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**Pandemic Recession Dynamics: The Role of Monetary Policy in
Shifting a U-Shaped Recession to a V-Shaped Rebound**

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Pandemic Recession Dynamics: The Role of Monetary Policy in Shifting a U-Shaped Recession to a V-Shaped Rebound

Michael T. Kiley¹

August 31, 2020

Abstract

COVID-19 has depressed economic activity around the world. The initial contraction may be amplified by the limited space for conventional monetary policy actions to support recovery implied by the low level of nominal interest rates recently. Model simulations assuming an initial contraction in output of 10 percent suggest several policy lessons. Adverse effects of constrained monetary policy space are large, changing a V-shaped rebound into a deep U-shaped recession absent large-scale Quantitative Easing (QE). Additionally, the medium-term scarring on economic potential can be large, and mitigation of such effects involves persistently accommodative monetary policy to support investment and long-run productive capacity. The simulations also illustrate the importance of coordinating QE and interest rate policy. Finally, the simulations, conducted within a model developed prior to the pandemic, illustrate limitations in economists' understanding of QE and the channels through which shocks like a pandemic affect medium-term economic performance.

JEL Codes: E52, E58, E44, E37

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1. Introduction

The COVID-19 pandemic has severely depressed economic activity. In the three months to May 2020, employment in the United States declined by 20 million—the most rapid and largest decline in employment in U.S. history. U.S. real Gross Domestic Product (GDP) contracted 10 percent in the second quarter of 2020, the largest decline ever recorded. Global economic activity has similarly contracted at an unprecedented pace in the first half of 2019. The depressed level of economic activity may persist for some time, even if the pandemic subsides quickly, as declines in employment and income lead to further pullbacks in consumption and investment and a weakening in household, business, and financial institution balance sheets.

The most critical policies to support economic activity involve medical and public-health efforts that would allow economic activity to proceed safely, without placing people at undue health risk. Supportive fiscal and monetary policies can also mitigate the adverse economic dynamics associated with declines in employment and income. But the space for monetary policy to support activity through reductions in the short-term nominal interest rate is limited.

Specifically, nominal interest rates were low by historical standards prior to the pandemic, owing to a range of structural shifts.² In late 2019, nominal interest rates from the overnight to a 10-year maturity averaged between 1.5 and 2 percent. In March 2020, the Federal Open Market Committee reduced the target range for the federal funds rate to near zero, a value at least near its effective lower bound. As a result, monetary policy, through reductions in short-term interest rates, will be constrained in its ability to provide further support to a recovery. Previous research has suggested that the effective lower bound (ELB) would amplify even a mild recession. At

² For a review of economic research in this area, see Kiley (2019b) and Kiley (2020).

least the initial phase of the COVID-19 downturn will be extremely sharp, not mild, pointing to the possibility of significant amplification owing to limits on traditional monetary stimulus.³

These developments point to three issues for analysis. The first is the degree to which constraints on monetary policy may amplify the COVID-19 recession. The second is the degree economic dynamics imply persistent declines in living standards following even purely transitory direct effects of the pandemic, and the degree to which monetary policy may mitigate these effects by stimulating investment to maintain productive capacity. The final is a set of limitations regarding economists understanding of these issue, including regarding the effects of QE in government bonds or private securities on financial markets and real activity and the impact of the pandemic on monetary transmission channels.

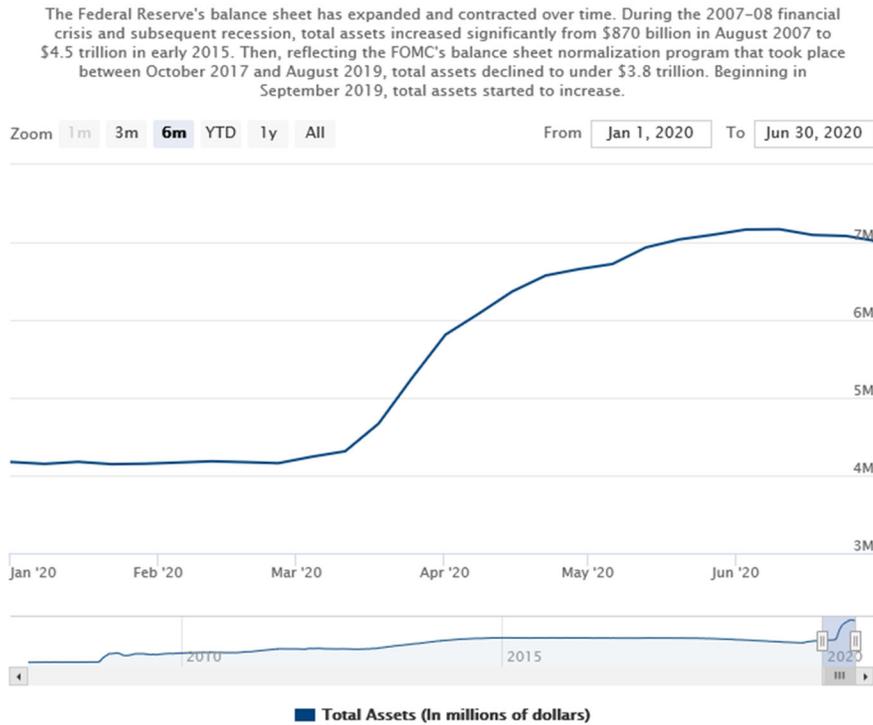
The analysis herein addresses each of these questions, focusing on the first two issues. Using a standard dynamic-stochastic-general-equilibrium (DSGE) model (Gertler and Karadi, 2013), I analyze the degree of amplification from the ELB and the volume of QE required to offset this amplification. Amplification is large: absent additional policy actions, the ELB doubles the adverse effects of the pandemic. Moreover, a U-shaped recession, rather than V-shaped rebound, follows the pandemic, with the economy's productive capacity persistently depressed absent sizable QE. These large effects reflect the structure of typical monetary-policy models and may overstate amplification owing to elements of the model's structure or the absence of other policy support (e.g., fiscal policy).⁴

³ Previous research has found a significant likelihood that short-term nominal interest rates would fall to their effective lower bound for an extended period and that such a constraint impedes economic performance a great deal (e.g., Kiley and Roberts, 2017; Bernanke, Kiley, and Roberts, 2019; Reifschneider and Wilcox, 2019; Kiley, 2020a).

⁴ Kiley (2016b, 2019a) and McKay, Nakamura, and Steinsson (2016) discuss the amplification in standard models. While research has questioned the degree of amplification, such models remain benchmarks in the literature (e.g., Andrade et al, 2020).

