Quantitative Easing and Direct Lending in Response to the COVID-19 Crisis

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Abstract

This paper develops a dynamic general equilibrium model to study quanti-

1 Introduction

The COVID-19 crisis cut off firms' cash flow and available funds, threatening the survival of many firms. The Federal Reserve responded with numerous programs, including quantitative easing (QE) and direct lending to firms, to prevent a collapse in firms' available funds. This paper develops a dynamic general equilibrium model to evaluate various channels through which these programs work.

QE refers to the Federal Reserve's large-scale purchases of Treasury bonds and other long-term securities financed by increased bank reserves. In March 2020, the Federal Reserve announced purchases of at least $500 billion in Treasuries and $200 billion in agency mortgage-backed securities totaling 3.3 percent of 2020 GDP. At the end of the same month, it modified the announcement, making the purchases open-ended as needed to support market functioning and monetary policy transmission. In June 2020, it announced purchases of at least $80 billion in Treasuries and $40 billion in agency mortgage-backed securities per month. For comparison, the first announced QE in November 2008 consisted of purchases of up to $600 billion in agency debt and mortgage-backed securities worth 4 percent of 2008 GDP.

The Federal Reserve also introduced new programs to lend directly to firms. In March 2020, it announced purchases of newly issued investment-grade corporate bonds and loans through the Primary Market Corporate Credit Facility. The purchase price was informed by market conditions plus a 100bps facility fee. In April 2020, the Federal Reserve announced loans to small and mid-size businesses through various Main Street lending facilities. The loans were for five years at LIBOR plus 3 percent, with interest payment and principal repayment deferred for one and two years, respectively.

This paper studies how QE works and finds that it was much less expansionary in 2020 than in 2008. Treasury bond purchases worth 4 percent of GDP would have raised real GDP by 3.1 and 0.5 percent in 2008 and 2020, respectively. The reason why QE was less expansionary in 2020 has to do with the level of bank reserves. QE

creates a credit risk premium that raises the lending rate above the rate of return of assets with no credit risk. I assume that the credit risk premium is negatively related to aggregate output and positively related to the ratio of firms' borrowing from banks to cash flow. The latter dependence captures the firm-level financial frictions modeled by Sims and Wu (2020) and Cardamone, Sims, and Wu (2023).

The di□erent liquidity and risk characteristics of deposits and loans create a spread between the lending and deposit rates. The loan-deposit spread is the sum of the three premiums: the liquidity premium, the volatility risk premium, and the y5re an

ee premiu-417.017(n)0.974098(-)-5.279001119.28699Tm[(c)3.3879(r)-1.42438(a)-2.83755(s)4.5(i) the Fed expansion of reserves in 2009-2011 lowered the liquidity premium and long-term interest rates.

2. QE reduces the net supply of Treasury bonds, while direct lending reduces firms' demand for bank loans. In both cases, banks' holdings of volatile assets decrease and lower the volatility risk premium. This channel depends on the imperfect substitutability of non-reserve assets and is the portfolio balance channel modeled by Vayanos and Vila (2009) and emphasized by the literature.

3. The economic stimulus generated by the first two channels lowers the credit risk premium. This channel is an amplification mechanism that works with expansionary policies.

As evident from this initial discussion, this paper studies some, but not all, Fed programs' mechanisms. While the volatility risk premium implicitly incorporates a component for market liquidity risk, the paper does not explicitly model market functioning and market liquidity, so it may underestimate the effects of Fed programs on market liquidity, market functioning, and output. Also, the paper does not model the signaling effects of Fed programs on expected future convent

in 2020 than in 2008 because of their mechanism and mine, respectively.

Our two interpretations also differ regarding the QE effectiveness between 2008 and 2020. In their model, the decrease in effectiveness depends on the worsening of firm-level financial frictions in 2020. In contrast, my model suggests that QE became less effective before the COVID-19 crisis since bank reserves rose after 2008. According to my model, because of the increase in bank reserves announced in 2008, later QE programs became 50 percent less expansionary. My mechanism, then, offers a possible reason why event studies tend to find that the announcements of later rounds of QE in 2010 and 2012 had smaller effects than the announcements of the first round in 2008-2009. This reason adds to the explanations proposed by the literature that the later rounds were better anticipated and financial conditions were less strained (Kr-

rowing rate and the household deposit rate.

