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ABSTRACT: We develop a pair of models that speak to the goals and design of the sort of business-lending and corporate-bond purchase programs that have been introduced by governments in response to the ongoing COVID-19 pandemic. An overarching theme is that, in contrast to the classic lender-of-last-resort thinking that underpinned much of the response to the 2007–2009 global financial crisis, an effective policy response to the pandemic will require the government to accept the prospect of significant losses on credit extended to private sector firms.

In response to the COVID-19 pandemic, governments around the world have responded with a range of business-lending and corporate-bond purchase programs to provide credit to nonfinancial firms. In this paper, we try to provide some conceptual grounding for thinking about the goals and design of these business credit programs. For concreteness, we draw motivation from two programs introduced by the U.S. Treasury and Federal Reserve—the suite of Main Street business lending facilities and the corporate-bond purchase facilities known as the Primary Market Corporate Credit Facility and Secondary Market Corporate Credit Facility (PMCCF and SMCCF, respectively). However, we believe that the main messages of our analysis apply more broadly and may be useful to other countries that are developing similar business credit programs.

We develop two distinct models. The first model, built with the Main Street and PMCCF facilities in mind, pinpoints the primitive market failures that might justify direct government lending to nonfinancial firms. Using this model, we explore how the market failures arising from today's pandemic-induced recession differ from those in "garden variety" recessions as well as those experienced in the 2007–2009 Global Financial Crisis (GFC). Thus, the model helps us understand

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why many governments have taken the extraordinary step of lending directly to nonfinancial businesses in recent months.

We highlight two features of the current COVID-19-induced recession that differentiate it from previous recessions. First, due to the pandemic and associated public health interventions, the relationship between a firm's current cashflows—and hence its ability to service its debts and other fixed obligations—and its long-run post-pandemic viability is likely to be much weaker than in a more typical recession. A large number of firms, including many that are likely to be viable in the long run, have suffered precipitous revenue declines in recent months. In the presence of credit market frictions that prevent these firms from borrowing against the full value of their future cashflows, they will not be able to be survive the pandemic without government support.

A second distinguishing feature of the current recession is extreme macroeconomic uncertainty due to our lack of knowledge about the path of the pandemic itself. We show that the combination of this high level of uncertainty with aggregate demand externalities means that there is "social option value" in keeping firms alive. If a surviving firm exerts positive spillovers on other surviving firms, then government support for firms essentially preserves society's option to capture such spillovers if macroeconomic uncertainty resolves favorably (e.g., if a vaccine is developed relatively quickly). These rationales are quite different from the ones that motivated government intervention in the GFC, suggesting that policies should also be designed differently this time around; we flesh out this logic in what follows.

Our second model looks at corporate bond-purchase programs such as the SMCCF, where the government announces its intention to buy securities that carry credit risk on the secondary market. As the U.S. case illustrates, even the announcement of such a purchase program can have powerful effects on market prices and primary issuance activity, before the government actually purchases any risky securities. While undeniably helpful in providing short-run stability to markets, we ask what potential risks might be associated with these strong announcement effects. In particular, we allow for the possibility that investors misperceive the implicit commitment that the Fed is making when it unveils its purchase programs—i.e., that investors fail to properly anticipate the states of the world in which the Fed will actually step in and buy risky bonds. We show that such misalignments of expectations can help stabilize markets in the short run, but also create the risk of sharp unwinds and fire sales further down the road. Of course, the costs and benefits of trading near-term stability for potential future instability depend on how actively firms, financial institutions, and households use the tranquil period to increase their financial buffers and prepare for a downturn. Nonetheless, the potential for the market to misinterpret the Fed's intentions means that how it communicates its intentions about future security purchases and how it adjusts its purchases in light of economic and financial developments have the potential to become key policy challenges going forward.

Although our two models are quite different, there is an overarching common theme. A classic framework for thinking about government interventions in financial markets is one in which there are important coordination problems between private-market actors that raise the prospect of multiple equilibria. In these settings, the mere promise of decisive action by the government can eliminate the "bad," pareto-inferior equilibrium, leaving only the "good," pareto-superior equilibrium. In the good equilibrium, the economy is sufficiently healthy that the government never actually loses any money on its lending programs, so the government is really just committing resources in an out-of-equilibrium sense. Indeed, the more aggressive are the government's commitments in such a multiple-equilibrium setting, the less it may stand to lose, and the better the overall economy may perform. In other words, a forceful and broadly-encompassing promise of government support can be a "free lunch" proposition. Diamond and Dybvig's (1983) seminal paper—in which a sufficiently committed lender-of-last resort can eliminate bank-run equilibria—is one example of this kind of logic and has helped shape a generation of crisis-management policy thinking, including the dominant thinking in the GFC. As former Treasury Secretary Tim Geithner argues, "it is also true for financial policymakers that once war is unavoidable, you need to commit to overwhelming force" (Geithner (2014)).

By contrast, we argue that in the current pandemic setting, this multiple-equilibrium free-lunch logic is not the right frame. Policy can certainly improve outcomes, but it is better thought of as fiscal policy, in which government expenditures potentially deliver high returns for society. Given the magnitude of the shock induced by the pandemic, policy cannot hope to fully stem the coming wave of corporate financial distress. A more forceful policy response—in either the Main Street or corporate-bond buying programs—therefore requires the government to accept a greater risk of credit losses. Of course, such risk does not imply that a forceful response is inappropriate. Indeed, we argue the opposite: the government needs to embrace the prospect of losing money on its programs if it is to have any hope of mitigating the economic and financial fallout from the pandemic. As it stands, however, the Main Street and PMCCF facilities are designed to take relatively little risk and in our view are therefore unlikely to be as effective as they might otherwise be.

That said, it appears that the Fed's unprecedented efforts to stabilize financial markets since March have for the time being shut doom the potential for a macro-financial "doom-loop," in which deteriorating financial conditions amplify the initial shock to the real macroeconomy. Thus, our analysis here amounts to a set of suggestions for enhancing the future effectiveness of government interventions. The need for such enhancements may become especially relevant if the recovery that has been underway since May stalls in the coming months.

The remainder of the paper proceeds as follows. In Section I, we provide a brief timeline of the U.S. government's interventions in credit markets since the onset of the COVID-19 pandemic in early 2020. Section II develops a model of government intervention in primary credit markets, which both provides rationales for such interventions and suggests how they should be designed. Section III analyzes secondary-market bond-purchase programs, and the potential for investors to misperceive the extent of the government's backstop. Section IV concludes.

I. Business Credit Programs in the U.S.

We begin by briefly outlining the timeline of the U.S. government's interventions in financial markets—emphasizing its interventions in business credit markets—since the onset of the COVID-19 pandemic in early 2020.

Investors' concerns about the economic and financial impact of the COVID-19 pandemic escalated rapidly beginning in late February 2020, with the U.S. stock market losing roughly 33% of its value between February 19th to March 23rd. Credit markets were also roiled, with credit spreads on high-yield corporate bonds rising by 730 basis points over this same period.

The Federal Reserve responded to these developments with unprecedented speed and force. On March 3rd, the Fed cut the (upper end of its target range for the) federal funds rate from 1.75% to 1.25%. On March 15th, it cut the funds rate to 0.25% and announced that it would purchase $500 billion in Treasury securities and $200 billion in agency MBS, resuming the large-scale asset purchases that it had undertaken from 2008–2014. On March 17th, the Fed announced a number of measures to support liquidity and functioning in short-term funding markets, including reopening the Primary Dealer Credit Facility, the Commercial Paper Funding Facility, and the Money Market Mutual Fund Liquidity Facility, which were crucial components of its response to the GFC. Finally, on March 23rd, the Fed signaled that it would purchase Treasury securities and agency MBS in whatever quantities were needed to hold down long-term Treasury and mortgage rates, which rose significantly in mid-March.[1] Thus, in less than three weeks, the Fed had cut the short-term policy rate to its effective lower bound and had deployed the full arsenal of nonconventional policy tools that it had developed during the GFC.

On March 23rd, the Fed and the Treasury broke new ground and announced their intent to intervene directly in business credit markets, unveiling the PMCCF and SMCCF. Under the original March 23rd PMCCF terms, the Fed would purchase up to $100 billion of newly-issued bonds and loans (maturing in less than four years) from investment grade U.S. firms (i.e., those with credit ratings of at least BBB-/Baa3). To finance these purchases, the PMCCF received an initial $10 billion equity investment from the Treasury's Exchange Stabilization Fund (ESF) and the Fed agreed to lend the PMCCF the remaining $90 billion on a secured basis under Section 13(3) of the Federal Reserve Act. Under the SMCCF's original terms, the Fed would purchase up to $100 billion of investment-grade corporate bonds (maturing in less than five years) in the secondary market as well as exchanged-traded funds (ETFs) that provide broad exposure to U.S. investment-grade bonds. The SMCCF would also be financed using a $10 billion equity investment from the ESF, with the Fed providing $90 billion of secured debt financing.

On March 27th, the Coronavirus Aid, Relief, and Economic Security (CARES) Act was signed into law. The CARES Act allocated an additional $454 billion to the Exchange Stabilization Fund to enable the Treasury to expand its joint lending facilities with the Fed. In addition, the Act established the Small Business Administration's (SBA) Paycheck Protection Program (PPP) to assist small firms—generally defined as those with fewer than 500 employees—in retaining their employees. While firms applied for PPP loans through private banks, these low-interest loans were guaranteed by the SBA. In addition, if most of the loan proceeds were used to cover payroll expenses, PPP loans would be forgiven by the SBA. The CARES Act initially appropriated $349 billion for PPP loans, but an additional appropriation of $320 billion was made on April 24th after demand from small firms exhausted the initial allocation. The SBA stopped accepting applications for PPP loans on August 8th.[2]

On April 9th, the Fed and Treasury significantly expanded the size of the PMCCF and SMCCF from the original $200 billion to a combined $750 billion. They also expanded the scope of the PMCCF and SMCCF so both facilities could purchase the debts of "fallen angel" firms—i.e., firms that had

[1] On March 23rd, the Fed and Treasury also announced they would re-establish a $100 billion Term Asset-Backed Securities Loan Facility, which had been formed during the GFC to support the issuance of asset-backed securities.

[2] Granja and others (2020), Autor and others (2020), Chetty and others (2020), and Bartik and others (2020) study the effects of the PPP.

investment-grade credit ratings on March 22 but had been subsequently downgraded to no worse than BB-/Ba3. In addition, they changed the scope of the SMCCF, allowing it to buy ETFs that provide broad exposure to the high-yield corporate bond market.[3, 4]

In the same April 9th announcement, the Fed and Treasury also established the $600 billion Main Street Lending Program (MSLP) to provide loans to small and medium-sized U.S. firms, with the Treasury making a $75 billion equity investment in the MSLP. Under the terms eventually adopted on July 28th, private banks make Main Street loans—which are typically secured—to qualifying firms with the MSLP purchasing 95% of the loan and the originating bank retaining the remaining 5%. Firms are eligible for the Main Street program if they satisfy size restrictions on the number of employees and revenues and also have relatively low leverage.[5] All loans made under the program have a five-year maturity with principal payments deferred for two years and carry an interest rate of LIBOR plus 300 basis points. Firms are generally prohibited from using Main Street loans to prepay or refinance existing debt. In addition, firms that participate in Main Street are subject to restrictions on executive compensation, dividends, and repurchases.

On May 29th, Fed Chair Jerome Powell made remarks at a Princeton University event that underscored the Fed's commitment to market stability, saying:

> The Fed is strongly committed to using our tools to do whatever we can for as long as it takes to provide some relief and some stability now, to support the recovery when it comes, and to try to avoid longer-run damage to people's lives through long spates of unemployment, or to their businesses through unnecessary insolvencies… We crossed a lot of red lines, that had not been crossed before […] This is a situation in which you do that, and you figure it out afterward.

On June 15, the Fed further amended the terms of the SMCCF, indicating that it would begin buying a portfolio of bonds designed to track a diversified index of corporate bonds that meet the program's eligibility requirements. This indexing approach was intended to complement the SMCCF's purchases of ETFs. Importantly, in a set of FAQs, the Fed indicated that it expected to slow or suspend

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[3] See Boyarchenko, Kovner, and Shachar (2020) and Gilchrist, Wei, Yue, and Zakrajsek (2020) for analyses of the PMCCF and SMCCF. Falato, Goldstein, and Hortacsu (2020) and Haddad, Moreira, and Muir (2020) also analyze bond markets in the COVID crisis.

