

Can the cure kill the patient?

Corporate credit interventions and debt overhang^{*}

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Abstract

Governments increasingly respond to crises by lending to non-financial firms or purchasing their debt. By increasing leverage, these interventions exacerbate debt overhang, thereby depressing investment after the crisis. We quantify this trade-off in a model of investment, financing, and default, estimated to match the empirical persistence of leverage and sensitivity of investment to leverage among U.S. firms. Interventions confined to credit markets reduce long-run capital whenever equity financing remains available. They are effective when they lower risk premia across markets, or when all financing disappears, crises are short, and support is targeted. Moral hazard effects are real but quantitatively modest.

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1 Introduction

The COVID-19 crisis prompted governments around the world to intervene directly in corporate credit markets on an unprecedented scale. Programs such as the Federal Reserve’s Primary and Secondary Market Corporate Credit Facilities, the Main Street Lending Program, and similar initiatives in Europe sought to preserve the flow of credit to non-financial firms during a period of severe economic and financial stress. By assuming direct exposure to corporate credit risk, these programs departed from the traditional approach to crisis management, in which governments support businesses indirectly through the banking system. These interventions are unlikely to remain a one-off response to the pandemic: similar programs have since been redeployed in response to other shocks, and central banks now describe direct market interventions as a standing part of the crisis toolkit.¹ Despite the growing role of this new policy tool, a basic question remains unresolved: under what conditions do direct credit market interventions improve real economic outcomes, and when do they instead increase leverage and exacerbate debt overhang?

A natural argument in favor of these interventions is that they alleviate financing constraints during crises, reducing defaults and supporting investment. However, these same interventions may also increase corporate leverage. Since leverage depresses investment incentives through debt overhang (Myers, 1977), interventions that expand debt financing today may reduce investment tomorrow. The magnitude of these effects depends not only on the initial increase in leverage, but also on how long the resulting debt remains on firms’ balance sheets. If leverage is persistent, temporary interventions can generate long-lived distortions. Whether credit interventions help or hurt depends

¹For a detailed overview of the 2020 corporate credit interventions, of their counterparts in other advanced economies, and of earlier examples, see [Appendix A.1. Bank for International Settlements \(2022\)](#) lays out principles for the design of central bank interventions in dysfunctional markets, treating them as a permanent part of the policy toolkit. The tools have since been used again: in October 2022, South Korean authorities reactivated the corporate bond purchase program they had used in 2020, following the default of the developer of a large theme park ([Reuters, 2022](#)), and in April 2022, France re-opened its 2020 program of state-guaranteed corporate loans for firms affected by the economic consequences of the war in Ukraine ([Direction générale du Trésor, 2022](#)). Expectations that they will continue to be used appear well anchored: during the market turmoil of April 2025, the president of the Boston Fed noted that the Federal Reserve had “had to deploy quite quickly, various tools” in the past, and “would absolutely be prepared to do that as needed” ([Financial Times, 2025](#)).

on the balance between their short-run stabilization benefits and their long-run effects on firms' capital structures.

This paper develops and estimates a quantitative framework to evaluate this trade-off. We build a dynamic corporate financing model in which firms jointly choose investment, debt issuance, and default policies.² Debt financing provides tax benefits but creates debt overhang, causing highly levered firms to invest less and default more frequently. We estimate the model on a 2010-2019 panel of U.S. public non-financial firms, targeting in particular the two moments that govern the size and duration of debt overhang effects: the sensitivity of investment to leverage, and the persistence of leverage. In the data, a 10 percentage point (p.p.) increase in book leverage is associated with a 1.1 p.p. decline in the gross investment rate within firm, and leverage mean-reverts over a horizon of approximately six years. The estimated model reproduces the persistence of leverage, and implies a sensitivity of investment to leverage within the range of existing empirical estimates. It also implies sizable steady-state costs of debt overhang for aggregate growth. We then use the estimated model as a laboratory to study credit market interventions during large macro-financial crises, which we model as a temporary fall in firm profitability combined with a rise in risk premia.

Debt overhang is not the only cost these interventions could create; they may also slow the reallocation of capital across firms, or attract participants that the government would prefer not to fund. We focus on debt overhang because it operates through the very margin the policies target: credit interventions work by inducing firms to issue debt that private markets would not fund at the same terms. The concern is also central to the policy debate: when various credit market interventions were launched in March 2020, commentators and policy groups warned that they could leave behind cohorts of highly indebted “zombie” firms, and official-sector assessments of the pandemic-era programs echo this concern.³

A preliminary observation organizes our experiments: government funding provided at market prices, leaving investors' risk pricing unchanged, is a perfect substitute for

²The model extends [DeMarzo and He \(2021\)](#): debt is long-term and defaultable, as in [Leland et al. \(1994\)](#), but firms can adjust it continuously and without commitment. We combine this financing problem with a standard q -theory model of investment.

³For early warnings about “zombie firms”, see [Financial Times \(2020\)](#) and [Group of 30 \(2020\)](#); for official-sector assessments, see [European Central Bank \(2021\)](#) and [International Monetary Fund \(2022\)](#).

private funding and has no effect on firm policies or aggregate outcomes. For credit interventions to matter, they must change the financing terms firms face, or provide funding when private markets no longer do. Our four main results characterize when these changes improve aggregate outcomes.

Our first result is that credit market interventions are counterproductive when firms retain access to equity markets. We study two such interventions: one in which the government restores access to the credit market after private lenders withdraw, and one in which it purchases debt above prevailing market prices, lowering the Sharpe ratio in credit markets. Because equity markets remain open, neither intervention relaxes a binding financing constraint. Their effect works entirely through financing incentives: firms respond to cheaper debt by issuing more of it, while their investment plans conditional on leverage are exactly the same as under *laissez-faire*. Firms therefore emerge from the crisis with higher leverage, and because they delever only gradually, debt overhang depresses investment throughout the recovery, leaving the long-run aggregate capital stock approximately 2% lower than under *laissez-faire* in both scenarios.

These distortions are persistent, but their magnitude is moderate, illustrating an important distinction between the *average* and *marginal* costs of debt overhang. Although debt has sizable effects on aggregate growth in our estimated steady state, the interventions considered here increase leverage only at the margin relative to an economy in which firms are already indebted. The resulting marginal debt-overhang costs are therefore quantitatively modest. Their magnitude is further limited by the incidence of the interventions. Restoring access to credit markets primarily increases borrowing among low-leverage firms, whose investment is relatively insensitive to leverage. Compressing credit-market risk premia instead affects highly levered firms, whose investment is more sensitive to leverage, but these firms account for only a small share of aggregate capital. This configuration is not a foregone conclusion: in alternative estimations, notably one based on a sample of smaller firms, the same interventions generate substantially larger long-run losses (Section 5).

Our second result is that this conclusion reverses when interventions spill over into equity markets. The Spring 2020 announcements moved stock prices along with corporate bond spreads, suggesting that credit interventions can lower risk premia across markets rather than in credit markets alone. We capture this case with an intervention

that lowers the price of risk faced by both debt and equity investors. Cheaper credit still encourages firms to lever up, but lower equity risk premia raise stock prices and Tobin's q , stimulating investment immediately. Quantitatively, the valuation channel dominates: the economy converges to a capital stock 9.7 p.p. below its no-crisis path under the intervention, compared with 14.5 p.p. under *laissez-faire*. This result comes with a caveat: it rests on the elasticity of firm valuations with respect to discount rates, and of investment with respect to Tobin's q , neither of which is directly disciplined by our estimation. If these elasticities were weaker than the model implies, the case for market-wide stabilization would be correspondingly weaker.

Our third result concerns crises severe enough that all financial markets shut down. Firms must then finance investment out of internal cash flows, and credit interventions relax a binding constraint: they reduce inefficient defaults and sustain investment during the crisis. Whether they improve long-run outcomes depends on their design and on the duration of the crisis. A targeted program, in which the government lends at a price low enough that only firms close to distress find it attractive, leaves the long-run capital stock 15.7% below its pre-crisis trend, compared with 16.4% under *laissez-faire*, for a crisis lasting two years on average. A broad program, priced so that nearly all firms participate, costs more and leaves the corporate sector with enough additional debt that the long-run overhang costs dominate the short-run stabilization benefits.

Targeting matters at least as much for fiscal efficiency: a program under which the government acquires newly-issued corporate debt at a fixed price of 80% costs approximately 0.5% of the pre-crisis capital stock and raises aggregate capital by 1.6% after one year, a gain that shrinks to 0.3% after ten years as debt overhang sets in. Simple pricing rules, such as an interest rate floor or a ceiling on the purchase price of debt, are sufficient to induce the desirable selection. Finally, longer crises weaken the case for intervention, as support must be maintained for longer, fiscal intervention costs climb and firms accumulate correspondingly more debt.

Our fourth result concerns anticipation effects. If firms expect the government to support credit markets in future crises, firms have an incentive to borrow more in normal times. This moral hazard concern was raised from the outset, including by the officials responsible for the 2020 facilities.⁴ In the model, the concern is qualitatively correct:

⁴Discussing the corporate credit facilities, Singh (2020) notes that “another distortion could be excessive

when firms anticipate systematic interventions, leverage in normal times rises by 0.2 to 0.6 p.p. in scenarios where only credit markets are affected, and by 1.5 p.p. when interventions extend to equity markets. The growth effects are nevertheless small: long-run growth falls by 0.05 to 0.06 p.p. per year in scenarios where only credit markets are affected, and it rises when interventions spill over to equity markets, because higher valuations more than offset the additional debt overhang effects. Leverage accumulation alone is thus an unreliable gauge of the real costs of anticipated interventions.

Section 5 examines the robustness of these findings to alternative estimations of the model, including on a sample of smaller firms, and to an extension of the model with equity issuance costs. The magnitudes of the long-run distortions vary, most notably with the size of investment adjustment costs, but the ranking of interventions and the mechanisms behind it are unchanged.

Taken together, our results imply that the effects of corporate credit interventions depend on the nature of the underlying financial disruption. When equity markets continue to function, supporting credit markets alone raises leverage without stimulating investment; interventions improve aggregate outcomes when they reach the margins that are impaired, namely elevated risk premia across markets, or the financing constraints that bind when external finance disappears. In all cases, the persistence of leverage determines how long the effects of the intervention last, and targeting determines its fiscal cost. These are the margins on which future credit market interventions should be evaluated.

Contribution to the literature Our paper relates to three strands of literature.

First, a growing literature studies direct interventions in corporate credit markets. Empirically, [Haddad, Moreira and Muir \(2021\)](#), [Boyarchenko, Kovner and Shachar \(2022\)](#), and [Gilchrist et al. \(2024\)](#) show that the Fed’s 2020 corporate credit facilities operated largely through announcement effects, compressing credit spreads well before any purchases took place. This evidence motivates the price-of-risk stabilization scenarios we study in [Section 4.3](#).⁵ On the quantitative side, [Elenev, Landvoigt and Van Nieuwerburgh](#)

amounts of corporate debt issuance based on future expectations of an official sector backstop,” a risk that “will bear watching over the coming years.”

⁵[Gilchrist et al. \(2024\)](#) rationalize this evidence with a model in which the announcements lower the risk premia demanded by marginal investors in credit markets.

(2022) evaluate the 2020 U.S. programs jointly in a general equilibrium model with corporate and intermediary sectors, and find that the interventions worked primarily by short-circuiting the feedback between corporate and financial-sector fragility. Li and Li (2025) study how credit interventions can amplify the misallocation of capital between firms by dampening the cleansing effect of crises.⁶ Relative to this work, we focus on the effects of interventions on firms’ capital structures. Closest to our paper, Brunnermeier and Krishnamurthy (2020) highlight debt overhang as a potentially important downside of direct credit market interventions. Our primary contribution is to quantify the long-run investment and growth distortions associated with debt overhang, and to show that their magnitude depends critically on the persistence of leverage.

Second, our paper relates to the theoretical and empirical literature on debt overhang. On the empirical front, a large literature has documented the negative effects of leverage on investment.⁷ In Section 3, we review these results and compare the steady-state implications of our model to them. Relative to this literature, we show that while there can be large *average* (or steady-state) effects of debt overhang in our model, the *marginal* effect of debt overhang on investment associated with a direct credit intervention generally remains small. On the theoretical front, the paper closest to ours is Hennessy (2004); while that article only analyzes the investment behavior a single firm that has legacy debt, we also study aggregation and the transmission of shocks that affect the distribution of corporate leverage.⁸

Finally, our paper also relates to the literature on the investment effects of securities

⁶Relatedly, Acharya, Lenzu and Wang (2021) develop a notion of zombie lending and analyze the effects of credit policies in this context, Faria-e Castro, Paul and Sánchez (2024) model private lenders’ incentives to evergreen loans to distressed firms, and Granja et al. (2022) document the targeting and take-up of the Paycheck Protection Program. Segura and Villacorta (2023) characterize optimal support to firms after a rare disaster with debt overhang and bank funding frictions. Chodorow-Reich, Iverson and Sunderam (2022) provide an assessment of the full set of U.S. pandemic-era business support programs.

⁷Among others, Opler and Titman (1994), Lang, Ofek and Stulz (1996), Matsa (2011), or Wittry (2021).

⁸A large theoretical literature has studied the conditions under which existing debt can depress investment, among others, Mello and Parsons (1992); Mauer and Ott (2000); Moyen (2007), and Diamond and He (2014). Additionally, though that paper does not focus on debt overhang, our model shares common features with Hennessy and Whited (2007). The main differences are (a) our model has constant returns to scale in production, allowing for easier aggregation; (b) we assume frictionless equity markets and a simpler corporate tax structure; (c) we allow for long-term debt, potentially magnifying the effects of debt overhang; and (d) we study a continuous-time framework in which equilibrium computations are considerably simpler. Section 5.3 considers a version of the model with equity issuance costs.

mispricing, including Stein (1996), Baker, Stein and Wurgler (2003) and Baker and Wurgler (2006). In particular, Stein (1996) highlights how mispricing in equity markets can create a motive for rational managers to issue or repurchase shares. In our paper, credit market interventions result in a discount rate wedge that encourages debt issuance. The difference is in the transmission to investment. In Stein (1996), issuance decisions only have real effects when the firm faces capital structure constraints. By contrast, in our model, even without these constraints, debt issuance has real effects, because of overhang, as higher leverage today increases the underinvestment problem in the future.

2 Model

In this section, we develop a model of firm investment, financing, and default, discuss its key economic mechanisms, and highlight some of its limitations.

2.1 Model description

We first describe individual firms' problem before turning to aggregation. For tractability, we specify investors' stochastic discount factors ("SDFs") exogenously.

2.1.1 Firm problem

There is a continuum of firms indexed by j . Managers choose investment, debt financing, and default policies, taking debt prices as given. Borrowing is motivated by the tax deductibility of interest, while investment is subject to convex adjustment costs. Competitive creditors price debt rationally, anticipating firms' optimal policies.

Firms' cash flows are exposed to idiosyncratic and priced aggregate shocks; equity and debt investors may price claims using different SDFs. In our baseline model, credit and equity markets are frictionless. Section 5.3 considers equity issuance costs.

