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Long-Run Inflation and Financial Panics*

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Abstract

We employ a medium-scale New Keynesian model with banks and endogenous financial panics (system-wide bank runs) to study whether and how (non-zero) average trend inflation affects the risk of bank runs. Consistent with descriptive empirical evidence for a panel of advanced economies, we find that trend inflation significantly affects the probability of banking panics - this probability more than doubles when annual trend inflation rises from 0% to 6% p.a. The incidence of a banking panic mainly depends on the magnitude of the associated decline in asset prices. With higher trend inflation this decline is stronger. The presence of an occasionally binding zero lower bound increases the likelihood of bank runs, but only for low levels of long-run inflation. Disinflations engineered by the central bank are associated with significantly higher bank-run probability in the short-run, especially when a sharp "cold turkey" disinflation is pursued. Finally, we discuss how trend inflation affects some of the trade-offs faced by monetary and macroprudential policy.

Keywords: Long-run inflation, bank runs, financial panics, crisis probability

JEL classification: E12, E23, E31, E32, E52, E44, G01, G21, G33

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1 Introduction

A recurring issue in recent policy debates and reports has been the question of whether a prolonged period of elevated inflation rates might have consequences for financial stability.[1] To a large degree this discussion was inspired by the inflation surge in many advanced economies in 2021-2022. Several institutions and observers, however, also emphasize that structural factors - like deglobalization, the pursuit of decarbonization, rising fiscal pressures due to defense spending and industrial policy, or the risk of deanchoring inflation expectations - might contribute to persistently high inflation in the future (IMF, 2022; Blanchard, 2022; IMF, 2023b; Afrouzi et al., 2024). More recently, concerns have been raised that political pressures in the United States could undermine the independence of the Federal Reserve (NYT, 2025a,b; The Economist, 2025; Athanasopoulos et al., 2025). A lower degree of central bank independence is typically associated with less well anchored inflation expectations and a higher long-run inflation (Alesina and Summers, 1993; de Haan and Eijffinger, 2019; Rogoff, 2021). The existing policy analyses have so far focused on the short-run financial stability risks resulting from inflation turning out to be more persistent than previously anticipated and thus, necessitating a stronger than expected policy-rate hike by the central bank. The current paper contributes to this discussion with an explicit focus on the impact of long-run inflation on financial stability. We find that higher long-run inflation by itself might be a reason for financial stability concerns, even apart from surprising policy-rate increases or the deanchoring of expectations.

There is a large body of studies investigating the macroeconomic effects of long-run inflation (Ascari and Sbordone, 2014; Cecchetti et al., 2023; Afrouzi et al., 2023; Marsal et al., 2023; Ascari et al., 2023). This literature is mainly theoretical in nature, resorting to DSGE models or very similar frameworks. Long-run inflation in most of these models is identical to the steady-state rate of price change, also called *trend inflation*.

[1] See for example IMF (2022), ECB (2022), ESRB (2022) and IMF (2023a).

The majority of the contributions points towards detrimental effects of trend inflation. The higher the latter, the poorer and more volatile the economy.[2] Moreover, in such an environment the central bank tends to face less favourable trade-offs and higher difficulties in anchoring inflation expectations and ruling out sunspot equilibria. On the other hand, several studies have argued in favour of a higher inflation target. This would equip the central bank with more room for maneuver in the face of large deflationary shocks, thus, reducing the likelihood of hitting the (effective) zero lower bound (ZLB) on short-term nominal interest rates (Krugman, 1998; Williams, 2009; Blanchard et al., 2010; Ball, 2013; Andrade et al., 2019, 2021). While being extraordinarily insightful, this literature has so far abstracted from assessing any potential *financial stability* consequences of trend inflation. This is where our study steps in.

To this end, we employ a modified version of the theoretical framework proposed by Gertler et al. (2020). It is an otherwise standard New Keynesian DSGE model in which system-wide *bank runs* may arise endogenously. The incidence of such runs (or banking panics) is the specific form of *financial instability* inherent in the economy. Our main finding is that trend inflation has substantial effects on the probability of bank runs. This probability more than doubles when annual trend inflation rises from 0% to 6% p.a. Our analysis further delivers several results which are important from a policy perspective. In particular, by performing exercises similar to those in Ascari and Ropele (2012a,b, 2013), we find that disinflations engineered by the central bank are associated with significant short-term costs in terms of financial stability. This is especially the case when a sharp "cold turkey" disinflation is pursued. By contrast, the increase in bank-run probability is more muted if the transition to the lower inflation target is more gradual or its start is announced in advance. These results underscore the importance and potential benefits of a timely and credible central bank communication in the fight against inflation. The model also implies that the presence of an occasionally binding zero lower-bound on the

[2]For empirical evidence in support of these theoretical findings see for example Ascari et al. (2023) and Adam et al. (2023).

nominal interest rate (ZLB) further increases the likelihood of banking panics, but only for fairly low levels of long-run inflation.[3] If the latter is higher than 1%, the ZLB almost never binds, and thus is effectively irrelevant from a financial-stability perspective. We further show that the monetary policy stance has an important impact on the likelihood of banking panics: the run probability is hump-shaped in the Taylor-rule parameter on inflation. In particular, as long as that parameter is below a critical value of around 1.8, a stronger response to inflation stabilizes inflation but is associated with a higher probability of a run. This trade-off is more pronounced for high long-run inflation levels. Macroprudential policy also faces a trade-off in our model economy: tighter bank capital requirements, although improving the resilience of the banking sector and thus reducing the frequency of crises, are associated with a lower long-run level of aggregate economic activity. This trade-off is relatively worse for higher rates of trend inflation.

Bank runs in our model economy typically arise in the case of relatively unfavourable macroeconomic conditions. In such situations, banks might suffer large deposit withdrawals and thus be forced to liquidate their assets, typically, at a rather low "fire-sale" price. In particular, the run is a special case of a self-fulfilling sunspot equilibrium. It occurs when two conditions are met simultaneously. First, a forced liquidation would drive the aggregate banking sector into insolvency and second, the typical depositor believes that all other depositors will run (Gertler and Kiyotaki, 2015; Gertler et al., 2016). The model economy also features a nominal friction in the form of staggered, Calvo-type price setting by goods-producing firms (Calvo, 1983).[4] Under the Calvo assumption, the long-run level of inflation has several non-trivial consequences relevant for our subsequent

[3]Rottner (2023) uses a similar theoretical framework and shows that the presence of the ZLB leads to a higher frequency of banking panics. Our results confirm his findings.

[4]Gertler et al. (2020) and Rottner (2023) assume nominal price changes are associated with convex adjustment costs as proposed by Rotemberg (1982). By assuming Calvo-pricing we follow the bulk of the literature dealing with monetary DSGE models (Ascari and Rossi, 2012; Ascari and Sbordone, 2014). Furthermore, several studies indicate that this assumption is a good approximation of more elaborate state-dependent pricing schemes as long as trend inflation is not too high (Alvarez et al., 2011; Costain and Nakov, 2011; Kehoe and Midrigan, 2015). Moreover, the empirical fit of standard New Keynesian models seems to be significantly better under Calvo pricing than under the frequently employed alternative of Rotemberg-pricing (Ascari et al., 2011).

analysis. In particular, the price dispersion and the average level of monopolistic markups increase in trend inflation. The associated distortions significantly depress the long-run level of output, consumption, real wages and other aggregates. Furthermore, with a higher average inflation, price-adjusting firms effectively become more forward looking, thus paying relatively less attention to current macroeconomic conditions. Accordingly, recessionary shocks - such as banking panics - are associated with smaller declines in the aggregate price level.[5]

The incidence of a banking panic in the model economy mainly depends on the magnitude of the decline in asset prices in the case of a run (Gertler and Kiyotaki, 2015). Our main analysis below shows that, under a higher trend inflation, this decline is stronger. Accordingly, the deterioration of banks' balance sheets is larger, thus making it more likely that the aggregate net worth will be wiped out in the case of a forced liquidation. The intuition behind the stronger drop in asset values is the following. A higher trend inflation makes firms' price setting more forward looking, i.e. it becomes less responsive to current economic conditions (Ascari and Sbordone, 2014). Accordingly, while the temporary recession induced by a bank run is associated with a decline in the current price level and inflation, this decline is smaller. The weaker drop in inflation magnifies the fall in run-equilibrium asset prices mainly via two channels. First, according to its Taylor rule, the central bank needs to engineer a smaller decrease in the policy rate. Accordingly, there is a weaker decline in the expected real interest rate. Since the latter reflects the opportunity costs of holding firm assets (physical capital), demand for those assets is relatively weaker, thus reinforcing the fall in asset prices. Second, the more forward looking pricing behavior associated with a higher trend inflation also implies a relatively stronger drop in aggregate demand as the fall in goods prices is muted. The weaker aggregate

[5] See e.g. Ascari and Sbordone (2014) for a detailed discussion of these as well as further effects of trend inflation. In particular, a higher trend inflation is associated with a faster average growth in nominal costs and thus a faster erosion of real profits if a firm's selling price is fixed over a certain period of time, as under the Calvo-assumption. Accordingly, if given the opportunity to reoptimize its price, it becomes worthwhile for a firm to pay more attention to that potential future profit erosion rather than respond to purely temporary changes in current marginal costs induced by a bank run or other structural shocks.

demand strengthens the downward pressure on the expected rental rate of capital and the associated earnings on assets, thus, deepening the drop in the liquidation asset price.

All results are derived under the assumption that in *normal times* the agents of the economy do not anticipate the possibility of bank runs. We do this for two reasons. First, this facilitates greatly the exposition of the model and the numerical solution method we can employ, as described in the model section below. Second, in the spirit of Gabaix (2020) we acknowledge the fact that both in reality and in our model economy financial panics are rare atypical events that are hard to predict. We therefore assume agents are rational in normal times but do not internalize the possibility of rare bank-run equilibria when forming expectations.

Our paper closely relates to three strands of the literature. First, as mentioned above, there are numerous studies investigating the effects of trend inflation within macroeconomic models, most of which of the DSGE type. The majority of these papers is comprehensively surveyed by Ascari and Sbordone (2014) while more recent contributions include Cecchetti et al. (2023), Marsal et al. (2023) and Ascari et al. (2023). These studies, however, only consider the potential effects of trend inflation on real activity, the volatility of business cycles and the uniqueness and learnability of the rational expectations equilibrium while being silent about possible financial stability consequences. The second related literature strand comprises papers explicitly integrating bank runs or financial crises into DSGE frameworks (e.g. Angeloni and Faia (2013), Angeloni et al. (2015), Gertler and Kiyotaki (2015), Boissay et al. (2016), Gertler et al. (2016), Gertler et al. (2020), Rottner (2023)). However, the corresponding models are either real or – when monetary – abstract from discussing trend inflation or disinflationary episodes. Finally, our paper is also related to papers dealing with the optimal rate of trend/target inflation. As mentioned above, several authors have argued in favour of a shift towards a higher inflation target in order to reduce the likelihood of a binding ZLB (Krugman, 1998; Williams, 2009; Blanchard et al., 2010; Ball, 2013; Andrade et al., 2019, 2021).

More recent contributions show that accounting for firm heterogeneity, product life cycles and firm-specific productivity trends in DSGE models imply significantly positive optimal trend inflation rates, e.g. between 1% and 3% for the US, around 3% for the UK and between 1.1% and 1.7% in the largest euro area economies (see Adam and Weber (2019, 2023) and Adam et al. (2022)). Occasionally binding financial constraints can also give rise to positive optimal trend inflation (Abo-Zaid, 2015). By contrast, factors like errors in measuring the price index, improvements in product quality or downward nominal wage rigidity seem to justify merely very low positive trend inflation (Schmitt-Grohe and Uribe, 2011).

More technically, compared to Gertler et al. (2020) and Rottner (2023), there are three main differences. First, in order to have a richer role of trend inflation, we assume Calvo pricing rather than price adjustment costs à la Rotemberg (1982) in a DSGE model with bank runs. Second, we focus on unanticipated bank runs allowing us to employ piece-wise perturbation techniques to solve the model. Accordingly, we are able to integrate many endogenous state variables and study a richer set of shocks (demand, supply, monetary). This flexibility is potentially advantageous for many analyses conducted at central banks and other policy institutions. Third, to the best of our knowledge, we are the first to calibrate such a bank run model to euro area data.

On the empirical front, Demirguc-Kunt and Detragiache (1998) find a significant positive correlation between actual inflation and the probability of financial crises, based on a panel of mainly emerging and developing economies. More recently, based on a panel of advanced economies, Albertazzi et al. (2025) find a causal relationship between inflationary shocks unrelated to changes in monetary policy and the probability of financial crises. The authors describe various mechanisms which might potentially be responsible for this relationship. By contrast, Jimenez et al. (2026) focus on the effects of changes in monetary policy rates on the likelihood of crises. In particular, based on a similar panel, they find a U-shaped relationship - policy rate hikes (raw or instrumented) increase crisis risk, but only if preceded by prolonged cuts. Jimenez et al. (2026) also find that prolonged cuts raise the likelihood of large credit and asset price booms while the subsequent hikes strongly reduce credit and asset prices, and increase banks' realized credit risk. We complement these empirical findings by explicitly focusing on trend inflation and its relationship with the likelihood of crises rather than looking at inflationary shocks or changes in monetary policy rates.

The remainder of the paper is structured as follows. Section 2 provides descriptive evidence on the relationship between trend inflation and the probability of financial crises. Section 3 sets up the theoretical model, while section 4 describes the calibration. Section 5 presents our main quantitative results. Section 6 discusses the effects of disinflation on financial stability, section 7 shows the results regarding the zero lower bound, and section 8 provides insights regarding financial stability implications of changes in monetary and macroprudential policy. Finally, Section 9 concludes.

2 Descriptive empirical evidence

As a further motivation for our analysis we provide descriptive evidence suggesting a positive relationship between proxies of trend inflation and the likelihood of financial crises. It is important to note, however, that our estimation results are based on reduced form regressions. Accordingly, they do not reflect a causal relationship but rather a statistical correlation.

We resort to the *Macrohistory Database* constructed by Jordà et al. (2017), comprising annual data for the major advanced economies, spanning more than 100 years. The database also contains a financial crisis indicator. It is based on the narrative definition of historical crisis episodes described in Schularick and Taylor (2012), and equals one if a country was in a financial crisis in a particular year and zero otherwise. In what follows, this indicator will be denoted by *"crisis dummy (CD)"* and will serve as the

Table 1: Regression of crisis dummy on lags of trend inflation and controls

Dependent variable: *crisis dummy (CD)*

		(1)	(2)	(3)	(4)
	Baseline	Using 4 lags of trend inflation	Define $\bar{\pi}$ as the HP-trend of inflation	Define $\bar{\pi}$ as the 5-year moving average of inflation	Probit (specification as in Baseline)
$\bar{\pi}_{t-1}$	0.00284**	0.0173**	0.00225*	0.00141*	0.0656**
$\bar{\pi}_{t-2}$		-0.00562			
$\bar{\pi}_{t-3}$		-0.00817			
$\bar{\pi}_{t-4}$		-0.00152			
Const.	-0.0129	-0.00562	-0.00854	-0.00787	-3.134***
Country FE	YES	YES	YES	YES	-
Country dummies	-	-	-	-	YES
Obs.	1,000	986	1,000	1,000	1,000
N countries	16	16	16	16	16

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Notes: Country panel covering the period 1955 - 2019, consisting of 16 advanced economies, based on annual data. Dependent variable: a *"crisis dummy"* equal to one in crisis years and zero otherwise. Main explanatory variable: various lags of trend inflation $\bar{\pi}$. For the definition of $\bar{\pi}$, the additional control variables and the list of countries see Appendix A. Coefficients on control variables omitted for brevity. Data source: *Macrohistory Database* by Jordà et al. (2017). For the linear probability models we use robust Newey-West standard errors to control for heteroscedasticity as well as serial correlation.

dependent variable in the regressions discussed below. The definition of our proxy for trend inflation $\bar{\pi}_t$ follows the empirical literature dealing with disinflation episodes and estimating sacrifice ratios (Goncalves and Carvalho, 2009; Gibbs and Kulish, 2017). Those contributions resort to quarterly data and define trend inflation as the 9-quarters moving average of the actual inflation rate. We resort to a similar definition, however, since we use an annual database, we assume that $\bar{\pi}_t$ corresponds to the 3-year *backward* moving average of inflation in the consumer price index (CPI), i.e.

$$\bar{\pi}_{i,t} = (\pi_{i,t} + \pi_{i,t-1} + \pi_{i,t-2})/3,$$

where the subscript i is the country index. In our baseline specification, we use a *backward* moving average instead of a *centered* one to reduce the endogeneity bias potentially present in our regression. Later on, however, we perform robustness checks with alternative definitions of trend inflation. The data employed in the estimation is taken from the

Macrohistory Database. Our sample comprises 16 advanced economies over the period 1955 - 2019.[6]

Our baseline specification for assessing the relationship between trend inflation and the frequency of financial crises is the following linear probability model

$$CD_{i,t} = \alpha_i + \sum_{k=1}^{L} \beta_k \bar{\pi}_{i,t-k} + \sum_{k=1}^{B} \gamma_k \Delta LtoGDP_{i,t-k} + \sum_{k=1}^{B} \Phi_k X_{i,t-k} + \epsilon_{i,t}, \tag{1}$$

where $CD_{i,t}$ is the crisis dummy, α_i is a country fixed effect and $\epsilon_{i,t}$ is the regression residual. In the baseline specification, we set the number of lags for trend inflation to one, i.e. $L = 1$. The main control variables are the lags of the year-on-year changes in the loan-to-GDP ratio $\Delta LtoGDP_{i,t}$. As pointed out by Schularick and Taylor (2012), Jordà et al. (2015) and Jordà et al. (2021), it is the main determinant (and predictor) of financial crises.[7] These papers also advocate using 5 lags of $\Delta LtoGDP_{i,t}$ since credit booms are typically phenomena that last for many years (Schularick and Taylor, 2012). We set $B = 5$ as well. The baseline regression (1) further includes five lags of each of the following additional control variables, stacked in the vector $X_{i,t}$: *(i)* growth rate of real GDP, *(ii)* short-term real interest rate and *(iii)* growth rate of real house prices. These variables have also been shown to have explanatory as well as predictive power for financial crises.[8]

The main empirical result is reported in the column "Baseline" in Table 1. As can be seen, the coefficient of lagged trend inflation $\bar{\pi}_{t-1}$ is positive and statistically significant, suggesting that an elevated trend inflation comes about with a higher crisis probability. The estimated coefficients of the control variables are omitted in Table 1 for brevity but the interested reader is referred to Table 5 in Appendix A.

[6]The panel is unbalanced due to data availability. The countries included in our sample are: Australia, Belgium, Denmark, Finland, France, Germany, Italy, Japan, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, UK and US. We restrict the analysis to the period 1955 - 2019 since major political transformations, shifts in country borders and two world wars in the period prior to 1955 and the Covid-19 pandemic in 2020 are potential sources of structural breaks which might bias our econometric results.

[7]See also Drehmann and Juselius (2014).

[8]See for example Schularick and Taylor (2012) and the literature cited there.

We perform the following robustness checks by varying the control variables, the definition of trend inflation or the estimation procedure: (1) replacing the 5 lags of the change in the loans-to-GDP ratio $\Delta LtoGDP_t$ by the 5-year change in that variable $\Delta^5 LtoGDP_t$; (2) replacing the lags of $\Delta LtoGDP_t$ by those of the growth rate in real loans; (3) replacing the lags of real house price growth by those of real equity price growth; (4) including up to 4 lags of trend inflation; (5) defining trend inflation as the trend based on the Hodrick-Prescott (HP) filter with a smoothing parameter equal to 100; (6) defining trend inflation as the 5-year moving average of actual inflation; (7) probit estimation with the same explanatory variables as in Baseline; (8) defining trend inflation as the *centered* 3-year moving average of actual inflation; (9) defining trend inflation as the *centered* 5-year moving average of actual inflation.[9] The results, shown in columns (1) - (9) of Table 6 in Appendix A, confirm our findings obtained with the Baseline specification.

3 The model

The baseline model framework follows closely Gertler et al. (2020). It is a New Keynesian model with investment where households consist of bankers and workers. Bankers operate the banks which use their equity capital (net worth) as well as the deposits collected from households to provide productive assets (capital) via a competitive rental market to non-financial firms. Households can rent their assets to firms directly, but are less efficient than bankers in doing so. Due to a moral hazard friction, the market restricts bankers' ability to raise external funds. In addition, banks may be subject to runs.

The production side of the economy is standard, consisting of three sectors - i.e. producing final goods, intermediate goods and capital goods, respectively. The nominal

[9] The *centered* 3-year and 5-year moving averages of inflation are defined as:

$$\bar{\pi}_{i,t} = (\pi_{i,t+m} + ... + \pi_{i,t} + ... + \pi_{i,t-m})/(2m+1),$$

where $m = 1$ or $m = 2$ respectively. Trend inflation defined in this way enters the regression equation (1) as a contemporaneous – i.e. not lagged – variable.

rigidity in this economy results from the assumption of staggered price setting in the intermediate goods sector where each firm faces a constant per-period probability of being unable to adjust its nominal price (Calvo, 1983). Finally, there is a central bank setting the nominal interest rate by means of a standard Taylor rule.

As discussed below, in certain states of nature - e.g. after a sequence of unfavourable macroeconomic shocks or when banks are highly leveraged, the model exhibits two equilibria. One is characterized by normal behavior of the economy and a smoothly operating banking sector, labelled the *"no-run equilibrium"*, the *"normal equilibrium* or simply *"normal times"* interchangeably. The second equilibrium corresponds to a situation in which households withdraw their bank deposits in a run-like manner and banks have to liquidate their assets. We will refer to this allocation as the *"run equilibrium"* or the *"crisis equilibrium"*.

3.1 Capital

Capital evolves according to

$$k_t = \left(\Gamma\left(\frac{i_t}{\Xi_t^k k_{t-1}}\right) + (1-\delta)\right)\Xi_t^k k_{t-1}$$

where i_t are real aggregate investment expenditures, δ is the rate of depreciation, and $\Xi_t^k = exp(\xi_t^k)$ is a capital quality shock that follows an AR(1) process

$$\xi_t^k = \rho_{\xi^k}\xi_{t-1}^k + \varepsilon_{\xi^k,t} \qquad \varepsilon_{\xi^k,t} \sim N(0, \sigma_{\xi^k}^2).$$

The presence of capital adjustment costs is captured by the concave function $\Gamma(\cdot)$ whose functional form and parametrization will be specified in Section 4. The total capital stock can be financed by households or bankers,

$$k_t = k_t^b + k_t^h.$$

A continuum of measure one of competitive capital goods producers, owned by households, produce new capital goods and sell them at a nominal market price Q_t, using the final goods, purchased at the nominal price P_t, as input. The decision problem for the representative capital producer is

$$\max_{i_t} \Pi_t^k = Q_t \Gamma \left(\frac{i_t}{\Xi_t^k k_{t-1}} \right) \Xi_t^k k_{t-1} - P_t i_t$$

The first order condition gives the Q-relationship for the capital price and investment

$$q_t = \left[\Gamma' \left(\frac{i_t}{\Xi_t^k k_{t-1}} \right) \right]^{-1}$$

where $q_t = Q_t / P_t$ denotes the real capital price.

