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Understanding Liquidity Shortages During Severe Economic Downturns

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Abstract

One feature of economic recessions is the appearance of aggregate liquidity shortages that can exacerbate the economic downturn. We develop a model in which the demand for liquidity arises suddenly in response to continued funding needs of partially completed investment projects whose outcomes are subject to idiosyncratic shocks and moral hazard. When the economy experiences an adverse aggregate productivity shock, incentive constraints that underlie equity contracts may bind, provided the shock is severe enough. In this case, credit-rationing appears, and the heightened demand for liquidity coincides with a greater reluctance to take on equity positions or deepen investments in on-going investment projects. The consequence is a reduction in new investment and termination of on-going projects due to a lack of liquidity, thereby worsening the economic slowdown.

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1 Introduction

Absent from most DSGE macroeconomic models of the business cycle is the important role that private information and financial contracts can play in affecting short-run economic fluctuations, particularly during severe economic downturns. Exceptions, based on the early work of Diamond (1984), include Williamson (1986) and Bernanke and Gertler (1989), in which incentive constraints were expressly incorporated into loan agreements between investors (lenders) and firms (borrowers). These models exhibit equilibrium credit rationing through which adverse economic shocks are seen to exacerbate economic downturns, and increase bankruptcies. In Williamson (1987), heightened uncertainty over the future outcome of funded projects is also seen to induce an economic slowdown, even if the mean expectation of project returns is unchanged. These results generally rely on a financial accelerator that operates through a procyclical net worth position of the firm which affects the ability of a firm to acquire working capital to fund new investments. These papers focus on debt-financing through financial intermediaries and do not address liquidity issues per se, i.e., when funds are suddenly needed to meet unanticipated expenditures associated with ongoing operations.[1]

Holmstrom and Tirole (1998) have investigated these liquidity issues in three-period, partial equilibrium models. They find that limited pledgeable future income generated by funded projects requires that incentive constraints be present in original loan contracts, which lead to "suboptimal" funding of socially valuable projects. Consequently, adverse shocks to individual firms may result in termination of ongoing projects and worsen the state of an already weakened economy. They examine conditions under which an inadequate provision of liquidity arising in the private sector may provide a rationale for an enhanced supply of liquidity by the government.

[1]One branch of this literature that deals with the liquidity issues of financial institutions is represented by the bank runs model of Diamond and Dybvig (1983) and the financial fragility as a commitment mechanism in Diamond and Rajan (2001). These rely on adverse selection associated with investor types and are not the subject of this paper which is more concerned with how the interaction of liquidity shortages and moral hazard during economic downturns can heighten the economy's contraction.

Kiyotaki and Moore (2005, 2008) have examined insufficient liquidity and its consequences for the business cycle in a different context. They focus on a combination of liquidity constraints – one in which new equity issues by entrepreneurs are bounded by entrepreneurs' inalienable human capital, and a second constraint in which existing equity shares are not fully marketable. Both constraints limit the value of equity in the financing of investment opportunities, and give rise to a demand for money. Their models are structured to capture some asset-pricing anomalies and to demonstrate how monetary policy may offset liquidity shortages through open market operations that take place in the equity market.

In this paper, we build a stylized DSGE model with entrepreneurs raising funds in an equity market to undertake risky multi-period projects with a positive expected social value. However, as in Holmstrom and Tirole (1997), moral hazard is present due to the private information possessed by the entrepreneurs whose actions bear on the equilibrium outcomes of the projects. Therefore, equity contracts are premised on incentive constraints designed to induce desirable actions on the part of the entrepreneur that ensure a positive expected return on the funded project. However, these provisions in the contracts do not affect the economy-wide supply of liquidity unless the economy experiences a sufficiently negative aggregate (productivity) shock, in which case, credit rationing may result.

Technically, the incentive constraints are not always binding, but when they bind, they affect the ability of the entrepreneur to raise funds for new investment projects and make it more difficult to bring these projects to completion should unexpected expenses suddenly arise. These unplanned expenses give rise to a demand for liquidity. However, the supply of liquidity decreases with adverse aggregate shocks, and if the shock is strong enough, the expected profitability threshold that these projects must meet if they are to receive additional injections of new funds required to bring these projects to fruition is raised. This greater reluctance of investors to take equity positions or to deepen their current investments in a weak economy is shown to exacerbate an economic downturn and to alter the cyclical properties of the macroeconomy by influencing investment decisions of households.[2]

The mechanism that we describe, through which financing requirements affect economic activity, differs from the financial accelerator described, for example, in Holmstrom and Tirole (1997) and Bernanke and Gertler (1989). In this model, net worth plays no role in limiting the need for external finance. Rather, when negative aggregate shocks are sufficiently strong, they can exacerbate the significance of firm-specific idiosyncratic shocks and lead to an excess demand for liquidity that causes credit rationing to limit overall economic activity. Some continuing projects that would otherwise be funded are terminated; while fewer new investment projects receive funding.[3]

To focus attention on the importance of the incentive constraints in dealing with the moral hazard issue, we calibrate the model such that the magnitude of the moral hazard problem is parametrically set sufficiently low that the incentive constraints never bind. The model is then re-calibrated with the importance of moral hazard increased sufficiently that the incentive constraints occasionally bind. Simulation results are then provided that illustrate how a lack of aggregate liquidity can "kick in" after a severe negative productive shock and exacerbate the subsequent downturn in the economy.

2 The Model

The economy is populated by a continuum of household of measure 1. Each household consists of an investor-worker-entrepreneur trio. The investor is responsible for managing the financial assets of the household whereas entrepreneur runs a project, the proceeds of both of which provide income to the household. The worker supplies

[2]We note in passing that this feature of an occasionally binding constraint is one-sided, in that it only binds during sharp negative aggregate shocks. This could be a factor helping to explain the asymmetry of business cycle fluctuations, in which economic recoveries are more gradual than economic contractions, as documented, for example, by Van Nieuwerburgh and Veldkamp (2006).

[3]We note that the credit rationing that occurs in this model may be present after the initial financing of the project takes place, when a demand for liquidity exceeds the expected liquidity needs of ongoing projects and requires additional funding.

labor to the projects which is yet another source of the household's income. The three are separated at the beginning of each period and they consume together at the end of the period when they meet again.

The household holds three financial assets: a risk-less bond, liquid real asset called money, and shares of the projects. As the household is risk averse and all projects are identical *ex ante*, the investor in the household invests equally in all projects. Thus, we assume that the household, as investor, diversifies away the idiosyncratic project risk through financial/asset markets. Households can achieve same diversification through finacial intermediaries/ banks. In that case, it will be more natural to consider financing to projects as loans and liquidity provision will be made by the banks. As in Tirole (2006, p. 119), these two financial arrangements are equivanlent in our model. To simplify exposition, we will assume that the diversification of idiosyncratic risk is achieved through financial markets.

2.1 Project Implementation and Financing

The projects require investment one period in advance which the entrepreneur finances by issuing shares. The projects are subject to a liquidity shock at the beginning of the next period when they can potentially produce. The entrepreneur does not have the funds to finance the second period liquidity shock. The outside investors decide at that time if they would finance the liquidity shock. If the liquidity shock is financed, the entrepreneur goes ahead with the project. The entrepeneur can affect the likelihood of a successful project (described below) through work effort. The project succeeds with probability p_H if entrepreneur does not shirk; otherwise, the probability of success falls to p_L.

