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ARTICLES

FINANCIAL INTERMEDIATION AND AGGREGATE FLUCTUATIONS: A QUANTITATIVE ANALYSIS

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We investigate the quantitative behavior of business-cycle models in which the intermediation process acts either as a source of fluctuations or as a propagator of real shocks. In neither case do we find convincing evidence that the intermediation process is an important element of aggregate fluctuations. For an economy driven by intermediation shocks, 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. The model economy thus fails to match unconditional moments for the U.S. economy. We also structurally estimate parameters of a model economy in which intermediation and productivity shocks are present, allowing for the intermediation process to propagate the real shock. The unconditional correlations are closer to those observed only when the intermediation shock is relatively unimportant.

Keywords: Financial Intermediation, Credit Shocks, Aggregate Fluctuations

1. 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

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and a vehicle for the propagation and magnification of shocks to technology, the money supply, and so forth.

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 for the post-World War II period has complemented these theoretical developments.

Our purpose here is to understand the implications of these models for observed aggregate fluctuations. In particular, is the intermediation process an important source of aggregate fluctuations? Moreover, to what extent does the intermediation process propagate shocks?

It is quite surprising, given the attention accorded these models in the discussion of business cycles, that quantitative analyses of the credit mechanism are relatively rare.[2] Clearly, the difficulty emerges from the introduction of an explicit model of the intermediation process, perhaps through the inclusion of contracting problems, into an otherwise standard dynamic stochastic framework.

To circumvent these difficulties, we study a model economy in which fluctuations are associated with variations in the costs of intermediation, the process that creates capital from savings. We interpret these intermediation shocks as reflecting variations in the processes of matching savings and investment, project evaluation, and project monitoring.[3] Although this structure admittedly does not have the full richness of the contracting models that have been constructed to analyze incentive problems and balance-sheet effects, it is a useful step in determining whether the many models encompassed by this framework have quantitative implications that broadly match observations of the aggregate economy. Further, these shocks also have the interpretation of changes in banking regulations, including variations in reserve requirements. Thus, the structure allows us to investigate a wide range of credit shocks both as sources of fluctuations and as propagators of other shocks.[4]

Our first and most pervasive finding is that intermediation shocks, either as impulses or as part of the economy's response to other shocks, *create substitution effects* that are not evident in U.S. data. In particular, the model with intermediation shocks produces a negative correlation between consumption and investment: In times of productive intermediation, consumption is reduced and investment is 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 Baxter and King

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(1991), in that they lead to negative comovements in consumption and investment.[5] As we shall see, the forces toward substitution imply that the real interest rate is procyclical, contrary to the evidence for the United States provided by Beaudry and Guay (1992). Further, shocks to the intermediation process, acting through the substitution between investment and consumption, create excess volatility of the capital stock. That is, the variance of the capital stock *exceeds* that of output, again contrary to observations for the United States. Finally, there are important wealth effects created by intermediation shocks, which lead to negative correlation between consumption and hours.

Thus, the view that intermediation shocks are the *only* source of fluctuations seems inconsistent with the *unconditional* moments reported for U.S. data. Essentially, the data display positive comovement of series, and models driven by variations in the returns to savings, such as intermediation shocks, produce negative comovements.

This does not imply, however, that intermediation shocks are unimportant; they may be one of many factors contributing to aggregate fluctuations. To identify the effects of these shocks, we use VAR techniques. As always, the difficult aspect of this exercise is the identification of intermediation shocks. Using our theory model as a guide, we look at various proxies for these shocks to isolate the banking-channel aspect of these policies. There is some support for the theoretical predictions of intermediation shocks: Periods of financial crunches and/or tight credit create some substitution toward consumption of nondurables and away from expenditures on consumer durables and investment.

Thus, models that incorporate intermediation shocks will have to contain mechanisms that counterbalance the fundamental forces of substitution in order to match aggregate observations. This motivates us to consider economies in which there are multiple sources of fluctuations, in particular, credit and technology shocks. With this structure, we allow for a fairly rich interaction between these two sources of uncertainty. We estimate the relative variability of the credit shock as well as its response to technology shocks using a simulated method-of-moments routine. These mixed economies match unconditional observations better, but *only* if the intermediation shocks are of secondary importance. Again, the key point is that intermediation shocks induce substitution and create volatile capital unless they are sufficiently insignificant.

2. INTERMEDIATION AND STOCHASTIC CAPITAL ACCUMULATION

In this section, we evaluate an economy in which the return to saving through an intermediary is stochastic. We first describe the decision problem for a representative agent and then discuss equilibrium.

2.1. Households

Consider the dynamic optimization problem of a household with wealth W facing an uncertain return on deposits made to an intermediary. Let r denote the current

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return (principal plus interest) on savings and let r' denote the future (uncertain) return. The current return r is part of the specification of the state space because it may contain information useful for predicting r', the return on current saving. The value function for the household solves the following functional equation:

$$v(W, r) = \max_{s,n} u(W + wn + \pi - s, 1 - n) + \beta E_{r'} v(r's, r'). \tag{1}$$

The household chooses a level of employment n and an amount of savings s in each period, given (W, r). Consumption by the representative household equals assets plus labor income plus profits π from the operation of the firms, less the amount of gross savings. Current utility flows depend on both consumption and hours worked. We assume that $u()$ is strictly increasing and strictly concave in both arguments.