3.2 Households

Each household is a family consisting of a continuum of members with mass unity. Within each household, there is a constant fraction $(1 - f)$ of workers and f bankers. Workers supply labor and earn wages, each banker manages a bank and transfers non-negative dividends to the household. Within each household, all resources deriving from wages, firm profits, and bank dividend payments are pooled and there is perfect consumption sharing. Households own the firms in the final, intermediate and capital producing sectors and receive the associated profits. In every period, bankers exit and become workers with an i.i.d. probability $1 - \sigma$. In case of exit, all accumulated earnings are returned to the household. To keep the population constant, each period a fraction of $(1 - \sigma) f$ workers become bankers. New bankers receive an exogenously given initial endowment of equity (or wealth) amounting to e_t.

The utility function of the household is given by

$$U_t = E_t \left\{ \sum_{s=t}^{\infty} \beta^{s-t} \left[\frac{c_s^{1-\eta}}{1-\eta} - \chi \frac{l_s^{1+\psi}}{1+\psi} \right] \right\} \qquad \eta, \psi > 0.$$

Households take as given the nominal price level, P_t, the nominal price of capital, Q_t, the nominal rental rate on capital, Z_t, the nominal wage, W_t, nominal profits from the firm and capital sector, $\Pi_t^{f,k}$, and nominal dividends of exiting bankers net of transfers to new bankers, Π_t^b. Households save by either lending funds in form of (uninsured) deposits to banks or by holding capital directly. As in Gertler et al. (2020), bank deposits D_t^h held from t to $t+1$ are nominal one-period bonds that promise to pay a non-contingent nominal gross rate of return $\bar{R}_t^n = 1 + r_t^n$ in *normal times (no-run equilibrium)*. In the event of a bank run - i.e. a *run equilibrium*, depositors receive a fraction $x_{t+1}^{\star} \in [0,1)$ of the promised return, where $x_{t+1}^{\star}$ is the total liquidation value of bank assets per unit of promised deposit obligations.[10] The return on deposits is then given by

$$R_{t+1}^n = \begin{cases} 1 + r_t^n & \text{if } \textit{no-run equilibrium} \\ x_{t+1}^{\star}(1 + r_t^n) & \text{if } \textit{run equilibrium.} \end{cases}$$

Throughout this paper, we focus on the case where bank runs are completely unanticipated events. Therefore, households choose consumption, labor supply, and savings under the assumption that the realized return on deposits equals the gross nominal interest rate with certainty.

Households are less efficient than banks in intermediating capital to the private sector. This comparative advantage, albeit being modeled in a stylized and reduced form as in Gertler et al. (2020), is meant to reflect the higher ability of banks to secure loans by properly evaluated collateral as well as to monitor borrowers and their projects, e.g. due to relationship lending and enhanced inside information.[11] This is captured by the

[10] As in Gertler et al. (2020), runs can only exist if and only if $x_{t+1}^{\star} < 1$.

[11] For theoretical and empirical evidence in support of this assumption see for example Berger and Udell (1992), Gande and Saunders (2012) and Boot and Thakor (2019) as well as the literature cited

following capital management/intermediation cost:

$$\varkappa_t = \frac{\gamma}{2}\left(\frac{k_t^h}{k_t} - \kappa\right)^2 k_t.$$

The interpretation of $\varkappa_t$ is that households have to hire a fund or asset manager to intermediate their capital. We assume that, in equilibrium, the costs reflected in $\varkappa_t$ are redistributed back to the household in the form of lump sum transfers T_t^m, the latter representing in a reduced form the profits of the asset manager.[12]

The household's budget constraint can then be written in nominal terms as:

$$P_t c_t + Q_t k_t^h + D_t^h + P_t \frac{\gamma}{2}\left(\frac{k_t^h}{k_t} - \kappa\right)^2 k_t = W_t l_t + (Z_t + (1-\delta)Q_t)\Xi_t^k k_{t-1}^h + R_t^n D_{t-1}^h + \Pi_t^{f,k} + \Pi_t^b + T_t^m$$

The corresponding first order conditions in real terms are:

$$\lambda_t = c_t^{-\eta}$$

$$\lambda_t w_t = \chi l_t^{\psi}$$

$$1 = \beta E_t \left\{ \frac{\lambda_{t+1}}{\lambda_t} \frac{1 + r_t^n}{\Pi_{t+1}} \right\} \tag{2}$$

$$q_t = \beta E_t \left\{ \frac{\lambda_{t+1}}{\lambda_t} (z_{t+1} + (1-\delta) q_{t+1}) \Xi_{t+1}^k \right\} - \gamma(k_t^h/k_t - \kappa), \tag{3}$$

where λ_t is the shadow price for marginally relaxing the budget constraint and q_t is the real capital price.

there.

[12]As in Gertler et al. (2020), the cost is not a deadweight cost as a shock that would induce higher capital management costs (like a negative productivity shock or contractionary monetary shock) would - contrafactually - imply that household work more compared to the steady state to make up for the deadweight cost. Presumably for the same reason, Gertler et al. (2020) assume a capital management costs that directly affects the households' utility. We also checked this specification and found that at long-run inflation rates below 8% the model behaves qualitatively and quantitatively very similar to our benchmark model; at very large long-run inflation rates above 8% it can differ in their prediction regarding the run probability. As we study an advanced economy where very high long-run inflation rates are empirically less relevant, we prefer our benchmark specification for expositional reasons.

3.3 Banks

Banks are completely unregulated,[13] invest in a long-term security (capital) financed by bank equity (accumulated through retaining earnings) and short-term debt. Households are not protected by deposit insurance and therefore banks are potentially subject to bank runs.

Each banker manages a financial intermediary with the objective of maximizing the expected discounted value of net worth, N_t, upon exit,[14] taking as given the stochastic discount factor of the household, $\beta^s \lambda_{t+s}/\lambda_t$:

$$V_t = \beta E_t \left\{ \frac{\lambda_{t+1}}{\lambda_t} \frac{P_t}{P_{t+1}} \left[(1-\sigma) N_{t+1} + \sigma V_{t+1} \right] \right\}$$

The probability of exit in period $t+1$ is $(1-\sigma)$, and N_{t+1} is nominal net-worth accumulated through retained earnings until date $t+1$. The banker is subject to the nominal flow of funds constraint[15]

$$Q_t k_t^b - D_t^b = (Z_t + (1-\delta) Q_t) \Xi_t^k k_{t-1}^b - R_t^n D_{t-1}^b$$

taking as given the capital price Q_t, the capital rental rate Z_t, and the nominal deposit interest rate r_t^n, and the balance sheet identity

$$Q_t k_t^b = N_t + D_t^b.$$

From the flow of funds constraint and the balance sheet identity – both written in real terms – it follows that the incumbent banker's net worth at the end of period t can be

[13] An alternative interpretation is that banking regulation is not the binding constraint for banks but the implied "capital requirement" requested by the market participants for lending to banks.

[14] See Gertler et al. (2020) for a formal proof that a surviving banker always wants to delay dividend payout until exit.

[15] Here we have already used that (1) incumbent bankers never want to pay positive dividends before they exit, and (2) that incumbent bankers cannot issue equity, so that net worth can only be accumulated through retaining earnings.

represented as:

$$n_t = R^b_t q_{t-1} k^b_{t-1} - R_t d^b_{t-1} = (R^b_t - R_t) q_{t-1} k^b_{t-1} + R_t n_{t-1},$$

with $n_t = N_t/P_t$, $d_t = D_t/P_t$ and the gross real return on capital and deposit defined as:

$$R^b_t = \frac{(z_t + (1-\delta)q_t)\Xi^k_t}{q_{t-1}} \qquad R_t = \frac{1 + r^n_{t-1}}{\Pi_t}.$$

It is convenient to write the law of motion for net worth n_t as

$$n_t = \left((R^b_t - R_t)\phi_{t-1} + R_t\right) n_{t-1},$$

where ϕ_t is bank leverage, defined as

$$\phi_t = \frac{q_t k^b_t}{n_t}.$$

The banker is protected by limited liability, so that $N_t \geq 0$ for all t. Furthermore, since it is costless for banks to default, a bank will do so whenever the value of his bank's assets is smaller than the debt it owes. In that case, bank net worth is zero, and creditors (households) receive the recovery value of the bank portfolio. In principle, even absent runs, banks can default due to the realisation of very bad shocks. However, for all calibrations considered in this paper, such "standard" insolvencies do not occur in *normal times*.[16] We describe bank defaults associated with bank runs in Subsection 3.4.[17]

[16]The result that only run-driven bank failures can occur is consistent with recent evidence emphasizing solvency and fundamentals Correia et al. (2026). In our model, runs can only occur when the real economy and banking sector already display weak fundamentals; the set of shocks that generates outright insolvency is a strict subset of the set that makes runs possible, see also Gertler et al. (2019). Under our calibration, insolvency-inducing shocks are so rare that they effectively never occur, while smaller adverse shocks can still trigger runs. We abstract from policy interventions (e.g. interbank coordination, equity injections, liquidity support) that could prevent such runs; the present framework could be used to assess in which states of the world such interventions would be necessary to prevent bank runs.

[17]In this framework, the firm sector does not explicitly face a Fisher debt deflation effect and the potentially associated firm defaults. Such effects are implicitly captured by the fluctuations in the required real rental rate on capital and the return on capital received by banks.

The banker can divert a fraction θ of the bank's assets. This gives rise to the incentive constraint that requires the continuation value of operating the bank without asset diversion to be larger than the value of diverting assets:

$$\theta Q_t k_t^b \leq V_t.$$

Gertler and Kiyotaki (2015) and Gertler et al. (2020) show that the value function of the banker divided by current net worth, $v_t \equiv V_t/N_t$, is linear in leverage:

$$v_t = \mu_t \phi_t + \nu_t$$

with

$$\mu_t = \beta E_t \left\{ \frac{\lambda_{t+1}}{\lambda_t} [(1-\sigma) + \sigma v_{t+1}](R_{t+1}^b - R_{t+1}) \right\} \tag{4}$$

and

$$\nu_t = \beta E_t \left\{ \frac{\lambda_{t+1}}{\lambda_t} [(1-\sigma) + \sigma v_{t+1}] R_{t+1} \right\}. \tag{5}$$

Therefore, as long as $\mu_t > 0$, the bank chooses to be as leveraged as possible and so the incentive constraint is binding and determines the maximum amount of leverage admissible to banks:[18]

$$\phi_t = \frac{\nu_t}{\theta - \mu_t} \tag{6}$$

For the banks' problem to be well defined, we need $\theta > \mu_t$ for all t. For the baseline as well as alternative calibrations used below, this is indeed the case in all the states of nature for which we simulate the model.

Law of motion for aggregate bank net worth. A fraction of σ of all bankers are incumbents that continue operations into next period. Their net worth evolves as

[18]Conversely, when the incentive constraint is not binding, we must have $\mu_t = 0$. The bank is then indifferent about the level of leverage. The latter is rather determined by the household's first order conditions, in particular, implying that in equilibrium there is indeed no credit spread, i.e. $\mu_t = 0$. For the calibrations considered in this paper, this case never happens.

described above. The net worth of the $(1-\sigma)$ exiting bankers is 0 because all net worth is paid out as dividends to households. New entering bankers (of mass $(1-\sigma)f$) receive an exogenous per capita equity endowment that is proportional of the aggregate value of productive capital, i.e. $e_t = \frac{\tau}{f} q_t \Xi_t k_{t-1}$ from households. Putting all this together implies that aggregate net worth evolves according to:

$$n_t = \sigma \left((R_t^k - R_t)\phi_{t-1} + R_t \right) n_{t-1} + (1-\sigma)\tau q_t \Xi_t k_{t-1} \tag{7}$$

3.4 Unanticipated bank runs

Bank defaults can happen either through insolvency due to a bad realisations of exogenous shocks or through bank runs. For all calibrations we employ in this paper, the former type of default never happens. We therefore consider only default due to bank runs. Two model assumptions are crucial for bank runs to be possible in this framework. First, the presence of the above described *incentive constraint* on banks to prevent asset diversion by bankers. The constraint requires that banks operate with sufficient net worth, and accordingly a sufficiently low leverage. Otherwise, in case the constraint is violated, depositors will immediately withdraw their funds to circumvent the losses associated with diversion. By implying that the bank cannot operate with non-positive net worth, the constraint opens the door for the possibility of runs. In the latter's event, the associated asset liquidation will wipe out bank's net worth, thus, violating the incentive restriction. Due to the moral hazard problem, a depositor investing in a zero net worth bank will lose her money for sure. Accordingly, if a run is expected, it becomes individually optimal to participate in it.

The second crucial assumption is that banks are relatively more efficient in intermediating credit than households, modelled by the households' capital management cost described above. In the case of a system-wide bank run, banks have to liquidate assets by selling them to non-banks. As the latter are relatively less efficient in intermediating assets, their demand for assets is low which, in turn, leads to a decline in asset prices. Without this comparative disadvantage of non-banks, the drop in asset prices will be typically insufficient to drive the banking sector into insolvency.

Furthermore, we focus on *unanticipated* runs only. In particular, we assume that while, under certain conditions that will be discussed shortly, a *run equilibrium* can exist and may materialize ex post, agents do not embed this in their expectations. That is, as long as the economy is in the *normal equilibrium*, households, firms and bankers are unaware of (or significantly underestimate) the possibility of bank runs. However, if in a given period a run materializes, it is expected that, from the following period on, households will resume supplying deposits to banks and the economy will gradually converge back to the *normal equilibrium*.

We believe this assumption is advantageous for two reasons. First, in our view this is a first-pass reasonable approximation for the workings of capital markets, as it is hard to predict atypical and rare events such as a financial crisis due to a run in financial markets (Gabaix, 2020). Second, it allows us to solve the model with piece-wise linear approximation methods, as we do not have to keep track of the feedback loop between the run equilibrium and the normal equilibrium. Details are described in the numerical section below.

Condition for existence of a bank run equilibrium. Following Gertler and Kiyotaki (2015) and Gertler et al. (2020), a bank run equilibrium exists in period t if and only if the per unit recovery rate, conditional on the real capital rental rate $z_t^\star$, the real asset liquidation price $q_t^\star$ and inflation rate $\Pi_t^\star$ in case of a run, is less than unity:

$$\begin{aligned} x_t^\star &= \frac{(z_t^\star + (1-\delta)q_t^\star)\Xi_t^k}{\frac{1+r_{t-1}^n}{\Pi_t^\star}} \frac{k_{t-1}^b}{d_{t-1}^b} \\ &= \frac{R_t^{b,\star}}{R_t^\star} \frac{\phi_{t-1}}{\phi_{t-1}-1} < 1, \end{aligned} \tag{8}$$

where the superscript ($\star$) indicates that the corresponding variable is evaluated at the *run/crisis equilibrium*.[19] The liquidation price $q_t^\star$ is generally smaller than the *normal-times* market price q_t, so a run may occur even if the bank is solvent at normal market prices. The existence of a *crisis equilibrium* also depends on the real interest rate, and therefore on the current realization of inflation conditional on a run. Finally, $x_t^\star$ is decreasing in bank leverage.

It is evident that long-run inflation or persistent deviations from the long-run target can impact $x_t^\star$ in four ways: (i) through $z_t^\star$ which is affected by the distortions due to price dispersion and monopolistic markups in the economy; (ii) through $q_t^\star$ as it depends on *expected* real interest rates and thus on future inflation; (iii) through the realized real interest rate $R_t^\star$ as it is inversely related to actual current inflation; and (iv) through leverage ϕ_{t-1}. The exercise below is to exactly show the impact of changes in long-run inflation on each of those components and quantify the total effect on the distribution of $x_t^\star$ in a stationary equilibrium.

Even if a run equilibrium is feasible, i.e. when $x_t^\star < 1$, the run can only occur if households decide to coordinate on the run equilibrium. As Gertler et al. (2020), we assume the latter is governed by the realization of a sunspot. Let ε_t^ι be a binary i.i.d. sunspot variable that takes on a value of 1 with probability ι and a value of 0 with probability $1 - \iota$. In the event of $\varepsilon_t^\iota = 1$, households coordinate on a run if the bank run equilibrium exists.

Hence, the associated unconditional probability of bank runs is given by

$$p_{\text{run}} = \text{Prob}(x^\star < 1) \cdot \iota.$$

Liquidation price. In case a bank run happens, banks default and sell their assets to households who become the holders of the entire physical capital stock, that is $k_t^h = k_t$.

[19]See Appendix B for the full set of equations describing the run equilibrium.

The liquidation price is then determined by the household's Euler equation (3) with respect to capital:

$$q_t^\star = \beta E_t \left\{ \frac{\lambda_{t+1}^\star}{\lambda_t^\star} \left(z_{t+1}^\star + (1-\delta) q_{t+1}^\star \right) \Xi_{t+1}^k | \text{run in } t \right\} - \gamma(1-\kappa)$$

Inflation and marginal costs in the *crisis equilibrium* are determined by the other forward looking equations, the household's Euler equation for deposits (2) and the Philips curve (9).[20] We assume that during a run households do not transfer any equity to new bankers. Therefore, the law of motion for aggregate net worth (7) implies that net worth in the period after the run is $n_{t+1} = (1-\sigma)\tau q_t \Xi_t k_{t-1}$.[21]

3.5 Production and aggregation in the firm sector

Since the production sector is fairly standard, here we solely provide a brief sketch of the most important definitions and optimality conditions. The full set of equations describing the behavior of goods producing firm can be found in Appendix B.

Final output is a CES aggregate over a continuum of intermediate goods

$$y_t = \left(\int_0^1 y_t(j)^{\frac{\epsilon-1}{\epsilon}} dj \right)^{\frac{\epsilon}{\epsilon-1}} \qquad \epsilon > 1.$$

[20]Even though equilibrium deposits are zero in a run equilibrium, the pricing of deposits still needs to be intact to support the equilibrium. Alternatively, we could assume the presence of one-period riskless nominal bonds in zero net supply. By no-arbitrage, households are indifferent between holding bonds or deposits, so that the bond return and the deposit return are equal in equilibrium.

[21]Gertler et al. (2020) assume instead that new bankers cannot operate in the period the run occurs but can store their equity endowment and use it in the period after the run to start bank operations again. We have considered this specification. We have also looked at the case where households run on incumbent banks but not on new entering bankers, that is, $k_t^h = k_t - (1-\sigma)\tau/q_t^\star$ and new bankers operate with 100% equity funding. The results are quantitatively very similar to the benchmark. The precise assumption about the evolution of banks' net worth after the run does not significantly affect our results. The reason for this insensitivity is that the transfers to new bankers are very small in all our calibrations.

The associated demand for intermediate good j is given by

$$y_t(j) = \left(\frac{P_t(j)}{P_t}\right)^{-\epsilon} y_t.$$

Intermediate good producers operate a constant return to scale production technology using capital and labor as inputs,

$$y_t(j) = A_t k_t(j)^{\alpha} l_t(j)^{1-\alpha}$$

where $\alpha \in (0,1)$ is the capital share and productivity $A_t = exp(a_t)$ follows an AR(1) process in logs:

$$a_t = \rho_a a_{t-1} + \varepsilon_t^a \qquad \varepsilon_t^a \sim N(0, \sigma_a^2).$$

Given common factor prices and identical production technologies, cost minimization implies that marginal costs are the same across firms. Let $z_t = Z_t/P_t$ denote the real rental rate of capital and $w_t = W_t/P_t$ be the real wage. Then, real marginal costs are given by

$$mc_t = \frac{z_t^{\alpha} w_t^{1-\alpha}}{A_t \alpha^{\alpha}(1-\alpha)^{1-\alpha}}.$$

Intermediate good firms operate under monopolistic competition, that is they enjoy some price-setting power. However, there is a nominal friction in the form of staggered price adjustment as in Calvo (1983). In particular, each firm faces a constant probability denoted by $1-\zeta$ of being able to change its price in a given period. The corresponding dynamic price-updating problem is then

$$\max_{P_t(j)} E_t \sum_{s=0}^{\infty} (\zeta\beta)^s \frac{\lambda_{t+s}}{\lambda_t} \left(\frac{P_t(j)}{P_{t+s}}\right)^{-\epsilon} \left(\frac{P_t(j)}{P_{t+s}} - mc_{t+s}\right) Y_{t+s}$$

where $\beta^s \lambda_{t+s}/\lambda_t$ is the stochastic discount factor by which households discount future real profits. The first order condition with respect to the optimal *real* reset price p_t^{adj} is identical for all j and can be written recursively as:

$$p_t^{adj} = \frac{\epsilon}{\epsilon - 1} \frac{F_t}{H_t} \quad \text{with} \tag{9}$$

$$F_t = mc_t y_t + \beta \zeta E_t \frac{\lambda_{t+1}}{\lambda_t} \Pi_{t+1}^{\epsilon} F_{t+1} \tag{10}$$

$$H_t = y_t + \beta \zeta E_t \frac{\lambda_{t+1}}{\lambda_t} \Pi_{t+1}^{\epsilon - 1} H_{t+1}, \tag{11}$$

where $\Pi_{t+1} = P_{t+1}/P_t$ is the gross inflation rate between period t and $t+1$ while the corresponding inflation rate is $\pi_{t+1} = \Pi_{t+1} - 1$. The auxiliary variables F_t and H_t reflect the expected present values of future marginal costs and revenues respectively. The aggregate price index written in terms of gross inflation is:

$$1 = (1 - \zeta)(p_t^{adj})^{1-\epsilon} + \zeta \Pi_t^{\epsilon - 1} \tag{12}$$

Finally, aggregate output is given by

$$y_t = \Omega_t^{-1} A_t (\Xi_t^k k_{t-1})^{\alpha} l_t^{1-\alpha}, \tag{13}$$

where $\Omega_t = \int_0^1 (P_t(j)/P_t)^{-\epsilon} \, dj$ measures the degree of price dispersion in the economy, evolving according to the following law of motion:[22]

$$\Omega_t = (1 - \zeta)(p_t^{adj})^{-\epsilon} + \zeta \Pi_t^{\epsilon} \Omega_{t-1}. \tag{14}$$

3.6 Some important consequences of trend inflation

To understand the effects of trend inflation on the bank run probability we will describe in section 5, it is instructive to first review some well known consequences of trend inflation in the Calvo setup. As can be inferred from equations (9) through (14), trend inflation can have several non-trivial consequences for the economy. In particular, it affects both,

[22] For all market clearing conditions, see subsection 3.7.

the model's dynamics as well as the long-run level of several macro aggregates. In this section, we focus on those effects of trend inflation which are of major relevance for our main results. A more comprehensive discussion, covering many more aspects related to the presence of non-zero steady state inflation, can be found in Ascari and Sbordone (2014).

