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FINANCIAL INTERMEDIATION AND AGGREGATE FLUCTUATIONS: A QUANTITATIVE ANALYSIS

Russell Cooper
João Ejarque

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ABSTRACT

This paper investigates the quantitative implications of two business cycle models in which aggregate fluctuations arise in response to variations in the process of financial intermediation. In the first, fundamental shocks in the capital accumulation process lead to fluctuations in the real returns from intermediated investment. For this economy, we find that the correlations produced are not consistent with observations of the U.S. economy. In particular, consumption is not smoother than output, investment is negatively correlated with output, variations in the capital stock are quite large and interest rates are procyclical. In an economy with both intermediation and total factor productivity shocks, the correlations we produce are closer to those observed in the U.S. economy only when the intermediation shock is relatively unimportant.

In the second economy, variations in the returns to intermediation are part of a sunspot equilibrium. Fluctuations here are driven by self-fulfilling beliefs by private agents regarding the returns to intermediation as in an economy beset by banking crises. For this non-linear economy, we find that the correlations are closer to those observed but the variability of capital relative to output is still too large.

Russell Cooper
Department of Economics
Boston University
270 Bay State Road
Boston, MA 02215
and NBER

João Ejarque
Department of Economics
Boston University
270 Bay State Road
Boston, MA 02215

Financial Intermediation and Aggregate Fluctuations: A Quantitative Analysis

I. Introduction

The goal of this paper is to understand the quantitative implications of models in which shocks to the financial intermediation process generate aggregate fluctuations. Our interest in this exercise stems from recent theoretical advances concerning the role of financial intermediation as both a source of aggregate fluctuations and a vehicle for their propagation and magnification.

In an important contribution to this literature, Bernanke [1983] studies the interwar years and finds that the post-1930 financial crisis is key to understanding the depth and length of the U.S. Great Depression. He argues that bankruptcies and bank runs disrupted the links between savings and investment and that this increased cost of intermediation propagated the initial downturn in real economic activity. In a related vein, Hamilton [1987] argues that contractionary monetary policy in the late 1920's led to unanticipated deflation which, operating through balance sheet effects, disrupted the process of financial intermediation after 1930. Again the emphasis of the analysis is on the increased costs of intermediation as a basis for the prolonged depression in economic activity.

Building upon these observations, theoretical models have been constructed to study the interaction between financial intermediation and real economic activity operating through the structure of lending arrangements.[1] Empirical work on the importance of balance sheet effects has complemented these theoretical developments. Our purpose here is to understand the implications of these models for key aggregate correlations.

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[1] See Gertler [1988] for a survey of this work and Bernanke, Gertler and Gilchrist [1993] for a recent synthesis of theoretical and empirical developments.

To do so, we consider two models which have a common ingredient: fluctuations are associated with variations in the costs of intermediation. In the first, fluctuations in the economy are a consequence of shocks to the process of intermediation. To construct such a model, we build upon the framework of King, Plosser and Rebelo [1988] and introduce disturbances into the intertemporal production process that creates capital from investment. We interpret these as intermediation shocks reflecting variations in the processes of matching savings and investment, project evaluation and project monitoring.[2] While this structure does not have the richness of the contracting models that have been constructed to analyze incentive problems and balance sheet effects, this is a useful first step in determining whether the broad class of models encompassed in this framework have quantitative implications that broadly match observations of the aggregate economy. In particular, the specification is consistent with the arguments of Bernanke [1983] that variations in the real costs of intermediation lie at the heart of financial crises underlying the propagation of the Great Depression.

On this score, we find that the model with intermediation shocks fails to match a number of key macroeconomic observations. First, these shocks produce a negative correlation between consumption and investment. In times of productive intermediation, consumption is reduced and investment increased in an effort to build up the capital stock. In many ways, shocks to the intermediation process operate as taste shocks, as in the work of

[2] Greenwood, Hercowitz and Huffman [1988] model the effects of investment specific shocks in a dynamic stochastic framework. Though the economic interpretations differ, the models are similar in many respects. As we proceed through the presentation of our first economy, the relationship between the models will be made clear. Greenwood, Hercowitz and Krusell [1994] analyze a related model in which there are equipment investment specific technology shocks. Diaz-Giménez et al. [1992] analyze a dynamic general equilibrium model with banking and provide some basic facts about the role of intermediation in the U.S. economy. They do not stress the importance of uncertainty arising from the intermediation process nor the implications of the model for business cycles.

Baxter and King [1991], in that they lead to negative comovements in consumption and investment. Second, the volatility of the capital stock relative to output is unreasonably large. Finally, the real interest rate is procyclical, contrary to the evidence provided by Beaudry and Guay [1992]. Thus the view that intermediation shocks are the only source of fluctuations seems inconsistent with the broad characteristics of aggregate fluctuations. Economies in which there are multiple sources of fluctuations, including intermediation shocks, match observations better if the intermediation shocks are of secondard importance.

A second model, built upon the theoretical models of Bryant [1987] and Weil [1989], also stresses financial fragility as a source of fluctuations. In contrast to the first class of economies, there are no fundamental shocks to the process of intermediation. Instead, fluctuations emerge from extrinsic uncertainty regarding the returns to saving and investment. To model this, we examine an infinite horizon economy with capital accumulation and use the arguments of Bryant and Weil to construct sunspot equilibria in the neighborhood of the multiple steady state equilibria.[3] The multiplicity, in turn, reflects a strategic complementarity in the intermediation process. The model is intended to capture the banking instability that was prevalent during the Depression period.[4] Our model allows us to evaluate models of financial instability due to variations in investor confidence by focusing on the processes of capital accumulation, output, investment, consumption and employment.

The economy exhibits fluctuations induced by sunspots that mimic certain features of

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[3] Thus our sunspot equilibria are similar to those constructed by Chatterjee, Cooper and Ravikumar [1993] for a dynamic model with entry and exit. In contrast, Farmer and Guo [1993] evaluate the behavior of an economy in which sunspot equilibria emerge due to local stability of a steady state.

[4] The model displays regime shifts that may also be consistent with post WWII evidence on regime shifts reported by Hamilton [1989] for output and by Garcia and Perron [1993] for real interest rates .

U.S. data. In particular, output, employment, consumption and investment are all positively correlated. In addition, these fluctuations are persistent. Further, the net return on savings, which would correspond to the deposit rate in a decentralized setting, is counter-cyclical. This is an important feature of the model. Though times in which savings is put into intermediaries yields high marginal returns, the average returns (which the deposit rates reflect) are less responsive due to the nonlinear return stream. Consequently, for some parameterizations the model produces the pattern of counter-cyclical real interest rates observed during the Great Depression.[5] A second aspect of the behavior of interest rates during this period is the dramatically increased gap that arose between the yield on corporate debt and government debt, reflecting perhaps a desire for liquidity and safety by investors.[6] We illustrate how our model accounts for this gap.

These results do appear though to require relatively large fluctuations in the stock of capital. In particular, the variance of the capital stock is often four times more than that of real output. Given this, the pattern of correlations produced by the model mimics the correlation pattern found along the transition path of the neoclassical growth model. Intuitively this makes sense since a relatively permanent shock to the intermediation process leads to the accumulation (deaccumulation) of capital as the economy heads back to the steady state associated with the current intermediation shock.[7]

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[5] Friedman and Schwartz [1963, pg. 304] indicates that between 1929 and 1933, the yield on corporate bonds increased, the yield on government bonds stayed constant while the commercial paper rate fell. Once these nominal yields are deflated by the actual rate of inflation, the real returns all rise through this period. Hamilton [1987, Table 2] computes the ex post real interest rate using short term government bonds and finds that the rates were 7.4% , 11.3%, 11.3% and 5.8 % for the 1929-32 period. The ex post real rates were negative from 1933-36.

[6] See Bernanke [1983] and Friedman and Schwartz [1963] for a discussion of this gap.

[7] Since the economy has multiple steady states, a persistent extrinsic shock will lead to the convergence of the economy to the steady state associated with that shock until the sunspot variable changes again. These dynamics are displayed in some detail below.

II. Stochastic Capital Accumulation

(i) Basic Model

In this section of the paper we evaluate a model in which the accumulation of capital is stochastic. While the model does not include any particular formalization of the intermediation process, it encompasses a variety of such models.

