Can the Covid Bailouts Save the Economy? *

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Abstract

The covid-19 crisis has led to a sharp deterioration in firm and bank balance sheets. The government has responded with a massive intervention in corporate credit markets. We study equilibrium dynamics of macroeconomic quantities and prices, and how they are affected by this policy response. The interventions prevent a much deeper crisis by reducing corporate bankruptcies by about half and short-circuiting the doom loop between corporate and financial sector fragility. The additional fiscal cost is zero since program spending replaces what would otherwise have been spent on financial sector bailouts. An alternative intervention that targets aid to firms at risk of bankruptcy prevents more bankruptcies at much lower lower fiscal cost, but only enjoys marginally higher welfare. Finally, we study longer-run consequences for firm leverage and intermediary health when pandemics become the new normal.

JEL: G12, G15, F31.
Keywords: covid-19, bailout, credit crisis, financial intermediation

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1 Introduction

The global covid-19 pandemic has resulted in unprecedented contraction in aggregate consumption, investment, and output in nearly every developed economy. For example, U.S. GDP fell 5% in 2020.Q1 and 33% in 2020.Q2 annualized. Mandatory closures of non-essential businesses and voluntary reductions in spending cut off revenue streams and brought many firms to the brink of insolvency. Firms pulled credit lines (Li, Strahan, and Zhang, 2020), raided cash reserves, and laid off or furloughed workers.

In an effort to stabilize the economy and prevent an economic collapse, the U.S. Congress authorized four rounds of bailouts worth \$3.8 trillion. The Federal Reserve Board launched a slew of programs, worth \$2.3 trillion, several of which are aimed at keeping credit to businesses flowing. In this paper, we ask how effective the government's corporate loan programs are likely to be, once fully deployed.

Because the deepest recessions are typically associated with financial sector weakness (Reinhart and Rogoff, 2009; Jorda, Schularick, and Taylor, 2017), a key question is whether the interventions are able to short-circuit a doom loop in which corporate defaults bring down the financial intermediary sector which, in turn, leads to a corporate credit crunch. Using a rich model of corporate and financial sector interactions, we compare a situation with and without the corporate sector bailout programs. The additional bank stress tests that the Federal Reserve conducted in May 2020 show that the pandemic has the potential to do much harm to the banking sector, despite the strong balance sheets going into the crisis.[1] Second, we ask what fiscal ramifications these programs have in the short and in the long run. Third, we propose an alternative corporate loan policy design that increases welfare and has lower fiscal cost. Finally, we study the long-run impact on non-financial and financial sector health from the realization that pandemics may be recurring events in the future.

We set up and solve a general equilibrium model, extending Elenev, Landvoigt, and Van Nieuwerburgh (2020) to allow for government interventions in the credit market. The model features a goods-producing corporate sector financed with debt and equity and an intermediary sector financed by deposits and equity. The household sector consists of shareholders and

[1] https://www.federalreserve.gov/publications/files/2020-sensitivity-analysis-20200625.pdf

savers. Savers invest in safe assets, both bank deposits and government debt, and in risky corporate debt. Financial intermediaries make long-term risky loans to non-financial firms funded by short-term safe liabilities obtained from savers. Shareholders own the equity of non-financial and financial firms. The model produces occasional but severe financial crises whereby corporate defaults generate a wave of bank insolvencies, which feed back on the real economy. The calibrated model matches many features of macro-economic and financial quantity and price data.

We conceptualize the covid-19 shock as the joint effect of four changes. First, there is a large decline in average firm revenue in the non-financial corporate sector, engineered through a decline in average firm productivity. Second, the dispersion in firm-level productivity increases (Barrero, Bloom, and Davis, 2020), capturing the stark heterogeneity in how firms and sectors are affected by the pandemic. The increase in cross-sectional dispersion is likely to remain in place for a second year. Third, labor supply declines, capturing illness, child care duties, or worries about getting infected on the job. Finally, the onset of covid-19 triggers the realization that pandemics will be a rare but recurring phenomenon in the future. The first three changes affect the short-run economic response, while the fourth one matters for the long-run. The covid shock triggers severe firm revenue shortfalls, making it impossible for many firms to pay their employees, their rent, and their existing debt service in the absence of government intervention.

Absent policy, the covid shock triggers a wave of corporate defaults. The corporate defaults inflict losses on their lenders, principally the financial intermediaries (e.g. banks and insurance companies) but also the households who directly hold corporate debt (including bond mutual funds). The financial sector distress manifests itself in higher credit spreads. The higher cost of debt for firms and the uncertain economic outlook generate a large decline in corporate investment. A substantial share of intermediaries fail and are bailed out by the government. The cost of these rescue operations adds to the already higher government spending and lower tax revenues that accompany any severe recession (e.g., higher spending on unemployment insurance and food stamps). The mutually reinforcing spirals of firm distress, financial sector distress, and government bailouts create a macro-economic disaster. The non-linearity of the model solution is crucial to generate this behavior.

We then evaluate three government policies aimed at short-circuiting this doom loop. The first one is a policy that buys risky corporate debt on the primary or secondary debt market, funded by issuing safe government debt. It is calibrated to the size of the primary and secondary market corporate credit facilities and the term asset lending facility. We call this intervention the corporate credit facility (CCF). The CCF are allowed to buy $850 billion in corporate debt, which represents 8.9% of the outstanding stock of debt or 3.9% of GDP. The second one is a program in which banks make short-term bridge loans to non-financial firms at a low interest rate. The loan principal is forgiven when loans are used to pay employees. The government provides a full credit guarantee to the banks. This policy captures the institutional reality of the Paycheck Protection Program (PPP). The PPP program has a size of $671 billion or 3.1% of GDP. The third program also provides bank-originated bridge loans to non-financial firms. However, these loans are not forgivable, and they carry a modest interest rate. Moreover, banks must retain a fraction of the risk so that the government guarantee is partial. This program reflects the details of the Main Street Lending Program (MSLP), which has a size of $600 billion or 2.8% of GDP. We consider the combination of all three programs to be the counterpart to the real world intervention.

Our main result is that the bridge loan programs (PPP and MSLP) are successful at preventing corporate bankruptcies and a financial crisis. Intermediaries are able to continue making loans, suffering merely a decline in net worth rather than a major meltdown. Credit spreads still rise but not as much as they would absent policy. Facing a modestly higher cost of debt, firms borrow and invest less. However, investment shrinks by much less than it would absent policy. Preventing intermediary defaults avoids the fiscal outlay associated with intermediary bailouts. This cost reduction is offset by the direct costs of the programs. The PPP provides debt forgiveness and therefore has a much higher direct cost than the MSLP, which contains no forgiveness. In contrast to the PPP and MSLP, the CCF is much less effective. It lowers credit spreads, as intended, but increases risk-free interest rates. The latter reflect the higher cost of government debt resulting from the purchases of corporate debt. The loan rate falls by much less than the credit spread, muting the investment response. Deploying all three programs (the PPP, MSLF, and CCF) increases societal welfare by 6% in consumption equivalent units compared to a do-nothing scenario. The primary deficit balloons relative to the no-pandemic situation, but not more than it would have absent policy. The government issues 18% of GDP in additional debt in 2020. Savers who must absorb the extra debt in equilibrium require a higher interest rate, relative to no-policy. Government debt takes twenty years to come back down to pre-pandemic levels.

Since the loans are given to all firms, the PPP in particular wastes resources on firms that do not need the aid. We contrast the actual government programs with a hypothetical policy that conditions on need. Both which firms receive credit and how much credit they obtain now depend on firm-level productivity. We find that a much smaller-sized program is needed to prevent a lot more bankruptcies. The conditional bridge loan (CBL) program increases welfare by 7% compared to a do-nothing scenario. This also suggests that the real-life policy combination (with a 6% gain) is not far off that of a perfectly targeted program, at least in terms of aggregate welfare. The distributional consequences, however, differ across the programs. Of course, the informational requirements on the government to implement this CBL program are more stringent.

Finally, we turn to the longer-term implications. The pandemic not only creates a massive unanticipated shock, but also creates an "awakening" to the possibility that pandemics may be recurring—albeit low-probability—events forever after. This is in the spirit of Kozlowski, Veldkamp, and Venkateswaran (2020), who emphasize the effects of "beliefs scarring." While this "awakening" has only minor implications in the short-run response of the economy, it leads to an economy that is different in the long-run. The post-pandemic economy features less corporate debt, lower output, and a smaller but more robust financial sector.

As a methodological contribution, we extend the numerical solution procedure developed in Elenev, Landvoigt, and Van Nieuwerburgh (2020) to compute the economy's response to unanticipated ("MIT") shocks. Global solution methods, such as transition function iteration from Elenev, Landvoigt, and Van Nieuwerburgh (2020), approximate the economy's rational expectations equilibrium; the policy functions obtained through this solution method generally do not capture the economy's response to an unexpected shock. In this paper, we calculate transition paths that return the economy to the rational expectations law of motion after unexpected shocks.

Related Literature Our paper contributes to three strands of the literature. The first one is a new literature that has sprung up in response to the covid-19 pandemic. The focus of this literature has been on understanding the interaction of the spread of the disease and the macro-economy.[2] This literature has not yet studied the role of government intervention in an equilibrium model of non-financial firms and financial intermediaries. Faria-e-Castro (2020) provides a DSGE model to analyze fiscal policies that help stabilize household income. It finds that unemployment insurance is the most effective stabilization tool for borrowing households, while saving households favour unconditional transfers. Liquidity assistance programs are effective if the policy objective is to stabilize employment in the affected sector. Fahlenbrach, Rageth, and Stulz (2020) show that firms that had better liquidity buffers before the pandemic showed smaller stock market declines. A few papers have begun to analyze the empirical effects of the PPP program. Granja, Makridis, Yannelis, and Zwick (2020) find that PPP loans were unevenly distributed in space, not always going to the areas that were hit hardest, in part due to unequal distribution by banks. Humphries and Ulyssea (2020) finds that information frictions and the "first-come, first-served" design of the PPP program skewed its resources towards larger firms. Cororaton and Rosen (2020) studies the public firm borrowers of the PPP and emphasizes the need for better targeting towards firms with liquidity needs, consistent with our findings.

A second branch of the literature studies government interventions in the wake of the Great Financial Crisis. In contrast with the current crisis, most of these interventions were aimed at stabilizing the financial sector. TARP provided equity injections, the GSEs were bailed out, FDIC guarantees on bank debt, and a myriad of Federal Reserve commitments worth \$6.7 trillion (TALF, TSL, CPFF, etc.) provided liquidity to the banking and mortgage sectors. Blinder and Zandi (2015) provide a retrospective. The only direct interventions in the non-financial sector were the auto sector bailouts. Of the \$84 billion of TARP money committed, the cost of the auto bailouts was ultimately \$17 billion. A large literature studies the micro- and macro-

[2] Some of the early contributions to this fast-growing literature include Atkeson (2020), Eichenbaum, Rebelo, and Trabandt (2020), von Thadden (2020), Krueger, Uhlig, and Xie (2020a,b), Kaplan, Moll, and Violante (2020), Hagedorn and Mitman (2020), Rampini (2020), Brotherhood, Kircher, Santos, and Tertilt (2020), Bethune and Korinek (2020), Guerrieri, Lorenzoni, Straub, and Werning (2020), Ludvigson, Ng, and Ma (2020), Alvarez, Argente, and Lippi (2020), Jones, Philippon, and Venkateswaran (2020), Glover, Heathcote, Krueger, and Rios-Rull (2020), Greenstone and Nigam (2020), Kozlowski, Veldkamp, and Venkateswaran (2020), Farboodi, Jarosch, and Shimer (2020), and Xiao (2020).

prudential policy response to the financial crisis. Elenev, Landvoigt, and Van Nieuwerburgh (2020) provides references and studies the effect of tighter bank capital requirements. The calibration in this paper starts from the higher capital levels in place at the end of 2019.

While some are sanguine about the government's ability to spend trillions more (Blanchard, 2019), Jiang, Lustig, Van Nieuwerburgh, and Xiaolan (2020b) warn of higher yields on government debt. Our model predicts that the covid-19 bailouts will lead to higher interest rates in the short run and require higher future tax rates to bring the debt back down. To keep government debt finite, tax rates must increase in the level of government debt at medium-run frequencies. At business-cycle frequencies, tax revenues are pro-cyclical. The model also captures the increase in transfer spending, such as unemployment insurance and food stamps, that accompanies a deep recession. While the awakening to future pandemics creates persistent changes, the model has no permanent shocks. This is an important assumption to keep government debt risk-free (Jiang, Lustig, Van Nieuwerburgh, and Xiaolan, 2020a).

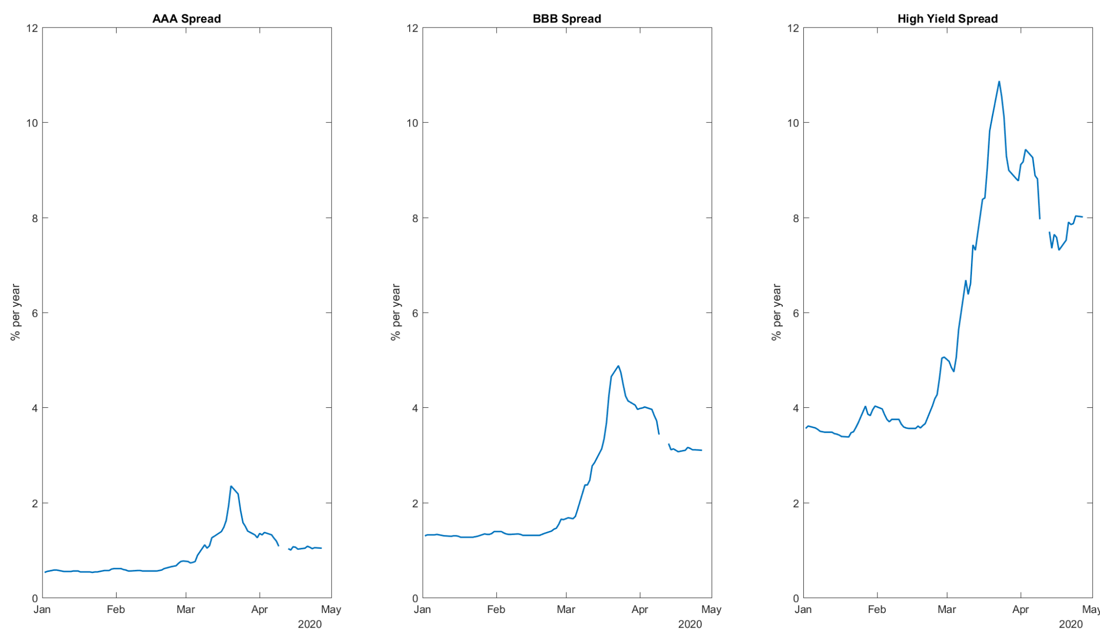
The rest of the paper is organized as follows. Section 2 discusses the evolution of credit spreads and the institutional detail of the corporate lending programs introduced during the covid pandemic. Section 3 provides a discussion of the model. Section 3.2 presents the covid shock and the policies aimed to fight it. Section 4 contains the main results on the short-run policy effects. Section 6 concludes.

