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When Do Credit Frictions Matter for Business Cycles?

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The Great Recession took a turn for the worse in October 2008, at the same time as the collapse of Lehman Brothers. Many researchers viewed this confluence of events as evidence that credit frictions—disfunction in credit markets that distort the cost of intertemporal trade—were, if not the ultimate cause, at least a key mechanism that made the recession much deeper and more prolonged than it would otherwise have been.[1] As a consequence, there has been renewed interest in constructing macroeconomic models that are able to capture this idea (see Kiyotaki and Gertler [2011], Quadrini [2011], and Brunnermeier, Eisenbach, and Sannikov [2012] for recent reviews of that literature).

One difficulty that stems from that view is that adding credit frictions to an otherwise standard frictionless general equilibrium business cycle model is not necessarily sufficient to generate dynamics that are quantitatively or even qualitatively compatible with actual business cycles. The reasons behind this difficulty are fairly general, and stem from the fact that most models of credit frictions normally work by distorting the terms of *inter*-temporal tradeoff faced by firms or households. However, as we will see, realistic business cycle dynamics require shocks to affect *intra*-temporal labor supply decisions.

In order for models with credit frictions to generate compelling results, it is necessary to depart from more conventional ways of modelling preferences and technology, for example by adding a capacity

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[1] See Campello, Graham, and Harvey (2010); Ivashina and Scharfstein (2010); and Puri, Rocholl, and Steffen (2011) for empirical articles that establish the link between changes in credit conditions over that period and production decisions.

utilization margin, by introducing working capital requirements, or by allowing for firm-level heterogeneity. Furthermore, credit frictions can play a more realistic role in the presence of additional frictions, such as sticky prices and incomplete contracts. This article is a guide to these modifications, explaining how they work, why they are necessary, and how they can be motivated

The identification of credit frictions with distortions to the intertemporal tradeoffs faced by particular agents allows us to cover a large part of the literature, but not all of it. The last section of this article discusses a couple of recent examples in the literature where credit frictions act instead by affecting agents' risk management opportunities and bargaining position. This line of research is promising exactly because it sidesteps a lot of the difficulties associated with a heavy reliance on intertemporal distortions.

As with any literature review, this is by necessity limited in scope. The focus is on articles that strive to make a quantitative point, rather than only exposing a qualitative mechanism. Furthermore, we do not discuss the vast literature about what exactly gives rise to these frictions, rather, taking as given that they might become more important in certain instances and tracking down what this implies.

We proceed as follows: First, we motivate interpreting credit frictions as a tax on intertemporal trade. This is a simplification that will be useful for the rest of the text, since it will allow us to focus sharply on the impact of credit frictions on the decisions of households and of non-financial firms while abstracting from the precise mechanism that gives rise to those frictions. We then review two ways in which general equilibrium considerations can limit the impact of credit frictions. The first is that changes in the demand for physical capital induced by changes in the intensity of credit frictions only translates into a significantly lower capital stock over a long period of time. Second, changes in intertemporal tradeoffs faced by households often lead them to increase consumption as they reduce labor supply and vice versa. We then discuss extensions and modifications to the baseline model that help mitigate or reverse some of these effects. The last section concludes.

1. CREDIT FRICTIONS AS A TAX ON INTERTEMPORAL TRADE

Credit frictions appear in many forms. They can originate from asymmetric information (as in Bernanke and Gertler [1989]) or from limited commitment problems (as in Kiyotaki and Moore [1997]), and may show up in the data as quantitative limits on borrowing, down payment or margin requirements, non-linear pricing for debt, and outright exclusion of particular agents from credit markets. All of these forms have one feature in common: The agents directly affected behave as if they were subject to a tax on borrowing, effectively applying to their decisions interest rates that are higher than if they were not subject to the friction. Furthermore, in the same way as a tax on credit, credit frictions impact equilibrium interest rates, which also impact agents who are not subject to the underlying commitment or informational problems.

In that spirit, much of this article will take a reduced form approach to credit frictions, equating variations in the intensity of the friction with variations in the "after tax" interest rate faced by borrowers or the "before tax" rate faced by lenders. The reduced form approach is appropriate given that the purpose of the article is to describe model dynamics rather than to discuss policy. It has the added advantage of putting the focus sharply on the reaction of individual agents to changes in the credit frictions as opposed to the details about how they are determined.

In many instances it will be useful to take a partial equilibrium approach, to take other prices as given when discussing the impact of the change in the after tax interest rate on an agent's decision. This should capture the primary impact of credit frictions in most of the models under review. In some important instances a full comprehension of the mechanism will also require referring to general equilibrium effects. We will address these as needed.