Trend inflation affects the dynamic response to shocks by making price adjusting firms more forward looking. Given that the price set in period t may remain unchanged in the future, such firms are aware that inflation will over time erode their future markups/profits. Accordingly, with higher average inflation, price adjusters pay a relatively higher attention to the future while viewing changes in current economic conditions - as reflected in current marginal costs - as relatively less important. Formally, this effect is reflected in the discount factors applied to future marginal costs and revenues in equations (10) and (11) respectively, both of which are adjusted by expected inflation. The consequence of gross trend inflation $\bar{\Pi} = 1 + \bar{\pi}$ is easiest to see by rewriting (9), (10) and (11) under the assumption that the future gross inflation will be equal to its trend, i.e. $\Pi_{t+s} = \bar{\Pi}$, $\forall s$, and the marginal utility of consumption λ_t remains constant. Then we would have

$$p_t^{adj} = \frac{\epsilon}{\epsilon - 1} \frac{E_t \sum_{s=0}^{\infty} \beta^s \zeta^s \bar{\Pi}^{s\epsilon} y_{t+s} mc_{t+s}}{E_t \sum_{s=0}^{\infty} \beta^s \zeta^s \bar{\Pi}^{s(\epsilon-1)} y_{t+s}}.$$

Note that the resulting factor for discounting future marginal costs is higher than that applied to future revenue.[23]

The level of aggregate output is also affected by trend inflation mainly *via* two channels The first reflects the effects of price dispersion. Price dispersion is a distortion as it indicates an asymmetric allocation of demand across consumption goods. By contrast,

[23]Since $\epsilon > 1$ by assumption, $\bar{\Pi}^{\epsilon}$ is higher than $\bar{\Pi}^{\epsilon-1}$ as long as $\bar{\Pi} > 1$. Accordingly, the discount factor for marginal costs is more strongly affected by inflation than that for revenue. The reason is the following. If the nominal price of a firm is to stay fixed, future inflation Π_{t+1} will increase the relative demand for the firm's products by a factor Π_{t+1}^{ϵ} and thus, the corresponding production costs by $\Pi_{t+1}^{\epsilon} mc_{t+1}$. By contrast, trend inflation has two opposing effects on expected revenue. On the one hand, relative demand increases by the same factor of Π_{t+1}^{ϵ}. However, on the other hand, the real profit per unit sold decreases by Π_{t+1}. As a consequence, the discount factor applied to revenue is adjusted by $\Pi_{t+1}^{\epsilon} \cdot \Pi_{t+1}^{(-1)} = \Pi_{t+1}^{\epsilon-1}$.

the corresponding efficient allocation would require the expenditure share of each good to be the same. Formally, the effect of trend inflation on price dispersion Ω is easily seen by evaluating equations (12) and (14) at the steady state, resulting in:

$$\Omega = (1-\zeta)^{\frac{1}{1-\varepsilon}} \frac{(1-\zeta\bar{\Pi}^{\varepsilon-1})^{\frac{\varepsilon}{\varepsilon-1}}}{1-\zeta\bar{\Pi}^{\varepsilon}}.$$

Inspection of the latter equation reveals that Ω rises in trend inflation. Furthermore, it can be shown that also outside the steady state, $\Omega_t \geq 1$ (Ascari and Sbordone, 2014). Thus, in equilibrium, price dispersion acts as a negative productivity shifter, that is, it reduces the aggregate amount of goods produced for any given input level (see equation (13)).

The second effect of trend inflation on the level of output operates through the distortion associated with the average monopolistic markup in the economy $mu_t = 1/mc_t$. Its steady state value mu can be derived by using equations (9) through (12):

$$mu = \frac{\varepsilon}{\varepsilon-1} \frac{(1-\beta\zeta\bar{\Pi}^{\varepsilon-1})(1-\zeta\bar{\Pi}^{\varepsilon-1})^{\frac{1}{\varepsilon-1}}}{(1-\zeta)^{\frac{1}{\varepsilon-1}}(1-\beta\zeta\bar{\Pi}^{\varepsilon})}.$$

It can be shown, that within the empirically relevant range of values for the elasticity of substitution ε and the discount factor β, the average markup increases in trend inflation.[24] The intuition again stems from the stronger forward lookingness of firms in an environment of higher trend inflation. In particular, when the latter is higher, future profits will erode faster if a firm's nominal price is to remain unchanged. As a consequence, if given the opportunity for price adjustment, firms tend to set higher nominal prices for any given level of current marginal costs.[25]

[24]The opposite is the case only for extremely high values of ε and/or extremely low values of β.

[25]More precisely, as discussed by King and Wolman (1996) and Ascari and Sbordone (2014), trend inflation exerts two opposing effects on the average markup. In particular, the latter can be decomposed as follows

$$mu = \left(\frac{P}{p^{adj}}\right)\left(\frac{p^{adj}}{MC}\right),$$

where MC denotes nominal marginal costs. The ratio P/p^{adj} is termed the *"price adjustment gap"* and relates the aggregate price index to the price chosen by price adjusters in the current period. p^{adj}/MC

In sum, trend inflation tends to strengthen the distortions associated with price dispersion and monopolistic competition. Unsurprisingly, and as we show quantitatively in Section 5.1, the long-run levels of aggregate output, consumption, real wages, real asset returns and other aggregates substantially decrease in steady-state inflation. To close this section, we derive the relationship between output, price dispersion and average markups in the stationary equilibrium. For expositional simplicity, we only show the result for an otherwise identical economy, however, without financial frictions. In such an economy's steady state, the real rental rate of capital z relates to the real deposit rate R as $z + (1 - \delta) = R = 1/\beta$. For aggregate output we obtain:

$$y = \vartheta \Omega^{-\frac{1+\psi}{(1-\alpha)(\psi+\eta)}} \cdot mu^{-\frac{1+\alpha\psi}{(1-\alpha)(\psi+\eta)}} \cdot \left(1 - \frac{\alpha\delta}{z}\frac{1}{mu}\right)^{-\frac{\eta}{\psi+\eta}},$$

where ϑ is a composite parameter depending on z as well as other model parameters.[26] Accordingly, y depends negatively on both, price dispersion Ω and the markup mu. Both of them increase in trend inflation as discussed above.

3.7 Monetary Policy and Market Clearing

Monetary policy follows a standard Taylor rule. According to it, the nominal policy rate r_t^n is a function of past nominal interest rate, and responds to current output and

is the *"marginal markup"*, i.e. the one chosen by price adjusting firms. The *price adjustment gap* is decreasing in trend inflation since the overall price index P heavily depends on prices set in the (distant) past. By contrast, the *marginal markup* increases in trend inflation. Formally, for p^{adj}/MC we have

$$\frac{p^{adj}}{MC} = \frac{\varepsilon}{\varepsilon - 1}\frac{1 - \beta\zeta\bar{\Pi}^{\varepsilon-1}}{1 - \beta\zeta\bar{\Pi}^{\varepsilon}}.$$

For empirically plausible parameterizations and as long as $\bar{\Pi} \geq 1$, the *marginal-markup* effect dominates.

[26] Regarding ϑ we get:

$$\vartheta = \left(\frac{1-\alpha}{\chi}\right)^{\frac{1}{\psi+\eta}} \left(\frac{\alpha}{z}\right)^{\frac{\alpha(1+\psi)}{(1-\alpha)(\psi+\eta)}} A^{\frac{1+\psi}{(1-\alpha)(\psi+\eta)}}.$$

inflation, and features interest rate smoothing:

$$1 + r_t^n = (1 + \bar{r}^n)^{1-\tau_r}(1 + r_{t-1}^n)^{\tau_r} \left(\frac{\Pi_t}{\bar{\Pi}}\right)^{\tau_\Pi(1-\tau_r)} \left(\frac{y_t}{\bar{Y}}\right)^{\tau_Y(1-\tau_r)} \Xi_t^n,$$

where the long-run targets for inflation $\bar{\Pi}$, output $\bar{Y}$ and the nominal interest rate $\bar{r}^n$ correspond to their respective levels in the deterministic steady state. The policy parameters satisfy $\tau_\Pi > 1$, $\tau_Y \geq 0$ and $\tau_r \in (0, 1)$. $\Xi_t^n = exp(\varepsilon_t^n)$ is a monetary shock that follows a White-Noise process in logs with $\varepsilon_t^n \sim N(0, \sigma_{\varepsilon^n}^2)$.

The labor market clears when households' labor supply equals demand by goods producing firms:

$$\int l_t(j)dj = l_t$$

Market clearing in the capital rental market requires total capital stock available for production at the beginning of the period, $\Xi_t^k k_{t-1}$, to equal firms' demand:

$$\int k_t(j)dj = \Xi_t^k k_{t-1}$$

Market clearing for new capital and deposits implies

$$k_t = k_t^b + k_t^h$$

$$D_t^h = D_t^b$$

Finally, goods market clearing implies

$$y_t = c_t + i_t$$

where y_t is defined in (13).

4 Calibration and solution method

The model is calibrated to the euro area by partly borrowing parameter values from the related DSGE literature and partly targeting certain empirical stylized facts. In case of the latter, we require that the model's steady state in *normal times*, i.e. *absent runs*, is consistent with the historical averages of several variables or ratios in the euro area. The calibration further assumes $\bar{\pi} = 2\%$ p.a. for the trend inflation rate. The empirical data used in the calibration is described in Appendix F.

The majority of the parameters in the non-financial sectors of the economy as well as those shaping the exogenous shock processes are set at values lying within the range of calibrations or estimates found in the related DSGE literature (see Table 2). These are the households' discount factor β, the risk aversion parameter η, the inverse Frisch-elasticity of labor supply ψ, the elasticity of substitution between intermediate goods ε, the depreciation rate δ, the capital share in production α, and the parameters of the monetary policy rule τ_Π, τ_Y, and τ_r. The corresponding values chosen are shown in Table 3. Regarding investment technology, we assume the following functional form:

$$\Gamma\left(\frac{i_t}{\Xi_t^k k_{t-1}}\right) = \frac{a}{1-\nu}\left(\frac{i_t}{\Xi_t^k k_{t-1}}\right)^{1-\nu} + b.$$

The elasticity ν is calibrated by requiring that the standard deviation of real investment i_t is three times larger than that of GDP. The slope a and constant b are chosen such that, in the stationary equilibrium, the real asset price q_t is equal to 1 and the investment-to-capital ratio is δ. The weight on disutility of labor χ is chosen such that, on average, households work one-third of their time. Average firm productivity A is set such that the steady state capital stock is normalized to 1.

The banking sector parameters are summarized in Table 4 and are selected as follows. The survival probability σ, the return on assets for bankers when diverting funds θ, and the equity injection τ for entering new banks are jointly chosen to match the following data

Table 2: Calibrated/estimated parameter values in the literature

Study	η	ψ	ε	τ_Π	τ_Y	τ_r
Gali et al. (2001)	–	–	10	–	–	–
Smets and Wouters (2003)	1.6	1.2	–	1.7	0.10	0.81
Rabanal (2003)	3.9	1.0	6	1.5	0.34	0.85
Leith and Malley (2005)	2.0	1.5	11	1.93	0.28	0.70
Welz (2006)	1.0	1.0	10	1.25	0.33	0.75
Rabanal and Rubio-Ramirez (2008)	5.9	1.6	6	1.01	0.06	0.85
Huelsewig et al. (2009)	2.0	2.0	11	1.16	0.57	0.80
Gerali et al. (2010)	1.0	1.0	6	2.0	0.35	0.90
Paries et al. (2011)	1.0	1.3	4.3	2.4	0.03	0.85
Hristov and Huelsewig (2017)	2.0	1.0	7.3	3.3	0.05	0.80

Notes: The table lists papers calibrating or estimating DSGE models for the Euro Area. The methodology, the observable macro variables used as well as the sample vary across papers. "–" indicates that the corresponding parameter is not reported. Each of the listed papers assumes a discount factor β of 0.99, a depreciation rate of physical capital δ of 0.025 and a capital elasticity of production α of 0.3.

targets: *(i)* the average bank dividend to asset ratio, *(ii)* the average credit spread $R^b - R$, and *(iii)* the average bank leverage. The dividend-to-asset ratio is taken from Lang and Menno (2025), while the other two ratios are computed based on the data provided by the Statistical Data Warehouse (SDW) of the European Central Bank. Households' capital management cost function $\varkappa_t$ is parameterised as follows. The fraction of costless direct asset financing by households κ is chosen to match the average share of financial assets intermediated by banks. The corresponding data is provided by Eurostat and described in Appendix F. The parameter governing the convexity of the capital management cost γ is calibrated such that investment drops by around -15% on impact when the economy enters a bank run. This value corresponds to the decline – from peak to trough – in the euro area during the Global Financial Crisis 2008/2009.

The sunspot probability ι for starting a run if the latter is possible, is calibrated to match the average frequency of financial or banking crises in advanced economies. Several empirical studies estimate the average *quarterly* probability of a *crisis start* for advanced economies at slightly above 1% (Reinhart and Rogoff, 2009; Schularick and Taylor, 2012; Beutel et al., 2019). Basu et al. (2017) and Laeven and Valencia (2020) arrive at higher values of 2.5% and 2.3% respectively. Based on panels including advanced, emerging and developing economies, Nakatani (2020) and Greenwood et al. (2022) estimate the crisis-start probability to be 0.7% and 1.1% respectively.[27] Given these findings and noting that in some crises episodes there was no outright banking panic, we calibrate the sunspot probability at 24% per quarter, i.e. $\iota = 0.24$. This implies a quarterly frequency of runs of around 1%, which is at the lower end of the empirical estimates.

Finally, the exogenous shock processes are calibrated matching the standard deviation and the first-order autocorrelation of the following variables: real GDP, annual inflation, nominal short-term interest rate and real aggregate investment (gross fixed capital formation). Real GDP and real investment are measured as the percentage deviation from their respective linear trends, estimated with quarterly data for the period 1997 -2019. The other two variables are percentage-point deviations from their corresponding linear trends estimated on the same sample. The resulting parametrization of the stochastic processes is shown in Table 3.[28]

Solving for the run equilibrium. In order to see how unanticipated runs substantially simplifies the numerical implementation, we rewrite the run capital liquidation price in recursive form. The relevant state variables are the exogenous shocks, that we collectively denote by the vector s_t, bank net worth n_t, and price dispersion Ω_t. Then the expectation part in the households' Euler equation for capital can be expressed as a function of current sates only:

$$\beta E_t\{(\lambda_{t+1}/\lambda_t)(z_{t+1} + (1-\delta)q_{t+1})\Xi^k_{t+1}\} = \mathcal{F}(s_t, n_t, \Omega_t)$$

[27] Note that these values refer to the likelihood of a *crisis start*. As indicated by Laeven and Valencia (2020), a typical banking crisis in an advanced economy lasts slightly more than a year. This means that the likelihood being in a crisis quarter is larger than the likelihood of a *crisis start*.

[28] Following the literature (see table 2), the autocorrelation of the monetary policy shock is normalized to zero because of the interest rate smoothing motive in the Taylor rule. The results are very similar if we over-identify the simulated methods of moments with adding the first-order autocorrelation of all variables.

Table 3: Calibration of non-financial sectors at trend inflation of 2% p.a.

Parameter	Value	Description
Households:		
η	1	Intertemp. elast. of substitution
ψ	1	inv. Frisch elasticity
χ	7.159	Labour disutility
β	0.996	Discount factor
Capital production:		
δ	0.025	Capital depreciation rate
ν	0.25	Investment elast. wrt Tobin's q
a	0.3976	Inv. adjustment cost
b	-0.0083	Inv. adjustment cost
Production and price setting:		
α	0.3	Capital production share
A	0.26	Productivity parameter
ε	10	Elast. of subst. across goods
ξ	0.75	Calvo parameter
Monetary policy:		
$\overline{\Pi}$	0.005	Trend inflation (quarterly)
τ_{Π}	2	Taylor parameter (inflation)
τ_Y	0.105	Taylor parameter (output)
τ_r	0.8	Taylor parameter (interest rate)
Shocks:		
ρ_a	0.7717	Autocorr. productivity shock
ρ_m	0	Autocorr. monetary shock
ρ_ξ	0.6081	Autocorr. capital quality shock
σ_a	0.0049	Stnd. dev. productivity shock
σ_m	0.0011	Stnd. dev. monetary shock
σ_ξ	0.0031	Stnd. dev. capital quality shock

Notes: The calibration is based partly on existing DSGE literature for the euro area (see Table 2) and partly on targeting certain stylized facts for the euro area.

Given the policy function $\mathcal{F}(\cdot)$ that is obtained by solving the normal times equilibrium, the price in a (hypothetical) bank run solves the following equation

$$q_t^\star = \mathcal{F}(s_t, 0, \Omega_t^\star) - \gamma(1-\kappa)$$

where the expectation part in the Euler equation is evaluated at the bank net worth in a run ($n_t^\star = 0$) and the prevailing price dispersion in a run, $\Omega_t^\star$, determined by the law of motion of the price dispersion (14) together with the Philips curve (9).

Table 4: Calibration of financial sector at trend inflation of 2% p.a.

Parameter	Value	Description	Target	Target in model	Target in data
Banks:					
σ	0.93	Survival probability	Bank dividend to asset ratio[1]	0.37%	0.2%
θ	0.3218	Incentive constraint	Credit spread[2]	1.5 pp	1.5 pp
τ	0.0038	Endowment (new banks)	Bank leverage[3]	16	16
ι	0.24	Sunspot probability	Prob. of financial crises (p.a.)	4%	4%
Intermediation cost of households:					
κ	0.5645	Threshold	Banks' financial assets share[4]	0.4	0.4
γ	0.1051	Slope	Investment drop in a run[5]	-15%	-15%

Notes: [1]average over 2005 - 2019 taken from Lang and Menno (2025); [2]average over 2001 - 2019, taken from SDW; [3]average over 2001 - 2019, taken from SDW; [4]average over 2001 - 2019; [5]decline (peak to trough) of aggregate investment during 2008/2009, National accounts, Eurostat. Averages are based on aggregate data for the euro area. SDW refers to the Statistical Data Warehouse of the European Central Bank.

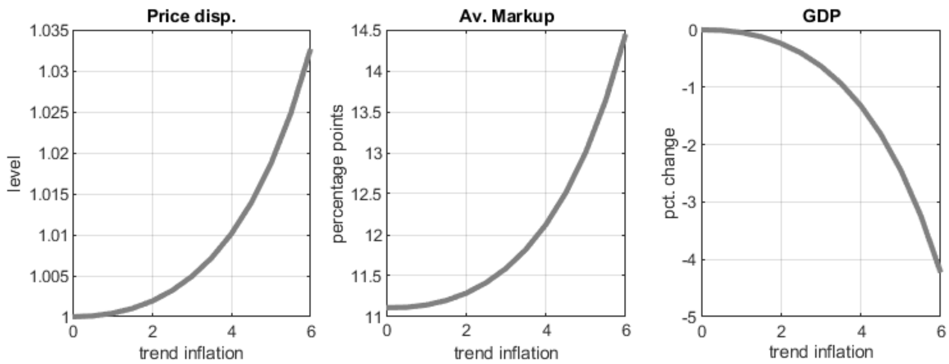
When households form expectations about the future outside runs, they do not take into account the possibility that a run equilibrium exists. With other words, when solving for the policy function $\mathcal{F}(\cdot)$ households disregard the possibility of a run.

Therefore, we can solve the equilibrium policy functions for the normal market equilibrium independent of the run equilibrium. We then introduce the expectation part in all the forward looking equations (Euler conditions and Philips curve) as auxiliary variables and solve for them along the other policy functions. Once we have the equilibrium policy for the expectation part, we can solve the run equilibrium basically as a static non-linear problem by evaluating the expectation policies at the prevailing run values for all the state variables. In practice, we solve the two equilibria piecewise-linear using occbin Guerrieri and Iacoviello (2015). In doing so, in every period of the simulation path, we force the economy with an exogenous shock into a bank run and check whether the run indicator in this forced bank run is smaller than one. If this is the case, the run equilibrium exists and will materialize if the draw of the sunspot variable is equal to one in this period.

5 Trend inflation and the stationary equilibrium

5.1 Trend inflation and economic activity (absent runs)

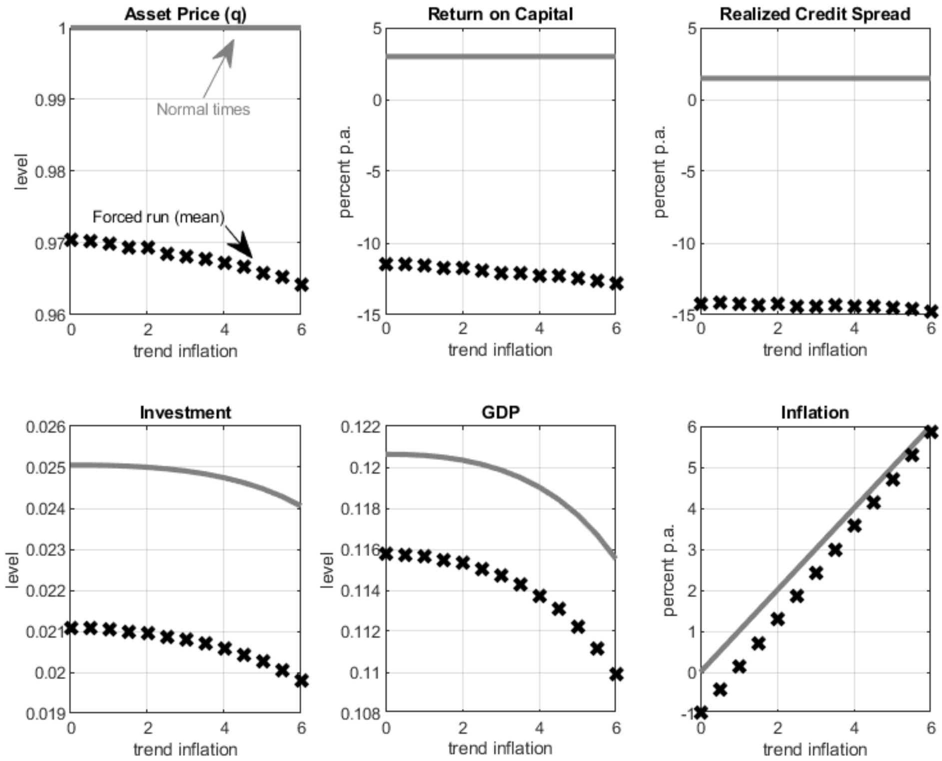
Figure 1: Steady states for different trend inflations. No-run case



Notes: "pct. change" refers to the percentage deviation from the zero-inflation steady state. x-axis: trend inflation in % per annum.