2 Institutional Background

2.1 Credit Market Disruption

Credit Spreads A first sign of trouble in the corporate sector showed up in the prices of corporate bonds. Figure 1 shows the ICE BofA US AAA, BBB, and High Yield index option-adjusted spreads between January 1, 2020 and April 27, 2020. The time series measures the spread for corporate debt over a duration-adjusted safe yield (swap rate). Naturally, credit spread are lower for the safest firms (AAA), intermediate for the lowest-rated investment-grade firms (BBB), and highest for the firms rated below investment grade (High Yield). The AAA spread went from 0.56% on February 18, before the covid crisis began in the U.S., to a peak value of 2.35% on Friday March 20 and remained very high on Monday March 23 at 2.18%. The BBB spread increased from 1.31% on February 18 to 4.88% on March 23. The HY spread went from 3.61% on February 18 to 10.87% on March 23. For comparison, the only other two peaks of comparable magnitude in the HY index were October 2011 (European debt crisis, 8.98%) and February 2016 (Chinese equity market crash, 8.87%). On both occasions, the BBB spread remained below 3.25% and the AAA spread below 1%. To find a widespread spike like the one in the covid pandemic, we have to go back to the Great Financial Crisis. On December 15, 2008, the HY index peaked at 21.8%, the BBB index was at 8.02%, and the AAA spread was 3.85%.

Figure 1: High Yield Bond Spread



The left panel plots the ICE BofA AAA U.S. corporate index option-adjusted spread. The middle panel plots the ICE BofA BBB U.S. corporate index option-adjusted spread. The right panel plots the ICE BofA High Yield U.S. corporate index option-adjusted spread. The data are daily for January 1, 2020 until April 27, 2020. Source: FRED.

The policy interventions of March 23 and April 9, 2020, discussed in detail below, have partially closed credit spreads. The high yield spread tapered back off to 7.35% by April 14. The BBB spread was at 3.11%, and the AAA spread at 1.00%. Since then, spreads have been stable, with the HY spread drifting up slightly to 8.01% on April 27. In sum, the HY spread

Table 1: CLO Bond Prices

Rating	Transport	Hotel, Gaming, Leis.	Bev., Food, Tobacco	Retail, Cons. Serv.
Overall	**-16.77%**	**-21.98%**	**-14.64%**	**-17.94%**
BBB-	-9.30%	-10.53%		
BB+	-6.73%	-8.58%	-5.05%	-5.70%
BB	-8.06%	-11.36%	-4.70%	-5.48%
BB-	-11.91%	-12.83%	-8.37%	-8.70%
B+	-18.94%	-18.76%	-9.09%	-13.03%
B	-12.85%	-20.24%	-12.95%	-17.84%
B-	-17.85%	-25.39%	-15.94%	-16.88%
CCC+	-17.74%	-29.43%	-14.89%	-22.53%
CCC	-18.14%	-42.00%	-19.43%	-26.14%
CCC-	-6.98%	–	-23.87%	-22.95%
CC	–	–	-2.37%	-20.41%
C	-11.11%	–	–	–
D	-90.62%	-91.57%	-30.00%	-28.44%

Source: Trepp. Price changes between January 31, 2020 and April 6, 2020.

has stabilized at nearly twice the pre-pandemic level of two months earlier. BBB and AAA spreads have also doubled.

CLO Prices Over the past five years, many corporate loans have been sold to special purpose vehicles who issue collateralized loan obligations to bond market investors. CLO tranches have various credit ratings. The CLO market, which was already subject to credit deterioration issues in 2019 and early 2020, has been particularly hard hit by the pandemic. Table 1 shows price changes in CLO tranches between January 31 and April 6, 2020. The average CLO bond lost around 15% in value, with much larger losses in lower-rated tranches and in industries that were affected more strongly by the pandemic.

Treasury Yields and Sovereign CDS Spreads Figure 2 shows U.S. Treasury yields of maturities 1, 5, and 10-years in the left panel and U.S. sovereign CDS spreads of maturities 1-, 5-, and 10-years in the right panel. Ten-year Treasury yields decline from 1.55% on February 18 to 0.54% on March 9. This corresponds to a 10.5% increase in bond prices in 14 business days. We interpret this sharp decline in interest rates as a combination of (i) lower growth expectations (Gormsen and Koijen, 2020), (ii) precautionary savings/flight-to-safety as the market woke up to the possibility of a severe crisis.

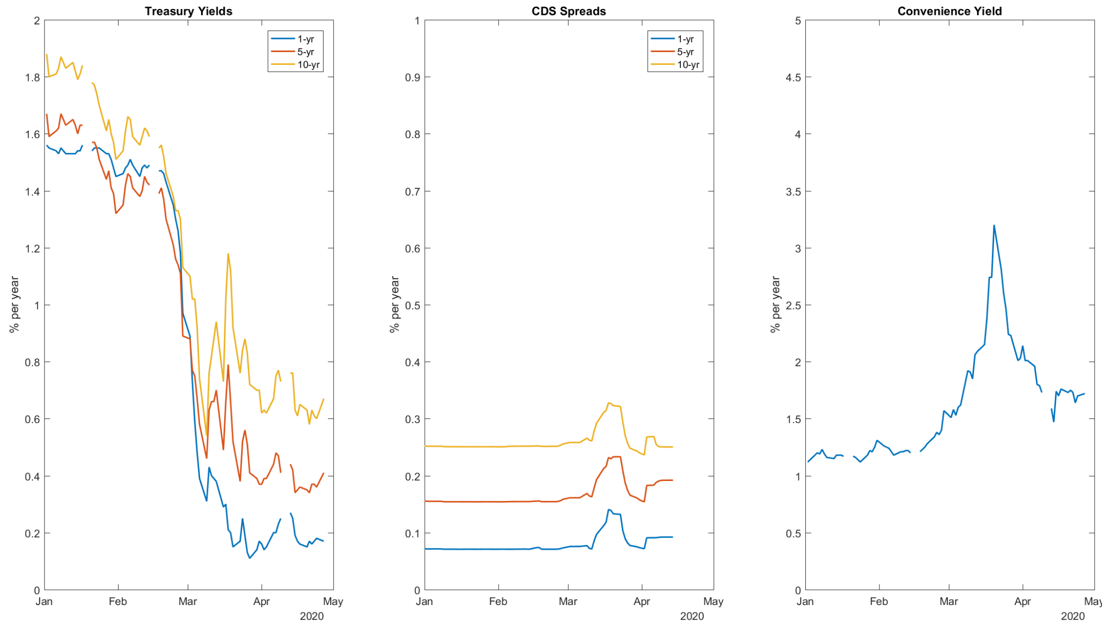
In the following seven trading days, there is a sharp reversal and 10-year interest rates doubles from 0.54% to 1.18% on March 18, a 6.1% drop in the bond price. We believe this sharp decline in interest rates is due to a combination of (i) expectations of large bailouts which need to be absorbed by savers, (ii) increased credit risk of the U.S. government, and (iii) distressed selling of safe assets to meet margin calls in other parts of investors' portfolios and regulatory constraints preventing others from stepping in (He, Nagel, and Song, 2020). We see a 5-7bps jump in CDS spreads between March 9 and 18.[3] Just prior to the peak in interest rates, in an emergency meeting on Sunday March 15, the Fed lowered the policy rate from 1.25% to 0.25% and announced a $700bn Treasury and Agency purchase program. This followed an earlier rate cut by 50 bps on March 3. On March 23, the Fed announced that the QE program would be unlimited in size. The intervention was successful in propping up government bond prices and 10-year yields fell back down to around 65 bps by April 27, a 5.2% increase in bond prices from March 18. U.S. sovereign CDS spreads also normalized to pre-crisis levels. Investors –so far– seem quite sanguine about the massive expansion in government debt, projected to be 21% of GDP in 2020, fueled by a 19% of GDP primary deficit. This debt expansion would push the U.S. federal debt held by the public above 100% in 2020 and above 107% of GDP in 2021, exceeding the previous 1947 record.

The U.S. benefits from its status as global safe asset. The true safe rate, without convenience, is higher than the Treasury bond yield. A standard measure of the convenience yield advocated by Krishnamurthy and Vissing-Jorgensen (2012)), the spread between the AAA-rated corporate bond yield and the 10-year Treasury, increased substantially in March, peaking on March 20, before settling back down to a level 50 bps above its pre-crisis level. Of course, the AAA-corporate spread reflects all interventions by the Fed in both the Treasury and corporate bond markets, and extracting the true convenience yield from this measure is a difficult task. With this caveat in mind, the evidence suggests that the risk-free rate did not fall as much as the Treasury yield during the first two months of the covid crisis.

Corporate Default The delinquency rate on commercial and industrial loans at all commercial banks has increased modestly from 1.12% in 2019.Q4 to 1.27% in 2020.Q2. Data from Fitch Ratings shows that the trailing twelve-month default rate for leveraged loans was 4%

[3] CDS spreads peak across developed countries (Augustin, Sokolovski, Subrahmanyam, and Tomio, 2020).

Figure 2: High Yield Bond Spread



The left panel plots the U.S. Treasury Bond constant-maturity yields on bonds of maturities 1, 5, and 10 years. The middle panel plots the U.S. sovereign CDS spread of maturities 1, 5, and 10 years. The right panel plots the Moody's AAA-rated corporate bond yield minus the 10-year constant maturity Treasury yield. The data are daily for January 1, 2020 until April 27, 2020. Source: FRED and Datastream.

in July 2020, the highest level since 2010. The default volume was $47 billion so far in 2020, and projected to rise to $80 billion by the end of 2020. Fitch predicts a two-year cumulative default rate of 15 by the end of 2021. Commercial bankruptcy filings under Chapter 11 number 2,537 in March-July 2020, according to aacer, the highest tally since 2012 for these four months and up 43% from 2019. Evidence of rising defaults also come from the commercial mortgage market. Trepp reports a sharp rise in the CMBS delinquency rate (60+ days late) from 2.04% in February 2020 to 7.15% in May and 10.32% in June, equalling the previous peak distress levels from 2010. Taken together, these numbers show rising corporate distress despite massive government intervention.

2.2 Policy Response

2.2.1 Institutional Details

Chronology Both Central Banks and Treasury departments around the world have mounted massive responses to the crisis. We focus on the United States. Most relevant for our purposes are several new government programs that provide bridge loans to the corporate sector as part of the $2.2 trillion CARES Act passed on March 27, 2020. The Fed is using its balance sheet to lever up the equity commitments made by the Treasury. The Fed first announced the establishment of these programs on March 23. On April 9, the Fed clarified how much leverage it would provide to each of the facilities to scale up the aid to corporations. The Fed announcement amounted to a $2.3 trillion relief package. On April 23, Congress approved a new $484 billion rescue package, which included $321 billion in additional money for the paycheck protection program defined below. On April 30, the modalities of the MSLP were announced.

Program Details

1. Credit facilities for large firms

   – The Primary Market Corporate Credit Facility (PMCCF) is for new bonds and loans with maturities up to four years, issued by non-financial companies that are investment-grade (or were as of March 22). Interest rates are issuer-specific and informed by market conditions, plus a 100 bps facility fee. Loans may be syndicated, in which case the PMCCF participates under the same terms as the other syndicate partners.

   – The Secondary Market Corporate Credit Facility (SMCCF) provides liquidity for outstanding corporate bonds with (mostly) investment grade ratings. The Facility also may purchase U.S.-listed ETFs whose investment objective is to provide broad exposure to the market for U.S. corporate bonds. Bonds are bought at fair market value. The ETF purchases allow for non-IG bond purchases, for example, through a HY credit index.

   – The Term Asset-Backed Securities Loan Facility (TALF) enables the issuance of asset-backed securities backed by student loans, auto loans, credit card loans, loans guaranteed by the Small Business Administration (SBA), existing commercial mortgage-backed securities (CMBS) and collateralized loan obligations (CLO). TALF only purchases AAA-rated tranches.

  - These three programs support up to $850 billion in credit backed by $85 billion in credit protection provided by the Treasury. The PMCCF, SMCCF, and TALF receive $50bn, $25bn, and $10bn in equity from the Treasury, respectively. Loans from the Fed to these facilities provide leverage of 10-to-1 to the Treasury funds. In the case of the SMCCF, the leverage from Treasury depends on the instrument: 10x for IG corp bonds, 7x for IG ETF, and 3x for HY ETF.

2. The Main Street Lending Program targets small and mid-sized businesses (below 15,000 employees or with 2019 revenues of $5 billion or less). Banks originate these loans, retain a portion and sell the remainder to the facility. Principal and interest on these four-year loans are deferred for 1 year. The facility's size is $600 billion in loans, backed by $75 billion in equity from the Treasury. As announced on April 30, there are three facilities that differ in the details of the loan features and banks' risk retention requirements. Firms may only participate in one of the three programs and only if they have not also participated in the PMCCF and have not received other direct support under the CARES Act. All loans carry an interest rate of LIBOR + 300bps.

  - The Main Street New Loan Facility (MSNLF): loan made on or after 4/24/2020; banks retain 5% share; minimum loan size $0.5 mi; maximum loan size $25 mi as long as the total debt after the loan remains below 4 times 2019 EBITDA; amortizes 1/3 in years 2, 3, and 4; is not junior to any existing firm debt.
  - The Main Street Priority Loan Facility (MSPLF): loan made after 4/24/2020; banks retain 15% share; minimum loan size $0.5 mi; maximum loan size $25 mi as long as the total debt after the loan remains below 6 times 2019 EBITDA; amortizes 15% in years 2 and 3, and 70% in year 4; is senior to all other corporate debt except mortgage debt.
  - The Main Street Expanded Loan Facility (MSELF): upsized tranche upsized after 4/24/2020 on a loan made before 4/24/2020 with at least 18 months remaining

maturity; banks retain 5% share; minimum loan size \$10 mi; maximum loan size \$200 mi as long as the total debt after the loan remains below 6 times 2019 EBITDA and the loan amount is less than 35% of existing corporate debt that is pari passu with the loan; amortizes 15% in years 2 and 3, and 70% in year 4; is senior or pari passu to all other corporate debt except mortgage debt.

3. The Small Business Administration's Paycheck Protection Program (PPP) targets small companies with fewer than 500 employees. Initially, up to \$350 billion in loans made by banks are guaranteed by the Small Business Administration. The money ran out within days. The April 23 top-up increased the size of the program to \$671 billion. The loan principal is up to 2.5 months of payroll, with a maximum of \$10 million. The loan maturity is two years and the interest rate is 1%. The CARES Act provides for forgiveness of up to the full principal amount of qualifying PPP loans. The amount of loan forgiveness depends on the total amount of payroll costs, payments of interest on mortgage obligations, rent payments on leases, and utility payments over the eight-week period following the date of the loan. However, not more than 25 percent of the loan forgiveness amount may be attributable to non-payroll costs. The Fed provides term financing to banks, collateralized by PPP loans up to their face value.