Technology Firm j produces revenue $y_t^{(j)} = ak_t^{(j)}$ per unit of time, where $k_t^{(j)}$ denotes efficiency units of capital and a is the marginal product of capital, common across firms. Spending $\Phi(g_t^{(j)})k_t^{(j)}dt$ allows the firm to increase its capital stock by $g_t^{(j)}k_t^{(j)}dt$, where

Φ is increasing and convex. Thus $g_t^{(j)}$ is the net investment rate and $\Phi(g_t^{(j)})$ the gross investment rate. Firm j 's capital satisfies

$$dk_t^{(j)} = k_t^{(j)} \left(g_t^{(j)} dt + \sigma \left(\rho dZ_t + \sqrt{1 - \rho^2} dz_t^{(j)} \right) \right). \quad (1)$$

Z_t and $z_t^{(j)}$ are Brownian motions representing aggregate and idiosyncratic shocks to efficiency units of capital. The shocks $z_t^{(j)}$ are i.i.d. across firms and independent of Z_t .⁹ In our numerical calculations,

$$\Phi(g) := \delta + g + \frac{\gamma}{2} g^2, \quad (2)$$

where δ is depreciation and γ governs adjustment costs.

Capital structure The firm has access to debt and equity markets. Debt is long-term, pays fixed coupon κ , and its face value amortizes exponentially at rate m . If $b_t^{(j)}$ denotes face value and $\iota_t^{(j)} k_t^{(j)} dt$ the face value issued between t and $t + dt$, then

$$db_t^{(j)} = \left(\iota_t^{(j)} k_t^{(j)} - mb_t^{(j)} \right) dt. \quad (3)$$

Depreciation and debt interest payments are tax deductible, and θ denotes the corporate income tax rate. Issuing one unit of face value raises $d_t^{(j)}$, the endogenous debt price per unit of face value. During $[t, t + dt)$, dividends $\pi_t^{(j)} k_t^{(j)} dt$ equal

$$\underbrace{ak_t^{(j)}}_{\text{EBITDA}} - \underbrace{\Phi(g_t^{(j)}) k_t^{(j)}}_{\text{investment}} - \underbrace{(m + \kappa) b_t^{(j)}}_{\text{debt P\&I}} + \underbrace{\iota_t^{(j)} k_t^{(j)} d_t^{(j)}}_{\text{debt issuance proceeds}} - \underbrace{\theta (ak_t^{(j)} - \delta k_t^{(j)} - \kappa b_t^{(j)})}_{\text{tax liability}}. \quad (4)$$

Shareholders cannot commit to repay the firm's debt, which is therefore credit-risky. At a default time τ , bankruptcy costs reduce capital to $k_\tau^{(j)} = \alpha_k k_{\tau-}^{(j)}$, while renegotiation reduces debt to $b_\tau^{(j)} = \alpha_b b_{\tau-}^{(j)}$. We impose $0 < \alpha_b < \alpha_k < 1$, so bankruptcy entails positive costs and lowers leverage. Denote $n_t^{(j)}$ the associated default counting process.

⁹Throughout the paper, capital letters denote aggregates, except for $E(k, b)$ and $D(k, b)$, the firm-level value functions for equity and debt defined below.

Investors Let r denote the risk-free rate, and v_e (resp. v_d) the price of risk in equity (resp. debt) markets. The SDF $\xi_{n,t}$ for investor type $n \in e, d$ satisfies

$$\xi_{n,t} = \xi_{n,0} \exp \left(- \left(r + \frac{v_n^2}{2} \right) t - v_n Z_t \right). \quad (5)$$

When $v_e \neq v_d$, credit and equity markets must be segmented to rule out arbitrage.¹⁰

Firm problem From now on, we omit the firm's superscript j for notational simplicity. Shareholders take the debt price process d_t as given. Their equity value E is defined via:

$$E(k, b) := \sup_{g, \iota, \tau} \mathbb{E}^{k, b} \left[\int_0^{+\infty} \frac{\xi_{e,t}}{\xi_{e,0}} \pi_t k_t dt \right], \quad (6)$$

where τ is the sequence of default times chosen by management and $\mathbb{E}^{k, b}$ conditions on $(k_0, b_0) = (k, b)$. Creditors take the default policy τ and associated counting process n_t as given, and price one unit of debt according to

$$D(k, b) := \mathbb{E}^{k, b} \left[\int_0^{+\infty} \frac{\xi_{d,t}}{\xi_{d,0}} \alpha_b^{n_t} e^{-mt} (\kappa + m) dt \right]. \quad (7)$$

We focus on a Markov perfect equilibrium ("MPE") in which E is homogeneous of degree one in (k, b) , D is homogeneous of degree zero, policies ι and g are homogeneous of degree zero, and the continuation region is a cone in the (k, b) plane. For $x := b/k$, we can therefore write $D(k, b) = d(x) := D(1, x)$ and $E(k, b) = ke(x) := kE(1, x)$, with issuance and investment policies $\iota(x)$ and $g(x)$. Default follows a cutoff rule,

$$\tau = \inf\{t \geq 0 : x_t \geq \bar{x}\}. \quad (8)$$

At sufficiently high leverage, management prefers default to servicing outstanding

¹⁰Such segmentation may arise from institutional mandates, regulatory constraints, or intermediary frictions that prevent investors from freely arbitraging across the two markets. Throughout the paper, we take the wedge between these risk prices, when it exists, as exogenous.

debt. The normalized equity value satisfies (see [Appendix A.2.3](#))

$$e(x) = \sup_{\tau, g, \iota} \tilde{\mathbb{E}}^x \left[\int_0^{+\infty} e^{-\int_0^t (r + \rho\sigma v_e - g_u) du} \alpha_k^{n_t} \pi_t dt \right], \quad (9)$$

$$dx_t = [\iota_t - (g_t + m - \rho\sigma v_e) x_t] dt - \sigma x_t d\tilde{Z}_t + \left(\frac{\alpha_b}{\alpha_k} - 1 \right) x_t dn_t, \quad (10)$$

where $\tilde{\mathbb{P}}$ reflects our normalization and $\tilde{Z}_t$ is Brownian motion under $\tilde{\mathbb{P}}$. Equation (9) values dividend-to-capital flows at the growth- and risk-adjusted rate $r + \rho\sigma v_e - g_t$. Capital's exposure to aggregate risk adds a drift adjustment $+\rho\sigma v_e x_t$ to the leverage dynamics in (10): under this measure, leverage grows faster when firms are more levered. Creditors anticipate financing policy $\iota(x)$, investment policy $g(x)$, and the default cutoff $\bar{x}$. The debt price satisfies

$$d(x) = \hat{\mathbb{E}}^x \left[\int_0^{+\infty} \alpha_b^{n_t} e^{-(r+m)t} (\kappa + m) dt \right] \quad (11)$$

$$dx_t = [\iota(x_t) - (g(x_t) + m - \sigma^2 - \rho\sigma v_d) x_t] dt - \sigma x_t d\hat{Z}_t + \left(\frac{\alpha_b}{\alpha_k} - 1 \right) \bar{x} dn_t,$$

under the pricing measure $\hat{\mathbb{P}}$ (see [Appendix A.2.5](#)), with $\hat{Z}_t$ a Brownian motion under $\hat{\mathbb{P}}$.

Equity valuation For arbitrary investment and debt issuance choices g, ι , define the infinitesimal operator $\tilde{\mathcal{L}}_{g, \iota}$ by

$$\tilde{\mathcal{L}}_{g, \iota} \phi(x) := [\iota - (g + m - \rho\sigma v_e) x] \phi'(x) + \frac{(\sigma x)^2}{2} \phi''(x). \quad (12)$$

Equity value satisfies the Hamilton-Jacobi-Bellman (“HJB”) variational inequality

$$0 = \max \left[\alpha_k e \left(\frac{\alpha_b}{\alpha_k} x \right) - e(x), \max_{\iota, g} \left[- (r + \rho\sigma v_e - g) e(x) + \pi(x; \iota, g) + \tilde{\mathcal{L}}_{g, \iota} e(x) \right] \right]. \quad (13)$$

The first term captures shareholders' default option; the second is the continuation value, where the discounted equity gains process must be a martingale.

Debt valuation Given policies $g(\cdot)$ and $\iota(\cdot)$ and default threshold $\bar{x}$, define

$$\hat{\mathcal{L}}_{g,\iota}\phi(x) := \left[\iota(x) - \left(g(x) + m - \sigma^2 - \rho\sigma\nu_d \right) x \right] \phi'(x) + \frac{(\sigma x)^2}{2} \phi''(x). \quad (14)$$

The martingale condition for discounted debt gains implies

$$(r + m)d(x) = \kappa + m + \hat{\mathcal{L}}_{g,\iota}d(x), \quad x \in [0, \bar{x}), \quad (15)$$

$$d(\bar{x}) = \alpha_b d \left(\frac{\alpha_b}{\alpha_k} \bar{x} \right). \quad (16)$$

The differential equation incorporates policies $g(x)$ and $\iota(x)$ from the shareholder problem (13), while (16) reflects the default cutoff. Equations (13) and (15) are therefore coupled functional equations for e and d . Without equity market frictions, however, the system decouples, simplifying the equilibrium analysis.

Optimal investment The optimal capital growth rate satisfies

$$\Phi'(g(x)) = e(x) - xe'(x) := q(x), \quad (17)$$

where $q = \partial_k E$ is Tobin's q . Investment therefore follows standard q -theory.

Optimal debt issuance The first-order condition for debt issuance is

$$d'(x) = -e'(x). \quad (18)$$

The firm issues debt until the marginal proceeds equal the marginal reduction in equity value caused by higher leverage, as in DeMarzo and He (2021). As shown in Appendix A.2.4, combining (18) with the martingale condition (15) yields

$$\iota(x) = \underbrace{\frac{\theta\kappa}{-d'(x)}}_{\text{tax motive}} + \underbrace{\rho\sigma x(\nu_e - \nu_d)}_{\text{arbitrage motive}}. \quad (19)$$

The first term is the conventional tax motive: issuance increases with the tax shield and decreases with the slope of the bond price function. When equity and debt investors coincide, $v_e = v_d$, this is the only force driving issuance. When $v_e \neq v_d$, an “arbitrage” motive arises: firms issue additional debt when Sharpe ratios in credit markets are lower than in equity markets, and this motive strengthens with leverage.¹¹ Equation (19) plays a central role in our analysis of government interventions: policies affecting debt prices directly alter financing incentives and, through debt overhang, investment and default.

Finally, default optimality implies the smooth-pasting condition

$$e'(\bar{x}) = \alpha_b e' \left(\frac{\alpha_b}{\alpha_k} \bar{x} \right). \quad (20)$$

2.1.2 Aggregation

Let $K_t := \int_j k_t^{(j)} dj$ denote aggregate capital and use capital letters for aggregate variables. Let $\omega_t^{(j)} := k_t^{(j)} / K_t$ be firm j 's share of aggregate capital, and $f_t(x, \omega)$ the time- t density over leverage and capital shares. [Appendix A.2.9](#) shows that aggregate capital satisfies

$$\frac{dK_t}{K_t} = \left(\hat{g}_t - (1 - \alpha_k) \hat{\lambda}_t^d \right) dt + \rho \sigma dZ_t, \quad (21)$$

where $\hat{g}_t$ is the capital-weighted average growth rate and $\hat{\lambda}_t^d$ the capital-weighted default rate. Let $\hat{f}_t(x) := \int_\omega \omega f_t(x, \omega) d\omega$ denote the fraction of aggregate capital at firms with leverage x . Then

$$\hat{\lambda}_t^d = -\frac{1}{2} \sigma^2 \bar{x}^2 \partial_x \hat{f}_t(\bar{x}), \quad \hat{g}_t = \int g(x) \hat{f}_t(x) dx. \quad (22)$$

[Appendix A.2.9](#) derives the Kolmogorov equation governing $\hat{f}_t$ as a function of firms' policies. Aggregate shocks imply that the economy has no deterministic steady state and that $\hat{f}_t$ varies with Z_t . Firm leverage nevertheless admits an ergodic capital-weighted

¹¹This mechanism is analogous to [Stein \(1996\)](#), where equity “mispricing” induces rational managers to issue or repurchase shares. In [Stein \(1996\)](#), however, these financing choices affect investment only in the presence of capital-structure frictions. Here leverage affects investment even with frictionless debt and equity markets through debt overhang, a mechanism absent from [Stein \(1996\)](#).

density $\hat{f}_\infty$, which satisfies

$$\mu_{K,\infty} \hat{f}_\infty(x) = \mathcal{L}^* \hat{f}_\infty(x), \quad (23)$$

with $\mathcal{L}^*$ the adjoint of the capital growth operator $\mathcal{L}$,¹² defined for any smooth ϕ via

$$\mathcal{L}\phi(x) := g(x)\phi(x) + (\iota(x) - (g(x) + m)x)\phi'(x) + \frac{(\sigma x)^2}{2}\phi''(x). \quad (24)$$

The constant $\mu_{K,\infty}$ is the economy's long-run growth rate and the largest eigenvalue of $\mathcal{L}^*$.¹³ We use $\hat{f}_\infty$ as the starting point for our experiments on the aggregate effects of credit market interventions.

2.2 Discussion

Investment and debt overhang Corporate debt depresses investment in our model. Highly levered firms invest less because part of the value created by the resulting decline in leverage accrues to creditors through higher debt prices.

In [Appendix A.2.6](#), we show that e is convex in leverage in our MPE. Since g satisfies (17), this implies $g'(x) < 0$: investment falls with leverage. The appendix also shows that if g^* is the optimal growth policy of a firm without access to credit markets, then $g(x) \leq g^*$ for all x . Debt overhang therefore reduces investment both at the margin, as leverage rises, and overall, relative to a no-debt firm.

[Figure 1a](#) illustrates these properties, plotting the optimal gross investment rate $\Phi(g(x))$ and ergodic density $\hat{f}_\infty$ using the estimated parameters from [Section 3](#). These debt-overhang effects will be amplified by government interventions that extend credit to businesses.

“Zombie” firms and creative destruction The investment behavior of our firms can be related to that of “zombie” firms. [Appendix A.2.7](#) shows that the default boundary $\bar{x}$ exceeds the boundary $\bar{x}^*$ of a firm committed to the no-leverage investment rule g^* , but

¹²We refer to $\mathcal{L}$ as the capital growth operator because $h(x, t) := \mathbb{E}^x[k_t/k_0]$ satisfies $\partial_t h = \mathcal{L}h$, with boundary conditions $h(x, 0) = 1$ for all x and $h(\bar{x}, t) = \alpha_k h((\alpha_b/\alpha_k)\bar{x}, t)$ for all t .

¹³See, for instance, [Hansen and Scheinkman \(2009\)](#).

otherwise free to choose its capital structure. Highly levered firms therefore sacrifice investment, pay dividends (or reduce equity issuance), and postpone default.

Although privately optimal, this behavior depresses investment because some firms remain active at leverage levels at which they would otherwise default under g^* . Firms with $x > \bar{x}^*$ can thus be viewed as zombie firms. A sufficiently long sequence of adverse productivity shocks eventually triggers default, after which they emerge with lower debt and higher investment. Credit market interventions alter this process of creative destruction by keeping such firms alive.

Financial policies Figure 1c and Figure 1d report equity values and dividends, while Figure 1e and Figure 1f report debt prices and issuance. Firms' debt issuance behavior is pinned down by (19). Since $d'(x) < 0$, it implies $\iota(x) > 0$ for all x , so firms continuously issue debt. Numerically, because d is concave, issuance declines with leverage.¹⁴

In our estimation, dividends also decline with leverage. At low debt levels, firms pay large dividends financed largely by bond issuance. At higher leverage, dividends fall because debt-service costs rise, debt issuance falls, and newly issued debt commands lower prices. The decrease in investment does not fully offset these forces. At sufficiently high leverage, dividends become negative, so firms issue equity.