In the incentive based theories of intermediation, studied by Bernanke and Gertler [1989] among others, variations in the wealth of borrowers influences the costs of borrowing and lending. These costs of intermediation reflect the need to monitor the activity of borrowers. Bernanke and Gertler [1989] specify a capital accumulation process of

$$k_{t+1} = (\kappa - h_t \gamma) i_t \tag{1}$$

so that the capital stock in period t+1 depends on period t investment (i_t) times the return per unit investment. This return includes a constant κ less the costs of monitoring in period t, $h_t\gamma$. Thus in their model, variations in costs of capital accumulation reflect fluctuations in the frequency of monitoring a representative project captured by h_t. Much of their analysis is then concerned with the determination of this probability. Our formulation studies the same accumulation process but views the returns to intermediation as an exogenous stochastic process. Bernanke [1983] provides further discussion of this point that variations in the real costs of intermediation underlie aggregate fluctuations.

Alternatively, the model represents shocks to the process of intermediation. Further, variations in financial regulations, such as the enforcement of capital requirements or reserve requirements, will directly influence the real costs of intermediation independently of any incentive problems underlying the structure of intermediaries. A convenient representation of this is to assume that the cost, in terms of current consumption foregone, of obtaining a given amount of capital in the future is stochastic.

To be more precise, consider an economy in which a representative agent lives forever.[8] Utility over consumption (c_t) and leisure (l_t) in period t is given by $U(c_t,l_t)$, which is assumed to be strictly increasing and quasi-concave. Assume that intertemporal preferences are given by $\Sigma_{t=1}^{\infty} \beta^t\, U(c_t,l_t)$, where $\beta \in (0,1)$ is the discount rate.

The individual faces three constraints. The first is a time constraint that labor input (n_t) plus leisure time cannot exceed the time endowment: $n_t + l_t \leq 1$. The second constraint requires that total output plus the undepreciated capital is either consumed or invested, i.e.

$$c_t + I_t = A_t F(K_t, n_t) + (1-\delta)K_t \tag{2}$$

where $\delta \in (0,1)$ is the rate of capital depreciation, c_t is the period t level of consumption and I_t is the period t level of investment. In this constraint, the production function determines total output (y_t) from the inputs of labor, capital (K_t) and a stochastic production parameter that is common to all agents, A_t. We assume that F(K,n) is strictly increasing in both of its arguments and is strictly concave. The third constraint is that the capital stock evolves according to

$$K_{t+1} = I_t \theta_t \tag{3}$$

In this accumulation equation, θ_t is the shock to the intermediation process that is the focus of this exercise. Note that the specification of the accumulation process reflects a putty-putty

[8] We adopt the representative agent formulation as a convenience. Introducing heterogeneity into a model in which borrowing constraints limit borrowing and lending is an obviously important extension of the model. Fisher [1994] analyzes the effects of monetary shocks in an economy with credit market imperfections regarding firms producing intermediate goods. That model introduces heterogeneity across borrowers and explicitly models the actions of depositors and borrowers.

view of capital. In each period, undepreciated capital and the current flow of output are identical so that the capital stock for the following period must come from investment today and hence is subject to intermediation shocks. Further, the timing is such that the shocks to intermediation are <u>known</u> at the time of investment. Alternative specifications might imply that only current investment flows are influenced by the state of the intermediation process and/or would require the agent to make choices prior to knowing the returns on investment.[9]

Substitution of the constraints leads the representative household to choose $\{c_t,n_t,K_t,I_t\}_{t=0}^{\infty}$ to maximize $\Sigma_t\, \beta^t u(c_t,n_t)$ subject to (2) and (3). The first-order conditions from this problem, given a sequence of shocks $\{A_t,\ \theta_t\}$ are given by:

$$\frac{u_l(c_t,1-n_t)}{u_c(c_t,1-n_t)} = A_t F_n(K_t,n_t) \tag{4}$$

$$u_c(c_t,1-n_t) = \beta u_c(c_{t+1},1-n_{t+1})[A_{t+1}F_K(K_{t+1},n_{t+1})+(1-\delta)]\theta_t \tag{5}$$

$$c_t + K_{t+1}/\theta_t - (1-\delta)K_t = A_t F(K_t,n_t) \tag{6}$$

Our analysis of this system follows King, Plosser and Rebelo [1988]. This involves the log linearization of these conditions around the steady state using a certainty equivalence approach so that future (random) variables are replaced by their conditional expectation. The functional forms used in this approximation, again following King, Plosser and Rebelo, ensure that the low frequency observations of the economy are consistent with observations on per capita hours and real interest rates. We assume that $U(c,l)=\log(c) + \upsilon\log(l)$ and

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[9] Thus a useful extension of the model is to assume that only current additions to the capital stock are put through the intermediation process so that $K_{t+1} = K_t(1-\delta) + I_t\theta_t$. We comment on this extension further below. This is the approach taken by Greenwood, Hercowitz and Huffman [1988]. Marcet and Marimon [1992] adopt a similar specification in their study of growth and financial arrangements though they assume that the shock is not known at the time of the investment decision.

that the production function is Cobb-Douglas with constant returns to scale: $y_t = A_t K_t^{\alpha} n_t^{1-\alpha}$.[10]

(ii) Calibration

The parameterization of the economy is quite standard and again follows King, Plosser and Rebelo [1988] to facilitate a comparison of results. Labor's share in national income is used to calibrate the production function: i.e. $1-\alpha=.65$.[11] The parameter υ in the utility function is set so that the average amount of time allocated to work is .2. As in King, Plosser and Rebelo, the annual rate of depreciation is set at 10% and discount rate is set so that the steady state real rate of return is 6.5%.

There are two parameters that we add to this model: the standard deviation and serial correlation of the intermediation shock. At this point, the standard deviation of the intermediation shock is set at the same level as the total factor productivity shock in King, Plosser and Rebelo.[12] Since our interest is in understanding the pattern of correlations produced by this type of disturbance, the magnitude of its standard deviation is not critical. The serial correlation of the intermediation shock is used as a treatment variable.

(iii) Results

In evaluating this economy, our goal is to obtain a better understanding of the workings of the theoretical model. We summarize the behavior of the economy through a variety of moments and impulse response functions. In addition, we compare the model

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[10] In contrast, Greenwood, Hercowitz and Huffman [1988] assumed that $U(c,n)=u(c-G(n))$ where $u(\cdot)$ is strictly increasing and strictly concave and $G(\cdot)$ is strictly increasing and strictly convex. This specification implies that the marginal rate of substitution between consumption and hours is independent of consumption which has strong implications for the behavior of hours. Further, their production function allows for variation in the utilization of capital, a point we discuss further after presenting our results.

[11] Here, in fact, we follow most of the real business cycle literature and set labor's share at .65 instead of the smaller share assumed by King, Plosser and Rebelo.

[12] The assumed standard deviation is .0075.

economy against important features of U.S. data, such as the cross-correlations of consumption, investment, employment and output and the standard deviation of the capital stock relative to output. We take the statistics for U.S. data reported in King, Plosser and Rebelo [1988] as our benchmark. Note though, as in Greenwood, Hercowitz and Huffman [1988], that the capital stock series derived for the U.S. is not consistent with a model emphasizing shocks to the accumulation process.[13]

The quantitative aspects of this economy are summarized in Tables 1-2 and Figure 1. The rows of Tables 1 and 2 correspond to two treatments. The first is the traditional real business cycle model in which fluctuations are due to total factor productivity (TFP) shocks. The second row corresponds to the case of iid intermediation (INT) shocks. For Table 1 the shocks are assumed to be serially uncorrelated while for Table 2 the shocks were assumed to have serial correlation of .9 The columns of this table represent various statistics for key macroeconomic variables computed for our model economy.

As is well understood, the real business cycle model with iid shocks (see the first row of Table 1) corresponds in some but not all ways to observations of U.S. data. In particular, consumption smoothing is quite apparent as is the fact that investment is more volatile than output. Further, employment, consumption, investment and productivity are all positively correlated with output. Note though, from the first row of Table 1, that the standard model has little endogenous propagation of shocks since the serial correlation in output is quite small.