2.2. Intermediaries

Intermediaries take deposits from households and make loans to firms to finance next period's capital. Let r^L be the gross loan rate (principal plus interest), D be the total deposits at the intermediary, and L be its loans, so that the profits of the intermediary in any period are

$$r^L L - rD. \tag{2}$$

The key issue in the description of the intermediary is the relationship between loans and deposits, that is, the intermediation technology. The usual specification of the stochastic growth model essentially assumes that loans equal deposits, so that the process of intermediation is not a source of interesting economic phenomena. In fact, intermediaries are a rich center of activity involved in the screening and monitoring of loans and the provision of transaction services. As a consequence, the link between deposits and loans reflects both regulatory restrictions and informational problems.

In general, one might consider a fairly complex model of the intermediation process in which this sector of the economy utilizes capital and labor in the process of creating new capital from current savings.[6] Our goal is to investigate the effects of shocks to this intermediation technology from regulatory actions, technological advance, and so forth. Hence, we simplify the intermediation technology to

$$L = \theta D, \tag{3}$$

with $\theta \in [0, 1]$. So $(1 - \theta)$ represents the fraction of deposits utilized in the intermediation process. Stochastic variations in θ then represent shocks to the intermediation process.

One interpretation of (3) is that a fraction $(1 - \theta)$ of deposits must be held as reserves. If we assume that the net return on reserves is zero, then profits of the intermediary per deposit would be

$$r^L \theta - r. \tag{4}$$

With competitive intermediaries, fluctuations in reserve requirements would be reflected in the gap between loan and deposit rates.[7]

As is well understood, government regulation of intermediaries extends well beyond the presence of reserve requirements, and variations in these regulations are another source of fluctuation in the intermediation process. In the United States, there have been restrictions imposed on both the assets (credit restrictions) and liabilities (deposit-rate restrictions) of intermediaries. As discussed by Owens and Schreft (1993) and others, there were periods during the 1960's in which massive disintermediation occurred as banks were unable to compete for funds, leading to a period of severely tight credit. Introducing the relevant regulations and differences across intermediaries that are part of the disintermediation story are beyond the scope of this paper. Still, one could argue that these periods of binding regulations effectively reduced the efficiency of the intermediation process modeled here as a reduction in θ.

Another source of variation in θ stems from technological advance in the intermediation process. The process of loan evaluation certainly has evolved over time, through stochastic technological advance in information services. In this case, variations in θ represent changes in total factor productivity in the intermediation process.

Finally, variations in the efficiency of the intermediation process arise from incentive models that effectively tie θ to the underlying state of the economy. From the perspective of these theories, changes in θ are not exogenous but instead are linked to variations in total factor productivity and the stock of capital. As we shall see, this alternative view requires a slightly different type of quantitative analysis.

In the incentive-based theories of intermediation, studied, for example, by Bernanke and Gertler (1989), and Bernanke et al. (1998), 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

$$k_{t+1} = (\kappa - h_t\gamma)i_t, \tag{5}$$

so that the capital stock in period $t+1$ depends on period t investment, i_t, times the return per unit investment.[8] 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.

2.3. Firms

Firms in this economy have a technology given by $AF(k, n)$, where A represents the state of total factor productivity and $F(k, n)$ is assumed to be strictly increasing

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and strictly concave. A typical firm hires workers at a wage of w and rents capital from the intermediary at a rate of r^L.[9] Capital depreciates at a rate of $\delta \in (0, 1)$ in use. The firm's first-order conditions for the choice of labor and capital are given by

$$AF_n(k, n) = w \tag{6}$$

and

$$AF_k(k, n) + (1 - \delta) = r^L. \tag{7}$$

2.4. Equilibrium Analysis

Using the zero-profit condition for the intermediary along with the firm's factor demand functions in the first-order conditions for the consumer's choice problem (1) yields the following system of equations:

$$\frac{u_l(c_t, 1 - n_t)}{u_c(c_t, 1 - n_t)} = A_t F_n(K_t, n_t) \tag{8}$$

$$u_c(c_t, 1 - n_t) = \beta E u_c(c_{t+1}, 1 - n_{t+1})[A_{t+1} F_k(K_{t+1}, n_{t+1}) + (1 - \delta)]\theta_t \tag{9}$$

$$c_t + I_t = A_t F(K_t, n_t) + (1 - \delta)K_t. \tag{10}$$

Equation (8) is the static intratemporal decision of the household, which links the marginal rate of substitution between consumption and leisure to the marginal product of labor. The Euler equation is given in (9), where the return on deposits, r^L, has been replaced by the marginal product of capital at the representative firm and θ_t, the current intermediation shock. Here, the expectation is over (A_{t+1}, θ_{t+1}) given (A_t, θ_t). The final equation in the system is the resource constraint that links consumption and investment to the flow of output. Note that the evolution of the capital stock is influenced by the intermediation shocks since K_{t+1} is the amount of loans through the intermediary, while output less consumption equals deposits or investment, I_t.

From the intermediation technology, $K_{t+1} = \theta_t I_t$, so that all capital is intermediated each period.[10] This is because we have modeled the intermediary as a one-period entity. We argue in the next section that our qualitative results obtain even if only new investment flows are intermediated.

The effects of intermediation shocks in this economy can be deduced from this system of equations. From (9), an increase in θ_t raises the return to investment and thus induces substitution away from current consumption. With the capital stock predetermined, the reduction in consumption implies that employment will increase to maintain (8). This will, in turn, increase output. Hence, as we shall see, the impact effect of an intermediation shock is to move output, investment, and employment in one direction and consumption in the other.