The interpretation of credit frictions as a tax on borrowing is in line with the interpretation given by Chari, Kehoe, and McGrattan (2005) and, in policy circles, is used by the Estimated, Dynamic, Optimization-based Model of the U.S. Economy used by the Federal Reserve Board (see Chung, Kiley, and Laforte [2010]). Chari, Kehoe, and McGrattan (2005) discuss how the canonical models with credit frictions by Bernanke and Gertler (1989), Carlstrom and Fuerst (1997), and Kiyotaki and Moore (1997) can be reinterpreted as models of the determination of a tax on borrowing. In these models, the tax wedge appears as one operating between households, who save, and firms, who borrow. In richer environments with firm or household heterogeneity, the tax wedge can also appear as differences in the interest rate faced by different firms or different households (see Buera and Moll [2012] for a discussion).

When bringing the models to the data, it is important to remember that from the perspective of individual agents, changes in this tax wedge can appear either as a change in the risk premium paid by an agent on her loans, or, given a quantitative limit on debt, as an increase in the shadow cost of funds. Therefore, the intensity of credit frictions are not well-measured by the riskless interest rate paid by the U.S. Treasury or the overnight interest rate paid in interbank markets, both of which often drop in recessions. Rather, they are best measured by a wide spectrum of credit indicators that are strongly pro-cyclical such as credit flows, the fraction of senior bank managers who report tightening of credit standards, and spreads between bonds with different ratings (see Quadrini [2011] for a discussion of these indicators).

Not all the effects of credit frictions can be easily summarized with a tax on credit relationships. In the last section we examine two cases of recent articles where the most interesting effects of the credit frictions are unrelated to that particular aspect.

2. PROBLEMS FOR MODELS WITH CREDIT FRICTIONS

Take a basic real business cycle model such as King, Plosser, and Rebelo (1988) and add credit frictions to it. Most likely, these frictions are going to either imply counterfactual dynamics or will matter very little for aggregate fluctuations. There are two main problems: The first is that while investment might react strongly to increases in credit frictions, the capital stock is a slow-moving variable. Thus, for credit frictions to matter, they need to have an impact on employment. The second problem is that the typical impact of credit frictions on employment is such that employment and consumption have the wrong co-movement, with consumption booming when employment drops and vice versa. We discuss each of these problems in turn.

Problem 1: Capital Stock is Inelastic in the Short Run

Firms that face higher borrowing costs are likely to reduce their investment. If nothing else, this should be one channel through which tighter credit would lead to lower output. However, given conventional calibration of technology and preferences, tightening credit will only have a modest impact on output through this channel.[2]

Over the short run, the capital stock is inelastic because buildings and equipment in place do not become unproductive overnight for lack of replacement or maintenance. For example, suppose yearly depreciation is 10 percent of capital and steady-state investment is 12 percent of

[2] This is a problem originally pointed out by Kocherlakota (2000).

capital stock (so that capital grows by 2 percent a year). Furthermore, suppose that over the course of a year, investment drops by 18 percent, which is approximately the drop in fixed capital formation over the four quarters starting in Q4:2008 when compared to the previous four quarters. Then, the capital stock drops by about 0.16 percent. With a capital elasticity of output of about $\frac{1}{3}$, this would account for a drop in output of 0.05 percent. While this is a significant deviation for an economy that grows at 2 percent in a normal year, it cannot account for the almost 4 percent drop in gross domestic product that took place in the year after the collapse of Lehman Brothers.

One may wonder whether the almost 20 percent drop in investment is an understatement, given imperfect measurement of intangible capital and the violence of the crisis. As it turns out, this drop in investment is in line with recent quantitative work by Khan and Thomas (2011), who model the impact of a credit shock on investment decisions made by firms. Their model includes two mechanisms that keep investment from falling more substantially. First, there are adjustment costs to capital at the firm level. Second, consistent with empirical work that has found little effect of interest rates on household savings decisions (see Deaton [1992] for a review of that work), in equilibrium, interest rates have to drop substantially to convince households to reduce their savings. The drop in the interest rate, in turn, relaxes the constraints faced by firms, undoing much of their effect on investment. (This effect is emphasized and discussed in detail by Coen-Pirani [2005].)

Problem 2: Co-Movement between Labor Supply and Consumption

Business cycle models with credit frictions will usually change the households' incentives to save. This may occur directly if households are subject to time varying credit frictions, as in Cúrdia and Woodford (2009), Mendoza (2010), and Guerrieri and Lorenzoni (2011), or indirectly if, as in Carlstrom and Fuerst (1997), changes in the intensity of credit frictions applying to firms affect the equilibrium interest rate received by households who lend to these firms. Such an equilibrium adjustment is necessary since credit frictions imply that, for a given interest rate received by lenders, borrowers do not borrow as much as they would otherwise. Fluctuations in the interest rate can assure that equilibrium is maintained.

As discussed above, the empirical evidence suggests that household savings are unlikely to be very elastic to interest rates or, more generically, to incentives for intertemporal substitution. However, to the extent that they are, under conventional assumptions households will choose to reduce labor supply at the same time that they choose to increase consumption and vice versa. If a household faces a higher borrowing interest rate, it will choose to reduce borrowing both by consuming less and by working longer hours to increase income.