The treatment with intermediation shocks, reported in the second row of Table 1, is

[13] We deal with this measurement issue in our second economy by creating a capital stock series as measured in current U.S. data from our simulations.

quite different and in many cases inconsistent with observation. Here we see that there is substantial serial correlation in output of .75 even though the intermediation shocks are serially uncorrelated. The endogenous propagation is a consequence of substantial movements in the capital stock. For this treatment, the standard deviation in the capital stock is about five times that of output. In contrast, for the case of serially uncorrelated technology shocks, the capital stock is about one third as volatile as output. For the post-War U.S. economy, the capital stock, as currently measured, has a standard deviation about ½ of that for output.

The intermediation shock treatment also produces some counterfactual implications for the behavior of consumption and investment. In particular, while consumption is positively correlated with output, investment and employment are negatively correlated with output. In fact, the correlation between consumption and investment for this treatment is -.89. Further, there is no evidence of consumption smoothing here in that both consumption and investment are more volatile than output. Finally, the real interest rate (i.e. the real return on equity) in this economy is highly procyclical in contrast to observation.[14]

To better understand the behavior of this economy, Figure 1 presents the impulse response to a temporary intermediation shock that increases the return on investment by 1 percentage point. Here we see that the increased return to intermediation creates a burst of investment at impact. This investment is "financed" in two ways. First, there is an increase in overall economic activity as output goes above its steady state. Second, consumption falls

[14] See Beaudry and Guay [1992] for a discussion of the cyclical properties of interest rates relative to the implications of real business cycle models. They find that post war U.S. data imply a slightly negative correlation between output and the ex post real rate of interest on 3-month Treasury Bills.

below its steady state level. In subsequent periods, the neoclassical adjustment process takes over starting from a value of the capital stock that is now above its steady state. Along this path, which is detailed in King, Plosser and Rebelo [1988], investment is below steady state since the capital stock is falling over time. Output and consumption though are above steady state since the stock of capital provides an opportunity to produce more output. Finally, employment is less than its steady state level reflecting both wealth effects and the relatively low real interest rates (due to the large accumulation of capital) along the transition path.

The correlations reported in Table 1 for the intermediation shock treatment reflect both the response of the economy to an intermediation shock and the comovements produced by the transitional dynamics. In particular, the negative correlation between investment and output, as well as that reported between employment and output, reflect the transition path.

Table 2 considers the case in which the technology and intermediation shocks are serially correlated. For the standard real business cycle (TFP shock treatment), we see many basic features of the business cycle emerge. In contrast with Table 1, the model also exhibits substantial serial correlation in output due to the correlated technology stocks.

From the second row of Table 2, in response the serially correlated intermediation shocks, consumption smoothing is still not evident in that consumption is more volatile than output. Further, investment is slightly negatively correlated with output and remains negatively correlated with consumption.[15] Finally, as in the case of uncorrelated shocks, employment remains negatively correlated with output.

[15] One might think that this is a consequence of the amount of serial correlation in the intermediation shock since a permanent shock will lead to a higher level of both consumption and the capital stock. The negative correlation of investment and consumption is present even if the serial correlation of the intermediation shock is .98.

(iv) Additional treatments

Thus far, our results indicate that intermediation shocks alone produce a negative correlation between consumption and investment and create excessive volatility of the capital stock relative to output. While we have not undertaken a complete comparison of the model with U.S. data, these two features of the model are clearly at odds with observed time series. Given that, we consider variations on the model to deal with these "problems". These variations are of interest as well as they illuminate some additional properties of an economy with intermediation shocks.

As discussed by Greenwood, Hercowitz and Huffman [1988], this first property is an almost immediate implication of the model as long as consumption and leisure are normal goods: shocks to the returns to one activity (investment) create an incentive to substitute away from another (consumption). Their solution to this problem was to allow for variations in the utilization rate of the capital stock so that output could respond to increased returns to investment and consumption would then increase as well. As discussed below, ours is to allow for a form of social returns to scale, advocated by Bryant [1983] and brought into quantitative macroeconomics by Baxter and King [1991].

As for the excessive volatility of the capital stock relative to output, consider the production function (the variables are all in logs):

$$y_t = a_t + \alpha k_t + (1-\alpha)n_t.$$

In the absence of variations in total factor productivity and holding labor supply fixed, the standard deviation of output must be less than the standard deviation of capital. If labor varies and has a positive covariance with capital, then it might be possible to have the standard deviation of output exceed that of capital. In fact, the covariance of labor and capital was negative for the treatment with iid INT shocks.

There are a number of additional treatments of this model which might bring the implications closer to observations. In particular, are there variations in parameters and/or the stochastic process which might produce a positive correlation between consumption and investment and reduce the variance of the capital stock?

First, one might consider a parameterization in which labor supply is more elastic than the case explored thus far. This is particularly relevant for reducing the relative standard deviation of the capital stock. To explore this, we considered our baseline treatment with an iid intermediation shock in which labor supply was infinitely elastic. The iid case was chosen since this would create the most intertemporal substitution. The results of this exercise were: (i) the capital stock was still more volatile than output and (ii) consumption and investment were negatively correlated.

A second alteration to our model, motivated by Baxter and King [1991], is to introduce a production externality into the specification of the technology for the representative agent.[16] In particular, suppose the agent's production function is given by:

$$Y_t = A_t K_t^{\alpha} n_t^{1-\alpha} \overline{Y}_t^{\gamma}$$

where $\overline{Y}_t$ represents the average level of output in the economy in period t and γ parameterizes the extent of the externality. A conservative estimate of γ is .23, as discussed by Baxter and King [1991]. Using this specification of technology and this estimate of γ, the Nash equilibrium of the dynamic economy is characterized by a system of first order

[16] Bryant [1983] discusses this type of production externality in the context of a coordination model.

conditions, not unlike those stated above, derived from the optimization of a single agent taking the evolution of the aggregate output measure as given. These conditions are then linearized and the moment implications of the model are determined. This procedure is discussed in detail by Baxter and King [1991].

The relevance of this exercise relates to the relationship between our model of intermediation shocks and a model with taste shocks. Baxter and King argue that in the presence of a production externality, shocks to the marginal rate of substitution between consumption and leisure can produce fluctuations that have many business cycle characteristics, including consumption smoothing and the positive comovement of consumption and investment with output. The role of the externality is clear: without this effect, taste shocks produce a negative correlation between consumption and investment and consumption smoothing is not evident. Through the externality, the increased activity resulting from the intermediation shocks creates an endogenous increase in total factor productivity for the individual producer and this leads to an increased production of consumption goods.[17] Thus one might conjecture that introducing production externalities into the model of intermediation shocks might have similar effects to the extent that the intermediation shock is acting like an intertemporal taste shock.

Our results indicate that for $\gamma=.23$, the economy with the production externality and serially correlated intermediation shocks continues to exhibit negative correlation between consumption and investment and the capital stock is still more volatile than output. Raising

[17] Greenwood, Hercowitz and Huffman [1988] allow for variable utilization of capital and endogenous depreciation. In their model, productivity of the capital stock is increased when there is a positive innovation to the return on investment since agents will choose to work their capital harder to increase its depreciation. Thus both formulations create a basis for increased production in response to the innovation.

the production externality above this level ($\gamma = .375$) combined with infinitely elastic labor supply implies that consumption is smoother than output and consumption, investment and labor productivity are all positively correlated with output.[18] Still, the standard deviation of capital to output is about 1.5, well above that observed in U.S. data.

Third, we consider a setting in which both real and intermediation shocks exist. Since the model with productivity shocks alone has some desirable characteristics (consumption smoothing and capital less volatile than output) it is not surprising that an economy with both productivity and intermediation shocks can produce these effects simply by appropriate parameterization of these two sources of uncertainty. The issue, of course, is to evaluate the behavior of the economy for the actual relative standard deviations and variance/covariance matrix for these shocks. One approach then is to identify the intermediation shocks from the Euler equation. The other, which we pursue here, is to provide some idea about the relative importance of the shocks such that the model has certain properties.