[4] On April 9th, the Fed and Treasury introduced a Paycheck Protection Program Liquidity Facility (PPPLF) that would extend credit to banks that had originated PPP loans, taking the PPP loans as collateral at face value. The Fed and Treasury also announced the creation of a $500 billion Municipal Liquidity Facility (MLF) that would purchase short-term notes issued by U.S. states as well as eligible counties and cities.

[5] To qualify for a Main Street loan, firms and organizations must have fewer 15,000 employees or 2019 revenues of less than $5 billion. For for-profit firms, the firm's ratio of total debt to 2019 EBITDA is capped at either four or six, depending on the specific Main Street subprogram. Nonprofit organizations must meet a lengthy list of financial conditions.

its secondary-market bond purchases if indicators of market functioning, including credit spreads, were to return to "to levels at or near those prevailing prior to the COVID-19 dislocation" and, conversely, that it expected to increase its purchases if market conditions deteriorated.

As shown in Table 1, of the numerous credit programs announced by the Fed and Treasury in response to the COVID-19 pandemic, only the PPP had seen significant take-up as of September 2, 2020. The PPP closed on August 8th after extending $525 billion of loans to small businesses, compared to a program capacity of $659 billion. By contrast, the PMCCF and SMCCF have a combined program capacity of $750 billion, but the PMCCF had not purchased any newly-issued bonds or loans as of September 2nd and the SMCCF had purchased only $12.8 billion of bonds and ETFs. Similarly, the Main Street program has the capacity to lend up to $600 billion, but had made just $1.2 billion of loans as of September 2nd.

II. A Model of Government Intervention in Business Credit Markets

We start our analysis by developing a model that provides a rationale for government support to private firms during the COVID-19 pandemic. A key goal is to highlight how the current pandemic-induced recession differs from both garden-variety recessions and the GFC, and why these differences provide a motive for direct intervention in credit markets today.

In the model, there are two key frictions that drive a wedge between the private market outcome and the social planner's solution. First, credit market frictions can prevent firms from borrowing to survive the pandemic, even if continuation would be value-maximizing in the absence of these financing frictions. Second, aggregate demand externalities exist: the benefits to society if a given firm survives can exceed the private value of survival.

While these frictions provide broad rationales for government intervention that could apply in any recession, we use the model to highlight how pandemic-specific conditions turbocharge these rationales. First, in the presence of credit market frictions, the government finds it attractive to provide firms with a bridge through a recession to preserve the value those firms can create in the subsequent recovery. This rationale is strongest in recessions where firm cashflows are very low in the short run but are expected to recover in the long run, and when credit market frictions are more severe. While credit market frictions are always potentially present, the COVID-19 recession differs from typical recessions in that a decline in firm cashflows today is less informative about long-run firm viability than in an ordinary recession. Normally, one might argue that government support for firms in financial distress amounts to keeping alive a set of economically nonviable "zombies." Our point is that in the current pandemic-induced recession this zombie argument loses much of its normal force.

Aggregate demand externalities can also provide a general rationale for government action. However, we focus on the interplay between aggregate demand externalities and the heightened macroeconomic uncertainty created by the pandemic. In the model, the aggregate demand externality from keeping alive an additional firm is larger if the economy recovers quickly than if it stagnates in a protracted recession. Thus, by keeping alive firms that the private market would allow to fail, the government preserves the option to have a large, positive aggregate demand externality if the health emergency subsides quickly. In other words, there is social option value for the government in providing short-term aid to firms. Of course, in the private market equilibrium, there is also some option value for individual firms in delaying their exit decisions—some firms are willing to operate with negative cashflows, in case the economy recovers. However, as we show below, aggregate demand externalities create additional social option value, which makes preserving the option to exit later even more attractive to the planner than to private firms. Thus, unusually high macroeconomic uncertainty of the sort that exists today strengthens the case for government intervention.

II.A Model Setting

The model has three periods—which we label $t = 1$, $t = 2$, and $t = \infty$—and a continuum of firms $f \in [0,1]$ that differ solely in their exposure to a negative shock that first hits the economy at $t = 1$. Specifically, we assume the economy enters the initial stages of a recession at $t = 1$, which leads to a larger decline in cashflows for more highly exposed firms. There is also aggregate uncertainty at $t = 1$: the recession will be mild or severe at $t = 2$. Finally, at $t = \infty$, the economy arrives in a new steady state. This steady state depends on the severity of the recession realized at $t = 2$, meaning that the recession may have a permanent scarring effect on firms' cashflows even in the long run.

All agents in the economy are risk neutral with a constant time discount factor given by $\delta \in (0,1)$. We use F_{S_t} to denote the mass of firms that are operating in state S_t at time t. It will turn out that all firms $f \in [0, F_{S_t}]$ will operate in state S_t at time t.

Each firm can be shut down at any date t. If a firm is shut down, it generates zero cashflow in that period and all future periods. If a firm operates in a given period, it generates some cashflow. If this cashflow is positive, some portion of it can be paid to the firm's outside investors. If the cashflow is negative, it represents an investment that the firm's investors must make to keep it alive.

If firm f operates at $t = 1$ it generates the following cashflow:

$$X_1(f, R_1) = \mu + \gamma - R_1 - \Delta \times f \ . \tag{1}$$

Here $R_1 > 0$ parameterizes the impact of the recession on firm cashflows at $t = 1$, while f captures cross-sectional heterogeneity in firms' exposure to the recession, with higher f representing greater exposure. In the current pandemic, high-f firms might represent firms in "non-essential" industries that rely on close physical proximity—e.g., firms in the hospitality and leisure sector.

All uncertainty is resolved at $t = 2$ and there are two possible states at $t = 2$: $S_2 \in \{B_2, G_2\}$. With probability p the recession will be severe, denoted $S_2 = B_2$, and with probability $(1 - p)$ the recession will be mild, denoted $S_2 = G_2$. If firm f operates in state S_2 at $t = 2$ it generates cashflow:

$$X_2(f, R_{S_2}, F_{S_2}) = \mu + \gamma \times F_{S_2} - R_{S_2} - \Delta \times f \ . \tag{2}$$

$\gamma \times F_{S_2} \geq 0$ is a reduced form for the aggregate demand externality we assume exists at $t = 2$. The cashflows of any individual firm are greater when more firms are operating at $t = 2$. Individual firms take as given the total number of firms operating, while the social planner recognizes that an additional surviving firm generates positive aggregate demand spillovers on all other surviving firms.[6]

The severity of the recession can affect firm cashflows in the long-run steady state. Specifically, at $t = \infty$, the state of the economy is $S_\infty = B_\infty$ if $S_2 = B_2$ and $S_\infty = G_\infty$ if $S_2 = G_2$. If firm f operates in state S_∞ at $t = \infty$, we assume it generates cashflow:

$$X_\infty(f, R_{S_\infty}) = \mu + \gamma - R_{S_\infty} - \Delta \times f \ , \tag{3}$$

To introduce financial-market frictions at $t = 1$, we assume that private investors can only appropriate a fraction $0 < (1 - \varphi) \leq 1$ of the firm's total value of $t = 2$, where $\varphi \in [0,1)$. Thus, if firm f requires an outside cash investment at $t = 1$ (i.e., if $X_1(f, R_1) < 0$), it cannot raise the full value of continuation from outside investors. Financial markets are frictionless in the limit where $\varphi = 0$. Limited pledgeability constraints of this sort emerge from moral hazard problems between investors and firm managers (Holmstrom and Tirole [1997]). Alternatively, $\varphi > 0$ can be seen as capturing the idea that some of the surplus a firm generates accrues to stakeholders other than the firm's investors and managers (e.g., to employees).

[6] Aggregate demand externalities refer to market failures that can arise from the fact that individual agents fail to internalize how their actions impact aggregate demand in the macroeconomy and, hence, the broader economic conditions faced by other agents. These externalities arise generically in the presence of nominal price rigidities or a zero lower bound on nominal interest rates (Farhi and Werning [2016]), but vanish in frictionless, flexible-price settings.

Parametric Assumptions

We make a few technical assumptions to focus on the most interesting part of the parameter space. First, we assume a natural ordering of cashflows across states and time periods so firm cashflows are lower in the bad state than the good state and there is recovery between time 2 and the new steady state. Second, we assume that the most exposed ($f = 1$) firms have negative cashflows in all states and all time periods, implying that the recessions renders some firms nonviable in the long run and that some firms must tap external investors to survive at $t = 1$ and 2. Third, we assume that aggregate demand externalities at $t = 2$ are not so powerful that the social planner wants to keep all firms alive at $t = 2$. Finally, to isolate cases where there is option value to delaying exit at $t = 1$, we assume that the marginal firm that operates at $t = 1$ continues to operate at $t = 2$ if the good state is realized but exits if the bad state is realized. These conditions are stated more formally in the Internet Appendix.

II.B Model Solution

In the Internet Appendix, we solve the model by backwards inducting from $t = \infty$. Specifically, for each state S_t, we conjecture that we enter the state with all firms $f \in [0, F_{S_{t-1}}]$ still intact from the preceding state S_{t-1} at time $t - 1$. We then find a new cutoff $F_{S_t} \leq F_{S_{t-1}}$ such that all firms $f \in [0, F_{S_t}]$ continue operating in state S_t at time t. Thus, an equilibrium in our model is a set of five cutoffs $\{F_1, F_{G_2}, F_{B_2}, F_{G_\infty}, F_{B_\infty}\}$ that identify the most-exposed firm that is still operating in each state.

At each time, a firm's private value reflects the fact that it has the option to exit and earn zero. Thus, the private value of f firm at $t = \infty$ is:

$$V_\infty(f, S_\infty) = \frac{1}{1-\delta} \cdot \max\{X_\infty(f, R_{S_\infty}), 0\}, \tag{4}$$

which is simply value of receiving the greater of $X_\infty(f, R_\infty)$ or zero in perpetuity. At $t = 2$ the private value of the firm is:

$$V_2(f, R_{S_2}, F_{S_2}) = \max\left\{X_2(f, R_{S_2}, F_{S_2}) + \delta \cdot V_\infty(f, R_{S_\infty}), 0\right\}, \tag{5}$$

and at $t = 1$ the private value of the firm is:

$$V_1(f, F_1) = \max\left\{X_1(f, R_1) + (1-\varphi)\delta \cdot \left[(1-p) \cdot V_2(f, R_{G_2}, F_{G_2}(F_1)) + p \cdot V_2(f, R_{B_2}, F_{B_2}(F_1))\right], 0\right\}. \tag{6}$$

In equation 6, the potential for financial-market frictions at $t = 1$ is captured by the fact that the term in square brackets—i.e., the firm's expected value at time-2—is multiplied by $(1 - \varphi)\delta \leq \delta$.

The planner's solution and the private market solution diverge when there are either aggregate demand externalities at $t = 2$ ($\gamma > 0$) or credit market frictions at $t = 1$ ($\varphi > 0$). When there are aggregate demand externalities, the key difference between the planner's solution and the private market's is that private firms take as given the endogenous state of aggregate demand in the macroeconomy at $t = 2$, captured by F_{S_2}. In contrast, the planner recognizes that its decisions change F_{S_2}, impacting the time-2 cashflows of all surviving firms. When there are credit market frictions, the key difference between the planner and the private market is that the planner ignores the friction, effectively acting as though $\varphi = 0$. This does not mean that we are assuming that the planner is immune to frictions facing the private market. We are instead assuming that the planner is willing to make investments that are negative NPV from the private market's perspective. Because the planner is maximizing total social surplus, the planner is willing to make an investment in a firm that exceeds the pledgeable value of future firm cashflows even if it will take a direct loss on such an investment.