2.2.2 Mapping to the Model

To map this intricate set of interventions into our model, we consider three programs: bond purchases, forgivable bridge loans, regular bridge loans.

CCF = Corporate Bond Purchases First, we model a government purchase program of corporate bonds. It is calibrated to the combined size of the PMCCF, SMCCF, and TALF, which is \$850 billion. According to S&P Global, the size of the U.S. corporate bond market is \$9,300 billion as of January 2019. Of this, \$7,144 billion is bonds issued by non-financial corporations, of which \$4,717.6 is rated investment grade. The size of the corporate loan market, the C&I loans held by all U.S. commercial banks, is \$2,360 billion at the end of 2019. Since the model has only one type of debt, we scale the \$850 billion purchases by the size of the overall non-financial corporate debt market of \$9504 (\$7144+\$2360). This generates a purchase share of 8.9% of the overall corporate debt market. This program is \$850/\$21,729=3.9% of 2019 GDP. The model matches the share of GDP since it matches the ratio of the corporate debt market to GDP.

PPP = Forgivable Bridge Loans The second type of program is modeled after the Small Business Administration's Paycheck Protection Program. Banks make loans to non-financial firms that are 100% guaranteed by the government and that are 100% forgiven. There is no risk retention requirement for the banks. We abstract from the fact that the PPP loans target small firms. In reality, several larger firms ended up receiving these loans as well (Humphries and Ulyssea, 2020; Cororaton and Rosen, 2020). PPP loans feature debt forgiveness to the extent that firms use them to keep employees on the payroll. For example, the part of the loan that is used to pay rent is not forgiven. We suspect that the vast majority of firms who obtained PPP loans will enjoy full debt forgiveness since money is fungible and firms can always "use the proceeds to make payroll." Moreover, the fraction of loan proceeds that must be used for payroll expenses to preserve debt forgiveness was lowered from 75% to 60% on July 20. The forgiveness is modeled as a -100% interest rate earned by the government. Banks earn a 1% interest rate on the loans, just like in the data. The size of the PPP program is \$671 billion, which is 3.1% of 2019 GDP. For simplicity, these are one-period loans. In the model, firms can refinance these loans after a year in the regular long-term corporate debt market.

MSLP = Regular Bridge Loans The third policy is modeled after the MSLP. Firms receive bridge loans from banks. Banks have a 5% risk retention requirement; the government bears 95% of the default risk. Banks earn an interest rate of 3% on the bridge loans. For simplicity, these are one-period loans, which can be refinanced in the regular debt market. The size of this program is \$600 billion or 2.8% of 2019 GDP.

Combo We also study the combination of these three programs. Combined, they represent an outlay of 9.8% of GDP. This is the model counter-part to the real world intervention.

3 The Model

In the interest of space, we highlight the key features of the model setup here. We refer the reader to Elenev, Landvoigt, and Van Nieuwerburgh (2020), henceforth ELVN, for a formal treatment.

3.1 Summary

Setup The model features two groups of households: borrowers and savers. Both have Epstein-Zin preferences. Savers are more patient than borrowers. Borrowers are the shareholders of both goods-producing firms, called producers, and financial intermediaries, called banks. Borrowers and savers inelastically supply their labor.

A continuum of producers combine capital and labor using a Cobb-Douglas production technology to produce output. Production is subject to aggregate, persistent TFP shocks and to idiosyncratic i.i.d. productivity shocks. The cross-sectional dispersion of the idiosyncratic productivity shock constitutes a second aggregate persistent shock. We refer to the latter as an uncertainty shock; it can alternatively be interpreted as a capital misallocation shock. Producers issue long-term debt to both financial intermediaries (banks for short) and savers. They issue equity to borrowers. Interest expenses are tax deductible. After aggregate and idiosyncratic productivity shocks are realized but before new equity or debt can be raised, each producer must pay its employees, fixed costs of operation (e.g., rent and insurance), and service its existing debt. Firms with negative profits default (liquidity default). Lenders seize the collateral of defaulted firms and liquidate the firms, suffering a loss in the process. Some of the loss is a deadweight loss to society. Shareholders replace liquidated firms with new ones. The model leads to fractional default. The default rate depends on exogenous and endogenous state variables. For example, default is higher in periods of high uncertainty. Firms are subject to a standard collateral constraint.

A continuum of financial intermediaries are profit-maximizing firms that buy the debt of non-financial firms. They fund these corporate loans with short-term liabilities that they issue to savers and with equity capital that they raise from borrowers. We refer to these intermediaries as banks and their liabilities as deposits, but aim to capture (and calibrate to) the entire levered financial sector rather than only deposit-taking banks. Bank debt enjoys government guarantees (e.g., deposit insurance or state insurance fund guarantees). Banks are subject to a standard regulatory capital constraint to limit moral hazard associated with deposit insurance (capturing regulation under Basel 2/3 or Solvency 2/3). Banks can issue new equity subject to an equity issuance cost. Banks make optimal default decisions (strategic default), trading off preserving franchise value versus shifting debt onto the government. Banks are hit with idiosyncratic profit shocks, resulting in fractional default. Defaulted banks are taken over by the government and liquidated, subject to a loss (some of which is a deadweight loss). Shareholders replace liquidated banks with new ones.

We make assumptions that imply aggregation into a representative producer and a representative bank, allowing us to focus on incomplete risk-sharing between savers, borrowers, firms, and banks.

The government follows a set of mostly exogenous spending and tax rules. Discretionary and transfer spending are countercyclical while tax rates are pro-cyclical. Spending on bank bailouts and on government debt service are endogenously determined. The government issues one-period risk-free debt chosen to satisfy the government budget constraint.[4]

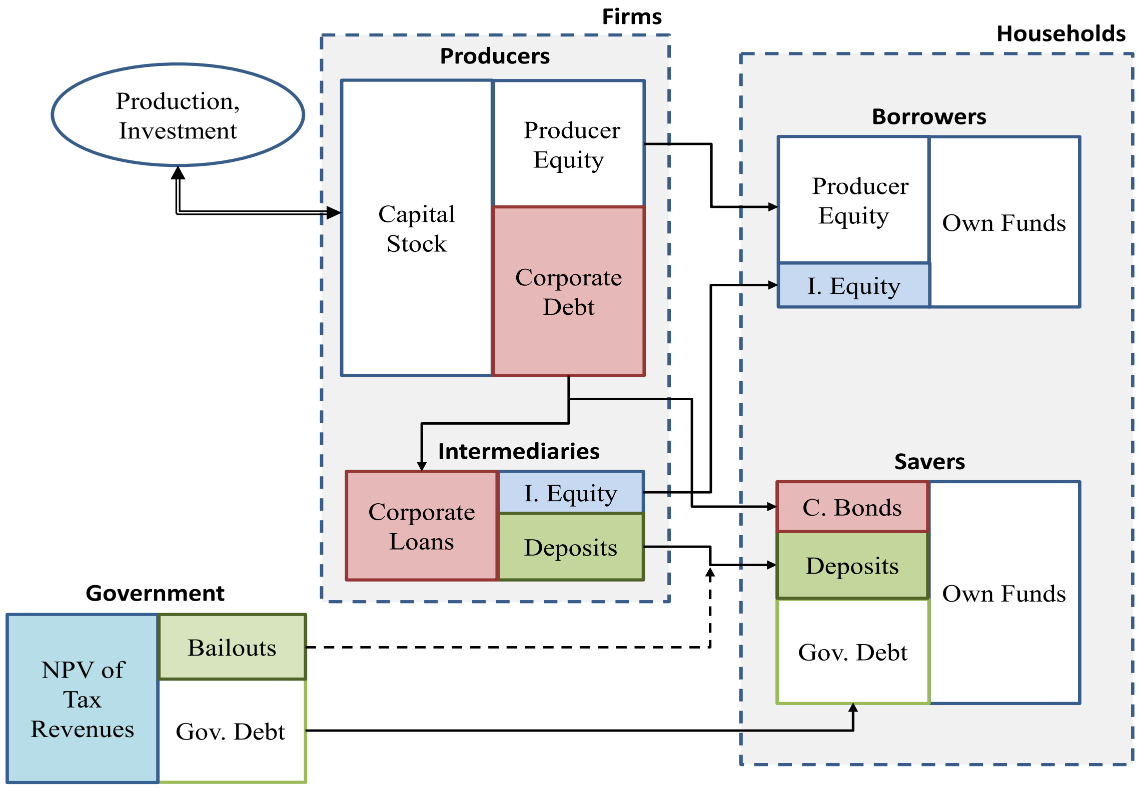
Savers do not directly hold corporate equity to capture the reality of limited participation in equity markets. However, they invest in both risk-free assets (bank and government debt) and risky corporate debt issued by firms. Unlike banks, savers incur holding costs when they buy corporate debt. This cost creates a comparative disadvantage for saver ownership of corporate debt, and provides a role for intermediaries to transform short-term safe deposits into long-term risky loans.

Figure 3 illustrates the balance sheets of the model's agents and their interactions.

Equilibrium Given a sequence of aggregate productivity and uncertainty shocks, idiosyncratic productivity shocks, and idiosyncratic intermediary profit shocks, and given a government policy, a competitive equilibrium is a consumption and capital investment choice for borrowers;

[4]The tax rate also depends on the level of government debt. This is necessary to keep government debt stationary and risk-free. Since this a model with transitory shocks, like most macro models, the stochastic discount factor does not contain a large permanent component (Alvarez and Jermann, 2005). A model with a permanent component in both output and the SDF would require much larger adjustments to tax rates to keep government debt risk-free (Jiang, Lustig, Van Nieuwerburgh, and Xiaolan, 2020b,a).

Figure 3: Overview of Balance Sheets of Model Agents



a debt issuance, equity issuance, capital demand, and labor demand choice for producers; a debt issuance, equity issuance, and loan supply decision for financial intermediaries; a consumption and financial investment choice of short-term safe debt and long-term risky debt for savers; and a price vector, such that given the prices, borrowers and savers maximize life-time utility, producers and intermediaries maximize shareholder value, the government satisfies its budget constraint, and markets clear.

The markets that must clear are the markets for risk-free bonds (deposits and government debt), risky corporate debt, physical capital, labor, and goods. Goods market clearing states that total output (GDP) equals the sum of aggregate consumption, discretionary government spending, investment (including capital adjustment costs), bank equity adjustment costs, and aggregate deadweight losses from corporate and intermediary bankruptcies.

Welfare In order to compare economies that differ in their policy parameter vector Θ, we must take a stance on how to weigh borrower and saver households. We compute an ex-ante measure of welfare based on compensating variation similar to Alvarez and Jermann (2005). Consider the equilibrium of two different economies $k = 0, 1$, characterized by policy vectors Θ^0 and Θ^1, and denote expected lifetime utility at time 0 for agent j in economy k by $\bar{V}^{j,k} = \mathrm{E}_0[V_1^j(\cdot;\, \Theta^k)]$. Denote the time-0 price of the consumption stream of agent j in economy k by:

$$\bar{P}^{j,k} = \mathrm{E}_0 \left[\sum_{t=0}^{\infty} \mathcal{M}_{t,t+1}^{j,k} C_{t+1}^{j,k} \right],$$

where $\mathcal{M}_{t,t+1}^{j,k}$ is the SDF of agent j in economy k. The percentage welfare gain for agent j from living in economy Θ^1 relative to economy Θ^0, in expectation, is:

$$\Delta \bar{V}^j = \frac{\bar{V}^{j,1}}{\bar{V}^{j,0}} - 1.$$

Since the value functions are expressed in consumption units, we can multiply these welfare gains with the time-0 prices of consumption streams in the Θ^0 economy and add up:

$$\mathcal{W}^{cev} = \Delta \bar{V}^B \bar{P}^{B,0} + \Delta \bar{V}^S \bar{P}^{S,0}.$$

This measure is the minimum one-time wealth transfer (expressed in units of the numeraire) in the Θ^0 economy (the benchmark) required to make agents at least as well off as in the Θ^1 economy (the alternative). If this number is positive, a transfer scheme can be implemented to make the alternative economy a Pareto improvement. If this number is negative, such a scheme cannot be implemented because it would require a bigger transfer to one agent than the other is willing to give up.

Solution Each agent's problem depends on the wealth of others; the entire wealth distribution is a state variable. Each agent must forecast how that state variable evolves, including the bankruptcy decisions of borrowers and intermediaries. We solve the model using projection-based numerical methods. A detailed description of the globally nonlinear algorithm can be found in Appendix B of Elenev, Landvoigt, and Van Nieuwerburgh (2020).

A technical contribution of this paper is to incorporate unexpected shocks, such as the covid shocks discussed below. The solution algorithm established in ELVN relies on Markov dynamics in the model's state variables. In particular, ELVN define "transition functions" that map today's aggregate state variable realizations into tomorrow's endogenous aggregate state, for each possible realization of the exogenous stochastic process driving the economy. These transition functions encode the rational expectation equilibrium's law of motion for the state variables, and jointly with the policy functions for prices and agent choices characterize the economy.

However, transition and policy functions computed based on the algorithm in ELVN assume that all exogenous shocks affecting the economy are completely described by the Markov transition laws for the exogenous state variables; in the specific model of this paper, these are aggregate TFP and uncertainty shocks. When an unanticipated shock hits the economy in period t, the transition functions no longer provide the correct law of motion for the state variables from t to $t+1$. Rather, the transition $t \to t+1$ is a one-time event that depends on the exact nature of the unexpected shock in t. Assuming that no further unanticipated shocks occur in $t+1$, the economy follows the "usual" law of motion encoded by the transition functions from $t+1$ onward. Our methodological innovation in this paper is to extend the algorithm in ELVN to allow for such one-time transitions back to the saddle path of the rational expectations equilibrium. This requires us to compute the one-time transitions $t \to t+1$ for all endogenous state variables jointly with policy functions in t. Appendix C contains details.[5]

3.2 Covid Crisis

This section discusses how we model the covid pandemic shock, covid-related government policies, and how we calibrate the model.

3.2.1 Covid Shock

Firms' production function is given by

$$y_t^i = Z_t^A \omega_t^i \left(k_t^i\right)^{1-\alpha} (l_t^i)^\alpha$$

The model features two aggregate shocks: aggregate TFP shocks Z_t^A and shocks to the

[5] In case of multiple consecutive periods with unexpected shocks, the procedure outlined in Appendix C can be applied sequentially.

cross-sectional dispersion of firm-level productivity shocks (uncertainty shocks). Firm-level productivity shocks are denoted by $\omega_i \sim \Gamma_\omega(\mu_\omega, \sigma^2_\omega)$, where Γ_ω denotes the cdf, parameterized by two parameters, a mean μ_ω and a variance σ^2_ω. The cross-sectional variance σ^2_ω follows a two-state Markov chain fluctuating between a low and a high-uncertainty regime. Aggregate TFP shocks follow an independent 5-state Markov chain.