In particular, consider a version of our baseline economy in which both real and intermediation shocks coexist and are, by assumption, uncorrelated. Assume further that both sources of fluctuation have a serial correlation coefficient of .9. Given this structure, we searched over the standard deviation of the intermediation shock relative to that of total factor productivity to determine when the correlation of consumption and investment was zero and when the standard deviation of the capital stock was about equal to that of output. The results are quite surprising. If the standard deviation of the intermediation shock is 3%

[18] Even for this high value of γ, the steady state is still saddle-path stable. See the discussion in Farmer and Guo [1993] about the relationship between alternative parameterizations of this economy and stability.

of the total factor productivity shock, then the correlation between consumption and investment is nearly zero. For larger relative values of the standard deviation of the intermediation shock, the correlation of consumption and investment is negative. Further, the standard deviation of the intermediation shock must be reduced to .5% of the standard deviation of the total factor productivity shock before the standard deviation of the capital stock nearly equals that of output. This exercise suggests that a mixed model can indeed bring the model's implications for the standard deviation of capital relative to output and the correlation between consumption and investment closer to observation but that this requires a parameterization with an extremely small role for the intermediation shock.

Alternatively, as described by Bernanke and Gertler [1989], perhaps the intermediation shocks as modeled here actually follow productivity shocks instead of being independent. For example, an initial productivity decline reduces the wealth of borrowers and thus reduces the productivity of the intermediation process. Thus, initial productivity shocks are propagated through the intermediation process. Thus, we experimented with an economy in which a temporary technology shock is positively correlated with a serially correlated intermediation shock. The issue, once again, is the magnitude of the link between the productivity shock and the resulting intermediation shock.

To study this issue, we parameterized the response of the intermediation shock to the iid productivity shock and then computed the correlation between consumption and investment as well as the standard deviation of the capital stock relative to output. We found that if a 1% innovation to total factor productivity was followed by a .05% innovation to the intermediation shock, the capital stock was slightly more volatile than output and the correlation between consumption and investment was negative. One could of course reduce the relative innovation to the intermediation variable further but the point is clear: only when the innovation to intermediation induced by a real shock is quite small will the predictions of the model match up with observation.

(v) Summary

In summary, our first model attempts to capture the spirit of a wide range of models in which aggregate fluctuations are associated with variability in the intermediation process. In our analysis, we thus consider the impact of shocks to the accumulation process on the aggregate economy. These shocks represent variations in the cost today of acquiring a given level of capital in the following period. We see that the types of correlations produced by this model are at variance with basic features of economic fluctuations. In particular, consumption and investment are often negatively correlated, the capital stock is quite volatile relative to output and real interest rates are procyclical. The model with social increasing returns remedies some of these problems if the production externality is sufficiently large.

At an extreme, these results indicate that a model of the intermediation process in which variations in the costs of accumulation are a key component is likely to produce correlations that are inconsistent with basic features of aggregate data. In particular, intermediation shocks alone seem to produce correlations at variance with observations on the U.S. economy. Further, the mixed models do better only when the intermediation effects are of secondary importance.

III. A Model of Financial Fragility

In this section of the paper we consider a model in which fluctuations reflect strategic uncertainty with regard to the returns to intermediation. Relative to the experience of the U.S. economy during the Depression period, our model is intended to represent the strategic uncertainty underlying many accounts of financial crises. The model relies on a thick markets externality such that the returns to participating in financial markets increases with the level of activity in that market. Thus the model captures, in an extreme way, the breakdown of the intermediation process (bank failures and depositors search for liquidity and safety) during the Depression period.[19]

The economy we construct is an infinite horizon version of the two period models considered by Bryant and Weil. In those models, two period lived agents made a savings decision where the return to savings was an increasing function of the overall level of savings. As shown by Bryant and Weil, this form of social returns to scale can lead to multiple equilibria of the game played by the savers. In our formulation this returns to scale is modeled through an assumption of a fixed cost to the process of intermediation, reflecting the processes of loan evaluation, monitoring, outstanding obligations of the intermediary and other transactions costs. Diamond [1984] argues that a key role of intermediaries is to efficiently monitor the behavior of borrowers. Our model assumes that agents who join the intermediary share in the fixed cost of its operation. This fixed cost creates a participation externality (a form of strategic complementarity, emphasized by Cooper and John [1988]) which underlies the multiple equilibria. In one equilibrium, the average savings level is low so that the representative agent chooses to save little reflecting the low return. This savings is associated with non-intermediated investment, which may include flows to the government

[19] The model is extreme in that during a period of pessimism, all activities through intermediaries ceases.

and firms with high credit ratings. In the other equilibrium, the average saving level is high and the resulting high returns promote high savings by the individuals as well as an active process of intermediation.

Our economy differs from the papers by Bryant and Weil in two ways. First, we represent this interaction across savers in an infinite horizon economy so that this "savings game" is played each period. Second, we assume that the resolution of the strategic uncertainty can be represented through a sunspot process. That is, there is assumed to be a correlation device that determines the outcome of the "savings game" in each period. Our focus is on the dynamics induced by the capital accumulation process in the presence of extrinsic uncertainty.[20]

This model captures a key element of financial fragility found in the models of Bryant and Weil as well as the bank run models of Diamond and Dybvig [1983]. Profitable intermediated activities requires the participation of others who share confidence in the viability of the intermediaries.[21] This confidence leads agent to deposit resources in these institutions (Bryant and Weil) and to leave them there (i.e. to avoid the runs stressed by Diamond and Dybvig).

The approach outlined for the previous model of linearizing around a steady state is not sufficient here due to the presence of the nonlinearities induced by the sunspot variables. So, we model this dynamic economy by determining the policy function of a representative agent assuming that the set of agents is in a symmetric Nash equilibrium (induced by the

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[20] The dynamics are thus associated with fluctuations in the neighborhood of the two steady states of the infinitely repeated stage game.

[21] By an intermediary, we are thinking of a coalition of agents that takes deposits, makes loans and then liquidates the proceeds, not unlike the structure set forth by Boyd and Prescott [1987]. Note that this implies that the intermediary has no capital to make offers to depositors which might overcome the coordination problems.

extrinsic uncertainty) in each period. The policy function, in turn, is determined from a value function iteration procedure. More formally, consider the following dynamic programming problem for a representative agent:

$$V(K,\theta) = \max_{K',n} U(f(K,n) + (1-\delta)K - I(K',\theta), n) + \beta E_{\theta'|\theta} V(K',\theta')$$

where (9)

$$I(K',\theta) = \begin{cases} K'/(1+\underline{r}) & \text{if } \theta = \theta_p \\ K'/(1+\bar{r}) + F & \text{if } \theta = \theta_o. \end{cases}$$

In this problem, the current state for the representative agent is given by the current capital stock (K) and the state of the sunspot variable (θ). Given these state variables, the representative agent chooses a level of work (n) and the capital stock for the next period (K'). The current consumption level is determined by the total resources available from both current production and the undepreciated capital stock less the investment level, $I(K',\theta)$. The key to the dynamic programming problem is this investment function.[22]

In keeping with the spirit of Bryant and Weil, the intermediation process can be in one of two states: i.e. $\theta \in \{\theta_o, \theta_p\}$ where θ_o represents optimism and θ_p is the state of pessimism. When optimism occurs, each agent believes that other will save through the intermediary so that each is willing to incur a fixed cost (F) to obtain a marginal return of $(1+\bar{r})$. In the state of pessimism, other agents do not frequent the intermediary and the representative agent does not either thus avoiding the (large) fixed cost of operating the intermediation process alone and earning a lower marginal return of $(1+\underline{r})$. As discussed

[22] Note that investment here is the amount of current output plus the undepreciated capital stock that is not consumed.

below, this model thus rests on the existence of multiple equilibria for each point in the capital state space. In one equilibrium, participation at the intermediary is high and at the other intermediation is absent.

To establish the existence of sunspot equilibria through (7) two conditions must be met. First, there must be a solution (a function $V(K,\theta)$) that satisfies the functional equation, (7). Second, we must demonstrate that for all values of the capital stock K in the relevant state space, there exists an indeterminacy about the form of intermediation that the realization of θ resolves. We summarize our findings in the following two propositions.

Proposition 1: There exists a $V(K,\theta)$ that satisfies (7) for $K \in \kappa$.

Proposition 2: There exists a value of F such that an equilibrium exists with $V(K,\theta_o) \neq V(K,\theta_p)$ for $K \in \kappa$.