This point is made transparently by Barro and King (1984) in a slightly different context. They investigate the impact of intertemporal prices on household behavior. Their result relies on two assumptions: 1) leisure is a normal good, its demand increasing in household wealth, and 2) utility is time separable, with consumption or leisure in a given time period having no effect on the enjoyment of consumption or leisure in subsequent periods. The first assumption conforms to the long-run evidence that, in spite of substantial increases in wages over time, labor supply does not exhibit a strong secular trend (King, Plosser, and Rebelo 1988). The second assumption is more controversial since models with habits are very common, but should be less controversial the longer it is under consideration.

Suppose we write the intertemporal optimization problem of a household as:

$$\max_{C_t, L_t} \sum_{t=0}^{\infty} \beta^t u\left(C_t, 1 - L_t\right)$$

$$s.t. \quad : \quad \sum_{t=0}^{\infty} \frac{1}{R_{0,t}} \left[C_t - w_t L_t\right] \leq B_0,$$

with u increasing and concave in both arguments. C_t is consumption, L_t is labor supply, $1 - L_t$ is leisure, B_0 is initial wealth, w_t is the rate at which the household can transform labor hours into consumption goods (the wage rate), and $\frac{1}{R_{0,t}}$ is the price of time t consumption relative to time 0 consumption. The one-period interest rate between t and $t+1$ is $R_{t,t+1} = \frac{R_{0,t+1}}{R_{0,t}}$.

We are interested in knowing how consumption and leisure change in response to changes in the interest rate. This can be interpreted either as the equilibrium rate faced by households or, more generally in the case where households are directly affected by credit frictions, as the "after tax" interest rate that captures the incentive impact of those frictions.

We can solve the problem in two steps. First, for a given saving decision $\{S_t\}_{t=0}^{\infty} \equiv \{w_t L_t - C_t\}_{t=0}^{\infty}$, we find how the household optimally chooses consumption and labor supply. This is the solution to the static optimization problem:

$$\begin{aligned} \{C\left(S_t, w_t\right), L\left(S_t, w_t\right)\} &= \arg\max_{C_t, L_t} u\left(C_t, 1 - L_t\right) \\ & \quad C_t + S_t \leq w_t L. \end{aligned}$$

Given the solution to the static problem, we then choose a sequence of $\{S_t\}$s to solve the dynamic problem:

$$\max_{e_t} \sum \beta^t u\left(C\left(w_t, S_t\right), 1 - L\left(w_t, S_t\right)\right)$$
$$s.t. \quad : \quad \sum_{t=0}^{\infty} \frac{1}{R_{0,t}} S_t \geq -B_0,$$

where the constraint states that the discounted present value of savings cannot be less than the negative initial assets of the household.

It is easy to see that consumption and leisure choices only depend on the interest rate through its effect on savings, S_t. Thus, in order to understand the impact of changes in credit frictions on consumption and labor supply, we need to understand the impact of a change in S_t in the static problem. We can rewrite the budget constraint of the static problem as:

$$C_t + w_t\left(1 - L_t\right) \leq w_t - S_t.$$

Given the saving decision, S_t, and the wage rate, w_t, the static problem has the same form as an intermediate microeconomics textbook consumer maximization problem over two goods, C_t and $1 - L_t$, with relative price w_t and wealth given by $w_t - S_t$. Since both goods are normal, the optimal response of the household to an increase in S_t is to reduce *both* consumption and leisure. Thus, if a household decides to increase saving, it will both reduce consumption and increase employment. Negative co-movement of consumption and employment is of course at odds with business cycle data.

How big are wealth effects on labor supply likely to be? Baseline calibrations of preferences imply that they ought to be substantial. Over a span of several decades, hours worked have moved relatively little when compared to the manifold increase in wages over that same period. A commonly used functional that captures this fact is[3]

$$u\left(C, L\right) = \frac{\left(C^{1-\kappa}\left(1 - L\right)^{\kappa}\right)^{1-\sigma}}{1 - \sigma}.$$

[3] More generally, King, Plosser, and Rebelo (1988) show that, in order for hours worked to remain constant over time, even as wages increase, the period utility function of households has to be:

$$u\left(C, L\right) = \frac{1}{1-\sigma} C^{1-\sigma} v\left(1 - L\right) \quad \text{or}$$
$$u\left(C, L\right) = \log\left(C\right) + v\left(1 - L\right).$$

The solution to the period-by-period static problem implies

$$\frac{\kappa}{1-\kappa}\frac{C}{1-L} = w,$$

so that L remains constant if wages and consumption grow at the same rate. A typical calibration chooses κ so that $L = \frac{1}{3}$ since this implies that people work approximately one-third of their available time (eight hours in a day). Applying the implicit function theorem,

$$\begin{aligned} \frac{dC}{C} &= -\frac{L}{1-L}\frac{dL}{L} \\ &= -\frac{1}{2}\frac{dL}{L}. \end{aligned}$$

Thus, a change in the interest rate that leads to a 1 percent drop in consumption will also generate a 2 percent rise in employment.