The entrepreneur from each household starts a project sothat new projects with measure 1 are started every period. The projects are indexed by $i \in [0, 1]$. A project's output depends on the amount of labor employed in the first period. Thus, the output of a project i started in period t, if successfully implemented, is

$$y^i_{t+1}(\theta_{t+1}) = \theta_{t+1}(n^i_{1,t})^\alpha, \tag{1}$$

where $n^i_{1,t}$ is the labor employed in period t and θ is the random aggregate productivity parameter. Thus, the project output is random and depends on the realization of θ at the beginning of time $t+1$.

In addition to the aggregate shock, each project started in period t also experiences, at the beginning to time $t+1$, a project-specific liquidity shock ρ_{t+1} with a known distribution $F(\rho)$ and corresponding density $f(\rho)$. As a result, the entrepreneur needs to make an additional investment in period $t+1$ for the project to potentially succeed. To be precise, the liquidity shock results in the need to hire an additional $n_{2,t+1}$ workers

$$n^i_{2,t+1} = \rho^i_{t+1}. \tag{2}$$

The reason this shock is labeled as liquidity shock is that the shock has to be funded with a liquid asset.

The entrepreneurs do not have funds to finance either the first-period wage bill or the second-period liquidity shock. They issue equity in the first period to outside investors to meet the wage bill. The liquidity shock at the beginning of the second period is also financed by the outside investors and they are aware of this fact when they decide to invest. With all costs already paid, when the project actually produces, the entire revenue proceeds are profits that are distributed among the shareholders at the end of the second period on completion of the project. We normalize the total shares of a project to 1. The enterpreneur sells s^i_t shares to finance the wage bill, so that

$$s^i_t p^i_t = w_t n^i_{1,t}, \tag{3}$$

where p^i_t is the price of the share of project i started in period t in the period of issue, t, and w_t is the wage rate in period t.[4] Thus, s^i_t represents the "outside equity" (see

[4]Note that while it is possible for the entrepreneur to divest the shares of his firm more than

Tirole, 2006, p. 119) in the project.

The investors realize they will need to finance the liquidity shock for which they carry a liquid asset from period t to $t+1$. However, not all projects have their liquidity needs financed by investors. After observing ρ_{t+1}^{i}, they compare their expected benefit from financing with the cost of financing. The benefit from the project is uncertain even after the liquidity need is met as not all projects finally succeed in producing output. Yet, conditional on being financed, the expected benefit to the investor is the same for all continued projects. Thus, there exists a threshold value of $\rho_{t+1}^{*}(\theta_{t+1})$ such that all projects with lower liquidity needs than this threshold are financed in period $t+1$. The functional dependence of this cutoff value on θ_{t+1} arises from the facts that the project revenue, conditional on liquidity needs being financed, and the liquidity needs both depend on the aggregate shock.

2.2 Entreprenuer's Problem

As the project under management by the entrepreneur is subject to moral hazard, the probability of success of the project depends on effort of the entrepreneur. It is p_H if he exerts effort and p_L if he shirks. Shirking provides an exogenous benefit to the entrepreneur. It is assumed that entrepreneurs have all the bargaining power as they have the hidden action. They appropriate all the surplus from the projects and the investors just break even relative to their alternative investment options.

We assume that the entrepreneur maximizes his profits subject to his incentive compatibility constraint and investors' individual rationality or participation constraint. He is the residual claimant to fraction $(1 - s_t^i)$ of period $t+1$ gross revenues

what is needed to raise finance for the first period funding needs, it is not optimal. The reason is straightforward. Issuing a larger number of shares does not raise the revenue of the project but it reduces the share of the revenue going to the entrepreneur. The extra shares sold also generate cash flow but that does not completely offset the loss due to the reduced number of shares.

To see this consider a simple case with a one period project with revenue of $100. Suppose, an investment of $30 has to be made before hand. The entrepreneur issues .30 shares to an outsider who then lends $30. After the project is completed, the entrepreneur gets 0.70*$100=$70. The investor also breaks even. Now suppose, instead, the entrepreneur issues 0.31 shares to the investor getting $31 dollars. After investing $30, the revenue now is $101. The entrepreneur gets .69*$101=$69.69 dollars which is less than $70.

(which are the same as profits) that are realized if the project succeeds. It is assumed that the loss from shirking is high enough that it is always optimal to incentivize the entrepreneur to exert effort so that in equilibrium the probability of success, conditional on the liquidity need being financed, is p_H.

If successful, the revenue from the project is

$$\hat{R}^i(\theta_{t+1}) \equiv q^i_{t+1} y^i_{t+1}(\theta_{t+1}) = q^i_{t+1}\theta_{t+1}(n^i_{1t})^\alpha, \tag{4}$$

where q^i_{t+1} is the price of good i produced by entrepreneur i's project. The expected revenue accruing to the investor, conditional on the liquidity need being financed, is $p_H s^i_t \hat{R}(\theta_{t+1})$. The liquidity need of a project will be financed as long as it does not exceed this amount, if the liquidity is available, i.e.,

$$\rho^*_{t+1}(\theta_{t+1}) \leq \frac{p_H s^i_t \hat{R}^i_{t+1}(\theta_{t+1})}{w_{t+1}}. \tag{5}$$

This is so because the past investment decision is not relevant for liquidity financing. In addition, since the investor is diversified over a large number of identical projects, he is risk-neutral with respect to any single project. Finally, we are implicitly invoking symmetry across projects.[5] It may be mentioned that, while maximizing his profits, the entrepreneur views ρ^*_{t+1} as parametrically given.

Coming back to the entreprenuer's profit maximization, his profits are $(1 - s^i_t)\hat{R}^i_{t+1}$ with probability p_H and zero otherwise. Thus, the entrepreneur's objective of maximization is

$$\max_{p^i_t, s^i_t, n^i_{1t}} E_{t,\theta}\left\{\beta\frac{U_{C_{t+1}}}{U_{C_t}}\left[(1 - s^i_t)p_H\hat{R}^i(\theta_{t+1})F\left(\rho^*_{t+1}(\theta_{t+1})\right)\right]\right\}, \tag{6}$$

where the profits are discounted back to time t using the household's stochastic discount factor and $E_{t,\theta}$ denotes expectation over θ_{t+1} conditional on information at t.

[5] Note we have variables indexed by i on the right side but not on the left side of (5).

The incentive compatibility constraint for the entrepreneur is

$$p_H \left(1 - s_t^i\right) \hat{R}_{t+1}^i \left(\theta_{t+1}\right) \geq p_L \left(1 - s_t^i\right) \hat{R}_{t+1}^i \left(\theta_{t+1}\right) + P s_t^i, \tag{7}$$

where the total benefit from shirking, Ps_t^i, $P > 0$, is an increasing function of outside equity, s_t^i. Note that there is one incentive compatibility constraint for each aggregate state. In addition, the entrepreneur also faces the investor's participation constraint. Thus, the maximization of (6) is subject to $(3-4)$, (7) and the investor participation constraint

$$p_t^i \leq p_t^{-i}, \tag{8}$$

where p_t^{-i} is price of share of a representative firm other than i. Thus, (8) says that, given the fact that all projects are ex ante identical, the entrepreneur i cannot charge a price of shares of her firms that is higher than the going price of the shares of the other projects.