Finally, Figure 1e shows that d decreases with leverage and remains below its risk-free value.¹⁵ Credit spreads $cs(x)$ therefore increase with leverage and remain positive even at $x = 0$, reflecting dilution risk.

The role of limited commitment Firms lever aggressively to monetize the tax deductibility of interest. Because they cannot commit to future financing, they issue until expected future default costs eliminate the tax benefits of debt, as emphasized by DeMarzo and He (2021).

As shown in Appendix A.2.4, condition (18) implies that, for *any* leverage ratio x , equity value equals that of a firm whose shareholders commit never to issue additional debt. Shareholders' time-consistency problem is therefore "self-defeating": it prevents

¹⁴This discussion concerns the baseline environment $v_e = v_d$, in which the arbitrage motive is absent. From (19), debt buybacks can arise when v_d is sufficiently high relative to v_e .

¹⁵The risk-free debt value is $d^* = (\kappa + m)/(r + m)$. Credit spreads are defined explicitly in Appendix A.2.5.

them from benefiting from the tax shield. This feature is useful for our analysis because firms actively take on debt, giving debt overhang the greatest scope to affect investment.

Default resolution Upon default, firms are restructured rather than liquidated. Restructuring generates deadweight losses in productive capital, $\alpha_k < 1$. A large literature documents such losses; in [Section 3](#), we use this evidence to calibrate α_k . Avoiding these losses is also an important potential benefit of credit interventions during crises.

Creditors accept a haircut, $\alpha_b < 1$, while shareholders are not fully wiped out, formally violating the absolute priority rule (“APR”). This assumption is primarily theoretical: zero recovery for equityholders combined with positive recovery for creditors is inconsistent with a smooth debt issuance equilibrium.¹⁶ The assumption also has empirical support. [Bris, Welch and Zhu \(2006\)](#), for example, find APR violations in 12.2% of the Chapter 11 reorganizations they study, while [Weiss \(1990\)](#) documents violations in a majority of his sample. Our bankruptcy protocol is therefore consistent with observed APR violations.

Cash holdings The model does not feature cash holdings: cash inflows are either distributed to creditors, invested, or paid as dividends rather than retained as reserves. Consequently, a decline in productivity a combined with financial-market frictions cannot be cushioned by pre-existing cash balances, potentially magnifying the shock. Abstracting from cash keeps the model tractable and leaves leverage as the unique state variable driving ex-post firm heterogeneity.

Model interpretation The model is an A-K model of investment and financing with ex-post heterogeneous firms. Aggregate growth arises through capital accumulation, while leverage heterogeneity generates endogenous differences in financing, investment, and default. Because the crises we study are transitory, they affect the level of aggregate capital and output through (a) temporary changes in firms’ investment, financing, and default policies and (b) persistent leverage dynamics, but do not permanently change the economy’s balanced-growth rate.

¹⁶As discussed in [DeMarzo, He and Tourre \(2023\)](#), existence of the smooth MPE requires $e'(x) + d(x) = 0$ in both the continuation and default regions. If shareholders are wiped out, smooth pasting requires $e'(\bar{x}) = 0$, which is consistent with a smooth MPE only if $d(\bar{x}) = 0$.

3 Estimation

We now turn to model estimation. We focus on the capital-weighted ergodic leverage density $\hat{f}_\infty$ in an environment with integrated financial markets, i.e. $\nu_e = \nu_d := \nu$. The model has 12 parameters: $\{r, \rho, \nu, \alpha_k, \alpha_b, a, \delta, \theta, \kappa, \sigma, m, \gamma\}$. For reasons discussed below, we calibrate $\{r, \nu, \rho, \alpha_k, \alpha_b\}$ and estimate the remaining seven parameters, $\{a, \delta, \theta, \kappa, \sigma, m, \gamma\}$, using a panel of U.S. non-financial public firms from 2010 to 2019.

3.1 Calibrated and estimated parameters

The parameters $\{\alpha_b, \alpha_k\}$ govern restructuring outcomes after default. In practice, restructuring occurs through either private workouts or Chapter 11 proceedings. To our knowledge, systematic data on private workouts are unavailable for public firms, the focus of our baseline estimation. We therefore cannot estimate $\{\alpha_b, \alpha_k\}$ jointly with the other parameters using the panel approach described below.

We instead calibrate α_b, α_k using the Bankruptcy Research Database (LoPucki and Doherty, 2007), which reports Chapter 11 outcomes for public firms with more than \$100m in assets, measured in 1980 dollars, at filing. We compute the average ratio of post- to pre-bankruptcy book assets, which maps to α_k , and the average ratio of post- to pre-bankruptcy book leverage, which maps to α_b/α_k . This yields $\alpha_k = 0.720$ and $\alpha_b = 0.580$, implying deadweight capital losses of 28%.¹⁷

We also calibrate, rather than estimate, the risk-free rate r , the price of risk ν , and the loading ρ of the capital quality shock on the aggregate process Z_t . Together, these parameters determine the risk-adjusted required return on capital, $r + \rho\sigma\nu$. Estimating them jointly with the other parameters would require targeting firm-level asset-price moments, whose dynamics our model is not designed to match. We set $r = 0.033$ and $\nu = 0.42$, consistent with the average annual real risk-free rate and Sharpe ratio computed from Kenneth French’s data over 1927-2022. We set $\rho = 0.5$, consistent with Herskovic et al. (2016), who show (see, e.g., Panel B of their Fig. 2) that average idiosyncratic volatility is close to average total-return volatility.

¹⁷Appendix A.3.1 provides details and compares these values with other estimates of deadweight bankruptcy losses.

To estimate the seven remaining parameters, we use firm-level panel regressions:

$$x_{i,t} = \hat{c}^{(x)} + \hat{\rho}_x x_{i,t-1} + \varepsilon_{i,t}^{(1)} \quad (25)$$

$$\Phi_{i,t} = \hat{c}^{(\Phi)} + \hat{\Gamma} x_{i,t-1} + \varepsilon_{i,t}^{(2)} \quad (26)$$

$$x_{i,t} = \hat{x} + \varepsilon_{i,t}^{(3)} \quad (27)$$

$$\Phi_{i,t} = \hat{\Phi} + \varepsilon_{i,t}^{(4)} \quad (28)$$

$$dep_{i,t} = \widehat{dep} + \varepsilon_{i,t}^{(5)} \quad (29)$$

$$tax_{i,t} = \widehat{tax} + \varepsilon_{i,t}^{(6)} \quad (30)$$

$$int_{i,t} = \widehat{int} + \varepsilon_{i,t}^{(7)} \quad (31)$$

from which we target the seven following moments:

$$\hat{\beta} = \left\{ \hat{\Phi}, \hat{x}, \hat{\rho}_x, \hat{\Gamma}, \widehat{dep}, \widehat{tax}, \widehat{int} \right\}. \quad (32)$$

Here, i indexes firms and t years; $x_{i,t}$ is book leverage, $\Phi_{i,t}$ the gross investment rate, $dep_{i,t}$ depreciation relative to EBITDA, $tax_{i,t}$ taxes paid relative to EBITDA, and $int_{i,t}$ interest paid relative to EBITDA.¹⁸ Before estimating Equations (25)-(31), we apply a within-firm transformation to all variables.¹⁹ Because our counterfactuals focus on aggregate outcomes, all estimates are weighted by firm assets. Thus, $\hat{\Phi}$ is the asset-weighted average investment rate, while $\hat{\Gamma}$ captures the within-firm relationship between investment and leverage. We choose the targeted moments parsimoniously to keep parameter identification transparent; we discuss identification below.

We estimate the model by Method of Moments. Because the mapping from model parameters to $\hat{\beta}$ is unavailable in closed form, a standard approach would simulate the model (Simulated Method of Moments, [Pakes and Pollard, 1989](#)). Instead, we follow the non-stochastic, distribution-based method of [Young \(2010\)](#), widely used in quantitative models of firm dynamics (e.g., [Terry, 2017](#); [Terry, Whited and Zakolyukina, 2023](#)). This approach propagates the model's cross-sectional distribution using the state dynamics

¹⁸In the model, $\Phi_{i,t} = \Phi(g(x_{i,t}))$; $dep_{i,t} = \delta/a$; $tax_{i,t} = \theta(1 - (\kappa/a)x_{i,t} - \delta/a)$; and $int_{i,t} = \kappa/ax_{i,t}$.

¹⁹ $z_{i,t} = \tilde{z}_{i,t} - \hat{\mathbb{E}}_i[\tilde{z}_{i,t}] + \hat{\mathbb{E}}[\tilde{z}_{i,t}]$, with $\hat{\mathbb{E}}_i$ the within-firm mean, $\hat{\mathbb{E}}$ the unconditional mean, and $\tilde{z}_{i,t}$ the data.

induced by optimal policies, avoiding simulation noise. Our one departure, detailed in [Appendix A.3.2](#), is that because our targeted moments are coefficients from dynamic panel regressions evaluated under the ergodic distribution, we combine that distribution with the model’s transition kernel to compute the coefficients directly, without iterating the distribution forward. This improves the speed and smoothness of computing the model counterpart to $\hat{\beta}$.

We estimate Equations (25)-(31) using the 2010-2019 panel of U.S. Compustat non-financial firms. The sample contains 22,405 firm-year observations from 3,319 firms. [Table 1](#) reports $\hat{\beta}$ in this panel, while [Appendix A.3.3](#) describes the model-to-data mapping, variable construction, sample selection, summary statistics, and comparisons with estimates from existing work.

3.2 Parameter estimates and model fit

[Table 1](#) presents the estimation results. At the point estimates, the model closely matches the targeted moments, with near-exact fit along most dimensions. The main exception is the sensitivity of investment to leverage: the model delivers a value near the lower bound of the confidence interval for $\hat{\Gamma}$.

[Appendix A.3.4](#) explains how the targeted moments identify the seven estimated parameters. The moments $\{\widehat{dep}, \widehat{tax}, \widehat{int}\}$ identify $\{\delta, \theta, \kappa\}$, respectively. Conditional on these parameters, $\{\hat{\Phi}, \hat{x}\}$ help jointly identify a and σ : a affects Tobin’s q , while σ primarily determines average distance to default. Finally, leverage autocorrelation $\hat{\rho}_x$ helps identify the debt maturity rate m , while the sensitivity of investment to leverage $\hat{\Gamma}$ helps identify γ , the convex component of adjustment costs.²⁰

[Appendix A.3.4](#) also compares our parameter estimates with values in the literature. The empirical value $\hat{\Gamma}$ implies that a 10 p.p. increase in book leverage changes investment by $0.1 \times (-11.10) = -1.1$ p.p. This semi-elasticity produces an estimate of γ consistent

²⁰As hinted at in [DeMarzo and He \(2021\)](#) in their model without investment, the speed of mean reversion of leverage is increasing with the maturity intensity m ; for the parameter γ , a given change in leverage is less likely to lead to a large investment adjustment when investment adjustment costs are high. [Appendix Figure A-2](#) reports the comparative statics of the four moments $\{\hat{\Phi}, \hat{x}, \hat{\Gamma}, \hat{\rho}_x\}$ with respect to the four parameters $\{a, \sigma, m, \gamma\}$, clarifying the heuristic relationships described here. [Appendix Figure A-2](#) is analogous to the sensitivity matrix proposed by [Andrews, Gentzkow and Shapiro \(2017\)](#), though it highlights global, not local comparative statics of estimates with respect to targeted moments.

with existing evidence. Similarly, $\hat{\rho}_x$ implies a debt maturity at issuance of $1/m = 5.53$ years, shorter than that of bonds issued by large investment-grade firms but in line with syndicated loans. The balance between the sensitivity of investment to leverage and leverage persistence will play an important role in the counterfactual calculations of [Section 4](#).²¹

[Table 1](#) also reports five non-targeted moments measured in the same sample: average return on assets, the equity payout rate, gross debt issuance, and within-firm variances of leverage and investment. The model produces returns, issuance, and payout rates broadly consistent with the data. Its main shortcoming is that the within-firm investment variance is substantially lower than in the data. Empirically, this dispersion reflects large but temporary investment bursts; in the model, investment is bounded above by the first-best rate and therefore lacks such bursts. Fixed investment costs could generate this lumpiness, but at the cost of a more complex joint investment and financing policy.

3.3 Validation

We conclude with two external validation exercises for the baseline estimate.

3.3.1 Leverage persistence

We first compare the model’s implications for leverage persistence with the moments constructed by [Lemmon, Roberts and Zender \(2008\)](#). They use Compustat to sort firms into four initial leverage portfolios corresponding to quartiles of the empirical leverage distribution, then track subsequent leverage in each portfolio, repeating the exercise across sample years and averaging over time.

In [Appendix Figure A-3](#), we replicate this exercise using all Compustat non-financial firms from 1979 to 2019. We construct the model counterpart to each initial leverage

²¹Estimates of other parameters are also within the range documented in existing work. In particular, we estimate a corporate income tax rate of $\theta = 26\%$, close to the average marginal tax rates estimated for Compustat firms by [Graham \(2000\)](#) and [Blouin, Core and Guay \(2010\)](#) in earlier data. [Appendix A.3.4](#) provides a more extensive discussion of how our model estimates compare to existing evidence in the literature.

portfolio and track its evolution after formation. We also construct asset-weighted versions in both model and data.²² The comparison in [Appendix Figure A-3](#) yields three main findings. First, consistent with [Lemmon, Roberts and Zender \(2008\)](#), in the raw data (left column of [Appendix Figure A-3](#)), leverage does not revert to a common mean across portfolios. This supports the view that there are permanent differences in leverage between firms and highlights the need to include firm fixed effects, as we do in our baseline approach. Second, after removing fixed effects, leverage mean-reverts over roughly six years across portfolios. Third, the model closely reproduces this pattern for firms with both high and low initial leverage. Overall, this exercise suggests that the model produces a realistic degree of leverage persistence in the cross-section when compared to the leverage dynamics of firms in Compustat over the last four decades.

3.3.2 Real effects of debt overhang

We next assess the model’s implications for the magnitude of debt overhang. A common reduced-form proxy for debt overhang is the elasticity of investment with respect to leverage.²³ This is one of our targeted moments. The model-implied elasticity is -5.63 , at the lower end of the confidence interval around the empirical estimate $\hat{\Gamma} = -11.10$. Thus, a 10 p.p. increase in book leverage is associated, through the model, with a -0.56 p.p. change in gross investment. [Table 2](#) compares this estimate with prior reduced-form work.²⁴ The elasticity generated by the model is close to the median estimate across these papers, suggesting that the sensitivity of investment in our baseline calibration is consistent with existing evidence.

Second, the structural debt-overhang literature often measures agency costs by comparing the enterprise value of a levered, equity-maximizing firm with a benchmark without debt overhang, typically an unlevered firm.²⁵ [Table 2](#) compares our model’s implication for this statistic with existing estimates. Unlike prior work, which typically

²²Details on sample selection, portfolio construction, weighting, and model counterparts are reported in [Appendix A.3.5.1](#).