II.C Comparing the Planner's Solution with the Private Market Solution

Letting $F_{S_t}^{**}$ denote the cutoffs in the planner's solution and $F_{S_t}^{*}$ the cutoffs in the private- market solution, the following proposition outlines the basic properties of each solution:

Proposition 1: *Under the assumptions outlined above, weakly more firms operate at $t = 1$ than at $t = 2$ in both the planner's solution and the private market solution, reflecting the option value of delaying exit. When either $\varphi > 0$ or $\gamma > 0$, weakly more firms survive in the planner's solution than in the private market outcome at $t = 1$ and in all possible states at $t = 2$ and $t = \infty$. When $\gamma > 0$, strictly more firms survive at all times. Specifically, we have*:

- $F_1^{**} > F_1^{*}$ *when $\varphi > 0$ or $\gamma > 0$. Moreover, $F_1^{**} - F_1^{*}$ is strictly increasing in both φ and γ.*
- $F_{S_1}^{*} \geq F_{S_2}^{*}$ and $F_{S_1}^{**} \geq F_{S_2}^{**}$. *Furthermore, $F_{S_2}^{**} \geq F_{S_2}^{*}$ when $\varphi > 0$ or $\gamma > 0$ (with strict inequality when $\gamma > 0$). $F_{S_2}^{**} - F_{S_2}^{*} \geq 0$ is strictly increasing in γ and is weakly increasing in φ.*
- $F_{S_2}^{**} = F_{S_\infty}^{**}$ *and* $F_{S_2}^{*} = F_{S_\infty}^{*}$.

In both solutions, some firms with negative cashflows continue operating at $t = 1$ in hopes that the good state is realized at $t = 2$. If the bad state occurs, these firms exit. Both market failures in our model lead to fewer surviving firms at $t = 1$ in the private solution than in the planner's solution—i.e., the private market underinvests in firm continuation. And, naturally, the underinvestment at $t = 1$ becomes more pronounced as each of the market failures becomes more severe.

We next explore how the initial severity of the recession affects the wedge between the private market and planner's solutions. To capture the intuition as simply as possible, we assume there is no uncertainty about the path of the recession, i.e., we assume $R_{G_2} = R_{B_2} = \bar{R}_2$ and $R_{G_\infty} = R_{B_\infty} = \bar{R}_\infty$.

***Proposition 2**: If $\varphi > 0$ and $\gamma = 0$ and there is no uncertainty about the path of the recession, then, under the assumptions outlined above, $F_1^{**} - F_1^*$ is increasing in R_1 and decreasing in both $\bar{R}_2$ and $\bar{R}_\infty$.*

For starkness, we focus on the case where there are credit market frictions but not aggregate demand externalities.[7] In this case, the planner and the private market disagree most about firm continuation when the recession is expected to be sharp (i.e., R_1 is large), but short (i.e., $\bar{R}_2$ and $\bar{R}_\infty$ are small). When the shock to the average firm in the economy becomes more transient (i.e., $\bar{R}_2$ and $\bar{R}_\infty$ fall holding fixed R_1), more firms will survive in both the planner's solution and the private market solution. As the initial shock becomes more severe (i.e., R_1 rises holding fixed $\bar{R}_2$ and $\bar{R}_\infty$), however, it becomes more necessary for firms to borrow against the value of future cashflows to survive. When credit market frictions are significant, firms cannot borrow enough in the private market. As a result, injecting funds into these firms so that they can survive is socially worthwhile, even though the planner may not be able to financially recoup these investments in full. In other words, when the fundamental shock that hits the economy is expected to be short and severe, the planner wants to build a temporary bridge to the economy's new steady state. Private markets are less willing to provide this bridge to individual firms because they will be unable to fully capture its social benefits.

This bridging motive is particularly strong in the current recession because the COVID-19 pandemic and associated public health interventions have had an unprecedented short-run impact on firm cashflows. In more normal circumstances, including in a garden-variety recession, if a firm's revenue falls by 75%, this is likely to be a strong signal that the firm is not viable in the long run. Thus, it is both privately and socially optimal for firms to exit when they suffer significant revenue losses, and if the government leans against such exits, it may rightly be accused of propping up economically nonviable zombie firms. In contrast, in the current pandemic setting, sharp declines in near-term firm revenues are less informative about long-run firm viability. While the prospects of some businesses may suffer long-run damage from the pandemic (e.g., hotels catering to business travelers), others seem likely to recover once the health emergency ends (e.g., bars, daycare providers, gyms, and restaurants).

[7] More generally, the comparative static on R_1 in Proposition 2 holds when credit market frictions are relatively important relative to aggregate demand externalities in the sense that $\varphi(\Delta - (1-\delta)\gamma) > (1-\delta)\gamma$. The comparative statics on $\bar{R}_2$ and $\bar{R}_\infty$ hold whenever either $\varphi > 0$ or $\gamma > 0$.

While our formal analysis emphasizes government investments that are designed to enable firms to continue operating, a related motive for government investments may arise if financial distress leads to deadweight losses—e.g., because financial distress can distort firm investment (debt overhang) or destroy valuable business relationships. In this case, government investments that prevent a temporary decline in firms' cashflows from resulting in value-destroying financial distress may create surplus that private actors are unable to capture on their own due to financial frictions—e.g., because of conflicts between a firm's existing debt and equity holders. See Greenwood and others (2020) for an assessment of financial distress costs in the COVID-19 pandemic.

We next explore the impact of macroeconomic uncertainty on the wedge between the private market and planner's solutions.

Proposition 3: *Under the assumptions outlined above, $F_1^{**} - F_1^*$ is decreasing in both R_{G_2} and R_{G_∞} when either $\varphi > 0$ or $\gamma > 0$, but does not depend on either R_{B_2} or R_{B_∞}. As a result, a small increase in the amount of time-1 uncertainty about exogenous macroeconomic fundamentals at either $t = 2$ or $t = \infty$, raises $F_1^{**} - F_1^*$. Specifically, suppose R_{G_2} declines and R_{B_2} increases such that $\bar{R}_2 = pR_{B_2} + (1 - p)R_{G_2}$ remains fixed. This is associated with an increase in $F_1^{**} - F_1^*$.*

When $\varphi = 0$ and $\gamma > 0$, there is social option value to keeping firms alive at $t = 1$, over and above the option value each firm perceives in the private-market solution. If the good state is realized at $t = 2$, then many firms are viable. The existence of aggregate demand externalities ($\gamma > 0$) means that the demand spillovers the private market does not internalize are particularly large if the good state is realized. Intuitively, society has access to a valuable real option of generating positive spillovers, which will make the recession shallower, if aggregate uncertainty resolves favorably. Consistent with standard intuitions, the value of this social real option is increasing in the uncertainty about the severity of the recession, so the motive for government interventions is stronger when there is greater uncertainty at $t = 1$ about the future course of the macroeconomy.[8]

When $\varphi > 0$ and $\gamma = 0$, the intuition is even simpler. In this case, an increase in time-1 uncertainty raises the private option value of keeping firms alive until $t = 2$. However, when there are

[8] This social-option value point hinges on the idea that the externality is more positive when aggregate uncertainty resolves positively. This need not be the case. For instance, suppose there are fire-sale externalities at $t = 2$. When deciding whether to shut down and liquidate an individual firm, private investors take liquidation prices as given. By contrast, the social planner internalizes the fact that liquidating an additional firm reduces the liquidation price for all firms. In the presence of financial-market frictions, the resulting pecuniary externality leads to too many private market liquidations when compared to the social planner's solution. Since this fire-sale externality is more pronounced when the recession is more severe at $t = 2$, a model with only fire-sale externalities will imply that the disagreement between private markets and the planner is *increasing* in R_{G_2} and R_{G_∞}.

credit market frictions ($\varphi > 0$), private investors cannot fully capture the value of this option. Thus, an increase in time-1 uncertainty leads private markets to underinvest more in firm continuation.

These considerations loom large in the current context. As detailed in Altig and others (2020), macroeconomic uncertainty has arguably never been greater than it is today due to the uncertainty about factors including the underlying epidemiology of COVID-19, the efficacy of our public health responses, new treatment options, and the search for a vaccine. Figure 1 makes this point by plotting cross-sectional dispersion in the Survey of Professional Forecaster expectations for current-period real GDP growth and option-implied stock market volatility.

II.D Implications for Program Design

In addition to providing rationales for government aid to firms during the COVID-19 pandemic, the model also has implications for how the support should be designed. The model does not explicitly feature a support program, but one is implicit in the difference between the planner's solution and the private-market outcome. Since the planner's solution involves keeping alive some firms that would exit in the private market solution, we are implicitly assuming that the government provides the funds necessary for those firms to keep operating and finances these investments with lump-sum taxes. While these investments are socially worthwhile, the future cashflows of the specific firms receiving funds need not be sufficient to repay the government. In other words, the government's support may be thought of as containing an element of outright grant to the firms it aids.

Three elements of program design emerge directly from the model. First, the government must be willing to make investments in risky, marginal firms that the private sector is unwilling to finance. In Proposition 1, $F_{S_t}^{**} \geq F_{S_t}^{*}$ state-by-state. The planner supports more firms—in other words, it makes financing more widely available—than the private market, and the marginal firms it supports are more exposed to the shock (i.e., they are higher-f firms). To the extent that government support in the model is targeted, it is allocated based on the temporary component of firms' current cashflow shortfalls.

Second and relatedly, the government should expect to lose money on the investments it makes in some firms. When there are either aggregate demand externalities or credit market frictions, the planner is willing to invest enough in marginal firms that they can survive at $t = 1$, even though it will not directly recoup these investments in expectation. When there are aggregate demand externalities, the spillovers these firms generate if the good state is realized outweigh the direct losses from supporting them. When there are credit market frictions, the marginal firms create enough value to warrant support themselves, but the planner may not be able to directly recoup that value for the same reasons private investors cannot—e.g., because some of it accrues to other stakeholders.

Put differently, the logic of intervention in the model is not the standard multiple-equilibrium logic for lender-of-last-resort interventions (e.g., Diamond and Dybvig 1983). In a lender-of-last-resort context where there is the potential for a purely non-fundamentally-driven bank run, government interventions can coordinate private agents on the good equilibrium where there are no credit losses. In contrast, here the government cannot shift the economy from the bad state to the good state at $t = 2$. Whether we are in the good or bad state at $t = 2$ is solely determined by the path of the pandemic, which is not affected by government financial policies towards firms (though it is of course influenced by the government's public health policies). Instead, government intervention here counteracts market failures that lead private markets to underinvest in firm continuation, both in the face of the incipient recession at $t = 1$ and ex post once the severity of the recession is realized at $t = 2$.

A third implication of the model is that government financial support should be staged. That is, disbursements of government financing should initially be just enough keep firms alive between $t = 1$ and 2, but should not be sufficient to guarantee that firms can survive beyond that. Proposition 3 implies that this staged-financing approach is particularly important when aggregate uncertainty is high. In this case, the planner helps many firms survive at $t = 1$ in hopes that the good state is realized at $t = 2$. If the bad state is realized, however, the planner allows some firms to fail. As in a venture-capital setting, staged financing is necessary for the planner to adapt to the information that is revealed over time, and to capture the social option value of delaying firm exit. At $t = 1$, the planner should not commit to supporting firms until the steady state; it simply wants to support firms long enough to see whether a quick economic recovery is possible.[9]

In addition to these direct implications for the design of government aid, the logic of the model informally suggests that the repayment terms of any government investments should be relatively "soft," in the sense of being economically more equity-like than debt-like. One relevant observation from the model is simply that the government's investments are not riskless: the government cannot expect to directly recoup the full amount it provides to firms in all states of the world. Thus, using relatively hard repayment terms (e.g. highly senior, collateralized debt with short repayment periods)

[9] Staging refers to the quantity of funds provided, not to the maturity of the government's investment. Specifically, staging simply means that the first round of funding is only enough to allow firms to survive until $t = 2$.

in an effort to guarantee that the government's investments are fully repaid in all states runs counter to the basic logic for providing government support in the first place.

One could imagine further enriching the model to capture other benefits of softer terms. In particular, reducing the seniority of the government's debt claims or giving firms the option to defer interest or principal payments without filing for bankruptcy protection could help bridge more firms through the pandemic and maintain the health of firm balance sheets, mitigating future debt overhang problems that could otherwise hamper the subsequent recovery. In the language of the model, softer contractual terms on government investments would serve three purposes: (i) increasing the cashflows each firm generates at $t = 2$ by mitigating debt overhang, (ii) decreasing any potential credit-market frictions facing firms at $t = 2$ by improving the health of their balance sheets, and (iii) increasing positive spillovers across firms at $t = 2$ by raising the number of firms that survive.