2.3 The Household sector

In every period, the representative household h maximizes utility, $U(C, L)$, over consumption and leisure. The varieties produced by different projects are perfect substitutes in consumption. Hence, the aggregate good, C, is a linear aggregate of different varieties

$$C_t = \int_0^1 c_t^j dj, \tag{9}$$

where c_t^j is the consumption of variety or good j. The household consumes jointly but the three members of the household–the investor, the entrepreneur, and the worker–specialize in different income earning activities. Based on the consumption-leisure decision of the household, the worker provides the labor, n_t, which is one source of household income. The entrepreneur starts a new project in each period and the profits for maturing projects $\left(\Pi_t^h\right)$ provide another source of income for the household's consumption.

The final source of income is the household's assets. These assets are managed by the investor who determines the household's optimal consumption-saving decision and makes the portfolio allocation decision for investing the household's savings in three assets. It buys B_{t+1} units of riskless bond each unit of which provides one unit of aggregate output in the next period. Second, it decides to buy s_t^i shares of every project $i \in [0,1]$. As the number of shares of each project is normalized to 1, s_t^i shares entitle the household to a corresponding fraction of the gross revenue from sales of project's output in period $t+1$, if the project is eventually successful and produces the output. Among other things, the project produces output only if its random liquidity need at the beginning of period $t+1$ is financed by the household. This liquidity need arises from the fact that the entrepreneur needs to pay for unanticipated extra costs of operations in period $t+1$ before the revenue from the output becomes available. The provision of this liquidity is the third investment option for the household. In particular, the household carries M_{t+1} units of liquid assets (the composite good which is assumed to be costlessly storable), which are held across periods but yield zero net return.

Besides, these investment decisions for the next period, in the beginning of the period t, household's investor also determines the liquidity needs of which projects– that started last period–will be financed. This decision is made after observing the current period aggregate shock (θ_t) and the individual realization of ρ_t^j, where index j is used for the projects that were started in period $t-1$ which contrasts with the use of subscript i for the projects being started in period t. As discussed earlier, this decision would take the form of a cut-off value of the liquidity shock, ρ_t^*, such that all firms that receive a liquidity shock smaller than

$$\rho_t^*(\theta_t) \leq \frac{p_H s_{t-1}^j \hat{R}_t^j(\theta_t)}{w_t} \tag{5'}$$

will be financed.[6] The total liquidity need for project j is $\rho_t^j w_t$ which amounts to a

[6]This fact was already referred to earlier (see, (5)), and as we shall see later, comes out clearly from household's optimization (on substituting (10) in (19e)).

liquidity need per outstanding outside share of

$$m_t^j\left(\rho_t^j\right) = \frac{\rho_t^j w_t}{s_{t-1}^j}. \tag{10}$$

When the household provides liquidity to project j in proportion to the number of shares it holds, it takes m_t^j–the per share liquidity requirement as parametrically given.[7]

The household's total income, Y_t^h, is[8]

$$Y_t^h = w_t n_t + \int_0^1 \Pi_t^j dj + \int_0^1 p_H \hat{R}_t^j(\theta_t) s_{t-1}^j I_{[\rho_t^j \leq \rho_t^*]} dj. \tag{11}$$

The consumption-based price index for the aggregate goods is

$$Q_t = \min_j q_t^j, \tag{12}$$

which in equilibrium will imply that

$$q_t^j = q_t = Q_t = 1, \tag{13}$$

for all varieties j that are produced in equilibrium as the composite good is the numeraire.[9]

Thus, the household's budget constraint is

$$C_t + \int_0^1 p_t^i s_t^i di + \int_0^1 m_t^j(\rho_t^j) s_{t-1}^j I_{[\rho_t^j \leq \rho_t^*]} dj + M_{t+1} + \frac{B_{t+1}}{R_t} \leq M_t + B_t + Y_t, \tag{14}$$

where right side has the total funds available to the household: the liquidity carried from the last period, the revenues from maturing bonds, and the income described in (11). The left hand side is the use of those funds: consumption, purchase of shares in

[7]Note that there is an s_{t-1}^j in the expression for m_t^j but the household ignores this dependence of m_t^j on s_{t-1}^j.

[8]Note that in writing investment return symmetry has been imposed across all projects that are ex ante identical. Also, we have each household taking up one project but receiving the average of proceeds from all projects.

[9]We can generalize this to the case with less than perfect substitution in consumption but in that case the firms with have pricing power which they do not have now.

new projects, meeting the liquidity needs of existing projects, making provision for the liquidity need for the next period, and investment in risk-less bonds. In addition to this overall funding constraint, the ability to meet the current liquidity needs is constrained by the liquidity carried over from the previous period

$$\int_0^1 m_t^j(\rho_t^j)s_{t-1}^j I_{[\rho_t^j \leq \rho_t^*]} dj \leq M_t. \tag{15}$$

The household starts at the beginning of period 0 with given values of (M_0, B_0, s_{-1}^j) and solves the following problem:

$$\max_{\{C_t, L_t, n_t, M_{t+1}, B_{t+1}, s_t^i, \rho_t^*\}} E_0 \sum\nolimits_{t=0}^{\infty} \beta^t U\left(C_t, L_t\right) \tag{16}$$

subject to

$$n_t + L_t \leq 1, \tag{17}$$

and $(14 - 15)$. For the economy as a whole $n_{1,-1}$ is also given.

If we reformulate it as a dynamic programming problem, the household-specific state variables are (M, B, s^j). In addition, there are aggregate state variables θ and n_1. Thus, the problem can be written as

$$V\left(M, B, s^j; \theta, n_{1,-1}\right) = \max_{C, L, n, M', B', s^i, \rho^*} \left\{U\left(C, L\right) + \beta E_{\theta'}\left[V\left(M', B', s^i; \theta', n_1\right)\right]\right\}, \tag{18}$$

which is again maximized subject to $(14 - 15)$ and (17).

3 Solving the Model

We begin by solving the household's problem followed by that of the entrepreneur. Of particular interest will be the binding nature of the incentive compatibility constraint imbedded in the entrepreneur's problem. When it binds due to a significant adverse shock, the liquidity needs for continuation of the project may not be funded. Such a condition will be shown in the next section to exacerbate economic downturns.