The covid shock is modeled as the combination of five ingredients. The first aspect of the covid shock is a transition from the low- ($\sigma^2_{\omega,L}$) to the high-uncertainty regime ($\sigma^2_{\omega,H}$). Because of persistence in σ^2_ω, the economy is likely to remain in the high uncertainty state with probabilities dictated by the Markov chain.

Second, we assume that the productivity dispersion is unexpectedly high: $\sigma^2_{\omega,covid} > \sigma^2_{\omega,H} > \sigma^2_{\omega,L}$. This is modeled as a one-period MIT shock. The rise of VIX to an all-time high serves as motivation for this assumption. More broadly, the notion of increased firm productivity dispersion captures capital misallocation. During covid, some firms (like cruise companies and airlines) saw much greater reductions in revenues than others, while some even say significant increases in revenue (Amazon, Netflix, Zoom). Barrero, Bloom, and Davis (2020) provide evidence for rising firm dispersion during the covid-19 pandemic.

The third aspect of the covid shock is a decline in average firm productivity μ_ω, leading to a decline in average firm revenue. We model this as an additional unexpected change (MIT shock). A decline in average firm productivity has the same effect as a decline in aggregate TFP, except that TFP is persistent and TFP fluctuations are anticipated. We think the unexpected and pervasive nature of revenue drops in the cross-section of firms is well captured by the unanticipated one-year drop in μ_ω.

Fourth, we assume a reduction in labor supply. In the model, labor is supplied inelastically by both borrower ($\overline{L}^B$) and savers ($\overline{L}^S$) households. We assume a symmetric drop in labor supply. This captures government-mandated closure of non-essential businesses, forcing many workers to stay at home. It also captures inability to work due to covid-related illness and child care duties. The decline in labor supply lowers production, since labor demand $\int l^i_t di$ must equal labor supply in equilibrium.

Fifth, the pandemic causes the realization that an economic shock like the pandemic could reoccur in the future, an "awakening" to a "new normal." Formally, we include the pandemic state (low μ_ω, high $\sigma_{\omega,covid}$, low labor supply) as an extra state of the world that occurs with low but not zero probability, $p_{covid} = 1\%$. Furthermore, once the pandemic hits, it is likely to persist for an additional year with 50% probability. Pandemics last an average of 2 years.[6] The pandemic shock is thus not only an MIT shock in the first period, but also a change in beliefs from $p_{covid} = 0\%$ to $p_{covid} = 1\%$ going forward.

This last assumption has two important consequences, as we shall see. In the short-run it affects the response of short-term interest rates. Because the pandemic is expected to last two rather than one year, expected growth is low rather than high conditional on being in the first period of the pandemic. This makes interest rates low rather than high when covid hits. Second, the recurrent nature of pandemics has important implications for the long-run behavior of the economy which we explore in the last part of the paper.

3.2.2 How Corporate Bankruptcies Work

The decision problem of producers within each period has the following timing:

1. The aggregate productivity shock is realized. Given capital k_t and outstanding debt a_t^P, producers choose labor inputs l_t^j, $j \in \{B, S\}$. Further, producers pay a fixed cost of production to operate (rents, insurance, etc.) ς is the fixed cost that is proportional in capital k_t.

2. Idiosyncratic productivity shocks are realized. Production occurs. Producers that cannot service their debt from current profits default and shut down.

3. Failed producers are replaced by new producers such that the total mass of producers remains unchanged. All producers pay a dividend, issue new debt, and buy capital for next period.

The flow profit at stage 2 before taxes is

$$\pi_t = \omega_t Z_t k_t^{1-\alpha} l_t^{\alpha} - \sum_j w_t^j l_t^j - a_t^P - \varsigma k_t, \tag{1}$$

[6] The covid pandemic is widely predicted to recur in the Fall and may well last into 2021 since a vaccine is not believed to be widely available until late 2021. The 1918-1920 Spanish flu also ran over more than two full years.

Producers with $\pi_t < 0$ are in default and are seized and resolved by their creditors. This implies a default threshold

$$\omega_t^* = \frac{a_t^P + \varsigma k_t + \sum_j w_t^j l_t^j}{Z_t k_t^{1-\alpha} l_t^\alpha}, \tag{2}$$

such that producers with low idiosyncratic shocks $\omega_t < \omega_t^*$ default. Firms that do not have enough revenue to service their debt and pay their employees default. The crucial friction that generates defaults is a timing assumption that corporations must service their debt before they can raise new equity or debt.

Lenders (banks and savers) seize the firms that default, pay the employees, and liquidate the firm. Liquidation means that they earn a fraction $(1 - \zeta^P)$ of this period's output plus the non-depreciated value of the capital stock. A fraction ζ^P is a bankruptcy cost, of which a fraction η^P is a deadweight loss to society and the remainder a transfer payment to households. By inflicting losses on their lenders, corporate defaults cause financial intermediary fragility. Banks' net worth will go down because of the losses they suffer, as well as because of the lower equilibrium valuation of corporate loans. Lower corporate bond prices (higher yields) reflect both higher default risk and a higher default risk premium. For some banks, the losses will be so severe that they optimally choose to default. Defaulting banks are bailed out by the government; any equity is wiped out, depositors are made whole, and the government incurs bankruptcy costs ζ^F (a fraction η^F of which are deadweight losses to society). The government in turn needs to raise new debt on the Treasury market to finance these bank bailouts. The increase in safe asset supply increases equilibrium interest rates on safe assets, ceteris paribus. Since deposits are also safe assets, the bailout-induced increase in the safe rate increases the cost of deposit funding. The higher cost of funding hampers bank recapitalization and aggravates the financial fragility. This negative feedback loop can lead to severe financial crises in our non-linear model. When banks become fragile, credit to the real economy becomes scarce and expensive. Corporate investment tanks. This lowers capital formation and output in all future periods, adding persistence to the crisis.

3.2.3 Government Policies

The aim of government policies is to stave off or at least weaken corporate defaults. This weakens the vicious cycle between corporate and banking fragility which chokes off investment and economic activity. We consider four policies, motivated by the discussion in section 2.2.

CCF = Corporate Bond Purchases The corporate bond purchase policy has the government buying long-term risky corporate debt from both banks and savers in proportion to their holdings and at market prices. The government issues short-term government debt to finance these purchases. Treasury debt is held by the savers in equilibrium.

PPP= Forgivable Bridge Loans We consider a bridge loan program that closely reflects the Payroll Protection Program. Each firm receives an equal-size bridge loan from private lenders. The size of the loan is dictated by the total size of the program. The firm receives the loan in stage 2 of its problem, after production but before defaults and trading in financial markets. The loan must be repaid at the end of the period, in stage 3 of the firm's intra-period problem. At that point, firms can refinance the debt on the regular long-term corporate debt market. Since the firm receives the bridge loan before defaulting and the size of the loan is a multiple $\bar{A}^{brU}$ of the firm's wage bill, the default threshold becomes:

$$\omega_t^{*,brU} = \frac{\varsigma k_t + (1 - \bar{A}^{brU}) \sum_j w_t^j l_t^j + a_t^P}{Z_t k_t^{1-\alpha} l_t^{\alpha}}. \tag{3}$$

Producers with low idiosyncratic productivity $\omega_t < \omega_t^{*,brU}$ default. This is a smaller fraction since the policy lowers the default threshold compared to the no-policy case ($\omega_t^{*,brU} < \omega_t^*$). Thus the bridge loans help a mass of firms prevent default and the concomitant losses. It also avoids the deadweight losses to society associated with these defaults. Some firms with low productivity still default, notwithstanding the bridge loan program. The remaining losses are born by banks and the government depending on the extent of government guarantees. A policy parameter I_{br} measures the share of the losses born by the government, ranging from 0 (no guarantees for bridge loans) to 1 (full guarantees). In the PPP, $I_{br} = 1$.

Firms pay an interest rate $r^{br} = 1\%$ to banks on the bridge loans. After this interest payment, the loans are forgiven by the government. To capture the debt forgiveness aspect of the PPP, the bridge loans carry a $r^{gov} = -100\%$ interest rate to the government (i.e., the effective interest rate faced by firms is $r^{br} + r^{gov} = -99\%$).

MSLP= Regular Bridge Loans The third policy modeled after the MSLP is similar to the PPP, except for two features. First, there is partial risk retention by banks: $I_{br} = 0.95$. Second, the principal is not forgiven ($r^{gov} = 0$) and the interest rate paid to banks is higher: $r^{br} = 3\%$.

CBL=Conditional Bridge Loans As a fourth, hypothetical, policy we consider a conditional bridge loan program. The government can target firms that are most likely to default if they do not receive a bridge loan. Specifically, a firm of productivity ω_t receives a bank loan of size $\bar{A}^{brC}(1-\omega_t)\sum_j w_t^j l_t^j$ in stage 2 of the firm problem. The conditionality operates both on the extensive and intensive margins. First, only firms with $\omega_t < \omega_t^*$ receive bridge loans. Second, the loan size is larger the lower the firm's productivity.

This bridge loan program changes the default threshold from ω_t^* to $\omega_t^{*,brC}$:

$$\omega_t^{*,brC} = \frac{\varsigma k_t + (1-\bar{A}^{brC})\sum_j w_t^j l_t^j + a_t^P}{Z_t k_t^{1-\alpha} l_t^{\alpha} - \bar{A}^{brC}\sum_j w_t^j l_t^j}. \tag{4}$$

All other aspects of the program are the same as for the regular bridge loan program. In particular, we consider a program configuration that is the average of PPP and MSLP: a debt forgiveness of 50% of the principal ($r^{gov} = -50\%$), and interest payments to banks of $r^{br} = 2\%$ of the principal. The conditional bridge loan will generally be more effective, on a per-dollar-basis, in preventing firms from defaulting than the PPP. Hence, we do not fix the size of the CBL program, but rather compute what fraction of GDP the government must spend to eliminate all defaults.

The CBL policy imposes strong information requirements on the government: It must observe each firm's productivity. In reality, there is an issue of asymmetric information —firms know more about their drop in revenue than the government— as well as moral hazard —firms have an incentive to overstate their need. Imperfect verification on the part of the government, especially in an episode of scarce time and resources, makes these frictions potentially important. We view the cost difference between the PPP and the CBL programs as an estimate of the extra costs of imperfect information or enforcement.

3.3 Calibration

The model is calibrated at annual frequency and matches a large number of moments related to the macro economy, credit markets, non-financial and financial sector leverage ratios, default rates, loss rates, as well as a number of fiscal policy targets. We leave the calibration of ELVN mostly unchanged, except for the following aspects.

The first change we make is the nature of the covid shock, as discussed above.[7]

Second, we set the inter-temporal elasticity of substitution of the saver to a value of 2, higher than the value of 1 we use in ELVN. The higher saver EIS dampens the response of the safe interest rate to changes in the supply of safe assets by lowering the price elasticity of savers' demand.

Third, we change the maximum bank leverage ratio. Prior to the covid crisis, banks faced strict minimum bank equity capital requirements of 12% (maximum leverage of $\xi = .88$). ELVN choose a 7% minimum bank equity capital since they calibrate to the pre-GFC crisis data. This higher capital requirement reflects the changes made by the Dodd-Frank Act and Basel agreements after the GFC. The stronger capital buffer before the crisis hit helps absorb the impact of the covid shock.

Fourth, we introduce a small default penalty for banks in the period of the covid shock ($\rho = 0.04$). We simultaneously change the cross-sectional dispersion of bank idiosyncratic profit shocks (to $\sigma_\varepsilon = 0.05$). The two parameters jointly control the mean of the bank default rate and its sensitivity to bank value. A greater value of σ_ε makes bank failures less sensitive to fluctuations in the franchise value of banks, but also leads to more bank failures ceteris paribus. We choose the default penalty to match the unconditional bank failure rate from historical FDIC data. The default penalty can be motivated by government-provided moral suasion that

[7] This introduces the possibility of a drop in mean productivity μ_ω. Government discretionary spending, transfer spending, and income tax rates depend on $Z^A\mu_\omega$, so that declines in μ_ω lead to symmetric declines in tax revenue as declines in Z^A. ELVN held $\mu_\omega = 1$ so that this does not really represent a change in calibration.

banks who take bailout money need to stay afloat, or by a range of unmodeled government policies such as higher unemployment insurance, checks mailed to households, or quantitative easing that help de-risk the banks' balance sheets. The higher dispersion of bank idiosyncratic shocks can be motivated by the increased dispersion of profitability/losses on the part of banks' balance sheet unrelated to corporate loans, e.g., household mortgages. This parameter change is modeled as a MIT shock that coincides with the realization of a pandemic.

4 Results

Figures 4, 5, 6, and 7 summarize our main short-run results. Each graph plots the impact of the covid shock in the year in which it hits the economy, i.e., in 2020. The first (dark blue) bar shows the effect on the economy without any policy response. The other bars respond to the four actual government policies: forgivable bridge loans (PPP, orange), regular bridge loans (MSLP, yellow), corporate bond purchases (CCF, purple), and the combination of all three (Combo, green). The last bar is for the hypothetical conditional bridge loan program (CBL, light blue).

4.1 Do Nothing

We first consider a (counter-factual) scenario in which the government does nothing new in response to the covid crisis. It continues its usual counter-cyclical spending and pro-cyclical tax policies, as well as its bank bailout policies. It issues short-term government debt to plug any hole in the deficit.

In the absence of policy, corporate defaults and loan losses skyrocket in response to the covid shock. The default rate in the non-financial sector goes from its normal level of 1.9% per year to 11.6%, a sixfold increase. The loss rate also increases by a factor of six to 5.8%.