In practice, governments often prefer to make debt rather than equity investments in firms to avoid the significant political economy problems that arise when they have control rights over firms' operating decisions. With this in mind, the terms of the government's debt investments could be softened by reducing seniority and collateralization, extending maturities, and making principal and interest payments deferable. In other words, government investments could be made more similar to preferred stock.[10] Notably, the U.S. government's investments in banks during the GFC under the Troubled Asset Relief Program (TARP) took the form of preferred stock, for a similar reason: putting more debt into already over-leveraged banks would have exacerbated their solvency problems; and yet the government was reluctant to put in common equity because it did not want to be seen as nationalizing the banks. To further protect taxpayers, the government could also consider taking equity warrants in participating firms as it did under the TARP program during the GFC.

II.E Application to the Main Street Lending Program

The implications for program design that emerge from our model stand in contrast to the current design of some of the U.S. government's business lending facilities. Take for instance the Main Street Lending Program (MSLP) that was created by the Fed and the Treasury to support small and medium-sized businesses. As discussed above, under Main Street, private banks make secured loans to

[10] Based on our (admittedly imperfect) understanding of the CARES Act and Section 13(3) of the Federal Reserve Act, the government's investments would need to legally qualify as a form of indebtedness. In other words, based on current law, it seems unlikely that the Treasury and Fed could establish a facility that made true equity investments in firms. Thus, while existing facilities could not literally purchase preferred stock in firms, they could purchase economically very similar securities—e.g., junior subordinated debt with deferrable interest payments.

qualifying firms with the MSLP purchasing 95% of the loan and the originating bank retaining the remaining 5%. Firms are eligible for the Main Street program if they satisfy size restrictions on employees and revenues and have relatively low leverage. All loans have a five-year maturity with no principal payments for two years and carry an interest rate of LIBOR plus 300 basis points.

The requirement that banks retain an economic stake in their Main Street loans seems likely to hamper the program's ability to provide aid to firms that a social planner would choose to invest in but that the private sector is unwilling to finance. Though banks must retain only a small fraction of the loans they make, they will still require a privately-satisfactory return on the piece that they must retain. Since the government and banks share borrower repayments proportionally, the return on the piece the banks retain is the same as the return on the overall loan.[11] Thus, unless banks are highly capital constrained, the Main Street program seems unlikely to lead banks to make many additional loans that they would not already be willing to make. In contrast, the model suggests that a key element of any effective government intervention is a willingness to aid marginal firms that private lenders would not see fit to support, even when those private lenders are not capital constrained.

Similarly, Main Street's tight restrictions on firm leverage may also interfere with the program's ability to provide support to marginal firms that private lenders would not finance on their own. By only supporting firms with relatively low leverage, the government may effectively be shutting out those firms where the planner's motives diverge most sharply from those of the private capital providers, and where our model suggests that intervention is most socially valuable.

In addition, the maximum new loan size in the Main Street program is relatively large, ranging from \$35 to \$50 million depending on the specific subprogram. These large loan sizes may mean that for those small- and medium-sized firms that do pass the government's and the banks' lending screens, the program may actually be too generous, in the sense of giving firms enough financing to last several quarters, rather than staging the financing and re-upping only in more positive states of the world.

Putting these observations together, our recommendation would be that, to the extent the government wants to protect its Main Street investments, it should do so less by imposing tough *ex ante* underwriting standards to decide who qualifies for the facility, and more by meting out the financing in stages for those who do qualify. Again, the analogy to venture capital is helpful here. In a situation of very high uncertainty, venture-capital intermediaries do not seek to avoid investing in risky

[11] This problem can be mitigated to some extent if the banks are also granted generous origination and servicing fees for making the loans. Such fees are indeed a feature of the Main Street Loan Program.

firms, because, of course, that is where all the value-added lies. Rather they protect themselves by carefully controlling the quantity of financing they provide, and only adding to their investments when positive new information comes in. This is exactly the option-value approach that we are advocating.

Finally, the terms of Main Street's loans are relatively hard. These loans must be contractually senior to all other firm indebtedness, so we would generally expect participating banks to require collateral to secure Main Street loans. Moreover, their five-year maturity and the fact that principal and interest are not deferrable means that firms may be significantly squeezed by the obligation to repay their loans, even if the public health emergency subsides in the next year. Thus, the terms of Main Street loans may create significant future debt overhang problems. To the extent firms anticipate these problems, these terms may limit program take-up ex ante.[12] Alternatively, if there is ultimately a lot of take-up, the hardness of the loans may contribute to an otherwise-avoidable wave of defaults and bankruptcies just as the economy is beginning to emerge from the recession.

Our discussion thus far has treated the U.S. government as a single integrated actor. In practice, the relevant fiscal powers reside with the Treasury, which controls the ESF. The Fed only has the authority to establish facilities making loans that "are secured to the satisfaction" of the Fed.[13] In other words, while the Treasury can assume the risk and even the expectation of losses on its ESF investments, the Fed is not supposed to take risk on the loans it extends (English and Liang (2020)). Thus, while it makes no difference for the U.S. government's consolidated fiscal position, it is legally necessary for the Treasury to make sufficiently large equity investments in each credit facility so that the Fed is highly unlikely to suffer any losses.

Nevertheless, it would seem that the Treasury and Fed could together implement all of our core recommendations for the Main Street program under current law. Treasury has considerable untapped fiscal capacity under the CARES Act—by our count, Treasury has made equity investments totaling $215 billion across all of the Fed's facilities versus a $454 billion appropriation under the CARES Act—that could be used to insulate the Fed from losses if Main Street or other facilities were to extend

[12] In some respects, the Small Business Administration's Paycheck Protection Program is closer to program suggested by the model, though its primary focus was on helping firms maintain employment rather than helping them survive. PPP was widely available—in fact, since it did not condition on firm revenue declines, it may have been too widely available. For firms spending most of the funds on payroll, the terms of the program were quite soft: their loans were fully converted to grants. However, for other firms, the terms were quite hard—e.g., the loans initially had a two-year maturity.

[13] Furthermore, the Fed cannot establish Section 13(3) lending facilities that extend credit to "insolvent" borrowers—i.e., firms who are currently in bankruptcy proceedings—or to firms that are on the verge of failing.

credit to more risky, marginal firms.[14] Thus, most of Main Street's restrictive terms likely reflect an institutional unwillingness to assume risk, rather than a legal inability to take on risk.

II.F Business Credit Programs Outside the U.S.

In countries outside the U.S., business credit programs feature some, but not all, of the characteristics suggested by our model. Table 2 gives a brief summary. Programs in the U.K., France, and Germany feature both cash grants and loan subsidies or guarantees. In other words, these programs provide financing to firms on terms the private sector will not. In the U.K. under the Bounce Back Loan Scheme and Coronavirus Business Interruption Loan Scheme, in France under the Prêts Garantis par l'Etat program, and in Germany under the KfW-Schnellkredit program, guarantees cover the full loan, ensuring that private-sector willingness to lend does not restrict the set of firms that can participate.

Generally speaking, these programs are widely available, with restrictions only based on firm size and recent revenues. In some cases, such as the U.K.'s Retail, Hospitality, and Leisure Business Grants Funds and Germany's Überbrückungshilfe für Kleine und Mittleständische Unternehmen, eligibility for grants or loan forgiveness extends only to firms in hard-hit industries or with substantial revenue losses due to the pandemic.

In many countries, including the U.K., France, and Germany, the maximum amount of support is a fraction of firms' pre-crisis annual revenues, costs, or profits. While this financing is not explicitly staged, the governments have the option of renewing the programs, thus capturing some of the benefits of staging suggested by our model. Few countries have granted loans with soft terms, though France has a program (Prêts Participatifs Exceptionnels) focused on making equity investments, and the U.K. and Germany have small programs (the Future Fund and Corona-Matching-Fazilität, respectively) that match equity or convertible investments made by private investors. Finally, several countries have used value-added tax or payroll tax deferrals and holidays, which provide additional liquidity to firms.

III. Secondary Market Corporate Bond Purchase Programs

While the U.S. government's existing programs are quite different from the policy interventions suggested by our model in Section II, they have had surprisingly powerful effects on financial markets.

[14] To be sure, there is also scope for helpful Congressional action. For instance, to the extent that it is desirable for Main Street's loans to have a grant-like character, Congress could remove the provision in the CARES Act that explicitly forbids the government from forgiving any loans made by joint Treasury and Fed facilities. Relatedly, Congress could further clarify its intention under the CARES Act that the Treasury has the power to make ESF investments that expose taxpayers to the risk of loss when the Treasury deems this necessary to stabilize financial markets and the broader economy.

As Figures 2 and 3 show, the corporate bond market, which had been under tremendous strain in March, rallied sharply following the announcement of the PMCCF and SMCCF on March 23, 2020. In this section, we present a simple model exploring the possibility that the sharp increase in corporate bond prices since March has occurred, in part, because investors are overestimating the Fed's willingness to intervene in markets going forward.

In the model, the Fed may purchase outstanding corporate bonds in response to shocks—in other words, the Fed has a "bond purchase reaction function." Even before the Fed actually buys anything, the prospect of its state-contingent purchases can increase bond prices, for two reasons: (i) they reduce the future volatility anticipated by private market investors and thus the risk premium investors charge ex ante; (ii) they create an asymmetric put, mitigating downside outcomes for investors while allowing them to keep the upside.

Private market investors make conjectures about the Fed's purchase reaction function, and crucially, we allow for the possibility that these conjectures may be incorrect. We show that when the market's expectations about the Fed's reaction function are overly optimistic, bond prices will initially be too high and there is a risk of a subsequent crash. If a negative fundamental shock is realized, bond prices fall both because of the direct effect of the shock and because the market learns that the Fed will not provide the support it had previously anticipated.

III.A Baseline Amplification Model without Fed Intervention

We first introduce our baseline model without Fed intervention. The model considers the market for a single defaultable corporate bond and has three dates: $t = 1$, 2, and 3. The bond pays a random cashflow equal to X_3 at $t = 3$—i.e., the bond is subject to fundamental credit risk. Specifically, we assume that the bond's time-3 cashflow is given by:

$$X_3 = \bar{X} + \varepsilon_{X_2} + \varepsilon_{X_3}, \tag{7}$$

where $\bar{X} > 0$ is a constant and ε_{X_2} and ε_{X_3} are mean-zero *i.i.d.* random variables that are realized at dates $t = 2$ and 3, respectively, each with variance $\sigma_X^2 > 0$.

At $t = 1$ and $t = 2$, the net supply of the bond must be held by a group of risk-averse investors with mean-variance preferences over their one-period ahead wealth. We solve the model backwards. At $t = 2$, investors' demand for risky bonds is given by:

$$D_2 = \frac{1}{\gamma}\frac{E_2[X_3] - P_2}{Var_2[X_3]} = \frac{1}{\gamma}\frac{[\bar{X} + \varepsilon_{X_2}] - P_2}{\sigma_X^2}, \tag{8}$$

where $\gamma > 0$ denotes investors' risk aversion.

We assume that there is financial market amplification at $t = 2$: the marginal investors who we focus on must hold a larger quantity of corporate bonds when the price of these bonds turns out to be lower than expected. Specifically, the net supply, S_2, that these investors must hold at $t = 2$ is:

$$S_2 = \bar{S} + \varepsilon_{S_2} - \lambda \cdot (P_2 - \bar{P}_2), \tag{9}$$

where $\bar{P}_2 = \bar{X} - \gamma\sigma_X^2\bar{S}$ is the unconditional average price at time 2. Net supply at time-2 has two components. The first component, $\bar{S} + \varepsilon_{S_2}$, is an exogenous net supply term, where $\bar{S} > 0$ and ε_{S_2} is a mean-zero supply shock with variance $\sigma_S^2 \geq 0$ that is uncorrelated with fundamental news ε_{X_2}. The second component, $-\lambda \cdot (P_2 - \overline{P_2})$, captures in a reduced-form way a variety of positive-feedback mechanisms in financial markets. These include: (i) biased investors outside the model who over-extrapolate recent price changes (De Long and others (1990) and Barberis and others (2015)), (ii) traders who face price-based leverage constraints and are forced to unwind at fire-sale prices following an initial negative shock (Geanakoplos (2009) and Stein (2012)), and (iii) open-ended investment vehicles—e.g., hedge funds and mutual funds—that face capital outflows when performance is poor, and are similarly forced to liquidate their holdings (Shleifer and Vishny (1997)). $\lambda \geq 0$ captures the strength of these channels. When $\lambda > 0$, the marginal investors in our model must hold a larger than expected quantity of bonds when prices are lower than expected.

