Macroeconomic Dynamics, **18**, 2014, 1069–1090. Printed in the United States of America.
doi:10.1017/S1365100512000831

ECONOMIES OF SCALE IN BANKING, CONFIDENCE SHOCKS, AND BUSINESS CYCLES

SCOTT J. DRESSLER AND ERASMUS K. KERSTING
Villanova University

Equilibrium indeterminacy due to economies of scale (ES) in financial intermediation is quantitatively examined in a monetary business-cycle environment. Financial intermediation provides deposits that serve as a substitute for currency to purchase consumption, and depositing decisions are susceptible to nonfundamental shocks to confidence. The analysis considers various assumptions on nominal rigidities and the timing of deposit decisions. The results suggest that indeterminacy arises for small ES, and the resulting confidence shocks qualitatively mimic monetary shocks. A calibration exercise concludes that U.S. economic volatility from this nonfundamental source has increased over time while volatility from fundamental sources has decreased.

Keywords: Financial Intermediation, Inside Money, Indeterminacy, Business Cycles

1. INTRODUCTION

The role of extrinsic uncertainty (*animal spirits*, *sunspots*, etc.) as a source of economic fluctuations continues to generate interest.[1] If the economy can fluctuate independent of fundamentals, then there may exist a role for policy makers in reducing these fluctuations and improving welfare. Research in this literature has generally focused on externalities in the production sector as a source of extrinsic uncertainty. This paper investigates a decidedly different source: financial intermediation. Hughes and Mester (1998) and others find empirical evidence of significant individual-bank level economies of scale (henceforth, ES) for banks of all asset sizes.[2] Similarly to production externalities, ES can potentially deliver local indeterminacy in general equilibrium models by giving rise to self-fulfilling beliefs. Nonetheless, there has been little quantitative research on the impact of extrinsic uncertainty from financial intermediation in DSGE environments.

The economic environment studied here features multiple media of exchange, as in Freeman and Kydland (2000), and financial intermediaries, similarly to Cooper and Corbae (2002). Consumption in the model can be purchased with currency or capital deposit balances (i.e., checks). Financial intermediaries accept deposits from households and offer loans to firms, but also offer check-writing services

Address correspondence to: Scott J. Dressler, Department of Economics, Villanova University, 800 Lancaster Avenue, Villanova, PA 19085, USA; e-mail: scott.dressler@villanova.edu.

 1365-1005/13

and thereby provide an endogenously determined broad monetary aggregate.[3] It is assumed that intermediaries possess a technology such that the cost of managing deposits is a decreasing function of aggregate deposits. This technology can become a source of indeterminacy in a perfectly competitive intermediary sector when these changes in costs influence the effective return on deposits. In particular, allowing the return on deposits to be subject to extrinsic uncertainty implies that the household's composition of money balances, as well as the price level, is also subject to extrinsic uncertainty.

The intuition for how ES in intermediation delivers indeterminacy is straightforward. Starting from a particular equilibrium path, suppose households begin to believe that the deposit holdings of other households will increase (decrease) and are therefore optimistic (pessimistic) about the market returns to deposits. Because households are aware that the depositing decisions of others influence their own cost of deposits, the belief that other households will increase (decrease) their deposit holdings induces them to hold more (fewer) deposits, which effectively decreases (increases) the cost of deposits. Therefore, changes in beliefs concerning the size of the deposit market take the form of (self-fulfilling) sunspot shocks.[4]

The impact of indeterminacy arising from financial intermediation is explored in two versions of the model. In the first version, nominal wages are assumed to be rigid and deposits chosen in the current period can purchase current consumption. Given this timing assumption on deposits, the impact of the extrinsic uncertainty induced by ES in intermediation is predominantly nominal. Nominal wage rigidity therefore links the nominal fluctuations to real fluctuations and delivers belief-induced business-cycle responses.[5] In the second version, all prices are assumed to be perfectly flexible and only deposits chosen in the previous period can purchase current consumption. Although the absence of nominal rigidities shuts down the channel through which extrinsic uncertainty impacts the real economy in the previous version of the model, the deposits-in-advance assumption delivers a forward-looking component that impacts real investment, because deposits are composed of physical capital.[6]