Under the baseline calibration involving an initial contraction in real GDP of 10 percent (as reported in the United States in the second quarter of 2020) and assuming the effects of QE on long-term government bond yields as modeled previously, QE equal to 30 percent of (nominal) GDP, or about \$6½ trillion dollars, is required to offset the impact of the ELB. Note that the Federal Reserve initiated purchases of securities and a number of 13(3) facilities following the onset of COVID-19, and its balance sheet had increased by \$3 trillion between February and the end of June 2020 (figure 1). Within the DSGE model, QE stabilizes markets through relaxation of financial constraints facing financial intermediaries, in a manner akin to the mechanisms that appear to have motivated Federal Reserve actions.

Figure 1: Federal Reserve’s Balance Sheet



The analysis reveals two additional insights. First, QE supports economic activity by easing balance sheet constraints on financial intermediaries and relaxing financial conditions more

broadly, thereby supporting interest-sensitive spending. Within the model, QE prevents a large contraction in investment spending. As a result, the productive capacity of the economy is preserved. A consequence of such preserved productive capacity is avoidance of a highly persistent drag on living standards.

The simulations also highlight how the effects of QE similar to those of reductions in short-term nominal interest rates, at least in terms of GDP, the labor market, productive capacity, and inflation. This similarity highlights the need for coordinated QE and interest rate policy. For example, QE in excess of 30 percent of GDP results in a stronger economy and higher inflation, and hence results in a more rapid increase in short-term nominal interest rates. As a result, the additional impact of much larger amounts of QE is minimal—that is, QE runs in to diminishing returns in terms of effects on output, the labor market, and inflation if it is not accompanied by additional accommodation through lower short-term interest rates than implied by the central bank’s normal reaction function. This finding implies that it is important for the strategy underlying QE to be coordinated closely with short-term interest rate policy. It also implies that the benefits of QE largely accrue through its ability to provide accommodation while at the ELB and that the use of QE outside ELB episodes may bring modest benefits. These findings echo those in, for example, Kiley (2018).⁵

Within the model, QE in private securities is more effective, on a per-dollar purchased basis, than QE in government bonds. This finding is directly from Gertler and Karadi (2013) and stems

⁵ Regarding inflation, the analysis modifies the model in Gertler and Karadi (2013) to incorporate a very flat Phillips curve. The flat Phillips curve used in the model implies a sharp but very transitory decline in inflation associated with the decline in spending, with inflation rising modestly above its 2 percent target during the recovery. These dynamics highlight how a flat Phillips curve implies that the primary driver of monetary accommodation is the course of spending relative to long-run potential as revealed in labor-market developments. The qualitative conclusions, as well as many of the quantitative conclusions, are not significantly altered using the Phillips curve in Gertler and Karadi (2013) except with respect to inflation, as reported in appendix 3.

from the assumption in the model that the limits to arbitrage imposed by the balance sheet constraints of financial intermediaries are larger for private securities. (Note that this assumption is consistent with typical trading conditions, in which spreads and transaction costs are much higher for corporate bonds than Treasury securities.) While the result stems directly from earlier findings, it is worth highlighting as Federal Reserve actions since March 2020 have included emergency 13(3) facilities to purchase corporate bonds and bank loans to businesses.

Finally, the model simulations highlight a number of additional important considerations in shaping monetary policy responses within the model. First, monetary accommodation stimulates interest-sensitive spending within the simulation, reflecting the nature of the transmission mechanism in standard monetary-policy models (Boivin, Mishkin, and Kiley (2010)). Standard monetary policy models may fail to capture how pandemic shocks affect investment and other decisions, highlighting the value of integrating macroeconomic and epidemiological models. Such research is growing rapidly, but often does not incorporate monetary-policy channels or inflation dynamics.⁶

Section 2 outlines the model used for the analysis and the relationship of the analysis to some recent related research. Section 3 discuss the degree to which the ELB amplifies a stylized pandemic shock and to which QE relaxes this amplification, thereby governing whether a V-shaped rebound or deep U-shaped recession ensues. Section 4 highlights the role of monetary policy in mitigating the adverse effects of a pandemic on productive capacity over the medium term. Section 5 discusses a range of issues meriting further study, including the coordination of

⁶ As emphasized earlier, see https://www.nber.org/wp_covid19.html#4.

QE and short-term interest rate adjustments, the relative efficacy of government bond and private security purchases within the model, and modeling of the macroeconomy following a pandemic.

2. The Model and Related Literature

An assessment of the amplification of the COVID-19 shock owing to constraints on monetary policy requires a framework with (at least) three features. The initial impact of the shock must be accounted for in some way. Economic dynamics then propagate the shock. And, finally, monetary policy actions cushion such impacts.

2.1. A Macroeconomic Model with Conventional and Unconventional Monetary Policy

Standard macroeconomic models have focused on propagation and the role of monetary policy, but have not considered the impact of a pandemic. Research is rapidly emerging to fill this gap. For example, Bodenstein, Corsetti, and Guerrieri (2020), Eichenbaum, Rebelo, and Trabandt (2020), and Guerrieri et al (2020) each develop a model in which the effects and trajectory of a pandemic follow epidemiological principles and interact with economic activity through effects on production and other decisions. Such approaches involve complications of their own, and hence these authors do not consider monetary policy, the ELB, or QE.

The analysis herein takes a different approach. I use a standard macroeconomic model (Gertler and Karadi, 2013) that includes short-term interest rates and purchases of government or corporate bonds as instruments of monetary policy. The model includes rich propagation mechanisms, including those associated with investment dynamics and consumption smoothing as well as through financial institutions. The model is calibrated as in Gertler and Karadi (2013), with one exception: The calibration assumes that nominal prices are more rigid than in the calibration of Gertler and Karadi (2013), as a shortcut to modeling a very flat Phillips curve.

Two aspects of the model are central to the analysis (and appendix 1 provides the complete model). First, the key mechanism underlying the efficacy of QE in the model is the constraint that asset market activity is intermediated by financial institutions whose intermediation activities are limited by their net worth. (That is, the model has an (endogenous) capital constraint facing intermediaries that limits arbitrage.) Moreover, these frictions are larger for private securities/loans than for government bonds. As a result, shocks that lower the net worth of intermediaries result in a tightening of financial conditions facing nonfinancial firms and resulting adverse effects on economic activity via a financial accelerator. These effects will occur in the pandemic shock scenario and be a critical source of amplification.

