
	Baseline model	$\chi = 0$	$\chi = 0, \kappa = 0$
Remaining constrained	30	43	21
Becoming unconstrained	8	4	-6
Becoming constrained	4	51	90
Remaining unconstrained	58	2	-5

Notes: Same notes as Table 5 of the main text.

in the alternative models, as most of the action is in the constrained firms, as reported in Table A.2. Interestingly, when ϕ_H is lowered such that the model without labour and dividend adjustment costs matches the average cash ratio, aggregate capital slightly falls rather than mildly increasing as shown in the main text.⁸

Moreover, the time-varying correlation between cash ratio and employment growth is roughly similar with and without recalibration, as shown by Figure A.2. No alternative model is able to replicate the empirically observed patterns. This is because the precautionary channel is very limited, as confirmed in Table A.2.

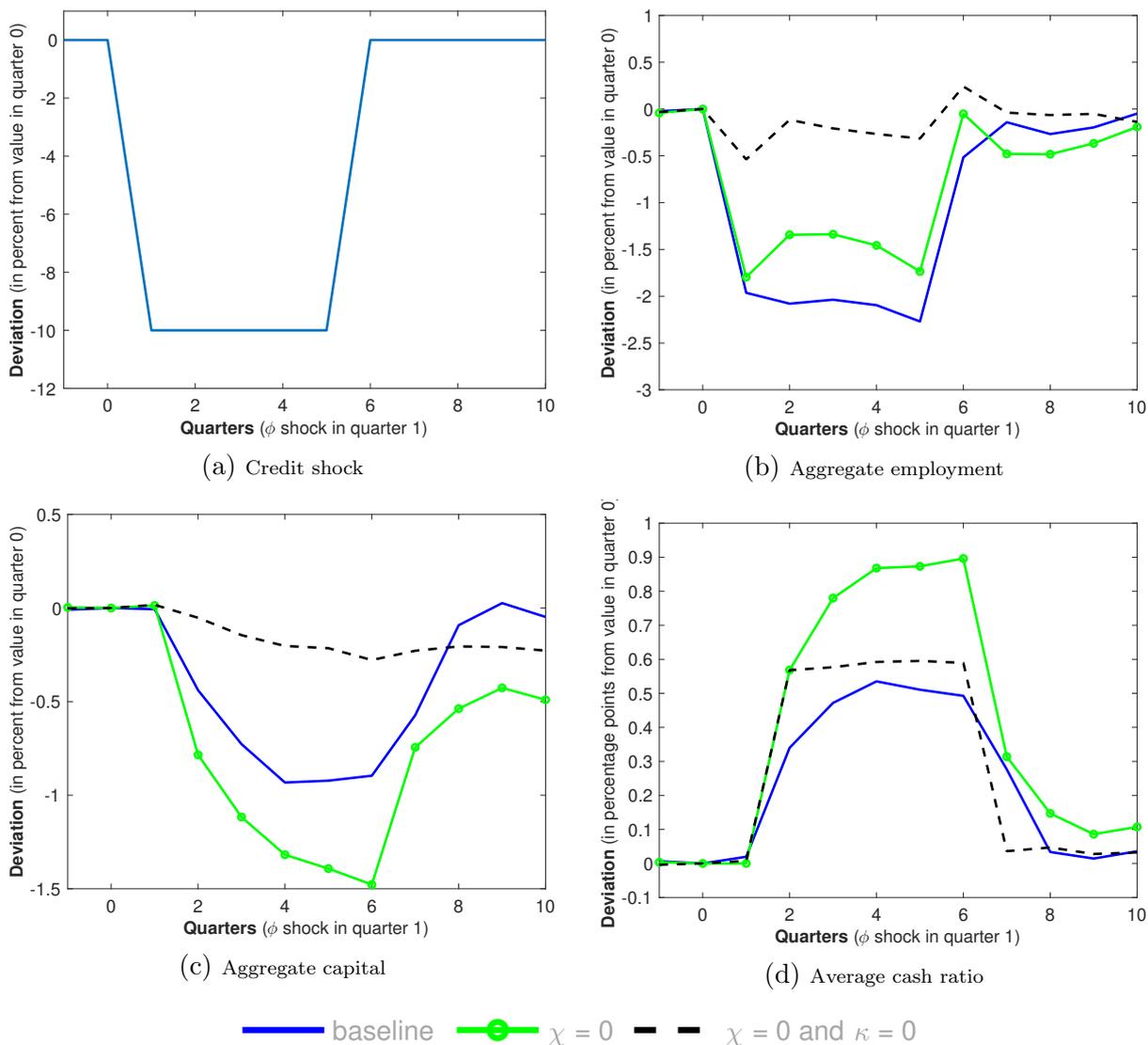
D.2 Alternative models without frictions

In this appendix I repeat the analysis of Section IV for a model in which the only friction is the working capital collateral constraint. Hence, in this model I also shut down the capital adjustment costs, such as $\vartheta = 0$ and $\Theta = 0$, besides $\kappa = 0$ and $\chi = 0$. Figure A.3 shows the responses of aggregate employment and the average cash ratio to a credit tightening as the one shown in Figure 4a of the main text. The black dashed line shows the alternative model without recalibration. In this setting, a credit crunch reduces aggregate employment by much less than the baseline upon impact. Moreover, the response is very short-lived and quickly overshoots above pre-crisis levels when credit conditions are restored. This absence of persistent effects is confirmed when recalibrating ϕ_H to match the empirical average cash ratio, as shown by the red dash-dotted impulse responses. Moreover, in this case the response of average cash ratio is excessively large, twice as much as in the data.