3.1 Solution to Household's Problem

The first-order conditions for the household's problem yield familiar Euler equation and the optimality condition for the consumption-leisure choice

$$w_t U_{C_t} = U_{L_t} \tag{19a}$$

$$U_{C_t} = \beta R_t E_{t,\theta} \left[U_{C_{t+1}} \right] \tag{19b}$$

In addition, optimization by households yields optimality conditions for the choice of liquidity (M_{t+1}), investment in projects (s_t^i), and the decision to finance the liquidity needs of previous-period projects (ρ_t^*) which are[10]

$$U_{C_t} = \beta E_{t,\theta} \left[U_{C_{t+1}} \frac{p_H \hat{R}_{t+1}(\theta_{t+1})}{m_{t+1}\left(\rho_{t+1}^*\right)} \right], \tag{19c}$$

$$U_{C_t} = \beta E_{t,\theta} \left[U_{C_{t+1}} \frac{p_H \hat{R}_{t+1}(\theta_{t+1}) F\left(\rho_{t+1}^*\right)}{p_t^i} \left\{ \frac{\hat{R}_{t+1}^i(\theta_{t+1})}{\hat{R}_{t+1}(\theta_{t+1})} - \frac{\bar{m}_{t+1}\left(\rho_{t+1}^*\right)}{m_{t+1}\left(\rho_{t+1}^*\right)} \right\} \right], \tag{19d}$$

$$U_{C_t} + \lambda_t = U_{C_t} \frac{p_H \hat{R}_t(\theta_t)}{m_t\left(\rho_t^*\right)}. \tag{19e}$$

where λ_t is the Lagrange multiplier on the liquidity constraint (15).

In each case, left hand side is the marginal (utility) cost of the choice and the right hand side the marginal benefit and in (19d)

$$\bar{m}_{t+1}\left(\rho_{t+1}^*\right) = \int_0^{\rho_{t+1}^*} m_{t+1}(\rho_{t+1}) \frac{f(\rho)}{F\left(\rho_{t+1}^*\right)} d\rho, \tag{20}$$

is the average liquidity need, conditional on the need being financed.

3.2 Solution to Entrepreneur's Problem

To begin, note that investor's participation constraint (8) will hold with equality so that

$$p_t^i = p_t^{-i}, \tag{8'}$$

[10] Note that in (19d) $\hat{R}_{t+1}$ without subscript refers to return from a generic project other than project i.

for otherwise, entrepreneur i will leave money on the table by selling share of her firms too cheap. Turning to (7), note that the incentive compatibility constraint has a version for each aggregate state. It is clear that if it binds for a realization of $\theta_{t+1} = \bar{\theta}$, then it will also bind for all $\theta_{t+1} < \bar{\theta}$. We assume that shirking is extremely costly (p_L is very low) so that it is never optimal for the investor to let the entrepreneur shirk. In particular, then the relevant incentive compatibility constraint is the one corresponding to a value, θ_{Lt}, which denotes the lowest possible draw for θ_{t+1}, to be specified in section 4.1, given current θ_t.

$$p_H \left(1 - s_t^i\right) \hat{R}_{t+1}^i \left(\theta_{Lt}\right) \geq p_L \left(1 - s_t^i\right) \hat{R}_{t+1}^i \left(\theta_{Lt}\right) + P s_t^i, \tag{7^L}$$

For the purpose of solving the entrepreneur's problem, let us write (6) as

$$\max_{s_t^i, n_{1t}^i} (1 - s_t^i) \left(n_{1,t}^i\right)^\alpha p_H E_{t,\theta} \left[\beta \frac{U_{C_{t+1}}}{U_{C_t}} \theta_{t+1} F\left(\rho_{t+1}^* \left(\theta_{t+1}\right)\right)\right], \tag{$6'$}$$

where note that p_t^i is missing from the list of choice variables. More importantly, notice that the entrepreneur's objective function has an expectational term $E_{t,\theta'}[.]$ which does not depend on his choice but only depends on the future state of the economy. We need to maximize ($6'$) with respect to s_t^i and $n_{1,t}^i$ subject to

$$s_t^i p_t^{-i} = w_t n_{1,t}^i, \tag{$3'$}$$

and $\left(7^L\right)$. There are two potential variations on solution to this problem depending on whether $\left(7^L\right)$ binds or not. First maximize ($6'$) assuming that the entrepreneur's incentive-compatibility constraint does not bind. In that case, the solution to ($6'$) yields

$$s_t^i = \frac{\alpha}{1+\alpha}, \tag{20}$$

and then ($3'$) gives the value of $n_{1,t}^i$. Note that, while the value of s_t^i is independent of t in this case, $n_{1,t}^i$ and the project's output are nonetheless dependent on t.

Having solved for $n_{1,t}^i$, now check if $\left(7^L\right)$ holds. For this to be the case, $n_{1,t}^i$ must be greater than the threshold value

$$\tilde{n}^i_{1,t} = \left(\frac{\alpha P}{\theta_{Lt}\left(p_H - p_L\right)}\right)^{\frac{1}{\alpha}}. \tag{21}$$

If $n^i_{1,t} < \tilde{n}^i_{1,t}$, the incentive-compatibility constraint binds and one needs to jointly solve $(3')$ and $\left(7^L\right)$ for $n^i_{1,t}$ and s^i_t (with latter holding with equality) and there is no further maximization involved; there is only one feasible choice.

It may be noted that having solved for the optimal values of s^i_t and n^i_t, $(19d)$ determines the equilibrium price of the shares of the projects, once equilibrium is imposed, to which we turn next.

3.3 Imposing the Equilibrium

In the equilibrium, only goods for which liquidity shock $\rho^i_t \leq \rho^*_t$ are produced. As all projects are *ex ante* identical and as all goods enter symmetrically in the utility function, for $\forall i$ such that $\rho^i_t \leq \rho^*_t$ we have

$$\begin{aligned} s^i_t &= s_t, \\ p^i_t &= p^{-i}_t = p_t, \\ y^i_t &= y_t = \theta_t \left(n_{1,t-1}\right)^{\alpha}, \\ q^i_t &= q_t = Q_t = 1 \\ \hat{R}^i_t &= \hat{R}_t = y_t \end{aligned}$$

The labor market must clear in equilibrium implying

$$n_{1,t} + \bar{n}_{2,t}\left(\rho^*_t\right) F\left(\rho^*_t\right) = n_t \tag{23}$$

where

$$\bar{n}_{2,t}\left(\rho^*_t\right) = \int_0^{\rho^*_t} \rho \frac{f\left(\rho\right)}{F\left(\rho^*_t\right)} d\rho, \tag{24}$$

is the average additional labor requirement, conditional on the liquidity need being financed. Furthermore, the household's time constraint must be satisfied

$$n_t + L_t = 1. \tag{25}$$

The clearing of the market for the aggregate good reqiures

$$C_t + M_{t+1} - M_t = y_t(\theta_t)\, p_H F(\rho_t^*) = \theta_t (n_{1,t-1})^\alpha p_H F(\rho_t^*) \tag{26}$$

The equilibrium demand for liquidity cannot exceed the supply so that

$$\int_0^{\rho_t^*} s_{t-1} m_t(\rho) f(\rho)\, d\rho \leq M_t \tag{27}$$

Finally, in equilibrium net supply of bonds is zero so

$$B_t = 0, \qquad \forall t. \tag{28}$$

The equations for $(19a - 19e)$, $(22c - 22e)$, (23), and $(25 - 28)$ contain the following endogenous variables: s_t, p_t, y_t, $n_{1,t}$, ρ_t^*, q_t, $\hat{R}_t$, w_t, L_t, n_t, C_t, M_{t+1}, R_t, $\lambda_{3,t}$, and B_{t+1}. So, we have 15 variables and 13 equations. Depending on which situation applies to the entrepreneur's optimization problem, either $(3')$ and (20) or $(3')$ and (7^L) will be added to the set of equations to have a complete system with 15 equations in 15 unknowns. In the case where, (20) is used, it must be checked that the computed solution for n_1 is greater than $\tilde{n}_{1,t}$ in (21).