3. QUANTITATIVE ANALYSIS

3.1. Calibration

Our analysis of this system follows King et al. (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 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 that the production function is Cobb-Douglas with constant returns to scale: $y_t = A_t K_t^{\alpha} n_t^{1-\alpha}$.[11]

The parameterization of the economy is quite standard and again follows King et al. (1988) to facilitate a comparison of results. Labor's share in national income is used to calibrate the production function: that is, $1 - \alpha = 0.65$.[12] The parameter υ in the utility function is set so that the average amount of time allocated to work is 0.2. We look at a quarterly model and parameterize it so that the annual rate of depreciation is 10% and the steady-state annual real rate of return is 6.5%.

There are two parameters that we add to this model: the standard deviation, σ_θ, and the serial correlation of the intermediation shock, ρ_θ. At this point, the standard deviation of the intermediation shock is set at the same level as the total factor productivity shock of King et al. (1988).[13] As long as our interest is in understanding the pattern of correlations produced by this type of disturbance in isolation, the magnitude of its standard deviation is not critical. The serial correlation of the intermediation shock is used as a treatment variable.

3.2. Results

We summarize the behavior of the economy through a variety of moments and impulse response functions. In addition, we compare the model economy against relevant 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 by King et al. (1988) as our benchmark. The data are linearly detrended so that it can be compared to the implications of our (trendless) model.

Note though, as in Greenwood et al. (1988), that the capital stock series derived for the United States is not consistent with any model, such as ours, with shocks to the accumulation process. To deal with this problem, we create a capital stock series using the standard national income and product account (NIPA) procedure: by adding undepreciated capital to investment to create a measure of new capital, denoted by Kn_t, and termed the NIPA capital stock in a later discussion.

The quantitative aspects of this economy are summarized in Tables 1 and 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 i.i.d.

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TABLE 1. IID shocks

	(A) Basic moments								(B) Other moments			
	Corr. with Y contemporaneous			Standard deviation relative to output			Statistics for Y		Correlation		SD ratios	
Shocks[a]	C	Hours	Inv	C	Hours	Inv	SD	SC	(C, Inv)	(C, Hrs)	K/Y	KN/Y
TFP	0.38	0.98	0.99	0.19	0.75	4.49	0.0146	0.017	0.24	0.2	0.33	0.33
INT	0.57	−0.28	−0.18	3.05	2.09	9.45	0.0044	0.67	−0.92	−0.95	5.43	3.6

[a] TFP = technology shocks, INT = intermediation shocks to new investment plus undepreciated capital.

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TABLE 2. Serially correlated (0.95) shocks

	(A) Basic moments								(B) Other moments			
	Corr. with Y contemporaneous			Standard deviation relative to output			Statistics for Y		Correlation			
Shocks[a]	C	Hours	Inv	C	Hours	Inv	SD	SC	(C, Inv)	(C, Hours)	K/Y	KN/Y
TFP	0.91	0.69	0.87	0.76	0.35	2.45	0.042	0.96	0.59	0.33	1.0	1.0
INT	0.8	−0.31	−0.06	1.66	0.84	3.72	0.135	0.98	−0.65	−0.82	3.66	1.6
INT-Inv	0.43	0.6	0.74	0.9	0.81	4.4	0.019	0.97	−0.29	−0.46	2.29	1.63
U.S. data	0.85	0.07	0.6	0.69	0.52	1.35	0.056	0.96	0.66	0.36		0.376

[a] TFP = technology shocks; INT = intermediation shocks to new investment plus undepreciated capital; INT-Inv. = intermediation shocks to new investment only; U.S. data for basic moments = linearly detrended, quarterly data, moments as reported by King et al. (1988); U.S. data for other moments = lineary detrended, quarterly data, 1959:3–1986:4, from the FRED database maintained at the Federal Reserve Bank of St. Louis, http://www.stls.frb.org/fred/data/. The capital stock series was obtained from Citibase for the 1959–1984 period.