The results are as follows. First, with the size of the intermediary sector calibrated to U.S. data, indeterminacy arises for very small degrees of ES in the intermediation sector. Second, because sunspot and monetary shocks both influence the trade-off between deposits (inside money) and currency (outside money), the economy's response to these shocks are qualitatively similar. These results are consistent across both versions of the model and are therefore unaffected by the assumptions placed on nominal frictions or timing of deposits in the environment. Finally, standard deviations of the fundamental and nonfundamental processes were calibrated for both versions of the model so that the predicted volatility of key macroeconomic variables matches postwar U.S. data. This calibration exercise concludes that volatility from nonfundamental sources has increased over time, whereas volatility from fundamental sources such as productivity and monetary policy has decreased.

The results presented here can be related to several works in the literature. With respect to the literature on indeterminacy via production externalities, this paper considers externalities from a different sector (intermediation), which makes a direct comparison rather difficult. Nonetheless, we show that indeterminacy from intermediation is possible in a model with empirically plausible degrees of ES and parameter values, and a standard (constant-returns-to-scale) production technology.[7] With respect to the literature on equilibrium banking crises, this paper shares the same intuition for self-fulfilling beliefs, and the nonfundamental shocks considered here could be interpreted as small-scale crises. However, this analysis assumes that only a portion of the capital stock is intermediated (as opposed to all capital), and is the first to quantitatively assess the degree of ES needed to deliver local indeterminacy and assess the impact of the resulting nonfundamental shocks in a relatively standard business-cycle environment. Finally, Dressler (2011) uses an analytically tractable model with ES in the intermediary sector to study the link between equilibrium indeterminacy and endogenous monetary policy. Dressler (2011) concludes that whenever the monetary authority predetermines the nominal interest rate (e.g., via a backward-looking Taylor rule), it predetermines the market returns of deposits and effectively shuts down equilibrium indeterminacy arising from intermediation for any degree of ES. Although Dressler (2011) assumes a minimal environment in order to analytically establish the link between indeterminacy and predetermined nominal interest rates, this link holds in the decidedly more sophisticated versions of the environment examined here. Although this precludes the analysis considering standard forms of endogenous monetary policy, the model is able to quantitatively assess features of indeterminacy (the sufficient degree of ES, the impact of resulting sunspot shocks, etc.) that cannot be considered in Dressler (2011). In addition, it should be noted that any monetary policy that failed to predetermine the nominal interest rate would accommodate this channel of equilibrium indeterminacy. Because these types of monetary policies either give rise to their own source of indeterminacy [see Carlstrom and Fuerst (2001)] or unnecessarily complicate the analysis, we restrict attention to exogenous monetary policy.[8]

The paper is organized as follows. Section 2 presents the model. Section 3 analyzes the model dynamics. Section 4 concludes.

2. THE MODEL AND EQUILIBRIUM

Two versions of the environment are considered. The first version assumes nominal wage rigidity and that deposits chosen in the current period can be used for current consumption. The second version assumes perfectly flexible prices and that only previously chosen deposits can be used for current consumption. We will refer to these two versions as the rigid wage (RW) and flexible wage (FW) models, respectively. The RW model is laid out in detail, and then the differences in the FW model are described.

https://doi.org/10.1017/S1365100512000831 Published online by Cambridge University Press

2.1. The Rigid Wage Model

Time is discrete and the horizon is infinite. The economy is populated by a continuum of households indexed by $i \in [0, 1]$, which supply differentiated labor; a continuum of industries indexed by $j \in [0, 1]$, which produce differentiated goods and have a large number of perfectly competitive firms within each industry; a large number of financial intermediaries; and a monetary authority. Differentiating households allows the model to exhibit nominal wage rigidity, whereas differentiating goods allows the model to endogenously split consumption between goods purchased with currency and deposits. The model contains enough symmetry to allow the analysis to focus on a representative household i and a single firm in a representative industry j.