A second key set of mechanisms involves how the pandemic affects economic activity. The COVID-19 shock is assumed to affect via two channels .First, the shocks lowers the desired consumption of goods and services and willingness to work, very sharply and for on quarter only; in modeling terms, the shock hits the marginal utility of consumption and the marginal rate of substitution between consumption and labor (thereby inducing reduced willingness to work).. This disturbance is consistent with the notion that the pandemic and associated social distancing led households to step back from many normal consumption and labor-market activities. The purely transitory nature of the shock is consistent with a scenario in which social distancing and health concerns recede quickly. Second, the pandemic lowers the quality of productive capital for one-quarter. The pandemic is modeled as two shocks in order to deliver similar-sized (and double digit) declines in consumption and investment along with a large decline in labor input. (Note that the individual shocks would tend to depress consumption or investment while raising the other, necessitating tow shocks. While a decline in total factor productivity would lead to declines in both consumption and investment, it would also tend to lead to a decline in

leisure/increase in labor input—and hence is not chosen). These assumptions, while imperfect, allow a focus on the effects of changes in the model’s state variables on subsequent economic dynamics—that is, the shocks are purely transitory, and all dynamics reflect the propagation channels stemming from the short-lived initial declines in consumption, investment, wealth, and other endogenous state variables. Some research has considered more precisely how to model a pandemic shock, for example how the closing of production chains and impediments to activity associated with social distancing lower the productivity of workers on the job.⁷

2.2. Monetary Policy Assumptions

Monetary policy involves two instruments in the model.

The short-term nominal interest rate, $i(t)$, is governed by an inertial Taylor (1999) rule governing the desired level of the rate $i^*(t)$ and is subject to an effective lower bound of zero. The simulations assume a steady-state real interest rate of 0 (consistent with evidence in, for example, Kiley (2019b)) and an inflation target of 2 percent, implying the nominal interest rate is determined by

$$i(t) = \max(i^*(t), 0)$$

$$i^*(t) = 0.85i^*(t) + 0.15(2 + 1.5(\pi(t) - 2) + y(t))$$

where $\pi(t)$ is inflation and $y(t)$ is the output gap, measured as labor market slack (the deviation of hours worked from their long-run level). Note that the policy rule includes the lagged shadow rate $i^*(t)$, not the lagged actual rate $i(t)$; this feature delivers additional accommodation following an ELB episode in a manner that improves economic stability around ELB episodes (e.g., Kiley

⁷ Such effects are discussed narratively in, for example, Baldwin and Weder di Mauro (2020), and some models include formal mechanisms that generate such effects, for example, Bodenstein, Corsetti, and Guerrieri (2020).

and Roberts, 2017; Bernanke, Kiley, and Roberts, 2019) and embodies a spirit of “lower interest rates for longer”.

QE ($QE(t)$) is governed by a simple autoregressive process, as in Reifschneider (2016) and Kiley (2018), implying a rapid increase a moderate decrease in central bank asset holdings following an initial purchase $e(t)$:

$$QE(t) = 1.5QE(t - 1) - .55QE(t - 2) + e(t).$$

Such purchases may consist of government bonds (i.e., in the model outlined in appendix 1, $B_g(t)$) or in corporate debt (i.e., denoted $S_g(t)$ in Gertler and Karadi (2013) and appendix 1).

This approach to QE is similar to previous research, such as Reifschneider (2016) and Kiley (2018). In general, previous research has not examined how monetary policy can ameliorate the COVID-19 shock and the relative role of short-term nominal interest rates and alternative types of QE. An exception is Sims and Wu (2020b), which considers how QE in government bonds and private securities can stimulate activity. The analysis in Sims and Wu (2020b) is akin to the analysis in Gertler and Karadi (2013) in that it focuses on mechanisms that may imply that QE in private securities may be more powerful than QE in government bonds; Sims and Wu (2020b) do not consider any shocks that may capture aspect of the pandemic nor do they consider the effects of the ELB. Notably, the model in Sims and Wu (2020b) differs from the model of Gertler and Karadi (2020) used herein by including financial frictions facing intermediaries and nonfinancial (production) firms. All told, the analysis herein is significantly different than Sims and Wu (2020b) in focusing on the size of the ELB constraint associated with COVID-19, its implications for the shape of the recovery, the required magnitude of QE needed to offset the

ELB constraint, the role of coordination between QE and interest rate policy in diminishing returns to QE, and the relative efficacy of purchases of government bonds and private securities.

3. Amplification of a Pandemic Shock via the ELB

The initial baseline scenario has three elements. First, large and transitory adverse shocks to the marginal utility of consumption and work ($\zeta(t)$, as specified in appendix 2) and to capital quality ($\xi(t)$, as specified in appendix 2) generate a pullback in economic activity. Second, the short-term nominal interest rate follows the inertial Taylor (1999) rule and is constrained by an effective lower bound (ELB). The economy is assumed to be hit by the shock while at steady state with an equilibrium real interest rate of 0 percent and inflation target of 2 percent (both at annual rates), implying the ELB binds at 2 percentage points below its initial level. Third, the baseline case includes QE in government bonds, as a device to illustrate Federal Reserve actions beginning in March 2020. The magnitude of QE in government bonds is calibrated to replace monetary accommodation precluded by the ELB; note that this is a modeling assumption designed to illustrate key issues and is not a forecast of likely Federal Reserve actions, as such actions would likely depend on policymakers' assessment of the economic outlook and views on the transmission of QE to policy goals—both of which may differ from the predictions of the model, especially in light of other government policy actions such as fiscal responses.

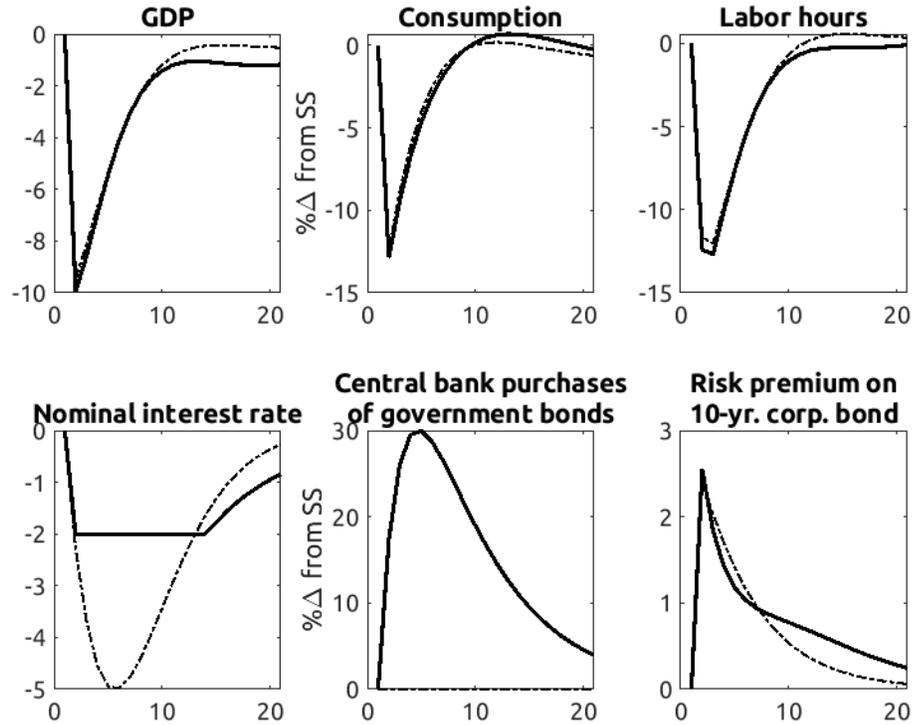
Putting these assumptions together, the overall shocks are calibrated to lead to a decline in real GDP of 10 percent in the first quarter of the pandemic, a magnitude in line with the initial estimate of the decline in U.S. real GDP in the second quarter of 2020 (released by the Bureau of Economic Analysis on July 30, 2020).

