DISCUSSION PAPER SERIES

DP14701

LIQUIDITY PROVISION DURING A PANDEMIC

Charles M. Kahn and Wolf Wagner

FINANCIAL ECONOMICS

ISSN 0265-8003

LIQUIDITY PROVISION DURING A PANDEMIC

Charles M. Kahn and Wolf Wagner

Discussion Paper DP14701
Published 04 May 2020
Submitted 02 May 2020

Centre for Economic Policy Research
33 Great Sutton Street, London EC1V 0DX, UK
Tel: +44 (0)20 7183 8801
www.cepr.org

LIQUIDITY PROVISION DURING A PANDEMIC

Abstract

We examine how public liquidity should be distributed to firms when immediate production entails externalities, such as by spreading a virus. Direct provision of liquidity can address externalities, but traditional distribution of liquidity (through banks) has informational advantages. We show that which mode is preferred is determined by the variance (but not the level) of firm characteristics in the economy. Traditional provision is always part of the optimal policy when liquidity modes can be combined, and involves promising low interest rates for when the pandemic is over in order to incentivize temporary production shutdowns at firms.

JEL Classification: G28, G20, G31, I18

Keywords: public liquidity, banks, Covid-10, mothballing

Charles M. Kahn - cmkahn@illinois.edu
University of Illinois Urbana-Champaign

Wolf Wagner - wagner@rsm.nl
Erasmus University and CEPR

Liquidity provision during a pandemic

Charles M. Kahn and Wolf Wagner*

Abstract

We examine how public liquidity should be distributed to firms when immediate production entails externalities, such as by spreading a virus. Direct provision of liquidity can address externalities, but traditional distribution of liquidity (through banks) has informational advantages. We show that which mode is preferred is determined by the variance (but not the level) of firm characteristics in the economy. Traditional provision is always part of the optimal policy when liquidity modes can be combined, and involves promising low interest rates for when the pandemic is over in order to incentivize temporary production shutdowns at firms.

Keywords: public liquidity, banks, Covid-10, mothballing

JEL codes: G28, G20, G31, I18

*Charles Kahn is at the Department of Finance, University of Illinois Urbana-Champaign. Email: cmkahn@illinois.edu. Wolf Wagner is at the Department of Finance, Rotterdam School of Management, Erasmus University and CEPR. Email: wagner@rsm.nl

1 Introduction

Central banks and treasuries around the world have announced unprecedented measures for emergency lending and other financial support for businesses in the wake of the Covid-19 pandemic. Governments have started to lend directly to firms, with and without the involvement of the traditional banking sector. In the United States, more than 4 trillion USD in state loans and guarantees will be extended through programmes such as the *Paycheck Protection Program* and the *Main Street Lending Program.* Funding is directed to small- and medium-sized firms as well as firms in specific sectors particularly affected by the crisis, like cargo and passenger airlines. The Fed has started to buy corporate bonds (including recently downgraded bonds), and purchases commercial paper and short-term, unsecured loans obtained by businesses for everyday expenses. At the same time, the Fed has also provided traditional liquidity support to the banking system, through measures such emergency interest rate cuts and by setting up various new borrowing facilities.

Public lending is not a new phenomenon, of course. Government programs focused on strategic sectors have been an important part of economic development programs (such as in Japan post WWII). In developed economies as well, programs have been put in place to direct funds towards favored sectors, such as housing or agriculture. In addition there are ample precedents for governments and central banks to provide loans and low interest rates in time of macroeconomic slowdowns. In this respect the current crisis would seem to fall in place, inasmuch as record rapid increases in unemployment are already being observed, and business failures are likely to follow.

But the needs for funding in the wake of the pandemic differ in significant ways from the problems faced before. On the one hand unlike the case of an economic downturn, the goal will not necessarily be to get all businesses in the economy up and running as soon as possible. The fear is that a restarting of business activity will cause a new jump in disease and mortality; thus a simple general provision of low interest loans will be unlikely to be the correct solution. On the other hand targeted lending in the past has generally not questioned which sectors were deserving of attention: it has either been taken as evident a priori that some sectors were crucial or politically to be favored.[1] Now, with needs and political pressures spread throughout the economy it becomes important to investigate

[1] There is some debate as to whether the Japanese experience in this respect was exceptional in developing a strategy for selecting targeted sectors.

the kinds of considerations that should lead to sectors receiving attention from targeted programs.

The measures introduced during the Covid-19 pandemic have differed in the degree to which the funding is decided on directly by the government or central bank, versus left to the discretion of traditional lending institutions.[2] Delegating authority to the private institution or leaving it with the public institution represents a trade-off: the private institution will have expertise in the quality and viability of the borrower; however it will generally not be prepared to take into account the additional considerations that make the emergency lending desirable or undesirable — in general the externalities, positive or negative, that the activities of the borrower impose on the rest of the economy. The purpose of this paper then is to delineate the circumstances in which greater or less discretion for the private lending institutions is desirable.

We consider an economy with heterogenous firms that have immediate liquidity needs to fund production. Production by these firms causes externalities. Our main interpretation of this is that during a pandemic, the production of goods and services (as well as their consumption) contributes to the spread of the virus.[3] Production decisions may also cause externalities outside a pandemic, for instance on financiers (in the presence of agency problems) or on other firms due to supply-chain interdependence. The externalities can be negative or positive and, importantly, may vary across firms (consider, for example, a restaurant business versus home delivery service during a pandemic).

We first analyze the polar cases of all liquidity being channelled through the banking system ("traditional lending") versus being directly allocated by public authorities ("direct lending). In the latter case liquidity is directly supplied to firms, while in the former case the central bank supplies liquidity to banks who then use it to make lending decisions. We find that either mode of lending can achieve higher welfare. The reason is that there is a trade-off between two objectives: funding firms with high returns versus funding firms with low (negative) externalities. Traditional lending utilizes the informational advantage

[2]Many programs in which private lending institutions have little or no decision making power still leave them in charge of distribution of funds, purely as a matter of implementation. However there are also programs in which the public institution lends directly to firms, or is a direct buyer of debt in the (secondary) market.

[3]See Eichenbaum, Rebelo and Trabandt (2020) and Bethune and Korinek (2020) for a microfoundation of production externalities in the context of a pandemic. As these authors note, externalities arise only once agents directly involved in production or consumption go on to infect other agents in the economy.

of banks in making lending decisions, resulting in a better allocation of capital in the classic sense, but disregards the externalities.[4] We show that which mode achieves higher welfare depends on the extent to which externalities and returns vary across firms, but not their averages in the economy. In particular, traditional lending may still be optimal if the externalities are high but uniformly so. The reason is that, by setting an appropriate price of liquidity in the economy, the central bank can force banks to internalize the social losses from production when making lending decisions. This no longer is possible when externalities vary among firms.[5] We show that direct lending is favoured if the variability of externalities across firms exceeds the variability of returns and derive implications for under which economic circumstances an economy should use direct lending (and whether, during an epidemic, this should happen at early or later stages) but also for which segments of the economy direct lending is most advantageous.