These loan losses trigger credit disintermediation: the fraction of corporate debt held by savers (intermediaries) rises (falls) sharply from 16% (84%) before the crisis to 83% (17%). The loan losses not only cause a smaller but also a weaker banking sector. Financial fragility manifests itself in an increase in the bank failure rate— 56% of the banks become insolvent—

Figure 4: Policy Responses to Covid Crisis: Non-financial Firms

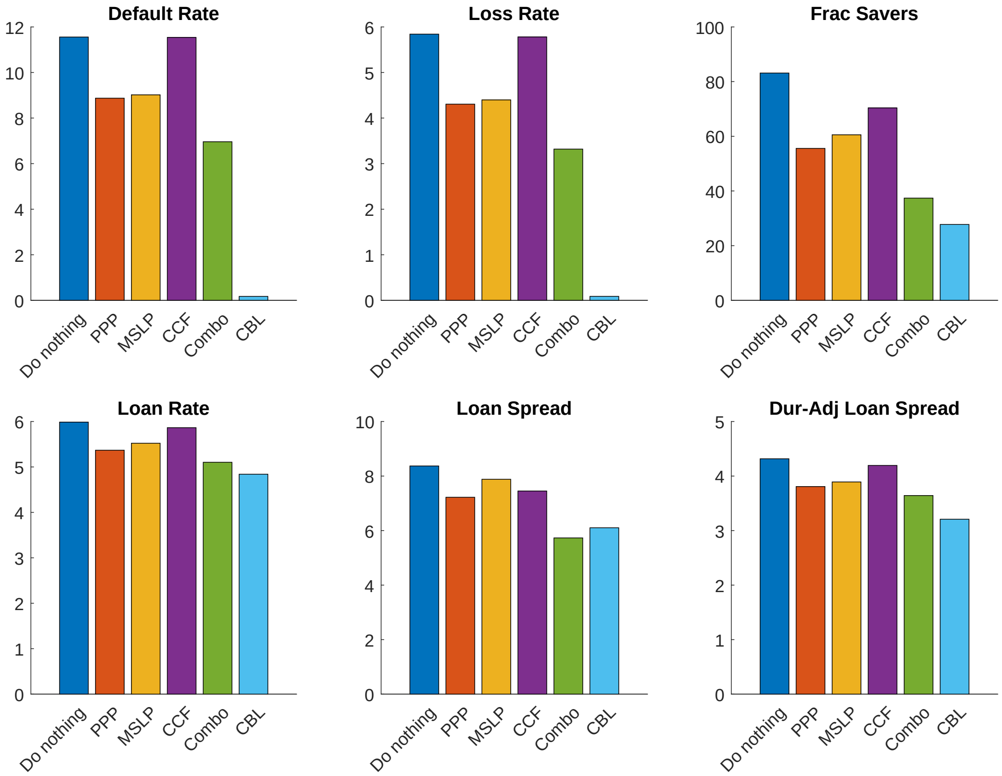
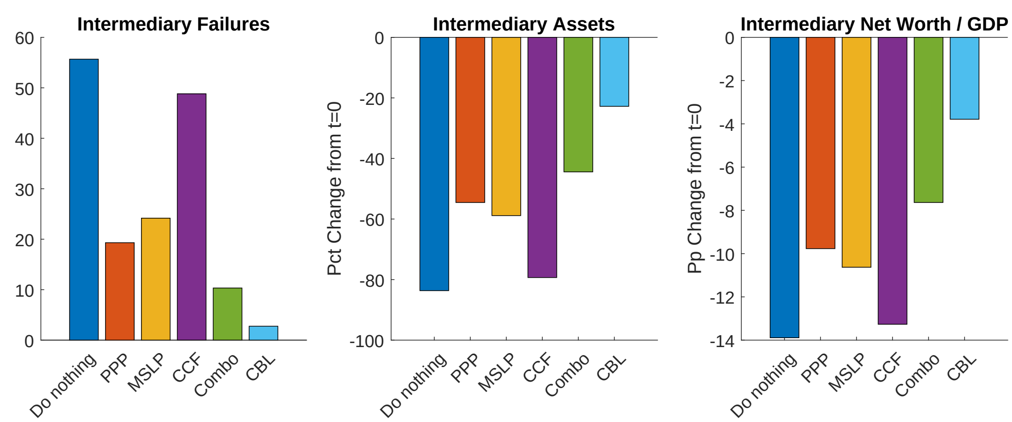


Figure 5: Policy Responses to Covid Crisis: Financial Intermediaries



and a decline in aggregate intermediary net worth, as shown in Figure 5. Higher credit spreads are a manifestation of the increased scarcity of banks' resources; they reflect not only a higher amount of credit risk but also a higher price of credit risk. The increase in the credit spread can be seen most clearly in the last panel of Figure 4 which plots a duration-adjusted loan spreads, as Figure 1 did for the data.

Faced with higher costs of debt, firms reduce investment. As shown in Figure 6, investment falls by 86%. Both firm and bank defaults create a surge in deadweight losses, which reduces resources available for investment or consumption. Aggregate consumption falls by 3.13%.

The economic downturn and the concomitant bank bailouts trigger a massive increase in the primary deficit which swells to 21% of $t = 0$ pre-covid GDP (short: GDP0) in the period of the shock. Government consumption (discretionary and transfer spending) is 3.5% points of GDP0 higher due to automatic stabilization programs (e.g., unemployment insurance, food stamps, etc.) and tax revenue falls by 5.0% points as a share of GDP0. However, the main spending increase comes from bailing out the banking sector to the tune of 15% of GDP0. Adding the interest service on the debt leads to a total of 24.4% of new debt that must be raised relative to current GDP, or equivalently 22.5% of GDP0. The one-year Treasury rate falls to -2.4% from a level of 2.2% before the crisis.

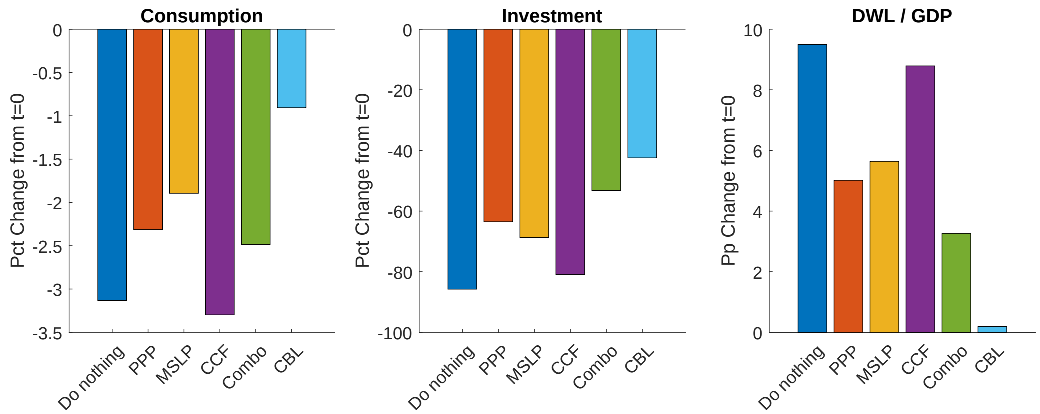
In sum, absent policy, the economy suffers a large decline in macro-economic activity, a rise in corporate defaults, a rise in bank defaults and loss in intermediary capacity, and a spike in credit spreads which feeds back on the real economy and discourages investment. The decline in economic activity depresses real interest rates, but the effect is offset by an increase in government debt due to counter-cyclical deficits, higher debt service, and bank bailouts. Can covid policy improve on this disastrous outcome?

4.2 PPP

The PPP policy (orange bars) provides forgivable bridge loans to all firms. The loans make a substantial dent in non-financial corporate defaults which fall by 2.7% points, a 23% reduction. This is enough to eliminate 2/3 of all bank bankruptcies. The fall in intermediary assets and net worth is also substantially smaller. The reduced financial distress mitigates the increase in the corporate loan rate. The intervention helps "close credit spreads." The forgivable loans put cash in firms' pockets which, combined with the lower loan rates, substantially reduce the fall in investment. Instead of falling by 86%, investment falls by 64%. Deadweight losses are half as large as in the do-nothing scenario.

Because PPP loans are forgivable, the direct effect of the policy is to add 13% of GDP0 to the

Figure 6: Policy Responses to Covid Crisis: Macroeconomy



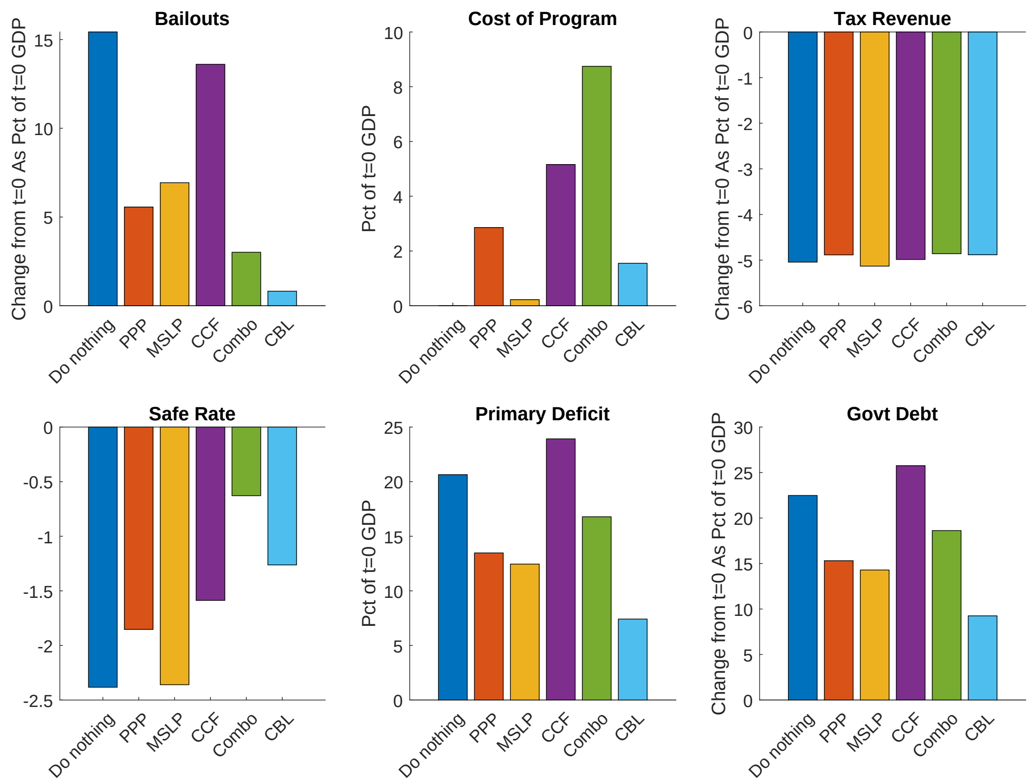
deficit. The policy also results in a 53 bps higher safe rate of interest which will cause higher debt service costs in the future. However, the policy saves about 9.9% of GDP0 in bank bailouts that do not occur. All told, the primary deficit is 13.5% of GDP0. The increase in debt is 15.3% of GDP0 which is 7.2% points lower than in the do nothing scenario. The government is saving money by spending money. The higher safe rate relative to the do-nothing case encourages saving over consumption. This helps explain why the fall in consumption is still 2.3% despite the sharp reduction in lost resources due to bankruptcies.

4.3 MSLP

Next we consider the MSLP (yellow bars), which gives regular bridge loans to firms with a 3% interest rate and 5% bank risk retention (95% government guarantee). The program has approximately the same size (2.8% of GDP vs. 3.1%) as the PPP. Even though the loans are not forgivable, the program is still successful at reducing firm defaults. Bank defaults are also lower than in the no-policy case (24.2%), but not quite as low as in the PPP (19.3%) because banks now share in some of the losses through the risk retention feature of the MSLP bridge loans. Because there is more residual financial fragility, credit spreads and interest rates on corporate loans remain somewhat more elevated than in the PPP. Corporate investment falls by 69%, a bit more than in the PPP.

The MSLP program is not expensive to the government since there is no debt forgiveness feature, and since most firms end up being able to pay back the loan. Yet, the program still

Figure 7: Policy Responses to Covid Crisis: Fiscal Policy



eliminates most bank bankruptcies, and saves much of the cost of bank bailouts. The primary deficit is about 12% of GDP0. The government must issue less new debt, 14.3% of GDP0. Lower new debt issuance helps keep the interest rate low, which in turn reduces the debt service going forward and the additional debt that needs to be issued. The safe rate of -2.4% is close to the do-nothing case, substantially lower than the 2.7% pre-pandemic level. The lower safe interest rate discourages saving and results in a smaller drop in aggregate consumption of -1.9%.

4.4 CCF

A large bond purchasing program of 8.9% of the stock of corporate debt (purple bars) is not very effective at mitigating the crisis. Loan losses are not reduced. More surprisingly, loan rates are not lowered much, only 12 basis points compared to the do nothing scenario. While the loan spread goes down 92 basis points, the effect is largely offset by an increase in the safe rate. Therefore, it is no surprise that the fall in investment is not very different compared to the no policy scenario. Similarly, the policy does not help much in terms of countering financial fragility. Bank bailouts are reduced, but by much less than under the other policies.

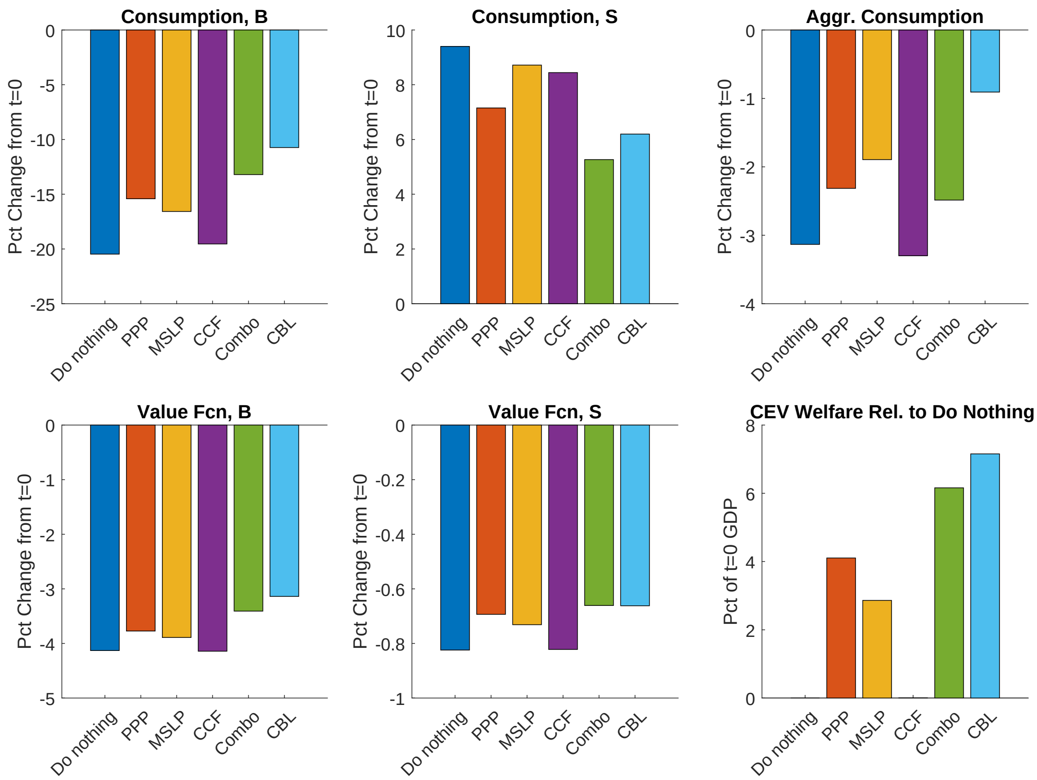
In order to finance the corporate debt purchases, the government must issue 8.9% of GDP worth of additional Treasuries. The primary deficit including the bond purchases is 23.9% of GDP0. The corporate bond purchases substantially increase safe interest rates relative to the do nothing scenario. The price effects on the debt imply that the government debt increases by 25.8% of GDP0, 3.3% points more than under no policy. The higher safe interest rates discourage consumption, which falls by 3.3%. Higher safe rates also increase the cost of funding for banks. This hampers their recapitalization and amplifies their financial fragility.

