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Abstract

We build a minimalist model of the macroeconomics of a pandemic, with two essential components. The first is productivity-related: if the virus forces firms to shed labor beyond a certain threshold, productivity suffers. The second component is a credit market imperfection: because lenders cannot be sure a borrower will repay, they only lend against collateral. Expected productivity determines collateral value and, in turn, collateral value can limit borrowing and productivity. Adverse shocks can be subject to large magnification effects, in an unemployment and asset price deflation doom loop. Multiple equilibria may also occur, and pessimistic expectations can push the economy to a bad equilibrium with limited borrowing and low employment and productivity. The model helps select policies to fight the effects of the pandemic. Traditional expansionary fiscal policy has no beneficial effects, while cutting interest rates has a limited effect if the initial real interest rate is low. By contrast, several unconventional policies, including wage subsidies, helicopter drops of liquid assets, equity injections, and loan guarantees, can keep the economy in a full-employment, high-productivity equilibrium. But such policies are fiscally expensive, so their implementation is feasible only with ample fiscal space or emergency financing from abroad.

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The Macroeconomics of a Pandemic: A Minimalist Model*

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I. Introduction

Imagine an entrepreneur who runs a consultancy that lost all of its customers because of the coronavirus emergency. Or a restaurant, forced to close its doors because of the government-mandated lockdown. Or a small manufacturing firm, also shuttered today.

Because she is an optimist, the entrepreneur expects the crisis will be temporary. That is, in some future period (3 months, 6 months?) she will be able to open up again, regain customers and operate normally. But in the meantime, the firm has no revenues. And remember that bank loan to buy new computer equipment? Well, it is coming due next month.

The entrepreneur is proud of what she has built. In her line of business, employees make the difference between success and failure. It has taken her years to find the right people and train them. If she lets them go now, the business will never be the same.

So she would like to retain most of them. But the cash reserve the firm has built is not enough to finance the wage bill for three months —much less for six months! And there is that loan coming due. To keep employees and stay current on debt service, the firm will have to borrow even more.

A bank will be happy to lend the money —if the firm has enough collateral. But smaller firms often do not have assets they can pledge. And larger firms find that at a time of great uncertainty the value of the physical and financial assets they hold is severely depressed, so those assets are not much good as collateral. The upshot is that many firms may be unable to borrow. And if credit does not flow, millions of jobs will be lost and massive amounts of entrepreneurial capital will be destroyed. That is the central economic challenge of the Covid-19 crisis.

To help sort out how it all works (or fails to), and what the alternatives for policy are, in this paper we build a minimalist model of the macroeconomics of a pandemic.[1] The story we tell has two essential components. The first has to do with productivity. We assume that that once the virus hits, firms can shed a few employees without much of an impact on productivity, but if forced to shed labor beyond a certain threshold, productivity will suffer.

The other key component is an imperfection in the credit markets. Because lenders cannot be sure of repayment, borrowers are subject to a constraint, with the amount they can borrow limited by the assets they can provide as guarantee or the future income they can credibly pledge.

The two components of the model interact: low expected productivity causes low collateral value, and low collateral value means limited borrowing and low productivity. These links are intuitive and simple, yet have noteworthy implications. One is that the economy responds to adverse shocks with large magnification effects, in what one might call an unemployment and

[1] So the focus of our model is very different from that of other Covid-19 macro papers, such as Eichenbaum, Rebelo and Trabandt (2020), Faria e Castro (2020) and Kaplan, Moll and Violante (2020).

asset price deflation doom loop (Fornaro and Wolf, 2020). For instance, if the firm starts out with one fewer dollar of initial net worth, its capacity to hire workers and pay wages goes down by more than one dollar, with the multiplier reflecting reduced access to outside finance through an drop in the value of the firm.

For some parameter values the model also displays multiple equilibria, so that pessimistic expectations can push the economy to a bad equilibrium. Suppose that lenders expect a low price for the assets the firm uses as collateral. Then lenders will be willing to lend little, which in turn will force the firm to shed many workers, with the resulting hit to productivity, which confirms lenders´ initial expectations about asset valuation. The opposite can also occur if lenders expect high asset values and strong productivity: those expectations can also be rational and self-fulfilling.

The model casts useful light on policy alternatives. Traditional expansionary fiscal policy has no beneficial effects. Cutting interest rates has an indirect effect via asset prices —firms are constrained not by the price of loans, but by the available quantity of loans— but that effect may be small if the initial real interest rate is low. By contrast, there are several unconventional policies —wage subsidies, helicopter drops of liquid assets, equity injections, and loan guarantees— that, if sufficiently large, can keep the economy in a full-employment, high-productivity equilibrium in the aftermath of a pandemic.

All of these policies can restore efficiency. But because they entail channeling resources to firms beyond what incentive-compatible borrowing limits would permit, entrepreneurs may be tempted to misbehave, leaving taxes unpaid (in the case of a wage subsidy or a helicopter drop), absconding with profits instead of distributing them as dividends (in the case of equity injections), or defaulting on debts (in the case of loan guarantees). So the policies will be feasible insofar as government is willing and able to do what private agents cannot: deploy the power of the state to make sure all relevant financial obligations are fulfilled.

Most of the unconventional policies require the government to spend resources upfront, at a time of crisis when revenues are down. So to fight the economic consequences of the pandemic governments will need to run deficits (albeit for reasons that are different from the traditional Keynesian reasons). And private sector firms, which have to keep paying wages while their sales and productivity are sharply down, will also be running deficits. So unless households are big savers, a country that adopts anti-virus policies will probably be running a current account deficit.

The upshot is simple: the capacity to borrow, for both the government and the nation as a whole, is critical. Emerging market economies that are rationed out of capital markets may find they cannot afford anti-crisis policies unless the international community channels fresh resources to them.

The paper is structured as follows. In section II we present our minimalist model. Section III analyzes feasible equilibria, while section IV sorts through policy alternatives. Section V provides a summary and discussion of the policy analysis. Section VI concludes.

II. The model

The economy is small and open. There is a single tradable good and an internationally-traded bond denominated in units of the good. Households and entrepreneurs live side by side. Households work, save and may lend resources to entrepreneurs. Entrepreneurs produce and may borrow to finance operations.

The economy lasts two periods. In the first period a pandemic strikes, drastically hurting productivity. The pandemic subsides in the second period, however, allowing productivity to recover. Because of adjustment costs, to be made precise below, it is beneficial not to fire labor in the first period. But this is only possible if firms overcome a financing problem.