An instructive example of how this mechanism operates in an equilibrium environment is Chari, Kehoe, and McGrattan (2005). The article studies the effect of a "sudden stop" in foreign capital flows to a small open economy. The shock takes the form of a temporary quantitative limit in net imports from abroad. The economy accommodates to the tightened limit with a reduction in consumption and investment, but an increase in employment. The sudden stop in foreign capital flows leads to an output boom.

Another example is Carlstrom and Fuerst (1997). They study the effect of a shock to entrepreneurial wealth in a closed economy. Given the credit friction, the shock reduces the borrowing capacity of entrepreneurs, forcing them to reduce investment. However, in general equilibrium this can only be accomplished through an increase in household consumption. The price change that supports this consumption boom is a reduction in the interest rate faced by households. In response, households increase leisure and reduce employment. In sum, in response to an entrepreneurial wealth shock, the model generates a recession with a consumption boom.

One important lesson from Barro and King (1984) is that, given their assumptions, for shocks to generate realistic co-movement between consumption and labor supply, they need to have an impact on the wage rate, w_t. In the rest of the article, we will review some of the strategies that the literature has devised to have the wage rate move in response to credit frictions.

Summary

The analysis above also gives some hints as to which mechanisms are likely to generate realistic business cycle fluctuations. These are typically mechanisms that 1) have an impact on employment and 2) affect real wages. Wages can drop if a shock generates a reduction in labor productivity or if the shock acts as a tax on wages (a "labor wedge"). Such shocks will lead firms to want to hire fewer workers and, in equilibrium, there will be a drop in wages that will induce households to reduce both their consumption and their leisure time.

Numerical studies of general equilibrium stochastic growth models bear out this intuition, implying that productivity shocks and labor wedge shocks account for the bulk of business cycle fluctuations, including the Great Depression (see Chari, Kehoe, and McGrattan [2005] and the various articles collected in Kehoe and Prescott [2002]), but an "interest rate wedge" (i.e., a tax on saving or investment) measured in a similar way cannot account for much.

3. MODIFICATIONS OF THE STANDARD MODEL

We now turn to modifications to the baseline model that help increase the potential impact of credit on the real economy.

Labor Supply

The literature on credit frictions has adopted particular functional forms for the utility function that eliminate or greatly mitigate the wealth effect on labor supply. One popular solution is to postulate a utility function as in Greenwood, Hercowitz, and Huffmann (1988):

$$u\left(C_t, L_t\right) = u\left(C_t - \psi\left(L_t\right)\right),$$

where ψ is increasing and convex. A static optimization problem using this utility function yields the following first-order condition:

$$w_t = \psi'\left(L_t\right),$$

where w_t is the wage rate. Now, labor supply depends only on current wages, regardless of consumption. Thus, with this utility function, a change in credit conditions can lead to a decrease in consumption without an increase in labor supply.

One motivation for using this utility function is that it captures home production (Greenwood, Rogerson, and Wright 1995). In this interpretation, $\psi\left(L_t\right)$ is the loss in goods produced at home that occurs when a household decides to offer its labor in the market. An objection to the Greenwood, Hercowitz, and Huffmann (1988) utility function is that it implies a long-run trend in working hours as wages increase over time. This need not be the case if labor productivity in home production increases at the same rate as labor productivity in market production. In modelling terms, all this assumption requires is substituting $\psi(L_t)$ for $(1+g)^t \psi(L_t)$, where g is the per-period growth rate in the economy.

An alternative proposed in a different context, but that preserves the long-run properties of the utility function advanced by King, Plosser, and Rebelo (1988) while generating short-term properties more in line with Greenwood, Hercowitz, and Huffmann (1988), is Jaimovich and Rebelo (2009), who put forward a utility function of the form

$$\begin{aligned} u(C_t, X_t, L_t) &= u\left(C_t - \psi L_t^{\theta} X_t\right), \\ X_t &= C_t^{\gamma} X_{t-1}^{1-\gamma}, \end{aligned}$$

where X_t can be interpreted as a habit in consumption. With $\gamma = 1$, the preference is in the class discussed by King, Plosser, and Rebelo (1988), whereas with $\gamma = 0$ it is as proposed by Greenwood, Hercowitz, and Huffmann (1988). In a model with news shock, Schmitt-Grohé and Uribe (2012) estimate γ to be close to zero, implying a utility function very close to the one proposed by Greenwood, Hercowitz, and Huffmann (1988).