4 Calibrating the Model

We begin with specifying the functional forms and distributional assumptions followed by the calibration of the model to the data.

4.1 Functional Forms etc.

We posit the utility function of the following form:

$$U(C, L) = \ln C + \eta \ln L. \tag{29}$$

In addition, we assume the aggregate productivity shock follows an autoregressive process

$$\ln \theta_t = \rho_\theta \ln \theta_{t-1} + \varepsilon_t, \tag{30}$$

with serial correlation ρ_θ where the innovation to aggregate productivity, ε_t, is assumed to be normally distributed with mean zero and a standard deviation of σ, but truncated at some lower bound, $\varepsilon_t \geq \varepsilon_L$. Hence, in the non-stochastic steady state $\theta_{ss} = 1$. The truncation of ε is necessary under a continuous distribution in order to prevent shirking in any aggregate state. The specification enables us to define

$$\theta_{Lt} = \theta_t^{\rho_\theta} \exp(\varepsilon_L),$$

the lowest draw possible for next period's productivity, θ_{t+1}, given current productivity. With serially correlated θ, θ_{Lt} becomes time dependent.

Also, the liquidity shock is assumed to be uniformly distributed over $[0, \bar{\rho}]$ so that

$$F(\rho) = \frac{\rho}{\bar{\rho}}, \qquad 0 \leq \rho \leq \bar{\rho}. \tag{31}$$

Given the distribution of the liquidity shock from (24) and (20) we have

$$\begin{aligned} \bar{n}_{2,ss}(\rho_{ss}^*) &= \frac{\rho_{ss}^*}{2}, \\ \bar{m}(\rho_{ss}^*) &= \frac{1}{2}\frac{w_{ss}\rho^*}{s_{ss}} = \frac{1}{2}m(\rho_{ss}^*). \end{aligned}$$

Using the functional form of the utility function, the optimality conditions $(19a - 19e)$

can be simplified as follows:

$$
\begin{aligned}
\frac{w_{ss}}{C_{ss}} &= \frac{\eta}{L_{ss}}, \\
1 &= \beta R_{ss}, \\
1 &= \beta \frac{p_H \hat{R}_{ss}}{m\left(\rho_{ss}^*\right)} = \beta \frac{s_{ss} p_H \hat{R}_{ss}}{\rho_{ss}^* w_{ss}}, \\
p_{ss} &= \beta p_H \hat{R}_{ss} F\left(\rho_{ss}^*\right)\left[1 - \frac{\bar{m}\left(\rho_{ss}^*\right)}{m\left(\rho_{ss}^*\right)}\right] = \frac{\beta}{2} p_H \hat{R}_{ss} F\left(\rho_{ss}^*\right), \\
\lambda_{3,ss} &= \frac{1}{C_{ss}}\left[\frac{p_H \hat{R}_{ss}}{m\left(\rho_{ss}^*\right)} - 1\right].
\end{aligned}
$$

4.2 Calibration

Using $(19c' - 19d')$ and (3), one can solve for

$$
n_{1,ss} = \frac{\left(\rho_{ss}^*\right)^2}{2\bar{\rho}} = \frac{n_{ss}}{2}, \tag{33}
$$

where last equality follows from (23) and $(24')$.

We calibrate the model so that in the non-stochastic steady state $n_{ss} = .36$, which is in line with results from survey data discussed in Juster and Stafford (1991). For annual calibration, we set β to the usual value of .96. The cost share of labor in production, α is set to 1/3, about half the value commonly used in the RBC literature. We note that on average, only half of total labor hours is devoted to new projects; the other half goes to finalize projects initiated in the previous period. Finally, the innovation in aggregate productivity σ is set at .02, and the lower bound for ε at $-.03$. The aggregate shock has serial correlation $\rho_\theta = .80$, a value widely assumed in annually calibrated RBC models, broadly equivalent to the quarterly value of 0.95 [see e.g Kydland and Prescott (1982)].

To ensure that it is never optimal to let the entrepreneur shirk, p_H is given a highish value of .9 and p_L is set to a low value of .4. The liquidity shock distribution parameter $\bar{\rho}$ is set to .5 so that second-period liquidity needs of approximately 85 per

Preference Parameters
$\beta = 0.96,\ \ \eta = 0.4267$
Production Parameters
$\alpha = 1/3$
$\rho_\theta = 0.8,\ \ \sigma = 0.02,\ \ \varepsilon_L = -0.03$
$p_H = 0.9,\ \ p_L = 0.4$
$\bar{\rho} = 0.50$
Calibrated Steady State
$n = 0.36,\ \ n_1 = 0.18,\ \ n_1/n = 0.50$
$\rho^* = 0.4243,\ \ \rho^*/\bar{\rho} = 0.8485$
$C = 0.4312,\ \ M = 0.0517,\ \ M/C = 0.1200$
$y = 0.5646;\ \ Y = 0.4312$
$p = 0.2070,\ \ s = 0.2500$
$w = 0.2875,\ \ R = 1.0417$

Table 1: Parameter values and steady state for the calibrated model with IC not binding.

cent projects are financed.

With nonbinding IC, we have $s_{ss} = \alpha/\left(1+\alpha\right) = .25$. The calibrated steady state is shown in Table 1. The steady state is independent of the value of P as long as P is less than the threshold value $P_* = .8469$ that solves (21) for $\tilde{n}_1 = n_{1,ss}$.

5 Results

The results from simulating three model versions are summarized in Table 2. The first specification is based on a lognormally, iid θ, the aggregate productivity shock. The other two assume an autoregressive θ, one with the incentive compatibility (IC) constraint never binding, the other with an occasionally binding IC constraint. The difference between the two lies in the values attached to P, in (7), the parameter capturing the gain from shirking. In the former case, P is set low enough for (7^L) never to bind; in the latter, it is set somewhat below its steady state 'threshold' value of 0.847, resulting in a tendency for the IC to bind during periods of low aggregate productivity.[11] The reported standard deviations are all in percentage terms.[12]

5.1 IID Shocks

The statistics in the first two columns in Table 2 refer to the most basic model version, a model with an iid productivity shock and a non-binding IC constraint. In order to obtain a comparable volatility of θ across all model versions, σ and ε_L are adjusted accordingly in the basic version, to 0.033 and -0.1 respectively. Several observations are noteworthy here. First, consumption exhibits just about as much volatility as output, the two being near perfectly correlated. Hence, very limited consumption smoothing takes place in the model. The reason is the absense of any asset (such as capital) that would serve to smooth out consumption across time in a significant manner. The stock of liquidity, M, only amounts to around 12% of C in the nonstochastic steady state, limiting its stabilizing role. Second, total employment, n, as well as employment engaged in new projects, n_1, are both smoother than output, which is in line with US data. However, while the latter is procyclical, the former is notably countercyclical, clearly at variance with data. With the limited smoothing possibility in consumption, the households will require a large enough increase in the real wage in order to encourage work effort, in face of a positive productivity shock. In this model specification, the increase in w simply falls short of providing a strong enough substitution effect. Third, the current cut-off value of the liquidity shock, ρ^*, is negatively correlated with current output, whereas next period's ρ^* shows a positive correlation. The negative contemporaneous correlation owes to the fact that a positive productivity shock raises the real wage, the unit cost of ongoing projects. With a given amount of liquidity, M, on hand, less funds are available for any single project. Fourth, we see a near perfectly negative correlation between the risk free gross real interest rate, R, and a positive correlation between share prices, p, and

[11] We assume that P is constant across all aggregate states of the economy.