Equating demand and supply—i.e., setting $D_2 = S_2$, the equilibrium price at $t = 2$ is:

$$P_2^* = [\bar{X} - \gamma\sigma_X^2\bar{S}] + \frac{\varepsilon_{X_2} - \gamma\sigma_X^2\varepsilon_{S_2}}{1 - \lambda \cdot \gamma\sigma_X^2}. \tag{10}$$

We assume $0 < \lambda \cdot \gamma\sigma_X^2 < 1$, implying that $1/(1 - \lambda \cdot \gamma\sigma_X^2) > 1$ so there is amplification at time 2. Specifically, when λ becomes larger, time-2 prices become more responsive to both news about fundamentals ε_{X_2} and to the exogenous net supply shock ε_{S_2}.

Folding back to $t = 1$, the additional volatility induced by financial market amplification at $t = 2$ makes bonds riskier for investors at $t = 1$. Due to this additional risk, time-1 prices are lower than they would be in a world without amplification. Specifically, at $t = 1$, we assume that the net supply of corporate bonds is $S_1 = \bar{S} > 0$ and that investors' demand for bonds is given by:

$$D_1 = \frac{1}{\gamma}\frac{E_1[P_2^*] - P_1}{Var_1[P_2^*]}. \tag{11}$$

Thus, equating demand and supply—i.e., setting $D_1 = S_1$, the equilibrium price at $t = 1$ is:

$$P_1^* = E_1[P_2^*] - \gamma Var_1[P_2^*]\overline{S}\ . \tag{12}$$

Computing the expected time-2 price and the variance of the time-2 price as of $t = 1$ and substituting these values into equation 12, we find that:

$$P_1^* = [\overline{X} - \gamma\sigma_X^2\overline{S}] - \gamma\left[\frac{\sigma_X^2 + (\gamma\sigma_X^2)^2\sigma_S^2}{(1-\lambda\cdot\gamma\sigma_X^2)^2}\right]\overline{S}. \tag{13}$$

When $\sigma_S^2 = \lambda = 0$, equation 13 becomes $P_1^* = \bar{X} - \gamma 2\sigma_X^2\bar{S} = E_1[X_3] - \gamma Var_1[X_3]\bar{S}$, which one can think of as the benchmark efficient-markets price in our model. This price is equal to the expected time-3 cashflow ($E_1[X_3]$) minus a risk premium that depends only on investor risk aversion (γ), the volatility of the time-3 cashflow ($Var_1[X_3]$), and the initial supply of bonds ($\bar{S}$).

When $\sigma_S^2 > 0$ or $\lambda > 0$, time-1 prices are lower than this efficient-markets benchmark. Specifically, equation 13 shows that time-1 prices are lower when time-2 amplification is high—i.e., $\partial P_1^*/\partial\lambda < 0$—because amplification raises the volatility of time-2 prices. Similarly, time-1 prices are lower when there is more non-fundamental supply risk at time-2—i.e., $\partial P_1^*/\partial\sigma_S^2 < 0$.

III.B A Fed Purchase Reaction Function

We now extend this baseline model to allow for Fed purchases and sales at time 2. We begin by supposing that the Fed has a linear purchase reaction function that governs the quantity of corporate bonds it will purchase in different states of the world at $t = 2$:

$$B_2 = \theta_S \cdot \varepsilon_{S_2} - [\theta_X / (\gamma\sigma_X^2)]\cdot\varepsilon_{X_2} - \theta_P\cdot(P_2 - \overline{P}_2)\ . \tag{14}$$

Equation 14 says that the Fed will purchase more bonds when the net supply rises unexpectedly (when ε_{S_2} is high), when credit fundamentals are unexpectedly poor (ε_{X_2} is low), or when prices are lower than expected.[15] The linear form of the reaction function makes the algebra simple to work with but prevents us from analyzing non-linear, put-like behavior on the part of the Fed. We return to this point in more detail below.

In the model, corporate bonds are all of the same credit quality and the Fed has one purchase reaction function. In reality, bonds differ in their riskiness with high-yield bonds having substantially higher default probabilities than investment grade bonds. If we extended the model to include a range of bonds with different credit risk exposures, our mean-variance investors would apply a consistent price of credit risk across all bonds and would require higher returns on riskier bonds. Further, the Fed

[15] Since there are just two shocks at time-2, the three-parameter reaction function in equation 14 is over-parameterized. We over-parameterize the reaction function this way to exposit different economic rationales for purchasing risky bonds.

would have a bigger impact on time-1 prices if it purchased riskier bonds—i.e., if it concentrated its purchases in high-yield bonds. This is the analog of the idea that quantitative easing has larger effects when the Fed buys longer-maturity Treasury bonds (e.g., Tobin (1958) and Vayanos and Vila (2019)). In such an extended model, if the Fed primarily bought investment grade bonds, it would have a smaller impact on overall credit spreads.

Equating demand and supply—i.e., setting $D_2 + B_2 = S_2$—the price at $t = 2$ is given by:

$$P_2^{**} = [\bar{X} - \gamma\sigma_X^2\bar{S}] + \frac{(1-\theta_X)\cdot\varepsilon_{X_2} - (1-\theta_S)\cdot\gamma\sigma_X^2\varepsilon_{S_2}}{1-(\lambda-\theta_P)\cdot\gamma\sigma_X^2}, \tag{15}$$

Thus, there will be less time-2 price volatility when the Fed chooses θ_X closer to 1, θ_S closer to 1, or θ_P closer to λ.

Folding back to time 1, we begin by assuming that investors accurately perceive the Fed's time-2 reaction function and know it with certainty. The equilibrium time-1 price is then given by:

$$P_1^{**} = [\bar{X} - \gamma\sigma_X^2\bar{S}] - \gamma\frac{(1-\theta_X)^2\cdot\sigma_X^2 + (1-\theta_S)^2\cdot(\gamma\sigma_X^2)^2\sigma_S^2}{(1-(\lambda-\theta_P)\cdot\gamma\sigma_X^2)^2}\bar{S}, \tag{16}$$

which can be contrasted with the no-intervention price in equation 13. A more aggressive reaction function raises time-1 prices—i.e., we have $\partial P_1^{**}/\partial\theta_P > 0$, $\partial P_1^{**}/\partial\theta_X > 0$, and $\partial P_1^{**}/\partial\theta_S > 0$.

One case of interest is where $\theta_S = 1$, $\theta_X = 0$, and $\theta_P = \lambda$. In this case, the Fed completely offsets exogenous net supply shocks ($\theta_S = 1$) and neutralizes all market-based amplification at $t = 2$ ($\theta_P = \lambda$), but allows prices to impound whatever fundamental news arrives ($\theta_X = 0$). Loosely speaking, this reaction function seeks to fully offset the effect of any "technical" factors that push prices away from fundamental value but does not interfere with the adjustment of prices to fundamental news. This reaction function shares some similarities with traditional lender-of-last-resort functions: the goal is not to offset weak fundamentals but rather to dampen positive feedback loops that push market prices away from fundamentals. However, if λ and σ_S^2 are large, this reaction function necessarily requires the Fed to take on large amounts of credit risk in some states at time 2. Thus, even in this case, when it does not attempt to lean against fundamental news, the Fed is going well beyond its normal lender-of-last-resort role. In this case, equation 16 becomes $P_2^{**} = \bar{X} + \varepsilon_{X_2} - \gamma\sigma_X^2\bar{S} = E_2[X_3] - \gamma Var_2[X_3]\bar{S}$ —i.e., the efficient-markets price for time 2. Similarly, equation 10 reduces to $P_1^{**} = \bar{X} - \gamma 2\sigma_X^2\bar{S}$ $= E_1[X_3] - \gamma Var_1[X_3]\bar{S}$, the efficient-markets time-1 price.

Another interesting case is where $\theta_S = 1$ and $\theta_X = 1$. Here the Fed is committed to *pegging* the time-2 risky bond price at the constant level: $P_2^{**} = \bar{X} - \gamma\sigma_X^2\bar{S} = \bar{P}_2$. To operationalize such a peg and prevent bond prices from impounding any negative fundamental information, the Fed would need to purchase risky bonds very aggressively in response to any negative fundamental news at time 2. Such a reaction function would potentially require the Fed to take on even more credit risk at time 2.

III.C Investor Misperceptions About the Fed's Purchase Reaction Function

Next, we consider the possibility that that investors may hold mistaken beliefs at time 1 about the Fed's time-2 reaction function. Specifically, we assume investors believe that the Fed's reaction function is given by:

$$B_2 = \hat{\theta}_S \cdot \varepsilon_{S_2} - [\hat{\theta}_X / (\gamma\sigma_X^2)] \cdot \varepsilon_{X_2} - \hat{\theta}_P \cdot (P_2 - \bar{P}_2). \tag{17}$$

Given these beliefs, the equilibrium time-1 price becomes:

$$\hat{P}_1^{**} = [\bar{X} - \gamma\sigma_X^2\bar{S}] - \gamma \frac{(1-\hat{\theta}_X)^2 \cdot \sigma_X^2 + (1-\hat{\theta}_S)^2 \cdot (\gamma\sigma_X^2)^2\sigma_S^2}{(1-(\lambda-\hat{\theta}_P)\cdot\gamma\sigma_X^2)^2}\bar{S}. \tag{18}$$

Of course, time-1 prices will be higher when investors believe that the Fed has a more aggressive reaction function at time 2—i.e., $\partial\hat{P}_1^{**}/\partial\hat{\theta}_P > 0$, $\partial\hat{P}_1^{**}/\partial\hat{\theta}_X > 0$, and $\partial\hat{P}_1^{**}/\partial\hat{\theta}_S > 0$.

We can then compare the actual market price ($\hat{P}_1^{**}$) to what the market price would be if investors properly perceived the Fed's reaction function (P_1^{**}). Doing so, we obtain:

$$\hat{P}_1^{**} - P_1^{**} = \gamma\left(\frac{(1-\theta_X)^2 \cdot \sigma_X^2 + (1-\theta_S)^2 \cdot (\gamma\sigma_X^2)^2\sigma_S^2}{(1-(\lambda-\theta_P)\cdot\gamma\sigma_X^2)^2} - \frac{(1-\hat{\theta}_X)^2 \cdot \sigma_X^2 + (1-\hat{\theta}_S)^2 \cdot (\gamma\sigma_X^2)^2\sigma_S^2}{(1-(\lambda-\hat{\theta}_P)\cdot\gamma\sigma_X^2)^2}\right)\bar{S}. \tag{19}$$

Equation 19 says prices will initially be too high if investors overestimate the aggressiveness of the Fed's future reaction function. This is effect arises since time-2 prices will be more volatile than investors anticipate and because investors do not charge for this unanticipated risk at time-1. Thus, one implication of equation 19 is that it illustrates the scope for a sudden decline in prices if investors update their beliefs about the Fed's reaction function in the direction of the truth. This might happen, for example, following new Fed communications that occur shortly after time 1.[16]

[16] As opposed to overestimating the government's resolve, one might theoretically expect rational investors to discount government commitments to make large purchases of risky bonds in certain future states. Specifically, the government may have a time-consistency problem, finding it desirable to stabilize markets by announcing interventions and then failing to follow through on those announcements to avoid actually taking risk. If markets recognize this time-consistency problem, they may react little to government announcements. While such a situation may arise in the future, it does not seem to capture the market's response to recent events.

Alternatively, we can compare the realized price change between times 1 and 2 when investors initially have mistaken beliefs ($P_2^{**} - \hat{P}_1^{**}$) with the corresponding price change when investors have correct beliefs ($P_2^{**} - P_1^{**}$). Suppose investors are overly optimistic about the Fed's purchase reaction function, so $\hat{P}_1^{**} > P_1^{**}$. It follows that for any possible realization of fundamentals or time-2 supply, we will have $P_2^{**} - \hat{P}_1^{**} < P_2^{**} - P_1^{**}$. Thus, the realized change in prices is always less favorable when investors initially overestimate the aggressiveness of the Fed's purchase reaction function. Thus, misperceptions of the Fed's reaction function create an obvious trade-off: greater misperception raises the time-1 price, but always results in a less favorable price change between times 1 and 2.