We consider first the effect of trend inflation on the steady-state level of economic activity in *normal times*, that is abstracting from bank runs. As discussed in Section 3.6 and numerically shown in Figure 1, higher trend inflation depresses the long-run level of real GDP. The profile and magnitude of this effect is in line with results in the literature (Ascari and Sbordone, 2014). The decline in real activity is due to the rising intensity of the distortions associated with both, price dispersion and the average monopolistic markup in the economy. In particular, a higher trend inflation implies a faster erosion of future profits when a firm's nominal price is fixed. Accordingly, if given the opportunity for price adjustment, a firm has an incentive to choose a higher markup in the current period. As a consequence, average markups increase in trend inflation. Consistent with the GDP decline, the long-run levels of consumption, investment and real wages also decrease.

Figure 2: Trend inflation and the average response to a hypothetical forced liquidation



Notes: Grey lines show steady state values at different levels of trend inflation for the no run equilibrium. *Crosses* correspond to the average realization of variables in a forced liquidation (hypothetical bank run) out of the corresponding steady state at the respective trend inflation rate. Trend inflation, interest rates, and spreads are shown in percentage points per annum.

5.2 Trend inflation and the average run response

Next, we investigate the average response of several variables if a banking panic suddenly occurs, forcing the economy to jump into the *run equilibrium*. In particular, for each level of trend inflation, we simulate the economy for a long time horizon and simulate the hypothetical on-impact responses under the assumption of a sudden materialization of a run equilibrium that is feasible but does not necessarily materialize.[29] Figure 2 shows the results of this exercise. The steady state in *normal times* is represented by the grey lines while the on-impact change of the corresponding macro variable, when (hypothetically) jumping into a banking panic, is represented by asterisks.[30]

Consider, for simplicity, the effect of a bank run on macro-variables for a given level of trend inflation, say at 2% p.a. Overall, the effects are broadly in line with Gertler et al. (2020): when banks are forced to liquidate their assets (hypothetical panic), they are left without net worth. Non-banks (households) have to intermediate the entire capital stock. However, because non-banks are relatively less efficient in managing those assets, they are only willing to hold them at a discount, which leads the asset price to drop. At a trend inflation of 2% p.a. trend, the average run (liquidation) asset price is about 3.2% lower than its counterpart in the *normal-times* steady state (upper left panel in Figure 2). Accordingly, if a run occurs, the realized return on bank assets $R_t^{b,\star}$ drops by about 11 percentage points p.a. on impact (upper middle panel). As in Gertler et al. (2020), the associated negative pressure on bank balance sheets leads to a sharp credit contraction, a spike in expected excess returns $E_t\{R_{t+1}^{b,\star}/R_{t+1}^{\star}\}$ and a large drop in aggregate investment by about -15% (lower left panel). The resulting decline in aggregate demand is accompanied by a decline in inflation (lower middle and right panel). The lower

[29]To be precise, we proceed as follows. Given a sequence of exogenous shocks drawn from their respective calibrated distributions, for each level of trend inflation, we simulate the economy for 30.000 periods. In each period, we simulate the occurrence of a bank run, calculate the associated liquidation asset price $q^{\star}$, bank profitability $R_t^{b,\star}/R_t^{\star}$ and leverage ϕ_{t-1} to obtain the value of the run indicator $x^{\star}$. If $x_t^{\star} < 1$, a run equilibrium is possible. This gives us the stationary distribution of the run indicator. Figure 2 shows averages for important variables in run equilibria that are actually feasible, given the state of the world.

[30]As shown below this happens on average in 1% of the time.

inflation rate raises the value of current deposit liabilities, thus reinforcing the decline in bank profitability.[31] The monetary authority reacts by reducing the nominal interest rate. However, this policy reaction is not sufficient to prevent output from dropping by about 3.5% (at 2% p.a. inflation rate) if a banking panic materializes.

As revealed by Figure 2, the decline in both, the price of assets and their returns, is stronger when trend inflation is higher. Accordingly, the average run indicator $x_t^\star$ becomes lower, gradually shifting closer to the critical value of one (see Figure 3). In the following section, we provide a detailed discussion of the underlying mechanism.

5.3 Trend inflation and the probability of runs

As revealed by the left panel in Figure 3, irrespective of the trend inflation rate, the steady-state (i.e. median) run indicator $x^\star$ introduced in equation (8) remains above unity. Put differently, if the economy is initially at its *normal-equilibrium* steady state, the on-impact decline in asset prices $q_t^\star$ and the associated worsening in real asset returns $R_t^{b,\star}$ and realized credit spreads $R_t^{b,\star}/R_t^\star$ is not sufficient to make the bank run equilibrium feasible given the steady state level of bank leverage.[32] Accordingly, as long as being at or very close to its *normal-times* steady state, the economy is not fragile and thus not prone to runs.

The *normal-times* long-run equilibrium, however, is solely one point in the economy's stationary distribution. The latter might imply strongly below or above average values for certain model variables, depending on the characteristics of the underlying macroe-

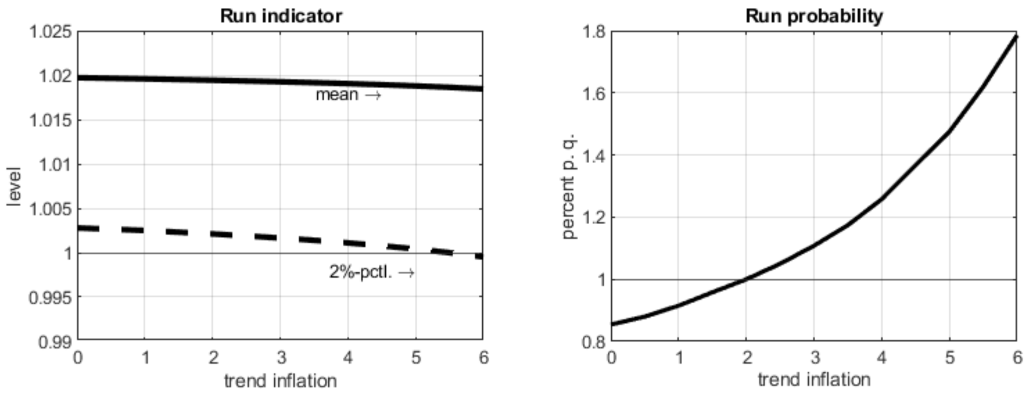
[31] Note that the real value of deposit liabilities, under a run, is given by $R_t^\star d_{t-1}^b$ and the *realized* gross real deposit rate is $R_t^\star = R_{t-1}^n/\Pi_t^\star$. A lower $\Pi_t^\star$ is associated with a higher $R_t^\star$ since R_{t-1}^n is a state variable.

[32] Recall that the run indicator $x^\star$ is given by

$$x_t^\star = \frac{R_t^{b,\star}}{R_t^\star}\frac{\phi_{t-1}}{\phi_{t-1}-1}.$$

Since leverage ϕ_{t-1} is a state variable - i.e. is given in the short run, the value of $x^\star$ solely depends on the realized $R_t^{b,\star}/R_t^\star$ evaluated under the assumption of a hypothetical run.

Figure 3: Trend inflation and the likelihood of bank runs



conomic shocks. Correspondingly, the model also implies a stationary distribution for the run indicator $x^\star$. For example, a combination of large enough adverse shocks will likely be associated with unfavourable pressures on banks' balance sheets which might let $x^\star$ fall below the critical threshold of one. To compute the stationary distribution, we proceed as described in footnote 29. The simulated $x^\star$ give the run indicator's stationary distribution at a particular level of trend inflation. If the simulated $x^\star$ falls below one, the run equilibrium is feasible and the realization of the sunspot shock then determines whether the economy ends up in a run or not. Based on this distribution, we compute the associated likelihood for $x^\star$ falling below one and the corresponding run probability $p_{\text{run}} = \text{Prob}(x^\star < 1) \cdot \iota$.[33]

As an illustration, Figure 3 shows the effect of increasing trend inflation $\bar{\pi}$ on the lower 2.5%-quantile of the run indicator $x^\star$ (left panel).[34] Similar to its mean, the 2.5%-quantile of $x^\star$ is downward sloping. For trend inflations above 5% p.a. it falls below the critical threshold $x^\star = 1$ below which a bank run can prevail. The neighbouring quantiles of $x^\star$ display a similar profile (not shown).

The right panel of Figure 3 shows the profile of the run probability p_{run}. As can be

[33]Recall ι is the probability of the sunspot variable being equal to one.

[34]Recall that we have calibrated the sunspot probability ι such that, at 2% p.a. trend inflation, the likelihood of a bank run is equal to 1% per quarter.

seen, p_{run} is increasing in trend inflation. Moreover, the magnitude is significant. The run probability more than doubles from around 0.8% per quarter at 0% p.a. trend inflation to almost 1.8% per quarter at 6% p.a. trend inflation.

5.4 Trend inflation and the run indicator: The mechanism

The purpose of this section is to highlight the economic forces shaping the relationship between the average run indicator $x_t^\star$ and trend inflation depicted in Figure 3. As discussed by Gertler et al. (2019) and Gertler et al. (2020), the major driver of $x_t^\star$ is the real asset price $q_t^\star$ in a *run equilibrium*. Accordingly, we focus the analysis on the relationship between $q_t^\star$ and trend inflation $\bar{\Pi}$. In Appendix C, we verify the claim that the behavior of the real asset price is the most important factor behind the fluctuations in the run indicator. In particular, we show that the run-induced drop in $q_t^\star$ leads to a sharp fall in the return on assets $R_t^{b,\star}$. This puts downward pressure on bank balance sheets thus, reducing $x_t^\star$.

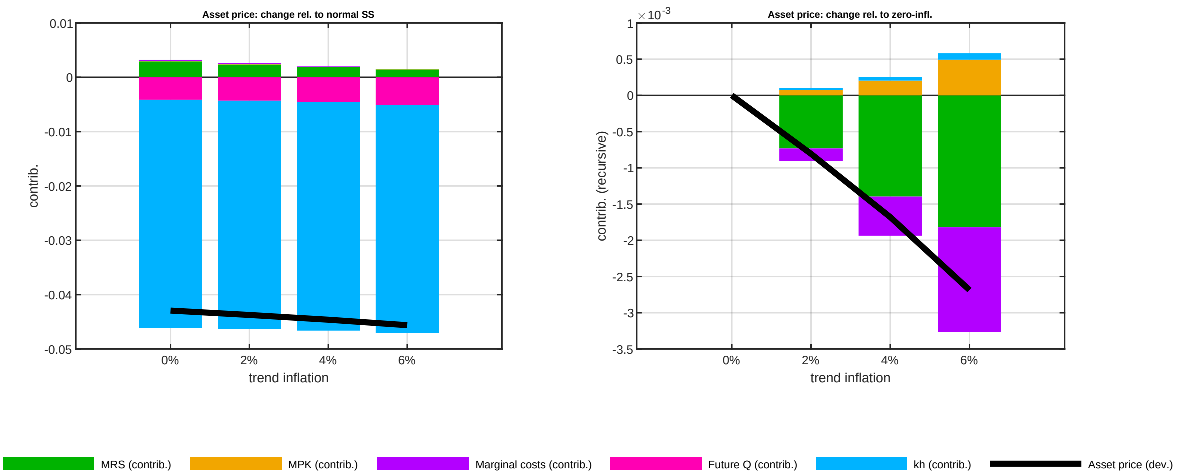
The starting point is the household's Euler equation for physical capital (3) evaluated at the *crisis equilibrium*, i.e. at a forced liquidation, which we restate here for clarity, albeit in slightly modified notation:

$$q_t^\star = E_t\Big\{MRS_{t+1}^\star\left(mc_{t+1}^\star MPK_{t+1}^\star + (1-\delta)q_{t+1}^\star\right)\Big\} - \gamma\left(\frac{k_t^{h,\star}}{k_t^\star} - \kappa\right), \tag{15}$$

where $mc_{t+1}^\star$ denotes real marginal costs, $MPK_{t+1}^\star = \alpha\frac{y_{t+1}^\star}{k_t^\star}$ is the marginal productivity of capital, $MRS_{t+1}^\star = \beta E_t\{\lambda_{t+1}^\star/\lambda_t^\star\}$ corresponds to the marginal rate of intertemporal substitution, while $k_t^{h,\star}/k_t^\star$ is the share of assets (physical capital) held by non-banks.

By means of a conventional total differentiation of equation (15) around the *normal-times* steady state, we decompose the run-related *on-impact* drop in the asset price $q_t^\star$ into the contributions of the individual components $MRS_{t+1}^\star$, $MPK_{t+1}^\star$, $mc_{t+1}^\star$, expected next-period's asset price $E_t q^\star_{t+1}$ and $k^{h,\star}_t / k^\star_t$.[35] The left panel in Figure 4 shows these contributions. Unsurprisingly, the on-impact decline in the asset price $q^\star_t$ is mainly driven by the term reflecting the asset-management cost $\gamma \left(k^{h,\star}_t / k^\star_t - \kappa \right)$ which jumps sharply as households need to absorb the entire capital stock.[36] The contribution of the expected decline in next-period's asset prices $q^\star_{t+1}$ is also non-negligible but much weaker (left panel in Figure 4).

Figure 4: Contributions to the change in the asset price $q^\star$.



Notes: Contributions of the intertemporal marginal rate of substitution $MRS^\star_{t+1} = \beta E_t\{\lambda^\star_{t+1}/\lambda^\star_t\}$, the marginal productivity of capital $MPK^\star_{t+1} = \alpha y^\star_{t+1}/k^\star_t$, marginal costs $mc^\star_{t+1}$, the future asset price $q^\star_{t+1}$ and asset management costs $\gamma \left(k^{h,\star}_t / k^\star_t - \kappa \right)$ to the drop of the current asset price $q^\star_t$ in the case of a run, according to the linearized version of equation (15). The left panel shows the corresponding contributions to the absolute deviation of $q^\star_t$ from the deterministic steady state q. The right panel shows the contributions to the absolute deviation of $q^\star_t$ from its value at zero trend inflation, i.e. $q^\star_t - q^\star_{t,\bar{\pi}=0\%}$.

But what magnifies the on-impact drop in $q^\star_t$ as trend inflation increases? To answer this question, we decompose the deviation between the on-impact response of $q^\star_t$ and its counterpart at zero trend inflation $q^\star_{t,\bar{\pi}=0\%}$ into the contributions of the expected present-value sums of the future *(i)* marginal rates of substitution $MRS^\star_{t+1}$, *(ii)* marginal productivities of capital $MPK^\star_{t+1}$, *(iii)* marginal costs $mc^\star_{t+1}$, and *(iv)* asset-management costs $k^{h,\star}_t / k^\star_t$.[37] The result is depicted in the right panel of Figure 4. As can be seen,

[35] See Appendix C for details on the derivation.

[36] This is consistent with the model mechanics discussed by Gertler et al. (2019) and Gertler et al. (2020).

[37] See Appendix C for details on the derivation.

the drop in the run asset price is amplified mainly due to the stronger decline of two of the present-value components - the first reflecting future marginal rates of substitution $MRS^\star$ while the second corresponding to marginal costs $mc^\star$. Both of these effects are directly related to trend inflation.

As discussed in Section 3.6, a higher trend inflation makes firms more forward looking, i.e. they pay less attention to the temporary shocks occurring in the current period. Accordingly, firms are less willing to reduce their current prices when the banking panic materializes. As a result, under a higher trend inflation, the central bank needs to engineer a smaller reduction in its policy rate and thus a smaller reduction in expected real interest rates $E_t R_{t+1}$. The relatively higher level of expected real interest rates corresponds to a relatively lower marginal rate of intertemporal substitution $MRS^\star_{t+1}$ as implied by the household's Euler equation for deposits.[38] Accordingly, a run under a higher trend inflation is associated with a heavier discounting of future earnings on assets which magnifies the downward pressure on asset prices $q^\star_t$. Put differently, the heavier discounting implies a relatively higher opportunity costs of holding physical capital, thus reducing the attractiveness of this asset. The contribution of relatively higher expected real interest rates $E_t R_{t+1}$ shows up in the increasingly negative "MRS"-bars in the right panel of Figure 4. The second channel *via* which trend inflation affects the responsiveness of the real asset price $q^\star_t$ operates through aggregate demand and the corresponding reaction of the present value of future marginal costs $mc^\star$. The relatively higher expected real interest rate under a higher trend inflation is associated with a comparatively deeper decline in aggregate demand. Under sticky prices, the drop in demand is reinforced by the weaker decline in goods prices associated with the more forward-looking behavior of firms. The stronger drop in aggregate demand in a run with higher trend inflation corresponds

[38] The Euler equation for deposits reads

$$1 = \beta E_t \left\{ \frac{\lambda_{t+1}}{\lambda_t} R_{t+1} \right\} = E_t \left\{ MRS_{t+1} R_{t+1} \right\} = E_t \left\{ MRS_{t+1} \frac{R^N_t}{\Pi_{t+1}} \right\},$$

where R^N_t is the gross policy rate. See also equation (2).

to a more pronounced decrease in expected marginal costs thus amplifying the fall in the expected rental rate of capital.[39] Ceteris paribus, this reinforces the decline in the run asset price. The contribution of lower marginal costs is given by the growing negative "Marginal costs"-bars in the right panel of Figure 4. An alternative way to describe the intuition is by recalling that marginal costs are inversely related to the average markup, i.e. $mc = 1/mu$. Under a higher trend inflation, expected monopolistic markups rise by more when the run hits. This worsens future earnings on assets even more, and puts additional downward pressure on the asset price $q_t^\star$.

5.5 Event study: the typical run

As a summary of the preceding results, Figure 5 shows averages of important variables in an event window of $\pm$ 8 quarters around a materialized bank run.

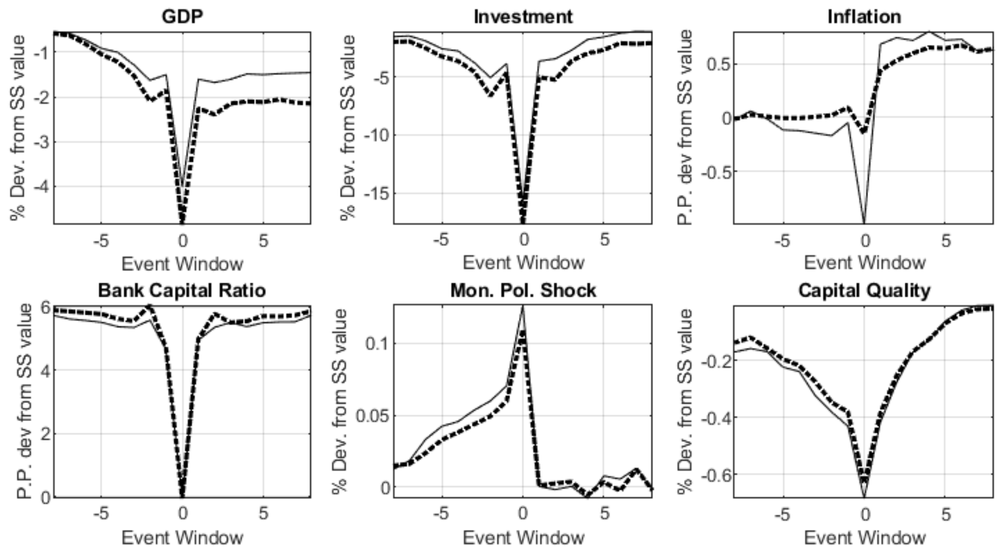
Preceding a typical run, asset prices, investment, GDP, inflation, and credit spread are below trend and decreasing. This is mainly driven by a sequence of negative capital quality shocks and contractionary monetary policy shocks (bottom middle and bottom right panel). At the same time, bank capital ratio is decreasing in the quarters preceding a run (bottom left panel), pushing the run indicator down (not shown). In the quarter when the run materializes, the economy is hit by a combination of an adverse capital quality and a contractionary monetary shock, both of around one-standard-deviation size. In the resulting *run equilibrium*, GDP, investment, inflation, (top panels), as well as asset prices and realized credit spread (both not shown) fall sharply.

With high trend inflation (dashed lines), the *crisis equilibrium* is associated with a lower impact on inflation but a stronger negative effect on real variables and asset prices than compared to the benchmark economy (solid lines). This reflects the mechanisms

[39] Recall that the rental rate of capital is given by

$$z_{t+1} = mc_{t+1}\alpha\frac{y_{t+1}}{k_t}.$$

Figure 5: Event window around the typical run



Notes: Solid lines show the event study for the model with 0% p.a. trend inflation, dashed lines for the model with 6% p.a. trend inflation. Asset price, investment, GDP, technology level, capital quality, and the monetary policy shock are shown as percentage deviations from its t-8 value preceding the run. Inflation and the realized spread is shown as P.P. p.a. deviations from its t-8 value preceding the run. Following Gertler et al. (2020), we assume the bank capital ratio to be zero in the period of the run. 'SS' - steady state.

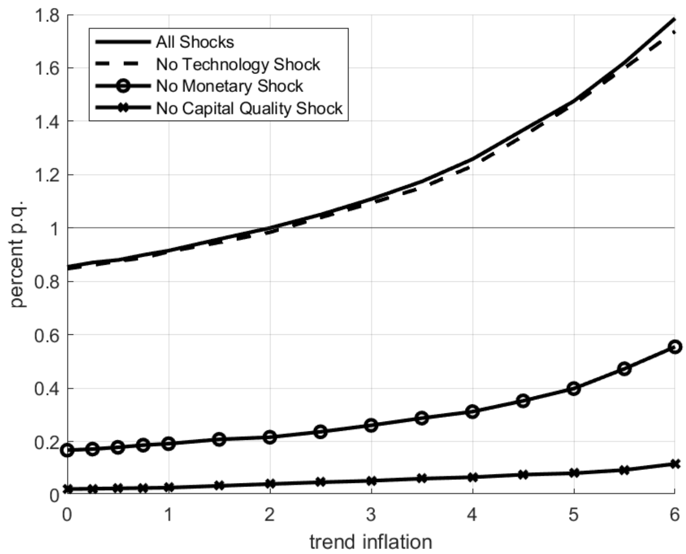
discussed in Subsection 5.4. At the same time, smaller adverse shocks are needed to push the economy into a banking panic. The latter is true in particular for monetary policy shocks (middle panel).

5.6 Importance of individual shocks for the probability of runs

The preceding section takes an *on average* perspective by focusing on the relationship between run probability and trend inflation in the stationary equilibrium. The latter is the product of combinations of the three structural shocks driving the cyclical fluctuations in the economy. In this section, we investigate the relative importance of each of these shocks for the likelihood of banking panics and highlight the underlying dynamic mechanisms by means of impulse response analyses.