²³See [Opler and Titman \(1994\)](#), [Sharpe \(1994\)](#), [Lang, Ofek and Stulz \(1996\)](#), [Hennessy \(2004\)](#), [Aivazian, Ge and Qiu \(2005\)](#), [Ahn, Denis and Denis \(2006\)](#), [Cai and Zhang \(2011\)](#), [Chu \(2021\)](#), and [Wittry \(2021\)](#).

²⁴Some studies use different measures of investment or leverage. Where possible, [Table 2](#) rescales their estimates into the units used here.

²⁵See, among others, [Mello and Parsons \(1992\)](#), [Mauer and Ott \(2000\)](#), [Childs, Mauer and Ott \(2005\)](#) and [Moyen \(2007\)](#).

considers ex-ante value differences at a given leverage level, our statistic measures ergodic average debt-overhang costs. We find agency costs equal to 2.2% of enterprise value, similar in magnitude to existing structural estimates. This value is also *smaller* than the reduced-form estimate in [Wittry \(2021\)](#), who finds that Canadian mining firms with unsecured reclamation liabilities forgo projects worth, on average, 6.34% of enterprise value.

Finally, [Table 3](#) shows how debt overhang affects aggregate growth in the baseline model. We consider two benchmarks: a no-debt economy, and an economy in which firms are levered but follow an exogenously fixed investment rate.²⁶ Debt-overhang costs can be decomposed into (a) an extensive margin, reflecting differences in default rates and associated deadweight losses, and (b) an intensive margin, reflecting differences in investment away from the default boundary. Relative to the no-debt case, aggregate growth is 0.99 p.p. lower, decomposing into a 0.43 p.p. extensive-margin effect and a 0.56 p.p. intensive-margin effect. Relative to the fixed-investment case, aggregate growth is 0.53 p.p. lower.²⁷ In the following section, we show that these sizable average effects coexist with quantitatively much smaller marginal debt-overhang costs from the additional leverage induced by credit interventions.

4 Credit market interventions in crisis times

This section presents our main findings on the central trade-off posed by credit market interventions during crises: short-run gains from stimulating investment and reducing defaults versus long-run costs from higher leverage and debt overhang.

²⁶We fix investment at the first-best level. See [Appendix A.2.2](#) for the detailed equilibrium calculations, which generalize [DeMarzo and He \(2021\)](#).

²⁷The intensive-margin effect relative to the fixed-investment benchmark is, by construction, the same as relative to the no-debt benchmark. The extensive-margin effect relative to the fixed-investment benchmark is close to zero. Additionally, [Table 3](#) shows that these effects depend strongly on capital adjustment costs; for instance, with $\gamma = 7.5$, intensive-margin effects fall by about one-third.

4.1 A crisis through the lens of the model

We model a crisis as a temporary real and financial shock affecting all firms. The crisis lasts an exponentially distributed amount of time (parameter χ). During the crisis, productivity falls from a to $a_c < a$, and the price of risk rises from ν to $\nu_c > \nu$.²⁸ Once the crisis ends, both permanently revert to their long-run values estimated in [Section 3](#).

At crisis onset, the capital-weighted leverage distribution is initialized at its ergodic value $\hat{f}_\infty$. Firms do not anticipate the crisis, but once it begins they correctly anticipate that it will eventually end and fundamentals will return to their steady-state values.

Our goal is to capture large, unexpected macro-financial shocks, for which there is no canonical calibration. Because the productivity shock is the main driver of defaults, modest cash-flow disruptions generate few defaults and interventions operate primarily through debt overhang, making their net effects unambiguously negative. Moreover, such modest shocks are unlikely to trigger large-scale government credit interventions in practice, which are typically deployed in response to severe, systemic disruptions. We therefore focus on a large shock, setting $a_c = 0.50a$, and later examine robustness to its magnitude.

We also model a sustained increase in the price of risk, which depresses investment through Tobin's q . Its magnitude is informed by [Lettau and Wachter \(2007\)](#), where the Sharpe ratio follows an AR(1) process with annual conditional volatility of 12%. We use a three-standard-deviation shock, corresponding to a 36% increase in the price of risk. Crisis duration governs the extent of debt accumulation under interventions: longer crises imply more prolonged support and greater debt burdens relative to laissez-faire. Our baseline sets $1/\chi = 2$ years, with sensitivity analysis below.

The crisis may also alter the functioning of financial markets. We consider three financial-market environments: both debt and equity markets remain open; credit markets shut down while equity markets remain open; or both markets shut down, preventing firms from raising external financing.

A simple observation guides our analysis. If government funding is provided at market prices and does not affect investors' SDFs, public and private funding are perfect substitutes and the intervention has no effect on firm policies or aggregates. This

²⁸Unless stated otherwise, we assume integrated credit and equity markets, so that $\nu_e = \nu_d = \nu$.

applies to debt funding and fairly priced credit guarantees, whether conditional or unconditional. Government interventions can therefore have real effects only if they (a) occur at prices different from market prices, (b) alter market prices through marginal investors' SDFs, or (c) provide funding when private markets are no longer perfectly elastic.

4.2 Understanding the trade-offs of credit market interventions

While our structural model is essential for precise counterfactual calculations, the key costs and benefits can be summarized heuristically.

The central cost of credit market interventions is higher leverage. Debt overhang depresses future investment, and the effect is persistent because leverage adjusts gradually. The magnitude of these debt overhang costs depends on (i) the additional debt induced by the intervention, (ii) the sensitivity of investment to leverage, and (iii) leverage persistence. The first depends on program terms and take-up, while the latter two are disciplined by our estimates. Thus, long-run effects depend not only on how much debt firms issue during the crisis but also on how slowly it is subsequently unwound.

Interventions may raise investment through two channels. First, they may relax financing constraints that prevent firms from following standard q -theory investment policies, especially when external markets shut down. Second, they may increase Tobin's q by lowering discount rates or risk premia. This channel is particularly important when credit interventions spill over into equity markets.

Interventions may also reduce defaults and bankruptcy-related deadweight losses. The fraction of firms avoiding default depends on the pre-crisis leverage distribution $\hat{f}_\infty$ and on how the intervention shifts the crisis-state default boundary. More generally, the model determines how interventions affect Tobin's q , financing constraints, debt issuance, default, and the resulting aggregate dynamics.

The model also disciplines fiscal costs and targeting. When public credit is extended above private market valuations, fiscal costs depend on the firms participating and on the intervention's effect on private debt prices. Because firms differ in leverage and financing needs, effectiveness also depends on which firms receive support. The model therefore lets us compare real benefits and fiscal costs under alternative targeting rules.

The table below summarizes our four intervention scenarios. They differ in which financial markets remain open and how policy changes firms' financing terms.

Scenario	Issuance		Intervention
	Debt	Equity	
Credit access restoration (§4.3.1)	shut	open	Government re-opens credit markets by buying debt at crisis-time market prices $d(x)$, so that firms can continue to issue debt during the crisis.
Credit market price-of-risk stabilization (§4.3.2)	open	open	Government purchases debt above market prices, lowering the credit-market price of risk: $\nu_d = \nu_c \rightarrow \nu_c^* < \nu_c$, with $\nu_e = \nu_c$ unchanged.
Market price-of-risk stabilization (§4.3.3)	open	open	Intervention spills over into equity markets, lowering the price of risk in both markets: $\nu_d = \nu_e = \nu_c \rightarrow \nu$.
Targeted credit extension (§4.4.1)	shut	shut	Government lends at a fixed debt price d_g (e.g. $d_g = 70\%$), up to the cash-flow shortfall $(a - a_c)k_t dt$.

Summary of intervention scenarios. In every scenario, the crisis lowers productivity from a to $a_c = 0.5a$ and raises the price of risk from ν to $\nu_c = 1.36\nu$. The “Debt” and “Equity” columns indicate whether firms can issue debt or equity during the crisis in the laissez-faire allocation. For each scenario, the laissez-faire benchmark is the same market environment without government intervention.

4.3 Interventions when equity markets remain open

We first consider environments in which equity markets remain open. In this case, credit interventions need not relax binding financing constraints and may instead primarily affect capital structure, inducing firms to issue more debt and worsening debt overhang.

4.3.1 Credit access restoration

The first scenario features a crisis in which credit markets shut down while equity markets remain open. Under laissez-faire, firms cannot issue new debt and therefore delever.

The government restores credit access by purchasing corporate debt at crisis-state market prices, allowing firms to continue issuing debt. We call this *credit access restoration*.

This policy generates no net benefit when equity markets remain open. Because firms can still issue equity, restoring credit access does not relax any financing constraint that might distort investment. Instead, it permits continued debt issuance and higher dividends during the crisis. Higher current dividends raise equity values and Tobin’s q , but the associated increase in future leverage lowers continuation values. In our model these effects exactly offset, leaving investment policies unchanged relative to *laissez-faire*.²⁹ The intervention therefore alters capital structure rather than investment: firms emerge from the crisis with higher leverage, greater debt overhang, and lower subsequent investment and long-run capital.

Figure 2 illustrates these dynamics. Without intervention, firms delever more aggressively because they cannot issue debt. This is costly from a dividend standpoint during the crisis, but leaves surviving firms with cleaner balance sheets in the recovery. Investment and capital accumulation are therefore stronger under *laissez-faire*, and its long-run capital stock is about 2% higher than under credit access restoration.

The effects are concentrated among low-leverage firms, which issue the most debt when credit markets are open. Although these firms account for a large share of aggregate capital, their debt-overhang distortion is relatively weak because investment is less sensitive to leverage at low debt levels. Nonetheless, the aggregate effect remains negative: restoring credit access mainly changes how firms finance themselves rather than how much they invest.

4.3.2 Credit market price-of-risk stabilization

The second scenario keeps financial markets open but has the government stabilize the price of risk in credit markets. The government purchases corporate debt above prevailing market prices, which we model as a decline in the credit-market Sharpe ratio from ν_c to $\nu_c^* < \nu_c$, while equity-market discount rates remain unchanged.³⁰ We call this *credit*

²⁹This result is discussed in “the role of limited commitment” in **Section 2.2**: absent frictions, equity value and investment policies — as functions of the state x — are identical to those in an environment where the firm does not have access to credit markets.

³⁰Upon announcement, either (a) the policy is credible and debt prices adjust immediately, or (b) it is not credible and the government absorbs the full stock of outstanding corporate debt. In both cases, firms’

market price-of-risk stabilization.

The intervention creates a wedge between marginal investors in credit and equity markets. Holding financing policies fixed, lower credit risk premia raise debt prices, equity values, and Tobin's q . Firms respond by issuing more debt, however, as captured by the term $\rho\sigma x(\nu_c - \nu_c^*) > 0$ in (19). The resulting increase in leverage pushes debt prices, equity values, and Tobin's q back down. In equilibrium, this response exactly offsets the direct valuation effect: equity values, investment, and default policies are unchanged relative to *laissez-faire*.³¹ Because equity markets remain frictionless and unaffected by the intervention, the policy operates entirely through financing choices, raising leverage and future debt overhang.

Figure 3 shows that cheaper credit raises aggregate leverage, credit spreads, and dividends. Unlike credit access restoration, however, the effects are concentrated among highly leveraged firms because the incentive to issue additional debt increases with leverage. These are also the firms whose investment is most sensitive to leverage, so their investment policies are substantially distorted.

The aggregate effects remain modest because highly leveraged firms account for a relatively small share of aggregate capital. Although the intervention materially raises leverage and depresses investment among affected firms, aggregate capital ultimately falls only about 2% relative to *laissez-faire*.

4.3.3 Market price-of-risk stabilization

The third scenario considers an intervention that stabilizes the market price of risk across both credit and equity markets. This is motivated by evidence that large-scale credit support during the COVID-19 crisis was associated with movements in both corporate bond and stock prices. We therefore lower the Sharpe ratio faced by debt and equity investors from ν_c to ν during the crisis. We call this *market price-of-risk stabilization*.

This intervention generates two opposing forces. Cheaper credit encourages additional borrowing, raising leverage and debt overhang, while lower equity risk premia

effective cost of debt declines.

³¹This result is another consequence of our discussion “the role of limited commitment” in Section 2.2: absent frictions, equity value and investment policies, as a function of the state variable x , do not depend on credit market's SDF; only the debt issuance policy does.

increase stock prices and Tobin's q , stimulating investment. Which force dominates is a quantitative question.

Figure 4 shows that the valuation channel dominates. Relative to *laissez-faire*, the intervention raises Tobin's q and mitigates the collapse in investment. The economy converges to a capital stock 14.5 p.p. below the no-crisis benchmark under *laissez-faire* but only 9.7 p.p. below it with intervention. Gross investment falls by 5.9 p.p. without intervention and 3.9 p.p. when financial conditions improve across both markets.

Thus, interventions affecting the overall cost of capital differ sharply from debt-only interventions. Although they also induce more borrowing, the resulting debt-overhang costs are dominated by the immediate investment response to higher valuations, yielding a positive aggregate effect.

This conclusion relies on the strength of the valuation channel. The counterfactual is therefore sensitive to (i) the elasticity of firm values to discount rates and (ii) the elasticity of investment to Tobin's q , neither of which is directly targeted in our estimation. If valuations or investment respond less strongly than in the model, the investment gains from lower risk premia would be smaller and might no longer offset the adverse effects of leverage. Our results should therefore be interpreted as identifying conditions under which market-wide stabilization dominates credit-market-only interventions, rather than as a conclusion independent of the strength of this channel.

4.4 Interventions when all financial markets shut down

We next consider a crisis in which firms cannot raise either debt or equity, so investment must be financed entirely through internal cash flows. Investment then satisfies

$$g(x) = (\Phi')^{-1} \left(\frac{q(x)}{1 + \lambda(x)} \right), \quad (33)$$

where $\lambda(x) \geq 0$ is the Lagrange multiplier on the equity issuance constraint $\pi(x) \geq 0$. Credit interventions can now generate genuine short-run benefits by relaxing binding financing constraints and reducing inefficient defaults.

We consider interventions in which the government extends credit at a fixed price, up to a notional balance equal to firms' pre-crisis cash-flow shortfall. Between t and $t + dt$,

it can acquire up to $(a - a_c)k_t dt$ face value of debt from firms with capital k_t , at price d_g .

4.4.1 Targeted vs. non-targeted interventions

The effects depend critically on targeting. Consider first a targeted intervention with $d_g = 70\%$. This price induces the most indebted firms to draw on public funding while remaining unattractive to low-leverage firms, concentrating support among those facing the tightest constraints. **Figure 5** shows that the policy shifts the crisis-state default threshold to the right, reduces bankruptcy, and supports investment. Long-run capital is 15.7% below its pre-crisis trend, compared with 16.4% under *laissez-faire*.

These gains come at the cost of higher leverage upon crisis exit. Firms enter the recovery with more debt, increasing debt overhang and depressing subsequent investment relative to *laissez-faire*. Leverage and investment therefore converge only gradually to steady state. In this calibration, however, lower bankruptcy losses and stronger crisis-time investment outweigh this subsequent drag.

The conclusion is not general. With $d_g = 100\%$, a much larger fraction of firms uses public credit. The resulting increase in leverage is large enough for long-run costs to dominate short-run stabilization benefits. Broader support further reduces crisis-time distress but leaves firms substantially more indebted during the recovery, persistently lowering investment and capital accumulation.