2.1 Households

Households consume c_t^H

V_{t+1}, be the difference between bank assets and liabilities,

$$V_{t+1} \equiv R_{t+1} + M_{t+1} + q_t N_{t+1} + L_{t+1} - D_{t+1}, \tag{7}$$

and let banks' risk-weighted assets, Z_{t+1}, be the weighted sum of long-term Treasury and bank loans,

$$Z_{t+1} \equiv \omega_N q_t N_{t+1} + \omega_L L_{t+1}, \tag{8}$$

where $\omega_N \in (0,1)$ and $\omega_L \in (0,1)$ are the risk weights of bonds and loans, respectively. I model the banks' need for equity using a penalty function that increases with the ratio of their risk-weighted assets to equity:

$$h_{t+1} = A_h \frac{1}{\rho} \left(\frac{Z_{t+1}}{V_{t+1}} \frac{V}{Z} \right)^{\rho}, \tag{9}$$

where Z and V are steady-state values, $A_h > 0$, and $\rho > 1$. This penalty function is smoother and more flexible than a minimum ratio of equity to risk-weighted assets. The friction creates a volatility risk premium that drives up the return of volatile assets, such as long-term Treasury bonds and bank loans, relative to risk-free ones, such as deposits, reserves, and Treasury bills.

four terms are the bank purchases of assets (reserves, Treasury bills, Treasury bonds, and loans). The sixth term represents the funds received from depositors. The final four terms are the penalties associated with the frictions minus their equilibrium values. On the right-hand side, the first four terms are the gross-of-interest payoffs from bank asset purchases in the previous period, while the last term is the gross-of-interest payoff paid to depositors.

The optimization problem solved by the owner of a bank is:

$$\max_{\{c_t, D_{t+1}, R_{t+1}, M_{t+1}, N_{t+1}, L_{t+1}, g_{t+1}, h_{t+1}\}_{t=0}^{\infty}} E_0 \sum_{t=0}^{\infty} \beta^t u(c_t) \tag{11}$$

subject to (6), (9), and (10),

where $\beta \in (0,1)$ is the banks' discount factor and $u(c)$ is the same function as the one for households.

The first-order conditions are:

$$1 = E_t \left[\frac{\beta u'(c_{t+1})}{u'(c_t)} \left(1 + r^M_{t+1} + \rho h_{t+1} / V_{t+1} \right) \right] \tag{12}$$

$$1 = E_t \left[\frac{\beta u'(c_{t+1})}{u'(c_t)} \left(1 + r^N_{t+1} + \rho h_{t+1} \right. \right.$$

value of loans. The equilibrium value of the difference is rebated lump-sum to the

The central bank gives the government the seigniorage, S_t, which is the difference between the returns of its assets and liabilities:

$$S_t = (1 + r_t^M)\tilde{M}_t + (1 + \kappa q_t)\tilde{N}_t + (1 + r_t^L)\tilde{L}_t - (1 + r_t^R)R_t. \quad (35)$$

2.5 Government

The government sells and redeems Treasury bills and bonds, spends a constant $G > 0$, receives the seigniorage, S_t, from the central bank, and distributes lump-sum transfers to households, T_t:

$$\hat{M}_{t+1} + q_t\hat{N}_{t+1} = (1 + r_t^M)\hat{M}_t + (1 + \kappa q_t)\hat{N}_t + G - S_t + T_t. \quad (36)$$

It uses the lump-sum transfers to balance its intertemporal budget constraint. I assume that the lump-sum transfers respond to changes in government debt enough to ensure that government debt is stationary and an equilibrium exists:

$$T_t = A_T - \tau r^M (\hat{M}_{t+1} + q_t\hat{N}_{t+1}), \quad (37)$$

where A_T is a constant, r^M is the steady-state Treasury bill rate, and $\tau > 0$.

2.6 Equilibrium conditions

Let

$$C_t \equiv c_t^H + c_t + c_t^F \quad (38)$$

be aggregate private consumption. The equilibrium condition for the goods market equates the demand for private consumption, government consumption, and investment to production:

$$C_t + G + x_t = y_t. \tag{39}$$

The remaining equilibrium conditions equate demand and supply in the markets for labor, deposits, Treasury bills, Treasury bonds, and loans:

$$l_t = n_t \tag{40}$$

$$D_{t+1} = D^H_{t+1} \tag{41}$$

$$M_{t+1} + \tilde{M}_{t+1} = \hat{M}_{t+1} \tag{42}$$

$$N_{t+1} + \tilde{N}_{t+1} = \hat{N}_{t+1} \tag{43}$$

$$L^F_{t+1} = L_{t+1} + \tilde{L}_{t+1}. \tag{44}$$

One variable that plays a crucial role is the loan-deposit spread, s_{t+1}, the spread between the rate paid by firms, $\tilde{r}^L_{t+1}$, and the rate received by depositors, r^D_{t+1}. A large spread discourages firms' investment and output. Using equations (19), (21), and (24), one can decompose the spread into the sum of three premiums:

$$\begin{aligned} s_{t+1} &\equiv \tilde{r}^L_{t+1} - r^D_{t+1} \\ &= (\tilde{r}^L_{t+1} - r^L_{t+1}) + (r^L_{t+1} - r^M_{t+1}) + (r^M_{t+1} - r^D_{t+1}) \\ &\approx \underbrace{A_z - \eta_y \log\frac{y_t}{y} + \eta_L \log\left(\frac{L_t}{CF_t}\frac{CF}{L}\right)}_{\text{credit risk premium } \pi^{cred}_{t+1}} + \underbrace{\omega_L A_h \frac{Z^{\rho-1}_{t+1}}{V^{\rho}_{t+1}}\frac{V^{\rho}}{Z^{\rho}}}_{\text{vol. risk premium } \pi^{vol}_{t+1}} + \underbrace{A_g \frac{D^{\lambda-1}_{t+1}}{R^{\lambda}_{t+1}}\frac{R^{\lambda}}{D^{\lambda}}}_{\text{liq. premium } \pi^{liq}_{t+1}}. \end{aligned} \tag{45}$$

decreases with reserves. By changing the net supply of assets with different liquidity and risk characteristics, Fed programs can reduce these premiums and stimulate firms' investment and output.

3 Calibration

In this section, I first describe the parameter setting for the 2020 case, and then the parameter changes for the 2008 case. The parameters are changed to target the different values of interest rates and bank balance sheets in the two cases. The parameter values for the two cases are listed in Table 1.

The length of a period is one quarter. Some parameters are set equal to standard values in the literature: The exponent of the production function is $\alpha = 0.35$; The capital depreciation rate is $\delta = 0.025$; The relative risk aversion is $\gamma = 2$. The value of the capital adjustment cost parameter, $\psi = 1$, is also within the range of standard values. The Frisch elasticity of labor supply, $\phi = 0.5$, is close to common econometric estimates. The scale parameters A and Φ are set so that $y = 1$ and $n = 1/3$, respectively.

I assume that the penalty functions g and h are quadratic ($\lambda = 2$ and $\rho = 2$), and I show how results change as λ and ρ

FRED), and investment grade bond yield (Moody's, seasoned Baa corporate bond yield, FRED), respectively. The values of banks' assets and liabilities (relative to y) are set to match the corresponding values for all commercial banks in 2019:Q4 (relative to quarterly GDP). Specifically, bank reserves, $R = 0.32$, match the cash assets of all commercial banks; banks' holdings of government debt, $B = 0.55$, match holdings of Treasury and agency securities; bank loans, $L = 1.99$, match bank credit net of Treasury and agency securities; and deposits, $D = 2.42$, match the deposits of all commercial banks (Federal Reserve statistical release, Table H.8, Haver Analytics). These values for interest rates and bank balance sheets, the agents' first-order conditions, and the friction definitions (6), (9), and (24) pin down the preference discount factors ($\hat{\beta}$, β, and $\tilde{\beta}$) and the friction parameters (A_g, A_h, and A_z).

The sensitivity of the credit risk wedge to output, $\eta_y = 0.25$, is set to approximate the increase (1 percentage point) in the quarterly credit spread (Moody's Baa corporate bond yield minus 10-Year Treasury yield, FRED) relative to the drop (4 percent) in GDP during the Great Recession. The sensitivity of the credit risk wedge to bank lending, η_L, is especially hard to pin down. I choose the benchmark value, $\eta_L = 0.042$, so that the yearly credit spread decreases by 8.4 percentage points (equal to the difference between the maximum and median of the corporate bond spread in Table 1 of Flannery et al. 2012) when bank lending decreases by 50 percent. I show how results depend on η_L in Section 4.3.

The decay parameter for the Treasury bond coupon payments equals $\kappa = 1 - 1/40$, so the Treasury bond duration is 10 years. The duration of a Treasury bill is one quarter. I assume that 50 percent of the value of government debt consists of Treasury bills and the remaining 50 percent consists of Treasury bonds, so the model average duration of government debt, 5.125 years, matches the weighted average maturity in the data, approximately (US Treasury Office of Debt Management). Similarly, I assume that both the central bank and private banks hold 50 percent of their government debt holdings in Treasury bills and the remaining 50 percent in Treasury bonds. The first-order autocorrelation coefficients of the policy processes are equal to 0.9 ($\rho_{QE} = 0.9$ and $\rho_{DL} = 0.9$).

Government spending is set to $G = 0.15$ to match the ratio of government spending to GDP. The constant A_T is set to balance the government budget constraint. The fiscal rule policy coe□cient is equal to $\tau = 0.01$, so the response of government transfers to government debt is small but su□cient to ensure the existence of an equilibrium.