[12] The model was solved by parameterizing the expectations in the Euler equations (19b) - (19d), a method proposed by Marcet (1988), and extended to include occasionally binding constraints by Christiano and Fisher (1994).

output. The former follows from the very limited smoothing opportunities in the model: about the only channel for households to absorb a higher output level is to increase consumption, which demands a falling interest rate.

5.2 Serially Correlated Shocks

The next pair of statistics in Table 2 is based on a serially correlated productivity shock, setting the autocorrelation coefficient at 0.8. The entrepreneurs never experience a binding IC constraint at any time. Time series plots for the endogenous prices and quantities are also shown in Figure 1. The innovation to the productivity shock is adjusted accordingly, keeping the standard deviation of θ intact across these two model versions. Autocorrelated aggregate productivity generally increases the volatility in the economy. Output, consumption, the real wage, and share prices all show increased volatility. Two factors seem to be at work here. First, the negative correlation between ρ^* and current output has loosened somewhat, with the coefficient reduced from -0.69 to -0.29. From the goods market equilibrium in (26), this should increase output for any given θ. Second, employment in projects initiated in last period, $n_{1,t-1}$ is now more closely correlated with current output, where the coefficient has risen from 0.15 to 0.23. In anticipation of θ remaining high after a positive productivity shock, the households now respond by setting aside more liquidity in order to meet increased demand for second period financing of projects beginning in the current period. The cut-off value, ρ^*, is still negatively correlated with current output, but only weakly so. The reason is that a high current productivity is now likely to go together with relatively high level of beginning of period liquidity, neutralizing to some extent the countercyclicality of ρ^*. Again, consumption smoothing is minimal, and for the same reason: the lack of any asset that could serve as a means to absorb idiosyncratic or aggregate shocks. This also explains the prevalent, albeit reduced, countercyclicality in total employment, n. Increased volatility in the real wage has a mitigating effect, although not big enough to turn n procyclical. Perhaps counterintuitively, the correlation between ρ^*_{t+1} and current output is reduced, from

0.55 to 0.19. With autoregressive θ, increased current productivity should, other things equal, raise the expected next-period cut-off point. This is however, complicated by the increasingly volatile and highly procyclical real wage, w. From (10) it is clear that a higher w_{t+1} takes ρ^*_{t+1} in the other direction.

Finally, the results from forcing the IC to bind occasionally for the entrepreneurs are reported in the last two columns of Table 2, together with time series plots in Figure 2. The productivity shock remains autoregressive. Overall, the occasionally binding IC further increases the volatility in output, consumption, real wages, real liquidity, and share prices. Notable is the vast increase in the standard deviation of n_1, from 0.27 to 0.68 percent. Further, the number of issued shares, s, is no longer constant, now being determined either by (20) (if the IC is slack), or by (7^L) (if it is binding.) In cases where the IC binds during periods of adverse productivity shocks, the economy is further dragged down from what would otherwise be the case, as can be seen from the impulse response functions in Figure 3. Notice how an adverse current productivity shock affects to lower the amount of M, the liquidity set aside for future second period financing of projects. This is also reflected in the negative response of the expected cut-off value of ρ^*_{t+1}. As in the other specifications, very limited consumption smoothing is at work. However, the real wage is now sufficiently volatile to make total employment, n, procyclical, changing the correlation coefficient from -0.33 to 0.32, bringing it a good deal closer to US data. In other words, the real wage volatility is now strong enough to generate a dominating substitution effect in the labor-leisure margin, (19a).

6 Conclusions

This paper examines the importance that occasionally binding incentive compatibility constraints in financial contracts have in affecting macroeconomic performance over the business cycle. The principal result is that sufficiently strong adverse aggregate (productivity) shocks cause these constraints to bind, in which case considerable volatility is added to the economy and the dynamic behavior of the economy changes. Of particular significance is the amplification of economic downturns as a result of a drying up of liquidity. Not only does the adverse aggregate shock reduce funding of new investment projects as new equity issues decline when the incentive constraint binds and credit is rationed, but also the shock reduces the willingness of shareholders in these firms to provide any additional future funding that may be needed for completion of ongoing projects, many of which would otherwise have received funding. Those projects are terminated due to lack of liquidity in the economy, further reducing employment and output from what otherwise would have been the case for the same aggregate shock had the incentive constraints not been binding and credit not been rationed.

This model is highly stylized in order to focus cleanly on a key feature of major economic downturns: the significant contraction in aggregate liquidity. For example, bank lending standards tighten and commercial paper issuance can all but dry up during recessions. For us, it is important to distinguish between savings channeled into new investments versus liquid low-yielding (in our model, non-interest bearing) funds. The former is used to exploit new investment opportunities, while the latter is used to continue ongoing investments, which would otherwise be terminated. An aggregate shortage of liquid funds so-defined is what we take to be the basis of liquidity crises, and normally occurs only during severe economic downturns. This phenomenon is what our model is intended to capture.

There are a number of extensions of this basic model that we believe would be useful. We list three: the introduction of financial intermediaries explicitly to examine such issues as the role of bank capital in cushioning liquidity crises; endogeneity of the "private benefit" on which the key incentive constraints in the contract is built and how protective covenants may affect the frequency with which the incentive constraint binds; and the role of the government provision of liquidity, and when, how much, in what market should their intervention take place to mitigate the macroeconomic consequences of a severe economic downturn.