4.4.2 Aggregate participation vs. fiscal costs trade-off

Fiscal costs further reinforce the importance of targeting. Because public credit is offered at a fixed price d_g above private market valuations for highly leveraged firms, the government subsidizes borrowing. Varying d_g generates selection: firms whose marginal value of debt lies below d_g participate, while those with higher valuations opt out. Lower d_g therefore concentrates support on more highly leveraged firms, reducing fiscal costs but also participation.

Figure 6 plots fiscal costs and changes in aggregate capital for different values of d_g . Program effects are nonlinear, non-monotonic, and horizon dependent. With a crisis lasting 2 years in expectation, for example, $d_g = 80\%$ costs about 0.5% of pre-crisis capital, targets firms near default, and raises aggregate capital by 1.6% after one year.

The gain falls to 0.3% after ten years as debt overhang builds. Extending support to lower-leverage firms adds little short-run benefit, increases fiscal costs, and lowers long-run capital through higher post-crisis leverage.

Crisis duration also matters. When crises are short, immediate gains from preventing default and preserving investment tend to dominate the future cost of higher leverage. As crises lengthen, even targeted interventions can become harmful because sustained support causes larger debt accumulation. Thus, when all markets shut down, interventions are beneficial only when crises are sufficiently short and support sufficiently targeted toward firms generating large real benefits relative to fiscal cost.

4.5 Moral hazard

The analysis above treats interventions as unexpected one-time policies. We now consider anticipated interventions, which may encourage firms to take on more debt in normal times and thereby generate moral hazard.

We allow the economy to switch between normal and crisis states, with firms and investors understanding the transition probabilities and anticipating future interventions. We revisit the three open-equity-market scenarios of [Section 4.3](#). Transition probabilities are calibrated so that the economy spends 90% of the time in the normal state and 10% in crisis, reflecting the rarity of the large shocks we study. We compute ergodic averages of leverage, investment, and growth both unconditionally and conditional on the prevailing regime.

Anticipated support raises the value of debt in adverse states, making leverage more attractive *ex ante*. Firms therefore enter crises with higher leverage, which depresses investment through debt overhang. Under market price-of-risk stabilization, however, expected interventions also raise valuations and Tobin's q , providing an offsetting investment stimulus.

[Table 4](#) reports the results. Relative to *laissez-faire*, normal-time leverage rises by 0.57 p.p. under credit access restoration, 0.23 p.p. under credit market price-of-risk stabilization, and 1.49 p.p. under market price-of-risk stabilization. Because interventions also raise crisis-time issuance, unconditional leverage increases by 0.93 p.p., 0.38 p.p., and 1.53 p.p., respectively.

Despite these leverage distortions, growth effects are modest. Long-run growth falls by only 0.06 p.p. under credit access restoration and 0.05 p.p. under credit market price-of-risk stabilization. Under market price-of-risk stabilization, by contrast, long-run growth rises by 0.76 p.p. despite the largest leverage distortion. Lower equity risk premia raise Tobin's q and stimulate investment immediately, while the adverse effects of leverage accumulate gradually, so the valuation effect dominates quantitatively.

Moral-hazard concerns therefore cannot be assessed from leverage alone. Anticipated interventions increase borrowing, but their aggregate effects remain small when policy supports only credit markets. Whether the net effect is positive or negative depends importantly on whether intervention also raises equity valuations. In our estimates, moral-hazard distortions are modest relative to the direct effects of crisis-time interventions.

4.6 Lessons from the intervention analysis

To begin with, a central lesson from our counterfactuals is that sizable average costs of debt overhang need not imply large marginal costs from credit market interventions. In [Section 3.3](#), we find sizable effects of debt on aggregate growth by comparing the estimated equilibrium with leverage to benchmarks in which debt overhang is absent. The policy experiments considered here address a different question: they measure the *marginal* debt-overhang cost of the additional leverage induced by a credit market intervention during a crisis, starting from an economy in which firms are already levered. These marginal effects are quantitatively much smaller. Thus, even though debt overhang is important for aggregate growth in our estimated steady state, moderate intervention-induced increases in leverage need not generate correspondingly large losses in aggregate capital.

We then summarize, via [Figure 7](#), our findings about the long-run effects of credit market interventions relative to *laissez-faire*, as a function of expected crisis duration. Three key results emerge.

First, interventions affecting only debt financing — *credit access restoration* and *credit market price-of-risk stabilization* — reduce aggregate capital regardless of crisis duration. When equity markets remain open, they primarily change financing rather than invest-

ment incentives and lead firms to accumulate more debt. Consistent with the distinction above, however, the resulting losses are modest: these policies increase leverage only at the margin relative to the laissez-faire equilibrium. The losses grow with crisis duration as firms have more time to accumulate additional debt. The policies differ mainly in incidence: credit access restoration primarily affects low-leverage firms, while credit market price-of-risk stabilization mainly affects highly leveraged firms.

Second, interventions that also lower equity risk premia have the opposite effect. Although they encourage borrowing, the increase in Tobin's q stimulates investment immediately and dominates the marginal future costs of additional debt overhang. They therefore raise long-run capital, with larger gains in longer crises. As discussed in [Section 4.3.3](#), this conclusion depends on the sensitivity of Tobin's q to risk premia and of investment to Tobin's q , neither of which is directly targeted in our estimation.

Third, when all financial markets shut down, interventions trade off short-run stabilization against long-run debt overhang. Targeted support relaxes financing constraints, reduces defaults, and sustains crisis-time investment, but longer interventions generate more leverage and increasingly severe debt-overhang distortions during the recovery. Policies that are beneficial in short crises can therefore become harmful when crises persist. Here again, the relevant cost is the marginal debt-overhang effect of the additional leverage generated by the intervention, rather than the total steady-state cost of debt. As a result, substantial short-run benefits can dominate these costs when support is sufficiently targeted and short-lived.

5 Robustness

This section examines the robustness of our conclusions regarding the effects of credit market interventions. We first consider alternative estimations of the baseline model ([Section 5.1](#)) and then analyze an extension with equity issuance costs ([Section 5.3](#)).

5.1 Alternative estimates of the baseline model

We consider several alternative estimations of the model, obtained by modifying either the targeted moments or selected parameter values relative to the baseline procedure

in [Section 3](#). Additional details are provided in [Appendix A.3.6](#). We then examine how these alternative estimations affect the quantitative implications of government interventions and debt overhang.

5.1.1 Small firms

Many of the credit market interventions implemented during the COVID crisis were targeted at small and medium-sized enterprises. Since Compustat firms are relatively large on average, one may therefore question whether our baseline estimates accurately capture the behavior of the firms most directly affected by these programs. To address this concern, we re-estimate the model using only firm-year observations with book assets below the median for that year.³² [Table A-5](#) reports the resulting moments and parameter estimates.

Two differences relative to the baseline stand out. First, leverage is less persistent, as reflected in a lower autocorrelation of leverage. Second, the sensitivity of investment to leverage is also smaller. These differences imply a higher estimated debt maturity intensity, m , and a lower estimate of the investment adjustment-cost parameter, γ , although the latter change is economically modest.³³ Overall, the resulting model features somewhat more responsive investment dynamics but less persistent leverage movements than the baseline specification.

5.1.2 Residualized investment rates

A potential concern with our approach is that there are determinants of investment rates that our model does not account for. To the extent that these determinants are correlated with leverage, they could bias the resulting investment-leverage sensitivity

³²We focus on this subsample because, to our knowledge, no publicly available dataset contains the financial information required to estimate our model for a representative sample of U.S. non-financial firms. Certain Census datasets, such as the Quarterly Financial Report ([Gertler and Gilchrist, 1994](#); [Kudlyak and Sanchez, 2017](#); [Crouzet and Mehrotra, 2020](#)), contain sufficient firm-level information to measure the within-firm moments used in our estimation, but access to the underlying microdata is restricted. Moreover, these datasets primarily cover the manufacturing and retail sectors.

³³Other moments also differ. Investment rates are higher on average, leading to a higher estimate of the marginal product of capital, while leverage is lower, leading to a higher estimate of the volatility of capital quality shocks.

that we estimate in the data. If the bias is such that we overstate the magnitude of the investment-leverage sensitivity, then our estimates of debt overhang effects might be exaggerated. In [Appendix A.3.6.2](#), we consider two such potential confounders: the sensitivity of investment to cash flows, and the investment- q relationship.³⁴ To address these confounders, we first project gross investment rates on a measure of cash flows and a measure of Tobin's q :

$$\Phi_{i,t} = \alpha_i + \beta_c c_{i,t-1} + \beta_q q_{i,t-1} + \eta_{i,t}. \quad (34)$$

Here, $c_{i,t-1}$ is a measure of cash flow scaled by assets, and $q_{i,t-1}$ is a measure of Tobin's q .³⁵ We repeat our baseline estimation exercise using the residuals $\eta_{i,t}$ in place of gross investment rates $\Phi_{i,t}$.³⁶ [Table A-5](#), columns marked (A3), shows the results. Our estimate of investment-leverage sensitivity is approximately unchanged, so the resulting estimate of the model differs very little from the baseline.³⁷ We conclude that any bias induced by either investment-cash flow sensitivities, or by the investment- Q relationship, is unlikely to have a large quantitative impact on our results.³⁸

5.1.3 Higher deadweight losses of restructuring

Next, we study how the size of deadweight losses associated with restructuring affects our key findings. In order to ensure that the comparison across models is fair, in [Table A-6](#), we re-estimate a version of the model where deadweight losses in restructuring are calibrated to a higher value, or equivalently, where asset recovery rates are calibrated to

³⁴Our model does not account for firm cash holdings, but a large literature has documented an empirical relationship between investment rates and changes in corporate cash holdings; see [Chen and Chen \(2012\)](#) for a review. Additionally, while our model does generate within-firm variation in Tobin's q , investment opportunities are fixed within firm, in the sense that the expected average return on capital is constant.

³⁵We use lagged ratios of EBITDA to assets for $c_{i,t-1}$ and the ratio of book debt plus market equity to book assets for Tobin's q , as described in [Table A-4](#).

³⁶[Appendix A.3.6.2](#) contains more details on the exact procedure.

³⁷Other targeted moments are, by construction, unchanged.

³⁸[Table A-8](#) reports results from panel regressions as in (34), where we additionally control for book leverage. These regressions show that adding controls for cash flows or Tobin's q does not substantially affect the point estimate of the sensitivity of investment with respect to leverage. This is not to say that investment-cash flow sensitivities or the investment- q relationship are absent from our sample; both are present and statistically significant, as the results of [Table A-8](#) show.

a lower value of $\alpha_k = 0.45$ instead of $\alpha_k = 0.72$.³⁹ The results in Table A-6 show that key parameter estimates are largely unchanged, except for the volatility of capital quality shocks (which is higher) and the rate at which debt matures (which is higher).⁴⁰

5.1.4 Other estimates

Appendix A.3.6 provides a discussion of other alternative procedures for estimating the model, and their implications for our key findings. First, we re-estimate the model when our targeted moments are computed without including fixed effects. This only affects the values of the targeted autocorrelation of leverage, which is higher without fixed effects, and the targeted sensitivity of investment to leverage, which is lower without fixed effects.⁴¹ The resulting point estimate of the debt maturity intensity, in particular, is lower in this version of the model, implying more persistent effects of shocks.

Second, we re-estimate the model when using a net leverage measure, instead of a gross leverage measure. While the overall level of leverage is lower, the sensitivity of investment to leverage in the estimated model is higher than in our baseline.

Third, we re-estimate the model when using a measure of investment rates relative to book assets, consistent with the rest of measurement, where book assets are treated as the empirical proxy for k (and different from our baseline, where we focus only on physical investment rates).⁴² Here again, point estimates using this alternative measure are roughly unchanged from the baseline, except for somewhat lower adjustment cost for investment.

Fourth, we re-estimate the model when imposing a value of the convex component of adjustment costs that is at the higher end of the range of existing estimates, $\gamma = 7.5$ (as opposed to our baseline estimate, which lies at the lower end of existing estimates).

³⁹As discussed in Appendix A.3.6.3, this value is drawn from Kermani and Ma (2023), who collected data on appraised liquidation values for specific asset types in a sample of Chapter 11 bankruptcy cases. Since the implied recovery rates are estimated with reference to a scenario in which the firm is liquidated, they likely provide an upper bound on the size of deadweight losses in restructuring.

⁴⁰Note that we also modify α_b , the recovery rate for debt at face value, so as to ensure that the ratio of post- to pre-restructuring leverage is consistent with our baseline exercise.

⁴¹Both effects would be consistent with the presence of fixed differences in leverage and in the marginal product of capital across firms, so long as the two types of fixed effects are positively correlated with one another. Since our model does not contain such fixed effects, purging the data from them is important.

⁴²Specifically, we use the ratio of the negative of net investing cash flows to book assets, where the former is measured from the cash flow statement; Appendix A.3.6.4 provides more details.

In re-estimating the model, we do not target the sensitivity of investment with respect to leverage, the main moment which identifies γ in our baseline estimation. The resulting model produces a sensitivity of -3.28 , compared to -5.63 in the baseline estimates. As a result, debt overhang effects are more muted than in our baseline estimate, as emphasized also in [Table 3](#) and [Table 2](#).

5.2 Resulting debt overhang distortions

In [Table A-9](#), we report various aggregate statistics summarizing, across estimations, (a) the steady-state effects of debt overhang (relative to the first-best no-debt benchmark), and (b) the long-run debt-overhang distortions generated by government interventions — measured as (i) the percentage deviation of the long-run capital stock relative to the laissez-faire benchmark (for the credit market price-of-risk stabilization intervention, the credit access restoration intervention, and the market price-of-risk stabilization intervention, which spills over into equity markets), and (ii) the change in long-run growth generated by the moral-hazard scenarios discussed in [Section 4.5](#).

Several patterns emerge. First, across estimations, debt overhang costs 100-175bps in economic growth, except in the small firms' estimation, where the combination of a shorter debt average life $1/m$, a higher productivity volatility σ , a higher productivity a and slightly lower investment adjustment costs leads to substantially higher growth costs. A similar conclusion can be reached when measuring the debt overhang costs as the difference between ergodic average enterprise value and the first best.

Second, the debt-overhang distortions induced by government interventions during crisis time are largest in the estimation based on the sample of small firms. This result is partly driven by the substantially higher estimate of the parameter a , which implies more severe crisis episodes. As a consequence, government interventions are larger and induce greater debt issuance during crises, leading to a higher post-crisis debt burden. In addition, this estimation implies stronger incentives to issue debt whenever Sharpe ratios in credit and equity markets do not coincide: since these incentives are proportional to the volatility parameter σ , these forces jointly amplify leverage accumulation and the resulting debt-overhang distortions.

Third, debt-overhang distortions are also relatively large in the calibration with higher

deadweight losses of restructuring. Relative to the baseline, this calibration produces a lower estimate of the investment adjustment-cost parameter γ , implying that firms adjust investment more aggressively in response to changes in financing conditions. Consequently, the increase in leverage induced by government interventions translates into larger reductions in future investment and capital accumulation through the debt-overhang channel.

More generally, the robustness exercises highlight the central role of investment adjustment costs in determining the magnitude of debt-overhang effects. This is particularly evident when comparing the high- and low-adjustment-cost calibrations. Higher values of γ dampen the responsiveness of investment to changes in firm value, thereby reducing both the immediate effects of interventions on investment and the longer-run distortions associated with leverage accumulation. Conversely, lower values of γ amplify these effects.