We next examine optimal liquidity provision when traditional and direct lending can be combined. We first show that such liquidity provision always entail some traditional lending, either on its own, or combined with direct lending. Under certain conditions it is optimal to partition the economy in three ranges, determined by firms' externalities. There is direct lending to *all* firms in the low-externality range, whereas funding is prohibited in the range with high externalities (effectively, a government shutdown of production). In addition, the central bank provides a liquidity line to banks, which (in equilibrium) will be used to funds *some* (but not all) firms with intermediate externalities. We show that the interest rate on the liquidity line depends on the size of the direct lending range: the central bank should charge a higher rate in an economy with more direct lending (this is because direct lending tends to eliminate firms with low externalities from the pool to be served by banks). As decisions about direct lending (to firms) and liquidity lines (to banks) are typically undertaken by different authorities, optimal liquidity policies thus require coordination.

Finally we expand our model to analyze the funding of temporary shutdowns in production. Several commentators in the Covid-19 crisis have noted that a pandemic causes

[4] Whereas our trade-off is described in terms of liquidity provision, it applies more generally applies to the question of whether support measures for firms should operate through banks (for example, by reducing reserve requirements or allowing leniency in loss provisioning) or target firms directly (e.g., a bailout of an industry).

[5] Multiple liquidity lines (to banks) that can condition on the usage of funds can theoretically implement the first-best but are likely to be gamed by banks.

an unusual problem. As production contributes to the spread of the virus, there are firms that we would clearly prefer not to produce during the pandemic. However, many of these firms have in principle a viable business, so we would like them to return to production once the pandemic is over. This requires firms to preserve their productive capacity in the meantime; such "mothballing", however, is costly (think of paying leases and rents, retaining workers and maintaining customer relationships). We show that the standard policy response to funding problems at firms is counterproductive in this situation. This is because a swift provision of cheap liquidity to firms subsidizes immediate production, not just mothballing.[6] Rather, an optimal liquidity policy requires promising attractive funding conditions for when the pandemic is over, coupled with a standard liquidity facility for immediate funding needs at an interest rate that reflects production externalities. This provides incentives for firms to "hang-on", that is, neither to go out of business nor to return to (full) production immediately.

The plan of the paper is as follows: The next section provides a brief literature review. Section 3 sets up a simple economy that we can use to evaluate liquidity policies. Section 4 compares traditional and direct lending. Section 5 consider liquidity policies that combine both forms of lending. Section 6 analyzes the mothballing problem. The final section concludes.

2 Literature

The traditional argument for public liquidity, formulated by Bagehot in 1873, is based on panics in the banking sector. Because of maturity mismatch, banks are periodically subject to liquidity runs (Diamond and Dybvig, 1983). This provides a rationale for a central bank to provide liquidity assistance to banks in need, taking for example the form of a liquidity line. Closer to the setting of the Covid-19 crisis, a role for public liquidity also arises from funding needs at firms. In Holmström and Tirole (1988) firms are constrained by limits to the pledgeability of their assets.[7] Firms can self-insure against liquidity shocks by holding precautionary liquidity but this is costly (as it reduces funds available for real investment),

[6] The problem cannot simply be solved by governments prohibiting production because only banks know a firms's productivity, and hence whether production has positive (social) surplus or not.

[7] The heterogeneities in externalities across firms in our model can be interpreted as arising from differences in pledgeabilities across firms.

creating a benefit to public liquidity. Our analysis, which considers an economy at the time of an immediate liquidity shortage, takes the need for public liquidity as given.

Whereas prior work has mostly focused on liquidity provision through the banking sector, there is also a literature on government-related lending, which is common in developing countries. This literature broadly suggests that such lending (taking place, for example, through state-owned banks) results in worse lending outcomes (e.g., Barth, Caprio and Levine, 2004, La Porta, Lopez-de-Silanes and Shleifer, 2002, and Beck, Demirguc-Kunt and Martinez Peria, 2007). Our model shows that inferior (lending) outcomes are fully consistent with optimality: the average quality of firms ultimately funded by banks is higher when public and traditional lending are efficiently implemented (this is because banks will be tasked with selecting the high quality borrowers, while the role of public lending is to fund firms that provide desirable externalities). The literature on government lending has been fairly mute on how funding in the economy should be distributed between different public and private lenders. Holmström and Tirole (1997) examine this question from the perspective of market versus bank funding (that is, uninformed versus informed lending). In their model – as in ours – the economy should make use of the informational benefit of bank funding at *intermediate* ranges of firm quality.[8]

Our analysis provides a new perspective on how central banks should set interest rates during crises. Prior work has suggested that central banks should provide emergency liquidity only at a penalty rate (Bagehot, 1873), to curb moral hazard. However, this has proven infeasible in practice, as there are overruling concerns about solvency and financial stability during crises. In Diamond and Rajan (2012) the central bank thus offsets moral hazard arising from cheap crisis funding by charging high interest rates outside a crisis. Interest rates have a different, and dual, role in our model: they should be set to correct externalities in production but also have to correct mothballing incentives. The consequences are that interest rates are not necessarily low during the crisis, but should be promised to be low for when the crisis is over. The latter argument relates to the practice of central banks to provide forward guidance for interest rates, to steer inflationary expectations (e.g., Swensson, 2015).

The Covid-19 crisis has highlighted a need for public interventions that differs from the

[8]There is also literature analyzing the relative merits of providing liquidity assistance to banks versus government bailouts of firms. For example, in Diamond and Rajan (2012) undirected liquidity assistance by the central bank is better than public interventions (bailouts) as it leads to less moral hazard.

usual one. During a pandemic, the production of goods and services (and their consumption) creates clear externalities by facilitating the spread of the virus (see Eichenbaum, Rebelo and Trabandt, 2020, Krueger, Uhlig and Xie, 2020, Bethune and Korinek, 2020). Thus, unlike in ordinary recessions, stimulating the economy to return to normal capacity is not a desirable situation; optimal policies will also vary with the intensity of the pandemic over time (e.g., Eichenbaum et al., 2020). Our analysis is primarily concerned with the cross-sectional aspect of interventions, as we examine how to bring liquidity to heterogenous firms. Commentators during the Covid-19 crisis have also emphasized the need for funding firms during *temporary* disruptions to their production (see Boot et al. 2020, Brunnermeier and Krishnamurthy, 2020, and Didier et al. 2020), and suggested immediate liquidity assistance as policy tool. Our model combines the objective of funding maintenance of firms through temporary disruptions (mothballing) with the objective of avoiding a stimulation of production during the pandemic, showing that there is a trade-off that requires a second policy tool (commitment to future interest rates).

3 Setup

The economy has two dates (date 1 and 2). There is a bank, a central bank, and a continuum of entrepreneurs that have one project each.