III.D An Asymmetric Fed Purchase Reaction Function

Thus far we have assumed the Fed's purchase reaction function is linear. To capture the idea of a Fed put, we instead suppose the Fed's reaction function is asymmetric, and is given by

$$B_2 = \theta_P \max\{\overline{P}_2 - P_2, 0\}, \tag{20}$$

and that investors believe that the Fed's reaction function is

$$B_2 = \hat{\theta}_P \max\{\overline{P}_2 - P_2, 0\}, \tag{21}$$

where $\bar{P}_2 = \bar{X} - \gamma\sigma_X^2\bar{S}$. In other words, the Fed will buy when P_2 is lower than $\bar{P}_2$ and will buy more as prices fall further. However, the Fed will not sell if P_2 is higher than $\bar{P}_2$. Further, since $\hat{\theta}_P$ need not equal θ_P, we allow for the possibility that investors misperceive the Fed's purchase reaction function.[17]

Equation 21 implies that investors anticipate the following time-2 pricing function:

$$\begin{aligned}\hat{P}_2^{**} = [\overline{X} - \gamma\sigma_X^2\overline{S}] &+ \frac{1}{1-(\lambda-\hat{\theta}_P)\cdot\gamma\sigma_X^2}\times(\varepsilon_{X_2} - \gamma\sigma_X^2\varepsilon_{S_2}) \\ &+ \left(\frac{1}{1-\lambda\cdot\gamma\sigma_X^2} - \frac{1}{1-(\lambda-\hat{\theta}_P)\cdot\gamma\sigma_X^2}\right)\times\max\{\varepsilon_{X_2} - \gamma\sigma_X^2\varepsilon_{S_2}, 0\}\end{aligned}. \tag{22}$$

In other words, $\hat{P}_2^{**}$ is an increasing, piece-wise linear function of the time-2 news ($\varepsilon_{X_2} - \gamma\sigma_X^2\varepsilon_{S_2}$) with a smaller slope when time-2 news is bad ($\varepsilon_{X_2} - \gamma\sigma_X^2\varepsilon_{S_2} < 0$) and a larger slope when time-2 news is good ($\varepsilon_{X_2} - \gamma\sigma_X^2\varepsilon_{S_2} > 0$). This change in slope reflects the fact that the Fed is only anticipated to buy bonds when time-2 news is bad, muting downside amplification but not upside amplification. The actual time-2 pricing function takes a similar form replacing $\hat{\theta}_P$ in equation 16 with θ_P. Folding back

[17] The analysis here is qualitatively unchanged if we instead assume that the Fed's purchase reaction function is $B_2 = \max\{\theta_S \cdot \varepsilon_{S_2} - [\theta_X/(\gamma\sigma_X^2)] \cdot \varepsilon_{X_2} - \theta_P \cdot (P_2 - \bar{P}_2), 0\}$.

to time 1, we have $\hat{P}_1^{**} = E_1[\hat{P}_2^{**}] - \gamma Var_1[\hat{P}_2^{**}]\bar{S}$. If we assume the news shocks are normally distributed, we can compute $E_1[\hat{P}_2^{**}]$ and $Var_1[\hat{P}_2^{**}]$ in closed form to obtain:

$$\begin{aligned}\hat{P}_1^{**} &= [\bar{X} - \gamma\sigma_X^2\bar{S}] + \overbrace{\left(\frac{1}{1-\lambda\cdot\gamma\sigma_X^2} - \frac{1}{1-(\lambda-\hat{\theta}_P)\cdot\gamma\sigma_X^2}\right)\sqrt{\frac{\sigma_X^2 + (\gamma\sigma_X^2)^2\sigma_S^2}{2\pi}}}^{\text{Impact of perceived Fed put on } E_1[\hat{P}_2^{**}]} \\ &\quad - \gamma\underbrace{\left[\left(\frac{1}{1-\lambda\cdot\gamma\sigma_X^2} - \frac{1}{1-(\lambda-\hat{\theta}_P)\cdot\gamma\sigma_X^2}\right)^2\frac{\pi-1}{2\pi} + \left(\frac{1}{1-(\lambda-\hat{\theta}_P)\cdot\gamma\sigma_X^2}\right)\left(\frac{1}{1-\lambda\cdot\gamma\sigma_X^2}\right)\right]\left(\sigma_X^2 + (\gamma\sigma_X^2)^2\sigma_S^2\right)}_{\text{Investors' perception of } Var_1[\hat{P}_2^{**}]}\bar{S}\end{aligned} \tag{23}$$

This expression implies intuitive comparative statics: since $\partial E_1[\hat{P}_2^{**}]/\partial\hat{\theta}_P > 0$ and $\partial Var_1[\hat{P}_2^{**}]/\partial\hat{\theta}_P < 0$, a higher value of $\hat{\theta}_P$ now raises $\hat{P}_1^{**}$ through two separate channels. The fact that the expectation of a more aggressive Fed reaction function raises time-1 prices because it reduces anticipated time-2 price volatility ($\partial Var_1[\hat{P}_2^{**}]/\partial\hat{\theta}_P < 0$) is the same effect we emphasized above in the case where the Fed has a symmetric reaction function. The fact that $\partial E_1[\hat{P}_2^{**}]/\partial\hat{\theta}_P > 0$ is new and arises from the option-like payoff created by the fact that investors expect the Fed to step in to mute price declines, but do not expect the Fed to mute price increases. Thus, if we initially have $\hat{\theta}_P > \theta_P$ and investors revise down their beliefs about the aggressiveness of Fed's purchase reaction function shortly after time-1, this will lead prices to fall for two distinct reasons.

With an asymmetric reaction function, there will also be an asymmetry in the way that investors revise their beliefs about the Fed's reaction function when news is revealed at time 2. Specifically, when $\hat{\theta}_P > \theta_P$ and the news at time 2 is good, the Fed will not transact in the bond market at time 2 and investors will never realize that they had misperceived the Fed's reaction function at time 1. By contrast, if $\hat{\theta}_P > \theta_P$ and the news at time 2 is bad, prices will fall for two reasons. First, prices will fall because of the bad news. However, prices will fall even more because the bad news will lead investors to realize that they had over-estimated the Fed's willingness to support prices. Thus, when $\hat{\theta}_P > \theta_P$, the time-2 price expected at time-1 by a rational and fully informed outside observer who knows the true level of θ_P will be less than the time-2 price that is expected by investors who think $\hat{\theta}_P > \theta_P$.

Our model is essentially a one-shot game between investors and the Fed. As a result, if the time-2 news is bad and the Fed intervenes less aggressively than investors had anticipated, time-2 prices will still be higher than they would have been if the Fed had not intervened at all. However, in a multi-shot extension of our model, investor misperceptions of the Fed's purchase reaction function could lead prices to fall below the no-intervention counterfactual. For instance, assume investors initially expect the Fed to always make some minimal purchases $\underline{\theta}_P > 0$ to mute downside amplification. Suppose a financial crisis leads the Fed to want to provide a higher level of downside support $\theta_P > \underline{\theta}_P$ to market prices, but investors over-interpret the Fed's commitment and expect $\hat{\theta}_P > \theta_P > \underline{\theta}_P$. If the Fed's subsequent purchases disappoint investors this might reduce the Fed's credibility, leading investors to revise their estimate of the Fed's downside support to some new $\hat{\theta}_P < \underline{\theta}_P$. In a multi-period setting, this could actually lead prices to fall to a lower level than they would have if the Fed had never signaled its heightened commitment to support prices.

III.E Is the Market Currently Misperceiving the Fed's Reaction Function?

As the above discussion suggests, the risk of an abrupt market correction in the prices of risky bonds is related to the extent to which investors overestimate the aggressiveness of the Fed's bond-purchase reaction function. In what follows, we present some suggestive—although admittedly not dispositive—evidence that the market may be misperceiving the Fed's current intentions to intervene in the corporate bond market going forward.

We focus on two lines of argument. First, with a few exceptions, the Fed's announcements suggest a greater willingness to purchase investment-grade than high-yield corporate bonds. For instance, under its current terms, the SMCCF will purchase individual corporate bonds that either (i) currently have an investment grade rating or (ii) that had an investment grade rating on March 22, 2020 but have since been downgraded to a rating no lower than BB-/Ba3. Similarly, while the SMCCF has purchased some high-yield ETFs, it has concentrated its purchases in investment-grade ETFs.[18]

In the same way that Fed purchases of short-dated Treasuries should have a smaller impact on term premia than purchases of long-dated Treasuries, a commitment to purchase low-risk investment-grade bonds should have a smaller impact on credit risk premia than a commitment to purchase higher-risk, speculative-grade bonds. However, despite their focus on investment-grade bonds, the Fed's announcements appear to have had a powerful impact on spreads throughout the corporate bond market, suggesting that investors may be overinterpreting the scope of the Fed's backstop. Specifically, as shown in Figure 2 and Table 2, the announcement of the PMCCF and SMCCF was associated with large rallies not only in investment-grade bonds, but also in high-yield bonds. Further Fed

[18] Specifically, the Fed is targeting a portfolio of individual corporate bonds consisting of 42% AAA-, AA-, and A-rated bonds, 55% BBB-rated bonds, and 3% BB-rated bonds. As of August 31st, the Fed had purchased \$8.7 billion of corporate bond ETFs, of which \$1.1 billion or 13% have been high yield ETFs.

communications about these programs—in particular, the expansion of the programs on April 9th and Chair Powell's "red lines" comments on May 29th—were also associated with large rallies in lower-rated bonds.[19]

Second, while in the language of our model it is plausible that the Fed's reaction function effectively embeds meaningfully positive values of θ_S and θ_P, it seems unlikely that it embeds a non-zero value of θ_X. In words, one can imagine the Fed leaning against non-fundamental supply shocks or market amplification mechanisms, but it is much harder to believe that they will try to prevent bond prices from adjusting to a significant deterioration in credit fundamentals. For example, the Fed might step in to stem a fire sale that is driven by outflows from bond mutual funds, but if there is a wave of downgrades or defaults because firms are facing large cashflow shortfalls, it seems quite doubtful that the Fed will—or even can—try to support the prices of these fundamentally-distressed bonds.

Yet, it is difficult to rationalize current market pricing without appealing to the notion that investors believe that $\hat{\theta}_X > 0$. Simply put, credit spreads are currently at a level that suggests that investors believe the Fed will offset even fundamental shocks to the value of risky bonds. Specifically, Figure 3 shows that the rally that began after March 23rd has resulted in credit spreads significantly below the levels typically witnessed during recessions. Even more strikingly, Figure 3 shows that spreads on investment-grade and most high-yield bonds are currently below their unconditional averages over the past 25 years. (Spreads on CCC-rated bonds remain slightly above their long run average level today.) By standard asset-pricing logic, these low credit spreads must either signal low future credit losses or low future excess returns over default-free Treasuries. Specifically, under simplifying assumptions, the expected return on a corporate bond in excess of like-maturity default-free Treasuries is given by $E[R_{Corp} - R_{Govt}] = S - \pi \times L$, where S is the bond's initial credit spread over Treasuries, π is the bond's constant default hazard probability (i.e., the probability the bond defaults in the next year conditional on surviving thus far), and L is the bond's expected loss-given-default (i.e., the expected fraction of par an investor will lose upon default).

Consider B-rated corporate bonds.[20] Based on data from the ICE BofAML Index, the average level of B-rated corporate bond spreads since 1996 has been 5.5%. According to S&P Global Ratings

[19] The window around Chair Powell's May 29th speech also includes Gilead's June 1st announcement that the antiviral drug Remdesivir showed promise in Phase 3 trials. While most market participants attribute the market rally to Chair Powell's speech and not this public health news, we cannot cleanly separate these two events.

[20] The formula is valid if a bond's default hazard probability is expected to be constant over time. In the data, this assumption has historically been reasonable for B-rated bonds.