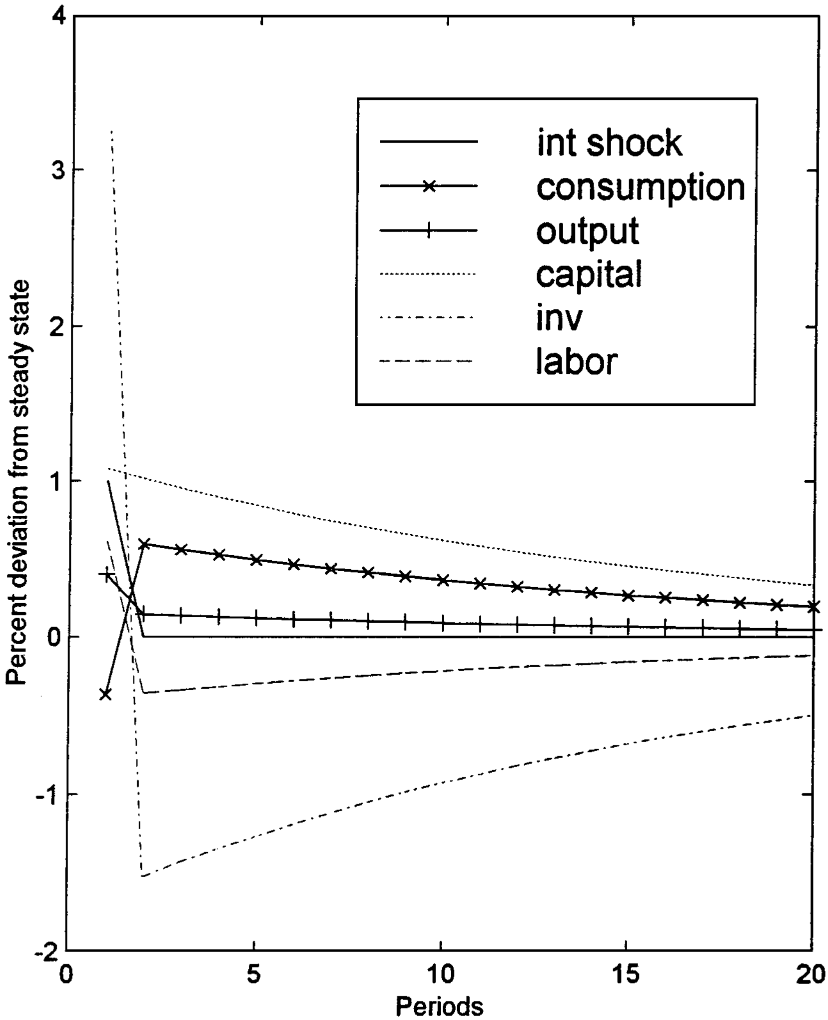

Figure 1. IID intermediation shock impulse response function.

intermediation (INT) shocks. For Table 1 the shocks are assumed to be serially uncorrelated whereas for Table 2 the shocks have a serial correlation of 0.95.[14] The columns of this Table 2 represent various statistics for key macroeconomic variables computed in our model economy.

As is well understood, the real business-cycle model with i.i.d. shocks (see the first row of Table 1A) corresponds in some but not all ways to U.S. data observations. 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,

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from the first row of Table 1A, that the standard model has little endogenous propagation of shocks since the serial correlation in output is quite small.

The treatment with intermediation shocks (denoted INT) is reported in the second row of Table 1A. Here we see that there is substantial serial correlation in output of 0.67 even though the intermediation shocks are serially uncorrelated. Though not shown in the table, this serial correlation appears in consumption, investment, and hours as well.

Additional moment implications are summarized in Table 1B. For the TFP treatment, the standard deviation in the NIPA capital stock is about one third that of output. In contrast, the standard deviation of the NIPA capital stock is over 3 times that of output for the INT treatment. For the postwar U.S. economy, the capital stock, as currently measured in the NIPA, has a standard deviation about 0.376 of that for output.

As indicated in Table 1A, the intermediation shock treatment also produces some counterfactual implications for the behavior of consumption and investment. In particular, whereas 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 −0.92. 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 (correlation with output of 0.6) in contrast to observation.[15]

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. To produce this extra output, employment rises above its steady-state level. Second, consumption falls 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 by King et al. (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 1A and 1B 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. Thus, as emphasized in our introduction, models driven by intermediation shocks display substitution that is not present in models driven by TFP shocks.

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Table 2A and 2B summarize the case in which the technology and intermediation shocks are serially correlated. Here, we also present evidence for the U.S. economy obtained by the linear detrending of quarterly data, 1948–1986.[16]

For the standard real business cycle (TFP treatment), we see many basic features of the business cycle emerge. In contrast to Table 1A, the model also exhibits substantial serial correlation in output due to the correlated technology stocks.

From the second row of Table 2A, in response to 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.[17] Finally, as in the case of uncorrelated shocks, employment remains negatively correlated with output.

Additional moments are reported in Table 2B. Here we find that many of the counterfactual implications of the INT treatment reported in Table 1B remain even in the presence of serially correlated shocks. In particular, consumption and investment as well as consumption and hours remain negatively correlated. Further, the NIPA capital stock is still more volatile than output. As in the case of transitory shocks, these negative comovements reflect two forces: the response of the economy to the initial shock and the transition dynamics.

4. ADDITIONAL TREATMENTS

Thus far, our results indicate that intermediation shocks produce a negative correlation between consumption and investment and create excessive volatility of the capital stock relative to output. These two features of the model are clearly at odds with observed *unconditional* time series.

As discussed by Greenwood et al. (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).

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

$$y_t = a_t \alpha k_t + (1-\alpha) n_t. \qquad \textbf{(11)}$$

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 i.i.d. INT shocks because of the transitional dynamics of our economy.

There are two ways to deal with the inability of the model to match the data. One is to consider alternative versions of the model and the other is to look at conditional rather than unconditional moments of the data. In this section, we consider variations of the model to deal with these "problems." These variations also are of interest because they illuminate some additional properties of an economy with intermediation shocks. In the next section, we take an alternative approach and compare the properties of the model against the impulse responses from intermediation shocks in U.S. data.

4.1. Investment Shocks

In the baseline model, the intermediation shocks affect the entire stock of capital rather than the new flow of investment. Here we consider an alternative formulation in which the only new investment flows are subject to the shock. This version of the accumulation equation is used, for example, by Carlstrom and Fuerst (1997) in their costly state verification models of credit market imperfections.

In this case, the accumulation equation becomes

$$K_{T+1} = K_t(1-\delta) + I_t\theta_t. \qquad \textbf{(12)}$$

With this formulation, variations in θ_t will have large effects on the margin (through investment) but will not create the large wealth effects that arose in the baseline model.[18] Given this, one would expect the economy to be more responsive to temporary variations in the returns to investment activity.