Table 2

Summary of Second Moments

	IID θ		Autoregressive θ			
	.		**Nonbinding IC**		**Occasionally Binding IC**	
Variable	stdev	corr w/y	stdev	corr w/y	stdev	corr w/y
y	2.41	1.00	3.09	1.00	3.25	1.00
c	2.26	0.99	3.05	0.99	3.20	0.99
θ	3.20	0.97	3.28	0.98	3.22	0.98
ρ^*	1.03	-0.69	0.55	-0.29	0.64	-0.03
ρ^*_{+1}	1.03	0.55	0.55	0.19	0.64	0.42
n_1	0.40	0.45	0.27	0.15	0.68	0.52
$n_{1,-1}$	0.40	0.15	0.27	0.23	0.68	0.54
n	0.84	-0.74	0.41	-0.33	0.49	0.32
w	1.94	0.96	2.99	0.99	3.32	0.99
m	2.05	0.99	3.02	0.99	3.67	0.99
s	0.00	-	0.00	-	0.71	0.69
R	1.57	-0.97	0.50	-0.57	0.65	-0.42
p	2.05	0.99	3.02	0.99	3.16	0.99

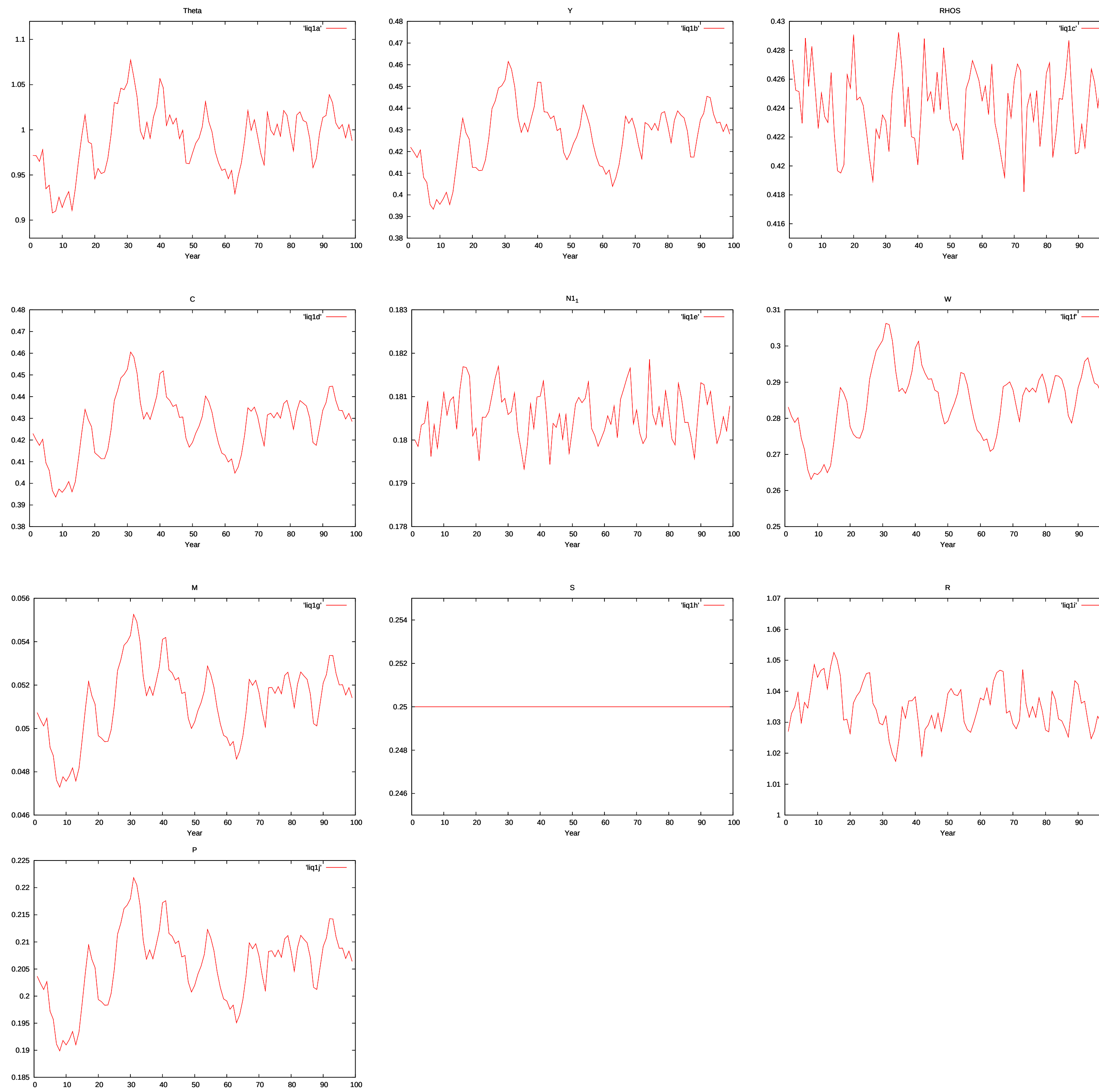

Figure 1: Autoregressive θ, nonbinding IC.

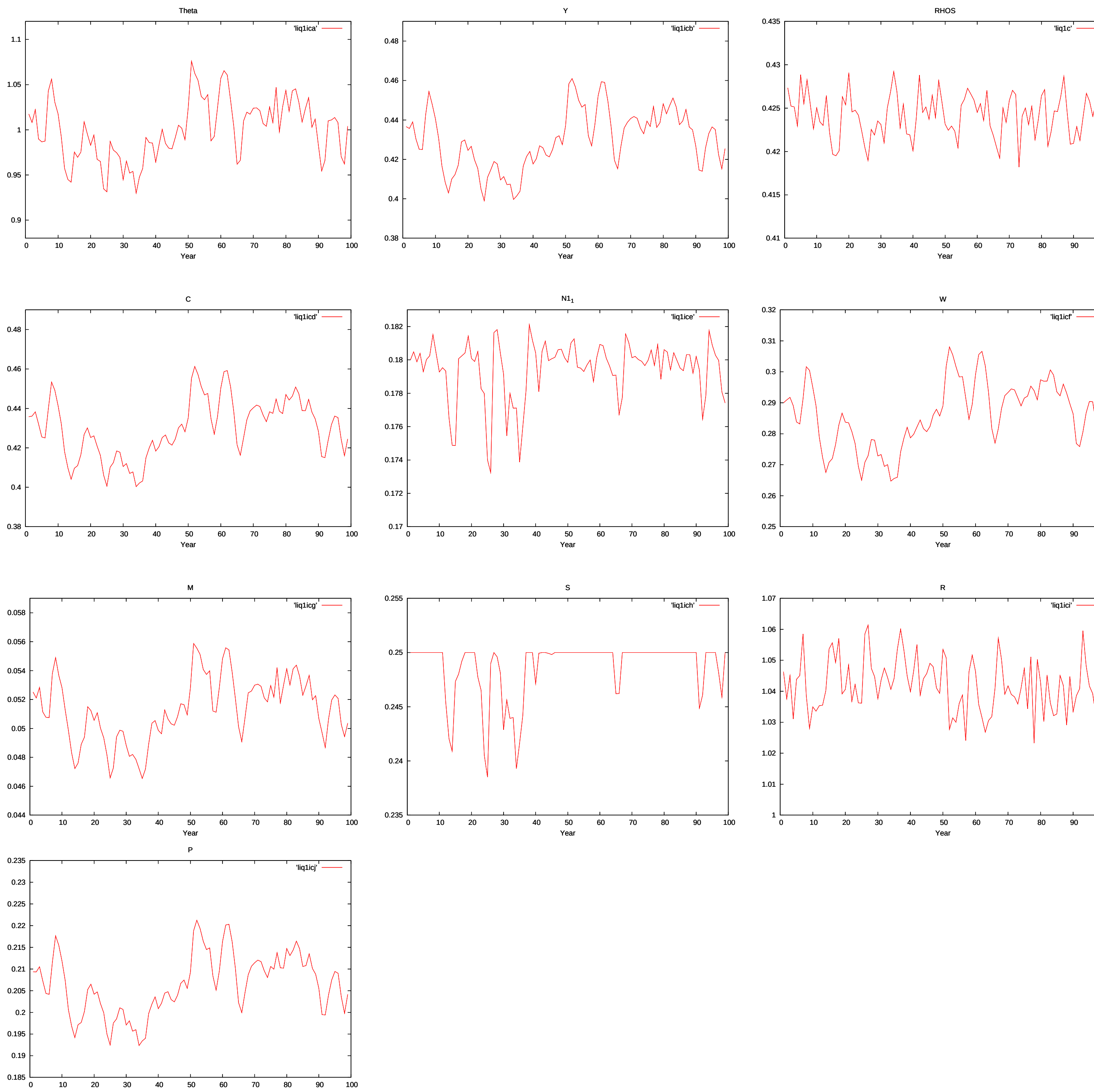

Figure 2: Autoregressive θ, occasionally binding IC.