Figure 2 highlights the effect of the assumed shock on economic activity and financial conditions in the baseline case involving QE. Real GDP declines 10 percent (upper left panel, black solid line), the short-term nominal interest rate quickly declines to its assumed effective lower bound of 0 percent (lower left panel, solid black line), and QE rapidly increases the central banks holdings of government bonds, by 17 percent of GDP in the initial quarter and ultimately by 30 percent of GDP after three quarters. In dollar terms, the increase in the initial quarter would be about \$3½ trillion, slightly more than the increase in the Federal Reserve’s balance sheet between March and June 2020, and the peak increase would be in excess of \$6 trillion, given the level of U.S. nominal GDP.

The short-term nominal interest rate is constrained by the ELB for about four years, despite a rapid recovery in economic activity. Consumption and labor input contract sharply and rebound quickly. Moreover, the adverse effects of the shocks on the financial sector’s net worth lead to a sharp rise in the risk premium on a 10-yr. corporate bond over the safe interest rate over that same period (lower right panel), by about 250 basis points.

Figure 2 also includes outcomes when the ELB on the short-term nominal interest rate is removed and QE is not undertaken (the dashed lines). Note that the outcomes are very similar for all variables, illustrating how QE amounting to 30 percent of GDP approximately alleviates the ELB constraint. All told, a V-shaped recovery occurs when monetary policy jointly holds the short-term nominal interest rate at its ELB for four years and rapidly undertakes QE.

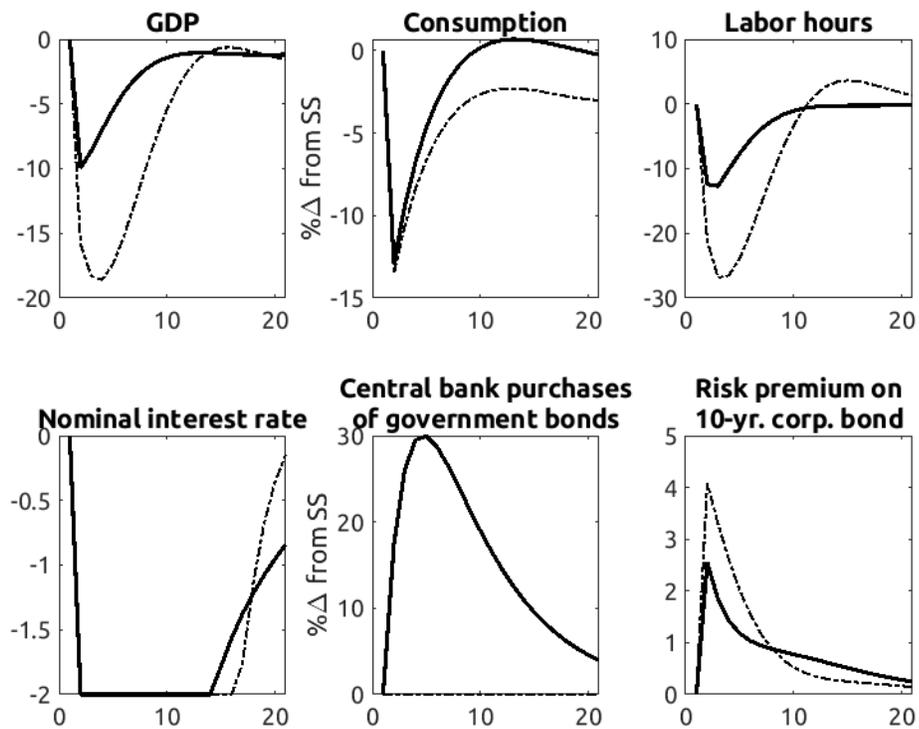
**Figure 2: Impact of COVID-19 Shocks: Baseline Case (solid lines)
and Case without an ELB (dashed lines)**



The importance of monetary policy to the V-shaped recovery, and in particular the combination of sustained low levels of the short-term interest rate and QE, can be seen by considering outcomes in the absence of QE, reported in figure 3. The solid black lines present the baseline outcomes with QE from figure 2, and the black-dashed lines report outcomes in the absence of QE. Several results are apparent. In the absence of QE, the ELB amplifies the severe recession sizably, arguably bringing economic activity to depression-like levels. Real GDP reaches a trough nearly 20 percent below its baseline value and the depressed level of GDP is much more persistent, reflecting the prolonged effect of the decline in economic activity on the productive capacity of the economy through lower investment. The amplification is even greater

on hours worked, which fall to a trough 25 percent below baseline (lower left panel). Note that the adverse impact of the pandemic on living standards, as measured by aggregate consumption, is substantial, with consumption remaining 3 percent below steady-state five year (20 quarters) after the shock (upper middle panel).

Figure 3: Impact of COVID-19 Shocks: Baseline Case (solid lines) and Case without QE (dashed lines)



The decline in economic activity leads to a sharp tightening in financial conditions, with the risk premium on the 10-yr corporate bond rising to 400 basis points (lower-middle panel) in the absence of QE.⁸ Comparing the risk premium paths with and without QE, the simulations show

⁸ The 10-yr. risk premiums reported are approximations computed as the average risk premium on one-quarter securities expected to prevail over the subsequent 10 years.