Households

Begin with the households. To keep things very simple we suppose they have a linear utility function. If ρ is the subjective discount rate (and also the world rate of interest) and θ the marginal disutility of labor supply, households maximize

$$c_1 - \theta n_1 + \frac{c_2 - \theta n_2}{1+\rho}$$

with respect to consumptions c_1 and c_2 and labor supplies n_1 and n_2, subject to the constraint

$$c_1 + \frac{c_2}{1+r} \leq f + w_1 n_1 + \frac{w_2 n_2}{1+r}$$

where r is the domestic real interest rate and f is initial holdings of the bond by households. Because of linearity, the household supplies any nonnegative amount of labor if

$$w_1 = w_2 = \theta$$

That is, if the real wage in each period is equal to the marginal disutility of labor supply. This is necessary in any equilibrium. Likewise, in equilibrium the real interest rate is pinned down by the world interest rate:

$$r = \rho$$

Firms

Output is produced using labor only. The pandemic shock means that labor productivity collapses in period 1 so that, in the absence of adjustment costs, firms would reduce labor employment in that period. But we assume that finding the right workers and hiring them takes time and is costly, so that if an entrepreneur fires them today she will not be able to resize the firm´s labor force to a different optimal level in the future. The extreme version of this assumption, which we adopt, is that labor input, denoted by n, is set in period 1 and cannot be changed in period 2.

In the first period, because of the virus, labor produces no output. In the second period the virus subsides, and output is an, where labor productivity a is given by

$$a = \begin{cases} a^{\ell} & \text{if } 0 \leq n \leq \tilde{n} \\ a^{h} & \text{if } \tilde{n} < n \leq \bar{n} \\ 0 & \text{otherwise} \end{cases}$$

where $a^h > a^\ell > \theta > 0$ and $\tilde{n} < \bar{n}$. So firms have a maximum scale of operation given by $\bar{n}$; they also have a minimum efficient scale, $\tilde{n}$. If in response to a shock the firm is forced to shed crucial employees and take employment to $\tilde{n}$ or below, productivity will drop.

Like households, entrepreneurs have a utility function that is linear in consumption and a subjective rate of discount that is equal to the world interest rate. There is no loss of generality, therefore, in treating them as though they consume in the second period only. That level of consumption is

$$an - \theta n - (1 + \rho)d$$

where d is the amount the firm borrows in period 1, given by

$$d = \theta n - b$$

where b denotes the entrepreneurs initial liquidity (i.e. an inherited stock b of bonds). Combining the last two equations we have

$$an - \theta n - (1 + \rho)(\theta n - b)$$

Clearly, if

$$a^\ell - \theta > (1 + \rho)\theta$$

which we assume holds, then the entrepreneur will prefer to make the employment level as large as possible. So in the absence of additional frictions, the economy would have a unique equilibrium with firms operating at maximum scale: $n = \bar{n}$. Firms would retain $\bar{n}$ workers during the pandemic, even if they produce nothing, because labor will be sufficiently productive once the virus disappears. This justifies paying wages in the first period just to retain workers.

Financial markets and frictions

A frictionless, maximum-employment equilibrium requires that firms be able to finance the initial wage bill $\theta\bar{n}$. This may be problematic in the presence of borrowing constraints.

Such constraints arise from an incentive problem: the entrepreneur can seize a share $1 - \lambda$ of output net of wage payments in period 2, default on any accumulated debts and abscond. To prevent this from happening, lenders will demand the firm´s own shares as collateral. Suppose there is an equity market in which firms can sell their shares. At the start of the pandemic, each entrepreneur owns a firm, the value of which determines the amount she can borrow. Shares are claims to a portion λ of earnings before interest in period 2 —selling a bigger claim is not credible, given the risk that the entrepreneur might abscond.

The details of the incentive problem are peripheral to our main discussion and therefore we relegate them to Appendix 1. Here we summarize the key results. Let v be the period-1 value of the firm in the stock exchange, which must equal the discounted value of pledged firm profits:

$$v = \frac{\lambda(a-\theta)n}{1+\rho}$$

Future profits are discounted by $1+\rho$, which is the relevant rate for both the firm and the households that could be the buyers of these shares. It is important that v is market-determined, and therefore a variable that entrepreneurs take as given in making their borrowing and hiring choices. Also important is that v is increasing in a, the expected marginal product of labor in period 2. Intuitively, when the firm is expected to be more productive and earn more, its market value goes up. (Recall that a can be a^h or a^ℓ, depending on n.)

Individual firms face a borrowing constraint given by

$$d \leq v$$

Using the definition of v, the previous inequality reduces in equilibrium to

$$an - \theta n - (1+\rho)d \geq (1-\lambda)(an - \theta n)$$

On the LHS is the value of firm profits —and therefore of entrepreneur consumption— in period 2. On the RHS is the amount entrepreneurs could consume if they defaulted and absconded. So the borrowing constraint ensures that an entrepreneur will never have incentives to misbehave. Alternatively, the borrowing constraint can also be written as

$$(1+\rho)d \leq \lambda(a-\theta)n$$

which has an intuitive interpretation: lenders will never lend more than they can recover.

We will also assume that

$$(1-\lambda)(a^\ell - \theta) \geq (1+\rho)\theta$$

As Appendix 1 shows, this ensures that entrepreneurs will wish to keep employment at $\bar{n}$.

But they may not be able to finance the wage bill $\theta\bar{n}$ if the borrowing constraint binds. In that case, using $d = \theta n - b$ we have

$$n = \frac{(1+\rho)b}{(1+\rho)\theta - \lambda(a-\theta)}.$$

So the labor a firm can hire is a multiple of its initial net worth b. From now we assume that λ is sufficiently small so that the denominator is positive, regardless of the value of a. Notice n is increasing in λ, which is intuitive: when λ is large, the incentive problem is less acute.

III. Constrained and unconstrained equilibria

We are now ready to examine the possible implications of the pandemic. Can the pandemic have no impact on the economy, in the sense that employment remains at its maximum level and financial constraints do not bind? It is straightforward to check that this is the case if under full employment the borrowing constraint $d \leq v$ does not bind, a condition that reduces to

$$(\theta\bar{n} - b)(1+\rho) \leq \lambda(a^h - \theta)\bar{n}$$

The inequality reveals that an equilibrium in which financial constraints do not bind is more likely to occur if λ and b are large. A large λ means that firms can credibly pledge more of their expected profits in the stock market, and hence that financial frictions are less severe. And a large b means that entrepreneurs have ample liquidity when the virus hits. Their initial liquidity allows them to cover more of the initial wage bill without having to find outside finance.

Next consider financially-constrained equilibria, where entrepreneurs borrow up to the stock market value of their firms, so that $d = v$. But that market value, and hence the financial capacity of the firms, depends on anticipated profits and therefore on the level of employment, which itself depends on how much entrepreneurs borrow.

It helps to define two important employment levels. If the financial constraint is binding and productivity is high, the level of employment must be:

$$n^h \equiv \frac{(1+\rho)b}{(1+\rho)\theta - \lambda(a^h - \theta)}$$

This is the maximum employment level lenders will finance if the value of firms is high, reflecting expectations of high productivity.