The row labeled INT-Inv in Table 2A pertains to a simulation of our model with this alternative accumulation equation and serially correlated (0.95) intermediation shocks. From this table, consumption, investment, and hours are all positively correlated with output. Further, the model displays consumption smoothing. Table 2B, however, shows that, in terms of other moments, the model's implications are not consistent with observations for the U.S. economy.[19] In particular, consumption remains negatively correlated with both hours and investment. Further, the NIPA capital stock is more volatile than output, in contrast to observation. From the impulse responses for this treatment, the response to the intermediation shock, relative to the case in which the shock affects the entire capital stock, is certainly muted. Nonetheless, the forces of substitution that dominate both the impact and the transition are present. The only exception is that the correlation of investment and output is positive for this treatment. From the impulse response functions, investment stays above steady state longer (to take advantage of the high productivity of investment) when the accumulation equation is given by (12) and thus is positively correlated with output movements.

4.2. Elastic Labor Supply

One might also 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 i.i.d. intermediation shock in which labor supply was infinitely elastic. The i.i.d. case was chosen because it would create the most intertemporal substitution. The results of this exercise were: (i) The capital stock was still

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more volatile than output and (ii) consumption and investment were negatively correlated.

4.3. Technological Complementarities

Greenwood et al. (1988) "addressed" the problem of negative correlations by allowing 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. However, as argued by Ejarque (1999), their model produces the counterfactual implication that capital is more volatile than output.

Our approach 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). 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.

For our model, the increased activity resulting from the intermediation shocks will create, through the production externality, an endogenous increase in total factor productivity for the individual producer, and this may lead to an increased production of consumption goods.[20] 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.

In particular, suppose the agent's production function is given by

$$Y_t = A_t K_t^{\alpha} n_t^{1-\alpha} \bar{Y}_t^{\gamma}, \tag{13}$$

where $\bar{Y}_t$ 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 0.23, as discussed by Baxter and King (1991).[21] 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 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, as discussed in detail by Baxter and King (1991).

Our results indicate that for $\gamma = 0.23$, 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 the production externality above this level ($\gamma = 0.375$), combined with infinitely elastic labor supply, implies that consumption is smoother

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than output and consumption, investment, and labor productivity are all positively correlated with output.[22] Still, the standard deviation of capital to output is about 1.5, well above that observed in U.S. data.

5. EVIDENCE FROM VAR'S

Our analysis thus far compares our model's implications against unconditional U.S. data. This is appropriate if one takes the extreme position that fluctuations are largely the consequence of intermediation shocks. A more reasonable position is that intermediation shocks are one of many sources of fluctuations contributing to aggregate behavior. Thus, to properly evaluate the implications of our model, we must isolate those shocks.

As always, identification is key. Here we consider a variety of (imperfect) measures of the intermediation shocks that drive our model. First, we consider the "credit crunch" dates identified by Owens and Schreft (1993, p. 4) as a "period of sharply increased nonprice credit rationing." These were periods in which funds were withdrawn from the intermediation process which, assuming that banks provide special services, yields an increase in the costs of capital accumulation. More broadly, we also consider the so-called "Romer dates," which, as discussed by Romer and Romer (1989, p. 134), identify "times when concern about the current rate of inflation led the Federal Reserve to attempt to induce a recession." By focusing on these events, Romer and Romer are trying to isolate times in which the Fed moved independently rather than in response to some other shocks that would influence real output. For our empirical analysis, while we make use of these Romer dates, we *include the federal funds rate in our equation system* to distinguish the credit channel from the effects of monetary policy acting through interest rates directly. Overall, our intention is to see whether there is some evidence of the substitution between consumption and investment predicted by our model during periods of changes in the cost of intermediation.[23]

In fact, there is some evidence of this substitution even in the raw data. In 1936–1937, reserve requirements were increased in the United States leading to a sharp recession. From 1937–1938, investment fell by $17.6 billion ($1992) and durable goods expenditures fell by an additional $9 billion (about 20% of total). In contrast, expenditures on nondurables increased in this period and expenditures on services fell by only $7 billion (2.8% of total).

Further, as discussed by Owens and Schreft (1993), the second and third quarters of 1966 are commonly viewed as a credit crunch period. This was a time of constrained loans and a period in which Regulation Q was binding, thus causing disintermediation. The behavior of real fixed investment and consumer expenditures during this period are quite interesting. Starting from the first quarter of 1966, real fixed investment fell until the second quarter of 1967. The overall reduction was about 15%. At the same time, consumer durable expenditures fell by about 5% in the second quarter of 1966, rebounded a bit during the year but remained low until the second quarter of 1967. Thus, as suggested by our model, durable

Table 3. VAR results: F-tests on joint significance[a]

Independent variable	Dependent variable: dur		Dependent variable: cnd	
	F-statistic	Significance	F-statistic	Significance
dur	2.8	0.009	1.14	0.39
cnd	1.97	0.06	27.4	0.0
ffr	0.7	0.69	0.85	0.56
romerdums	3.15	0.004	1.34	0.24

[a] The system included output and the capital stock and eight lags of all variables.

expenditures by firms and households were heavily hit by the "credit crunch" of 1966. However, expenditures on consumer services and consumer nondurables grew throughout this period.

To investigate these points further, we constructed a VAR system with five variables: consumer and producer durable expenditures (dur), consumer expenditures other than those on durables (cnd), output (y), capital (k), and the federal funds rate (ffr). The first four variables were linearly detrended logs of the per capita values. The data are quarterly from 1958:4 to 1989:3.[24]

Our main interest in this system is in the behavior of dur and cnd in response to intermediation shocks. Output was included in the system to capture the effects of the intermediation process, which influence dur and cnd through output. Further, including output allows us to evaluate the empirical counterpart of Figure 1. The capital stock was included because it represents one of the state variables in the theoretical model. We included eight lags of each variable in the system.