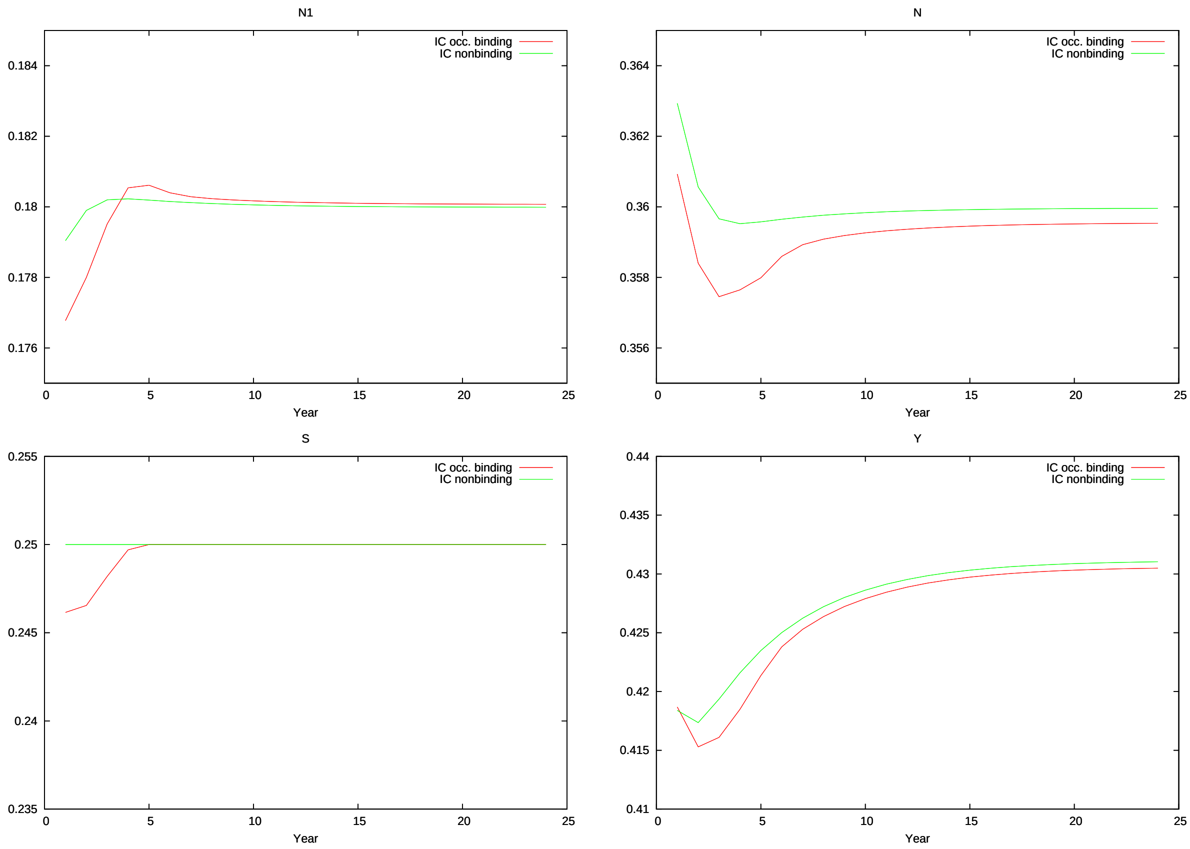

Figure 3: Impulse response functions. An ε_L shock in period 1 given $\theta_1 = 0.98$.

References

Bernanke, Ben and Mark Gertler. 1989. "Agency Costs, Net Worth, and Business Fluctuations," American Economic Review 79:14-31.

Christiano, Lawrence J and Jonas Fisher. 1994. "Algorithms for Solving Dynamic Models with Occasionally Binding Constraints," Federal Reserve Bank of Chicago Working Paper Series (Macroeconommic Issues), WP-94-6.

Diamond, Douglas. 1984. "Financial Intermediation and Delegated Monitoring," Journal of Economic Studies 51:393-414.

Diamond, Douglas and Philip Dybvig. 1983. "Bank Runs, Deposit Insurance, and Liquidity," Journal of Political Economy 91:401-419.

Diamond, Douglas and Raghuram Rajan. 2001. "Liquidity Risk, Liquidity Creation, and Financial Fragility: A Theory of Banking," Journal of Political Economy April.

Holmstrom, Bengt and Jean Tirole. 1997. "Financial Intermediation, Loanable Funds, and the Real Sector," Quarterly Journal of Economcis 112:662-692.

Holmstrom, Bengt and Jean Tirole. 1998. "Private and Public Supply of Liquidity," Journal of Political Economy 106:1-40.

Holmstrom, Bengt and Jean Tirole. 2001. "LAPM: A Liquidity-Based Asset Pricing Model," Journal of Finance 56:1837-1867.

Juster, F. Thomas and Frank P. Stafford. 1991. "The Allocatio of Time: Empirical Findings, Behavioral Models, and Problems of Measurement," Journal of Economic Literaure, 29 (June): 471-522.

Kiyotaki, Nobuhiro and John Moore. 2005. "Liquidity and Asset Pricing," International Economic Review 46:317-349.

Kiyotaki, Nobuhiro and John Moore. 2008. "Liquidity, Business Cycles, and Monetary Policy," Working Paper. Princeton University.

Kydland Finn E. and Edward C. Prescott. 1982. Time to Build and Aggregate Fluctuations," Econometrica 50(4) (November): 1345-1370.

Marcet, Albert. 1988. "Solving Non-linear Models by Parameterized Expectations," Manuscript. Carnegie-Mellon University, Graduate School of Industrial Administration.

Tirole, Jean. 2006. The Theory of Corporate Finance, Princeton University Press: Princeton and Oxford.

Van Nieuwerburgh, Stijn and Laura Veldkamp. 2006. "Learning Asymmetries in Real Business Cycles," American Economic Review 53(4): 753-772.

Williamson, Stephen D. 1986. "Costly Monitoring, Financial Intermediation, and Equilibrium Credit Rationing," Journal of Monetary Economics 18:159-179.

Williamson, Stephen D. 1987. "Financial Intermediation, Business Failures, and Real Business Cycles," Journal of Political Economy 95:1196-1216.

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