4.5 Combination Policy

The government is combining the three previous policies in reality. The results from the combo policy are plotted in the green bars. They are the model's closest prediction for what will happen by the end of 2020 after all policies have been fully rolled out. The three policies are a potent cocktail to fight the economic fallout from the pandemic. The policy combo lowers corporate defaults and losses by 40% compared to no policy. Bank bankruptcies are reduced by 80%, and bank net worth losses are only half as large as under no policy. Credit spreads are greatly reduced (by 264 bps), a place where the policy combination is more than the sum of the parts (256 bps). Safe rates fall by much less than other scenarios, which offsets some but not all of the effect of lower spreads on the corporate loan rate. Facing a lower cost of debt, investment falls by 53% compared to 86% under no policy. Higher safe rates mean a much larger debt service going forward. Yet the primary deficit of 16.8% of GDP0 is lower than under no policy. The government spends on policy measures less than what it would have spent on higher bank bailouts instead. Aggregate consumption falls by 2.5%, which is less than than under no policy.

Figure 8 summarizes the welfare effects of the various policies. The bottom row shows the change in value functions of borrowers and savers, relative to pre-pandemic period. The value function summarizes the expected, risk-adjusted discounted value of the current and all future consumption impacts. The bottom right panel shows a measure of how much permanent con-

Figure 8: Policy Responses to Covid Crisis: Welfare



Note: Aggregate welfare is unchanged under the CCF policy relative to the Do nothing scenario.

sumption the economy would be willing to give up to adopt each of the policies relative to a no-policy alternative. The CEV welfare measure aggregates the value functions of the two groups of households by their respective values of a dollar of consumption in the covid state; recall the welfare discussion in Section 3.1. The two bridge loan legs of the policy combo are both valuable, with the PPP being more valuable than the MSLP. The CCF does not increase welfare. Combined, they increase aggregate welfare by 6.2% of permanent consumption.

The top row of Figure 8 shows the first-period consumption response to the covid shock for each of the two agents. Borrowers, who are the shareholders of non-financial and financial firms, face a large drop in consumption and are substantially worse off. Savers consume more in the first period but, as we know from their value functions, are still worse off due to future consumption declines and the risk in consumption. Both agents benefit similarly from the policies.

4.6 Contingent Bridge Loans

The last policy we analyze assumes that banks make productivity-contingent loans (light blue bars). The loans are forgivable and 100% guaranteed by the government, just like the PPP loans. It is an alternative to the policies enacted, albeit a somewhat idealistic one given the informational requirements it imposes on the (banks who implement it on behalf of the) government. Nevertheless, the experiment is instructive. This policy eliminates nearly all corporate default. It also eliminates all bank default and most of the credit disintermediation. Bank net worth only falls by 3.8% of GDP rather than 13.9% under no policy. Since firms face a lower cost of debt under this policy than under the combo policy, investment falls by only 42%, the least among all experiments.

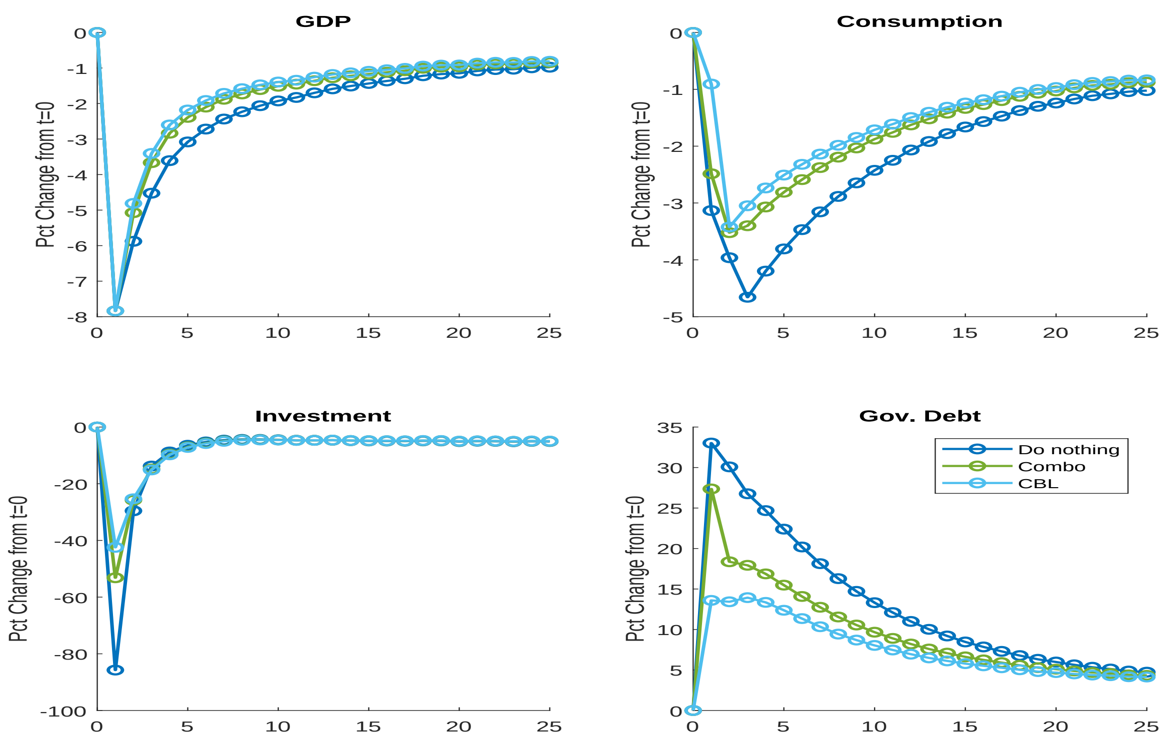
The size of this program is endogenous, and calibrated to eliminate all defaults. The cost ends up being 1.5% of GDP0. The lower direct fiscal outlay helps stem the rise in the primary deficit and the additional debt that needs to be raised. The primary deficit in the year of the covid shock is 7.4% of GDP0. Only 9.3% of GDP0's worth of new Treasury debt must be issued, 9% points less than under the combo policy. Interest rates are 63 bps lower than in the combo policy. Hence, this program is not only more effective at eliminating corporate defaults and improving the health of the banking sector, it also is cheaper for the government and results in smaller declines in aggregate consumption (-0.9%).

Welfare is 7.2% higher in the CBL scenario, an increase that is 1% greater than in the combo policy. We conclude that the real-life combo is not far off from a policy that seems much better targeted but (therefore) also much harder to implement.

4.7 Cumulative Effects

So far, we have analyzed only the first period of the covid shock. Figure 9 shows the long-run response of the macro-economic aggregates over 25 years. The model generates a very large cumulative loss in GDP, consumption, and investment as the economy transitions to a "new normal" in which rare pandemics are a fact of life. The sharp fall in investment is mostly a one-year phenomenon but it persistently depresses the stock of capital and hence the output-producing capacity of the economy. Persistence also comes from the two-year expected duration of the pandemic. Finally, intermediary recapitalization takes time and lends persistence to the crisis. The model produces a V-shaped recovery but with a long tail of modestly depressed economy activity. While the economy converges to the same long-run level regardless of the (one-time) pandemic policy, government intervention does substantially alter the paths along the transition. The CBL program boosts cumulative consumption over the transition path by 17% of pre-crisis GDP relative to the do nothing scenario, with the combo program not far behind at 12%.

Figure 9: Policy Responses to Covid Crisis: Long-run



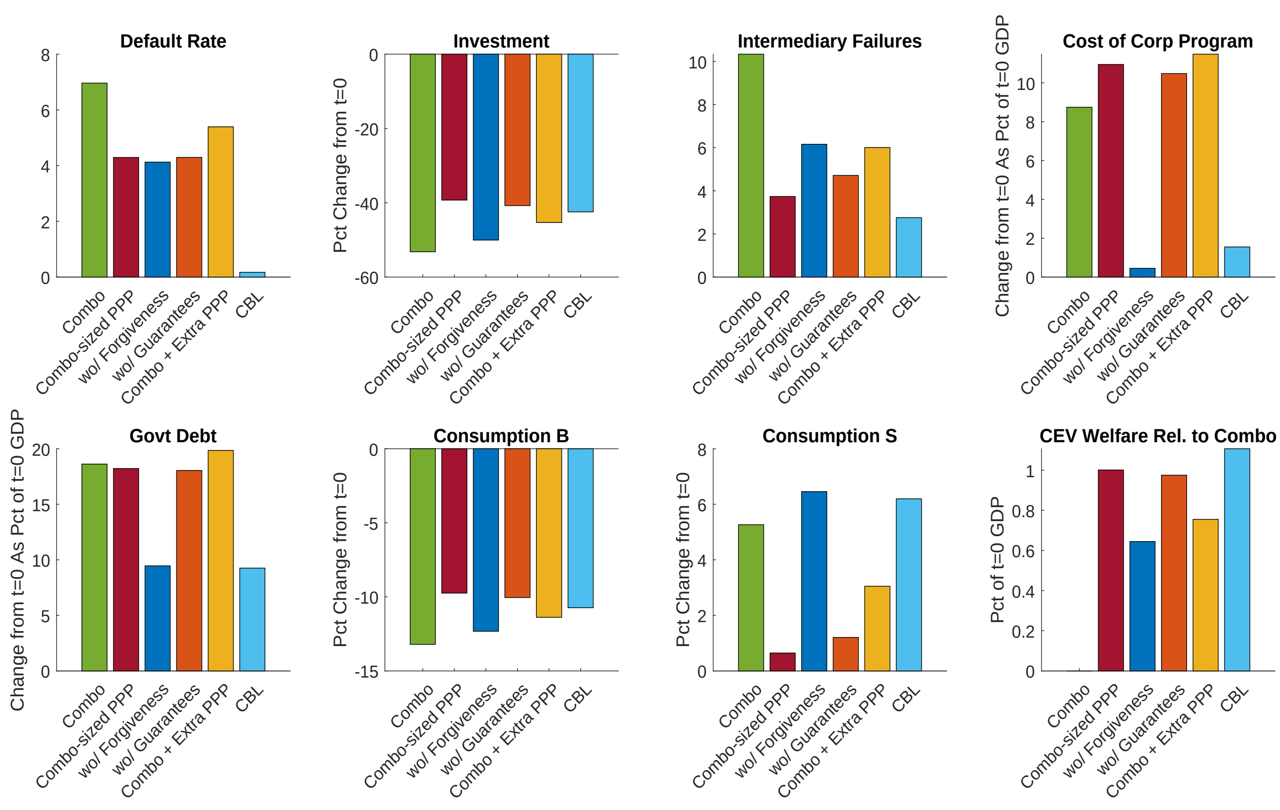
Note: this figure plots the increase in government debt as a percentage of its $t = 0$ level. Figure 7 plots the increase in government debt as a percentage of GDP0.

The last panel of Figure 9 shows the evolution of government debt, and suggests it will take a very long time to stabilize its level. Interestingly, even though the combo policy leads to only slightly lower expansion of debt, the debt is paid back faster than under no policy. This is due to the better health of the financial system along the transition path under the combo policy.

4.8 Some Policy Variations

The model can be used to evaluate the various levers inherent in the government policies. We consider four, summarized in Figure 10. In a first exercise, we envision that the government runs only a PPP but uses the combined resources of all three programs (9.8% of GDP). This "combo-sized PPP" is very effective at reducing bankruptcies, more so than the real-world combo policy. It promotes better financial stability and results in a smaller drop in investment. The program costs more, but saves more on bank bailouts, so that the increase in government debt is the same. It generates slightly higher welfare. The gains mainly accrue to borrowers who consume more in the crisis period at the expense of the savers.

Figure 10: Policy Levers: Some Variations



Next, we explore the effect of debt forgiveness. We keep the combo-sized PPP fixed but force firms to pay back the loans. The program becomes much cheaper to the government but is equally effective in terms of reducing corporate bankruptcies.[8] When firms need to repay

[8]There is a slight reduction in corporate bankruptcies through an equilibrium effect on wages which increases firm survival.

the loans, their net worth is lower, which leads to lower corporate bond prices in equilibrium. This lowers intermediary net worth and increases intermediary bankruptcies. Eliminating the forgiveness feature reduces welfare slightly.

Next, we turn back on loan forgiveness but switch off government guarantees. Banks bear all losses from corporate default, if any. Since the program is so effective at reducing defaults, eliminating government guarantees slightly increases intermediary failures but otherwise has only minor effects.

Finally, we consider an additional round of PPP loans, equal in size to the original PPP component of the Combo policy. This is the costliest policy, raising government debt the most. The additional PPP loans help bring down defaults and boost investment, but the policy is less effective than the other alternatives as it still includes the comparatively less effective MSLP and CCF legs.

In sum, a larger PPP effort with forgiveness and with government guarantees generates the highest welfare, closing almost the entire gap between Combo and CBL policies.

5 Long-Run Consequences

Eventually, the economy converges to a "new normal." Productivity and labor supply return to their steady-state values. Yet agents are still aware that once in a hundred years, a pandemic may strike. How does the steady state of this economy compare to that of the economy without pandemics? What are the long-term consequences of adding pandemics to the agents' information set?

Table 2 performs this comparison. Firm leverage adjust downward endogenously due to the higher inherent risk. This makes the economy safer, but also shrinks the size of the intermediary sector by about 5% of GDP. With less credit extended to the non-financial sector, the economy shrinks permanently. Further, investment and consumption growth are much more volatile. Both borrowers and savers are worse off. While borrower consumption volatility increases by over 23.1%, mean borrower consumption only falls by 0.3%. For borrowers, the reduction in GDP is partly offset by the expansion in equity financing of firms, which results in borrowers

Table 2: Long-Run Effects of a Pandemic State

	One-time Pandemic	Recurrent Pandemics
	Firms	
1. Mkt value capital/ Y	214.8	213.3
2. Book val corp debt/ Y	75.4	71.0
3. Book corp leverage	35.1	33.3
4. % producer constr binds	0.1	0.0
5. Default rate	1.90	2.02
6. Loss-given-default rate	48.7	46.2
7. Loss Rate	0.91	0.91
	Intermediaries	
8. Mkt val assets / Y	65.2	60.4
9. Mkt fin leverage	87.7	87.8
10. % intermed constr binds	73.0	86.9
11. Bankruptcies	0.01	0.54
12. Wealth I / Y	8.3	7.6
13. Franchise Value	6.8	7.5
	Savers	
14. Deposits/GDP	58.5	54.3
15. Government debt/GDP	71.2	73.7
16. Corp Debt Share S	15.5	16.6
	Prices	
17. Risk-free rate	2.21	2.21
18. Corporate bond rate	4.18	4.23
19. Credit spread	1.98	2.02
20. Excess return on corp. bonds	1.08	1.13
		% change
	Welfare	
21. Value function, B	0.263	-0.26
22. Value function, S	0.373	-0.38
23. DWL/GDP	0.612	12.57
	Size of the Economy	
24. GDP	0.986	-0.55
25. Capital stock	2.118	-1.22
26. Aggr. Consumption	0.633	-0.53
27. Consumption, B	0.262	-0.29
28. Consumption, S	0.371	-0.69
	Volatility	
29. Investment gr	9.20	79.32
30. Consumption gr	2.25	1.73
31. Consumption gr, B	2.74	23.06
32. Consumption gr, S	3.88	-6.81
33. Aggr. welfare* $\mathcal{W}^{cev}$		-8.72

*: Aggregate welfare is percentage of baseline GDP; see text.

capturing a larger share of aggregate income. Saver consumption declines by 0.7%, more than GDP. All told, households would be willing to pay 8.7% of baseline GDP to avoid the transition to the economy with infrequently occurring pandemics.