Capacity Utilization

While the stock of buildings and machinery cannot change quickly, the utilization of that stock can. However, in a conventional model of capacity utilization, the same credit frictions that lead firms to reduce fixed investment will also lead them to increase capacity utilization. The intuition is similar to the incentive for households to increase labor supply when facing a higher cost of borrowing: If borrowing is more costly, this raises the value of current income relative to future income.

Suppose capital depreciation is an increasing and convex function of capacity utilization u as in Greenwood, Hercowitz, and Huffmann (1988). That is, firms refrain from using their capital at full capacity because higher capital utilization subjects them to more frequent breakdowns in their machinery, thus requiring them to replace damaged capital. Suppose also that firms face convex installation costs to new capital, which imply that they would optimally choose to avoid wide swings in investment. Firms face a marginal one-period interest rate $R_{t,t+1}$ on borrowing and lending so that they use its inverse as its discount rate when evaluating production decisions. As before, we interpret this interest rate as being the "after tax" cost of capital faced by firms, including the various credit frictions that they might be subject to. At $t = 0$, the problem of a firm with convex capital installation costs is

$$\max_{\{u_t, K_{t+1}, L_t\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \frac{1}{R_{0,t}} \left[A_t F\left(u_t K_t, L_t\right) - w_t L_t - I_t - g\left(I_t\right)\right]$$
$$s.t. \quad : \quad K_{t+1} = I_t + \left(1 - \delta\left(u_t\right)\right) K_t,$$

where, as in the household problem, $R_{0,t}$ is the discount rate applied by the firm between 0 and t, I_t is investment, L_t is labor, K_t is capital, A_t is total factor productivity, w_t is the wage rate, $g(I)$ is the installation cost,[4] with g increasing and convex, δ is increasing and convex, and F has the usual properties (increasing, concave, differentiable, constant returns to scale). We can solve out L_t and write the problem as[5]

$$\max_{\{u_t, I_t, K_{t+1}\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \frac{1}{R_{0,t}} \left[\pi\left(w_t, A_t\right) u_t K_t - I_t - g\left(I_t\right)\right]$$
$$s.t. \quad : \quad K_{t+1} = I_t + \left(1 - \delta\left(u_t\right)\right) K_t,$$

where $\pi\left(w_t, A_t\right) u_t K_t$ is firm revenue net of the wage bill and $\pi_w\left(w_t, A_t\right) < 0$, $\pi_A\left(w_t, A_t\right) > 0$ since higher wages relative to labor productivity lead the firm to use less labor, thus decreasing the marginal product of capital.

The first-order condition with respect to u_t is (after cancelling out K_t)

$$\pi\left(w_t, A_t\right) = \delta'\left(u_t\right) \chi_t.$$

Since $\delta\left(u_t\right)$ is convex ($\delta''\left(u_t\right) > 0$), we have that capacity utilization u_t increases with productivity, decreases with wages, and decreases with the shadow value of capital at period t, χ_t.

The first-order condition with respect to I_t is

$$1 + g'\left(I_t\right) = \chi_t.$$

Since g is convex, g' is increasing in I_t, and investment increases with the shadow value of capital χ_t. Take the first-order condition with respect to K_{t+1}:

$$\chi_t = \frac{\pi\left(w_{t+1}\right) u_{t+1} + \left(1 - \delta\left(u_{t+1}\right)\right) \chi_{t+1}}{R_{t,t+1}}.$$

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[4] The functional form for capacity utilization costs is slightly unusual and is adopted for didactic purposes. More common forms are $g\left(\frac{I_t}{K_t}\right)$ and $g\left(\frac{I_t}{I_{t-1}}\right)$, with g increasing and concave. These forms ensure that $\frac{I}{K}$ remains cosntant over a balanced growth path. We adopt the simpler $g\left(I_t\right)$ because this conveys the main intuition without burdening the notation.

[5] For example, if $F\left(u_t K_t, L_t\right) = \left(u_t K_t\right)^{\alpha} L_t^{1-\alpha}$, then $\pi\left(w_t\right) = \alpha\left(u_t K_t\right)^{\alpha} \left(\frac{1-\alpha}{w_t}\right)^{\frac{1-\alpha}{\alpha}}$.

Iterating forward and imposing the transversality condition $\lim_{T\to\infty} \frac{\chi_T}{R_{t,T}} = 0$, we get that

$$\chi_t = \sum_{v=1}^{T-1} \Delta_{t,t+v} \frac{\pi(w_{t+v}) u_{t+v}}{R_{t,t+v}} = 0.$$

A higher interest rate $R_{t,t+v}$ decreases χ_t, the shadow value of capital in place. This implies that the firm has a lower incentive to invest, but also a higher incentive to utilize capacity more intensively. The reason is that a firm that faces high borrowing costs is less concerned about preserving its production capacity in the future relative to generating current cash flows. Thus, an increase in borrowing costs leads to a production boom.