When only the collateral constraint is present, the correlation between cash ratio and employment growth is weakly negative, as shown in Figure A.4a. Recalibrating ϕ_H allows the model to generate an increase in the correlation following a credit crunch, albeit much smaller than in the baseline. However, in the following periods, the correlation does not fall below 2008 levels. Finally, Table A.3 shows how, absent all real frictions, the precautionary channel is basically not existent.

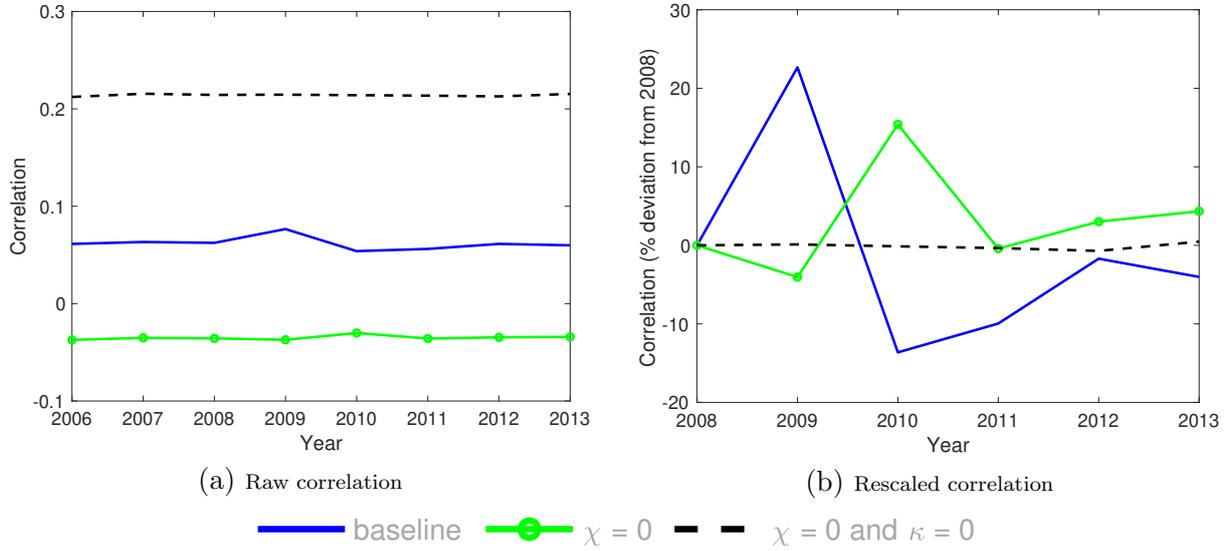
⁸Imposing $\chi = 0$ to the baseline model predicts an average cash ratio slightly higher than in the data. Hence, I recalibrate κ downwards, rather than ϕ_H , given a stronger sensitivity of the average cash ratio to κ in a region of high values of ϕ . The results shown in this section, however, are broadly unchanged with an alternative recalibration.

Figure A.1: Impulse response functions to a credit supply shock - alternative versions of the model (with recalibration)