It is easy to check that a financially-constrained equilibrium with high productivity exists if

$$\tilde{n} < n^h < \bar{n}$$

Symmetrically, suppose the financial constraint is binding and markets expect productivity to be low. Then the stock price is low, the constraint becomes more stringent, and employment is

$$n^{\ell} \equiv \frac{(1+\rho)b}{(1+\rho)\theta - \lambda(a^{\ell} - \theta)}$$

This is an equilibrium if

$$0 < n^{\ell} \leq \tilde{n}$$

With financial constraints expectations become paramount, and this opens the door to multiple equilibria. Financially-constrained equilibria with high and low productivity coexist if

$$0 < n^{\ell} < \tilde{n} < n^{h} < \bar{n}.$$

Suppose that lenders expect asset values caused by low productivity. Then, the most they will be willing to lend allows the firm to retain n^{ℓ} workers. If $n^{\ell} \leq \tilde{n}$, then this is an equilibrium: lenders lend little and as a result the firm has to shed key personnel and loses productivity. That confirms lenders´ initial expectations. The same can occur if lenders expect high asset values and high productivity and $\tilde{n} < n^{h}$: those expectation are also rational and self-fulfilling.

One can show that a constrained equilibrium with low productivity can also coexist with an unconstrained equilibrium. In this case, if market participants expect high productivity, firms´ shares go up in value, which leaves them financially unconstrained and able to pay a sufficient number of workers to keep productivity high. Conversely, if financial market participants are pessimistic, firms cannot borrow enough, must therefore fire workers, and productivity drops.

These multiple equilibria occur because of a pecuniary externality. Lenders not take into the account the effect their actions have on asset prices. And those asset prices in turn affect borrowing limits, employment and productivity.

A graphical representation

It helps to visualize equilibria using two simple curves in d, n space. A firm's debt is given by

$$d = \theta n - b$$

Call this the CD schedule, for credit demand. The financial constraint, if it holds with equality, is

$$d = \frac{\lambda(a-\theta)n}{1+\rho}$$

Call this the FC curve. It is piecewise linear in n, because a can be high or low depending on the level of employment.

For the CD schedule to be steeper than FC requires

$$\theta(1+\rho) > \lambda(a^h - \theta).$$

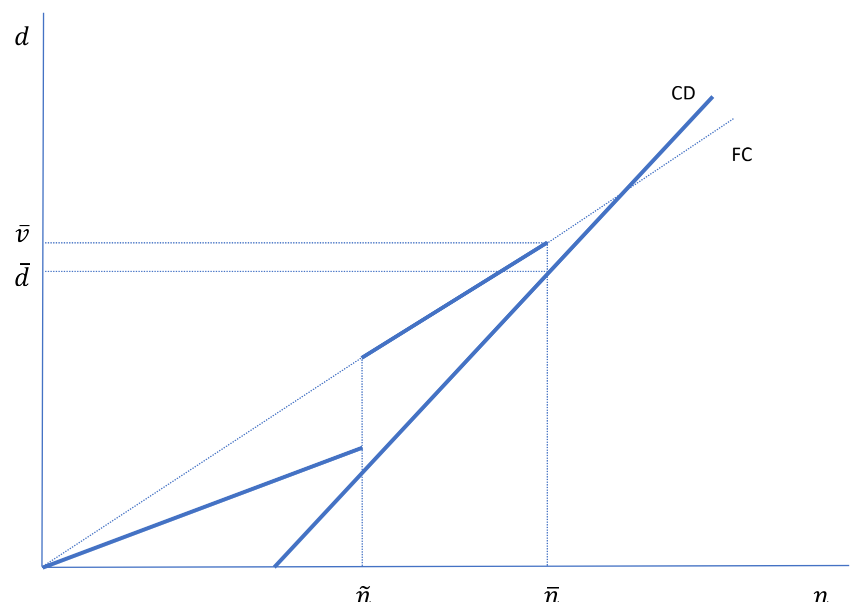
which we assumed already. It was the condition necessary to guarantee that in any constrained equilibrium, feasible employment levels are a positive multiple of the firm´s initial net worth.

Figure 1 depicts the case of a single unconstrained equilibrium at $\bar{n}$. To check that this is in fact an equilibrium, note that in the figure the firm´s debt acquired in period 1 is $\bar{d}$, which is the height of the credit demand schedule CD at $\bar{n}$. In turn, the value of firms is $\bar{v}$, which is the height of the financial constraint schedule FC at $\bar{n}$. In the figure $\bar{v} > \bar{d}$, which confirms that the firm is financially unconstrained.

The figure reveals what conditions are conducive to an unconstrained equilibrium. Given FC, the unconstrained equilibrium is more likely if CD is lower, which would happen if the firm´s initial net worth (its holding b of international bonds) is sufficiently large. The intuition is that the firm can then afford to borrow relatively little and still not shed labor when the virus hits.

Likewise, given CD an unconstrained equilibrium is more likely if the FC schedule is steeper, which is the case the higher a^h is. Then at full employment the value of firms is especially elevated, further relaxing the firms' borrowing constraint. Because an unconstrained equilibrium involves full employment, productivity is high as well. In fact, efficiency requires full employment, a fact that we prove formally in Appendix 2. So if an unconstrained equilibrium exists and is unique, it is an optimal outcome and there is no efficiency case for policy intervention.

Figure 1: single unconstrained equilibrium at $\bar{n}$



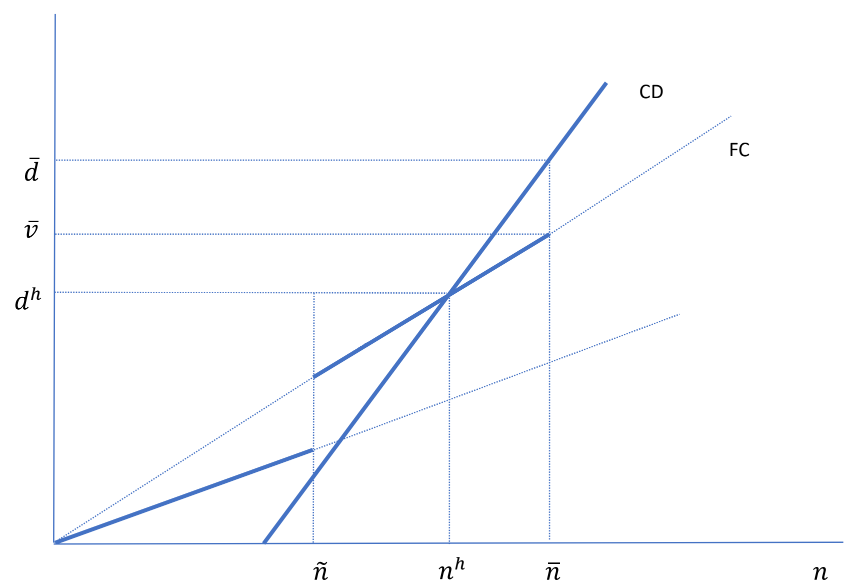
If firms' initial wealth is lower or financial constraints more stringent, the economy can have a single constrained equilibrium at n^h, as depicted in Figure 2. Here firms cannot hire $\bar{n}$ workers because that would require more collateral than they have: at $\bar{n}$ the CD schedule is above FC, so $\bar{d} > \bar{v}$. Firms must cut employment to n^h, the highest level they can finance given the value of the firm. This involves an inefficiency, since at n^h the productivity of labor exceeds its cost.[2]

Because both the CD and the FC have positive slopes, shocks are magnified by the interaction of collateral values and leverage, in what Fornaro and Wolf (2020) term a doom loop. This is most clearly seen by writing the wage bill in any constrained equilibrium as:

$$\theta n \equiv \left[\frac{(1+\rho)\theta}{(1+\rho)\theta - \lambda(a-\theta)}\right] b$$

On the RHS b is multiplied by a coefficient that is larger than one, which is intuitive given that firms can "leverage up" their net worth. So if the firm starts out with one fewer dollar of initial net worth, its capacity to hire workers goes down by more than one dollar, because the drop in the value of the firm reduces access to outside finance.