Proofs of these propositions are in the appendix. Note that these propositions hold for the capital stock in the set κ. As argued in the proofs, the set κ is the interval of capital stocks that lie between the steady state associated with permanent pessimism (K_p) and the highest obtainable capital stock under optimism ($\bar{K}_o$).[23] To verify the second proposition, we set F so that at $K=K_p$ the representative agent is indifferent between accumulating through the intermediary and utilizing the non-intermediated technique to obtain K_p in the following period. Since the desired capital stock is increasing in K, this implies that for $K>K_p$, the representative lender will prefer the intermediary when all others save in that fashion as well. Thus the optimistic equilibrium always exists. The pessimistic equilibrium always exists as

[23] These variables are defined precisely in the appendix and we prove, in an additional proposition, that if the capital stock is in the set κ, then it will remain in this set.

long as the cost of operating the intermediary by a single agent is, as we assume, prohibitive.

Given these propositions, the quantitative characteristics of the economy are determined by the two policy functions which map from the state, (K,θ) into the future capital stock and the current level of employment, $K'(K,\theta)$ and $n(K,\theta)$. There are three important properties of these policy functions that are important for our simulations. First, $K'(K,\theta)$ is an increasing function of K given θ. This reflects consumption smoothing and is the underlying property of the neoclassical model that generates convergence. Further, the desired capital stock is higher in states of optimism; i.e. $K'(K,\theta_o) > K'(K,\theta_p)$ for all $K \in \kappa$. Second, for the preferences we specify, $n(K,\theta)$ is decreasing in K and increasing in θ. The first effect, described above and in King, Plosser and Rebelo [1988], reflects wealth effects and response to interest rates as the capital stock varies. Finally, as noted above, $K'(K,\theta_o)$ and $K'(K,\theta_p)$ lie between the policy functions that characterize the capital accumulation process for the two extreme economies in which $\theta_t=\theta_o$ for all t and the other in which $\theta_t=\theta_p$ for all t. We use this property to characterize the sunspot equilibria.

From these two policy functions, all other variables of interest for the representative household (and thus for the macro economy) are determined. In particular, the production function determines the level of output, the resource constraint determines consumption from investment and output. In addition, given an initial stock of capital one can calculate a capital stock series in exactly the same manner as done for U.S. data. This allows us to address the implications of our model for the relative volatility of capital without an measurement problems.

In addition, there are two interest rates that can be determined. One is the return on the marginal unit of investment: the marginal product of the capital which the investment produces plus the undepreciated increment to the capital stock, R.[24] Second, there is the interest rate on deposits that a competitive intermediary would offer per unit invested, r^d. From the intermediary's liquidation constraint, $r^d=(1-(F/I))R$ for a current investment level of I. Note that the cyclical behavior of R reflects, among other things, variations in the marginal product of capital. Further, the behavior of r^d reflects not just that of R but also the size of the fixed cost relative to the amount of investment that is being undertaken. As we shall see, this implies that the correlation of R and r^d may in fact be negative.

For common variables, the parameterization of the model is close to that of King, Plosser and Rebelo.[25] The critical variables are the returns on investment in the two states and the fixed cost. As discussed earlier, we set F so that at K_p the representative agent is indifferent between the two techniques of producing future capital. We set $\underline{r}=0$ and $\dot{r}=.03$ and assume that $\text{Prob}\{\theta_{t+1}=\theta_o|\theta_t=\theta_o\}=\text{Prob}\{\theta_{t+1}=\theta_p|\theta_t=\theta_p\}=.9$ implying a considerable amount of persistence in the sunspot process. Numerically, the method of value function iteration converges to a value function which solves (7).[26]

The results from this exercise are given in Table 3 and Figures 2 and 3. Table 3 provides a summary of the behavior of some of the key macroeconomic variables in our economy. The statistics in Table 3 were computed from a 2000 period simulation of the

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[24] Formally, $R=(F_K + (1-\delta))*(1+r(\theta))$ where θ represents the current sunspot state.

[25] Thus, $\alpha=.65$, $\beta=.9$ and $\delta=.1$.

[26] Of course, this convergence is not exact but reflects the maximal difference across iterations which we set at .001. The program converges in less than 100 iterations.

economy while the paths given in Figures 2 and 3 represent a subperiod of the simulation.[27]

As with the model investigated in the previous section, it is still the case that large variations in the capital stock lie at the heart of our results. The standard deviation of the capital stock relative to output is 4.3, still well above the observed ratio of standard deviations. As noted above, we can calculate the capital stock series using the initial value, the assumed rate of depreciation and the simulated level of investment as if they were no shocks to the intermediation process: i.e. we can replicate the calculation used to construct the measure of the U.S. capital stock. Even for this alternative capital series, we find that the standard deviation of the capital stock far exceeds that of output.

In contrast to the previous model of real intermediation shocks, both consumption and investment are positively correlated with output and the relative volatilities are in accord with observed U.S. macroeconomic behavior: consumption is less volatile than output while investment is more volatile. Note too that in this model labor is positively correlated with output: when there is a change in regime, both output and employment move in the same direction and this effect dominates. Thus this model does a better job of matching observed patterns of correlations from U.S. data.

Figures 2 and 3 display the outcome of the simulation of the economy that underlies the statistics reported in Table 3.[28] These figures play a similar role as the impulse response function for the earlier model in that intuition about the behavior of this economy is best

[27] Note that though our economy is highly non-linear with regime changes, the statistics were computed as if the data generating process was linear. This point is discussed further below. Also, in Tables 3 and 4, "INV" is defined as output less consumption as was the case for Tables 1 and 2.

[28] The statistics reported in Table 3 are derived from a simulation of the model while the statistics given in Tables 1 and 2 are computed as population statistics from the linearized model.

developed through them. From Figure 2, note the response of the economy to a change in regime shown in period 30. When a pessimistic sunspot occurs (the sunspot variable equals 0 in Figure 2), agents do not save through the intermediary and the economy begins to move toward the pessimistic steady state. Along this transition path, the capital stock is falling along with output and consumption.

In terms of financial variables, recall that there are two variables of interest: the marginal product of an additional unit of investment (R) and the return to deposits (r^d). For our economy we find that there is a positive correlation between R and y. In the initial period of optimism, output expands and the return to investment increases as well. Within the optimism regime, the economy accumulates capital so that output increases while R falls. The positive correlation reflects the dominant effect associated with the change in regime.

Figure 3 outlines the behavior of interest rates. At the time of the pessimistic shock, the marginal efficiency of investment falls, implying that R falls as well in period 30. However, the reduction in the capital stock that follows leads R to rise during the transition. For our economy, the fall in both output and R that occurs at impact dominates in determining the positive correlation between these two variables. In contrast, the correlation between output and the deposit rate is negative. This is due to the fact that when a period of pessimism begins, the decrease in R is not reflected in r^d since the end of the intermediation process implies that the fixed cost of intermediation is not incurred. As a consequence, deposit rates do not decrease to the extend that R does though deposit rates do rise, along with R, during the capital deaccumulation process. Overall then there is a negative correlation observed between deposits rates and output.

To the extent that real interest rates on relatively safe investments (which is our interpretation of the alternative to the intermediation process) were quite high during the Depression, this is in accord with observation. Further, during periods of pessimism, a gap does emerge. Consider the return that could have been obtained in the event that the intermediation process was in fact utilized.[29] As our economy is extreme in that intermediation ceases in the event of pessimism, there is actually no investment taking place at this higher rate. In reality, there was intermediated investment during the Depression period (i.e. not all banks closed) which could be measured by the yield on corporate debt. We interpret the rate of return from the (non-functioning) intermediation process as a proxy for the return on this activity. Given this, one can construct the differential between the return on intermediated and non-intermediated investment. This gap is positive during a period of pessimism reflecting the relatively high yield projects that go unfunded due to the breakdown of the intermediation process.

Contrasting the two economies, recall that in the model with fundamental shocks, consumption smoothing was not observed and consumption was negatively correlated with investment. In contrast, for the sunspot economy, there is consumption smoothing. Further, in the first economy, employment was negatively correlated with output while in the second, it was positively correlated with output. These differences seem to stem from two sources.