QE lowering the risk premium by about 150 basis points, or about 50 basis points for QE of 10 percent of GDP. These QE effects are consistent with previous evidence. For example, the survey of empirical results in Gagnon (2016) reports a median estimate of the impact of QE on the 10-yr Treasury of just below 50 basis points, and Kiley (2016a), Gilchrist, Lopez-Salido and Zakrajsek (2015), and Rogers, Scotti and Wright (2014) all report approximately complete pass through of declines in Treasury yields to corporate bond yields. This combination of studies suggests previous empirical evidence is in line with an effect on long-term corporate bond spreads of about 50 basis points from QE in long-term Treasury securities in an amount equal to 10 percent of GDP.

More generally, the simulations suggest that the ELB could amplify the COVID-19 shock substantially. Note that amplification would be even greater if the Phillips curve were not as flat as assumed.⁹ All told, monetary policy actions—a combination of low short-term nominal interest rates and sizable QE—prevent a prolonged U-shaped recession that would be substantially more painful than would occur in the absence of an ELB constraint on monetary policy.

4. Monetary Policy and Medium-term Living Standards Following the Pandemic

The pandemic shocks are modeled as one-time (one-quarter) declines in consumption and labor input associated with the marginal utility of consumption and capital quality, and these effects imply no direct impact on the state of the economy in the period following the shock.¹⁰

⁹ Kiley (2016b) discusses in detail the role of the structure of the Phillips curve in shaping ELB amplification.

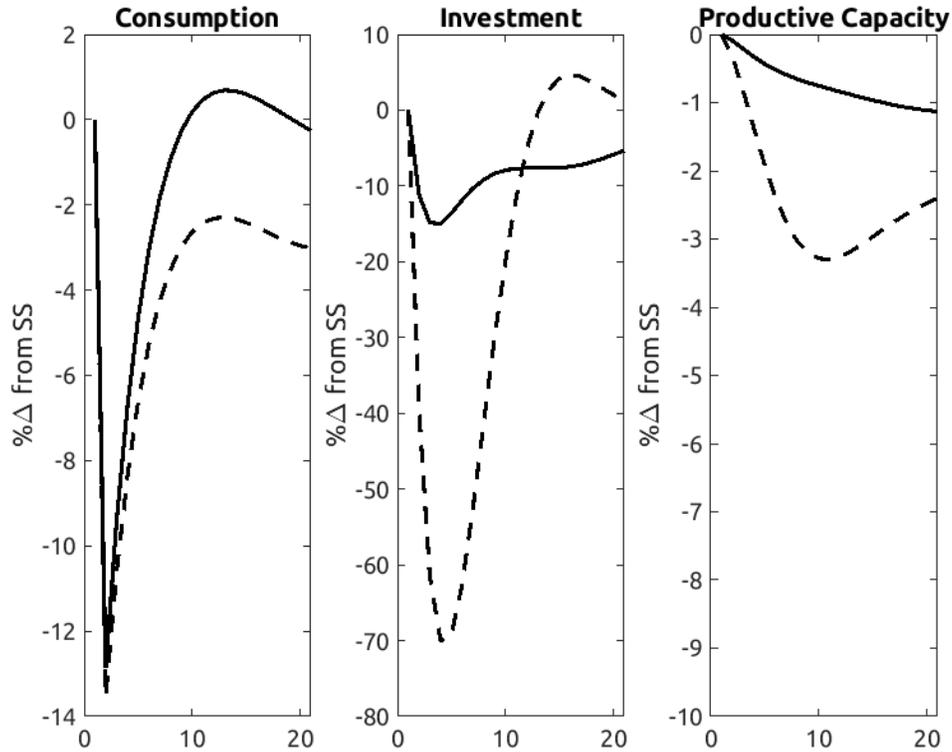
¹⁰ Note, as discussed in appendix 2, that the capital quality shock does not affect the stock of productive capital in the period after the shock – the direct period 1 effect is unwound in period 2.

As a result, the dynamics of the economy following the initial period solely reflect the endogenous propagation of the shock through state variables such as productive capital, the net worth of the financial sector, etc.

Figure 3 highlighted how QE is critical to minimizing medium-term effects on living standards when the ELB binds and strongly amplifies the pandemic shock. To illustrate the mechanism, figure 4 presents the outcomes for consumption, investment, and productive capacity with and without QE. Productive capacity is defined as output that would be produced using the available capital if labor input were at its steady-state level. The outcomes illustrate how QE—by fostering more accommodative financial conditions—limits the decline in investment. In the absence of QE, the decline in investment is very large. Because of this large decline, productive capacity is depressed substantially and for a prolonged period. Moreover, consumption is depressed relative to productive capacity, as investment must increase substantially to rebuild the lost productive capacity that occurs in the absence of QE.

This set of dynamics highlights how even very short-lived shocks can have very long-lived effects on living standards if the amplification of the initial shock through investment and productive capacity is not prevented by policy action. This lesson echoes that of, for example, Reifschneider, Wascher, and Wilcox (2015)—who emphasize the deleterious effect of sizable downturns on productive capacity (including through channels not incorporated in the model herein, such as those related to labor-force participation).

**Figure 4: Impact of COVID-19 Shocks on Productive Capacity and Living Standards:
Baseline Case (solid lines) and Case without QE (dashed lines)**



5. Additional Considerations:

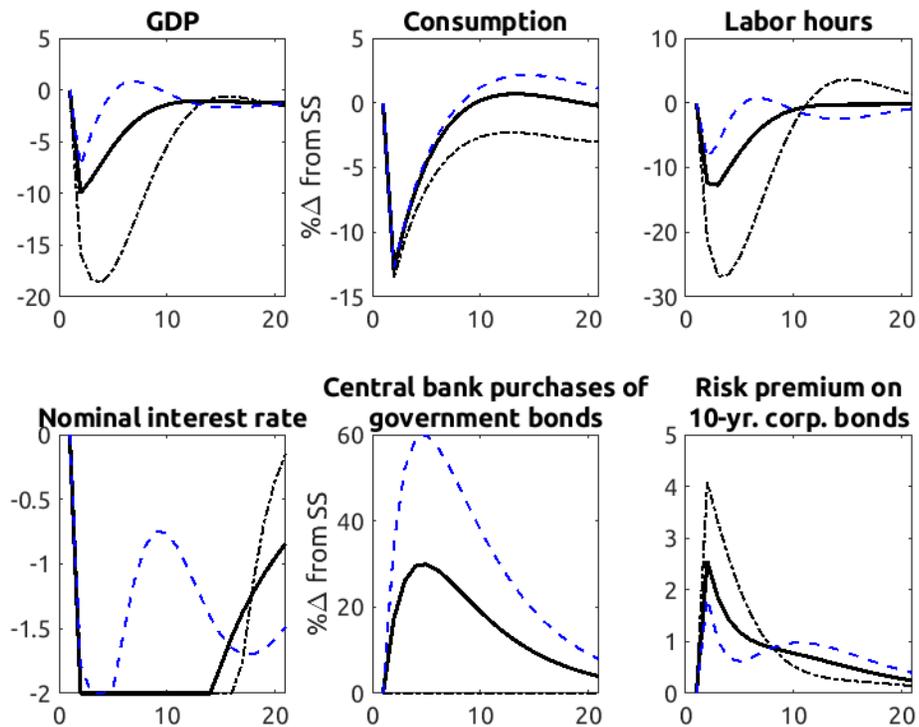
5.1. Coordination of QE and Short-term Interest Rate Policy

The simulations presented in previous sections involved QE at a scale required to offset the amplification from the ELB and deliver outcomes similar to those that would occur in the absence of the ELB constraint on reductions in the short-term interest rate. In principle, QE could be conducted at a different scale. However, additional QE raises important issues related to coordination with the setting of the short-term interest rate.