The parameter γ is also a key determinant of announcement effects. Lower adjustment costs imply that investment responds more strongly to increases in Tobin's q generated by reductions in equity discount rates. As a result, interventions that support financial markets generate larger increases in both firm valuations and investment when γ is low. This mechanism also explains the results obtained when investment is measured using investing cash flows rather than our baseline measure of physical investment. That specification yields a lower estimate of γ , leading both to larger announcement effects and to larger long-run debt-overhang distortions.

5.3 Equity issuance costs

5.3.1 Setup

What role do external equity financing costs play in our analysis? A large literature on corporate investment and financing decisions (e.g., [Hennessy and Whited \(2005, 2007\)](#)) argues that raising external equity is costly, for example because of informational frictions between firms and outside investors. To assess the robustness of our results to this friction, we follow [Bolton, Chen and Wang \(2011\)](#) and assume that shareholder payouts are subject to a proportional equity issuance cost, $c(\pi_t)k_t = -\psi \min(0, \pi_t)k_t$, which is incurred whenever the firm raises external equity. Consistent with [Bolton, Chen and](#)

Wang (2011), we set the marginal equity issuance cost parameter to $\psi = 6\%$.

5.3.2 Equilibrium characterization

In this extension of the baseline model, the insights of DeMarzo and He (2021) no longer apply, and equity value can no longer be computed *as if* shareholders never had access to credit markets. Since in our baseline model, the dividend policy is a downward sloping function of x , the equilibrium with equity issuance costs — if it exists — will feature 3 distinct regions, for some endogenous boundaries $0 < x^* < x^{**} < \bar{x}$:

low leverage region:	$x \in [0, x^*]$	$\pi(x) > 0$	$-\frac{e'(x)}{d(x)} = 1$
intermediate leverage region:	$x \in [x^*, x^{**}]$	$\pi(x) = 0$	$-\frac{e'(x)}{d(x)} \in (1, 1 + \psi)$
high leverage region:	$x \in [x^{**}, \bar{x}]$	$\pi(x) < 0$	$-\frac{e'(x)}{d(x)} = 1 + \psi$

In the low (resp. high) leverage region, the firm issues dividends (resp. equity) and does not (resp. does) incur equity issuance costs. In the intermediate leverage region, the firm neither pays dividends nor issues equity. When $x > \bar{x}$, shareholders elect to default and restructure the firm. Contrary to DeMarzo and He (2021), the debt price is no longer always equal to the equity marginal value of leverage, leading to distortions in the debt issuance and investment policies:

$g(x) = (\Phi')^{-1}(q(x))$	$\iota(x) = \frac{\kappa\theta}{-d'(x)} + \rho\sigma x (\nu_e - \nu_d)$	$x \in [0, x^*]$
$g(x) = (\Phi')^{-1}\left(\left(\frac{d(x)}{-e'(x)}\right)q(x)\right)$	$\iota(x) \text{ s.t. } \pi(x) = 0$	$x \in [x^*, x^{**}]$
$g(x) = (\Phi')^{-1}\left(\frac{q(x)}{1 + \psi}\right)$	$\iota(x) = \frac{\kappa\theta}{-d'(x)} + \rho\sigma x (\nu_e - \nu_d)$	$x \in [x^{**}, \bar{x}]$.

At low leverage, firms invest as in the baseline model, by equalizing investment marginal costs with Tobin's q . In the intermediate and high leverage regions, investment is distorted downwards — the more so as leverage increases — and marginal investment costs are strictly lower than Tobin's q . At low and high leverage, firms' debt issuance policy

is similar to the baseline model — i.e. it is driven by the tax shield $\theta\kappa$ and the price impact $d'(x)$. In the intermediate leverage region, firm’s debt issuance policy adjusts so that dividends and equity issuances are exactly null.

5.3.3 Balanced growth path

We solve for the equilibrium by iterating between the variational inequality satisfied by e and the pricing equation satisfied by d , convexifying the cost function so as to simplify the numerical analysis (see [Appendix A.2.11.2](#) for details). While the equilibrium differs from that studied in [Section 2](#), the qualitative properties of firms’ policies remain largely unchanged. In particular, both investment and debt issuance remain decreasing functions of leverage.⁴³ Relative to the frictionless benchmark, equity issuance costs reduce debt issuance (and thus dividend payouts) at low levels of leverage, while increasing debt issuance at higher levels of leverage, where firms seek to limit the likelihood and expected costs of future equity issuance. The prospect of incurring equity issuance costs also lowers firm value and Tobin’s q across the leverage distribution, leading firms to invest less than in the frictionless model.

Although lower Tobin’s q depresses investment, the reduction in debt issuance at low leverage dominates in equilibrium, causing the ergodic size-weighted leverage distribution to shift to the left relative to the frictionless benchmark. As a result, average leverage declines from 29.8% to 28.9%, while the gross investment rate falls from 11.7% to 11.3%. These effects ultimately reduce the growth rate along the balanced growth path by 33 bps relative to the frictionless economy. [Table A-10](#) provides several additional ergodic moments of interest for both the frictionless and its frictional extension. Overall, the moments implied by the model with equity issuance costs remain close to those generated by the baseline specification, supporting our decision not to re-estimate the model under this extension.

⁴³This is true for the investment policy across the state space, and for the issuance policy everywhere except near the default boundary; at these elevated leverage levels, since the firm is incurring equity issuance costs, the firm compensates by slightly increasing its debt issuance in order to fund investments and support debt payments.

5.3.4 Distortionary effects of credit market interventions

Credit market interventions continue to generate modest but adverse aggregate effects, except when they spill over into equity markets (see [Table A-10](#)). Relative to the frictionless benchmark, the distortions induced by credit market price-of-risk stabilization are largely unchanged. The distortions associated with credit access restoration, as well as with interventions that affect both credit and equity market valuations, are somewhat larger, but remain of the same order of magnitude as in the baseline model.

Overall, introducing equity issuance costs alters the equilibrium quantitatively but leaves the underlying economic mechanism unchanged. With or without equity market frictions, corporate debt generates debt overhang that becomes more severe as leverage rises. Consequently, interventions aimed at supporting credit market prices or expanding access to credit markets — provided they do not also improve equity market valuations — encourage greater leverage and ultimately worsen aggregate outcomes. Moreover, firms' financing and investment policies, both in steady state and during crises, remain qualitatively similar across the two environments. These results suggest that our baseline conclusions are robust to the introduction of equity issuance costs.

6 Conclusion

This paper studies the effects of direct interventions in corporate credit markets during periods of economic and financial distress. We develop and estimate a dynamic model in which firms jointly choose investment, financing, and default policies, allowing us to quantify both the short-run benefits of government support and the long-run costs associated with debt overhang. Our results show that credit market interventions often increase corporate leverage and, because leverage is highly persistent, can generate investment distortions that survive long after a crisis has ended.

Whether interventions improve economic outcomes depends critically on the nature of the underlying financing friction. When firms retain access to equity markets, interventions primarily alter financing choices rather than investment opportunities, leading to higher leverage and lower aggregate output. By contrast, interventions are more likely to be beneficial when financial disruptions are severe, when all sources of external financ-

ing become impaired, or when interventions improve firms' valuations more broadly by lowering risk premia. We also find that targeted interventions can achieve similar stabilization benefits at substantially lower fiscal cost than broad-based programs.

More generally, our findings suggest that the effects of crisis interventions cannot be evaluated solely through their impact on credit availability. The persistence of leverage and the resulting debt-overhang distortions are central to understanding their long-run consequences. In some circumstances, the cure can indeed harm the patient: policies that successfully preserve credit during a crisis may simultaneously create leverage distortions that impede the recovery they are intended to support.

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Panel A. Calibrated parameters

Parameter	Description	Value	Source
r	risk-free rate	0.03	Fama and French (2023)
ν	price of risk	0.42	Fama and French (2023)
ρ	aggregate capital shock loading	0.50	Herskovic et al. (2016)
α_k	1 – deadweight losses from restructuring	0.72	LoPucki and Doherty (2007)
α_b	1 – debt haircut in restructuring	0.58	LoPucki and Doherty (2007)

Panel B. Estimated parameters

Parameter	Description	Est.	Std.	90% c.i.
a	average product of capital	0.25	0.014	[0.23, 0.28]
δ	depreciation rate	0.09	0.006	[0.09, 0.11]
σ	volatility of capital quality shock	0.35	0.017	[0.33, 0.39]
m	debt amortization rate	0.18	0.015	[0.16, 0.21]
θ	corporate income tax rate	0.26	0.011	[0.24, 0.28]
κ	debt coupon rate	0.12	0.008	[0.16, 0.21]
γ	curvature of capital adjustment cost	4.39	1.962	[1.17, 7.63]

Panel C. Model fit

Moment	Description	Targeted?	Data	90% c.i.	Model
$\hat{\Phi}$	gross investment rate	✓	11.59	[11.21, 11.97]	11.69
$\hat{x}$	book leverage	✓	0.30	[0.29, 0.31]	0.30
$\hat{\rho}_x$	autocorr. of leverage	✓	0.67	[0.63, 0.70]	0.67
$\hat{\Gamma}$	slope of inv. wrt. leverage	✓	−11.10	[−14.99, −7.21]	−5.63
$\widehat{dep}$	depreciation/EBITDA	✓	37.15	[36.09, 38.20]	37.29
$\widehat{tax}$	taxes paid/EBITDA	✓	12.06	[11.23, 12.90]	12.49
$\widehat{int}$	interest paid/EBITDA	✓	13.72	[13.24, 14.19]	13.77
$\widehat{roa}$	return on assets	✗	15.08	[14.82, 15.36]	25.27
$\widehat{iss}$	gross debt iss. rate	✗	40.55	[34.65, 46.47]	27.63
$\widehat{pay}$	equity payout rate	✗	2.71	[0.80, 4.63]	11.28
$\widehat{var}^{(\Phi)}$	var. of investment rate	✗	27.69	[13.68, 41.69]	0.93
$\widehat{var}^{(x)}$	var. of leverage	✗	0.01	[0.01, 0.01]	0.01
$\widehat{c}^{(x)}$	intercept in Eq. (25)	✗	0.11	[0.10, 0.12]	0.10
$\widehat{c}^{(\Phi)}$	intercept in Eq. (26)	✗	14.76	[13.62, 15.91]	13.37

Table 1: Baseline estimation results. Panel A reports the values for the calibrated parameters. Panel B reports the point estimates, standard deviations, and 90% confidence intervals for the estimated parameters. Panel C reports moments drawn from the panel of Compustat firms, 2010-2019. Appendix A.3.2 report details on data and estimation methodology.

Panel A.		Elasticity of investment w.r.t. leverage		
Estimated model		Baseline	High adj. costs	Low adj. costs
		-5.63	-3.28	-10.32
Existing work		Reported	Scaled	Reference
Opler and Titman (1994)		-0.030	-22.73	Table IV
Sharpe (1994)		-0.140	-14.00	Table 1
Lang, Ofek and Stulz (1996)		-0.105	-10.50	Table 3
Hennessy (2004)		-0.174	-17.40	Table III
Aivazian, Ge and Qiu (2005)		-0.226	-22.60	Table 2
Ahn, Denis and Denis (2006)		-0.050	-4.60	Table 4
Cai and Zhang (2011)		-3.749	-3.75	Table 5
Chu (2021)		-6.794	-6.79	Table 4
Wittry (2021)		-0.023	-2.09	Table 10

Panel B.		Effect of debt overhang on enterprise value		
Estimated model		Baseline	High adj. costs	Low adj. costs
		-2.18%	-2.20%	-1.82%
Existing work		Reported		Reference
Mello and Parsons (1992)		-5.90%		Table IV
Mauer and Ott (2000)		-1.50%		Table 9.3
Childs, Mauer and Ott (2005)		-1.14%		Table 1
Titman and Tsyplakov (2007)		-5.27%		p.425
Moyen (2007)		-4.70%		Table 1
Wittry (2021)		-6.34%		p. 1724

Table 2: Comparison of the magnitude of debt overhang in the estimated model with prior literature. The two panels report model-implied values for the elasticity of investment with respect to leverage, and for the reduction in enterprise value due by debt overhang; see Appendix A.3.5.2 for details on the computation of each. Additionally, the panels report values of these moments from prior work. For the elasticity of investment with respect to leverage, we report estimates from reduced-form work, and scale reported coefficients in order to ensure comparability with model-implied moments where necessary; Appendix A.3.5.2 provides more details. For the effects of debt overhang on enterprise value, with the exception of Wittry (2021), the estimates reported are obtained from structural models.

Panel A.	<u>Baseline</u>		<u>No debt</u>	<u>Debt + fixed investment</u>	
Baseline model ($\gamma = 4.39$)	(1)	(2)	(2)-(1)	(3)	(3)-(1)
Economy's growth rate	1.71%	2.70%	0.99%	2.24%	0.54%
Firm-level average growth rate	2.14%	2.70%	0.56%	2.70%	0.56%
Default-induced deadweight loss rate	-0.43%	0%	0.43%	-0.46%	-0.03%

Panel B.	<u>Baseline</u>		<u>No debt</u>	<u>Debt + fixed investment</u>	
High adjustment costs ($\gamma = 7.5$)	(1)	(2)	(2)-(1)	(3)	(3)-(1)
Economy's growth rate	1.29%	2.08%	0.79%	1.62%	0.33%
Firm-level average growth rate	1.74%	2.08%	0.34%	2.08%	0.34%
Default-induced deadweight loss rate	-0.45%	0%	0.45%	-0.46%	-0.01%

Panel C.	<u>Baseline</u>		<u>No debt</u>	<u>Debt + fixed investment</u>	
Low adjustment costs ($\gamma = 2.5$)	(1)	(2)	(2)-(1)	(3)	(3)-(1)
Economy's growth rate	5.71%	6.92%	1.21%	6.51%	0.80%
Firm-level average growth rate	6.06%	6.92%	0.86%	6.92%	0.86%
Default-induced deadweight loss rate	-0.35%	0%	0.35%	-0.41%	-0.06%

Table 3: The steady-state effect of debt overhang on growth. Panel A reports results from the model in [Section 3](#). The "Baseline" column shows growth rates at our baseline estimate. "No debt" columns correspond to the same model with an added constraint that firms cannot issue debt. "Debt + fixed investment" columns report results from our baseline model but imposes a fixed investment rate, set to the first-best rate implied by our parameters — identical to the investment rate in the "No debt" version. Panels B and C report analogous results for models calibrated to high and low adjustment costs ($\gamma = 7.5$ and $\gamma = 2.5$), targeting the same moments as in the baseline except for the investment-leverage sensitivity. "Economy's growth rate" is the asset-weighted ergodic average growth rate, $\hat{g} - (1 - \alpha_k)\hat{\lambda}_d$; "Firm-level average growth rate" is $\hat{g}$; and "Default-induced deadweight loss rate" is $-(1 - \alpha_k)\hat{\lambda}_d$.