First, the real deposit rate is countercyclical in the second economy but strongly procyclical in the first. Thus the response of labor supply and consumption to variations in real returns is one factor that might distinguish the two economies. In fact, if we simulate

[29] This gap is given by the return on deposits during a period of pessimism (r) and the return that would have been paid if intermediation had occured at the given level of the capital stock.

the second economy allowing for regimes changes but assuming a zero fixed cost of intermediation, employment is again countercyclical and the deposit rate is procyclical. Further, without the fixed cost of intermediation, consumption smoothing disappears. Thus the presence of the fixed cost, which underlies the multiplicity of stage game equilibria, has implications for the behavior of interest rates and thus employment and consumption.

Second, the pattern of correlations reported in Table 3 reflects the shifts in regimes as well as variations within a regime. This nonlinearity may also be important in distinguishing the two economies. To investigate this point, Table 4 presents the regime contingent correlations from the simulations while Figure 4 shows the simulated series for investment, along with consumption and output.[30] Comparing these results with those in Table 3, note that within each regime, both investment and employment are negatively correlated with output. Thus the positive correlation of these variables with output for the overall simulation is a consequence of their behavior across regimes. Further, within regimes, consumption smoothing disappears as both investment and consumption are more volatile than output. Thus, the economy driven by sunspots has many of the same statistical properties of the first economy once one conditions on regime. This is perhaps not too surprising given that the pattern of correlations is largely driven by the neoclassical adjustment process, contingent on a regime in the case of the second economy.

To what extent are the statistics reported for our model economy a consequence of the fact that both new investment and undepreciated capital are assumed to go through the intermediation process? To address this issue, consider a variation on the basic model such

[30] The next step, of course, is to compare these moments against a non-linear representation of U.S. data.

that only savings out of current output passes through the intermediation process. That is, instead of (3) suppose that

$$K_{t+1} = K_t(1-\delta) + I_t\theta_t.$$

Using this accumulation equation in the dynamic programming problem, we can follow the steps taken for the previous model.[31] The resulting statistics for the overall sample are given in Table 5. Comparing these with those reported in Table 3, the same basic patterns of behavior emerge. Also, for this economy the ratio of the standard deviation of capital to that of output is 3.76. Thus our earlier findings appear robust to altering the specification so that only new investment is intermediated.

IV. Conclusions

The goal of this paper was to provide a quantitative assessment of models in which variations in the process of intermediation play a central role in aggregate fluctuations. This was accomplished by looking at two somewhat different models. The first attempts to capture the spirit of a number of models which focus on variations in the cost of creating new capital due to disruptions in the intermediation process. To study this, we introduced intermediation shocks into an otherwise standard real business cycle model. The results from this exercise were: (i) investment was not positively correlated with output, (ii) consumption was more volatile than output and (iii) the capital stock was more volatile than output. In these three respects, the behavior of the model economy is at variance with observed aggregate fluctuations. Further, interest rates and output were strongly positively correlated,

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[31] Since we do not prove Propositions 1 and 2 for this environment, the cautious reader should think of this exercise as exploring the effects of a fundamental shock to the intermediation process rather than a sunspot.

in contrast to observation[32].

The second model introduced financial fragility through extraneous uncertainty which influenced the perceived return to saving through an intermediary. As in Bryant and Weil, multiple equilibria arise in the static interaction between savers in their choice of technique for converting goods today into capital tomorrow. This indeterminacy was resolved using a sunspots approach and the quantitative features of the resulting economy evaluated. This economy exhibits large fluctuations and is best interpreted as a model of the Depression period in which the process of intermediation was almost shutdown.

As in the case of the model with real intermediation shocks, the capital stock was quite volatile. However, in the model with extrinsic uncertainty, consumption smoothing was evident and both consumption and investment were positively correlated with output. Furthermore, due to the presence of fixed costs in the intermediation process, deposit rates were negatively correlated with output, as observed during the Great Depression.

From these results, it appears that the behavior of both economies are driven by the effects of the returns from the intermediation process on the capital stock. The economies had different implications for correlations across macroeconomic variables due to the presence of fixed costs and nonlinearities in the sunspot economy.

In our analysis, we do not derive a series of intermediation shocks from observables. While it seems possible to use the errors from an Euler equation to generate an intermediation shock series, the identification assumptions necessary for such an exercise seem quite strong. Instead, we plan to study particular historical episodes in some detail,

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[32] Note though we have not gone the extra step of identifying the intermediation shocks and checking their correlations with interest rates, which is the counterpart of the exercise performed by Beaudry and Guay [1992].

such as the banking crisis during the Great Depression, to evaluate the implications of our model relative to U.S. experience.

Two other exercises are motivated by our findings. First, the intermediation process modeled here has no direct implications for the cost of borrowing to obtain consumption goods. Yet, purchases of durables are an important aspect of variations in the intermediation process and the model should be expanded to include this feature. In fact, Romer [1990] finds that at the time of the onset of the Depression purchases of consumer durables fell while purchases of some non-durable actually rose. Perhaps this reflects the fact that many consumer durable purchases (e.g. cars) were financed and hence were subject to intermediation shocks.

Second, the financial fragility model can be used to evaluate the gains to financial reform and stabilization. One interpretation of the period since the Depression is that financial reforms (most notably deposit insurance) have eliminated some of the strategic uncertainty over intermediated investment. In principle, one could use a more carefully calibrated version of our model to evaluate the welfare gains from this type of intervention.[33]

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[33] Diaz-Giménez et al. [1992] parameterize their model using low frequency observations for the U.S. economy.

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Table 1

Linearized Model

Impact of IID Real Shocks

TREATMENT	Corr. with Y Contemporaneous				Standard Deviation Relative to Output				Statistics for Y	
	C	Hrs	Inv	Prod	C	Hrs	Inv	Prod	sd	sc
TFP Shocks	.38	.98	.99	.88	.19	.75	4.49	.29	.0146	.017
INT Shocks	.57	-.28	-.18	.62	3.05	2.09	9.45	2.55	.0044	.67

Table 2

Linearized Model

Serially Correlated (.9) Real Shocks

TREATMENT	Corr. with Y Contemporaneous				Standard Deviation Relative to Output				Statistics for Y	
	C	Hrs	Inv	Prod	C	Hrs	Inv	Prod	sd	sc
TFP Shocks	.82	.80	.91	.90	.34	.48	3.07	.68	.032	.92
INT Shocks	.72	-.24	-.04	.77	1.85	1.06	4.79	1.6	.067	.96

Table 3

Sunspot Equilibrium

TREATMENT	Corr. with Y Contemporaneous				Standard Deviation Relative to Output				Statistics for Y	
	C	Hrs	Inv	Prod	C	Hrs	Inv	Prod	sd	sc
INT Sunspots	.50	.52	.67	.66	.78	.20	.91	2.9	.023	1.0

Table 4

Sunspot Equilibrium

Statistics by Regime

Regime	Corr. with Y Contemporaneous				Standard Deviation Relative to Output				Statistics for Y	
	C	Hrs	Inv	Prod	C	Hrs	Inv	Prod	sd	sc
Optimism	.98	-.95	-.94	.98	2.33	.4	1.37	8.22	.0076	1.0
Pessimism	.98	-.94	-.94	.98	2.29	.34	1.33	7.84	.0078	1.0

Table 5

Sunspot Equilibrium

Shocks to New Investment Flows Only

TREATMENT	Corr. with Y Contemporaneous				Standard Deviation Relative to Output				Statistics for Y	
	C	Hrs	Inv	Prod	C	Hrs	Inv	Prod	sd	sc
INT Sunspots	.43	.63	.72	.62	.73	.21	.95	2.58	.0081	1.0

Appendix: Proofs

As discussed in the text, $\kappa = [K_p, \overline{K}_o]$. Here K_p is the unique steady state level of capital for the economy with perpetual pessimism. It is determined from the two first order conditions to the accumulation problem: the intratemporal first-order condition and the Euler equation at the steady state values for employment and the capital stock. $\overline{K}_o$ is the largest value of K that satisfies: $K=(f(K,1)-F)(1+r)/(1-(1-\delta)(1+r))$. Thus it represents the highest level of the capital stock that can be reproduced if the agent has zero leisure and zero consumption.

Proposition 1: There exists a $V(K,\theta)$ that satisfies (7) for $K \in \kappa$.