In their study of the Korean crisis, Gertler, Gilchrist, and Nataluci (2007) propose a modification to the cost of capacity utilization that is able to sidestep this difficulty. Their proposed setup is equivalent to assuming that capacity utilization does not require replacing the capital stock, thus forcing the firm to incur new convex installation costs, but instead leads to an increase in maintenance expenses, which can be paid for without paying installation costs again. Under that assumption, the problem of the firm becomes[6]

$$\max_{\{u_t,K_{t+1}\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \frac{1}{R_{0,t}} \left[\pi(w_t) u_t K_t - I_t - \delta(u_t) K_t - g(I_t)\right],$$
$$s.t. \quad : \quad K_{t+1} = I_t + (1-\lambda) K_t,$$

where, as before, g is increasing and convex and δ is increasing and convex; λ is a scalar capturing the depreciation rate. The first-order condition for capacity utilization becomes

$$\pi(w_t) u_t = \delta'(u_t).$$

Utilization does not depend on the price of capital, since maintenance does not have any bearing on future capital stock and, therefore, the firm does not face any intertemporal tradeoff when setting its capacity utilization.

[6] Gertler, Gilchrist, and Nataluci (2007) define variables slightly differently, with investment given by the sum of new capital and maintenance costs. Under this redefinition, the problem becomes

$$\max_{\{u_t,K_{t+1}\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \frac{1}{R_{0,t}} \left[\pi(w_t) u_t K_t - \bar{I}_t - g\left(\bar{I}_t - \delta(u_t) K_t\right)\right],$$
$$s.t. \quad : \quad K_{t+1} = \bar{I}_t + (1-\lambda-\delta(u_t)) K_t,$$

where $\bar{I}_t \equiv I_t + \delta(u_t)$.

Working Capital

Macroeconomic models normally use capital as a metaphor for machinery and buildings. However, an important part of corporate finance concerns the management of working capital. This includes all the short-term assets and liabilities that firms need to hold in order to run their business. A large part of working capital is linked to payroll and to other variable inputs. Hence, increases in the cost of working capital could presumably lead to a reduction in the use of those variable inputs and of production. Early studies of banking crises have emphasized the effect of credit shocks on the ability of firms to manage working capital (see, for example, Sprague [1907]). More recently, models of financial crises often feature working capital as an important propagation mechanism (see, for example, Neumeyer and Perri [2005] and Mendoza [2010] for discussions of financial shocks in emerging economies and Perri and Quadrini [2011] and Jermann and Quadrini [2012] for discussions of financial shocks in advanced economies).

There are two motivations for the need to borrow in order to fund payroll and acquisition of materials. The first, and most common one, emphasizes the need to hold cash in order to pay for variable inputs. In its modern macroeconomics form it was pioneered by Christiano and Eichenbaum (1992) and Fuerst (1992). Increases in borrowing costs increase the opportunity cost of holding cash and, thus, of hiring labor and buying materials. This view of working capital also underlies much of the work on emerging market crises, starting with Neumeyer and Perri (2005). One difficulty for the emerging market literature is that many emerging economies experienced periods of very high inflation in which holding any cash whatsoever would be extremely costly. To get around this problem, articles in that literature assume that the opportunity cost of holding cash is proportional not to the nominal interest rate, but to the real interest rate. The implicit assumption is that firms are able to perform their payments with inflation indexed securities that, however, do not pay any real interest rate.

A second approach that does not rely on a need for a special asset to make payments is simply to recognize that there is a time lag between the acquisition and use of inputs and the sale of output, as evidenced by holdings of inventories not only of finished goods, but also of raw materials and work in process (Schwartzman 2010). This time to produce and distribute goods implies that fluctuations in borrowing costs affect the demand for variable inputs in a very similar way to the payment friction channel emphasized in other articles. One advantage of this approach is that it allows for a clean calibration of working capital demand using steady-state inventory/cost ratio as a target. Also, it provides a clear motivation for using real as opposed to nominal interest rates as the cost of working capital. Schwartzman (2010) shows that this channel allows a multi-sector small open economy model to account for a substantial part of the sectoral reallocation that takes place in the aftermath of emerging market crises.

Working capital requirements often appear in the firm's problem by requiring firms to pay for labor one period in advance, thus borrowing in order to pay for the wage bill. In a setup where labor factor is used one period before production takes place, the problem of a firm that faces decreasing marginal returns to labor input (suppose for simplicity its capital stock is fixed at 1) is

$$\max_{\{l_{t+s+1}\}_{s=0}^{\infty}} \sum_{s=0}^{\infty} \frac{1}{R_{t,t+s}} \left[A l_{t+s+1}^{\omega} - w_{t+s+1} l_{t+s+2} \right].$$

The first-order condition is

$$\omega A l_{t+s}^{\omega-1} = w_{t+s-1} R_{t+s-1,t+s}.$$

Hence, an increase in the one-period interest rate has a similar impact on labor demand as an increase in wages in the same proportion. However, households are only compensated for their labor through wages. In effect, because labor demand drops, in equilibrium wages must drop for the labor market to clear. The higher interest rate functions as a tax on labor, leading to a drop in employment and consumption.