Figure 2: Single constrained equilibrium at n^h



The case in Figure 3 involves two borrowing-constrained equilibria, with employment at n^ℓ and n^h. Equilibrium is pinned down by self-fulfilling expectations. If potential share buyers are optimistic, the market capitalization of firms is high. High collateral values enable firms to borrow and raise employment above the threshold level $\tilde{n}$. So productivity is high, making optimism self-fulfilling. Conversely, pessimism results in low share prices, which reduce firms' access to finance. Employment falls to n^l and expectations of low productivity are then justified.

[2] Given that $a^h - \theta > (1-\lambda)(a^\ell - \theta) \geq \theta(1+\rho)$, the constrained equilibrium in Figure 2 is inefficient.

Figure 3: multiple constrained equilibria at n^ℓ and n^h

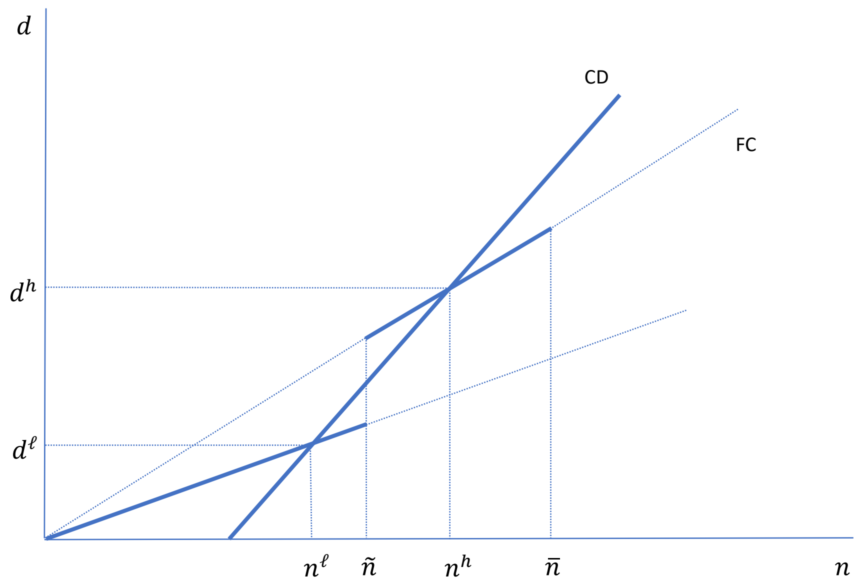
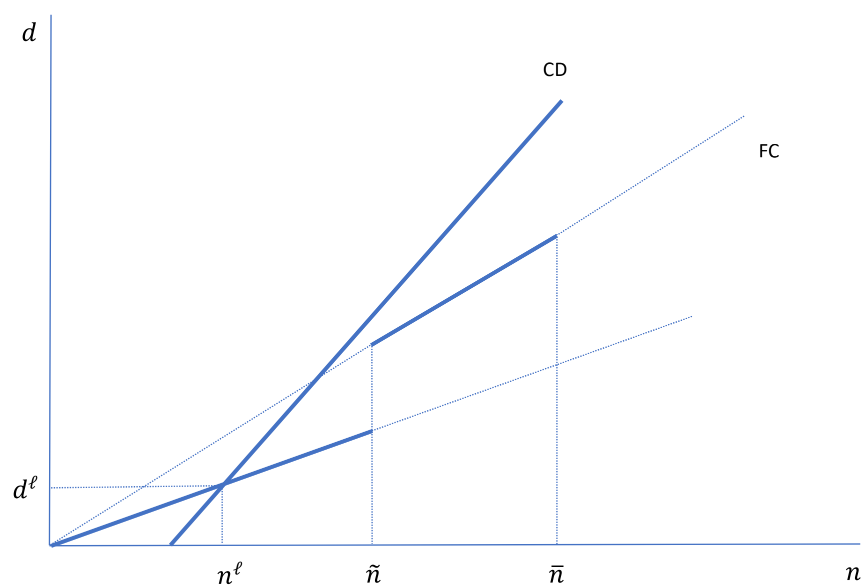


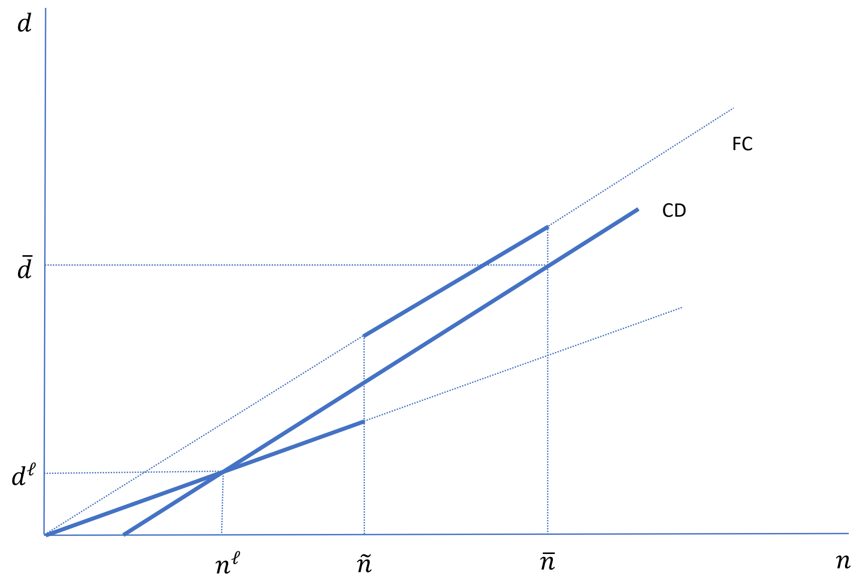
Figure 4 depicts the case of a single constrained equilibrium with low employment and low productivity. This outcome could occur if, for instance, initial firm net worth is very low. Productivity could be much higher if the firm could retain more workers after the virus hits, but financial constraints keep it from doing so. This is a highly inefficient case.