Figure 5 illustrates these issues by presenting the simulations of the pandemic without QE, with QE equal to 30 percent of GDP as in figure 2, and with a QE program twice the size of the baseline. The larger QE outcomes are presented in the blue-dashed lines. As shown in the lower middle panel, QE rapidly rises to 60 percent of GDP in this alternative.

A few results are worth emphasis. The additional QE reduces the decline in output and labor input. However, the path of consumption is not much different with the larger QE program. Because of the limited interest-sensitivity of consumption associated with consumption smoothing motives, the additional monetary stimulus results in only a modestly stronger consumption path. This implies that the sizable additional output response reflects additional investment spending.

Figure 5: Impact of COVID-19 Shocks with Alternative QE Magnitudes



Another set of results relate to financial conditions. The additional QE results in a more rapid escape of the short-term nominal interest rate from its ELB. In addition, the additional QE lowers the risk premium further. In particular, the risk premium is about 60 basis points lower than under the baseline QE assumption. This risk premium effect, at about 20 basis points for QE of 10 percent of GDP, is much smaller than under the baseline (where the effect was about 50 basis points); this effect also lies at the lower end of empirical estimates reported in Gagnon (2016) (which refer to effects on long-term Treasury yields). The smaller effect occurs because QE operates through the effect on the financial sector's net worth, and net worth is a function of all factors—including both QE and the path of the short-term nominal interest rate. Because QE results in a less accommodative stance of monetary policy through a nonlinear interaction with the ELB, the impact of QE depends on the coordination of QE with the path of the short-term nominal interest rate. These considerations underlie previous research results that demonstrated how QE may be effective during ELB episodes, but may not be a needed tool outside ELB episodes (Reifschneider, 2016; Kiley, 2018; Sims and Wu, 2020a).

5.2. Pandemic Dynamics

The simulation with additional QE highlights an additional set of issues related to monetary transmission and channels potentially absent from the model. As noted above, additional QE stimulates interest-sensitive spending. While this additional spending supports production and employment, the fact that additional QE disproportionately shifts investment relative to consumption highlights how such monetary stimulus can alter the composition of aggregate demand. Such alterations likely have important welfare consequences. These consequences lie beyond the scope of this paper but suggest careful analysis of a range of factors is important in judging the scaling of QE interventions.

The sizable increase in investment implied also highlights how these simulations rely on traditional monetary-policy transmission channels (as described in, for example, Boivin, Mishkin, and Kiley, 2010). It is possible that such transmission channels may be directly affected by pandemic conditions—a possibility not present in the simulation and that policymakers may wish to consider in evaluating the efficacy of monetary policy in such situations.

Research in which macroeconomic models explicitly incorporate epidemiological factors is growing rapidly; for example, the National Bureau of Economic Research maintains a webpage with working papers on this topic.¹¹

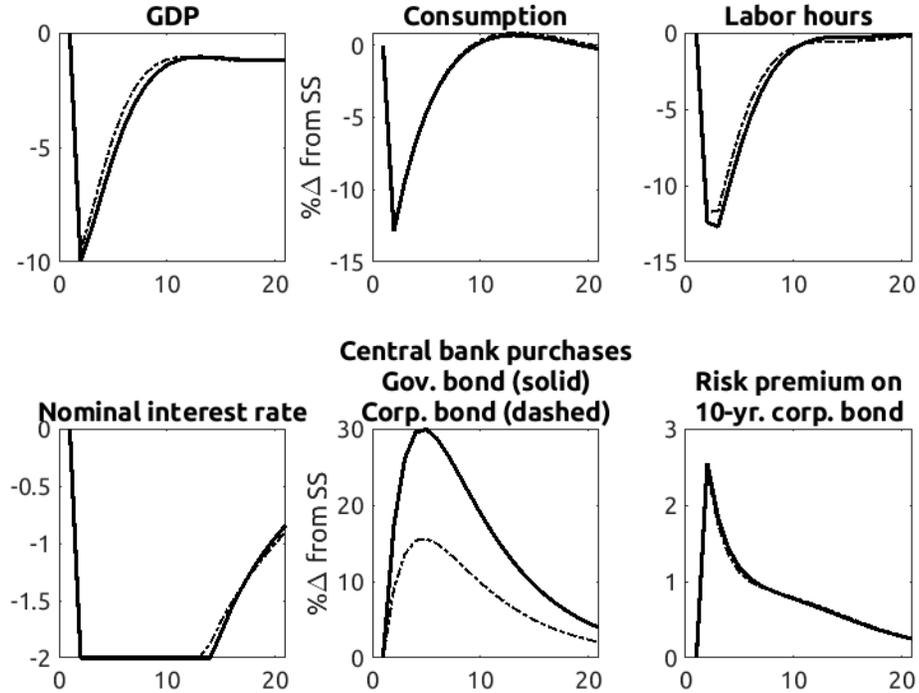
5.3. Additional Simulation Results: QE in Private Securities

The model simulations highlight how the ELB amplifies the effect of a pandemic shock and how QE can limit this amplification, thereby contributing to a V-shaped rebound rather than a U-shaped recovery. These simulations are instructive, and other aspects of the simulations and model point to additional issues for further research.

The first issue is the possible role of QE in private securities, as modeled in the Gertler and Karadi (2013) framework. Figure 6 considers purchases of private securities. The solid lines repeat the baseline case of QE in government bonds, and the dashed lines report results for a QE program in private securities that is one-half the size of the government bond program. As noted earlier, the structure of the model essentially assumes that the frictions associated with intermediation of private securities are twice as large as those associated with government bonds. As a result, a QE program in private securities that is one-half as large as a program in government bonds results in largely (although not literally) identical outcomes.