The demand for working capital and capacity utilization decisions reinforce each other. The point is clear in Schwartzman's (2010) study of emerging market crises in the presence of demand for working capital, where he finds that adding a capacity utilization margin to a model with working capital almost doubles the aggregate output reduction from an interest rate increase.

Firm Heterogeneity

One key benefit of well-functioning credit markets is that they direct resources to the most productive uses. If credit markets malfunction, aggregate productivity in the economy may suffer. Models with firm heterogeneity capture that idea. Credit frictions typically imply larger interest rates (or shadow cost of funds) for borrowers than for savers. Since borrowing firms tend to also be the most productive ones, this means that an exacerbation of credit frictions will lead capital and labor to move from high productivity units that borrow a lot, to low productivity ones that borrow little if at all. This reallocation reduces the average total factor productivity in the economy. Because productivity drops, wages drop, leading to reduced incentives for labor supply and to a recession.

The misallocation is at the heart of the output drop in Kiyotaki and Moore (1997) and Kiyotaki (1998), and more recently in Gilchrist, Sim, and Zakrajsek (2010). While intuitively appealing, the capital reallocation view has not fared particularly well in some quantitative studies. One notable example is Cordoba and Ripoll (2004). The authors show that in order for capital reallocation to have a large impact on output, it is necessary for capital to account for a large share of output. In their parameterizations, they find that large amplification requires capital shares of output close to 0.8. This, they argue, is too large in the face of an aggregate capital share of close to $\frac{1}{3}$.

Cordoba and Ripoll (2004) may exaggerate the difficulties of the capital reallocation model by focusing too narrowly on the reallocation of fixed capital while keeping labor reallocation in the background. To see this, consider the following firm problem:

$$\begin{aligned}&\max Y_t - (R_t - (1-\delta))\, K_t - w_t L_t \\ &Y_t = A_t K_t^{\alpha} L_t^{\beta},\end{aligned}$$

where K_t is capital and L_t is labor. Solving out the firm's problem yields

$$Y_t = A_t \left(\frac{\alpha}{R_t - (1-\delta)}\right)^{\frac{\alpha}{1-\alpha-\beta}} \left(\frac{\beta}{w_t}\right)^{\frac{\beta}{1-\alpha-\beta}}.$$

With credit frictions, interest rates are firm-specific. In many models, increases in credit frictions imply that interest rates are higher for firms with large productivity (high A_t) relative to those with low productivity (low A_t). Thus, there is a decrease in output of high productivity firms relative to that of low productivity, leading to a drop in aggregate output.

How much of a change in relative output there is for a given change in relative interest rates depends on the elasticity of output to the user cost of capital $R_t - (1-\delta)$. This elasticity is given by the exponent $\frac{\alpha}{1-\alpha-\beta}$. Cordoba and Ripoll (2004) assume that firms have a fixed labor input, which insofar as the firm problem is concerned, is equivalent to assuming $\beta = 0$. It follows that the elasticity of firm-level output to the user cost of capital $R_t - (1-\delta)$ is $\frac{\alpha}{1-\alpha}$. Cordoba and Ripoll's preferred calibration has α close to $\frac{1}{3}$, so that $\frac{\alpha}{1-\alpha} = \frac{1}{2}$. In comparison, if firms can choose how many workers to hire, then the elasticity is $\frac{\alpha}{1-\alpha-\beta}$. Supposing that $\alpha + \beta = 0.9$, which is not far from common estimates of the degree of decreasing returns to scale, and keeping the capital share to $\frac{1}{3}$, then the elasticity of firm-level output to the user cost of capital rises to a much more substantial $\frac{10}{3}$. This is an effect almost seven times as large.

Another, more recent quantitative study of a model with firm heterogeneity and credit frictions that allows for full labor mobility across firms is Khan and Thomas (2011). In the article, the authors introduce firms that face a quantitative constraint in their ability to borrow and fixed investment costs. The quantitative constraint on borrowing implies that firms for which the borrowing constraint binds face an infinite borrowing rate on the margin, and firms for which the constraint does not bind may refrain from borrowing to preserve financing capacity. Khan and Thomas (2011) study the impact of a shock to the maximum leverage that firms can hold. While they find that a persistent shock to leverage can have a sizeable impact on productivity after several quarters, the shock does not have any immediate impact on average productivity and leads, in fact, to a short-lived consumption boom. The reason is that with realistic investment adjustment costs at the firm level, capital reallocation takes time. Over the short run, productive firms keep their capital even in the face of tighter constraints and unproductive firms do not expand even in the face of lower interest rates.