Proof: The proof uses Proposition 9.6 from Stokey-Lucas [1989]. To make use of their result, we note that the return function is bounded and continuous for $K \in \kappa$, the feasible set is non-empty, compact valued and continuous and that our problem has discounting.

Proposition 2: There exists a value of F such that an equilibrium exists with $V(K,\theta_o) \neq V(K,\theta_p)$ for all $K \in \kappa$.

Proof: Let K_i for $i=o,p$ be the steady state level of capital stock if the economy was in state θ_i in all periods with certainty. From the steady state of the Euler equation, it is easy to see that $K_o > K_p$. Choose F so that at $K=K_p$, the cost to the agent of obtaining K_p of capital tomorrow is the same whether the accumulation is through the intermediary (assuming that all other agents are going to the intermediary) or through the non-intermediated technology. Thus, F satisfies:

$$F = F^* \equiv K_p\left[\frac{1}{(1+\underline{r})} - \frac{1}{(1+\bar{r})}\right]. \tag{A1}$$

So at $K=K_p$, the returns to intermediated accumulation are at least as large as non-intermediated accumulation as the agent could choose a capital stock not equal to K_p through intermediated investment and thus be no worse off. For $K>K_p$ and this value of F, it is clear that the intermediated technology is more efficient than the non-intermediated one. Thus, if all other agents go to the intermediary for $K>K_p$, the remaining agent will do so as well. Hence for each $K>K_p$, there is always an optimistic equilibrium. Further, as long as the fixed cost to intermediation is sufficiently large, if all other agents accumulate using the non-intermediated technology, the remaining agent will not have an incentive to use the intermediated accumulation process.

Proposition 3: If $F=F^*$, then $K'(K^p,\theta) \geq K_p$ and $K'(\overline{K}_o,\theta) \leq \overline{K}_o$ for all θ.

Proof: To see that $K'(K^p,\theta) \geq K_p$ for all θ, suppose that $K'(K^p,\theta_p) < K_p$. Given that $F=F_*$, the agent will then accumulate capital using the mattress technology. Since K_p is the steady state of the economy with perpetual pessimism, the agent could have done no worse by setting $K'(K^p,\theta_p)=K_p$. In a similar way, suppose that $K'(K^p,\theta_o) < K_p$. Again, from $F=F^*$, the best to accumulate is through the mattress. Once again, the capital is below K_p and the welfare of the agent, by revealed preference, cannot exceed that from remaining at K_p and using the mattress accumulation technology. Thus, $K'(K^p,\theta) \geq K_p$ for all θ.

To see that $K'(\overline{K}_o,\theta) \leq \overline{K}_o$ for all θ, note that it is feasible to remain at the capital stock $\overline{K}_o$ when $\theta=\theta_o$ but it is not feasible to have $K>\overline{K}_o$ under optimism as then consumption would be negative. Given that the maximal capital stock is higher under perpetual optimism than under perpetual pessimism, $\overline{K}_o > K_p$. So, using the fact that $F=F^*$, we know that the mattress is a less efficient storage technology at $\overline{K}_o$ so that under pessimism it is impossible to have $K'(\overline{K}_o,\theta_p) > \overline{K}_o$ without consumption being negative.

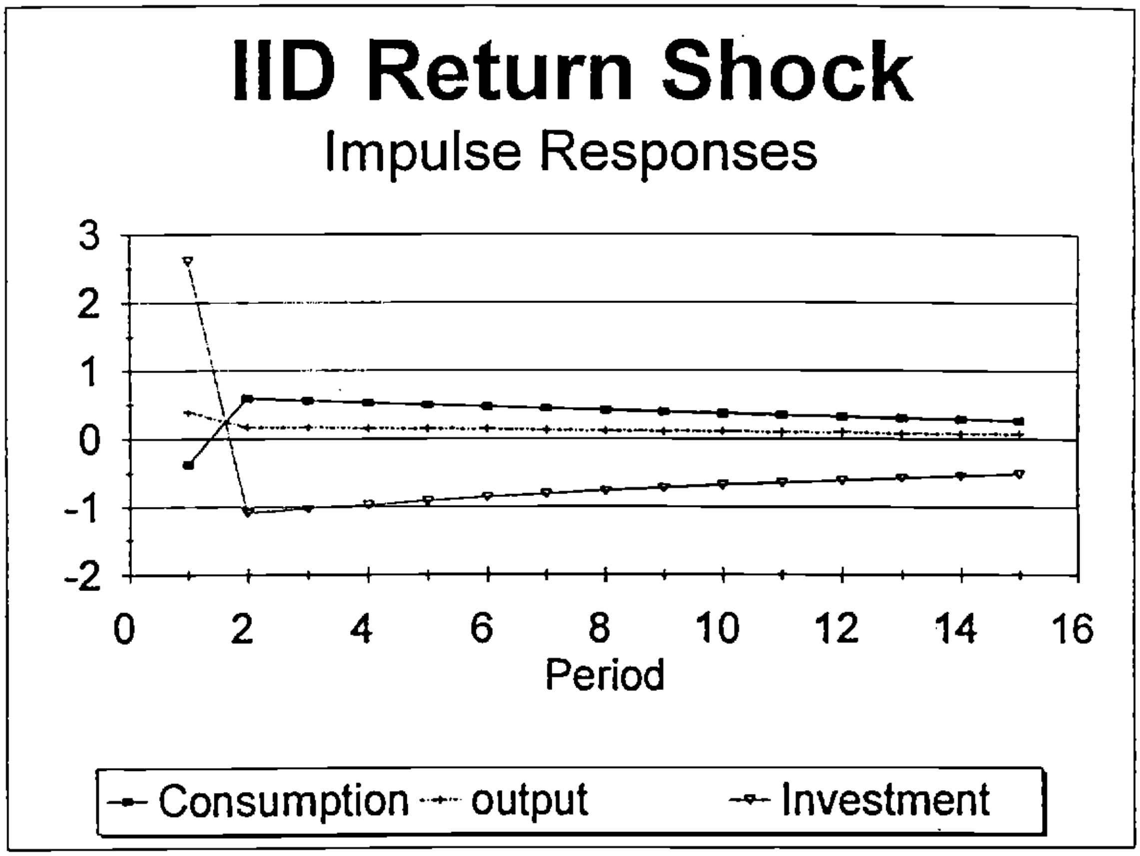

IID Return Shock
Impulse Responses
3
2
1
0
-1
-2
0
2
4
6
8
10
12
14
16
Period
Consumption
output
Investment