¹¹ https://www.nber.org/wp_covid19.html#4

Figure 6: Impact of COVID-19 Shocks and Effect of QE in Private Securities



This result largely arises from the structure of the model. However, it is a useful reminder of important areas for future work for several reasons. In March 2020, the Federal Reserve announced its Primary Market Corporate Credit Facility and Secondary Market Corporate Credit Facility, which will involve purchases of corporate bonds or similar securities, and the Main Street Lending Program, which purchases participations in bank loans. Moreover, similar purchases have been undertaken by other central banks over the past decade. At the same time, efforts to incorporate such actions into central bank’s macroeconomic frameworks have been limited. One exception is the recent work of Sims and Wu (2020b). In their analysis, Sims and Wu (2020b) present a model in which purchases of private securities may be more effective at stimulating economic activity than purchases of government bonds. In particular, their model

includes financial frictions on financial intermediaries and nonfinancial (production) firms, and their simulations emphasize that binding financial constraints on nonfinancial firms that are not directly connected to government debt markets in any way can be relieved by QE in private securities, but only indirectly affected by QE in government bonds. This mechanism is different from that in Gertler and Karadi (2013), where financial frictions affecting intermediaries and the role of such intermediaries in government and private security markets determine the effects of QE. Additional research on the magnitude of these channels may highlight the empirical relevance of different channels and their implications for policy choices.

6. Conclusions

The COVID-19 pandemic will directly depress economic activity for at least a short period through reductions in household consumption and hours worked as well as reduced incentives to invest. Further pullbacks in consumption, investment, and employment associated with lost income will amplify these direct effects. Moreover, the constraints on the ability of monetary policy to support a recovery could amplify the downturn. Model simulations suggest such amplification could be very significant, turning a V-shaped rebound into a deep U-shaped recession absent additional extraordinary policy actions.

Among the extraordinary policy actions that could mitigate the most adverse possible outcomes are QE programs in government bonds or private securities. Using a model calibrated to match past evidence, a QE program in government bonds that rapidly purchased bonds amounting to 30 percent of GDP may mitigate much of the amplification. A QE program in private securities could involve a lower level of purchases.

These results suggest policies such as a sustained QE program designed to lower long-term interest rates may be helpful in supporting a recovery. Moreover, even very transitory direct effects of the pandemic on consumption and investment, in the absence of sizable extraordinary measures, can morph into a persistent decline in productive capacity given the size of the shock and constraints on conventional monetary policy. The model simulations herein focus on the role of QE in potentially mitigating such effects—although other policy actions, including fiscal policy, are alternative (and likely complementary) policy tools.

At the same time, there is a great deal of uncertainty about the effects of COVID-19, the effects of QE, and economic dynamics in general.¹² As a result, the simulations herein are at best one suggestive step toward understanding appropriate monetary policy responses. The analysis points to several issues that are important policy and research questions. Additional empirical evidence on the effects of QE in different types of securities and alternative frameworks for assessing the effect of such actions on the macroeconomy are a clear priority, as the model used herein is quite simple. In addition, the nature of coordination across monetary policy instruments is important in shaping outcomes and has not been a major focus of research, despite the widespread use of QE over the past decade.

¹² Kiley (2014) highlights challenges associated with modeling the effects of QE on economic activity. Reifschneider (2016) and Kiley (2018) use approaches very different from the approach of Gertler and Karadi (2013) that is used herein.

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Appendix 1: Model Details

The model is drawn directly from Gertler and Karadi (2013). The code used in simulation is a modified version of that from the Macroeconomic Model Database (Wieland et al, 2012; Wieland et al, 2016).

Household behavior is standard.

	Households
(1) Utility function	$u_t = E_t \sum_{i=0}^{\infty} \beta^i \left[\ln(C_t - hC_{t-1}) - \frac{\chi}{1+\varphi} L_{t+i}^{1+\varphi} \right]$
(2) Budget constraint	$C_t = W_t L_t + \Pi_t - X_t + T_t + R_t D_{ht-1} - D_{ht}$
(3) Labor supply 1 st -order condition	$u_{C_t} W_t = \chi L_{t+i}^{1+\varphi}$
(4) Consumption 1st-order condition	$E_t \Lambda_{t,t+1} R_{t+1} = 1, \quad \Lambda_{t,t+1} = \beta \frac{u_{C_{t+1}}}{u_{C_t}}$

Banks, or more precisely financial intermediaries, play a key role as agents that hold government bonds and corporate debt for households. This role implies that the net worth of banks has important implications for real activity and the effects of QE.

	Banks
(5) Return on loan/private security	$R_{kt+1} = \frac{Z_{t+1} + (1-\delta)Q_{t+1}}{Q_t} \xi_{t+1}$
(6) Return on government bond	$R_{bt+1} = \frac{1/Q_t + q_{t+1}}{q_t}$
(7) Bank balance sheet constraint	$Q_t s_t + q_t b_t = n_t + d_t$
(8) Bank net worth equation	$n_t = R_{kt} Q_{t-1} s_{t-1} + R_{bt} q_{t-1} b_{t-1} - R_t d_{t-1}$
(9) Bank value function	$V_t = E_t \sum_{i=1}^{\infty} (1-\sigma) \sigma^{i-1} \Lambda_{t,t+i} n_{t+i}$
(10) Bank incentive constraint	$V_t \geq \theta Q_t s_t + \Delta \theta q_t b_t$
(11) Bank stochastic discount factor	$\widetilde{\Lambda}_{t,t+1} \equiv \Lambda_{t,t+1} \cdot \Omega_{t+1}$
(12) Bank 1 st -order condition for loans/private securities	$E_t \widetilde{\Lambda}_{t,t+1} (R_{kt+1} - R_{t+1}) = \frac{\lambda_t}{1 + \lambda_t} \theta$
(13) Bank 1 st -order condition for government bonds	$E_t \widetilde{\Lambda}_{t,t+1} (R_{bt+1} - R_{t+1}) = \Delta \cdot \frac{\lambda_t}{1 + \lambda_t} \theta$
(14) Endogenous bank capital constraint equation 1	$Q_t s_t + \Delta q_t b_t = \phi_t n_t \text{ if } \lambda_t > 0$ $< \phi_t n_t \text{ if } \lambda_t = 0$
(15) Endogenous bank capital constraint equation 2	$\phi_t = \frac{E_t \widetilde{\Lambda}_{t,t+1} R_{t+1}}{\theta - E_t \widetilde{\Lambda}_{t,t+1} (R_{kt+1} - R_{t+1})}$
(16) Banker adjustment to stochastic discount factor	$\Omega_{t+1} = 1 - \sigma + \sigma \frac{\partial V_{t+1}}{\partial n_{t+1}}$
(17) Marginal value of net worth to banker	$\frac{\partial V_t}{\partial n_t} = E_t \widetilde{\Lambda}_{t,t+1} (R_{kt+1} - R_{t+1}) \phi_t + R_{t+1}$

Resource and budget constraints reflect aggregation within the financial sector and the central bank (as government bonds and corporate debt are held either by financial intermediaries or the central bank).