Undertaking a project requires one unit of funds at date 1. Projects differ according to their return-type r, which indicates their (net) return at date 2. Projects also cause (assumed) externalities v that reduce date-2 surplus in the economy. In the context of the Covid-19 crisis, these are externalities that arise because production (and consumption) of services and goods results in infections (which become true externalities once directly affected individuals infect further individuals in the economy). Infections directly reduce surplus because health enters utility and, indirectly, due to increased healthcare costs. We assume the externalities to be fixed (for a microfoundation of contagion externalities, see Eichenbaum, Rebelo and Trabandt, 2020, and Bethune and Korinek, 2020) but discuss their endogeneity in an extension. The externality is net of any positive economic spillovers production may have on the economy and consumer welfare. For example, disruption in supply chains are a major cost of containment policies during the Covid-19 crisis (Inoue and Todo, 2020). In the context of the model this can be interpreted as not carrying out a project (that normally would be undertaken), imposing additional costs at others firms that rely on the output from the project.[9]

The return and externality types are uniformly distributed with mean $\widehat{r}$ and $\widehat{v}$ on the intervals $[\widehat{r} - s_r, \widehat{r} + s_r]$ and $[\widehat{v} - s_v, \widehat{v} + s_v]$ with $s_r, s_v > 0$ (note that we may have that $v < 0$, in case positive economic externalities exceed the costs of infections). A project's externality type can also be interpreted as indexed by the sector to which it belongs. For convenience of exposition, we make an assumption guaranteeing interior solutions

$$|\widehat{r} - \widehat{v}| < \min(s_r, s_v), \tag{1}$$

that is, the intervals of the two distributions have to be sufficiently overlapping. There is also a storage technology available in the economy, with (net) return of zero.

Entrepreneurs and the bank maximize profits. They have no endowments at date 1 (we can interpret the funding need at date 1 as one arising in excess of anticipated funding needs).[10] The central bank (CB) can create unlimited liquidity at date 1 at zero cost (if liquidity is interpreted in real terms, this can be thought of as funded by lump-sum taxation at date 2).

The date-1 informational structure in the economy is as follows. All agents know a project's externality-type v, however, only the bank knows the return type r. The motivation for the latter is that the bank has superior skills in evaluating (lending to) projects. In addition, the bank will probably already have funded the entrepreneurs in the past, and thus have knowledge specific to each project.

Welfare in the economy is given by

$$W = \int (r - v) \cdot \mathbf{1}(r, v) \frac{1}{4 s_r s_v} d(r, v), \tag{2}$$

where **1** indicates whether a project is undertaken. The first best solution is obvious: finance only projects with $r > v$, and abandon all others.

[9] For the purpose of the externalities, we should think of the (single) bank in our model representing a banking sector consisting of many small banks, so that each individual bank takes economy-wide aggregate as given.

[10] In reality, the date-1 funding decision will often be a decision of whether or not to *continue* a project that was started in a previous period. (Net) funding needs in this context may arise because projects are delayed (e.g., Holmström and Tirole, 1998) or require unexpected outlays (Kahn and Wagner, 2020).

4 Traditional versus direct lending

We first examine the traditional channel of liquidity distribution, that is, through the banking sector. At date 1, the CB opens a *liquidity facility*, allowing the bank to borrow any amount of liquidity it desires at an interest rate of i set by the CB. The bank can use this to fund entrepreneurs at date 1. We assume that the bank makes *take-it-or-leave-it* funding offers to entrepreneurs. The bank can thus extract r from a funded project at date 2; hence it will provide funding if r exceeds the interest rate i. It follows that only projects in the economy will be undertaken that have a return that exceeds the interest rate set by the CB ($r > i$).

As the bank funds projects where $r > i$, a total fraction $\frac{\widehat{r}+s_r-i}{2s_r}$ of projects in the economy are undertaken (without loss of generality we can assume that the CB sets only interest rates for which $\frac{\widehat{r}+s_r-i}{2s_r} \in [0,1]$). The average return of the funded projects is $\frac{i+\widehat{r}+s_r}{2}$ and their average externality is $\widehat{v}$. Welfare is thus given by

$$W_T(i) = \frac{\widehat{r}+s_r-i}{2s_r}\left(\frac{i+\widehat{r}+s_r}{2} - \widehat{v}\right). \tag{3}$$

From the FOC for i we can derive the optimal interest rate on the liquidity facility as

$$i^* = \widehat{v}. \tag{4}$$

The CB thus sets a rate that reflects the *average* externality from undertaking projects in the economy. The bank will hence fund projects if $r > \widehat{v}$. From condition (1) this implies that the bank funds an interior fraction of projects in the economy ($\frac{\widehat{r}+s_r-i^*}{2s_r} \in (0,1)$). Inserting i^* into welfare we obtain

$$W_T^* = \frac{(\widehat{r}-\widehat{v}+s_r)^2}{4s_r}. \tag{5}$$

As to be expected, higher $\widehat{r}$ and lower $\widehat{v}$ increase welfare. In addition, welfare also increases in s_r (this follows from condition (1)). This is due to the option value from evaluating projects: if the variance of project returns is high, there is large value to the bank optimally deciding to abandon some projects in favor of others (a similar result is obtained in Holmström and Tirole (1997) in the context of banks screening projects).

It is easy to see that welfare is strictly lower than under the first best. The reason is that – even though the bank makes efficient decisions regarding project returns – it does not do so regarding the externality. The CB, through setting the interest rate as in (4), can make the bank internalize the externality "on average", but not for individual projects (for half of the projects the interest rate charged will be too high, while for the other half too low). This means that when $v < \widehat{v}$, some socially desirable projects do not receive funding, while when $v > \widehat{v}$, the opposite problem arises.

We next consider the case of *direct lending*, where instead of relying on the bank, the CB distributes liquidity directly to firms.[11] As the CB does not know project returns, its lending can only be made conditional on externalities, or sectors. Since the CB has full control over funding in the economy, it can effectively decide which sectors obtain funding, and which not (note that the CB can always make funding worthwhile to entrepreneurs by offering a sufficiently low interest rate, possibly even negative).

If the CB decides to lend to a sector with externality v, the resulting surplus will be $\widehat{r} - v$. The CB will thus fund only sectors if $v < \widehat{r}$. This means that a proportion $\frac{\widehat{r}-(\widehat{v}-s_v)}{2s_v}$ ($\in [0,1]$) of projects will be funded. The average surplus in funded sectors is $\frac{\widehat{r}-(\widehat{v}-s_v)}{2}$ and welfare is

$$W_D^* = \frac{(\widehat{r} - \widehat{v} + s_v)^2}{4s_v}. \qquad (6)$$

Again, the first best welfare is not achieved. This time this is because funding decisions do not reflect the actual return of a project; only the average return $\widehat{r}$ across all projects.

Proposition 1 shows next that either mode of lending can be optimal in the economy.

Proposition 1 *Traditional lending achieves higher welfare if $s_r > s_v$, but lower welfare if $s_r < s_v$.*

Proof. *Follows from comparing (5) and (6) and using condition (1).* ■

It is important to note that the average returns and externalities $\widehat{r}$ and $\widehat{v}$ do not play a role in determining which type of lending more is preferable. One may have expected, for example, that if externalities are high, it is better to delegate lending decisions to the CB. The reason this is not the case is that *average* externalities can be decentralized, through the CB's interest rate.

Why does the optimal decision depend on the variances of the returns and externalities, s_r and s_v? The reason is that by choosing between traditional and direct lending, we effectively decide whether we condition lending decisions in the economy on r or v.

[11] Whereas in practice this may also happen through the treasury, for the purpose of our model all liquidity distribution occurs through the central bank.