Figure 1

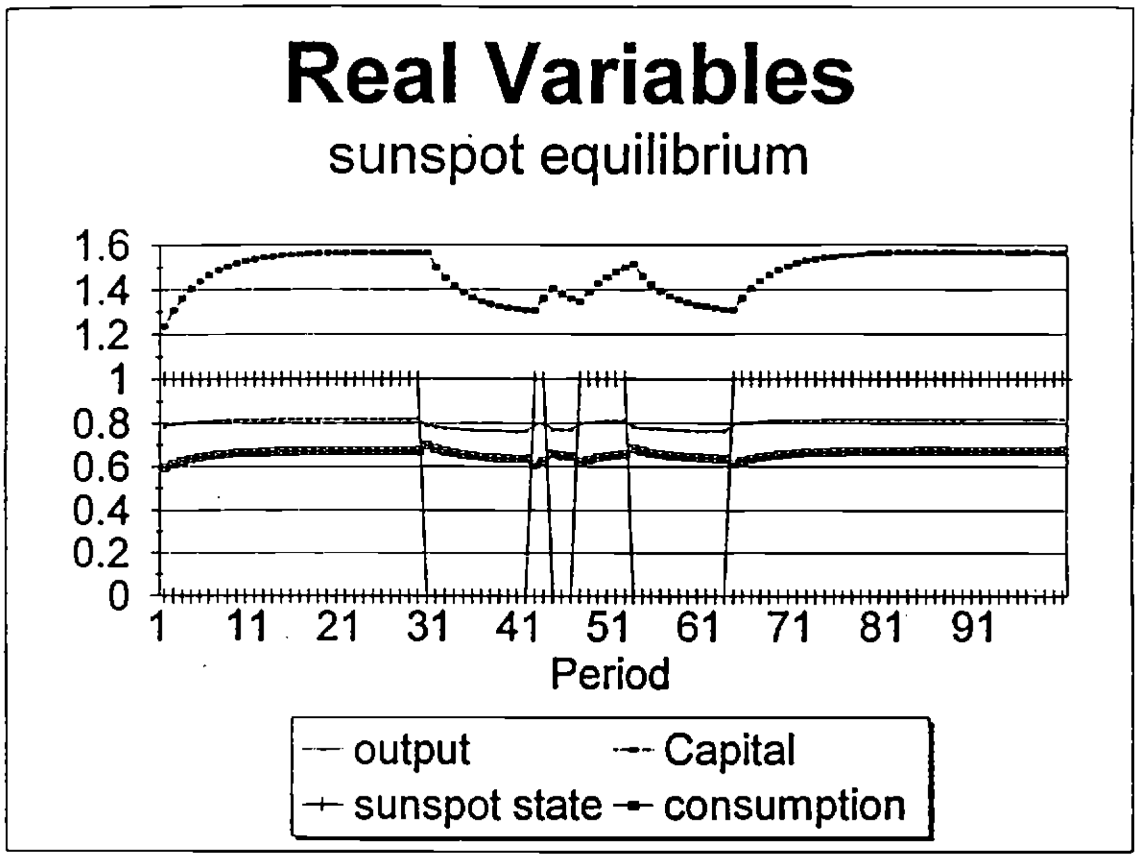
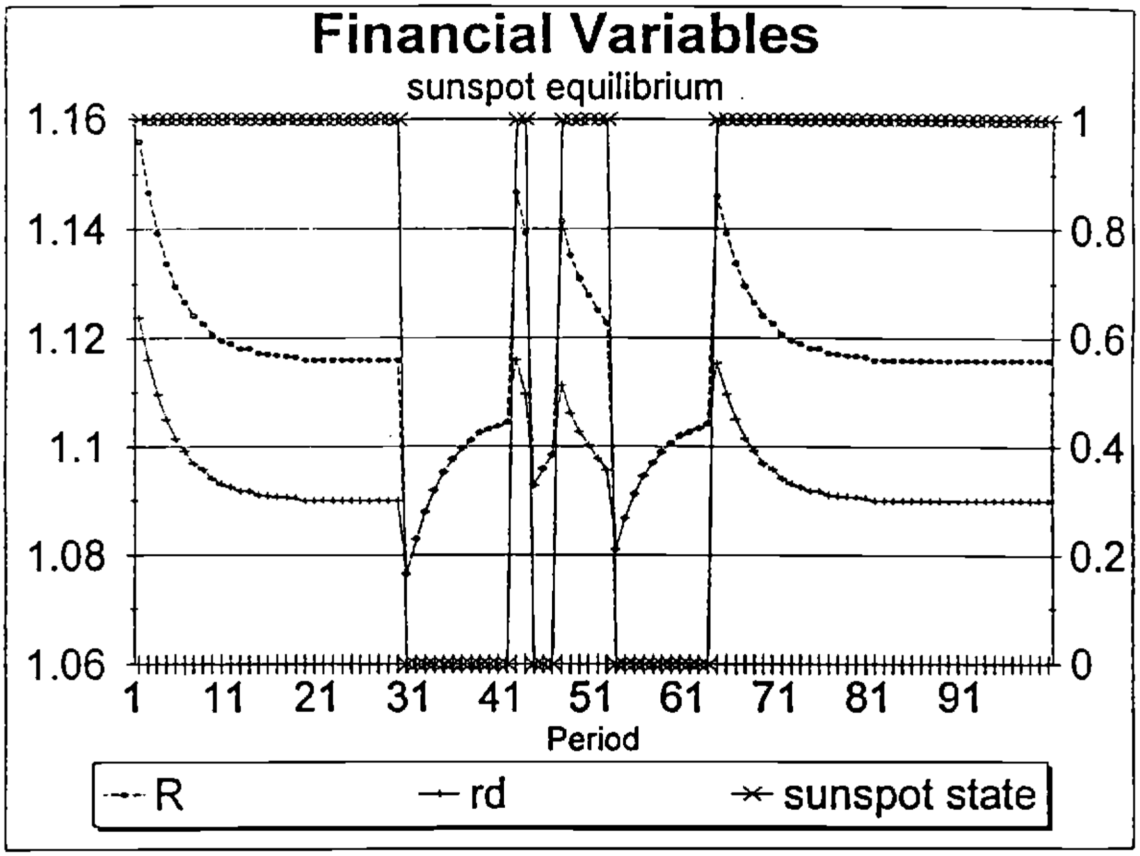
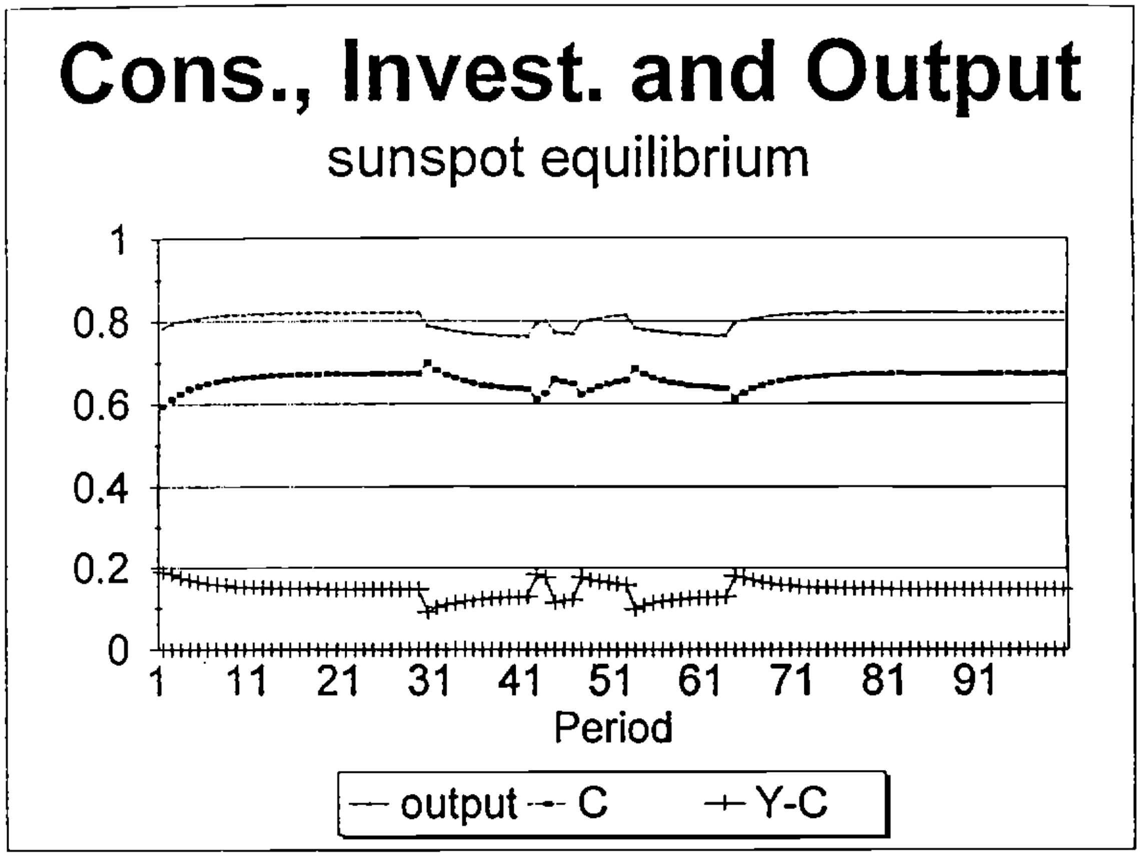

Real Variables
sunspot equilibrium
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1
11
21
31
41
51
61
71
81
91
Period
output
Capital
sunspot state
consumption

Figure 2



Financial Variables
sunspot equilibrium
1.16
1.14
1.12
1.1
1.08
1.06
1
0.8
0.6
0.4
0.2
0
1
11
21
31
41
51
61
71
81
91
Period
R
rd
sunspot state

Figure 3



Cons., Invest. and Output
sunspot equilibrium
1
0.8
0.6
0.4
0.2
0
1
11
21
31
41
51
61
71
81
91
Period
output
C
Y-C

Figure 4