Aggregation	
(18) Aggregate endogenous bank capital constraint	$Q_t S_{pt} + \Delta q_t B_{pt} \leq \phi_t N_t$
(19) Aggregate bank net worth	$N_t = \sigma \left[(R_{kt} - R_t) \frac{Q_{t-1} S_{pt-1}}{N_{t-1}} + (R_{bt} - R_t) \frac{q_{t-1} B_{pt-1}}{N_{t-1}} + R_t \right] N_{t-1} + X_t$
Central Bank	
(20) Central bank balance sheet	$Q_t S_{gt} + q_t B_{gt} = D_{gt}$
(21) Market clearing for loans/private securities and government bonds	$S_{pt} + S_{gt} = S_t$ $B_{pt} + B_{gt} = B_t$
Government	
(22) Government budget constraint	$G + (R_{kt} - 1)B = T_t + (R_{kt} - R_t - \tau_s)Q_{t-1}S_{gt-1} + (R_{bt} - R_t - \tau_b)q_{t-1}B_{gt-1}$

Nonfinancial production is governed by standard equations

Production	
(23) Production function	$Y_t = A_t K_t^\alpha L_t^{1-\alpha}$
(24) Labor demand	$W_t = P_{mt} (1 - \alpha) \frac{Y_t}{L_t}$
(25) Investment/capital demand	$Z_t = P_{mt} \alpha \frac{Y_t}{K_t}$
(26) Capital stock evolution	$K_{t+1} = \xi_{t+1} [(1 - \delta)K_t + I_t]$
(27) Tobin's Q	$Q_t = 1 + f \left(\frac{I_t}{I_{t-1}} \right) + \frac{I_t}{I_{t-1}} f' \left(\frac{I_t}{I_{t-1}} \right) - E_t \Lambda_{t,t+1} \left(\frac{I_{t+1}}{I_t} \right)^2 f' \left(\frac{I_{t+1}}{I_t} \right)$

Nominal variables are governed by the Fisher equation and a Phillips curve for nominal prices.

Nominal interest Rate and Phillips Curve	
(28) Fisher relationship	$1 + i_t = R_{t+1} \frac{P_{t+1}}{P_t}$
(29) New-Keynesian Phillips Curve equation 1	$E_t \sum_{i=0}^{\infty} \gamma^i \Lambda_{t,t+i} \left[\frac{P_t^*}{P_{t+i}} - \mu P_{mt+i} \right] Y_{t+i} = 0$
(30) New-Keynesian Phillips Curve equation 2	$P_t = [(1 - \gamma)(P_t^*)^{1-\varepsilon} + \gamma(P_{t-1})^{1-\varepsilon}]^{\frac{1}{1-\varepsilon}}$

Resource constraints must be satisfied in equilibrium

Resource Constraints	
(31) Expenditure/Production equilibrium	$Y_t = C_t + \left[1 + f \left(\frac{I_t}{I_{t-1}} \right) \right] I_t + G + \Phi_t, \quad \Phi_t = \tau_s Q_{t-1} S_{gt-1} + \tau_b q_{t-1} B_{gt-1}$
(32) Loan/Private security equilibrium	$S_t = (1 - \delta)K_t + I_t$
(33) Government bond market clearing	$B_t = B$
(34) Labor supply/demand	$(1 - \alpha) \frac{Y_t}{L_t} \cdot E_t u_{ct} = \frac{1}{P_{mt}} \chi L_t^\varphi$

Parameters for the model are the same as those in Gertler and Karadi, except for price stickiness (γ , which is set at a very high level, to flatten the Phillips curve).

<i>Households</i>		
β	0.995	Discount rate
h	0.815	Habit parameter
χ	3.482	Relative utility weight of labor
B/Y	0.450	Steady-state Treasury supply
K^h/K	0.500	Proportion of direct capital holdings of the households
B^h/B	0.750	Proportion of long-term Treasury holdings of the households
κ	1.000	Portfolio adjustment cost
ϕ	0.276	Inverse Frisch elasticity of labor supply
<i>Financial Intermediaries</i>		
θ	0.345	Fraction of capital that can be diverted
Δ	0.500	Proportional advantage in seizure rate of government debt
X	0.0062	Transfer to the entering bankers
σ	0.972	Survival rate of the bankers
<i>Intermediate Goods Firms</i>		
α	0.330	Capital share
δ	0.025	Depreciation rate
<i>Capital-Producing Firms</i>		
η_i	1.728	Inverse elasticity of net investment to the price of capital
<i>Retail Firms</i>		
ε	4.167	Elasticity of substitution
γ	0.9625	Probability of keeping the price constant
<i>Government</i>		
$\frac{G}{Y}$	0.200	Steady-state proportion of government expenditures

Appendix 2: Pandemic shocks

As discussed in the text, the model does not include epidemiological factors that could capture a pandemic, and the direct impact of the pandemic is introduced as large and transitory adverse shocks to the marginal utility of consumption and work ($\zeta(t)$) and to capital quality ($\xi(t)$), discussed below.

Marginal utility

A shock $\zeta(t)$ is introduced to equations (3) and (4). In both equations 3 and 4, the marginal utility of consumption in period (t) is multiplied by ζ . To capture a purely temporary pandemic, the shock occurs only in period 1.

Capital quality

The capital quality shock enters equation 26. It occurs in period 1. In addition, to ensure that the subsequent dynamics of the economy do not reflect direct effects of the pandemic, the direct effect of the shock on period 2 productive capital is unwound (a change that is not anticipated in period 1).

Appendix 3

As noted in the text and appendix 1, the model is altered relative to that in Gertler and Karadi (2013) by assuming a very flat Phillips curve. This change primarily affects inflation. To see this, figure A1 presents the baseline with QE under the flat Phillips curve (as presented in the main text) and for the original degree of price stickiness. The path of QE is not presented (as it is identical to that in figure 2) and is replaced with inflation. As shown, the dynamics are qualitative similar, except for inflation: with the original Phillips curve, inflation drops 150 percentage points (at an annual rate); the flat Phillips curve delivers more realistic predictions.

Figure A1: Dynamics with Original (dashed) and Flat (solid) Phillips Curves