Conditioning allows to benefit from the option value of being able not to undertake the project for an undesirable realization (of either r or v). Higher variance increases the option value, and thus increases the benefits from conditioning on one of the two project characteristics.[12]

Proposition 1 helps to distinguish in which circumstances the CB should follow which lending mode. In normal times, typical investments are likely to have only mild externalities, and limited variation. This justifies the historical practice of CBs distributing liquidity through the banking system. The disruption due to the pandemic is causing greater and unanticipated variation in the externalities across sectors, due to differences in the propensity for contagion during production and consumption of goods and service across specific businesses (consider for example restaurants versus online shopping). It may then become optimal for the CB to make use of direct lending.

Proposition 1 also suggests that the desirability of either lending mode depends on the stage of the pandemic. Heterogeneity in economic externalities from discontinuing production at firms (in the context of our model: not undertaking projects) is expected to be very large in early stages. This is because the disruption will come as a shock,[13] and due to differences in supply-chain dependencies the effects on the economy will vary greatly. However, over time, affected firms in the supply-chain will be able to adjust their production processes, becoming more self-sufficient and less susceptible to disruptions at other firms, reducing heterogeneities.[14] If containment policies are successful, the proportion of people who are (already) infected when they produce will decline; thus they will tend to infect less new people, reducing the scope for heterogeneities. The benefits from direct lending are thus expected to be the highest at the early stages of the pandemic. This justifies the actions taken by CBs and governments during the Covid-19 crisis, who have swiftly introduced direct lending programmes.

We can also use Proposition 1 to inform about whether direct lending is beneficial *within*

[12] Proposition 1 also holds if we drop assumption (1), that is, if we do not require interior solutions. Intuitively, this is because a corner solution is obtained for a lending mode when the relevant variance is low, in which case the lending mode is dominated anyway.

[13] Containment policies during the Covid-19 crisis were implemented across countries in very rapid succession, as demonstrated in the dataset put together by Olivier Lejeune (https://github.com/OlivierLej/Coronavirus_CounterMeasures).

[14] Beck and Wagner (2020) make a similar argument in the context of cross-border supply-chain externalities arising from national containment policies.

a certain segment of firms. For this we can interpret our model as describing a certain set of firms (that differ in terms of their project distributions). Consider for example large mature firms. For such firms there is high visibility regarding returns (thus reducing the informational advantage of bank lending) and also low dispersion of returns (as their returns will tend to approximate the equilibrium return in the economy). At the same time, these firms are expected to pose large externalities. This justifies the use of direct lending for such firms, as for example the Fed has done during the Covid-19 crisis through its purchase of corporate bonds. Another interesting case is the restaurant business. Restaurants tend to be only marginally profitable and have low dispersion of returns. At the same time, they have very large externalities that are likely to vary a lot across businesses (consider for example restaurants serving young versus old people). The restaurant business is thus also a prime candidate for direct lending.

4.1 Extensions

Systemic externalities. We have assumed an individual project's externality v to be exogenously given. In reality, the externality stemming from virus contagion is likely to have a systemic element. By the standard epidemiological model (the SIR-model, Kermack and McKendrick, 1927), the fraction of people that is newly affect by an interaction depends on the fraction of people already infected, and thus (in the context of our model) also on how many, and which, other projects have been undertaken in the economy. We may thus envisage the virus externality posed by a specific project v_i to be given by $v_i \cdot g(\int v \cdot \mathbf{1}(r,v)\frac{1}{4s_r s_v}d(r,v))$, where v_i is interpreted as the *virus-intensity* of the project's production and $\int v \cdot \mathbf{1}(r,v)\frac{1}{4s_r s_v}d(r,v)$ representing total (virus-intensity weighted) production in the economy. The g-function may be either increasing or decreasing.[15] Optimal lending (under either lending scheme) then has to be determined recursively, but follows the same considerations as before. Consider, for instance, condition (4) which states that the optimal interest rate equals the average externality ($i^* = \widehat{v}$). This externality will now itself depend on the interest rate, as higher rates will mean less production and hence lower externalities. If the g-function is increasing, this becomes a standard fixed-point problem: as the CB increases the interest rate, fewer projects will be undertaken, which will in turn reduce the externalities and reduce the need to increase the interest rate further.

[15] See Eichenbaum et al. (2020) for a full analysis of contagion externalities in an aggregate context.

Correlation between returns and externalities. Our setup considers realizations of r and v that are independent across firms. In practice, one may expect the two to be negatively correlated (a firm whose product or service is conducive to infection will find it more difficult to retain workers and sell its products, thus reducing returns), albeit imperfectly so. Negative correlation will alleviate the tension under both lending modes, as following one objective will then also tend to achieve the other at the same time (e.g., a bank abandoning low profitability projects is then also more likely to eliminate high externality projects).

Non-zero endowments. Suppose that the bank has an endowment at date 1. If the CB's rate exceeds the rate of storage in the economy (which will be the case if $\widehat{v} > 0$), the bank will use its own funds before tapping the liquidity line. As the bank will first fund the highest-return projects, this will eliminate the upper range of projects from the pool of projects in the economy, thus effectively shrinking the mean and variance of the return distribution. A practical consequence of this is that if the bank has more own funds, the benefits from direct lending decrease because of lower return variance in the remaining pool of projects.

Sector-specific liquidity policies. We have assumed that the CB offers one liquidity line under traditional lending (thus setting a single price of liquidity in the economy). Consider now that the CB offers multiple liquidity lines whose interest is conditional on the usage of funds. It is easy to see that by conditioning on the externality of the project to be funded, the first-best can be achieved (i.e., setting $i^*(v) = v$ achieves full efficiency). Under this policy, we can both make use of the informational skills of the banking sector, and at the same time make funding costs reflect project-level externalities. Difficulties are likely to arise in the full implementation of such a policy. A bank may for example claim a liquidity need for a (low externality) project that it would have funded anyway (using own resources), and use the extra liquidity from the CB (obtained at a lower interest) to fund a high-externality project. Still, externality-conditionining policies seem an attractive policy instrument, if feasible. They could be partially implemented, for instance, by making (bank) capital requirements during a pandemic conditional on the sectoral composition of lending portfolios.

5 Using both liquidity modes

The decision of whether or not to do decentralize lending was so far applied to the economy in its entirety. That is, either lending was fully delegated to the bank, or the CB took full control of the liquidity supply. In this section we allow the CB to apply different liquidity modes for different parts of the economy. We will examine whether there is a rationale for doing so, and if this is the case, what will determine the division between traditional lending and other forms of lending.

The CB can now partition the economy into three segments, based on externalities (sectors). First, a segment where the liquidity distribution may be left to the bank. The rest of the economy may be further divided, into one segment where the CB lends directly to all firms, and another one where no lending takes place. We can summarize the segments by two thresholds, $\underline{v}$ and $\overline{v}$. In the range where externalities are low ($v < \underline{v}$), the CB undertakes direct lending (that is, funds all projects), whereas in the range where externalities are high ($v > \overline{v}$), lending is prohibited (no projects are funded). In the middle range ($v \in [\underline{v}, \overline{v}]$), lending is delegated to the bank, resulting in projects with $r > i$ being funded. Note that the two liquidity modes considered in the previous section are special cases in this setup (there is only traditional lending when $\underline{v} = \widehat{v} - s_v$ and $\overline{v} = \widehat{v} + s_v$, whereas for $\underline{v} = \overline{v}$ there is only direct liquidity distribution).