(2020a), the 1-year default rate for B-rated bonds averaged 3.3% from 1981–2019. Thus, assuming a typical loss given default of 60%, our formula implies an average excess return on B-rated bonds of $E[R_{Corp} - R_{Govt}] = 5.5\% - 3.3\% \times 60\% = 3.5\%$. On August 31, 2020, B-rated bond spreads stood at 5.2%, slightly below their long-run average, despite the fact that U.S. is now in the midst of severe recession. According to S&P, the default rate on B-rated bonds has topped 11% in the last three recessions, reaching 13.8% in 1991, 11.6% in 2001, and 11.0% in 2009. If the default rate were to again reach 11% in this recession, that would imply an expected excess return of $E[R_{Corp} - R_{Govt}] = 5.2\% - 11\% \times 60\% = -1.4\%$. However, since B-rated bonds are quite risky, as well as less liquid than Treasuries, investors should always require a positive expected excess return to hold them. While highly simplistic, this analysis suggests that investors either expect (i) defaults of highly-levered firms to be much lower in the COVID-19 recession than in past recessions or (ii) that the Fed will to somehow put a firm floor beneath the prices of the these highly risky bonds.[21]

The rally in CCC-rated bonds is also noteworthy. CCC-rated bonds have very high default probabilities even in normal times (averaging 27% from 1981–2019) and their default probabilities topped 45% in the last two recessions. Under the current terms of the SMCCF, the Fed will not purchase CCC-rated bonds directly and will only support them indirectly through its purchases of high-yield bond ETFs. Moreover, because of limitations in Section 13(3) the Federal Reserve Act, the Treasury and Fed's joint facilities cannot buy the bonds of firms that are in bankruptcy proceedings, which presumably reduces the U.S. government's appetite for buying CCC-rated bonds, which are close to default. Thus, the large compression in CCC-rated spreads since March is particularly striking.

Firms have responded to this powerful market rally by issuing record quantities of corporate bonds and equity in recent months. The issuance boom began in the investment-grade bond market following the Fed's March 23rd announcement. U.S. investment-grade corporations issued $808 billion of bonds between March and May 2020, more than double the amount in any prior 3-month period on record. The issuance boom spread to lower-rated corporate bonds in April and then to public equities in May. According to data from Refinitiv Thomson ONE, the volume of high-yield bond issuance ($125 billion), convertible bond issuance ($46 billion), and seasoned public equity issuance ($100 billion) between April and June each exceeded any prior 3-month period in U.S. history.

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[21] Cox, Greenwald, and Ludvigson (2020), Gormsen and Koijen (2020), and Landier and Thesmar (2020) conduct analogous exercises for the U.S. stock market and conclude that either low investor risk aversion or positive market sentiment play a key role in explaining the high current level of U.S. stock prices.

There is an alternative explanation for the today's low level of corporate bond spreads that does not involve investor misperceptions: the Fed's interventions may have actually reduced the amount of corporate credit risk in the economy. Specifically, the market rally and subsequent issuance wave may have allowed firms to build up enough of a cash buffer to survive until the public health emergency ends and cashflows return to more normal levels. In this case, the lower credit risk going forward means that the Fed will not actually have to lean against fundamental shocks in their bond buying.

This alternative is difficult to rule out definitively, but a couple of pieces of evidence suggest it is not the whole story. First, as shown in Table 2, other types of news—e.g. news about recent improvements in the labor market—have not had as powerful effects on credit spreads as Fed announcements. In other words, the market appears to be reacting more strongly to Fed news than to fundamental macro news. Second, we are in fact already seeing a surge in credit rating downgrades and defaults. According to S&P Global Ratings (2020b), the number of corporate defaults in the first six months of 2020 (83) exceeded the total for the entirety of 2019 (77). Furthermore, S&P tallied more rating downgrades in the first six months of 2020 than in any prior 12-month period.

III.F Normative Implications: When is Central-Bank Magic Most Potent?

On July 26 2012, in the face of escalating market worries about the potential breakup of the euro, European Central Bank (ECB) president Mario Draghi famously said: "Within our mandate, the ECB is ready to do whatever it takes to preserve the euro. And believe me, it will be enough." In the wake of Draghi's speech, yields on Spanish and Italian sovereign debt declined dramatically and financial markets stabilized more generally.[22] The words "whatever it takes" have since become a shorthand for the almost-magical ability of central bank announcements to stabilize markets, in some cases with little in the way of follow-up action.

The power of central bank magic of this sort is most easily rationalized in the context of models with multiple equilibria such as Diamond and Dybvig's (1983) seminal model of bank runs. With regards to Draghi's quote, one can readily imagine circumstances in which there may be multiple equilibria in the market for Italian sovereign debt. If Italian interest rates are high, Italy will struggle to service its debt load, and there will be a significant risk of an Italian default, validating the high interest

[22] On July 24, 2012, the spread between the yield on 10-year Spanish government bonds and that on 10-year German bonds had reached 630 basis points. The corresponding spread for Italy was 530 basis points. By July 27th, one day after Draghi's speech, Spanish and Italian spreads had fallen to 530 and 450 basis points, respectively. And, by the end of 2012, Spanish and Italian spreads stood at 390 and 320 basis points.

rates. Conversely, if Italian interest rates are low, Italy can more comfortably service its debt, and Italian default risk is mostly eliminated, validating the low interest rates.[23] In a setting like this, if Italy is initially stuck in the high-rate equilibrium, a powerful commitment by the ECB to buy Italian bonds can shift the market to the low-rate equilibrium. And once the market shifts to this new low-rate equilibrium, little bond-buying may actually be necessary: all that is required is a credible off-equilibrium-path commitment. This ability to affect outcomes with promises alone, without taking any risk in equilibrium, is one way of thinking about central bank magic.

On the surface, the Fed's March announcements of the PMCCF and the SMCCF, and the Fed's follow-up communications including Chair Powell's May 29 "red lines" remarks, have had a similar "whatever-it-takes" shock-and-awe kind of impact on markets. Moreover, these words have not only led to a powerful rally in credit and equity markets, they have unleashed a wave of issuance by both investment-grade and high-yield firms that has undoubtedly helped improve the balance-sheet health of issuing firms and, thus, the resilience of broader economy. Indeed, in some recent models (e.g., He and Milbradt (2012) and Greenwood, Hanson, and Jin (2019)) improvements in investor sentiment may enable firms who might otherwise default to survive by allowing them to refinance maturing debt on more favorable terms. In other words, there is some potential for self-fulling dynamics to exist in the corporate bond market, just as in the sovereign bond market.[24]

Nevertheless, despite the potential for such positive feedback effects, it is hard to argue that we are currently in a situation where the strongest form of central-bank magic is available to the Fed—namely that the Fed can stabilize credit markets and move the economy to a better equilibrium without the prospect of having to actually take on significant credit risk. While all the issuance sparked by the Fed's communications has undoubtedly lowered the near-term default risk of many firms, given the magnitude of the economic downturn triggered by the pandemic, we still face the possibility of a coming wave of credit downgrades and defaults. If this negative scenario comes to pass, the Fed may feel pressure to step in and assume a considerable amount of credit risk to avoid disappointing investors. Alternatively, if the Fed does not step in, there is a risk that these downgrades and defaults will lead

[23] Beginning with Calvo (1988) and Cole and Kehoe (2000), there is a large literature that studies the potential for self-fulfilling sovereign debt crises of the sort.

[24] In, Greenwood, Hanson and Jin (2019), there is a two-way feedback loop between investors' biased beliefs and credit market outcomes. Investors form beliefs about default probabilities in part by naively extrapolating firms' recent repayment history. Following periods of low defaults, investors believe that corporate debt is safer than it truly is and refinance maturing debt on more attractive terms than unbiased investors would. Thus, investors' current biased beliefs influence future credit market outcomes, and past credit market outcomes shape investors' current biased beliefs.

market sentiment to worsen considerably, generating a credit crunch that triggers further firm defaults. In the latter case, the favorable self-fulfilling dynamics we have witnessed in credit markets since late March may begin to go in reverse.

To be clear, none of this is to suggest that the Fed's aggressive response to the crisis—or even the market's potential overinterpretation of the Fed's intentions—have been undesirable from a normative perspective. Quite the contrary: the Fed's efforts to stabilize financial markets since March, and especially the large volumes of issuance they have triggered, have had a clear benefit to the real economy. Indeed, we would argue that the Fed's forceful efforts to stabilize financial markets since March have thus far stemmed the potential for a damaging negative spiral, in which deteriorating financial conditions amplify the initial impact of the pandemic-induced shock. Our far more modest point is only that, in contrast to other settings where central bankers (or the government more broadly) can be helpful with their words alone, and without assuming a significant amount of fiscal risk, we are in a situation where risk-taking by the government may be a crucial part of the equation.

This observation connects back to the themes in the first part of the paper. There is an obvious parallel between the key point there—namely that we are not in a classic multiple-equilibrium lender-of-last resort situation and the Main Street facility therefore will have to take on meaningful levels of credit risk if it is to be effective—and our point here about the bond-purchase programs. Simply put, the economic impact of the pandemic is so devastating that even with the best possible financial policy response, enormous fundamental uncertainty remains; there is no low-solvency-risk equilibrium that can be readily attained. And if the government is not willing to take some credit risk in its programs, these programs cannot hope to be fully effective. The question then becomes not whether the government should take risk, but how to balance the fiscal costs of these risks against the benefits of intervention, and how to mitigate these risks with intelligent program-design features where possible.[25]

IV. Conclusion

The recession induced by the COVID-19 pandemic has not only been unusually severe, it has differed qualitatively from recent recessions in two important ways. First, the current level of macroeconomic uncertainty is extraordinarily high, and the resolution of this uncertainty seems to depend largely on non-economic factors, such as the future path of the pandemic and the rate of progress in developing

[25] See, e.g., Hanson, Scharfstein, and Sunderam (2019) for an explicit analysis of government fiscal risk-taking.

and then deploying a vaccine against the novel coronavirus. Second, the precipitous revenue declines that many firms have experienced in recent months have been driven primarily by their exposure to this temporary public health crisis—with those in "non-essential" industries that rely on close physical proximity being especially hard hit—and thus may carry little information about the long-run economic viability of these firms.

Our basic point is that, in such a setting, the theory of the case for government intervention in business credit markets is fundamentally different from the classic lender-of-last-resort liquidity-provision motive that shaped much of the response to the 2007–2009 Global Financial Crisis, and that remains a dominant policy paradigm more generally today. In particular, an effective policy response to the pandemic will require the government to accept the prospect of meaningful losses on any credit it extends to private sector firms. An analysis based on this premise also yields a number of more specific implications for policy design, which we have attempted to flesh out in some detail. But unless policymakers are prepared to embrace the essentially fiscal nature of the interventions that are required today, they are unlikely to be as successful as they might otherwise be in mitigating the economic and financial fallout from the COVID-19 pandemic.

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Table 1. Capacity and Take-up for the U.S. Government's Business Credit Programs

This table reports the lending capacity and take-up as of September 2, 2020 for the U.S. Government's business credit programs. Data are from the Federal Reserve's H.4.1 Release and the Small Business Administration.

Program	Total Capacity ($ billion)	Utilization ($ billion)
PMCCF and SMCCF	750	12.8
… of which is PMCCF		0.0
… of which is SMCCF		12.8
Main Street Loan Program	600	1.2
Paycheck Protection Program	659	525

Table 2. Characteristics of Government Business Credit Programs: International Context

This table lists major business support programs in the United Kingdom (UK), Germany, and France and interprets their characteristics through the lens of features in our model. We use the word "Uncertain" in cases for which the government's future actions will determine whether that characteristic ultimately applies. Information on UK programs comes from HMRC guidance pages (available at https://www.gov.uk) and from press reports in the Financial Times and BBC. Information on German programs comes from official government websites for each program (e.g., https://www.kfw.de) and from Bruegel, which is a European thinktank. Information on French programs comes from fact sheets at the Ministry of the Economy and Finance (available at https://www.economie.gouv.fr) and press reports in the Financial Times and Le Monde.