In Appendix D, we present the short-run impacts for a version of the model where the pandemic does not cause the realization that an economic shock like the pandemic could reoccur in the future. In other words, a pandemic shock lasts for one period. While "normal" i.e. non-pandemic levels of low TFP and high idiosyncratic productivity may persist, eventually the economy returns to its pre-pandemic state. A pandemic shock with no long-term consequences produces only a slightly milder crisis. The equilibrium impact of policies and their welfare ranking is unchanged.

6 Conclusion

The covid pandemic poses severe challenges for the economy of most developed countries. We focus on the health of the corporate sector and its ramifications for the health of the financial sector and the macro-economy. Absent policy intervention, a negative feedback loop between corporate default and financial intermediary weakness creates a macro-economic disaster. The Payroll Protection Program and Main Street Lending Program are effective at breaking the vicious cycle. They avoid most corporate bankruptcies and their financial sector and macro-economic fallout. In contrast, the corporate credit facility that buys corporate bonds is much less effective. Combined, the programs provide a potent cocktail that prevents 8.6% in cumulative output losses and creates huge welfare benefits compared to a do-nothing scenario. The interventions do have long-run fiscal implications, as well as effects for the long-run size of the non-financial and financial sectors.

Much work remains to be done. One could augment the model with a monetary sector and study how conventional and non-conventional monetary interventions interact with the corporate lending policies analyzed here. While we consider expansion of government transfer policies, the demand side of the model could be enriched as well. One could augment the model with an epidemiological block that captures the spread of the disease, introduce firms that produce different types of goods (social and private consumption) which are differentially affected, and endogenize labor supply. As the government programs are fully rolled out, it will be important to study their effectiveness using firm- and bank-level data. Our model can serve as a useful framework for hypothesis testing.

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A Targeted and Untargeted Bridge Loans

At the liquidity stage before defaults, firms receive a bridge loan $\bar{A}^{brP} \sum_j w_t^j l_t^j$ from banks, where $P \in \{T, U\}$ denotes the type of program, such that their profit is

$$\pi_t = \omega_t Z_t k_t^{1-\alpha} l_t^{\alpha} - (1 - \bar{A}^{brP}) \sum_j w_t^j l_t^j - a_t^P - \varsigma k_t. \tag{5}$$

This equation reflects that firms use the bridge loans for payroll expenses. Producers with $\pi_t < 0$ are in default and shut down. This implies a default threshold in the presence of bridge loans $\omega_t^{*,brP}$, given in equation (3) in the main text.

Non-defaulting firms immediately repay the bridge loan after the liquidity stage of the problem. Their net worth is only reduced by the interest payments associated with bridge loans, relative to the baseline model without such loans. The interest expense on the bridge loans, taking into account tax deductibility of interest, is:

$$(r^{br} + r^{gov})(1 - \tau^{\Pi}) \bar{A}^{brP} \sum_j w_t^j l_t^j.$$

Individual producer net worth at the beginning of next period becomes:

$$\begin{aligned} \Pi(\omega', \tilde{k}_t, \tilde{a}_t^P, \mathcal{S}_t) = {} & (1 - \tau^{\Pi}) \omega' Z_t^A \tilde{k}_t^{1-\alpha} \tilde{l}(\tilde{k}_t, \tilde{a}_t^P, \mathcal{S}_t)^{\alpha} - (1 - \tau^{\Pi}) \sum_j w_t^j \tilde{l}^j(\tilde{k}_t, \tilde{a}_t^P, \mathcal{S}_t) \\ & + \left((1 - (1 - \tau^{\Pi})\delta_K) p_t - (1 - \tau^{\Pi})\varsigma\right) \tilde{k}_t - \left(1 - \tau^{\Pi} + \delta q_t^m\right) \tilde{a}_t^P \\ & - (r^{br} + r^{gov})(1 - \tau^{\Pi}) \bar{A}^{brP} \sum_j w_t^j \tilde{l}(\tilde{k}_t, \tilde{a}_t^P, \mathcal{S}_t). \end{aligned} \tag{6}$$

This implies that bridge loans without interest and debt forgiveness, $r^{br} = r^{gov} = 0$, leave the net worth of surviving firms and their dividends unchanged. Aggregate firm net worth needs to be reduced by the collective interest expense on the bridge loans by integrating across producers. We denote the ω of the highest-productivity firm that receives a bridge loan as $\bar{\omega}_t^P$. For untargeted loans we have $\bar{\omega}_t^U = \infty$, implying that all firms receive loans, and for the targeted program $\bar{\omega}_t^T = \omega_t^*$, implying that only firms that would default without a bridge loan receive a loan. Thus aggregate interest is

$$r^{br}(1 - \tau^{\Pi}) \bar{A}^{brP} W_t \int_{\omega_t^{*,brP}}^{\bar{\omega}_t^P} dF_t(\omega) = \left(F_t(\bar{\omega}_t^P) - F_t(\omega_t^{*,br})\right) (r^{br} + r^{gov})(1 - \tau^{\Pi}) \bar{A}^{brP} W_t,$$

where we denote the aggregate wagebill of all firms as $W_t = \sum_j w_t^j \bar{L}^j$.

A.1 Banks

Bridge loans are junior to regular loans/bonds. Thus, defaulting firms do not pay back bridge loans. Lenders (banks and savers) apply bridge loan cash of defaulting firms towards the recovery value of regular loans/bonds. They can recover a fraction $1 - \zeta_t^{br}$ of each dollar of bridge loan. The total recovery per outstanding face value is:

$$M_t = \frac{F_{\omega,t}(\omega_t^{*,br})}{A_t^P}\left[(1-\zeta^P)\left(\omega_t^{-,brP}Y_t + ((1-\delta_K)p_t - \varsigma)\,K_t\right) - (1-(1-\zeta^{br})\bar{A}^{brP})W_t\right], \quad (7)$$

where we have defined

$$\omega_t^{-,brP} = \mathrm{E}_{\omega,t}\left[\omega \,|\, \omega < \omega_t^{*,brP}\right].$$

How bank wealth is affected by bridge loans depends on whether the government takes on losses incurred on these loans, i.e. whether it guarantees those loans. Aggregate bridge loan losses are:

$$\int_0^{\omega_t^{*,brP}} dF_t(\omega)\,\bar{A}^{brP}W_t = F_{\omega,t}(\omega_t^{*,brP})\bar{A}^{brP}W_t.$$

The variable I_{br} measures the fraction of losses that the government absorbs; it is between 0 (no guarantees) and 1 (full guarantee). We assume that banks receive the interest income from bridge loans, regardless of the government guarantees that are in place, as long as the interest rate on these loans is positive. Then bank net worth is:

$$N_t^{I,brP} = N_t^I + \bar{A}^{brP}W_t\left[(F_{\omega,t}(\bar{\omega}_t^P) - F_{\omega,t}(\omega_t^{*,brP}))r^{br} - (1-I_{br})F_{\omega,t}(\omega_t^{*,brP})\right],$$

where N_t^I is bank net worth in the baseline model without bridge loans.

A.2 Government

Government expenditure is

$$G_t^{br} = G_t + \bar{A}^{brP}W_t\left[I_{br}F_{\omega,t}(\omega_t^{*,br}) - (F_{\omega,t}(\bar{\omega}_t^P) - F_{\omega,t}(\omega_t^{*,brP}))r^{gov}\right],$$

where G_t is government expenditure in the baseline model without bridge loans. For the baseline case of full government guarantees $I_{br} = 1$ and debt forgiveness $r^{gov} = -1$, government spending goes up by $F_{\omega,t}(\bar{\omega}_t^P)\bar{A}^{brP}W_t$, i.e. the wage bill multiple $\bar{A}^{brP}$ for all firms that participate.

Taxes are

$$T_t^{br} = T_t - \tau^{\Pi}(F_{\omega,t}(\bar{\omega}_t^P) - F_{\omega,t}(\omega_t^{*,brP}))(r^{br} + r^{gov})\bar{A}^{brP}W_t.$$

Tax revenue is lower by the tax benefit to firms on bridge loan interest.

A.3 Deadweight Losses

DWL from bridge loans are

$$\zeta^{br}\eta^P F_{\omega,t}(\omega_t^{*,brP})\bar{A}^{brP}W_t.$$

These need to be added to aggregate deadweight losses from the baseline model. Similarly,

$$\zeta^{br}(1-\eta^P)F_{\omega,t}(\omega_t^{*,brP})\bar{A}^{brP}W_t$$

needs to refunded to households as a transfer.

B Conditional Bridge Loans

B.1 Firms

At the liquidity stage before defaults, firms with productivity below $\bar{\omega}_t^C$ receive a bridge loan $\bar{A}^{brC}(1-\omega_t)a_t^P$ from banks such that their profit is

$$\pi_t = \omega_t Z_t k_t^{1-\alpha} l_t^\alpha - \sum_j w_t^j l_t^j - (1 - \bar{A}^{brC} + \bar{A}^{brC}\omega_t)a_t^P - \varsigma k_t. \tag{8}$$

Firms now need to repay $\omega_t a_t^P$ in total, where a_t^P are the principal and interest payments due this period. Producers with $\pi_t < 0$ are in default and shut down. This implies a default threshold in the presence of bridge loans $\omega_t^{*,brC}$ given in equation (4) in the main text.

Non-defaulting firms immediately repay the bridge loan after the liquidity stage of the problem. Their net worth is only reduced by the interest payments associated with bridge loans, relative to the baseline model without such loans. The interest expense on the bridge loans, taking into account tax deductibility of interest, is:

$$(r^{br} + r^{gov})(1-\tau^\Pi)\bar{A}^{brC}(1-\omega_t)a_t^P.$$

Individual producer net worth at the beginning of next period becomes:

$$\begin{aligned}\Pi(\omega', \tilde{k}_t, \tilde{a}_t^P, \mathcal{S}_t) = {} & (1-\tau^\Pi)\omega' Z_t^A \tilde{k}_t^{1-\alpha}\tilde{l}(\tilde{k}_t, \tilde{a}_t^P, \mathcal{S}_t)^\alpha - (1-\tau^\Pi)\sum_j w_t^j \tilde{l}^j(\tilde{k}_t, \tilde{a}_t^P, \mathcal{S}_t) \\ & + \left((1-(1-\tau^\Pi)\delta_K)p_t - (1-\tau^\Pi)\varsigma\right)\tilde{k}_t - \left(1-\tau^\Pi + \delta q_t^m\right)\tilde{a}_t^P \\ & - (r^{br} + r^{gov})(1-\tau^\Pi)\bar{A}^{brC}(1-\omega')a_t^P. \end{aligned} \tag{9}$$

This implies that bridge loans without interest, $r^{br} = r^{gov} = 0$, leave the net worth of surviving firms and their dividends unchanged. Aggregate firm net worth needs to be reduced by the collective interest expense on the bridge loans by integrating across producers. To do this, we denote the aggregate bridge loan amount going to no-defaulting producers as

$$A_t^{brC} = \Big((1-F_t(\omega_t^{*,br}))(1-\omega^{+,brC}) - (1-F_t(\bar{\omega}_t^C))(1-\omega^{+,C})\Big)\bar{A}^{brC}A_t^P, \tag{10}$$

where we have defined

$$\omega_t^{+,brC} = \mathrm{E}_{\omega,t}\left[\omega \,|\, \omega \geq \omega_t^{*,br}\right]$$

and

$$\omega_t^{+,C} = \mathrm{E}_{\omega,t}\left[\omega \,|\, \omega \geq \bar{\omega}_t^C\right].$$

Total interest expenses for producers are

$$(1-\tau^\Pi)(r^{br} + r^{gov})A_t^{brC}.$$

B.2 Banks

Bridge loans are junior to regular loans/bonds. Thus, defaulting firms do not pay back bridge loans. Lenders (banks and savers) apply bridge loan cash of defaulting firms towards the recovery value of regular loans/bonds. They can recover a fraction $1 - \zeta_t^{br}$ of each dollar of bridge loan. The total recovery per outstanding face value is:

$$M_t = \frac{F_{\omega,t}(\omega_t^{*,brC})}{A_t^P} \left[(1-\zeta^P) \left(\omega_t^{-,br} Y_t + ((1-\delta_K)p_t - \varsigma) K_t \right) - \sum_j w_t^j \bar{L}^j + \bar{A}^{brC}(1-\zeta^{br})(1-\omega_t^{-,brC}) \right], \tag{11}$$

where we have defined

$$\omega_t^{-,brC} = \mathrm{E}_{\omega,t}\left[\omega \,|\, \omega < \omega_t^{*,brC} \right].$$

How bank wealth is affected by bridge loans depends on whether the government takes on losses incurred on these loans, i.e. whether it guarantees those loans. Aggregate bridge loan losses are:

$$O_t^{brC} = \int_0^{\omega_t^{*,br}} (1-\omega)\, dF_t(\omega)\, \bar{A}^{brC} A_t^P = F_{\omega,t}(\omega_t^{*,br})(1-\omega_t^{-,br})\bar{A}^{brC} A_t^P.$$

The variable I_{br} measures the fraction of losses that the government absorbs; it is between 0 (no guarantees) and 1 (full guarantee). We assume that banks receive the interest income from bridge loans, regardless of the government guarantees that are in place. Then bank net worth is:

$$N_t^{I,br} = N_t^I + r^{br} A_t^{brC} - (1 - I_{br}) O_t^{brC},$$

where N_t^I is bank net worth in the baseline model without bridge loans.

B.3 Government

Government expenditure is

$$G_t^{br} = G_t + I_{br} O_t^{brC} - r^{gov} A_t^{brC},$$

where G_t is government expenditure in the baseline model without bridge loans. As for the unconditional loans, the baseline case of full government guarantees with $I_{br} = 1$ and $r^{gov} = -1$ implies that government spending rises by the full amount of the loan program

$$F_t(\bar{\omega}_t^C))(1 - \omega^{-,C})\bar{A}^{brC} A_t^P,$$

with $\omega^{-,C} = \mathrm{E}_{\omega,t}\left[\omega \,|\, \omega < \bar{\omega}_t^C\right]$.

Taxes are

$$T_t^{br} = T_t - \tau^{\Pi}(r^{br} + r^{gov}) A_t^{brC}.$$

Tax revenue is lower by the tax benefit to firms on bridge loan interest.

B.4 Deadweight Losses

DWL from bridge loans are

$$\zeta^{br}\eta^P O_t^{brC}.$$

These need to be added to aggregate deadweight losses from the baseline model. Similarly,

$$\zeta^{br}(1-\eta^P)O_t^{brC}$$

needs to refunded to households as a transfer.