	Laissez-Faire	Intervention
Scenario: credit market restoration		
Crisis scenario: credit markets shut down, equity markets remain open		
Intervention: restores credit market access		
$\mathbb{E} [x_t \text{normal times}]$	24.82%	25.39%
$\mathbb{E} [x_t \text{crisis}]$	20.05%	24.58%
$\mathbb{E} [x_t]$	24.38%	25.31%
$\mathbb{E} [\Phi(x_t) \text{normal times}]$	8.40%	8.36%
$\mathbb{E} [\Phi(x_t) \text{crisis}]$	4.20%	4.02%
$\mathbb{E} [\Phi(x_t)]$	8.01%	7.97%
μ_K	-0.86%	-0.92%
Scenario: credit market price-of-risk stabilization		
Crisis scenario: all financial markets remain open		
Intervention: lowers credit market Sharpe ratios from ν_c to ν		
$\mathbb{E} [x_t \text{normal times}]$	25.39%	25.62%
$\mathbb{E} [x_t \text{crisis}]$	24.58%	26.33%
$\mathbb{E} [x_t]$	25.31%	25.69%
$\mathbb{E} [\Phi(x_t) \text{normal times}]$	8.36%	8.34%
$\mathbb{E} [\Phi(x_t) \text{crisis}]$	4.02%	3.89%
$\mathbb{E} [\Phi(x_t)]$	7.97%	7.94%
μ_K	-0.92%	-0.97%
Scenario: market price-of-risk stabilization		
Crisis scenario: all financial markets remain open		
Intervention: lowers credit and equity market Sharpe ratios from ν_c to ν		
$\mathbb{E} [x_t \text{normal times}]$	25.39%	26.88%
$\mathbb{E} [x_t \text{crisis}]$	24.58%	26.49%
$\mathbb{E} [x_t]$	25.31%	26.84%
$\mathbb{E} [\Phi(x_t) \text{normal times}]$	8.36%	9.26%
$\mathbb{E} [\Phi(x_t) \text{crisis}]$	4.02%	6.14%
$\mathbb{E} [\Phi(x_t)]$	7.97%	8.97%
μ_K	-0.92%	-0.16%

Table 4: Moral hazard of credit market interventions. For each scenario, the table shows average leverage and average investment, both conditional on the macro state of the economy (“normal times” or “crisis”) and unconditional, as well as the economy’s growth rate, in the laissez-faire and in the case of systematic government interventions in credit markets during crisis times.

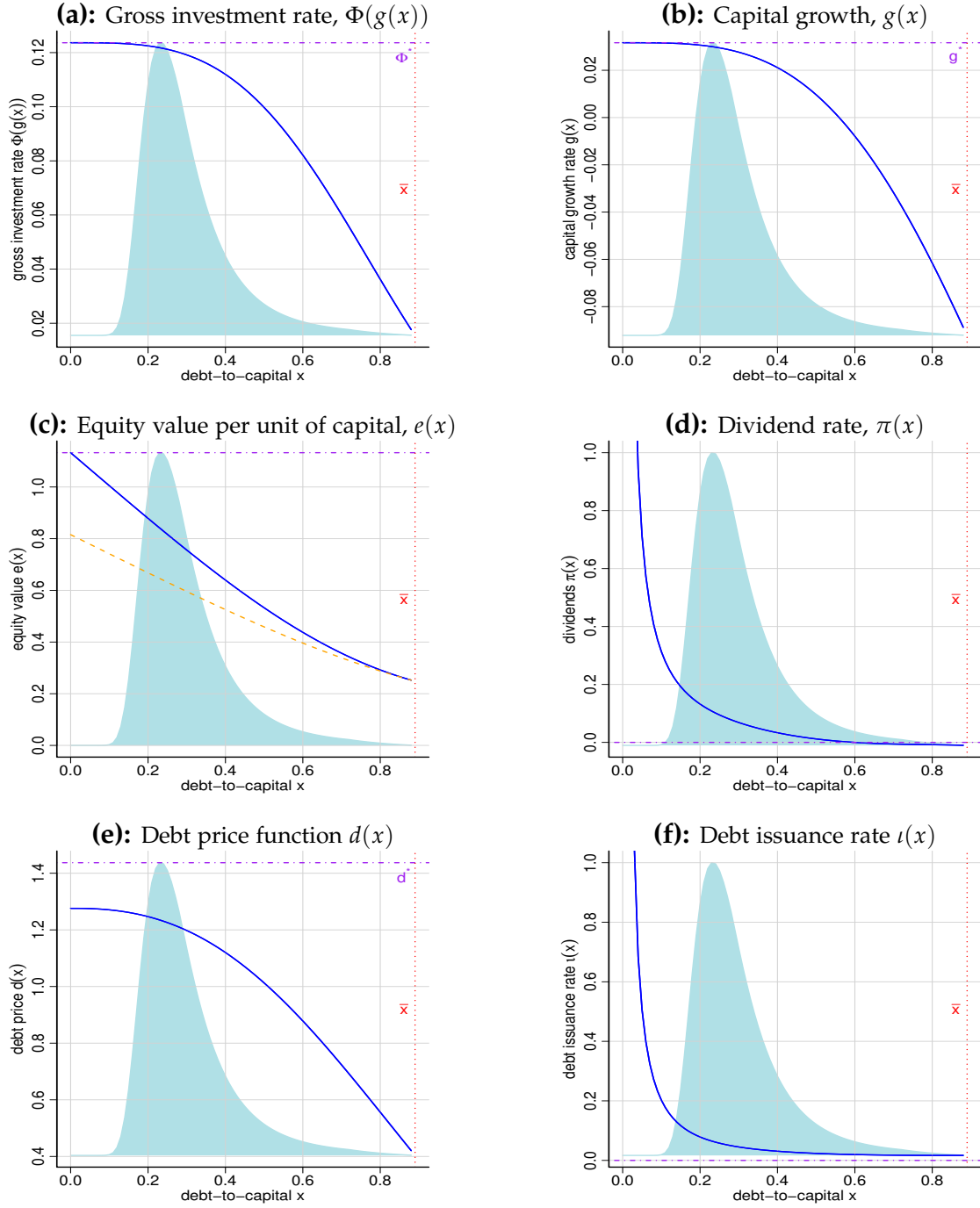


Figure 1: Policy functions in the model of [Section 2](#). In all graphs, the shaded blue area represents the long-run capital-weighted distribution $\hat{f}_\infty$, and the red dotted line to the right of the graph represents the default threshold. Φ^* (resp. g^*) refers to the gross (resp. net) investment rate in the no-debt model, and d^* refers to the risk-free debt price. The parameters used are those reported in [Table 1](#).

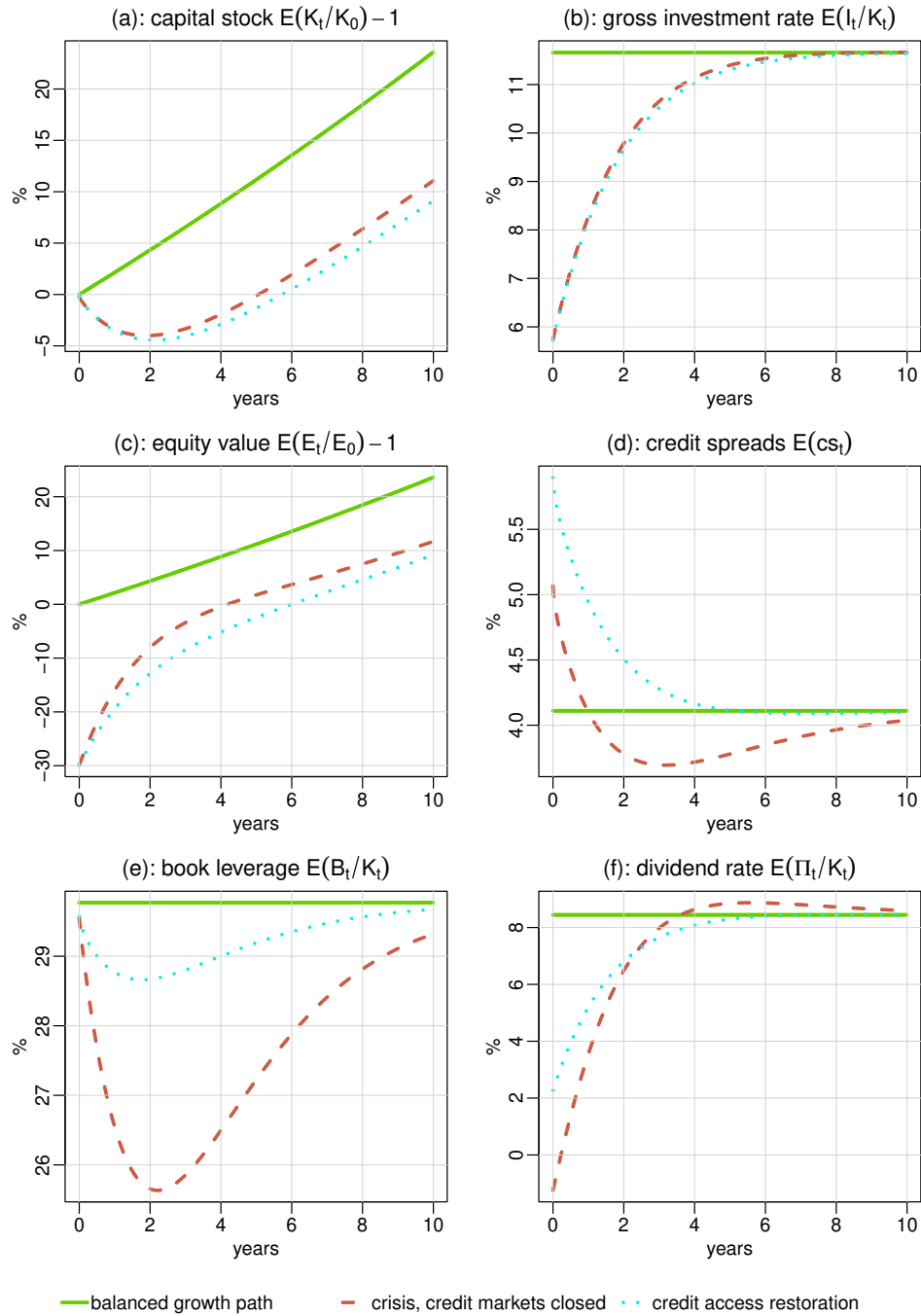


Figure 2: Crisis with credit market shut-down, without and with government intervention that restores credit market access (the “credit access restoration” scenario described in Section 4.3.1). Lines report expected path of various economic aggregates (see Section A.2.10.2 for exact definitions in terms of model objects).

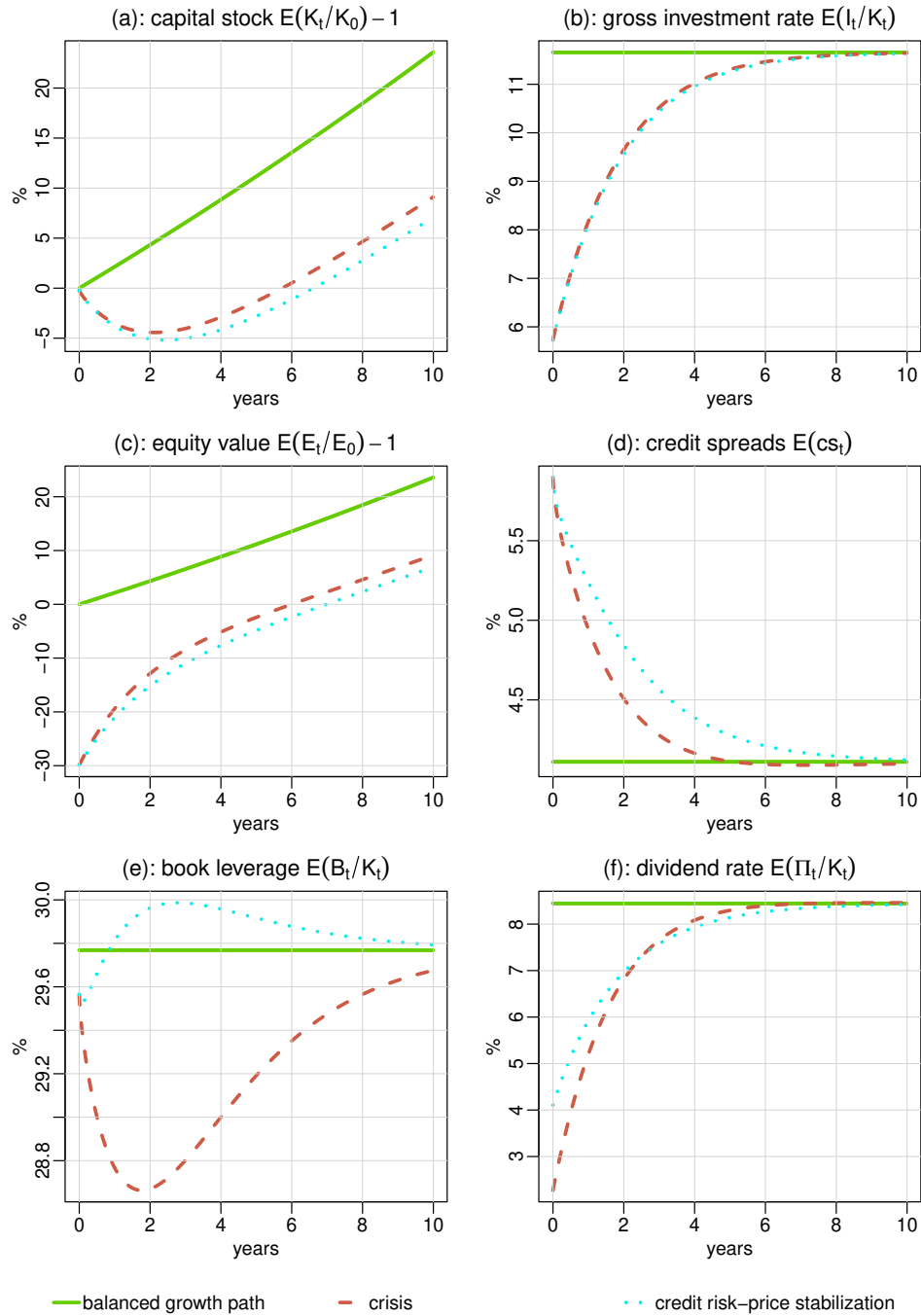


Figure 3: Crisis with functioning financial markets, without and with government intervention that lowers credit market Sharpe ratios (the “credit market price-of-risk stabilization” scenario described in Section 4.3.2). Lines report expected path of various economic aggregates (see Section A.2.10.2 for exact definitions in terms of model objects).