Country	Program Name	Better Terms than Private Sector	Widely Available	Staging	Soft Loan Terms
United Kingdom	Coronavirus Business Interruption Loan Scheme	Yes	Yes	No	Yes, Interest holiday
United Kingdom	Coronavirus Large Business Interruption Loan Scheme	Yes	No	No	Yes, Interest holiday
United Kingdom	Bounce Back Loan Scheme	Yes	Yes	No	Yes, Interest holiday
United Kingdom	Future Fund	No, Matching Fund	No	No	No
United Kingdom	Small Business and Retail, Hospitality, and Leisure Business Grants Funds	Yes	Yes	No	Yes, Grant
Germany	Immediate Assistance Program (Soforthilfe)	Yes	Yes	Uncertain	Yes, Grant
Germany	Financial assistance for SMEs (Überbrückungshilfe für kleine und mittleständische Unternehmen)	Yes	Yes	Uncertain	Yes, Conditional Grant
Germany	Economic stabilization fund (Wirtschaftsstabilisierungsfonds)	Uncertain	No	No	No
Germany	Instant Loans (KfW-Schnellkredit)	Yes	Yes	Uncertain	No
Germany	Entrepreneur Loans (KfW-Unternehmerkredit)	Yes	Yes	No	No
Germany	Special Program (KfW-Konsortialfinanzierung)	No, Bank Participation	No	No	No
Germany	Corona matching facility (Corona-Matching-Fazilität)	No, VC Coinvestment	No	No	Yes, Equity investments
France	Government-guaranteed loans (Prêts garantis par l'Etat)	Yes	Yes	Uncertain	Yes, Payment holiday
France	Solidarity fund (Fonds de solidarité)	Yes	Yes, Small firms	Yes	Yes, Grant
France	Subsidised loans (Prêts à taux bonifié)	Yes	Yes, Medium firms	No	No
France	Equity loans (Prêts participatifs exceptionnels)	Yes	Yes, Small firms	No	Yes, Junior in priority

Table 3. Changes in U.S. Corporate Bond Spreads around Major Market Announcements during 2020

This table reports changes in corporate bond spreads for each credit rating around major news announcements. The data are from ICE Bank of America/Merrill Lynch Corporate Bond Indices, obtained from the St. Louis Fed's FRED database. We report 3-day changes ($S_{t+2}^{i} - S_{t-1}^{i}$) surrounding events in basis points. Panel A reports Fed announcements, Panel B reports public health announcements, and Panel C report macroeconomic news announcements. * indicates that the reported 3-day changes are over $S_{t+3}^{i} - S_{t}^{i}$. We do this since credit spreads rose initially on March 23rd but fell dramatically over the following three days.

		AAA	AA	A	BBB	BB	B	CCC
Panel A: Fed Announcements								
Mar 23	PMCCF, SMCCF, TALF; Open-ended Treasury purchases*	-68	-66	-70	-64	-143	-176	-160
Apr 09	Expansion of PMCCF, Main Street	-19	-29	-39	-61	-134	-153	-188
May 29	Powell "Red Line" comments	-8	-4	-6	-9	-15	-48	-196
Jun 15	Term sheet for SMCCF amended	-9	-10	-10	-15	-41	-45	-44
Panel B: Public Health News								
Apr 06	Wuhan reopens; NYC deaths plateau over weekend	-18	-20	-22	-29	-60	-63	-64
Apr 13	Governors of NY, NJ, CT, PA announce reopening plans	-1	-12	-20	-30	-27	-29	-71
May 18	First Moderna human trial results; Italy begins to reopen	-18	-15	-17	-22	-61	-64	-66
Jul 01	E.U. reopens borders	-1	-4	-5	-8	-44	-48	-55
Panel C: Macroeconomic News								
Mar 27	CARES Act signed into law	-24	-25	-29	-28	-53	-56	-8
Apr 29	Q1 GDP release: -4.8%	0	-2	-6	-26	-16	-99	84
May 08	April jobs report: -20.5 million jobs	2	0	2	1	-16	-20	-22
Jun 05	May jobs report: +2.5 million jobs	-1	-3	-8	-15	-4	-10	-42
Jul 02	June jobs report: +4.8 million jobs	-5	-6	-6	-7	-26	-35	-30
Jul 30	Q2 GDP release: -32.9%	0	1	-2	0	0	0	-40

Figure 1. Macroeconomic Uncertainty and Financial Market Volatility

This figure shows the quarterly time series of the CBOE Stock Volatility Index (VIX; blue, right axis) and cross-sectional dispersion in the Survey of Professional Forecasters' (SPF) expectations for current-period real GDP growth (red, left axis). The SPF dispersion measure is calculated as the difference, in percentage points, between the 75th and 25th percentile forecasts reported. The SPF data are from the Federal Reserve Bank of Philadelphia; the VIX data are from CBOE and obtained from the St. Louis Fed's FRED database. The series run from 1990Q1 to 2020Q2.

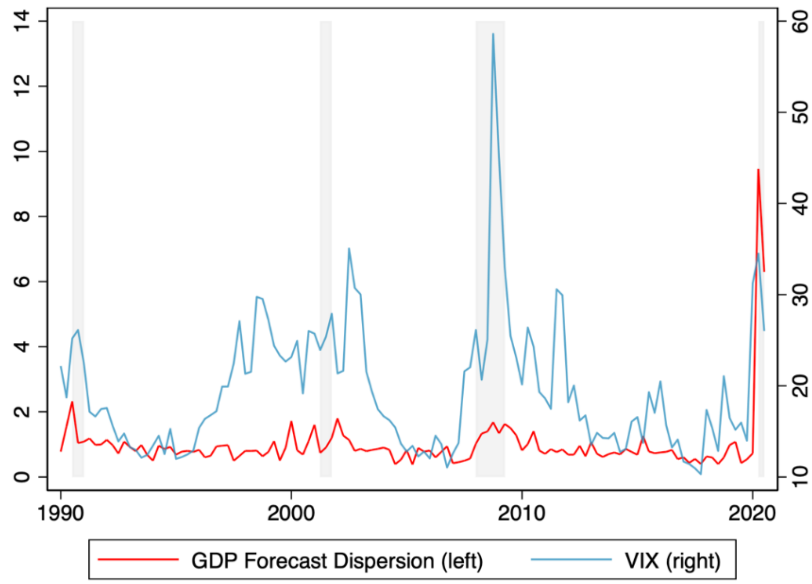
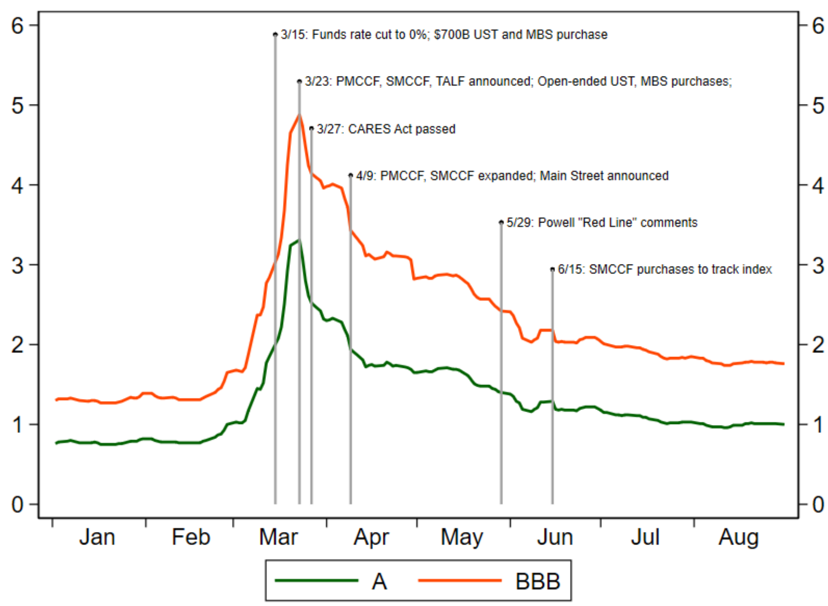


Figure 2. Investment Grade and High Yield Corporate Bond Spreads in 2020

This figure shows the daily time series of ICE BofAML Corporate Bond Index Option-Adjusted Spreads, in percentage points, for A-, BBB-, B-, and CCC-rated corporate bonds. The spreads are from the St. Louis Fed's FRED database. The sample begins on January 1, 2020, and ends on August 31, 2020. Gray lines indicate the following news events: (1) March 15th when the Fed cut the funds rate to 0% and announced \$700 billion of Treasury and MBS purchases; (2) March 23rd when the Fed announced the PMCCF, SMCCF, TALF and open-ended Treasury and MBS purchases; (3) March 27th when the CARES Act was passed; (4) April 9th when the Fed expanded the PMCCF and SMCCF programs and announced Main Street; (5) May 29th when Chair Powell gave his "Red Line" speech at Princeton; and (6) June 15th when the Fed announced the SMCCF would purchase corporate bonds to track an index. Panel A shows the time-series of A- and BBB-rated spreads. Panel B shows the time-series of B- and CCC-rated spreads.

Panel A: A- and BBB-rated bond spreads



Panel B: B- and CCC-rated bond spreads

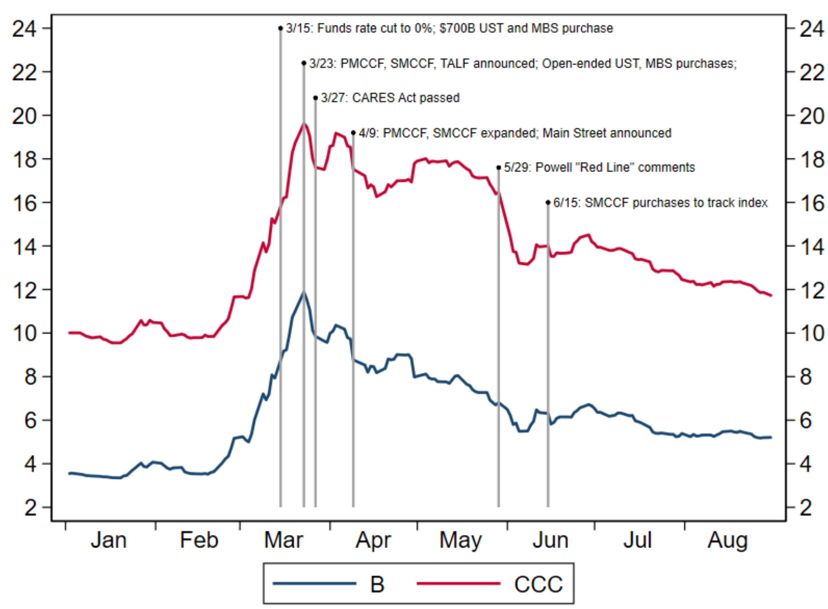
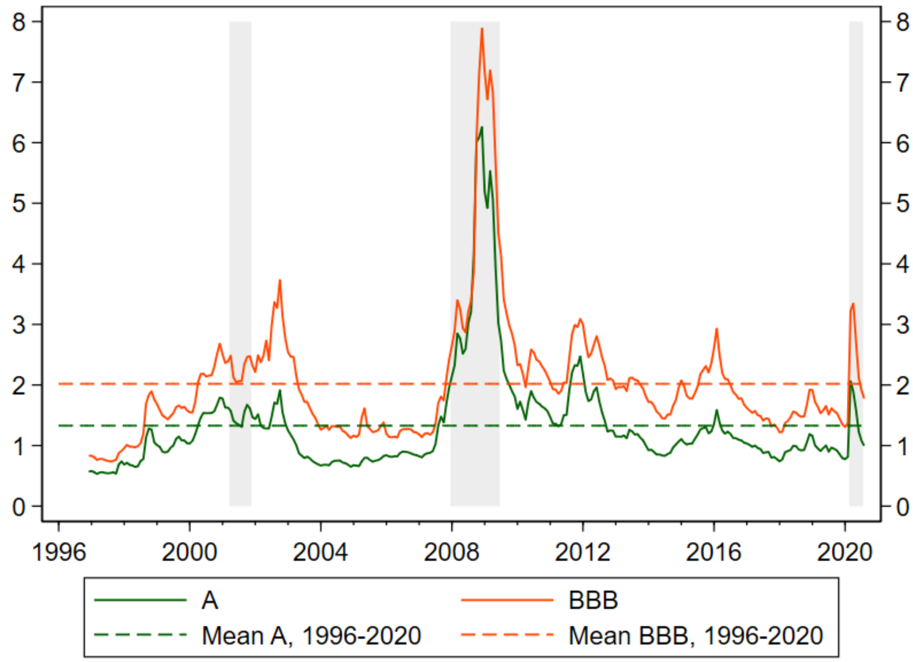


Figure 3. Investment Grade and High Yield Corporate Bond Spreads, 1996-2020

This figure shows the monthly time series of ICE BofAML Corporate Bond Indices Option-Adjusted Spreads for A-rated, BBB-rated, B-rated, and CCC and lower-rated bonds. Dashed lines indicate each series' unconditional mean over the sample period, which runs from December 1996 to August 2020. Panel A shows the results for AAA (green) and BBB-rated (orange) bonds. Panel B shows the results for B (navy) and CCC and lower-rated (red) bonds.

Panel A: AAA- and BBB-rated bond spreads



Panel B: High-Yield- and CCC-rated bond spreads