The optimal liquidity problem has now three parameters: the lower and the upper thresholds, $\underline{v}$ and $\overline{v}$ (with $\widehat{v} - s_v \leq \underline{v} \leq \overline{v} \leq \widehat{v} + s_v$), and the interest rate i for the traditional lending range.

Proposition 2 *The optimal liquidity policy always involves traditional lending ($\underline{v}^* < \overline{v}^*$). Traditional lending is either done on its own, combined with one other lending range (direct or no lending), or combined with both lending ranges (direct and no lending). In the latter case the optimal interest rate is $i^* = \widehat{r}$ and the lower and upper thresholds are $\underline{v}^* = \widehat{r} - \frac{s_r}{2}$ and $\overline{v}^* = \widehat{r} + \frac{s_r}{2}$.*

Proof. *Suppose the optimal liquidity policy did not involve traditional lending. We are then in the case of full direct lending analysed in Section 4, implying that the CB will fund only projects if $v < \widehat{r}$. By condition (1) this means that an interior fraction of projects in the economy will be funded. The surplus at (marginally) rejected projects (with $v = \widehat{r}$) is zero. However, if we delegate lending for these projects to the bank with an interest rate of $i = \widehat{r}$, we obtain surplus of $\frac{\widehat{r}+s_r+i}{2} - v = \frac{s_r}{2} > 0$. Thus the original policy cannot be optimal,* *and it follows that an optimal policy always involves traditional lending* ($\underline{v}^* < \overline{v}^*$).

We next derive optimal liquidity policies for when all three liquidity modes are used ($\widehat{v} - s_v < \underline{v} < \overline{v} < \widehat{v} + s_v$). *Welfare then consists of the surplus generated by projects funded in the direct lending and the traditional range. In the direct lending range* ($v < \underline{v}$) *all projects are funded. A total of* $\frac{\underline{v}-\widehat{v}+s_v}{2s_v}$ *of projects are hence funded in this range, with average surplus* $\widehat{r} - \frac{\underline{v}+\widehat{v}-s_v}{2}$. *In the traditional range* ($v \in [\underline{v}, \overline{v}]$) *only projects with* $r > i$ *are funded. Thus a fraction of* $\frac{\widehat{r}+s_r-i}{2s_r}$ *of projects in the range are funded. The total number of funded projects in this range is then* $\frac{\overline{v}-\underline{v}}{2s_v}\frac{\widehat{r}+s_r-i}{2s_r}$ *and their average surplus is* $\frac{i+\widehat{r}+s_r}{2} - \frac{\underline{v}+\overline{v}}{2}$. *Combining we obtain for welfare:*

$$W_{All}(i) = \frac{\underline{v} - \widehat{v} + s_v}{2s_v}(\widehat{r} - \frac{\underline{v} + \widehat{v} - s_v}{2}) + \frac{\overline{v} - \underline{v}}{2s_v}\frac{\widehat{r} + s_r - i}{2s_r}(\frac{i + \widehat{r} + s_r}{2} - \frac{\underline{v} + \overline{v}}{2}). \quad (7)$$

Consider first the choice of the upper threshold $\overline{v}$. *If the bank is left to decide whether to undertake projects with externality* v, *the average surplus (across funded projects with* v) *is* $\frac{i+\widehat{r}+s_r}{2} - v$. *If no lending takes place for projects with* v, *the surplus is zero. At an (interior) threshold between traditional and no lending, both lending modes have to give the same surplus:* $\frac{i+\widehat{r}+s_r}{2} - v = 0$. *Rearranging gives* $\overline{v}^* = \frac{i+\widehat{r}+s_r}{2}$. *Consider next the choice of the lower threshold* $\underline{v}$, *which requires indifference between traditional and direct funding. If the CB switches for projects with externality* v *from traditional funding to direct funding, all* v*-projects that were previously rejected by the bank will become funded. Since the bank rejected projects with* $r < i$, *the average surplus of rejected projects is* $\frac{i+\widehat{r}-s_r}{2} - v$. *Indifference requires* $\frac{i+\widehat{r}-s_r}{2} - v = 0$, *and rearranging gives* $\underline{v}^* = \frac{i+\widehat{r}-s_r}{2}$. *Finally, consider the optimal interest rate. From the FOC of* $W_{All}(i)$ *wrt. to* i *we find that* $i^* = \frac{\underline{v}+\overline{v}}{2}$ *(that is, the interest rate is the average externality in the traditional funding range). Combining the three expressions for* $\underline{v}^*$, $\overline{v}^*$ *and* i^* *we obtain* $i^* = \widehat{r}$, $\underline{v}^* = \widehat{r} - \frac{s_r}{2}$ *and* $\overline{v}^* = \widehat{r} + \frac{s_r}{2}$.

We finish by analyzing under which conditions which combinations of liquidity modes are being used. From the requirement that $\underline{v}^* = \widehat{r} - \frac{s_r}{2}$ *and* $\overline{v}^* = \widehat{r} + \frac{s_r}{2}$ *are interior, we obtain*

$$|\widehat{v} - \widehat{r}| \leq s_v - \frac{s_r}{2}. \quad (8)$$

If this condition is fulfilled, all three lending modes are being used. If $\widehat{v} - \widehat{r} < s_v - \frac{s_r}{2}$, *the direct lending range is empty, while if* $\widehat{v} - \widehat{r} > -s_v + \frac{s_r}{2}$ *the no-lending range is empty. If both* $\widehat{v} - \widehat{r} < s_v - \frac{s_r}{2}$ *and* $\widehat{v} - \widehat{r} > -s_v + \frac{s_r}{2}$, *only traditional lending is used.* ■

The proposition shows that if we allow the CB to combine liquidity modes, it is always optimal for the policy to include some traditional lending, but not necessarily any direct lending. This seems at odds with the analysis of pure liquidity policies in Section 4, which suggested a fully symmetric trade-off. The reason is that a direct lending economy can always be improved using traditional lending. This is because around the optimal funding threshold $v = \widehat{r}$ in the direct lending economy, average project surplus is zero. However, if we delegate lending for these projects, average surplus will be positive as the bank will not carry out the projects with lower returns. The reverse, however, is not necessarily true. If we move projects from bank funding to full funding (or no funding) there is always a trade-off as we lose the ability of banks to eliminate low-return projects.

The proposition shows that it can indeed be optimal to combine all three liquidity modes. If this is the case, the size of the traditional range is equal $\overline{v}^* - \underline{v}^* = s_r$, and thus increases with the return variance. This conforms with previous intuition that a higher return variance makes traditional lending more attractive. Since $\underline{v}^* = \widehat{r} - \frac{s_r}{2}$ and $\overline{v}^* = \widehat{r} + \frac{s_r}{2}$, a higher return-average $\widehat{r}$ simply shifts the traditional range to the right, hence projects with larger externalities are delegated to the bank. This implies that the range where projects are directly funded increases, while the range where projects do not deserve funding at all decreases.