Figure 4: single constrained equilibrium at n^ℓ



Finally, Figure 5 depicts a case in which an efficient, unconstrained equilibrium coexists with a low-productivity, financially-constrained equilibrium. This is a tricky case in which expectations are crucial: optimistic expectations result in the optimal outcome and there is no need for any policy measures, but adverse expectations can lead to the worst type of outcome.

Figure 5: constrained equilibrium at n^l and unconstrained equilibrium at $\bar{n}$



IV. Policy alternatives

What are policy alternatives in response to the crisis? Let us begin with what does not work. Conventional expansionary fiscal policy does not work. Imagine the government borrows in period 1 —either from households or from the rest of the world— and finances the operation with a lump-sum tax in period 2. If the government immediately rebates the borrowed amount to households, then the operation is neutral. If it chooses to store the resources and rebate them back to households in period 2, that is again neutral.

The problem arising from the virus is one of supply, and so it cannot be cured by conventional demand management policies. Demanding more goods from the representative firm has no impact if the firm is constrained from producing them.

What about interest rate cuts? We have assumed households can borrow or lend freely from the rest of the world at a real interest rate ρ. If households also lend to firms and are allowed to hold shares, arbitrage opportunities will arise unless the households earn the same return. So whenever borrowing occurs domestically it must also carry the real interest rate ρ.

But the government could reduce the costs of borrowing for firms by subsidizing the interest they pay on loans. In period 2, when loans came due, firms would only pay a fraction of the market rate and the government would pay the rest —financed by a tax on households or firms.

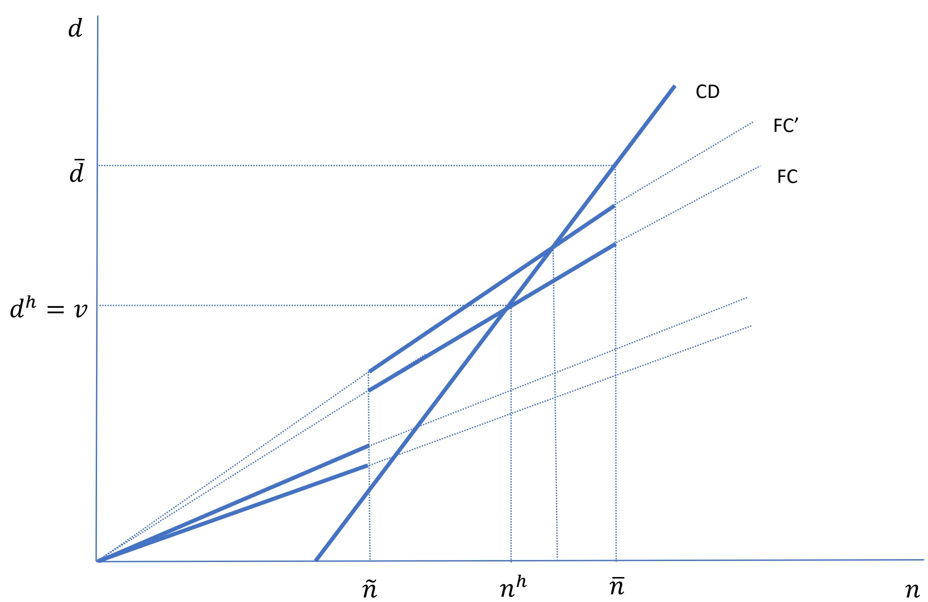
It is easy to see this policy has an effect via asset prices. The price of the firm is given by future (pledged) profits discounted back to the present using the interest rate that firms effectively face. Since this rate is now less than ρ, share prices go up.[3] Then the value of collateral goes up, allowing firms to raise employment if before they were financially constrained.

This situation is depicted in Figure 6, which assumes a unique laissez faire equilibrium with employment at $n^h < \bar{n}$. Subsidizing interest costs for entrepreneurs makes the FC schedule rotate counter-clockwise to FC'. Therefore employment goes up with the interest subsidy.

In Figure 6 a large enough interest rate subsidy raises share prices, relaxes borrowing constraints and brings about full employment. In practice, however, this policy can be of limited use. If the starting world interest rate ρ is close to zero, there is little room to subsidize interest costs. And in an environment of great uncertainty, asset prices are unlikely to be very responsive to interest rate subsidies. Last but not least, it may be politically touchy to subsidize firms' borrowing costs.

If multiple equilibria occur there is a further difficulty. Interest rate cuts in a situation such as that in Figure 3 could rotate the FC schedule counter-clockwise by just enough to eliminate the n^h equilibrium but still allow for the n^ℓ equilibrium. In that case the economy would remain vulnerable to sudden bouts of pessimism, which could take the economy from n^h to n^ℓ, with an accompanying loss of employment and output. To ensure that the n^ℓequilibrium is also eliminated, the interest rate subsidy would have to be even larger, which may be infeasible – whether because of practical, fiscal or political reasons.

Figure 6: Cutting interest rates with single constrained equilibrium at n^h



[3] We assume here that short selling in the stock market is not allowed or, alternatively, that market segmentation prevents households from participating in the stock market. Otherwise households would enjoy an arbitrage opportunity.

Given these difficulties, are there other policies with a higher chance of being effective? The model suggests that the crucial issue is to enable firms to survive the initial contagion period without shedding too many jobs. Could unorthodox policies work by temporarily helping firms finance wage costs and retain workers?

The simplest such policy is to have the government pay the firms´ wage bill, so that employment can remain at the optimal level $\bar{n}$.[4] Denmark, the Netherlands and the UK are doing that. Start from a constrained equilibrium with employment at n^h and assume that the government provides a subsidy s per unit of labor. In this case, the demand for loans by the firm is

$$d = (\theta - s)n - b$$

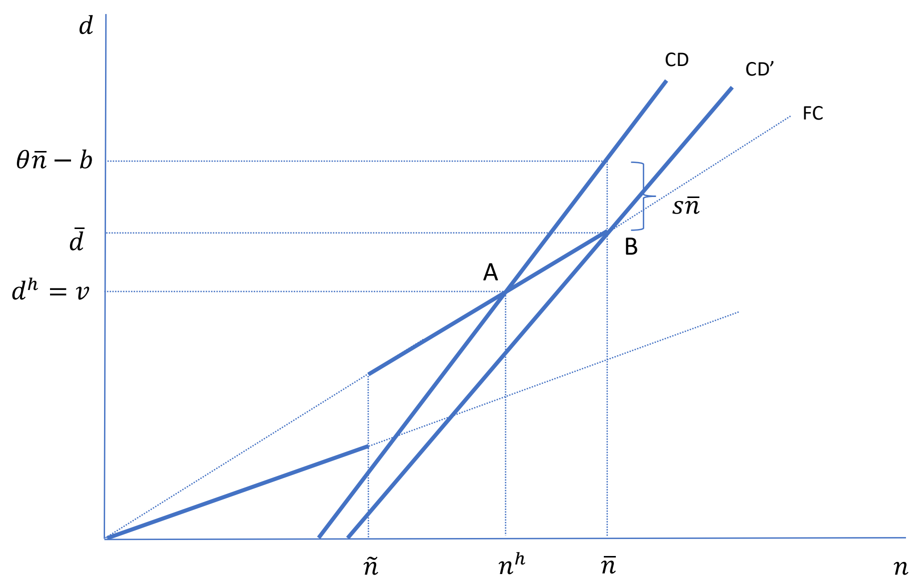
The CD curve shifts right and becomes flatter, as in Figure 7. Employment goes up, reflecting that the wage subsidy reduces the firm's financing requirements and therefore also makes it less necessary to shed workers in period 1.