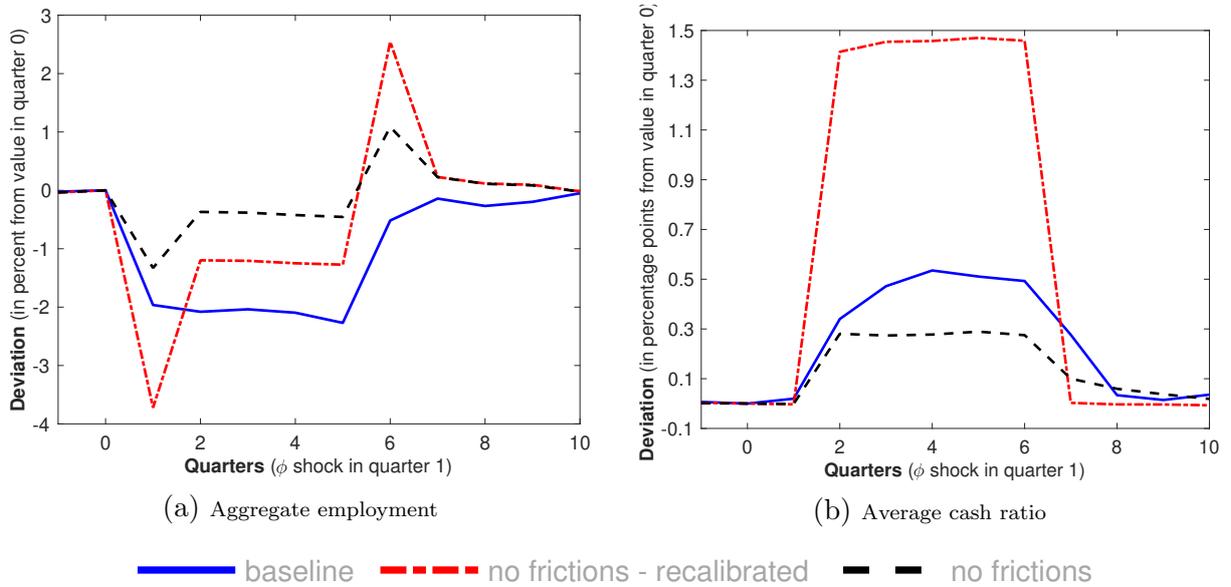
Notes: The economy starts with normal credit conditions and experiences a credit tightening in quarter 1, lasting 5 quarters. Previous notes on the simulation apply. χ has been set to 0 in the model shown by the green dotted lines and the black dashed impulse response, while κ is 0 in the black dashed impulse responses. Except for the baseline model, shown in solid blue, all the other variants have been recalibrated such that the economy matches the empirical average cash ratio in steady state. When $\chi = 0$, κ has been recalibrated to 0.74. When both κ and χ are set to 0, ϕ_H is 0.195.

Figure A.2: Cash and employment growth (with recalibration)



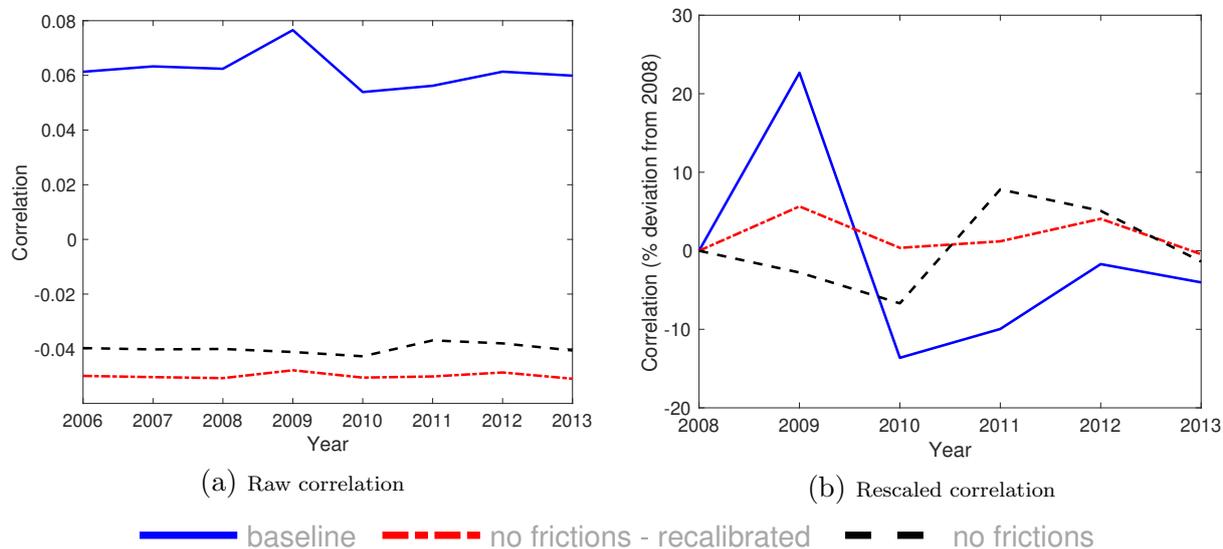
Notes: Notes on Figure 5 and 7 of the main text apply.

Figure A.3: Impulse response functions to a credit supply shock - model with collateral constraint only



Notes: The economy starts with normal credit conditions and experiences a credit tightening in quarter 1, lasting 5 quarters. Previous notes on the simulation apply. The solid blue lines depicts the baseline model whereas $\vartheta = 0$, $\Theta = 0$, $\kappa = 0$ and $\chi = 0$ in the other two models. In the dash-dotted red model, ϕ_H has been recalibrated to 0.285, in order to match the empirical average cash ratio.

Figure A.4: Cash and employment growth (no frictions)



Notes: Notes on Figure A.3 apply.

Table A.3: The precautionary channel in alternative models (no frictions)

	Contribution to aggregate employment growth (%)		
	Baseline model	No frictions	No frictions recalibrated
Remaining constrained	30	37	86
Becoming unconstrained	8	-9	-2
Becoming constrained	4	110	16
Remaining unconstrained	58	-38	0

Notes: Same notes as Table A.2.

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