For this system, we use Romer dates (1947:4, 1955:3, 1968:4, 1974:2, 1978:3, 1979:4) augmented by the credit crunch dates suggested by Owens and Schreft (1993) as our indicator of intermediation shocks.[25] We recognize that during periods of tight credit, restrictive monetary policy could be influencing dur, cnd, and y. To stress an important point raised earlier, because we do not include restrictive monetary policy as an intermediation shock, we included the federal funds rate in the VAR to control for these effects.[26] If anything, including the federal funds rate might include some of the effects of the intermediation shock that we are attempting to isolate. The VAR system included eight lags of the augmented Romer dummies.

The coefficient estimates indicate that the dummies have an influence on dur that is consistent with the theory we have presented: In periods of adverse credit conditions, durable expenditures fall. All of the eight coefficients are negative and three are significant at the 10% level. The coefficient estimates of this effect for consumer nondurables (cnd) are also negative, though only one is significant at the 10% level. The F-tests, presented in Table 3, indicate that the augmented Romer dummies jointly are significant in affecting dur: the F-statistic had a value

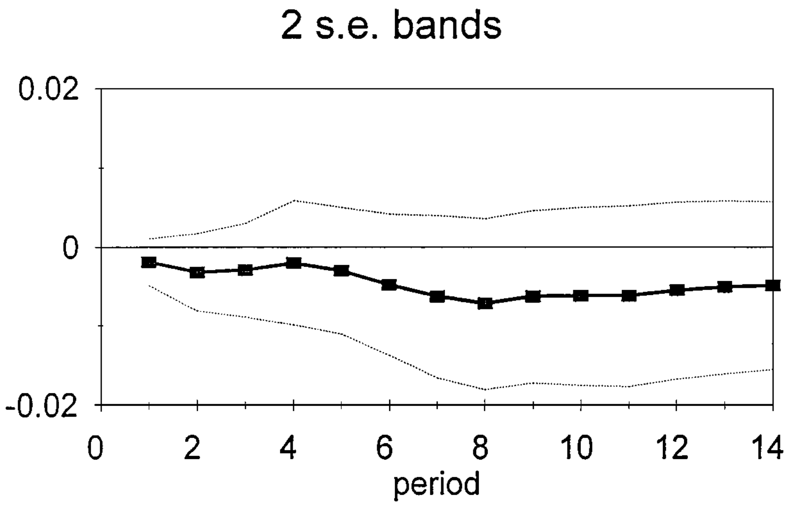

FIGURE 2A. Impulse response: nondurables.

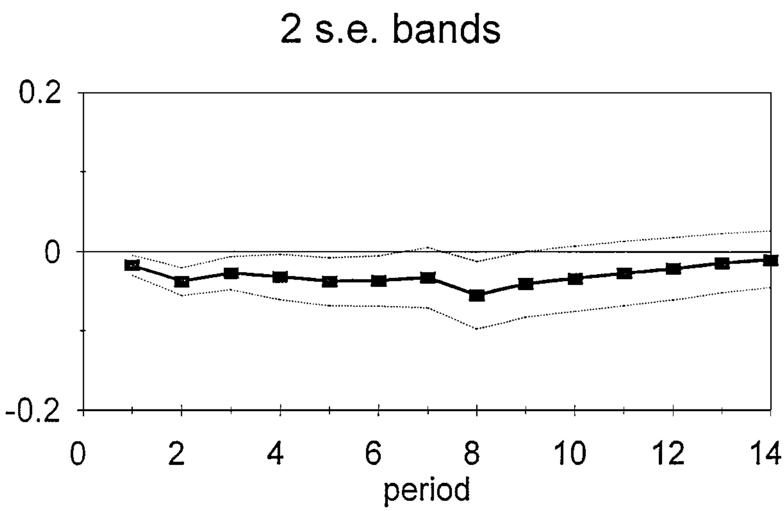

FIGURE 2B. Impulse response: durables.

of 3.146 and this was significant at a 0.0044 level. In contrast, the F-statistic on the augmented dummies in the consumer nondurable equation was 1.34 with a significance level of 0.239.

Figure 2 presents the impulse response from a temporary intermediation shock for both dur and cnd. Note that in producing these impulse responses, the augmented Romer dummy variables were in effect eight quarters. Thus the shock was more permanent than that underlying Figure 1. Nonetheless, the substitution effects

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predicted by the theory are, to some extent, evident in the data. In particular, we see that, in response to a shock, expenditure on durables falls and this reduction is statistically significant.[27] For consumer expenditures on services and nondurables, there is also a reduction in response to the shock but this reduction is not significant. In fact, the standard error bands are large enough that we cannot reject either an increase in cnd or a decrease. Further, the response is small enough that, in effect, there is apparently little response of consumption to these shocks.

Further evidence along these same lines is presented by Loungani and Rush (1995) who look at the effects of changes in reserve requirements on aggregate real variables. As illustrated in their Figure 1, there have been substantial changes in reserve requirements during the post-WWII period. To the extent that reserve requirements represent a tax on the flow of resources through intermediaries, variations in these requirements will produce the effects described in our model. Loungani and Rush look at the effects of reserve requirements on the growth of real GNP and investment (private domestic investment plus consumer durables). In a VAR framework, which includes measures of monetary policy, they find that investment is significantly reduced in periods of high reserve requirements. The effects on output are much smaller and in some cases statistically insignificant.