In Figure 7, the wage subsidy is large enough to bring about full employment $\bar{n}$. This requires

$$s = \theta - \frac{b}{\bar{n}} - \frac{\lambda(a^h - \theta)}{1 + \rho}$$

Of course, such a policy requires the government to have enough fiscal space to borrow and fund the operation, repaying the additional debt via higher taxes in period 2.

Figure 7: Wage subsidies with a single constrained equilibrium at n^h



[4] See Appendix 2 for a proof that $\bar{n}$ is the efficient level for the economy.

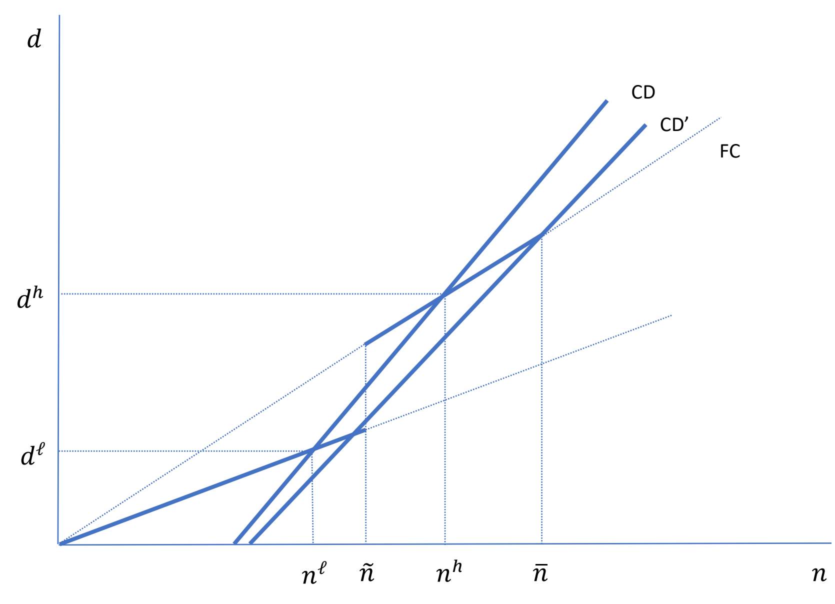
Who should pay for this operation? The obvious alternative is to tax entrepreneurs, who are the main beneficiaries of the scheme. To cover the cost for the government, tax revenues would have to increase by $(1+\rho)s\bar{n}$ in period 2. If this amount could be raised via lump sum taxes on entrepreneurs all agents would benefit, as can be easily checked. But that requires that the government have the capacity to enforce the payment of the extra taxes by entrepreneurs.[5]

An alternative is to tax households in period 2 and get them to pay for the wage subsidies in period 1. This is not entirely unfounded, since it was the workers who received those wage subsidies, which also allowed employment to remain at a level higher than would have been the case without policy intervention. One can easily show that the period-1 value of labor income of households´ labor income, net of taxes, increases by

$$\left(\frac{\bar{n}-n^h}{1+\rho}\right)[(1-\lambda)\theta+\lambda a^h]>0$$

However, this amount is just the compensation to households for the disutility of their additional labor. Hence, in this case, the wage subsidy policy restores full employment (and hence Pareto efficiency), but it does not provide workers with a welfare gain.[6]

Figure 8: Wage subsidies with two constrained equilibria



[5] In the context of the model the requirement is that the amount that the entrepreneur can seize is a share $1-\lambda$ of output net of wage *and* taxes.

[6] This statement is accurate if in period 1 workers are experiencing disutility of labor (for which they are being compensated) even though the output they produce is zero. One can imagine alternative assumptions, in which workers only experience partial disutility if they stay home instead of going to the workplace.

Again, the possibility of multiple equilibria makes the policy problem more delicate. If the initial situation is one with two constrained equilibria, as in Figure 8, a wage subsidy may take the economy to an equilibrium with employment at $\bar{n}$, but it may not if expectations are adverse: depending on the minimum efficient scale and other parameters, the subsidy may not be enough to eliminate the multiplicity of equilibria.

In that case the government would be spending fiscal resources but could not guarantee that the economy would settle on the full employment outcome. In order to achieve this outcome, the subsidy s would have to be higher, so as to shift the CD curve clockwise even further. Of course, the larger subsidy to eliminate the possibility of the bad equilibrium would require even more fiscal space and a larger tax in period 2.

A policy equivalent to wage subsidies is the proverbial helicopter drop of liquid government assets. The government could supplement the firm's initial net worth of b by sending out to firms the required amounts of government bonds bearing the market rate of interest and maturing in period 2. In turn, firms could sell the bonds to pay the wage bill or —even easier— could simply pay workers in government bonds.

Because there are no imperfections other than the borrowing constraint and the pecuniary externality that gives rise to multiple equilibria, in this model the issuance of liquidity through government bonds does not create net wealth. So this policy is not very different to the one in which the government pays the firms' wage bill. And all the same issues as to who pays the tax bill and what incentives this provides apply here.

Wage subsidies and helicopter drops help protect employment by providing firms with liquid resources they can use to bypass binding finance constraints. But they do not attempt to alleviate the severity of those borrowing constraints. Other policies go further in that direction. One alternative is an equity injection, by which we mean that government temporarily acquires ownership and control of firms in exchange for initial liquidity provision.

In order to illustrate how equity injections might work, imagine that without government intervention the economy would settle on a low-productivity unique equilibrium like the one described in Figure 4. The value of the firm in that equilibrium would be

$$v^\ell = \frac{\lambda\left(a^\ell - \theta\right)n^\ell}{1+\rho},$$

implying a debt limit that would restrict to the firm to hire just n^ℓ workers:

$$v^\ell = d = \theta n^\ell - b$$

In this equilibrium entrepreneurs would like to raise employment to $\bar{n}$, but they cannot borrow the $\theta(\bar{n} - n^\ell)$ they would need to finance the additional wage costs.

To correct this situation, the government may be able to send e dollars to the firm, and as a result acquire control rights. These control rights imply, in particular, that in period 2 the government can secure repayment of $(1 + \rho)e$ dollars out of the firm's final profits.