The calibration for the 2008 case is the same as for the 2020 case, except that parameters are set to match the average interest rates in 2002-2007 and the values of banks' assets and liabilities in 2008:Q3, before the first QE announcement. Specif- ically, the interest rates of deposits, Treasury bills, Treasury bonds, and loans are set to $r^D = 0.0008$, $r^M = 0.0068$, $r^N = 0.0111$, and $\tilde{r}^L = 0.0167$, respec-

For the 2008 case, the figure shows the increase in bank reserves, R_{t+1}, accompanied by the increase in central-bank-held government debt, $\tilde{B}_{t+1}$. Since bank reserves increase, the liquidity premium, π^{liq}_{t+1}, decreases. And since banks' holdings of Treasury bonds decrease, banks' risk-weighted assets, Z_{t+1}, decrease, and the volatility risk premium, π^{vol}_{t+1}, decreases. The decreases in the two premiums lower the loan-deposit spread, s_{t+1}, which, in turn, stimulates bank lending, investment, and output. Firms' available funds, one of Fed programs' primary objectives in 2020, increase. Banks expand their deposits to fund the increase in bank loans. Notice that the decrease in the liquidity premium is about 10 times larger than the decrease in the volatility risk premium, so the decrease in the liquidity premium is the main driver of the effects quantitatively.

The credit risk friction amplifies these first-round effects. The output increase lowers the credit risk premium, π^{cred}_{t+1}, further decreasing the loan-deposit spread and increasing investment and output. The predicted total effect on output, 3.1 percent, is between the estimate by Weale and Wieladek (2016) for a QE program worth 4 percent of annual GDP (4×0.62 percent = 2.5 percent) and the estimate by Baumeister and Benati (2013) for the first round of QE (3.5 percent).

Turning to the 2020 case, the qualitative effects of QE are the same as in the 2008 case. Quantitatively, however, the effects are much smaller. The output increase is 0.5 percent in 2020, 2.6 percentage points smaller than in 2008. The main cause is that the level of bank reserves (relative to GDP) is 3.5 times greater, so the percent increase in bank reserves is 3.5 times smaller. As a result, the decrease in the liquidity premium, defined by (45), is smaller. Since the decrease in the liquidity premium is the main driver of the effects, the effects of QE are smaller in 2020 than in 2008.

More generally, since bank reserves rose after 2008, this mechan

4.2 Direct lending to firms

In a direct lending program, the central bank lends to firms and finances the loans with increased bank reserves. Bank reserves, R_{t+1}, and firms' borrowing from the central bank, $\tilde{L}_{t+1}$, increase by the same amount. Figure 2 shows the effects of direct lending in 2008 (dashed line) and 2020 (solid line). The loans are worth 4 percent of annual GDP, the same size as the QE program we considered.

Some mechanisms through which direct lending works are similar to those of QE. Since bank reserves increase, the liquidity premium, π^{liq}_{t+1}, decreases. Firms substitute central bank loans for private bank loans. As bank lending, L_{t+1}, decreases, banks' risk-weighted assets, Z_{t+1}, decrease, and the volatility risk premium, π

4.2.1 Subsidized direct lending

Direct lending can have more expansionary effects if the central bank provides the loans at a subsidized rate lower than the market rate. In this case, there are two additional effects.

4.3 Sensitivity analysis

One message of this paper is that the expansionary impact of Fed programs is inversely related to the level of bank reserves before the program introduction. This relationship depends on the parameters of the liquidity friction, A_g and λ. Another message is that QE is less expansionary than direct lending because it worsens the financial frictions that constrain firms' borrowing from the private sector, while direct lending mitigates them. This result depends on η_L, the parameter that controls the credit risk friction associated with firms' borrowing from banks. The other parameters change some results quantitatively but do not affect the two main messages.

Figure 4 plots the response of output to QE and unsubsidized direct lending in 2020 for different values of the key parameters.

The parameters of the liquidity friction, A_g and λ, are important for the results because changes in the liquidity premium are the main drivers of the economy's response to Fed programs. A greater scale parameter, A_g, implies a greater liquidity premium, π^{liq}, a wider loan-deposit spread, s, and larger effects of Fed programs on the premium, the spread, and output. If A_g doubles, the liquidity premium doubles, the loan-deposit spread widens by 32 basis points, the output response to QE doubles

of QE and direct lending are approximately the same. The e□ects of QE and direct lending on output would be identical if the risk weights of bonds and loans were the same (ω_N = ω

According to the model, a QE program worth 4 percent of GDP would have raised

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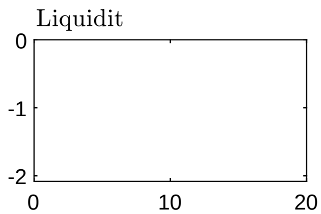
Description	2008 Case	2020 case	Targeted moments



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