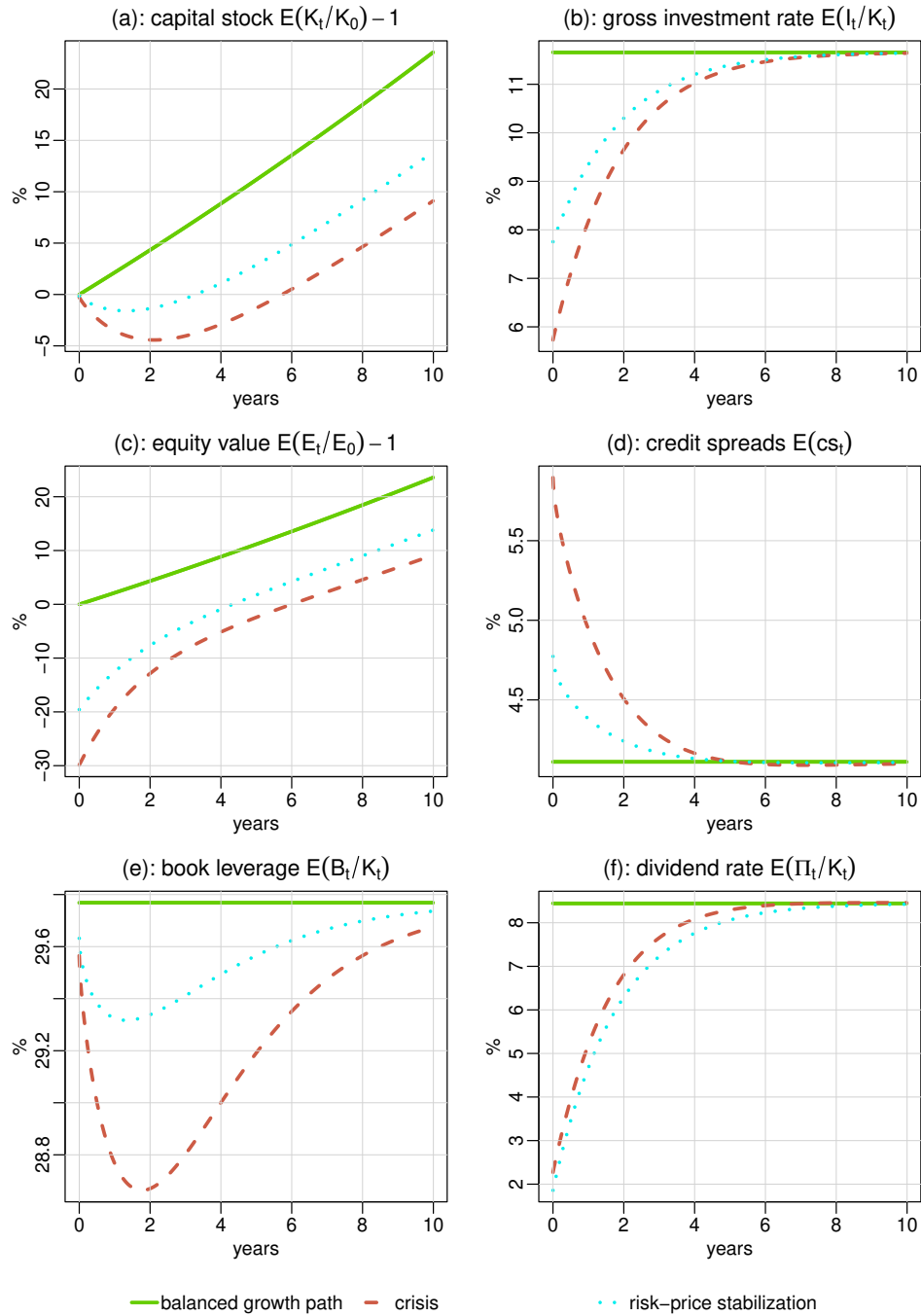


Figure 4: Crisis with functioning financial markets, without and with government intervention that lowers all prices of risk (the “market price-of-risk stabilization” scenario described in [Section 4.3.3](#)). Lines report expected path of various economic aggregates (see [Section A.2.10.2](#) for exact definitions in terms of model objects).

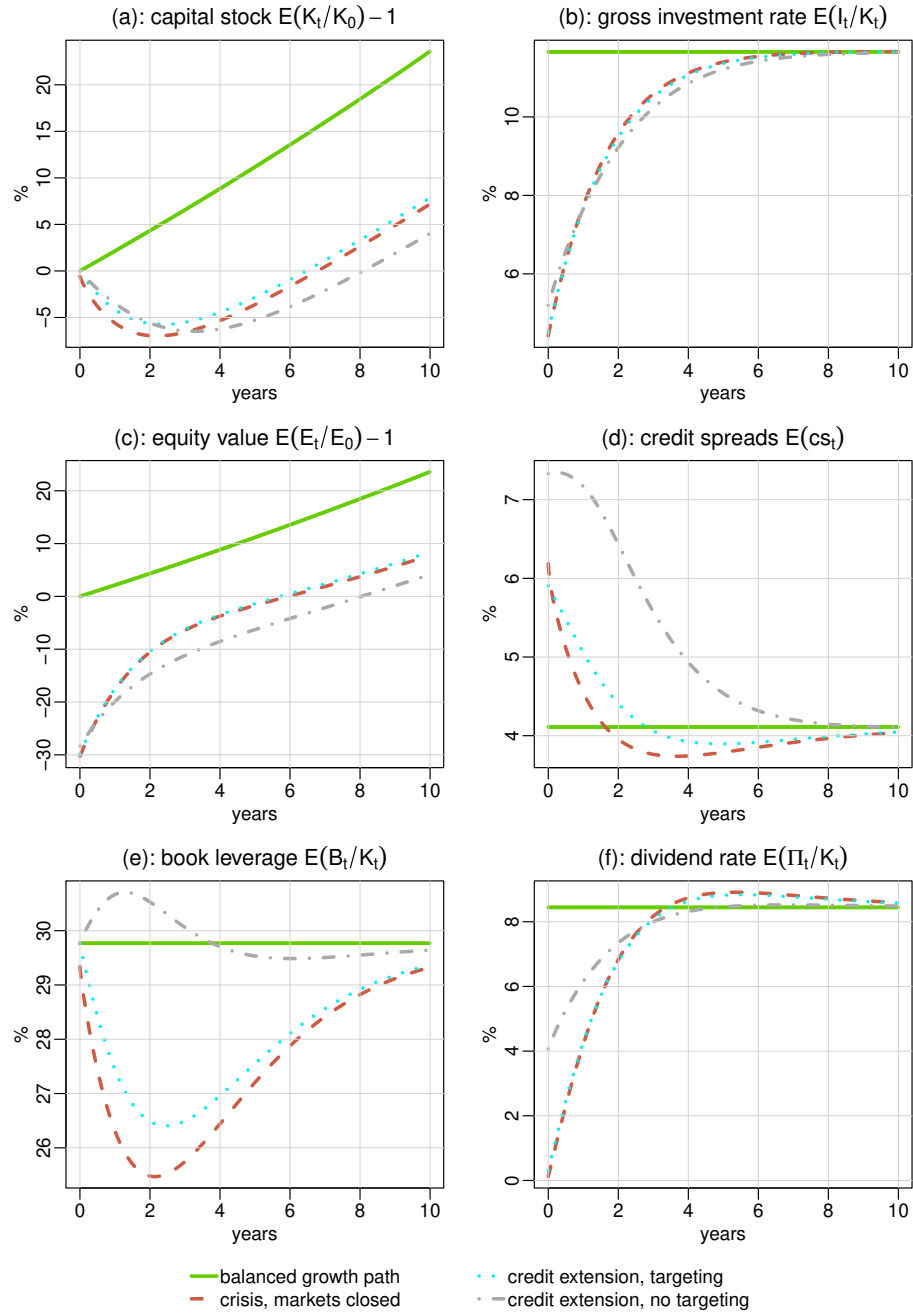


Figure 5: Crisis with sudden stop: the effect of subsidized debt purchases. Lines report expected path of economic aggregates following an unexpected crisis with a sudden stop, without and with credit extension by the government at a price $d_g = 70\%$ (“targeting”) and a price $d_g = 100\%$ (“no targeting”), as described in [Section 4.4](#). [Section A.2.10.2](#) reports the exact definitions of expected aggregates in terms of model objects.

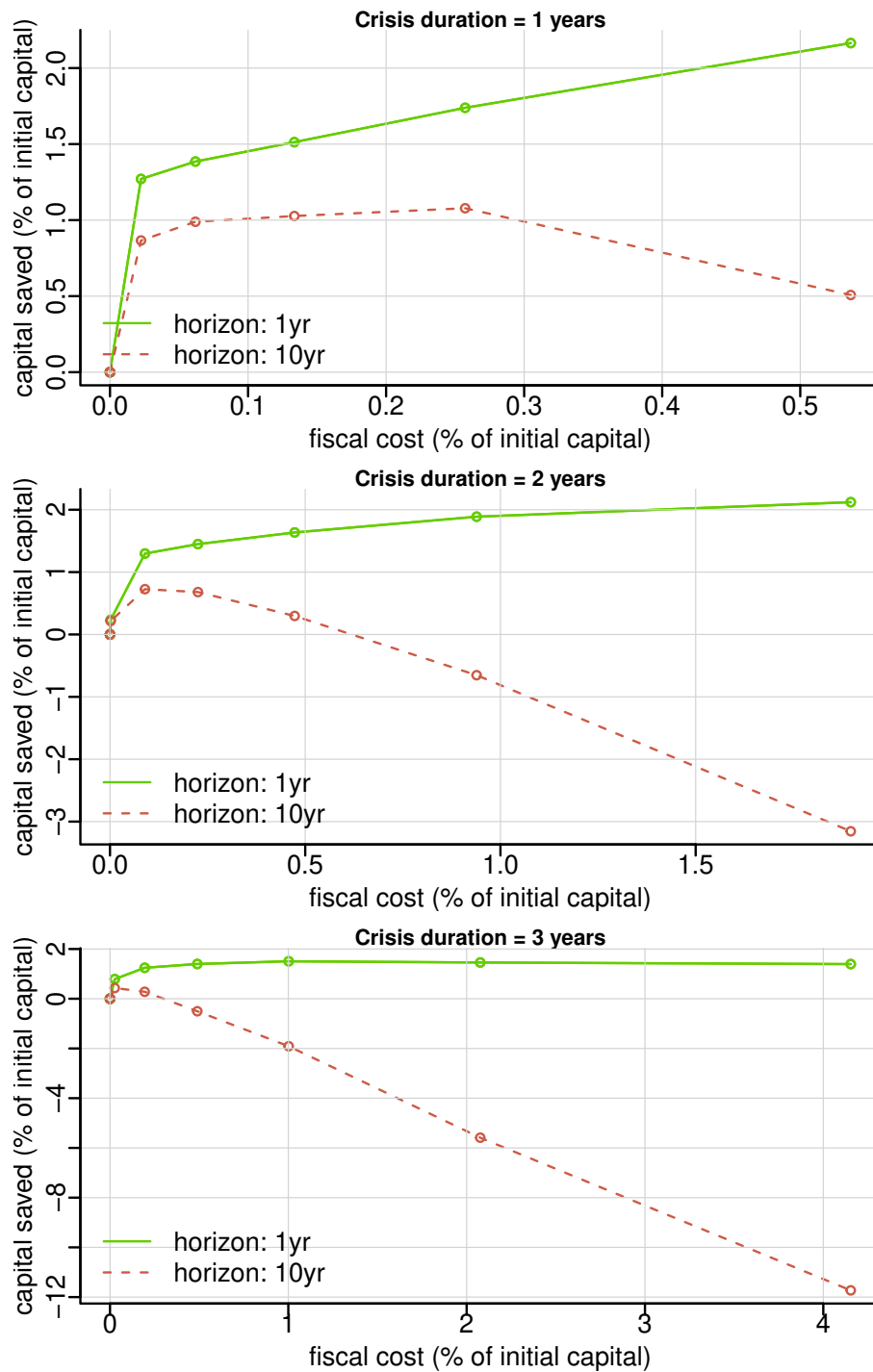


Figure 6: Trade-off between efficacy and fiscal costs. These figures show the change in aggregate capital relative to laissez-faire at different horizons, as a function of the fiscal cost of the intervention.

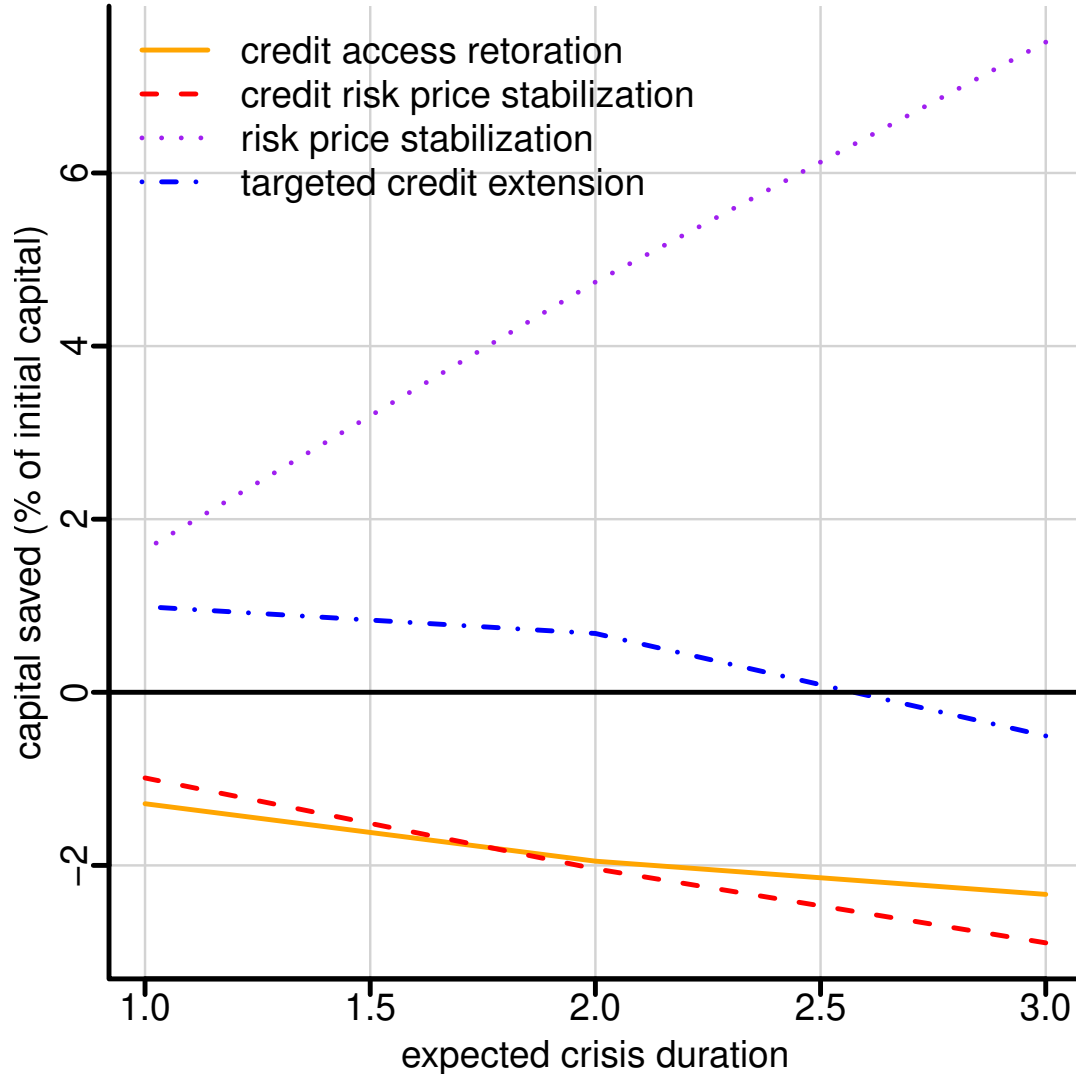


Figure 7: Long-run change in aggregate capital relative to laissez-faire, as a function of the expected crisis duration, for the *credit access restoration* scenario (orange solid line, see Section 4.3.1), the *credit market price-of-risk stabilization* scenario (red dashed line, see Section 4.3.2), the *market price-of-risk stabilization* scenario (purple dotted line, see Section 4.3.3), and the *targeted credit extension* when all markets are shut down (blue dot-dash line, see Section 4.4.1), where we assume that the government purchases debt at a price $d_g = 70\%$.