Suppose that, in fact, the equity injection is large enough to allow the firm to hire $\bar{n}$ workers. An interesting fact is that e does not need to be as large as $\theta(\bar{n} - n^\ell)$. Why? Because the increase in employment leads to higher share prices, allowing the firm to borrow more. In fact, the value of the firm would increase to

$$\bar{v} = \frac{\lambda(a^h - \theta)\bar{n}}{1 + \rho}$$

reflecting increased profits due to larger scale and higher productivity.

This implies that the minimum value of the equity injection that restores full employment would be given by $d = \theta\bar{n} - b - e = \bar{v}$, that is,

$$e = \theta\bar{n} - b - \frac{\lambda(a^h - \theta)\bar{n}}{(1 + \rho)}$$

which is less than $\theta(\bar{n} - n^\ell)$, as one can easily check.

In terms of Figure 4, the equity injection would move CD to the right until it intersects FC at the full employment level $\bar{n}$. This policy is particularly effective since government resources are leveraged up, in the sense that the e dollars allow the firm to finance an increase in the wage bill of more than e, the difference reflecting better access to outside finance through an increase in the value of the firm.

So equity injections can be powerful tools. This is so, however, on the assumption that they give the government the power to seize a fraction of the firm's profits that cannot be pledged to other outside investors, perhaps because it has acquired control (seats on the board of the company) in exchange for the equity injection. In the absence of formal board appointments, the government could impose conditions regarding dividend payments, stock buybacks and executive compensation, so as to ensure that the resources from the equity injection are first used to hire $\bar{n}$ workers and raise productivity, and then in period 2 to pay the corresponding dividends and debt service.[7]

[7] Another obvious caveat is that equity injections, coupled with temporary government control, make sense for firms above a certain size. It would make little senses for government to inject equity and attempt to run the corner shop or the restaurant down the street.

Similar observations apply to credit guarantees. Suppose that the government promises lenders to pay a fraction $0 < \gamma \leq 1$ of their loans outstanding in case of default by the firm. This would effectively change the collateral constraint to

$$d(1-\gamma) \leq v = \frac{\lambda(a-\theta)n}{1+\rho}$$

In terms of the previous figures, the credit guarantee would move the FC schedule counterclockwise from the origin. A large enough guarantee would be able to raise employment to $\bar{n}$. So this policy might seem like a win-win: it would deliver the full-employment, high-productivity equilibria without requiring fiscal resources in period 1. Unfortunately, the guarantee may expose the government to moral hazard. From the perspective of the entrepreneur it would be optimal to default in period 2 and abscond, as any reader can check.

So we conclude that credit guarantees, like equity injections, may not sufficient by themselves. In order to make the guarantees incentive-compatible, the government would have to combine them with a strengthening of the incentives for the entrepreneur to repay. In the context of the model, that means reducing the fraction $1-\lambda$ of profits the entrepreneur can seize before absconding. That is exactly what some European governments have done, excluding from loan guarantees those companies that operate out of tax havens. Alternatively, the government could again condition the provision of a guarantee to the suspension of dividend payments or the limiting of executive compensation.

V. Policy discussion

So several unconventional policies —wage subsidies, liquidity injections, equity injections, and loan guarantees— if sufficiently large, can keep the economy in a full-employment, high-productivity equilibrium in the aftermath of a pandemic.

What these policies all have in common is that government provides entrepreneurs with resources in excess of what borrowing constraints, which are really incentive constraints, would have allowed. The policies differ in terms of the implied enforcement requirements in period 2, when the entrepreneur has an incentive to abscond with a share of the profits, leaving taxes unpaid (in the case of a wage subsidy or a liquidity injection), dividends unpaid (in the case of equity injections), or debts unpaid (in the case of loan guarantees).[8] This point is crucial, because it reveals that the policies will be feasible insofar as government is able to do what private agents cannot: compel entrepreneurs to play by the rules.

[8] Potentially, there is a period-1 incentive problem as well. The entrepreneur could take the resources provided by the government, plus his own liquid resources, and abscond without hiring any workers or paying any wages. This potential problem would bias the policy choice toward alternatives in which government pays workers directly (wage subsidies) or controls the actions of management (equity injections).

In some cases, such as tax collection, this means appealing to the coercive powers of the state. In other cases, such as equity injections, it means that government can either limit *ex ante* certain actions by the firm (like pay large bonuses to management and deplete a firm´s cash reserves), or become a large enough shareholder to prevent the company board from approving such actions. The argument is weakest in the case of loan guarantees, but even here government can do things private lender cannot, like seizing tax returns (or even assets) in case of non-payment.[9]

All these policies become more complex in the presence of multiple equilibria. The size of the intervention necessary to make full employment feasible is not necessarily one that will rule out other less attractive equilibria with lower employment and potentially lower productivity. A larger intervention may rule out the bad equilibria, but it will necessarily be a more expensive intervention, which may not be affordable for governments with limited fiscal space.

Alternatively, governments may choose to stick to the smaller of the two interventions (the one that leaves open the possibility of a bad equilibrium) but try actively to coordinate expectations on the good outcome. Optimistic talk alone may not do the trick, because lenders will lend more if and only if they expect other lenders will lend more. One possibility is to rely on large state-owned lenders who internalize the pecuniary externality and lend enough to coordinate expectations on the good outcome. A few countries did exactly that during the great recession of 2007-09, and some of those countries are doing it again today.[10]

Fiscal space is also an issue. In all of our exercises above we assumed that the government could levy lump-sum taxes in period 2 to finance whatever additional expenditures it undertook in period 1. This might be unrealistic, of course, in that political constraints might limit any future tax increases, and/or taxes that are politically feasible could be highly distortionary.

The sequence of events in which government spends in period 1 and taxes in period 2 also assumes implicitly that the government can borrow more or run down assets in period 1. That is not problematic for most advanced economies, but could be a difficult issue for many emerging market governments, whose ability to borrow large amounts may be severely limited, particularly during a pandemic-driven crisis.

Moreover, constraints on international borrowing could also be an obstacle to the implementation of unconventional policies. In all scenarios above, the policies involve inducing the firm to run a deficit (it keeps paying wages even though it has no revenue) and also prompting the government to run a deficit (spend today and raise taxes tomorrow to pay the bill). So unless private households are big savers in period 1, the country as a whole is likely to be running a current account deficit.

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[9] Someone could ask why a large enough private agent could not itself carry out the equity injection and seek control of actions by the firm. One possible answer is that this is imaginable in individual cases, but it is more difficult to envision if many firms across the economy require equity injections. Another answer is that at a time of generalized crisis (like a pandemic) private agents themselves are likely to be liquidity-constrained and unable to invest.
[10] See Biron, Cordova and Lemus (2019).

Who will finance the current account gap? In the model, households have initial assets f and firms have initial assets b, both presumably holdings of the internationally tradable bond. Government could also be holding liquid international assets, perhaps in a sovereign wealth fund or as central bank reserves. But only a few countries are short-term net creditors, in the sense of holding more short-term claims on the rest of the world than the rest of the world holds on them. For all other countries, the only way out in the event of a pandemic is to borrow abroad, as we implicitly assumed in the policy exercises carried out above.