What is striking though is the complete irrelevance of the externalities (both in terms of variance and means) for the optimal liquidity policy. The reason is the following. As in the case of pure liquidity policies, the optimal interest rate is set equal to the average externality in the traditional range, now given by $i^* = \frac{\underline{v}+\overline{v}}{2}$. The threshold externalities $\underline{v}$ and $\overline{v}$, however, are endogenously determined and depend on the average return. As a result, an optimal policy (that combines all three lending ranges) becomes independent of the externalities, which contrasts with the analysis of pure liquidity policies in the previous section.[16]

Taken together, the results in this section suggest that it can be optimal to lend directly to low-externality firms and to delegate lending for firms with intermediate levels of the externality to banks (and to enlarge the latter range when the dispersion of project returns in the economy is high). Note that this partioning outcome resembles actual lending during

[16] Note, however, that the externality (both in terms of mean and variance) still affects the condition under which the optimal liquidity policy has three ranges (condition (8)). In addition – even though higher externality variance s_v does not affect the thresholds – it will affect the *probability* fraction of projects in a given range (in particular, for higher s_v the likelihood of a project being allocated to delegated lending decreases).

the Covid-19 crisis. High externality sectors are shut down by government decree whereas for the rest of the economy both direct and traditional lending coexist. Our results suggest that within these sectors, direct lending should focus on serving the low-externality firms, at the same time sufficient liquidity should be given to the banking sector to lend to firms with intermediate externalities.[17] Note that this is not necessarily how Covid-19 lending programmes are designed, as eligibility for these programmes does not appear to condition on externalities, but rather on the existence of an immediate funding need.

The liquidity policies considered in this section entail deciding about the range where direct lending takes place (and where lending is prohibited) but also about interest rates. In practice, these decisions are often taken by different authorities. Our results emphasize the need for coordination among these authorities. The optimal interest rate (for given lending thresholds $\underline{v}$ and $\overline{v}$) is $i^*(\underline{v}, \overline{v}) = \frac{\underline{v}+\overline{v}}{2}$, that is, the average externality in the traditional range (see the proof of Proposition 2). This implies that if, for example, the treasury increases direct lending in the economy (thus increasing $\underline{v}$), the CB should *raise* the interest rate on its liquidity facility. The reason for this interdependence is that an expansion of direct lending eliminates low-externality projects from the pool, hence increasing average externalities when banks do the lending.

5.1 Co-lending

The preceding section considered dividing lending decisions between private banks and public authorities. Several programmes introduced during the Covid-19 crisis involve joint lending at the project level by the central bank (or the government) and the banking system, typically coupled with a guarantee for the bank. Co-lending seems to aim at the best of both worlds: utilizing the bank's information advantage in lending decisions, and pooling this with the CB's care for externalities and its ability to provide unlimited liquidity. However this section shows that within our framework co-lending generally lowers welfare.

[17]The optimality of three funding ranges has some resemblance to Holmstrom and Tirole (1997). In their paper firms are borrowing-constrained because of adverse selection. Good firms obtain direct funding (from the market in their context). Intermediate firms require bank and market funding (because banks are needed to solve an adverse selection problem), while bad firms cannot borrow at all. The mechanism is very different, but we share the result that it is optimal to make use of banks' informational advantages in the "middle" region.

Suppose the CB announces at date 1 that it will co-finance every project deemed to be worthwhile by the bank (so the lending decision remains with the bank). The CB will fund half of any such project and will charge entrepreneurs a rate of i_{co} (possibly different from the "normal" CB-rate i charged to the bank) for this. The CB will also guarantee a fraction β ($\in (0,1)$) of the bank's part of the loan. As the CB cannot observe the project type at date 1, this requires promising a fixed return r_{co} ($\in [\widehat{r}-s_r, \widehat{r}+s_r]$) on the guaranteed part. The CB's policy has now four parameters: the interest rate on bank funding i, the interest rate on co-lending i_{co}, the coverage ratio of the guarantee β, and the guaranteed amount r_{co} (both being measures of guarantee generosity).

Proposition 3 *Co-lending lowers welfare (compared to optimal traditional lending) whenever it changes funding outcomes.*

Proof. *The bank's profit from funding a project has now three parts. First, the amount it can extract from the project's return at date 2, which is $r - \frac{1}{2}i_{co}$ (the entrepreneur has to pay $\frac{1}{2}i_{co}$ to the CB, reducing funds available). Whenever r is below r_{co}, the bank gets in addition $\beta(r_{co} - r)$ from the CB at date 2, as the guarantee is invoked. Finally, the bank has to pay $\frac{1}{2}i$ due to date-1 borrowing (used to fund the project) to the CB. Total profit is thus $r - \frac{i+i_{co}}{2}$ whenever $r \geq r_{co}$, and $r + \beta(r_{co} - r) - \frac{i+i_{co}}{2}$ otherwise. We see that the co-lending rate affects outcomes exactly in the same way as the (normal) CB-rate. Without loss of generality, we can thus set it equal to the CB rate: $i_{co} = i$. It follows that profit equals $r - i$, plus $\beta(r_{co} - r)$ whenever $r < r_{co}$.*

From setting equal to zero, we obtain that the bank's break-even project return is $r = i$ if $r_{co} \leq i$, and $r = \frac{i-\beta r_{co}}{1-\beta}$ if $r_{co} > i$. The first case is exactly the same as under traditional lending, and can hence be ignored as it leads to the same funding outcomes. Without loss of generality we thus restrict ourselves to $r_{co} > i$. The bank will hence accept projects iff $r > \frac{i-\beta r_{co}}{1-\beta}$, resulting in a fraction $\frac{\widehat{r}+s_r-\frac{i-\beta r_{Co}}{1-\beta}}{2s_r}$ of projects in the economy with average surplus $\frac{\frac{i-\beta r_{Co}}{1-\beta}+\widehat{r}+s_r}{2} - \widehat{v}$ to be funded. We obtain for welfare:

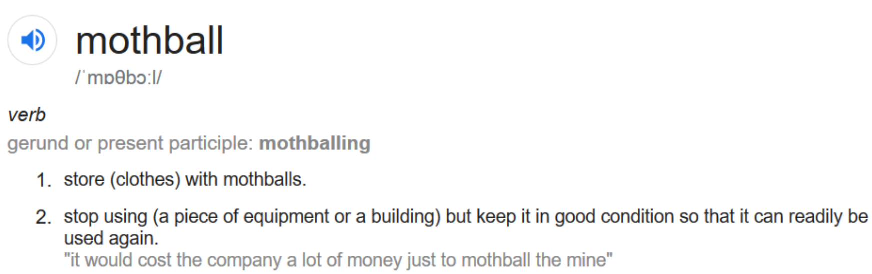
$$W_{co}(i) = \frac{\widehat{r} + s_r - \frac{i-\beta r_{Co}}{1-\beta}}{2s_r}\left(\frac{\frac{i-\beta r_{Co}}{1-\beta} + \widehat{r} + s_r}{2} - \widehat{v}\right). \tag{9}$$

This expression is strictly lower than welfare under traditional lending (W_D^*) whenever $\frac{i-\beta r_{Co}}{1-\beta} \neq \widehat{v}$. The case of $\frac{i-\beta r_{Co}}{1-\beta} = \widehat{v}$ can be ignored as the threshold return is then $r = \widehat{v}$, in which case co-lending just replicates the traditional lending outcome. ■

The reason co-funding lowers welfare is that it distorts the decision that actually worked well under direct lending. Due to its profit-maximizing behavior, the bank previously only accepted projects that provided a return in excess of opportunity costs. This is no longer the case. Because of the guarantee, the bank may now also accept projects with lower returns, reducing welfare.[18] Note that the potential effect of co-lending only comes through the guarantee part; the co-funding itself has no effect on funding decisions (the CB could equally channel these fund to projects using the banking sector).[19]

Of course, if we were to allow the CB to condition co-lending on the externality, co-lending may also provide benefits. However, we would then still be left with the problem that co-lending distorts the bank's behavior. We would thus face a complex scheme that still does not achieve the first best. Co-lending thus does not appear an attractive option in the context of the trade-offs considered in our model. This suggests that if public authorities prefer to channel funds directly to banks, they should do so without leaving discretion to the banking sector.