6. MULTIPLE SOURCES OF FLUCTUATIONS

Finally, we consider a setting in which both real and intermediation shocks exist. Since there is some weak evidence of the effects of the intermediation shocks model, it is of interest to investigate a setting in which both shocks coexist and interact, as suggested by the theoretical analysis of Bernanke and Gertler (1989) and others.[28]

6.1. Coexistence of TFP and Intermediation Shocks

Consider first a version of our baseline economy in which both real and intermediation shocks coexist and are, by construction, uncorrelated. Assume further that the technology shock has a serial correlation coefficient of 0.95. Given this structure, we estimated the standard deviation of the intermediation shock (σ_θ) and its serial correlation (ρ_θ) to minimize the distance between actual and simulated moments. The estimation exercise focused on two key moments traditionally used to evaluate dynamic stochastic macroeconomic models: corr(C, Y) and corr(I, Y) without the restrictions imposed by any one of the theories of credit market imperfections.[29]

As summarized in Table 4A under the treatment labeled TFP and INT, we find that, indeed, mixing the intermediation shocks with technology shocks "improves" the fit of the model. The criterion is minimized at $\sigma_\theta = 0.0007$ and $\rho_\theta = 0.9782$. In fact, at these values the model produces correlations between consumption and output and between investment and output that match the correlations of U.S. data.

However, at these parameter values the model produces counterfactual predictions. In particular, as summarized in Table 4B, the correlation of consumption with investment is 0.089, the correlation of consumption and hours is -0.30 and

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TABLE 4. Mixed models

	(A) Basic moments								(B) Other moments			
	Corr. with Y contemporaneous			Standard deviation relative to output			Statistics for Y		Correlation		SD ratios	
Treatment[a]	C	Hours	Inv	C	Hours	Inv	SD	SC	(C, Inv)	(C, Hours)	K/Y	KN/Y
TFP and INT	0.85	0.24	0.6	1.02	0.44	2.49	0.05	0.97	0.09	−0.31	2.01	1.08
Spillover	0.82	0.27	0.6	1.01	0.48	2.67	0.061	0.97	0.046	−0.32	1.84	0.84

[a] TFP and INT: independent, serially correlated TFP and INT shocks: $\rho_{AA} = 0.95$, $\rho_{A\theta} = 0$, $\rho_{\theta\theta} = 0.98$, $\rho_{\theta A} = 0$, $\sigma_A = 0.0075$, $\sigma_\theta = 0.0007$. Spillover: $\rho_{AA} = 0.95$, $\rho_{A\theta} = 0$, $\rho_{\theta\theta} = 0$, $\rho_{\theta A} = 0.139$, $\sigma_A = 0.0075$, $\sigma_\theta = 0$.

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the standard deviation of the NIPA capital stock relative to output is 1.07.[30] Essentially this model has many of the counterfactual implications of the others explored above.

Further, the moment-matching exercise implies a standard deviation of the intermediation shock that is 10% of the technology shock. Evidently, to match the data, the intermediation shock must be accorded a relatively minor role.

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. However, this requires a parameterization with an extremely small role for the intermediation shock.[31]

6.2. Spillovers: TFP and INT Interactions

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, induces further monitoring and thus reduces the productivity of the intermediation process. Thus, initial productivity shocks are propagated through the intermediation process.

To study the propagation role of intermediation shocks, we constructed an economy in which a serially correlated technology shock induces comovement in the intermediation shock. To do so, we set the independent variation in the intermediation shock at zero and assumed that intermediation shock in period $t+1$ is proportional to the technology shock in period t: $\theta_{t+1} = \rho_{\theta A} A_t$. So, in this formulation, the mechanism described by Bernanke and Gertler, in which technology shocks in one period are propagated by reducing monitoring costs in the future, is captured by a single parameter, $\rho_{\theta A}$. We then estimated this parameter by finding the value of $\rho_{\theta A}$ that minimized the same criteria as described before.

The results are reported in Table 4A and 4B under the treatment termed Spillover. In this case, we estimated $\rho_{\theta A} = 0.139$. For this parameter value, the simulated moments were very close to those observed in U.S. data: $\text{corr}(C, Y) = 0.8249$ and $\text{corr}(I, Y) = 0.6$. However, once again, the model was inconsistent with other observations. In particular, as indicated in Table 4B, the consumption hours correlation is still negative (-0.317) and consumption is only slightly correlated with investment (0.0457). In contrast to previous cases, the standard deviation of the NIPA capital stock is below that of output but still too high relative to observations.

With these estimates, the standard deviation of the TFP shock is over 7 times that of the intermediation shock "induced" through $\rho_{\theta A} = 0.139$. In this sense, once again, the model is closer to the data only if variations in the costs of intermediation are relatively small.

7. 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. To do so, 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. Further, interest rates and output are positively correlated in our simulations.

These implications are not consistent with observations in unconditional U.S. data. However, we do see some evidence of the predicted negative comovement between consumption and investment at the start of "credit crunch" periods. This point can be seen from raw data and is more apparent from the impulse response functions that we estimate.

Drawing upon this evidence, we extend the model to allow for different mixtures of intermediation and productivity shocks. Using a simulated method-of-moments algorithm, we estimate features of the intermediation shock process. Although the fit of the model certainly improves, it remains inconsistent with some features of U.S. data.