To gauge the relative importance of the different macroeconomic shocks, we construct four counterfactual stationary equilibria. Each of them assumes that one of the shocks is excluded while the remaining three structural disturbances are active. The probability of banking panics associated with each of these counterfactuals is depicted in Figure 6, alongside the *baseline* in which all three macro shocks are present. The distance to that baseline proxies the relative importance of the shock that is switched off in the respective counterfactual. Note that the individual contributions do not add to the *baseline* run probability as the latter's average value is a non-linear function of the distributions of the underlying shocks. As can be seen, irrespective of the trend-inflation level, innovations to capital quality and monetary policy are the main drivers of banking panics with the former being the most important. Turning off the monetary policy disturbance more than halves the likelihood of bank runs (it falls by 0.8 percentage points), while the effect of removing the capital-quality shock is even more drastic. By contrast, the technology shock plays a modest role for the average likelihood of banking panics.

Figure 6: Counterfactual run probability: Contribution of individual shocks



Notes: Run probability associated with the actual and three counterfactual stationary equilibria. Each counterfactual assumes that one particular structural shock is switched off while the remaining three ones are active. *"all shocks"* - actual stationary equilibrium, i.e. with all four shocks active; *"w/o techn. shock"* - without technology shock; *"w/o monetary shock"* - without monetary shock; *"w/o cap. qual. shock"* - without capital quality shock.

To shed light on these results, the upper row of Figure 7 shows the effect of each innovation type on the run indicator, with the impulse occurring in period $t = 4$. The figure reveals that the bulk of the run-indicator's response is concentrated in the impact period.

Accordingly, what happens on impact crucially shapes each shock's relative importance, depicted in Figure 6. Before discussing the underlying intuition, it is instructive to recall that, according to the definition of the run indicator $x_t^\star$ (equation (8)), in the short run, the behavior of $x_t^\star$ is driven by the realized spread ratio $R_t^{b,\star}/R_t^\star$ while leverage ϕ_{t-1} is given. In addition, the *realized* gross real deposit rate is $R_t^\star = R_{t-1}^N/\Pi_t^\star$ implying that the short-run changes in $R_t^\star$ solely reflect the fluctuations in current inflation.[40]

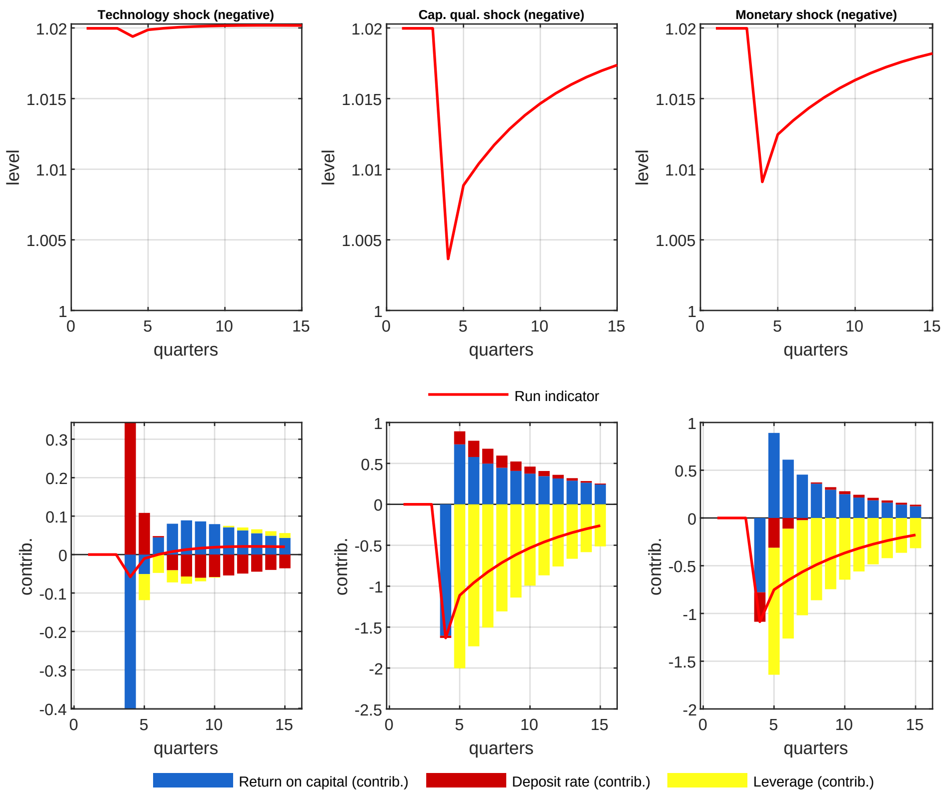
There are two main reasons for the limited importance of technology shocks. The first reason is economic and relates to the response of the *realized* real deposit rate $R_t^\star$. In particular, in the case of contractionary innovations to either monetary policy or capital quality, $R_t^\star$ increases on impact since inflation falls. This reinforces the decline in the run indicator already under way due to the drop in the real return on bank assets $R_t^{b,\star}$. By contrast, the *realized* deposit rate declines when there is an adverse technology shock which partly compensates the drop in return on capital, thus attenuating the decrease in the run indicator. The bottom row in Figure 7 shows the contribution to the on-impact deviation of $x_t^\star$ from its *normal-times* steady state attributable to each of the three variables, i.e. $R_t^{b,\star}$, $R_t^\star$ and leverage ϕ_t (see equation (8)). As can be seen, in the case of technology shocks, the contribution of the real deposit rate $R_t^\star$ is positive while being negative for the other two types of structural disturbances. We refer the reader to Appendix E for further details on the dynamic transmission of structural shocks and the corresponding intuition.

The second reason, why disturbances to technology are relatively less important, is purely mechanical. It reflects the estimated magnitude of that shock, in turn implying that it is less potent in moving asset prices and accordingly the run indicator $x_t^\star$. Nevertheless, even after normalizing the three innovations such that they induce the same drop in real asset prices, the technology shock remains the least potent one in moving the run indicator. The corresponding impulse responses are shown in Figure A8 in Appendix E.

[40]See also the discussion in Section 5.4.

Figure 7 also reveals that the evolution of the run indicator $x_t^\star$ in the aftermath of an impulse is crucially shaped by bank leverage ϕ_t. The latter increases in reaction to each of the three contractionary innovations and remains above average over several quarters, thus exerting a negative contribution on $x_t^\star$. Put differently, leverage is a major medium-term driver of financial fragility in this economy, even though, in the short run, the realized spread $R_t^{b,\star}/R_t^\star$ is the main force behind $x_t^\star$. Finally, we find that irrespective of the adverse shock hitting the economy, higher trend inflation magnifies the drop in real asset prices as well as the rise in bank leverage. As a consequence there is a relatively deeper decline of the run indicator.[41]

Figure 7: Impulse responses of the run indicator and the contributions of its components.



Notes: First row: Impulse response of run indicator $x_t^\star$ to different shocks. Each shock occurs in period $t = 4$ and corresponds to 3 standard deviations. The solid line shows for each period the on-impact deviation of $x_t^\star$ under the assumption of a forced liquidation in that period. *Second row:* Contributions of the return on capital $R_t^{b,\star}$, the deposit rate $R_t^\star$ and leverage ϕ_t to the deviation of the run indicator $x_t^\star$ from its normal-times steady state, according to the relationship $x_t^\star = R_t^{b,\star}/R_t^\star \cdot \phi_{t-1}/(\phi_{t-1} - 1)$.

[41] See Figure A9 in Appendix E and the discussion there. In particular, our results also confirm previous results, e.g. by Ascari and Rossi (2012) and Ascari and Sbordone (2014), that higher trend inflation is typically associated with a higher volatility in real economic activity.

6 Disinflation and its financial stability effects

Several theoretical studies dealing with trend inflation also investigate the consequences of a permanent shift in the central bank's inflation target to a lower value.[42] Such "disinflation exercises" typically focus on the potential costs and benefits of disinflation in terms of aggregate output or - in some cases - welfare. In this section, we conduct a similar exercise, however with a focus on financial stability.

Following the literature on disinflation, we assume that the economy is initially in a steady state characterized by a high trend inflation ($\bar{\Pi}^{high}$), the latter being inherited from the past for reasons outside of the model. In period, $t = 1$ the central bank credibly announces a new lower inflation target $\bar{\Pi}^{low}$ for the future. We then simulate the transition path from the initial to the new stationary equilibrium. We consider three alternative ways for engineering the disinflation. The first is labeled *"cold turkey"* and amounts to an unexpected (sudden) once and for all shift in the inflation target, i.e. in period $t = 1$ the central bank announces that from $t = 1$ on the new inflation target will be

$$\bar{\Pi}_t = \bar{\Pi}^{low}, \qquad t = 1, 2, 3, ...$$

The second case assumes that in $t = 1$ the central bank announces a *gradual* adjustment of its inflation target, i.e.

$$\bar{\Pi}_t = (\bar{\Pi}^{new})^{\vartheta} \bar{\Pi}_{t-1}^{1-\vartheta}, \qquad t = 1, 2, ...$$

$$\text{where} \qquad \vartheta \in (0, 1),$$

$$\bar{\Pi}_0 = \bar{\Pi}^{high}, \qquad \bar{\Pi}^{new} = \bar{\Pi}^{low},$$

[42]See for example Ascari and Ropele (2012a, 2013), Gibbs and Kulish (2017) and the literature cited there.

$\bar{\Pi}_t$ is the *actual*, time varying target while ϑ is a parameter governing the speed of adjustment in $\bar{\Pi}_t$. Finally, the third type of disinflation is again a once and for all change in $\bar{\Pi}_t$, however, unlike the "cold turkey" case, it is *announced in advance*. That is, the actual target of the central bank is given by

$$\bar{\Pi}_t = \bar{\Pi}^{initial} \qquad \text{for} \qquad t = 1, 2, ..., f-1$$

and

$$\bar{\Pi}_t = \bar{\Pi}^{new} \qquad \text{for} \qquad t = f, f+1, ...,$$

where f is the announcement horizon. For illustrative purposes, we consider a disinflation from 4% to 2% per annum.

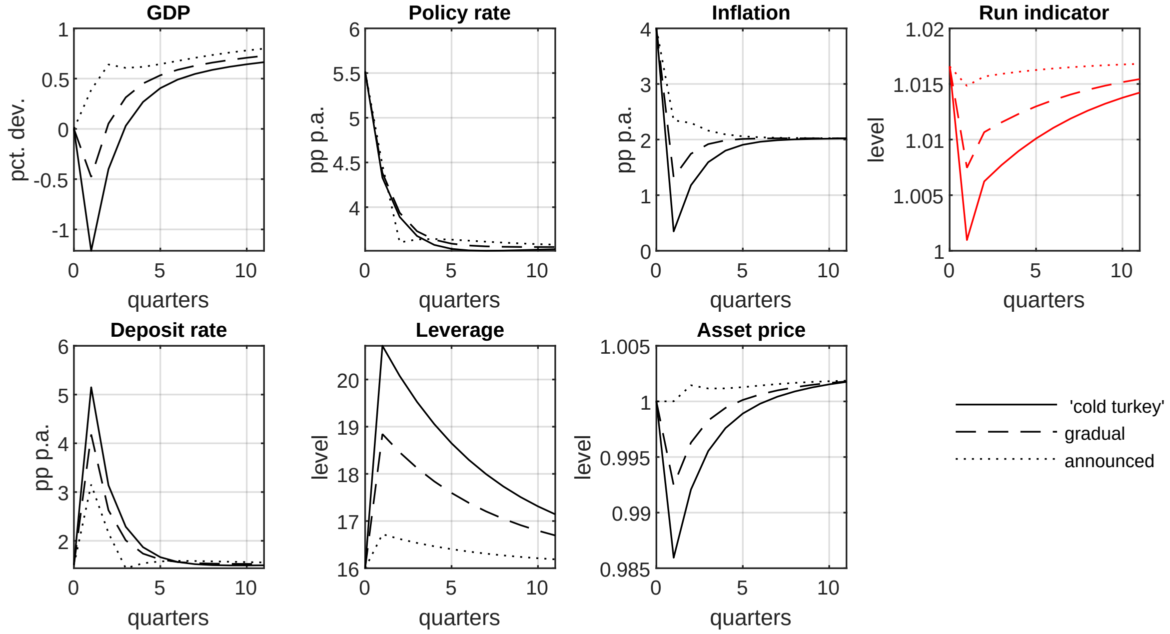
For each of the three scenarios just described, Figure 8 depicts the first 3 years of the transition to the low inflation steady state. GDP is depicted in percentage deviations from the initial steady state (i.e. the one associated with high trend inflation). The remaining variables are shown in levels. The sudden *"cold turkey"* disinflation, represented by solid lines, is akin to a sizable negative monetary policy shock. It is associated with a rise in real interest rates which - by depressing aggregate demand - leads to a short-run recession. Over time, GDP recovers and converges to its new long-run level. The latter is higher than the initial one since the distortions stemming from price dispersion and monopolistic markups are weaker when trend inflation is lower. This transition path is qualitatively similar to that discussed by Ascari and Ropele (2012a, 2013). Due to the sharp short-run recession, actual inflation first undershoots the new 2%-target before reaching it from below after slightly more than a year. Similarly to an adverse monetary shock, the *"cold turkey"* disinflation is also associated with a sharp decline in real asset prices and a rise in bank leverage. As a consequence, the run indicator $x_t^\star$ substantially drops on impact and remains lower than its initial level for several quarters. Thus, the early stage of a *"cold turkey"* disinflation is associated with substantially elevated financial stability risks. Over time, however, the run indicator rises towards its new, more favourable long-run value associated with the lower trend inflation (see also the discussion in Section 5.3).

If the central bank disinflates by a credible commitment to a *gradual* adjustment of its inflation target, the induced short-run recession is greatly attenuated as the associated rise in real deposit rates is much weaker (Ascari and Ropele, 2013; Gibbs and Kulish, 2017). This is indicated by the dashed lines in Figure 8 where we set $\vartheta = 0.6$ for illustrative purposes. Furthermore, the associated financial stability costs are as well much lower than in the *"cold turkey"*-case: the short-run drop in the run indicator $x_t^\star$ is far smaller and its convergence to its more favourable new steady state level is faster.

Finally, the dotted lines in Figure 8 correspond to a disinflation *announced* in advance. In particular, it is assumed that - unlike the *"cold turkey"* case - the central bank credibly announces the once and for all shift in its inflation target half a year in advance, i.e. $f = 2$. Put differently, the reduction in trend inflation to take place in $t = 3$ is announced in $t = 1$. In this case, forward looking firms can front-load part of the necessary price adjustments thus allowing the burden of the policy change to be more evenly distributed over the first three quarters. As the associated increase in the real deposit rate is sufficiently weak a short-run recession can be avoided. In particular, consumption records a healthy increase while the decline in investment is very limited. The latter is associated with at most a marginal short-run worsening in asset prices and the run indicator.

In sum, the model implies that, if implemented surprisingly and forcefully as in the *"cold turkey"*-case, a disinflation will likely be associated with substantial financial stability risks in the short-run. However, if the implementation is *gradual* or credibly *announced* in advance, the costs in terms of financial stability can be greatly alleviated. Given that the *gradual* case can be viewed as an approximation of a specific type of preannounced change in the inflation target, the results presented in this section underscore the importance and potential benefits of a timely and credible communication of upcoming policy changes by the central bank.

Figure 8: Disinflation from 4% p.a. to 2% p.a. Transition path under different disinflationary designs.



Notes: Transition from a steady state with 4% trend inflation to a new one with 2% trend inflation. *'cold turkey'* - a sudden, once and for all shift in the central bank's inflation target; *gradual* - a slow adjustment in target inflation; *announced* - the once and for all shift in the inflation target is announced two quarters in advance. The policy rate, inflation, deposit rate, leverage, the real asset price and the run indicator are shown in levels. GDP is shown as a percentage deviation from the initial (4%-inflation) steady state.

7 The role of the Zero Lower Bound

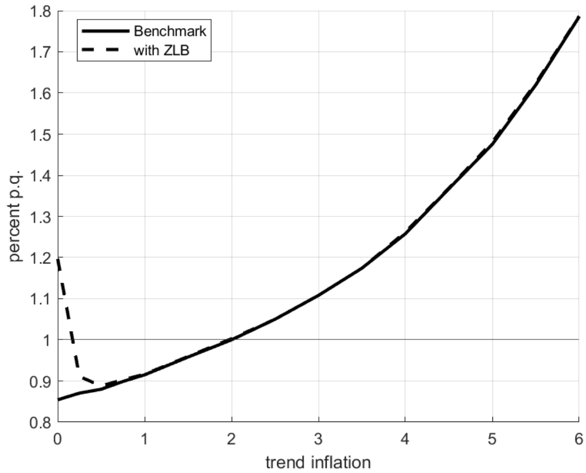
The analyses discussed in Sections 5 and 6 abstract from the potential presence of an effective lower bound on nominal interest rates. Put differently, we have so far implicitly assumed that, even in the case of sizable adverse shocks, the central bank is still able to provide some monetary stimulus. This assumption can be viewed as proxying the possibility of unconventional monetary interventions like quantitative easing or forward guidance.[43] Such non-standard measures were heavily employed by advanced economies' central banks during the Global Financial Crisis, the European debt crisis as well as the Covid-19 pandemic. By contrast, in this section, we take the opposite perspective and assume the presence of an occasionally binding Zero Lower Bound (ZLB) on the policy rate, i.e. the latter cannot take negative values. Accordingly, as soon as the ZLB is reached in a sharp downturn, the central bank will be fully unable to provide any further monetary stimulus. While such an assumption appears unrealistic given the recent historical experience, the analysis presented below might nevertheless be informative for policy makers regarding the potential financial-stability consequences if the central bank would abstain from unconventional monetary interventions even in deep recessions.

Figure 9 shows that the presence of a ZLB increases the likelihood of bank runs compared to the benchmark without a ZLB, in particular for levels of long-run inflation below 1%. As trend inflation rises from 0% to 1% p.a., episodes of a binding ZLB become increasingly rare and the probability of banking crisis gradually declines towards its value in an otherwise similar economy without a ZLB. For steady-state inflation rates higher than 1%, the ZLB is irrelevant as the central bank enjoys a larger policy space for

[43] See e.g. Debortoli et al. (2019) for a similar line of argument. Furthermore, by performing policy counterfactuals in an empirical model of the banking sector, Albertazzi et al. (2022) show that unlimited but costly liquidity facilities by the central bank might not be enough to eradicate bad (run) equilibria. Similar to that paper, we also find that monetary policy - even if allowed to set negative policy rates - is not sufficient to prevent the materialization of crises. A substantially more aggressive accommodation by the central bank might potentially reduce the likelihood of runs. However, this could be associated with social costs in terms of monetary authority's credibility and/or moral-hazard behavior by private agents. In the current paper, we abstract from analysing these normative issues.

reacting to deflationary shocks. This is consistent with findings in the existing theoretical literature (Krugman, 1998; Williams, 2009; Blanchard et al., 2010; Ball, 2013; Andrade et al., 2019, 2021) arguing in favor of higher inflation targets for monetary policy.

Figure 9: Trend inflation and the likelihood of bank runs: role of the Zero Lower Bound



The mechanism that drives the higher bank run probability for low trend inflation levels works mainly through the larger drop in inflation and the consequently larger surge in the *realized* real interest rate during a run. This is because with ZLB monetary policy cannot lower the nominal interest rate below 0, amplifying the initial demand drop. In addition, holding inflation expectations constant, the expected *run-equilibrium* real interest rate is relatively higher and the corresponding marginal rate of intertemporal substitution is lower than in an the economy without a ZLB. Therefore the asset price drop is also relatively larger. Both, the higher realized real interest rate on impact and the larger asset price drop, shift down the whole distribution of the run indicator (not shown), therefore increasing the bank run probability in the economy with ZLB relative to the one without such a bound.

The results presented in this section deliver an important message to macroprudential authorities. In particular, even though very low trend inflations are associated with a higher average aggregate economic activity as discussed in Section 5.1, the associated financial stability risks might be substantial when the ZLB constraint is present. Accordingly, macroprudential policy might need to adopt a relatively tighter stance - e.g. by imposing higher capital and/or liquidity requirements for banks - in order to ensure that the financial system is sufficiently resilient.

8 Implications for monetary and macroprudential policy

In this section, we highlight some potential trade-offs economic policy makers might be confronted with and how these trade-offs are affected by different levels of trend inflation. However, the findings presented below should not be interpreted normatively as they arise from purely positive analyses and are not benchmarked against deeply founded objective functions for monetary and macroprudential policy. Accordingly, the results do not speak in favor of or against certain policy options.

In particular, Subsection 8.1 discusses the extent to which a stronger responsiveness of monetary policy to changes in the price level - e.g. in an attempt to better stabilize inflation - might jeopardize financial stability. In Subsection 8.2, we investigate how a better average capitalization of the banking sector - e.g. brought about by macroprudential policy in a pursuit to reduce the likelihood of bank runs - might facilitate or complicate inflation stabilization, or pose costs in terms of aggregate economic activity.