6 Mothballing


mothball
/ˈmɒθbɔːl/
verb
gerund or present participle: **mothballing**
1. store (clothes) with mothballs.
2. stop using (a piece of equipment or a building) but keep it in good condition so that it can readily be used again.
"it would cost the company a lot of money just to mothball the mine"

Pandemics, such as the Covid-19 crisis, generate an unusual problem. There are many firms that we do not want to operate during the pandemic because of contagion risk (such as restaurants). But these firms were viable businesses in the absence of the pandemic. We

[18] In principle, the CB could undo this by raising the interest rate i by an appropriate amount. However, in this case it would (at best) just replicate the traditional lending outcome. Williamson (1994) obtains a similar result in the context of costly state verification problem. In his model direct government lending simply displaces private lending and does not affect welfare.

[19] We have assumed that there is no agency problem at banks. Co-funding may have additional effects in the presence of agency problems. For example, the guarantee may further exacerbate risk-taking effects that arise in the presence of limited liability.

thus do not want them to go out of business; we want to preserve their productive capacity so that they can operate again once pandemic is over.

Such "mothballing" requires funds. Firms incur fixed costs (such as rent for buildings and lease payments) even if not currently producing. Equipment needs to be maintained in good working order (for example, some machinery cannot simply be shut down without damaging it). In order to be ready to produce again in the future, firms also need to retain workers in order to maintain valuable firm-labor relationships (companies cannot just rehire the same number of workers after the crisis, and expect to operate with the same efficiency as before). Finally, firms will also need to preserve their relationships with customers and suppliers (think for example of continuing customer service).

We amend our model to allow for mothballing. Specifically, we add a new production period (from date 2 to date 3). In this period, the pandemic is assumed to be over (or least to be under control); the externality is thus only present for production between date 1 and 2. There are now three funding possibilities for a project at date 1:

1. *Full funding*: This requires one unit of funds at date 1 and results in production of $\frac{r}{2}$ at date 2 and at date 3, plus an externality of v at date 2.

2. *Mothballing*: Mothballing requires funding at date 1 (to pay for the mothballing) plus funding at date 2 (to restart the business). We assume that the total required funds are $\frac{1}{2}$ and are equally split among the dates (thus, $\frac{1}{4}$ at each date). The project returns $\frac{r}{2}$ at date 3.

3. *No funding*: If neither the funding requirements under full funding nor under mothballing are met, the project is worthless and returns zero at date 2.

The total surplus from fully funding a project is $r - v$ (as in the baseline model), while the surplus from mothballing is $\frac{r}{2}$, compared to 0 for no funding. It follows that it is optimal to mothball a project when

$$\frac{r}{2} - v < 0 < \frac{r}{2}, \tag{10}$$

that is, if one period of production generates positive surplus without externality, but a negative a one with the externality. Note that mothballing can only be optimal if $v > 0$; we assume in the following that $\widehat{v} > 0$ (that is, at the average-externality project mothballing can be desirable).

We derive next the optimal liquidity policies under traditional lending. Since there are two funding dates, the CB offers two liquidity lines (one at date 1, and one at date 2), with interest rates i_1 and i_2. As projects differ with respect to their returns and externalities, some projects should be fully funded, others should be mothballed, whereas some projects should not receive funding at all. How can the CB induce optimal funding choices in the economy? There is a clear tension. In order to induce mothballing for a project, the CB has to offer sufficiently attractive funding conditions at date 1 to provide incentives for entrepreneurs and the bank to incur the mothballing costs. But in doing so, it will also make full funding more attractive, potentially leading to undesirable outcomes.

The next proposition shows the solution to this problem.

Proposition 4 *The optimal date-1 and date-2 interest rates are $i_1^* = \widehat{v}$ and $i_2^* = -\widehat{v}$.*

Proof. *We derive the bank's project funding decisions for interest rates i_1 and i_2. Full funding provides a profit of $r - i_1$, whereas mothballing gives profits of $\frac{r}{2} - \frac{i_1+i_2}{4}$ (and no funding gives zero). It follows that if $r > i_1 + \frac{i_1-i_2}{2}$, the bank will choose full funding. If $r \in [\frac{i_1+i_2}{2}, i_1 + \frac{i_1-i_2}{2}]$, it will mothball, and when $r < \frac{i_1+i_2}{2}$, it will not fund. Without loss of generality we can assume that $i_2 \leq i_1$ (if i_2 were larger than i_1, the mothballing range is empty; in this case setting the date-2 rate is irrelevant and setting it equal to i_1 achieves the same outcome). The bank will thus fully fund a fraction $\frac{\widehat{r}+s_r-(i_1+\frac{i_1-i_2}{2})}{2s_r}$ of projects; these projects have an average surplus of $\frac{i_1+\frac{i_1-i_2}{2}+\widehat{r}+s_r}{2} - \widehat{v}$. It will mothball a fraction of $\frac{i_1-i_2}{2s_r}$ of projects with surplus of $\frac{i_1+\frac{i_1-i_2}{2}+\frac{i_1+i_2}{2}}{4} = \frac{i_1}{2}$. Welfare is thus*

$$W_T^{MB}(i_1, i_2) = \frac{\widehat{r} + s_r - (i_1 + \frac{i_1-i_2}{2})}{2s_r}(\frac{i_1 + \frac{i_1-i_2}{2} + \widehat{r} + s_r}{2} - \widehat{v}) + \frac{i_1 - i_2}{2s_r}\frac{i_1}{2}. \tag{11}$$

From the FOC for i_1 and i_2 we then obtain that $i_1^* = \widehat{v}$ and $i_2^* = -\widehat{v}$. ■

Why is this the optimal liquidity policy? Consider the case of a project that is fully funded. As this requires funding at date 1, the bank's opportunity cost is $i_1^* = \widehat{v}$. As full funding produces an (average) externality of $\widehat{v}$, the opportunity costs are thus set correctly (given of course that the CB cannot condition on the actual v). Consider next the case of mothballed project. Such a project requires funding at date 1 and date 2 and the opportunity cost is hence $\frac{i_1^*+i_2^*}{2} = 0$, which is again correct given that mothballing does not cause an externality. By setting the interest rates as in Proposition 4, the CB thus passes on the (average) social cost of each funding mode onto the bank, resulting in optimal funding decisions.