This leads us to the conclusion that if the intermediation shock model succeeds in explaining aggregate fluctuations, other features will have to be added to the model in order to reduce the patterns of substitution between consumption, investment, and employment created by these shocks. Put differently, these models with intermediation shocks fit the data best when these shocks are of secondary importance. From this perspective, one can understand the results reported by Bernanke et al. (1998), where a financial accelerator model is specified and shown to produce magnification and propagation of underlying shocks. Those results appear to require some combination of sticky prices, capital adjustment costs, and a monetary policy that seeks to stabilize interest rates—all forces that work together to offset substitution effects.[32]

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 nondurable 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, financial flows as modeled here are associated directly with capital accumulation. The other aspects of intermediaries, particularly in the provision of working capital and the financing of inventory holdings, are worth investigating within this framework as well.[33]

NOTES

1. See Gertler (1988) for a survey of this work and Bernanke et al. (1996) for a recent synthesis of theoretical and empirical developments.

2. Fuerst (1995) has a similar motivation but his approach and emphasis are much different. In particular, Fuerst focuses on the propagation of technology shocks through net-worth effects and does

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not directly relate the properties of his model to U.S. data. Since the first version of this paper, Carlstrom and Fuerst (1997) and Bernanke et al. (1998) have appeared, which make progress on the quantitative aspects of financial contracting problems in dynamic general equilibrium models. As our analysis proceeds, we discuss differences in approach and results with these alternative models.

3. Greenwood et al. (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 is made clear. In particular, our empirical work tries to isolate the effects of intermediation shocks and our mixed models look at the interaction between total factor productivity (TFP) and intermediation shocks. Greenwood et al. (1997) analyze a related model in which there are equipment-investment-specific technology shocks and focus mainly on low-frequency implications. 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 or the implications of the model for business cycles.

4. Put differently, the more abstract structure allows us to generate more general insights, in contrast to the results obtained through the intensive study of a particular model of credit market imperfections.

5. Similar effects are described by Greenwood et al. (1988) and by Christiano and Eichenbaum (1992) for money shocks.

6. For a recent example along these lines, see Aiyagari et al. (1995).

7. Chari et al. (1995) look at variations in reserve requirements as well in their study of the role of intermediaries during periods of inflation. Loungani and Rush (1995) look at the implications of reserve requirement changes on output and investment. Here, we look at broader implications of intermediation shocks.

8. Fuerst (1995) provides a version of the stochastic growth model with a static incentive problem. In equilibrium, the capital accumulation equation is similar in that the costs of monitoring are in terms of capital. In this model, variations in technology lead, through the optimal contract, to variations in the probability of monitoring and thus in the capital cost of intermediation.

9. This capital comes from the deposits made in the previous period.

10. We report later on an alternative specification in which only new investment flows are intermediated.

11. In contrast, Greenwood et al. (1988) assumed that $U(c, n) = u[c - G(n)]$ where $u()$ is strictly increasing and strictly concave and $G()$ 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.

12. Here, in fact, we follow most of the real business-cycle literature and set labor's share at 0.65 instead of the smaller share assumed by King et al. (1988).

13. The assumed standard deviation is 0.0075.

14. We choose this degree of serial correlation to match that observed in the data for the TFP treatment.

15. 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 postwar U.S. data imply a slightly negative correlation between output and the ex post real rate of interest on 3-month Treasury Bills.

16. To be precise, the evidence for the United States in Table 2A comes from King et al. (1988) whereas the evidence in Table 2B comes from the FRED database maintained at the St. Louis Federal Reserve Bank, for the 1959:3–1986:4 period.

17. One might think that this is a consequence of the amount of serial correlation in the intermediation shock because 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 0.98.

18. In fact, (12) is also the correct specification for the analysis of an investment tax credit on capital accumulation, though the model then would have to be supplemented to include a government budget balance condition.

19. Interestingly, these issues are not apparent in the discussion by Carlstrom and Fuerst (1997) as they focus more on the hump-shaped response of output and spending components to a technology shock. Some elements of substitution are evident in their Figure 2.

20. Greenwood et al. (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.

21. Cooper and Haltiwanger (1996) provide an extensive discussion of estimates of this parameter.

22. Even for this high value of γ, the steady state is still saddle-path stable. See the discussion by Farmer and Guo (1994) about the relationship between alternative parameterizations of this economy and stability.

23. From our review of the literature, there are no studies that look at a measure of intermediation shocks on the components of spending. Bernanke and Gertler (1995) report a large number of impulse response functions for monetary innovations. Interestingly, they find no negative comovement in consumption and investment. Loungani and Rush (1995) report impulse response functions for shocks to reserve requirements but focus only on the response of investment.

24. The data series are from Citibase.

25. By focusing on these dates, we can isolate the effects of intermediation shocks and distinguish them from sector-specific technology shocks, as in Greenwood et al. (1988).

26. Thus, our results should be contrasted with impulse responses produced by monetary innovations, such as those reported by Bernanke and Gertler (1995). From their Figure 3, we do not see the substitution between durable and nondurable expenditures predicted by our theory and weakly confirmed in our findings.

27. That is seen by the 2 standard error bands around the impulse response.

28. Here we present results that mix TFP shocks and intermediation shocks using (10) as the accumulation equation. Our basic conclusions hold even when we use (12) as the accumulation equation.

29. That is, we found the parameters to minimize the unweighted sum of the percent deviation of simulated from actual moments.

30. To stress an important point, this measures the capital stock using the NIPA procedure on our simulated data and is thus comparable to statistics computed from the U.S. NIPA.

31. For this parameterization, the other moments of the model were quite close to those reported for the serially correlated technology shock case.

32. Discussions with Simon Gilchrist on this point were quite helpful.

33. Cooper and Corbae (1997) present a model of financial fragility in which loans provide working capital.

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