Sticky Prices

Fluctuations in the intensity of credit market frictions generate the correct patterns of business cycle co-movement in the presence of an unrelated but widely used friction: sticky prices. Examples of models with financial frictions that use sticky prices are Bernanke, Gertler, and Gilchrist (1999); Del Negro et al. (2009); Gertler and Karadi (2011); and Christiano, Motto, and Rostagno (2013)

Sticky prices do not change in any way the direct impact of changes in the borrowing rate on investment, consumption, or labor supply decision. Rather, what they do is translate changes in the demand for investment or consumption goods into changes to the real wage. In this class of models, monopolistic firms commit to matching whatever demand they face at a price they have previously set, irrespective of what this implies to their marginal costs. If both consumption and investment drop in a given period, firms keep their price constant but hire fewer workers, thus paying lower real wages and increasing their markups. This lower real wage leads workers to want to work less and consume less.[7]

[7] With sticky wages the workers pre-commit to supplying as much labor as needed to satisfy demand at the pre-determined prices, so that over the short run they lose the ability to adapt labor supply decisions to credit conditions.

Closing sticky price models requires a policy rule adopted by the central bank, such as the Taylor rule, to determine the nominal interest rate. In principle, the policy rule could be chosen so as to keep markup fluctuation at a minimum, thus essentially replicating the allocation of a flexible price model. However, if the central bank is constrained by a zero lower bound on the nominal interest rate, then the central bank does not have any option but to allow markups to vary a lot. In such an environment, fluctuations in borrowing costs can be particularly potent (see Del Negro et al. [2009] and Gertler and Karadi [2011]).

Recently, New Keynesian models with credit spreads as a main driving force have been used to suggest that credit frictions are important to explain regular business cycles. In terms of making the quantitative case, the most well-developed model is the one by Christiano, Motto, and Rostagno (2013). There, the authors find that volatility shocks (which, in their model have a direct impact on credit spreads) account for about 60 percent of business cycle fluctuations.

Risk Management and Bargaining

The bulk of the survey was concerned with models where the action occurs because of changes in the cost of borrowing and lending faced by firms or households. These are not the only way in which credit markets affect the economy. In this section we give two examples from the recent literature where credit frictions operate indirectly by affecting risk management decisions or bargaining relationships.

Borrowing limits when combined with incomplete insurance can lead to significant risk management concerns that distort allocations. This is the focus of the article by Arellano, Bai, and Kehoe (2010). There, all of production takes place within the same period and there is no need to borrow in order to pay the wage bill. Rather, the friction is that firms pre-commit to using a certain amount of labor before they learn what their production will be. Firms normally borrow because there is a tax advantage for debt, but if output turns out to be low, they need to borrow an additional amount in order to pay for their previous commitments. There is a possibility that, at the end of the period, firms could find themselves in default because they face a borrowing limit. When this happens, they have to close, thus losing future production opportunities. In order to avert this inefficient outcome, firms may decide to restrict hiring ex-ante in order to reduce the risk of default. The increased cost of default increases the cost of hiring, thus acting like a tax on labor and reducing wages.

The second example relies on the fact that credit contracts are commitments to the transfer of future income between particular agents.

Such a pre-commitment can have implications for future bargaining with third parties. This is the route taken by Monacelli, Quadrini, and Trigari (2011). Their idea is that firms pre-commit to paying creditors before bargaining with workers. Hence, by increasing their indebtedness, firms are able to take part of the surplus out of the negotiation when negotiating wages. This leads to lower wages. While this should lead to an incentive for more job creation, it also decreases the incentive for workers to supply labor, with the latter more likely to happen over the short run.

Both of these examples serve as reminders that credit frictions can matter for business cycles even if they are not directly distorting intertemporal decisions. Exploring such possibilities is a particularly promising avenue for future research.

4. CONCLUSION

The study of quantitative macroeconomic models with credit frictions has come a long way since the seminal contributions of Bernanke and Gertler (1989), Carlstrom and Fuerst (1997), and Kiyotaki and Moore (1997). The case for an important quantitative role for such frictions is still unsettled for various reasons. On the one hand, a first brush approach using standard growth models may lead researchers to discount heavily how important such shocks can be. On the other hand, recent research shows that a number of more or less reasonable modifications can help amplify their role and imply better behaved predictions.

Many of the modifications may make models more cumbersome to write down but can be justified. That firms need to finance working capital, and that they have an important capacity utilization margin, should be uncontroversial. Firm level heterogeneity is also a well-documented fact. Finally, while the importance of sticky prices is still a matter of some controversy, it is routinely accepted as an important mechanism by a very large fraction of applied macroeconomists. Other modifications such as the adoption of preferences that shut down wealth effects on labor supply might be harder to justify.

The financial crisis of 2008–2009 has highlighted for many economists the importance of taking the financial sector seriously when thinking about macroeconomic dynamics. However, establishing that the financial sector matters for business cycles involves close attention to the seemingly unrelated issues surrounding the details of preferences, technology, and the importance of other frictions. This attention should be an important focus of future research.

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