The key insight from Proposition 4 is that during a pandemic, there is also a role for the CB to commit to future funding conditions. In order for firms to "hang-on" and incur the running costs, the CB has to promise favorable funding conditions once the pandemic is over. This is achieved by setting very low rates on future liquidity (date 2). During the pandemic (date 1), the CB should still fully satisfy the liquidity needs of firms, however, the funding rates should not be too low as they need to reflect the externalities in production.[20]

The need to provide "mothballing" incentives is particularly prevalent during a pandemic, but may also be present in ordinary recessions. During a recession, the surplus from production is temporarily depressed. Firms may thus decide to go out of business instead of keeping idle and waiting until economic conditions have improved.[21] Again, there is a potential role for the CB in encouraging mothballing, potentially by setting attractive funding conditions for the future.

Our paper examines support to firms during crises in the form of public liquidity. Governments, however, also implement measures that subsidize labor during crises. In particular, several European countries have schemes that allow companies facing temporary problems to reduce the hours worked for workforce.[22] This achieves something very similar to our liquidity policies. As the schemes only subsidize labor if companies reduce hours worked, companies are incentivized to discontinue full production, avoiding the externalities. At the same time, the subsidies are only paid if the companies retain the workers, that is, if they "mothball" the labor force.

These labor market schemes, however, are known to create moral hazard. As actual hours worked are difficult to observe for outsiders (in particular so in times of home working), firms can claim to operate under reduced hours (in order to benefit from the subsidies) but continue to employ labor more or less fully.[23] Implementing mothballing through liquidity policies does not suffer from this problem as the CB does not need to

[20] In monetary policy it is well-known that *forward guidance* (where the CB provides information about its future interest rates) can play a role in shaping inflationary expectations (see e.g., Svensson, 2015). By contrast, the objective in our context is to implement optimal production choices.

[21] Firms may make inefficient mothballing decisions because of financial constraints: the return on mothballing (at date 1) acrues in the far future (date 3) and is hence difficult to pledge.

[22] In Germany, for example, the scheme is called *Kurzarbeitergeld*, translating into "money for limited working".

[23] Another problem with subsidizing labor in the context of a pandemic is that it disensitizes companies to move to a production process that is less prone to virus contagion (likely involving more capital and *less* labor).

observe whether a project is actually mothballed: given the interest rates set by the CB, it is incentive compatible for banks and entrepreneurs to undertake mothballing.

7 Conclusions

This paper has examined liquidity policies when production at firms entails externalities. We have shown there is a trade-off between traditional lending (where liquidity is channeled through the banking system) and direct lending (by public authorities). Direct lending can be targeted according to the externalities, but will be less efficient in bringing liquidity to the highest quality firms. Which side of the trade-off an economy is on depends on the variability (but not the level) of externalities and productivities across firms. This has clear implication as to when direct lending should be favoured, and which segment of the economy benefit most from it.

We have shown that when different lending modes can be combined, traditional lending is always part of optimal liquidity policies. Under certain conditions it is optimal to split the economy in three ranges, where low-externality firms obtain directed lending, lending to high-externality firms is prohibited, and banks serve the middle-region. Under this policy, the quality of projects funded directly is lower than the ones funded by banks, consistent with empirical evidence of lending performance of different types of lenders. We also show that optimal policies will typically require coordination among public authorities, as the extent to which direct lending takes place (typically decided upon by treasuries) affects the interest at which the central bank should provide liquidity to the banking system.

We have also analyzed the funding of mothballing. Such funding creates a clear tension as traditional liquidity policies will stimulate mothballing as well as production. Efficiently segmenting the economy into ranges with full production, mothballing and no funding requires a new tool. We have shown that committing to future interest rates can be such a tool. Attractive funding conditions for when the crisis is over provides incentives for firms to “hang-on”, that is, neither to go out of business nor to return to production immediately.

References

[1] Bagehot, Walter, 1873, Lombard Street: A Description of the Money Market, London, H. S. King.

[2] Barth, James, Gerard Caprio and Ross Levine, 2004, Bank supervision and regulation: what works best?, *Journal of Financial Intermediation*, **13**, pages 205-248.

[3] Beck, Thorsten, Asli Demirguc-Kunt and Maria Martinez Peria, 2007, Reaching out: access to and use of banking services across countries, *Journal of Financial Economics*, **85**, pages 234-266.

[4] Beck, Thorsten and Wolf Wagner, 2020, National containment policies and international cooperation, *Covid Economics, Vetted and Real-Time Papers*, **8**, pages 120-134.

[5] Bethune, Zachary and Anton Korinek, 2020, Covid-19 Infection externalities: Pursuing herd immunity or containment?, *Covid Economics, Vetted and Real-Time Papers,* **11**, pages 1-34.

[6] Boot, Arnoud, Elena Carletti, Rainer Haselmann, Hans-Helmut Kotz, Jan Pieter Krahnen, Loriana Pelizzon, Stephen Schaefer and Marti Subrahmanyam,2020, Coronavirus and Financial Stability, SAFE Policy Letter No. 78.

[7] Brunnermeier, Markus and Arvind Krishnamurthy, 2020, COVID-19 SME Evergreening proposal: Inverted Economics, mimeo, Princeton University.

[8] Diamond, Douglas and Phil Dybvig, 1983, Bank Runs, Deposit Insurance, and Liquidity, *Journal of Political Economy*, **91**, pages 401-19.

[9] Diamond, Douglas and Raghuram Rajan, 2012, Illiquid Banks, Financial Stability, and Interest Rate Policy, *Journal of Political Economy*, **120**, pages 552-591.

[10] Didier, Tatiana, Federico Huneeus, Mauricio Larrain and Sergio Schmukler, 2020, Hibernation: Keeping firms afloat during the COVID-19 crisis, Vox EU 24 April.

[11] Eichenbaum, Martin, Sergio Rebelo and Mathias Trabandt, 2020, The Macroeconomics of Epidemics, NBER Working Paper No. 26882.

[12] Holmström, Bengt and Jean Tirole, 1997, Financial Intermediation, Loanable Funds, and The Real Sector, *Quarterly Journal of Economics*, **112**, pages 663-691.

[13] Holmström, Bengt and Jean Tirole, 1998, Private and Public Supply of Liquidity, *Journal of Political Economy*, **106**, pages 1-40.

[14] Kahn, Charles and Wolf Wagner, 2020, Sources of Liquidity Shortages, *Journal of Financial Intermediation*, forthcoming.

[15] Kermack, William and Anderson McKendrick (1927), A Contribution to the Mathematical Theory of Epidemics, *Proceedings of the Royal Society of London*, pages 700-721.

[16] Krueger, Dirk, Harald Uhlig and Taojun Xie (2020), Macroeconomic Dynamics and Reallocation in an Epidemic, CEPR Discussion paper no. 14607.

[17] La Porta, Richard, Florencio Lopez de Silanes and Andrei Shleifer, 2002, Government ownership of banks, *Journal of Finance*, **57**, pages 265-301.

[18] Svensson, Lars (2015), Day One Keynote Address: Forward Guidance, *International Journal of Central Banking*, **11**, pages 19-64.

[19] Inoue, Hiroyasu and Yasuyuki Todo, 2020, The propagation of the economic impact through supply chains: The case of a mega-city lockdown to contain the spread of COVID-19, *Covid Economics, Vetted and Real-Time Papers*, **8**, pages 43-59.

[20] Williamson, Stephen (1994), Do informational frictions justify federal credit programs?, *Journal of Money, Credit and Banking*, **26**, pages 523-544.