8.1 The price stability/financial fragility trade-off for monetary policy

First we ask how variation in the Taylor-rule parameter on inflation τ^{π} affects the volatility of inflation and the probability of bank runs. τ^{π} serves as a natural proxy of the central bank's aggressiveness towards inflation. Higher values of this parameter reflect a stronger response to changes in inflation. Since trend/target inflation is an exogenous parameter in our framework, we use the unconditional variance of inflation around that target as a proxy for the price stability goal of the central bank. Inflation volatility is a major - for typical parameterizations even the most important - component in welfare loss functions frequently used to proxy monetary policy's objective (Woodford, 2002; Benigno and Woodford, 2005). Likewise, we assume that the containment of the run probability is the main goal pursued by the policy branch in charge of financial stability - e.g. a macroprudential authority.[44]

Figure 10: Financial fragility and volatility of important real variables for different Taylor parameters

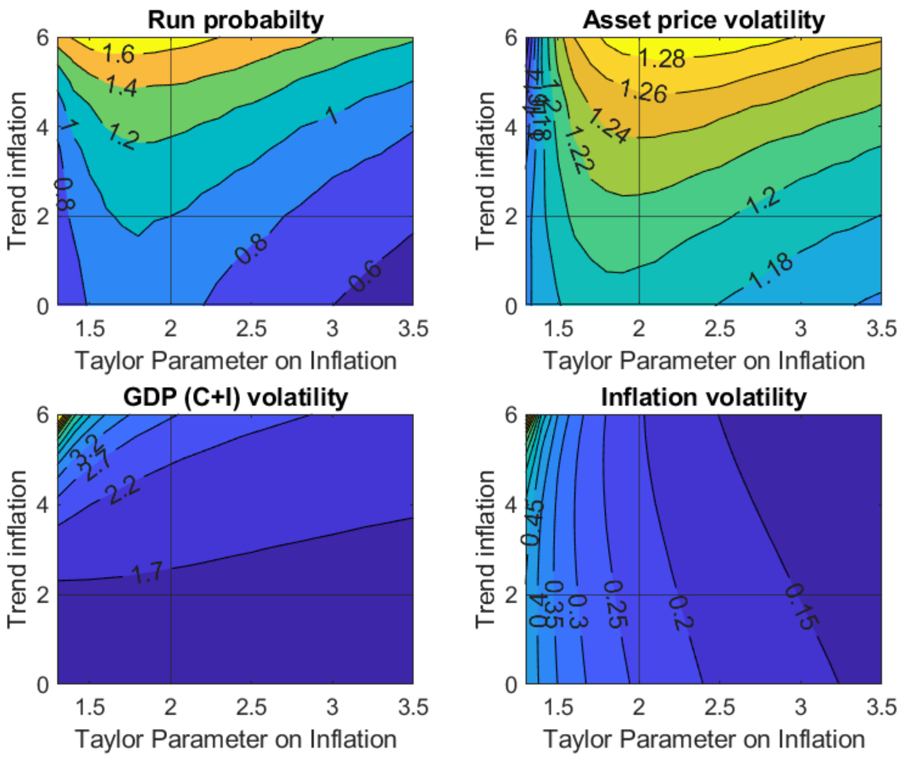


Figure 10 shows the long run implications on the bank run probability and volatility of important macro variables when varying the monetary policy stance, by changing the Taylor parameter on inflation τ^{π} in the monetary policy rule. As can be seen, the run probability is non-monotonic - i.e. hump-shaped - in that parameter and the hump-shape

[44]However, we acknowledge that, unlike monetary policy and its price-stability objective, there is much less consensus on the precise definition of financial stability or the exact goals of macroprudential policy (ESRB, 2019).

decreases with increasing trend inflation (top left panel). This pattern is mirrored by the asset price volatility (top right panel), implying that for any given level of trend inflation asset price volatility is largest for a critical value of $\overline{\tau^\pi}$ of the Taylor rule parameter around 1.8. Accordingly, as long as τ^π is below that value, small increases in this parameter are associated with a trade-off: while inflation becomes less volatile, financial crises become more frequent. This trade-off is absent when τ^π is higher than the critical value $\overline{\tau^\pi} \approx 1.8$ as, in that range, an increase in the Taylor parameter reduces both, the volatility of inflation and the likelihood of bank runs.

To understand the mechanism behind the non-monotonic relationship between the Taylor-rule parameter τ^π and the probability of banking panics, recall that a bank run acts similarly to an adverse aggregate demand shock, that is, it leads to a temporary drop in economy-wide consumption and investment. On impact, the weaker aggregate demand depresses firms' marginal costs and thus inflation. However, the fall in investment and the associated deceleration in capital accumulation lead to persistently above average marginal costs and thus inflation in subsequent periods following the shock (Sveen and Weinke, 2005, 2013). Accordingly, the economy experiences a temporary *negative inflation gap* in the short run but a long lasting *positive inflation gap* in the medium term. As a consequence, an increase in the Taylor-rule parameter on inflation τ^π has two opposing effects on the path of expected real interest rates and thus on asset prices.[45] First, a higher τ^π is associated with relatively lower real interest rate in the short run which cushions the drop in asset prices. Second, a larger τ^π shifts the path of real rates in subsequent periods persistently upwards. This implies a heavier discounting of future earnings on assets and thus reinforces the drop in asset prices. As long as the Taylor parameter τ^π is below a critical value $\overline{\tau^\pi}$, the positive inflation gap in the subsequent periods following the shock is sufficiently large and persistent. As a result, the second effect of a rise in τ^π dominates. This implies a relatively stronger drop in asset prices in

[45]These effects are generally present in any standard New Keynesian Model with capital (independent of a banking friction) and can lead to indeterminacy, as discussed in Sveen and Weinke (2005, 2013).

the case of a run and therefore a higher likelihood of crises. By contrast, for values of the Taylor parameter τ^{π} above the threshold $\overline{\tau^{\pi}}$, the positive inflation gap in the periods following a shock is sufficiently small and less persistent. Accordingly, small increases in the Taylor parameter operate almost entirely via the contemporaneous first effect, which relatively stabilizes asset prices and therefore the likelihood of crises decreases.

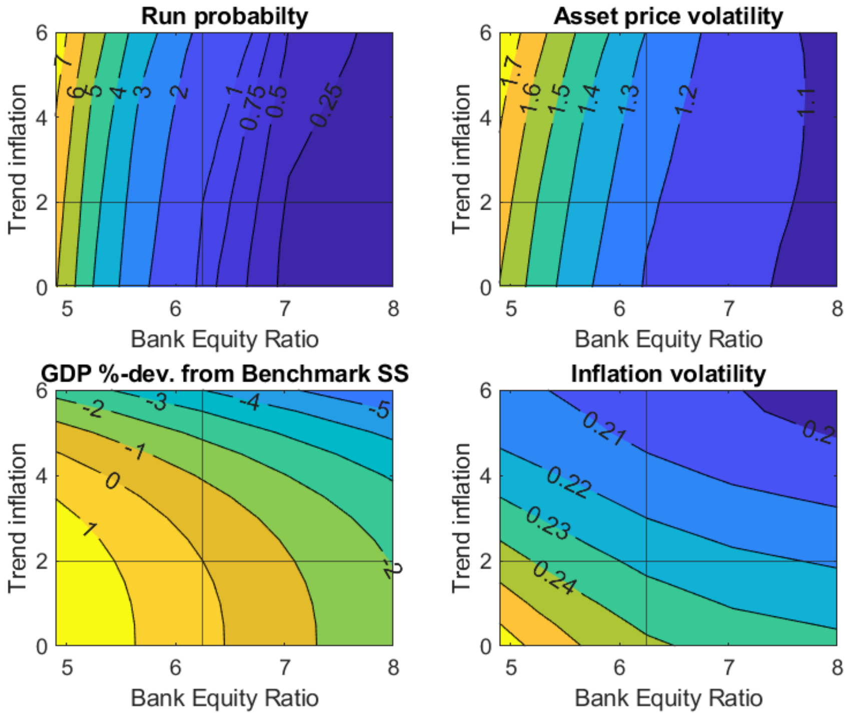
Furthermore, the trade-off between financial and price stability that arises for relatively low values of the Taylor parameter τ^{π} is more pronounced under higher trend inflation. In particular, increases in τ^{π} lead to a stronger reduction in inflation volatility but a more pronounced rise in the probability of runs in an environment of high trend inflation. Likewise, when τ^{π} is relatively high, higher trend inflation implies that both, the frequency of bank runs and the volatility of inflation decline faster when raising τ^{π}.

8.2 The price stability/financial fragility trade-off for macroprudential policy

Next we investigate the long run consequences of varying the steady state level of bank leverage (or its inverse bank equity ratio). We implement this by changing the parameter θ that determines the tightness of the banks' incentive constraint, while holding the remaining model parameters constant. Higher values of θ might result from a stronger market pressure on banks but might be also viewed as implicitly capturing a more stringent macroprudential regulation.

As indicated by Figure 11, a better bank capitalization reduces the average run probability. The volatility of inflation around the corresponding target also declines as a lower bank leverage weakens the bank-balance-sheet channel of shock transmission (Gertler and Kiyotaki, 2010; Gertler and Karadi, 2011). However, a better capitalization of the banking sector comes at costs in terms of lower steady state economic activity. In particular, an increase in banks' steady-state equity ratio from 6.25% to 6.75% halves the run

Figure 11: Financial fragility and volatility of important real variables for different bank equity ratios



probability, the long-run level of GDP is reduced by around 0.6%. The negative effect on GDP is due to the higher costs of capital - the spread between the return on capital and the risk free rate rises - emerging when banks are forced to operate with more equity.

Figure 11 also indicates that a higher trend inflation makes it more difficult to reduce the run probability by a given amount, i.e. a stronger improvement in bank capitalization is needed. Higher trend inflation also worsens the trade-off between reductions in the probability of runs and a lower level of economic activity. Accordingly, if long-run inflation is elevated, macroprudential authorities should be aware of the potentially substantial costs associated with improvements in bank capitalization.

9 Conclusion

We employ a medium scale New Keynesian model with banks and endogenous financial panics (system-wide bank runs) to study whether and how (non-zero) average trend inflation affects the average risk of bank runs. Our results indicate that trend inflation has substantial effects on the probability of such runs. In particular, the probability of bank runs more than doubles when annual trend inflation rises from 0% to 6% p.a. We show that the incidence of a banking panic mainly depends on the magnitude of the associated decline in asset prices. Under a higher trend inflation, this decline is stronger. Accordingly, the deterioration of banks' balance sheets is larger, thus making it more likely that the aggregate net worth will be wiped out in the case of a forced liquidation. The underlying mechanism works through a weaker aggregate asset demand associated with higher trend inflation leading to a larger drop in the liquidation asset price in a potential bank run.

We further find that, in the short run, disinflations engineered by the central bank are associated with significant costs in terms of financial stability. This is especially the case when a sharp "cold turkey" disinflation is pursued. By contrast, the increase in bank-run probability is more muted if the transition to the lower inflation target is more gradual or its start is announced in advance.

Finally, the model also implies that the presence of an occasionally binding zero lower-bound on the nominal interest rate (ZLB) further increases the likelihood of bank runs, but only for fairly low levels of long-run inflation. As trend inflation rises from 0% to 1% p.a., episodes of a binding ZLB become increasingly rare and the probability of crises gradually declines towards its value in an otherwise similar economy without a ZLB. For steady-state inflation rates higher than 1%, the ZLB is effectively irrelevant.

The results in this paper are important from a policy perspective. First, we show that the monetary policy stance has an important impact on the likelihood of banking panics:

the run probability is hump-shaped in the Taylor parameter on inflation, in particular for low long-run inflation levels. Second, macroprudential policy should be aware of the potentially higher fragility of the financial system associated with higher long run inflation rates. With higher long-run inflation, certain macroprudential measures might be warranted in order to increase the resilience of the banking sector. At the same time, our results suggest the costs of macroprudential policy in terms of GDP increases with long-run inflation.

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A Further details on the empirical estimation

Table 5 shows the estimation results obtained with our baseline specification by either using a linear-probability or a probit model (see equation (1) in Section 2). $\bar{\pi}_t$ denotes our proxy for trend inflation, $\Delta LtoGDP$ is the year-on-year change of the loans-to-GDP ratio, ΔHP_t is the year-on-year growth rate of real house prices, ΔGDP_t is the growth rate of real GDP and r_t is the ex post real interest rate.

The signs of the statistically significant coefficients are in line with those in related empirical studies (Demirguc-Kunt and Detragiache, 1998; Schularick and Taylor, 2012; Jordà et al., 2015). Inflation corresponds to the percentage change in the consumer price index (CPI). Real house prices HP_t are defined as nominal house prices deflated by the CPI. In some of the robustness checks we use the growth rates of real equity prices and the real loan volume. Both real variables are obtained by deflating the corresponding nominal variable by the CPI.

Table 6 shows further robustness checks in addition to the ones shown in the main text, namely using different measures for the debt to GDP ratio (specifications (1) and (2)), using equity prices instead of house prices as controls (specification (3) and defining trend inflation as the non-lagged *centered* moving average of inflation (specifications (8) and (9)).

Table 5: Regression of crisis dummy on lags of trend inflation and controls (full)

Dependent variable: *crisis dummy (CD)*

	Baseline (linear)	Probit
$\bar{\pi}_{t-1}$	0.00284**	0.0656**
$\Delta LtoGDP_{t-1}$	0.00517	0.158
$\Delta LtoGDP_{t-2}$	0.0105*	0.0786
$\Delta LtoGDP_{t-3}$	0.0121	0.171
$\Delta LtoGDP_{t-4}$	0.00942	0.311*
$\Delta LtoGDP_{t-5}$	-0.00504	-0.158
ΔHP_{t-1}	-0.000533	-0.00860
ΔHP_{t-2}	0.00136*	0.0185
ΔHP_{t-3}	0.00106	0.0129
ΔHP_{t-4}	0.000493	0.00791
ΔHP_{t-5}	-0.000185	0.00530
ΔGDP_{t-1}	0.00228	0.0809*
ΔGDP_{t-2}	0.00156	0.0267
ΔGDP_{t-3}	-0.00279*	-0.0488
ΔGDP_{t-4}	-0.00128	0.00273
ΔGDP_{t-5}	-0.00701***	-0.150***
r_{t-1}	0.00356**	0.0803**
r_{t-2}	-0.00108	-0.0339
r_{t-3}	-0.000880	-0.00824
r_{t-4}	-0.00164	-0.0578
r_{t-5}	0.00334***	0.0956***
Country FE or dummies	YES	YES
Obs.	1,000	1000
N countries	16	16
R^2 or Pseudo-R^2	0.0550	0.212

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Notes: Country panel covering the period 1955 - 2019, consisting of 16 advanced economies, based on annual data. Dependent variable: a *"crisis dummy"* equal to one in crisis years and zero otherwise. For the definition of $\bar{\pi}$, the additional control variables and the list of countries see Section 2. The country fixed effects are omitted for brevity. Data source: *Macrohistory Database* by Jordà et al. (2017). For the linear probability model we use robust Newey-West standard errors to control for heteroscedasticity as well as serial correlation.

Table 6: Regression of crisis dummy on lags of trend inflation and controls

Dependent variable: *crisis dummy (CD)*

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Baseline	Replace lags of $\Delta LtoGDP$ by the 5-year change in $LtoGDP$	Replace $\Delta LtoGDP$ by real loan growth	Replace house prices by equity prices	Using 4 lags of trend inflation	Define $\bar{\pi}$ as the HP-trend of inflation	Define $\bar{\pi}$ as the 5-year moving average of inflation	Probit (specification as in Baseline)	Define $\bar{\pi}$ as the 3-year **centered** moving average	Define $\bar{\pi}$ as the 5-year **centered** moving average
$\bar{\pi}_{t-1}$	0.00284**	0.00264**	0.00267**	0.00341***	0.0173**	0.00225*	0.00141*	0.0656**		
$\bar{\pi}_{t-2}$					-0.00562					
$\bar{\pi}_{t-3}$					-0.00817					
$\bar{\pi}_{t-4}$					-0.00152					
$\bar{\pi}_{c,t}$									0.00419**	0.00315**
Const.	-0.0129	-0.0152	-0.0152	-0.0156*	-0.00562	-0.00854	-0.00787	-3.13***	-0.00958	-0.00955
Country FE	YES	YES	YES	YES	YES	YES	YES	-	YES	YES
Country dummies	-	-	-	-	-	-	-	YES	-	-
Obs.	1,000	1,000	1,000	982	986	1,000	1,000	1,000	985	969
N countries	16	16	16	16	16	16	16	16	16	16

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Notes: Country panel covering the period 1955 - 2019, consisting of 16 advanced economies, based on annual data. Dependent variable: a *"crisis dummy"* equal to one in crisis years and zero otherwise. Main explanatory variable: various lags of trend inflation $\bar{\pi}$. For the definition of $\bar{\pi}$, the additional control variables and the list of countries see Appendix A. Coefficients on control variables omitted for brevity. Data source: *Macrohistory Database* by Jordà et al. (2017). For the linear probability models we use robust Newey-West standard errors to control for heteroscedasticity as well as serial correlation.

B Appendix: Model details

Equilibrium conditions (no run equilibrium)

Capital producing sector

$$k_t = \left(\Gamma\left(\frac{i_t}{\Xi_t^k k_{t-1}}\right) + (1-\delta)\right)\Xi_t^k k_{t-1} \tag{16}$$

$$q_t = \left[\Gamma'\left(\frac{i_t}{\Xi_t^k k_{t-1}}\right)\right]^{-1} \tag{17}$$

Goods producing sector and price setting

$$y_t = \Omega_t^{-1} e^{a_t} (\Xi_t^k k_{t-1})^{\alpha} l_t^{1-\alpha} \tag{18}$$

$$\Omega_t = (1-\zeta)(p_t^{adj})^{-\epsilon} + \zeta \Pi_t^{\epsilon} \Omega_{t-1} \tag{19}$$

$$mc_t = \frac{z_t^{\alpha} w_t^{1-\alpha}}{e^{a_t} \alpha^{\alpha} (1-\alpha)^{1-\alpha}} \tag{20}$$

$$p_t^{adj} = \frac{\epsilon}{\epsilon - 1} \frac{F_t}{H_t} \tag{21}$$

$$F_t = mc_t y_t + \beta \zeta E_t \frac{\lambda_{t+s}}{\lambda_t} \Pi_{t+1}^{\epsilon} F_{t+1} \tag{22}$$

$$H_t = y_t + \beta \zeta E_t \frac{\lambda_{t+s}}{\lambda_s} \Pi_{t+1}^{\epsilon-1} H_{t+1} \tag{23}$$

$$1 = (1-\zeta)(p_t^{adj})^{1-\epsilon} + \zeta \Pi_t^{\epsilon-1} \tag{24}$$

Households

$$\lambda_t = c_t^{-\eta} \tag{25}$$

$$\lambda_t w_t = \chi l_t^{\psi} \tag{26}$$

$$1 = \beta E_t \left\{ \frac{\lambda_{t+1}}{\lambda_t} \frac{1 + r_t^n}{\Pi_{t+1}} \right\} \tag{27}$$

$$q_t = \beta E_t \left\{ \frac{\lambda_{t+1}}{\lambda_t} (z_{t+1} + (1-\delta) q_{t+1}) \Xi_{t+1}^k \right\} - \gamma (k_t^h / k_t - \kappa) \tag{28}$$

Banks

$$n_{t+1} = \sigma \left((R_{t+1}^b - R_{t+1}) \phi_t + R_{t+1} \right) n_t + (1-\sigma) \tau q_t \Xi_t^k k_{t-1} \tag{29}$$

$$\phi_t = \frac{q_t k_t^b}{n_t} \tag{30}$$

$$\phi_t = \frac{\nu_t}{\theta_t - \mu_t} \tag{31}$$

$$\mu_t = \beta E_t \left\{ \frac{\lambda_{t+1}}{\lambda_t} [(1-\sigma) + \sigma v_{t+1}] (R_{t+1}^b - R_{t+1}) \right\} \tag{32}$$

$$\nu_t = \beta E_t \left\{ \frac{\lambda_{t+1}}{\lambda_t} [(1-\sigma) + \sigma v_{t+1}] R_{t+1} \right\} \tag{33}$$

$$v_t = \mu_t \phi_t + \nu_t \tag{34}$$

Monetary Policy

$$1 + r_t^n = (1 + \bar{r}^n)^{1-\tau_r} (1 + r_{t-1}^n)^{\tau_r} \left(\frac{\Pi_t}{\bar{\Pi}} \right)^{\tau_{\Pi}(1-\tau_r)} \left(\frac{y_t}{\bar{Y}} \right)^{\tau_Y (1-\tau_r)} e^{\xi_t^n} \tag{35}$$

Market clearing

$$k_t = k_t^b + k_t^h \tag{36}$$

$$y_t = c_t + i_t \tag{37}$$

Shock processes

$$a_t = \rho_a a_{t-1} + \varepsilon_t^a \qquad \varepsilon_t^a \sim N(0, \sigma_a^2) \tag{38}$$

$$\xi_t^n = \rho_{\xi^n} \xi_{t-1}^n + \varepsilon_t^n \qquad \varepsilon_t^n \sim N(0, \sigma_{\xi^n}^2) \tag{39}$$

$$\xi_t^k = \rho_{\xi^k} \xi_{t-1}^k + \varepsilon_t^{\xi^k} \qquad \varepsilon^{\xi^k} \sim N(0, \sigma_{\xi^k}^2) \tag{40}$$

Computing the bank run indicator. In order to compute the bank run indicator, we need to solve for capital rental rate, the asset price, and inflation in a forced *run equilibrium*, i.e. $z_t^\star$, $q_t^\star$, and $\Pi_t^\star$. The following system of equations summarizes the equations needed to do that:

$$x_t^\star = \frac{z_t^\star + (1-\delta)q_t^\star}{\frac{1+r_{t-1}^n}{\Pi_t^\star}} \frac{k_{t-1}^b}{d_{t-1}^b} \tag{41}$$

$$\lambda_t^\star = (c_t^\star)^{-\eta} \tag{42}$$

$$k_t^\star = \left(\Gamma\left(\frac{i_t^\star}{\Xi_t^k k_{t-1}}\right) + (1-\delta)\right)k_{t-1} \tag{43}$$

$$k_t^\star = k_t^{h,\star} \tag{44}$$

$$q_t^\star = \left[\Gamma'\left(\frac{i_t^\star}{\Xi_t^k k_{t-1}}\right)\right]^{-1} \tag{45}$$

$$\lambda_t^\star w_t^\star = \chi(l_t^\star)^\psi \tag{46}$$

$$1 = \beta E_t\left\{\frac{\tilde{\lambda}_{t+1}}{\lambda_t^\star}\frac{1+r_t^{n,\star}}{\tilde{\Pi}_{t+1}}\right\} \tag{47}$$

$$q_t^* = \beta E_t\left\{\frac{\tilde{\lambda}_{t+1}}{\lambda_t^\star}\left(\tilde{z}_{t+1} + (1-\delta)\tilde{q}_{t+1}\right)|\text{run in } t\right\} - \gamma(1-\kappa) \tag{48}$$

$$y_t^\star = (\Omega_t^\star)^{-1}e^{a_t}(\Xi_t^k k_{t-1})^\alpha (l_t^\star)^{1-\alpha} \tag{49}$$

$$\Omega_t^\star = (1-\zeta)(p_t^{adj,\star})^{-\epsilon} + \zeta(\Pi_t^\star)^\epsilon \Omega_{t-1} \tag{50}$$

$$mc_t^\star = \frac{(z_t^\star)^\alpha (w_t^\star)^{1-\alpha}}{e^{a_t}\alpha^\alpha(1-\alpha)^{1-\alpha}} \tag{51}$$

$$p_t^{adj,\star} = \frac{\epsilon}{\epsilon-1}\frac{F_t^\star}{H_t^\star} \tag{52}$$

$$F_t^\star = mc_t^\star y_t^\star + \beta\zeta E_t\left\{\frac{\tilde{\lambda}_{t+1}}{\lambda_t^\star}\tilde{\Pi}_{t+1}^\epsilon \tilde{F}_{t+1}|\text{run in } t\right\} \tag{53}$$

$$H_t^\star = y_t^\star + \beta\zeta E_t\left\{\frac{\tilde{\lambda}_{t+1}}{\lambda_t^\star}\Pi_{t+1}^{\epsilon-1}\tilde{H}_{t+1}|\text{run in } t\right\} \tag{54}$$

$$1 = (1-\zeta)(p_t^{adj,\star})^{1-\epsilon} + \zeta(\Pi_t^\star)^{\epsilon-1} \tag{55}$$

$$y_t^\star = c_t^\star + i_t^\star \tag{56}$$

$$1 + r_t^{n,\star} = (1+\bar{r}^n)^{1-\tau_r}(1+r_{t-1}^n)^{\tau_r}\left(\frac{\Pi_t^\star}{\bar{\Pi}}\right)^{\tau_\Pi}\left(\frac{y_t^\star}{\bar{Y}}\right)^{\tau_Y} e^{\xi_t^n} \tag{57}$$

$$n_{t+1}^\star = (1-\sigma)\tau q_t^\star \Xi_t^k k_{t-1} \tag{58}$$

$$\tag{59}$$

plus the shock process as above and where variables in the expectation terms with a tilde denote the equilibrium policy functions obtained from solving the system of equations in *normal times* (see above), evaluated at the values of the endogenous state variables implied by the *run equilibrium*. Denoting by s_t the vector that collects all exogenous shock processes, we have, for example, $\tilde{q}_{t+1} = q(s_{t+1}, n^{\star}_{t+1}, k^{\star}_t, \Omega^{\star}_t)$, and analogously for all other variables with a tilde.