But it could well be that the country is rationed out from international private capital markets. Or that international capital markets effectively freeze for a period of time, as it happened in 2008-09. Then the country as a whole (the private *and* public sectors) would not have access to the necessary resources to finance the interventions required to guarantee the full-employment, high-productivity outcome.

Official lending, whether on a bilateral basis or through multilateral lenders such as the IMF or the World Bank, could in theory make up the difference. But one thing this crisis has confirmed is that multilateral lenders have nowhere near the volume of resources required, and their main shareholders (the large advanced countries plus China) are reluctant to provide more capital. Large shareholders like the US have also refused to provide more short-term international liquidity via an extraordinary and sizeable issue of SDRs. So for many countries living through this pandemic, welfare-improving policy interventions may be unattainable simply because of lack of resources from abroad.

A last and important caveat has to do with the length of the shock. In the model of this paper we assumed that if unconstrained, the firm always wishes to stay at the pre-crisis, full-employment level. For our purposes that assumption makes sense. But one can easily imagine scenarios in which the productivity shock lasts many periods, so that it does not make sense from an economic point of view for the firm to keep everyone employed. That could happen, for instance, if there are second, third or fourth waves of infection. Or in a number of sectors —air transport, tourism, other services— the pandemic itself could trigger either changes in demand or technological innovations (the rise of Zoom and Teams?) that render firms insolvent or unprofitable over the long run. In those scenarios, the policy discussion would need to have a different focus: how to help firms reduce their scale or wind down operations.

VI. Conclusions

The world has seen many banking crises, debt crises, exchange rate crises, inflation crises and recessionary crises. But never before did it witness a crisis triggered by government orders telling firms to suspend operations and workers to stay home. It is a negative supply shock or negative productivity shock of unprecedented size.

A firm holds much of its productive capital in the workers it has recruited, hired and trained. If the Covid-19 crisis forces an entrepreneur to fire those workers, the firm´s productivity will suffer. But to keep paying the wage bill while sales and revenue are close to zero, the entrepreneur needs credit. And credit flows are notorious for being available at all times except when you really need credit —in a crisis.

The social and economic shock of the coronavirus pandemic is tremendous. But capital market failures have the potential to make it even larger still. To prevent toxic multiplier effects from kicking in, conventional fiscal policy is useless, and conventional monetary policy faces severe limitations. Unconventional fiscal and financial policies are imperative. This is not the time for governments to be timid.

In this paper we have shown *which* unconventional measures work, *when* it is they work and *why* they work. The catch is that they can be fiscally expensive. In a world of near-zero or negative real interest rates, that is not a problem for advanced countries, which have the fiscal space to issue huge quantities of bonds and money (which in turn a near-perfect substitutes as long as interest rates remain very low).

It is a problem, however, for many emerging and developing countries, which have very limited fiscal space. The macroeconomic vaccine to deal with the employment fallout from Covid-19 exists. It will be a tragedy if that vaccine is not used because patients cannot afford it and no friend steps forward to help pay the bill.

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Appendix 1: Financial constraints and the value of firms

In the main text we mentioned that the equilibrium equations in the model of financial frictions can be derived from a setting with a stock market that determines the value of firms, which in turn determines the borrowing constraint. In this appendix we develop that.

As mentioned in the text, shares in a firm are claims to a fraction λ of the firm's profits in period $t = 2$. Each entrepreneur starts period $t = 1$ owning one share in her firm. She buys or sells ϕ shares in the stock market at price v. Of course, in equilibrium $\phi = 1$, but we need to allow for arbitrary ϕ to analyze the entrepreneur's decision problem.

The entrepreneur´s budget constraint in period 1 is

$$d = \theta n - b + (\phi - 1)v$$

and her final consumption is

$$c^e = (1 - \lambda)(a - \theta)n - (1 + \rho)d + \gamma\Delta$$

where Δ denotes dividends per share.

Finally, the entrepreneur is subject to the borrowing constraint

$$d \leq v$$

Note that the RHS is given by the value of the entrepreneur's initial share holdings (of one).

Combining the first two equations, we see that the entrepreneur´s consumption level is

$$c^e = (1 - \lambda)(a - \theta)n - (1 + \rho)[\theta n - b + (\phi - 1)v] + \gamma\Delta$$

It follows that the entrepreneur will choose the highest affordable n if

$$(1 - \lambda)(a^\ell - \theta) \geq \theta(1 + \rho)$$

which is the condition in the text.

Now, naturally dividends per share are given by $\Delta = \lambda(a - \theta)n$. Absence of arbitrage requires

$$1 + \rho = \frac{\Delta}{v}$$

which means that $v = \frac{\lambda(a-\theta)n}{1+\rho}$, as in the text.

The borrowing constraint $d \leq v$ then reduces to

$$(1+\rho)d \leq \lambda(an - \theta n)$$

And, finally, in equilibrium $\phi = 1$, so that the budget constraint becomes

$$d = \theta n - b$$

The last two equations are the ones we exploit in the text.

Appendix 2: Efficiency

Consider the standard problem of maximizing a social welfare function $W(u_h, u_e)$, where W is strictly increasing in the welfare of households:

$$u_h = c_1 - \theta n_1 + \frac{c_2 - \theta n_2}{1+\rho}$$

and the welfare of entrepreneurs

$$u_e = \frac{c^e}{1+\rho}$$

The choice set must respect the labor adjustment constraint

$$n_1 = n_2 = n$$

and the intertemporal resource constraint

$$c_1 + \frac{c_2 + c^e}{1+\rho} = b + f + \frac{an_2}{1+\rho}$$

where

$$a = \begin{cases} a^\ell & \text{if } 0 \leq n \leq \tilde{n} \\ a^h & \text{if } \tilde{n} < n \leq \bar{n} \\ 0 & \text{otherwise} \end{cases}$$

The resource constraint is the appropriate one for the economy as a whole, assuming that it can borrow or lend at the world interest rate *ρ.*

As usual, for given W, a solution to this problem identifies a Pareto optimal allocation. By varying W one can then trace the Pareto frontier.

Combining the previous expressions, the resource constraint can be rewritten as

$$u_h + u_e = b + f \; + \frac{an}{1+\rho} - \theta\left(1 + \frac{1}{1+\rho}\right)n$$

The assumption that $(a^l - \theta) > (1+\rho)\theta$ implies that full employment $n = \bar{n}$ maximizes the right hand side. Since this is independent of the choice of W, it follows that any Pareto optimal allocation must feature full employment. Conversely, under that condition, any equilibrium with less than full employment is socially inefficient.

Hence the set of all Pareto efficient allocations is given by full employment $n = \bar{n}$ and by any consumption distribution that satisfies the resulting resource constraint:

$$c_1 + \frac{c_2 + c^e}{1+\rho} = \; b + f + \frac{a\bar{n}}{1+\rho}$$