C Transitions With Unanticipated Shocks

This section uses the notation of Elenev, Landvoigt, and Van Nieuwerburgh (2020), Appendix B. In particular, we denote the sets of policy, transition and forecasting functions defined in ELVN by $\mathcal{C}_P$, $\mathcal{C}_T$ and $\mathcal{C}_F$, respectively. The timing of the unanticipated shocks is as follows:

- At the beginning of period t, the aggregate state of the economy is known and given by realizations of the state variables $[Z_t^A, \sigma_{\omega,t}, K_t, A_t^P, N_t^I, B_t^G]$.
- An unexpected shock to the parameter vector of the model hits at the beginning of t, before production or trade in any markets occur. Denote the vector of parameters in t by Θ_t.
- Agents observe the unexpected shock and adjust their decisions and expectations accordingly, believing that from $t+1$ onward the only stochastic events are characterized by the exogenous state variables $[Z_t^A, \sigma_{\omega,t}]$, and all parameters revert to the vector $\bar{\Theta}$, at which values they will remain forever after.

This timing implies that the dynamics of the economy from $t+1$ onward is fully characterized by the functions $\mathcal{C}^{(t+1)} = \{\mathcal{C}_P(\bar{\Theta}), \mathcal{C}_T(\bar{\Theta}), \mathcal{C}_F(\bar{\Theta})\}$. We first compute these functions by running the algorithm in ELVN to convergence for the baseline calibration of the economy $\bar{\Theta}$.

To solve for the dynamics following the unexpected shock, we need to solve for policy and transition functions $\mathcal{C}^t = \{\mathcal{C}_P(\Theta_t), \mathcal{C}_T(\Theta_t)\}$. Forecasting functions do not need to be separately computed for time-t parameters since we explicitly compute the transition from t to $t+1$, and apply forecasting functions $\mathcal{C}_F(\bar{\Theta})$ to the correct $t+1$ values of the aggregate state variables.

Intuitively, agent choices and market prices at t depend on parameters Θ_t *and* expectations of $t+1$ state variables for each possible realization of the exogenous shocks. The values of $t+1$ state variables in turn depend on time-t choices and prices. The algorithm in ELVN solves this fixed point problem iteratively for a constant parameter vector $\bar{\Theta}$. For any given iteration, the algorithm does not enforce that agents' expectations of next period's aggregate state are consistent with today's choices and prices. However, as the algorithm converges, current period decisions and expectations about next period's state become mutually consistent. This approach is tractable even for large models with many state variables, since it keeps the system of equations that must be solved at each point in the state space as small as possible. However, it no longer works with a one-time unexpected shock Θ_t.

Hence, in case of an MIT shock, we need to solve for policy and transition functions from t to $t+1$ jointly. In practice, this means that in period t, we need to solve the system of equations (E1) – (E15) from Step 2.C of ELVN's algorithm jointly with transition functions (T1) – (T4) from Step 2.D. The system of equations that needs to be solved thus consists of the 15 equilibrium conditions in (E1) – (E15), and $4N^x$ additional equations that apply (T1) – (T4) for each possible realization of the exogenous aggregate state in $t+1$ (there are N^x possible realizations). Expectations for $t+1$ are computed under the assumption that from then on, the economy will follow the law of motion given by $\mathcal{C}^{(t+1)}$.

Solving for policy and transition functions jointly guarantees that these function are mutually consistent and agents are optimally responding to the shock Θ_t. Our approach to computing transition paths after unexpected shocks is therefore similar to what the algorithm developed in Cao and Nie (2017) refers to as "consistency equations". Unlike the transition function approach of ELVN, Cao and Nie (2017) apply consistency equations at each iteration of the algorithm, unrelated to transitions after unexpected shocks.

D Pandemic as a One-Time Shock

We perform the same experiments as in Section 4, but now without assuming that agents' expectations take into account the possibility of future pandemics. In these experiments, the pandemic hits unexpectedly, persists for one period, and then the economy converges back to its original steady state consistent with the laws of motion for the two exogenous state variables: TFP and idiosyncratic productivity dispersion.

Figure D.1: Policy Responses to Covid Crisis: Non-financial Firms

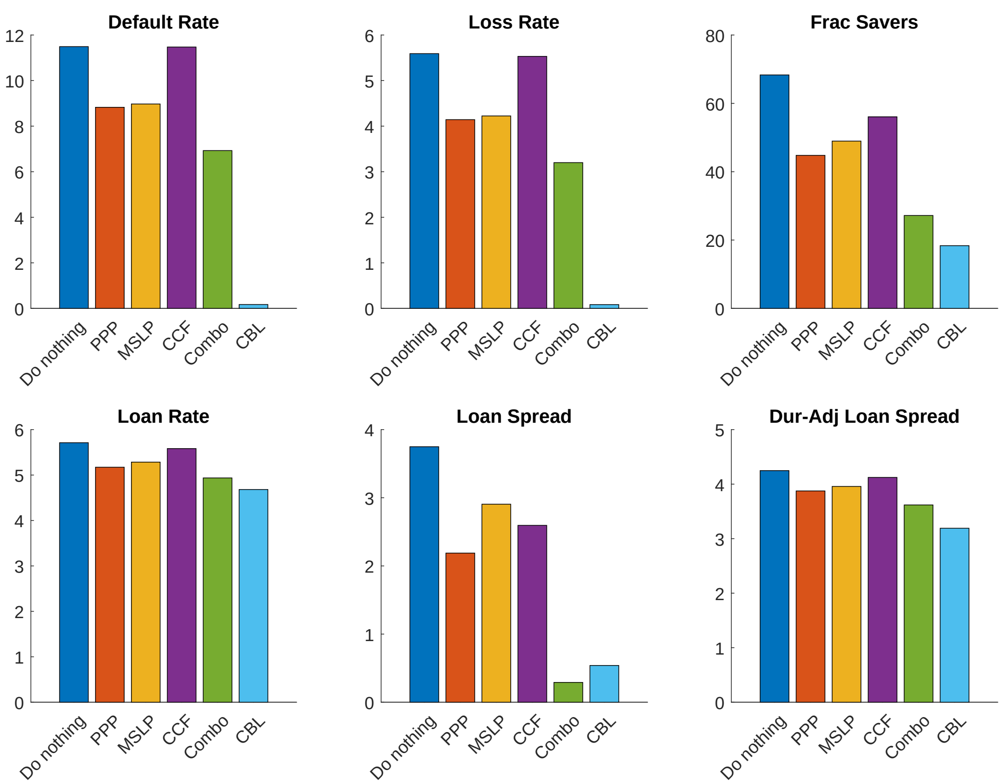


Figure D.2: Policy Responses to Covid Crisis: Financial Intermediaries

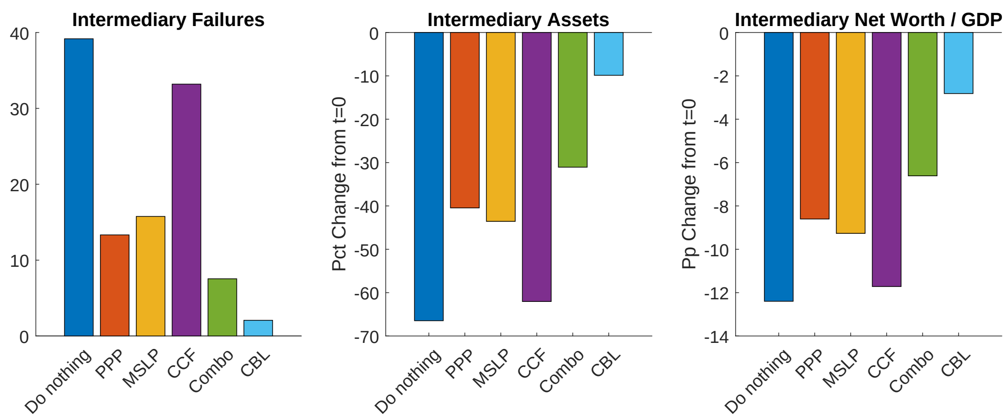


Figure D.3: Policy Responses to Covid Crisis: Macroeconomy

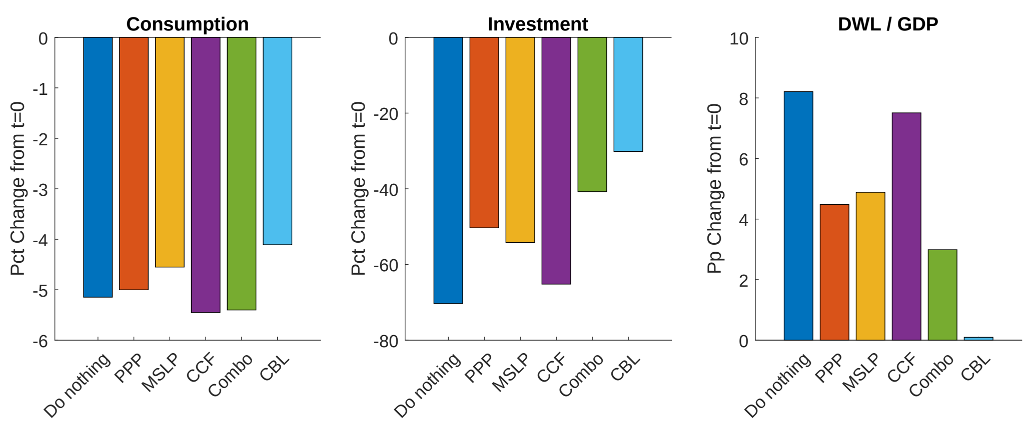


Figure D.4: Policy Responses to Covid Crisis: Fiscal Policy

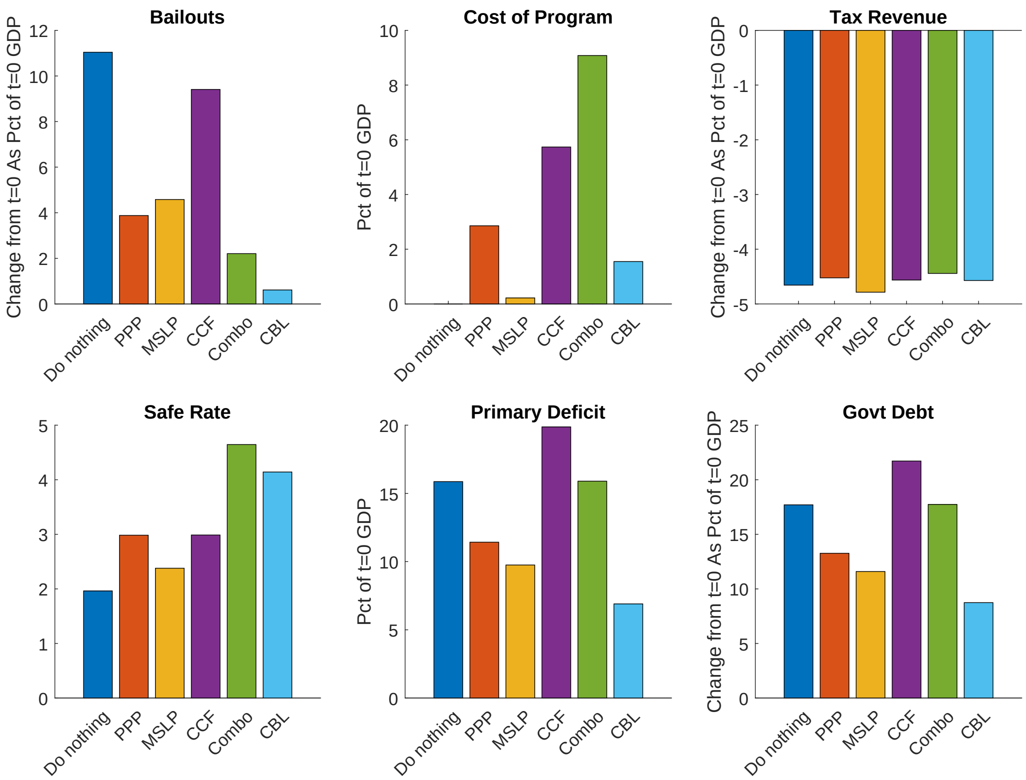
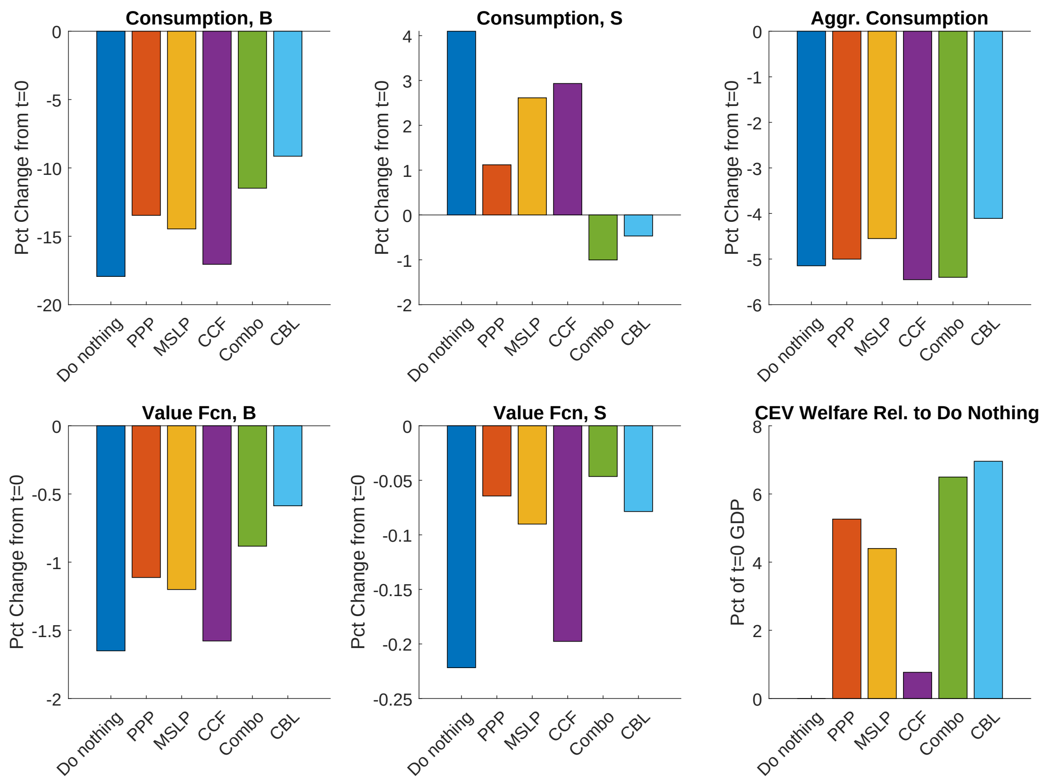


Figure D.5: Policy Responses to Covid Crisis: Welfare



Note: Aggregate welfare is unchanged under the CCF policy relative to the Do nothing scenario.

Figure D.6: Policy Responses to Covid Crisis: Long-run