Note that we follow Gertler et al. (2020) and assume in the benchmark model that the run lasts only for one period. Therefore agents in a run equilibrium use the policy functions of normal times to form expectations and deposits are consistently priced with the household Euler equation.[46]

C Appendix: The mechanism underlying the bank run

The starting point is the household's Euler equation for physical capital (3) evaluated at a forced liquidation (*run equilibrium*), which we restate here for clarity:

$$q^{\star}_t = \beta E_t \left\{ \frac{\lambda^{\star}_{t+1}}{\lambda^{\star}_t} \left(mc^{\star}_{t+1} \alpha \frac{y^{\star}_{t+1}}{k^{\star}_t} + (1-\delta) q^{\star}_{t+1} \right) \right\} - \gamma \left(\frac{k^{h,\star}_t}{k^{\star}_t} - \kappa \right),$$

where $mc^{\star}_{t+1}$ denotes real marginal costs and $\alpha \frac{y^{\star}_{t+1}}{k^{\star}_t}$ is the marginal productivity of capital $MPK^{\star}_{t+1}$. The marginal rate of intertemporal substitution $MRS^{\star}_{t+1}$ corresponds to the stochastic discount factor $\beta E_t \left\{ \lambda^{\star}_{t+1} / \lambda^{\star}_t \right\}$, while $k^{h,\star}_t / k^{\star}_t$ is the share of assets (phys-

[46]Note that as pointed out by Christiano et al. (2022) leverage in the run equilibrium and therefore the run indicator in the period after the run is undefined. Alternatively, we could follow Rottner (2023) and assume that households can distinguish between incumbent and new bankers and only run on incumbent banks while still lending to new bankers. Then leverage and the run indicator are well defined. However, for all calibrations considered in this paper the run indicator in the period after the run is always much larger than one in all states as leverage of new bankers is low. Furthermore, like Christiano et al. (2022) we could assume that households run on the whole banking sector including incumbent and new bankers but new bankers in the run period can invest all their equity into assets. Then by definition leverage would be 1 and the run indicator in the period after the run would go to infinity.

ical capital) held by non-banks. By totally differentiating the last equation around the normal-equilibrium steady state we arrive at

$$\Delta q_t^\star = \quad \left(mc \cdot \alpha \frac{y}{k} + (1-\delta) q\right) E_t \Delta MRS_{t+1}^\star + \beta \cdot mc \cdot E_t \Delta MPK_{t+1}^\star$$

$$+\beta \cdot MPK \cdot E_t \Delta mc_{t+1}^\star + \beta(1-\delta) E_t \Delta q_{t+1}^\star - \gamma \Delta \left(\frac{k_t^{h,\star}}{k_t^\star}\right), \qquad (60)$$

where variables without a time index correspond to their respective values at the deterministic *normal-times* steady state. $\Delta(*)$ is the absolute deviation of variable $(*)$ from that steady state, e.g. $\Delta q_t^\star = q_t^\star - q$. The left panel in Figure 4 shows the contribution of each term on the right-hand side in (60) to the *on-impact* drop in asset prices $q_t^\star$ if, for whatever reason, a banking panic erupts.[47]

To develop an intuition about how a higher trend inflation magnifies the drop in the real asset price $q_t^\star$ in the case of a banking panic, we proceed as follows. First we iterate equation (60) forward and, by imposing the terminal condition $\lim_{j\to\infty} \beta^j (1 -$

[47]For example, the contribution of the marginal rate of substitution to the on-impact change in the asset price is given by

$$\left(mc \cdot \alpha \frac{y}{k} + (1-\delta) q\right) E_t \Delta MRS_{t+1}^\star.$$

The contributions of $MPK_{t+1}^\star$, $q_{t+1}^\star$ and $k_t^{h,\star}/k_t^\star$ are defined analogously.

$\delta)^j E_t \Delta q_{t+1+j} = 0$, obtain the recursive representation

$$\Delta q_t^\star = \widetilde{MRS}_t^\star + \widetilde{MPK}_t^\star + \widetilde{mc}_t^\star - \widetilde{k}_t^{h,\star}, \tag{61}$$

where

$$\widetilde{MRS}_t^\star = \left(mc \cdot \alpha \frac{y}{k} + (1-\delta)q\right) E_t \Delta MRS_{t+1}^\star + \beta(1-\delta) E_t \widetilde{MRS}_{t+1}^\star$$

$$\widetilde{MPK}_t^\star = \beta \cdot mc \cdot E_t \Delta MPK_{t+1}^\star + \beta(1-\delta) E_t \widetilde{MPK}_{t+1}^\star$$

$$\widetilde{mc}_t^\star = \beta \cdot MPK \cdot E_t \Delta mc_{t+1}^\star + \beta(1-\delta) E_t \widetilde{mc}_{t+1}^\star$$

$$\widetilde{k}_t^{h,\star} = \gamma \Delta \left(\frac{k_t^{h,\star}}{k_t^\star}\right) + \beta(1-\delta) E_t \widetilde{k}_{t+1}^{h,\star}.$$

Note that the expected discounted sums appearing on the right hand side of (61) take into account, that, after the run period, the economy will gradually return to the normal equilibrium, that is, banks will slowly resume credit intermediation as their access to deposits will progressively improve. Next, we rewrite equation (61) into deviations from the zero-trend-inflation case, i.e.

$$q_t^\star - q_{t,\bar{\pi}=0}^\star = (\widetilde{MRS}_t^\star - \widetilde{MRS}_{t,\bar{\pi}=0}^\star) + (\widetilde{MPK}_t^\star - \widetilde{MPK}_{t,\bar{\pi}=0}^\star)$$

$$+ (\widetilde{mc}_t^\star - \widetilde{mc}_{t,\bar{\pi}=0}^\star) - (\widetilde{k}_t^{h,\star} - \widetilde{k}_{t,\bar{\pi}=0}^{h,\star}).$$

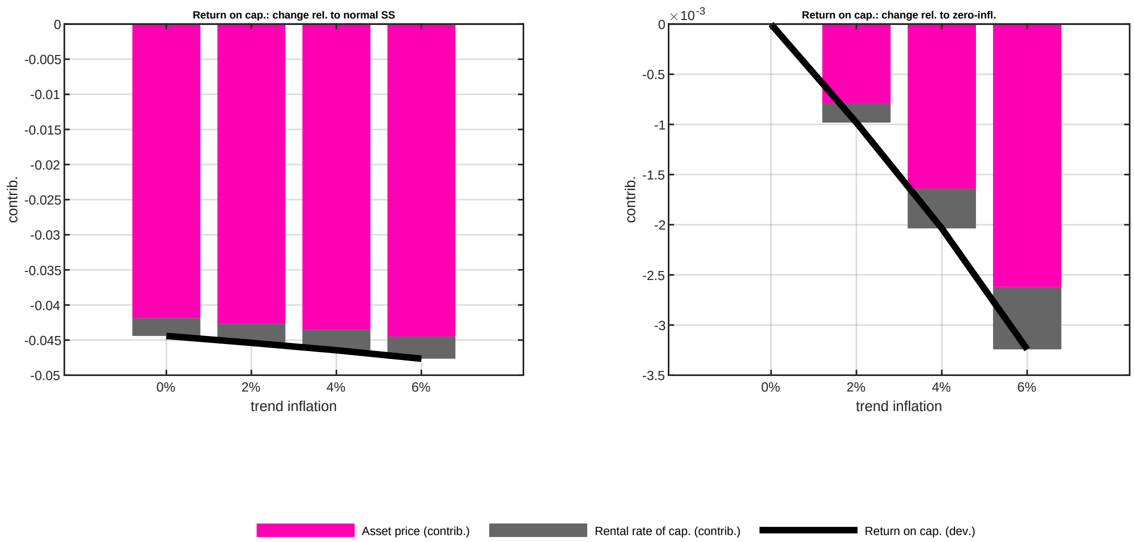
Each term on the right-hand side of the last equation reflects the contribution - in present value terms - of the corresponding variable to the difference between the run asset price $q_t^\star$ and its counterpart under zero trend inflation. These contributions are depicted in the right panel of Figure 4. As can be seen, the drop in the *run-equilibrium* asset price is amplified mainly due to the stronger decline of the marginal rate of substitution $\widetilde{MRS}_t^\star$ and marginal costs $\widetilde{mc}_t^\star$. Both of these effects are directly related to trend inflation.

Next, we verify that the *on-impact* drop in the realized real return on assets $R_t^{b,\star}$ in the case of a run is mainly driven by the decline in the asset price $q_t^\star$. To this end, we proceed similarly as above and compute the contributions of $q_t^\star$ and the real rental rate of capital $z_t^\star$ based on the totally differentiated version of

$$R_t^{b,\star} = \frac{z_t^\star + (1-\delta)q_t^\star}{q_{t-1}}.$$

The result, depicted in the left panel of Figure A1, confirms the major importance of the fall in the real asset price $q_t^\star$. The latter is also responsible for the strengthening in $R_t^{b,\star}$'s response to the forced liquidation as trend inflation increases (see right panel in Figure A1).

Figure A1: Contributions to the change in the return on assets $R^{b,\star}$.



Notes: Contributions of the real asset price $q_t^\star$, its lagged counterpart q_{t-1}, the real rental rate of capital $z_t^\star$ and the capital quality shock Ξ_t^k to the return on assets $R_t^{b,\star}$ according to the linearized version of $R_t^{b,\star} = \frac{z_t^\star + (1-\delta)q_t^\star}{q_{t-1}}$. The left panel shows the corresponding contributions to the absolute deviation of $R^{b,\star}$ from the deterministic steady state R^b. The right panel shows the contributions to the absolute deviation of $R^{b,\star}$ from its value at zero trend inflation, i.e. $R^{b,\star} - R^{b,\star}_{\bar{\pi}=0}$.

Next, we verify that the drop of the realized real return on bank assets $R_t^{b,\star}$ shapes the behavior of the run indicator $x_t^\star$ and its relationship with trend inflation. First, recall that $x_t^\star$ is defined by

$$x_t^\star = \frac{R_t^{b,\star}}{R_t^\star} \frac{\phi_{t-1}}{\phi_{t-1} - 1},$$

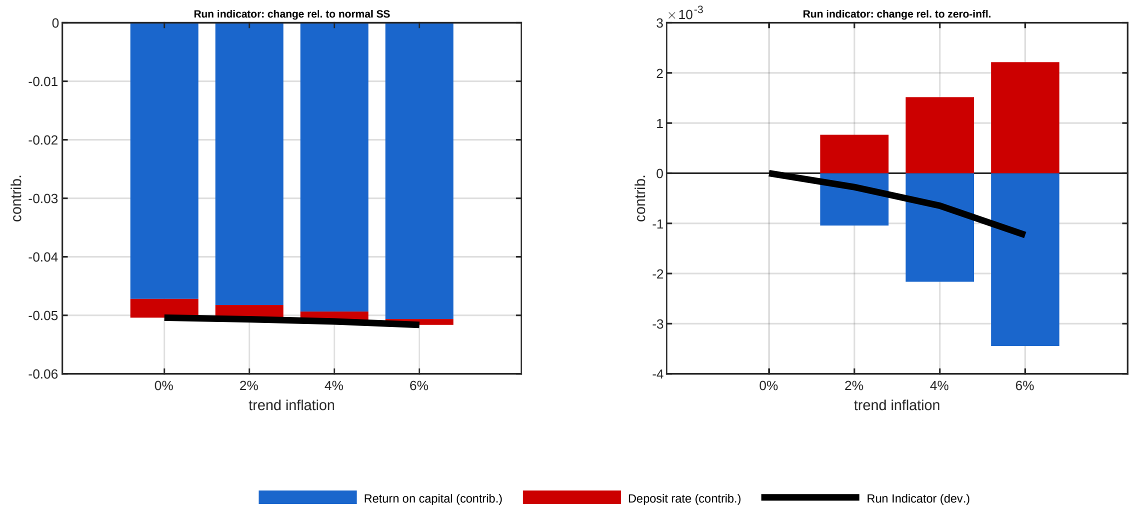
where ϕ_{t-1} is bank leverage. The *on-impact* contribution of $R_t^{b,\star}$ and $R_t^\star$ to the deviation of $x_t^\star$ from its value at the *normal-times* steady state, x, is displayed by the left panel in Figure A2.[48] As can be seen, irrespective of the trend inflation rate, the level of the run indicator is almost entirely driven by the decline in the *realized* real asset return $R_t^{b,\star} - R^b$. By contrast, the contribution of the real deposit rate is much smaller. Since leverage ϕ_{t-1} is fixed in the short run, its contribution is zero.

Finally, to understand, why the *on-impact* value of the run indicator $x_t^\star$ worsens in trend inflation, we compute the contributions of $R_t^{b,\star}$, $R_t^\star$ and ϕ_{t-1} to $x_t^\star$'s deviation from its value at zero trend inflation. The right panel of Figure A2 depicts the corresponding decomposition. As can be seen, there are two opposing effects: the stronger decline in the real asset return magnifies the worsening of the run indicator, while the contribution of the *realized* real deposit rate puts an increasing upward pressure. Quantitatively, the former effect dominates. The intuition behind the beneficial contribution of the *realized* real deposit rate $R_t^\star$ is straightforward. Since $R_t^\star = R_{t-1}^N / \Pi_t^\star$ and the policy rate R_{t-1}^N is fixed in the short run, the on-impact rise in $R_t^\star$ solely reflects the drop in inflation $\Pi_t^\star$ associated with the bank run. However, as discussed above as well as in Section 3.6, a higher trend inflation attenuates the drop in current inflation $\Pi_t^\star$ when a banking panic erupts. Accordingly, the real value of banks' outstanding deposit obligations rise by relatively less as reflected by a more muted rise in the *realized* real deposit rate $R_t^\star$. This eases the adverse pressure on bank balance sheets.

[48] To compute the contributions of the individual variables to the run indicator, we totally differentiate the equation defining $x_t^\star$ around the *normal-equilibrium* steady state and obtain

$$\Delta x_t^\star = \frac{\phi}{R(\phi - 1)} \Delta R_t^{b,\star} - \frac{R^b \phi}{R^2(\phi - 1)} \Delta R_t^\star - \frac{R^b}{R(\phi - 1)^2} \Delta \phi_{t-1},$$

Figure A2: Contributions to the change in the run indicator $x^{\star}$.



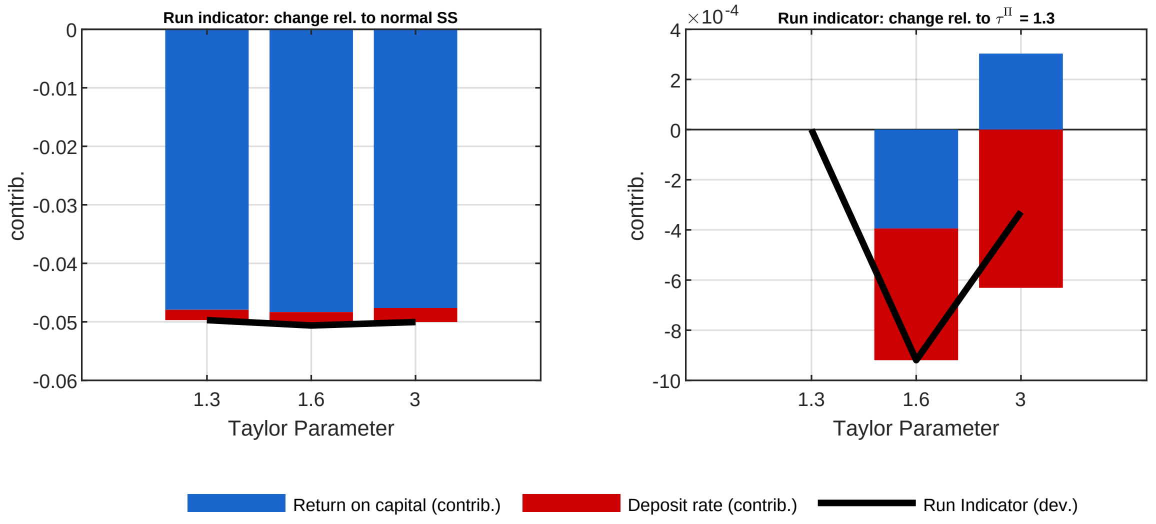
Notes: Contributions of the real asset return $R_t^{b,\star}$, the real deposit rate $R_t^{\star}$ and leverage ϕ_{t-1} to the run indicator according to the linearized version of $x_t^{\star} = \frac{R_t^{b,\star}}{R_t^{\star}} \frac{\phi_{t-1}}{\phi_{t-1}-1}$. The left panel shows the corresponding contributions to the absolute deviation of $x^{\star}$ from the deterministic steady state x_{SS}. The right panel shows the contributions to the absolute deviation of $x^{\star}$ from its value at zero trend inflation, i.e. $x^{\star} - x^{\star}_{\bar{\pi}=0}$.

D Appendix: The mechanism underlying the bank run with different Taylor Parameters

This section explains why the run probability is hump-shaped in the Taylor parameter. For that purpose, we compare economies at 2% p.a. long-run inflation rates varying the Taylor parameter on inflation in the monetary policy rule. It is evident from figure A3 that the hump-shape in the run probability when increasing Taylor parameters is mirrored by the run-indicator and the main driver again is the return on capital (mainly shaped by the asset price, not shown): for intermediate Taylor parameters the asset price drops relatively more, while it drops less for high Taylor parameters (see figure A4.)

The lower response of the asset price for very high Taylor parameters is intuitive. With a high Taylor parameter on inflation, the central bank responds very strongly to the drop in inflation in a run. Therefore the expected real interest rate is relatively lower than compared to an economy with a Taylor parameter close to one. Consequently the

Figure A3: Contributions to the change in the run indicator $x^\star$, different Taylor parameters on inflation

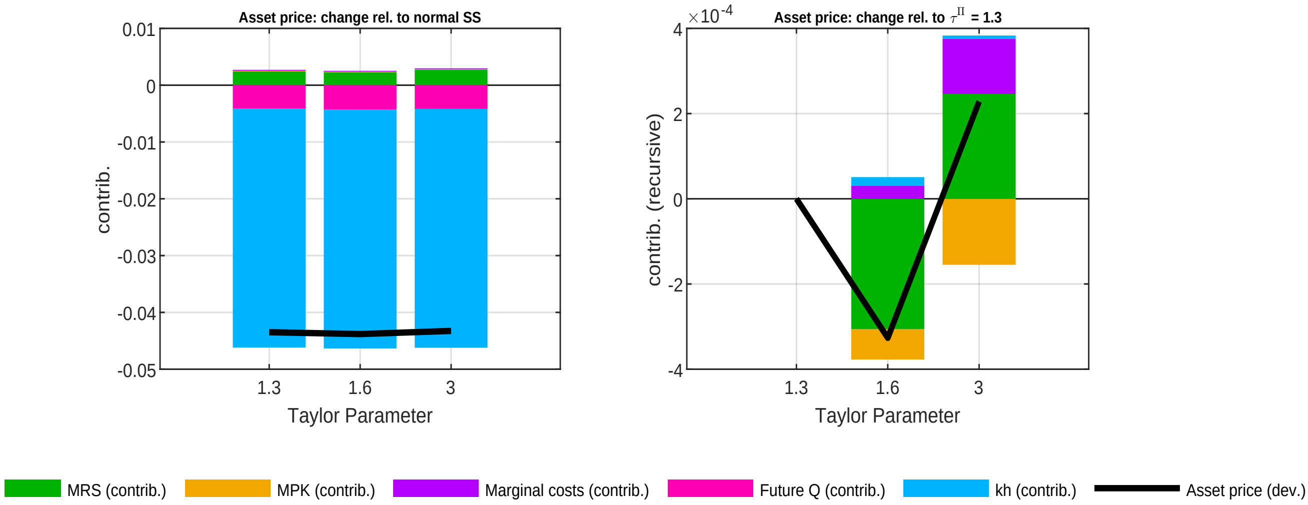


Notes: Contributions of the real asset return $R_t^{b,\star}$, the real deposit rate $R_t^\star$ and leverage ϕ_{t-1} to the run indicator according to the linearized version of $x_t^\star = \frac{R_t^{b,\star}}{R_t^\star}\frac{\phi_{t-1}}{\phi_{t-1}-1}$. The left panel shows the corresponding contributions to the absolute deviation of $x^\star$ from the deterministic steady state x_{SS}. The right panel shows the contributions to the absolute deviation of $x^\star$ from its value at zero trend inflation, i.e. $x^\star - x^\star_{\bar{\pi}=0}$.

marginal rate of intertemporal substitution is higher making it relatively more attractive for households to invest in capital, so this counteracts the drop in assets prices due to the fire sale in the banking sector.

Interestingly for intermediate Taylor parameters in the range between 1.5 and around 2, the asset price in a forced bank liquidation drops by more than compared to a very dovish (low Taylor parameter) and very hawkish (high Taylor parameter) monetary policy rule. It is again related to the response in the real interest rate. For these intermediate Taylor parameters the real interest rate decreases by less than the economy with low/high Taylor parameters and, consequently, the marginal rate of substitution is relatively lower, pushing down households' asset demand in a run, amplifying the drop in asset price in a run. In this intermediate range of Taylor parameters, for a given response of nominal interest rate in a run, expected inflation increases by more than compared to low/high Taylor parameters. The main reason comes from the price adjusting firms choosing a relatively higher mark-up. They expect inflation to be higher for intermediate Taylor

Figure A4: Contributions to the change in the asset price $q_t^\star$, different Taylor parameters on inflation

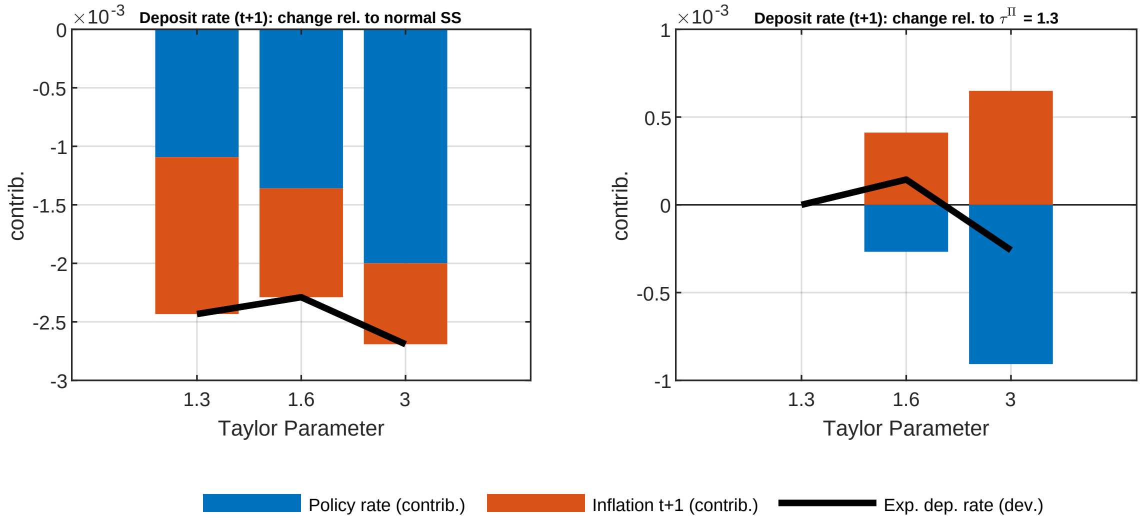


Notes: Contributions of the intertemporal marginal rate of substitution $MRS_{t+1}^\star = \beta E_t\{\lambda_{t+1}^\star/\lambda_t^\star\}$, the marginal productivity of capital $MPK_{t+1}^\star = \alpha y_{t+1}^\star/k_t^\star$, marginal costs $mc_{t+1}^\star$, the future asset price $q_{t+1}^\star$ and asset management costs $\gamma\left(k_t^{h,\star}/k_t^\star - \kappa\right)$ to the drop of the current asset price $q_t^\star$ in the case of a run, according to the linearized version of equation (15). The left panel shows the corresponding contributions to the absolute deviation of $q_t^\star$ from the deterministic steady state q. The right panel shows the contributions to the absolute deviation of $q_t^\star$ from its value without ZLB at 2% trend inflation, i.e. $q_t^\star - q_{t,\bar{\pi}=2\%}^{\star,noZLB}$.

Parameters and therefore decrease prices by relatively less, so that their profits do not erode too fast in the future when they are likely not be able to adjust.

We conducted sensitivity analysis and found that this non-linearity of the run response of asset prices in changes of the Taylor parameter is absent when the monetary authority does not respond on aggregate output or aggregate demand.

Figure A5: Contributions to the change in the expected real interest rate $E_t(R_t^{n,\star}/\Pi_{t+1}^{\star})$, different Taylor parameters on inflation



Notes: Contributions of the nominal interest rate $R_t^{n,\star}$, and expected inflation $\Pi_{t+1}^{\star}$ to the drop of the expected real interest rate $R_t^{\star}$ in the case of a run, according to the linearized version of equation $\hat{R}_t^{\star} = \hat{R}_t^{n,\star} - \hat{\Pi}_{t+1}$. The left panel shows the corresponding contributions to the absolute deviation of $R_t^{\star}$ from the deterministic steady state $R = 1/\beta$. The right panel shows the contributions to the absolute deviation of $R_t^{\star}$ from its value with a Taylor parameter of 1.3, at 2% trend inflation, i.e. $R_t^{\star} - R_{t,\bar{\pi}=2\%}^{\star,\tau_\pi=1.3}$.

E Macroeconomic shocks

E.1 Impulse responses at a given trend inflation rate

Figures A6 and A7 depict the impulse responses of important macro variables under the assumption of a trend inflation of 2% p.a. For illustrative purposes, we assume that each shock corresponds to three standard deviations. Black lines show the reaction in *normal times*. Red lines show, for each period along the impulse horizon, the *on-impact* value of the corresponding variable if a hypothetical forced liquidation (*run equilibrium*) would occur in that period.

In *normal times*, each structural innovation is associated with a drop in investment demand and asset prices. The latter reduces the realized return on capital which puts a drag on bank balance sheets leading to an increase in leverage. These effects are qualitatively in line with those discussed by Gertler and Karadi (2011) or Gertler et al. (2020).

As revealed by the red lines, in each period along the impulse horizon, a hypothetical bank run would be associated with a much lower level of investment, GDP, asset prices and inflation. However, the three structural shocks are heterogeneous regarding their effects on inflation, and thus with respect to the policy rate set by the central bank and the real deposit rate.

Via standard channels, a **contractionary monetary shock** depresses aggregate demand and inflation. Since the *realized* gross real deposit rate is defined as $R_t = (1 + r^n_{t-1})/\Pi_t$, it rises. R_t remains above average for a couple of quarters as the policy rate is above average due to the shock. Under a hypothetical bank run, the *on-impact* deposit rate $R^\star_t$ is higher than in *normal times* as the *run-equilibrium* inflation $\Pi^\star_t$ is *on impact* lower than Π_t. For a given leverage inherited from the past, the rise in the deposit rate $R^\star_t$ reinforces the decline in the run indicator $x^\star_t$, on top of the effect resulting from the asset price drop (from q_t to $q^\star_t$). The run indicator remains below average due to the rise in bank leverage. Accordingly, even though exerting their strongest effect on impact, contractionary monetary policy surprises are also associated with an elevated financial fragility in the medium term (i.e. $x^\star_t$ closer to its critical threshold than without an adverse monetary disturbance).

A **contractionary capital quality shock** is associated with a much weaker and merely short-lived increase in the real deposit rate, but nevertheless leads to a worsening of the run indicator which is similarly pronounced as that resulting from the monetary disturbance. The reason is that, by assumption, exogenous shifts in capital quality directly affect the real return on capital, thus reducing it very strongly. Recall that the realized return on capital is given by

$$R^b_t = \frac{(z_t + (1-\delta)q_t) \cdot \Xi^k_t}{q_{t-1}},$$

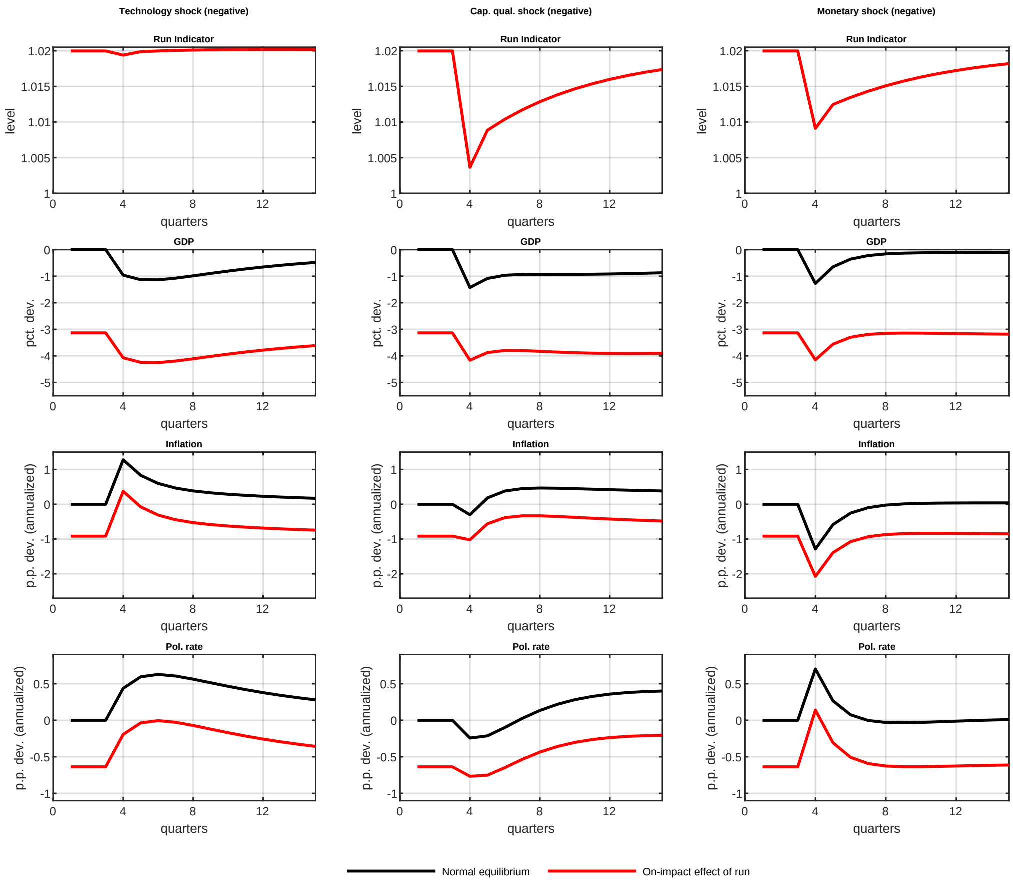
where $\Xi^k_t = \exp(\xi^k_t)$ is the capital quality shock. Moreover, the latter acts as a typical demand disturbance: A sudden deterioration in the quality of capital does not only depress investment demand but also leads to a decline in consumption. Accordingly, real GDP and the inflation rate decrease. The inflation decline, however, is much weaker and less persistent than in the case of a monetary policy surprise. The reason is that exogenous deteriorations in capital quality mainly affect investment while the associated decline in private consumption - the largest demand component - is comparably muted. The response of inflation is further attenuated as the capital quality shock does not only depress aggregate demand but simultaneously also reduces total factor productivity and thus aggregate supply. Due to the weaker drop in inflation, the deposit-rate's contribution to the run indicator is much smaller than in the case of a monetary disturbance (see Figure 7).

In the *normal-times* equilibrium, an **adverse productivity shock** is associated with a persistent increase in inflation. As a consequence, the real deposit rate R_t declines on impact and remains below average over several quarters. Its *run-equilibrium* counterpart $R_t^{\star}$ follows a similar pattern, thus attenuating the worsening in the run indicator (see equation (8)). The increase in leverage, although persistent, is far weaker than in the case of the other structural shocks.

E.2 Impulse responses to rescaled shocks

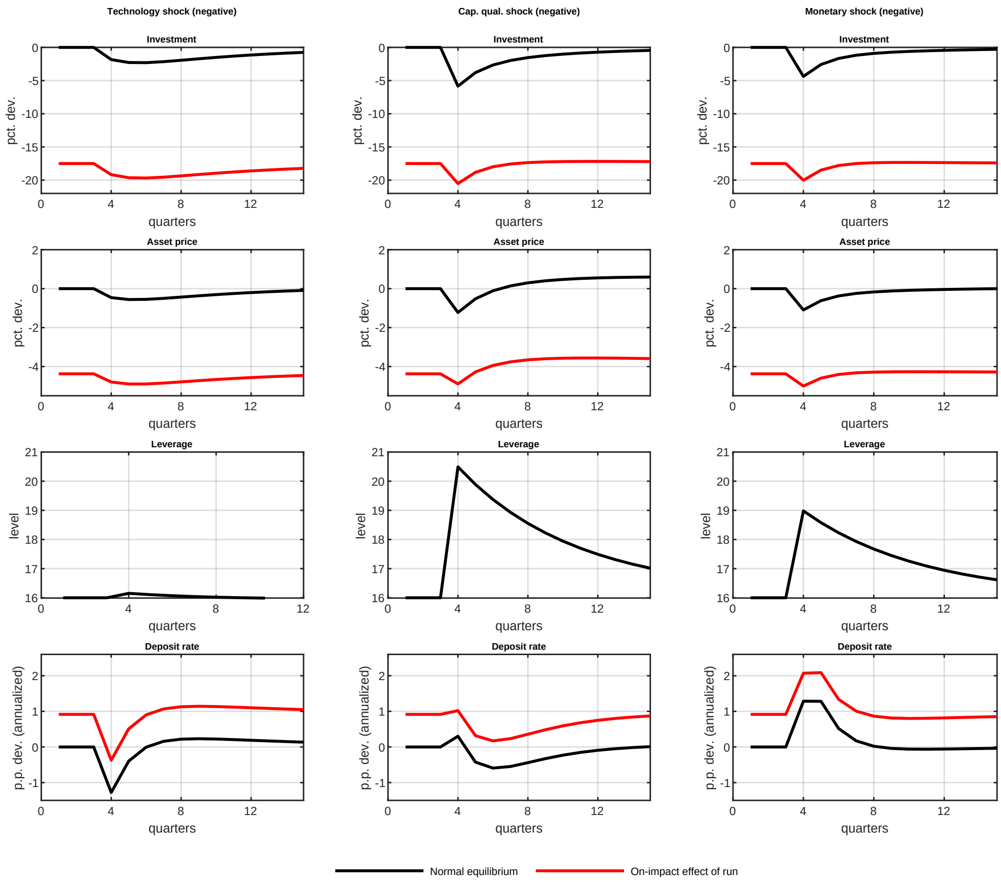
As discussed in Section 5.6, the individual structural shocks are not equally relevant for financial (in)stability. One reason is that, due to the calibration, the structural disturbances are very unequal with regard to the impled magnitude of the drop in real asset prices (see also Figure A7). To assess the importance of this aspect, we recompute the impulse responses at 2% trend inflation by normalizing the shocks such that each of them is associated with roughly the same maximum decline in the real asset price. The results are given in Figure A8. They reveal, that even after the normalization, the innovation to total factor productivity remains the least important for the run indicator.

Figure A6: Impulse responses of various variables at 2% trend inflation.



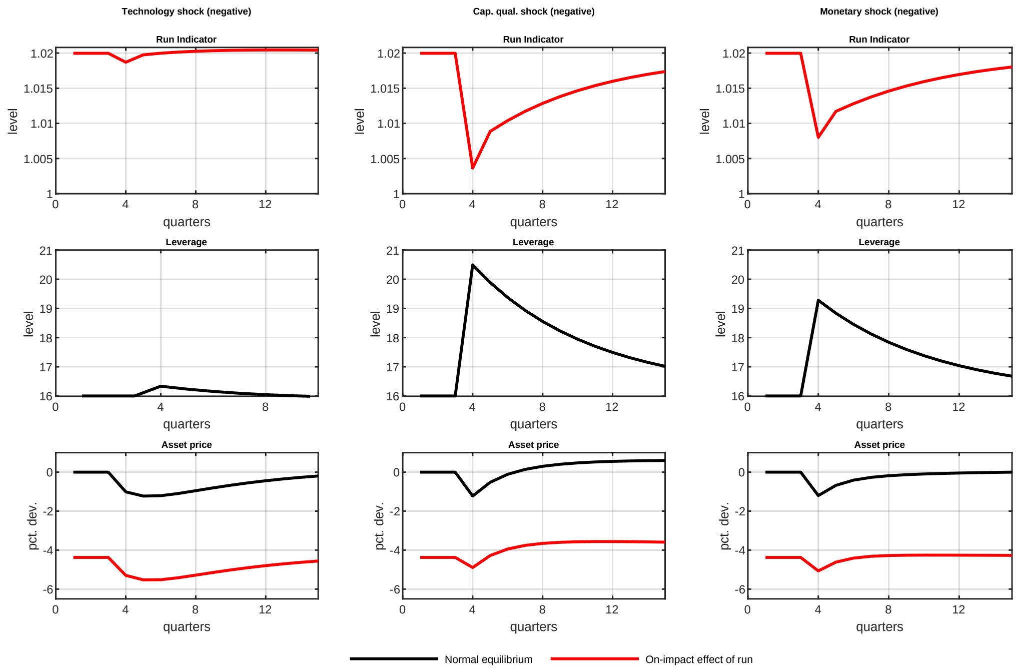
Notes: Each column corresponds to one of the structural macroeconomic shocks. Shocks occurring in period $t = 4$ and corresponding to 3 standard deviations. *Black lines:* Impulse responses in the normal equilibrium. *Red lines:* on-impact deviation of the corresponding variable under the assumption of a forced liquidation in that period.

Figure A7: Impulse responses of various variables at 2% trend inflation.



Notes: Each column corresponds to one of the structural macroeconomic shocks. Shocks occurring in period $t = 4$ and corresponding to 3 standard deviations. *Black lines:* Impulse responses in the normal equilibrium. *Red lines:* on-impact deviation of the corresponding variable under the assumption of a forced liquidation in that period.

Figure A8: Impulse responses of various variables at 2% trend inflation. Rescaled shocks.

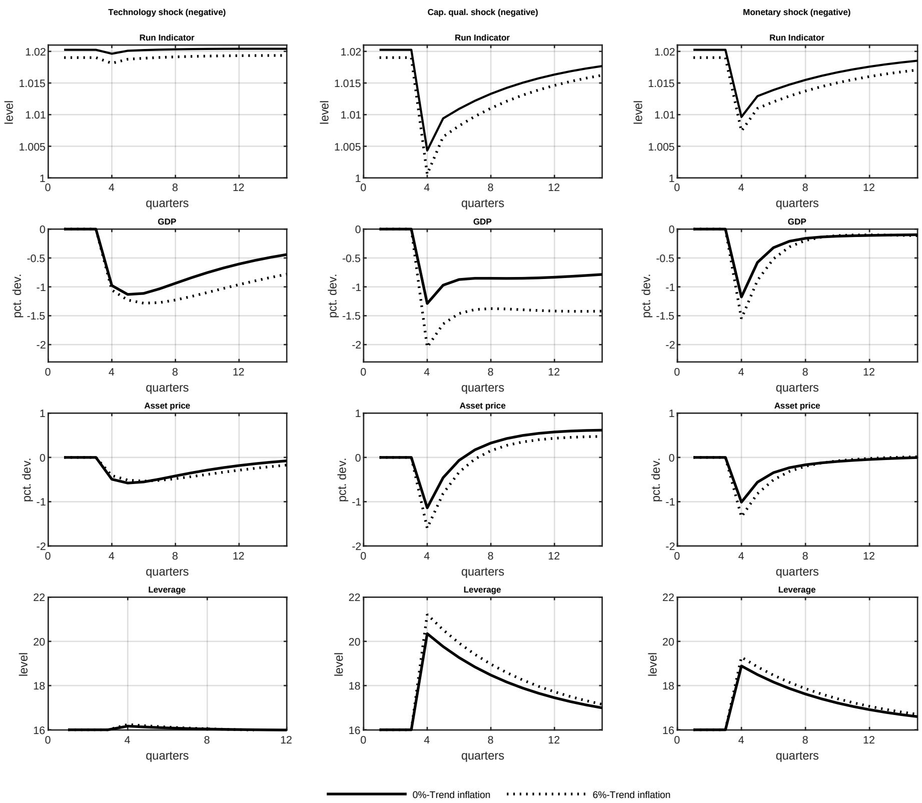


Notes: Each column corresponds to one of the structural macroeconomic shocks. Shocks are rescaled such that the peak response of the real asset price in the normal-times equilibrium is roughly the same across shocks. Shocks occurring in period $t = 4$. *Black lines:* Impulse responses in the normal equilibrium. *Red lines:* on-impact deviation of the corresponding variable under the assumption of a forced liquidation in that period.

E.3 Impulse responses at different trend inflation rates

Figure A9 summarizes the effects of the three structural shocks at two different levels of trend inflation, i.e. 0% and 6% per annum. In accordance with the results in Ascari and Rossi (2012) and Ascari and Sbordone (2014), higher trend inflation magnifies the response of real economic activity in the *normal equilibrium*. We further observe that the drop in real asset prices as well as the rise in bank leverage are also amplified, especially in the case of the capital quality shock. This amplification translates into the associated *on-impact* responses for the *crisis equilibrium* as well, the reasons being discussed in Section 5.4. The consequence is a deeper decline of the run indicator in the period of the respective shock.

Figure A9: Impulse responses of various variables at different trend inflation rates.



Notes: Each column corresponds to one of the structural macroeconomic shocks. Shocks occurring in period $t = 4$ and corresponding to 3 standard deviations. *Solid lines:* Impulse responses at 0% trend inflation. *Dashed lines:* Impulse responses at 6% trend inflation. The responses of GDP, Asset prices and Leverage correspond to the *normal-times* equilibrium.

F Appendix: Data for calibration

The macroeconomic data used for the calibration is mainly taken from Eurostat (obtained via Datastream) or the Statistical Data Warehouse (SDW) of the European Central Bank (ECB). Each individual series is an euro-area aggregate. Depending on data availability, the sample covered is either 1997 - 2019 or 2001 - 2019. We do not consider observations after 2019 in order to avoid potential biases due to the exceptionality of the Covid-19 period (i.e. 2020 - 2022).

- Gross domestic product at market prices, chained linked volumes (ESA 2010, quarterly, seasonally and working-day adjusted),

  Source: Eurostat

  Obtained via Datastream, mnemonic: EMESNFVCD

- Gross fixed capital formation at market prices, chained linked volumes (ESA 2010, quarterly, seasonally and working-day adjusted),

  Source: Eurostat

  Obtained via Datastream, mnemonic: Z8ESLUVSD

- Harmonized index of consumer prices (HICP) (monthly, seasonally adjusted),

  Source: SDW (ECB)

  Obtained via Datastream, mnemonic: EMEBCPGS%

- Total assets of euro-area's MFIs, outstanding amount (stock) in millions of euro, (monthly),

  Source: SDW (ECB)

  Mnemonic: BSI.M.U2.N.A.T00.A.1.Z5.0000.Z01.E

- Capital and reserves (banks' equity) of euro-area MFIs, outstanding amount (stock), in millions of euro, (monthly), Source: SDW (ECB)

Mnemonic: BSI.M.U2.N.A.L60.X.1.Z5.0000.Z01.E

- Share of financial assets held by banks,

  Source: Eurostat

  Detailed source: Sectoral National Accounts (ESA 2010)/ Financial balance sheets/Total financial assets/liabilities

  Obtained via: https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nasa_10_f_bs&lang=en

- Policy rate, proxied by Leo Krippner's shadow short rate for the Euro Area (Krippner, 2013)

  Source: https://www.ljkmfa.com/visitors/.

- Spread of non-financial corporate bonds with respect to German government bonds (Bund), constructed by Gilchrist and Mojon (2018)

  Source: Banque de France Working Paper Series no. 482