Households. The preferences of household i are given by

$$E_0 \sum_{t=0}^{\infty} \beta^t u\left(c_t^i, h_t^i\right), \tag{1}$$

where c_t^i is a composite consumption good, $h_t^i = \int_0^1 h_{jt}^i dj$ is labor supply across industries, and $\beta \in (0, 1)$ is the discount rate.

Household i begins period t with physical capital k_t^i and nominal currency M_t^i. Every household receives a lump-sum transfer T_t of currency from the monetary authority, and buys/sells nominal bonds B_t^i, which are zero in net supply and earn a gross nominal return $1 + R_t$. The household then deposits d_t^i of its capital into a financial intermediary earning a gross real return r_{dt} and lends $a_t^i = k_t^i - d_t^i$ directly to firms earning a gross real return r_t.

Both deposits and currency can be used to purchase consumption. As in the standard cash-in-advance model, previously held currency can costlessly purchase consumption goods. Deposits are transfers of capital to the intermediary and pay interest, but bear a real cost γ for each good purchased. This cost can be interpreted as a per-check processing cost.

To expedite the description of the environment, we now describe how composite consumption gets endogenously separated between goods purchased with currency and deposits. Let composite consumption be given by

$$c_t^i = \min\left(\frac{c_{jt}^i}{2j}\right), \tag{2}$$

where c_{jt}^i denotes household i's consumption of good j.[9] This expression delivers the amount of each type-j good for a given amount of total composite consumption

$$c_{jt}^i = 2jc_t^i. \tag{3}$$

Equation (3) states that goods with index numbers closer to zero (one) make up a relatively smaller (larger) portion of total consumption.[10] Because goods with low index numbers are purchased in small quantities, the check-writing cost γ

https://doi.org/10.1017/S1365100512000831 Published online by Cambridge University Press

associated with using deposits becomes prohibitively expensive and these goods are therefore purchased with currency. Conversely, goods with high index numbers are purchased in large enough quantities that the interest earned on the deposits makes it optimal to pay γ and purchase these goods with checks. Because j has continuous support, there exists a specific good type where the household i is indifferent between making the purchase with currency or deposits because they offer the same return. Denote this good type as j_t^{i*}. In what follows, this critical good index becomes a choice of the household and delivers an endogenous separation between currency and deposit goods.[11] In particular, the use of money balances deliver the conditions

$$\frac{M_t^i + T_t - B_t^i}{P_t} \geq \int_0^{j_t^{i*}} c_{jt}^i dj = j_t^{i*2} c_t^i, \tag{4}$$

$$d_t^i \geq \int_{j_t^{i*}}^1 c_{jt}^i dj = \left(1 - j_t^{i*2}\right) c_t^i, \tag{5}$$

where P_t denotes the price of composite consumption as well as capital (and capital deposits).

Household i is a monopoly supplier of type-i labor, which is sold to all firms. Because labor types are imperfect substitutes in production, households sell their labor in a monopolistically competitive market. Household i sets the nominal wage W_{jt}^i offered to a representative firm from industry j (henceforth, firm j), and supplies labor such that it satisfies firm j's demand taking all prices as given. It is assumed that the household faces a quadratic cost when adjusting its nominal wage as in Rotemberg (1982),

$$\frac{\phi}{2}\left(\frac{W_{jt}^i}{\pi W_{jt-1}^i} - 1\right)^2,$$

where $\phi > 0$ governs the size of the real adjustment cost and π denotes the gross, long-run inflation rate.

The flow budget constraint of household i is given by

$$c_t^i + \frac{M_{t+1}^i}{P_t} + k_{t+1}^i + \gamma\left(1 - j_t^{i*}\right) + \int_0^1 \frac{\phi}{2}\left(\frac{W_{jt}^i}{\pi W_{jt-1}^i} - 1\right)^2 dj \tag{6}$$

$$\leq \int_0^1 \frac{W_{jt}^i}{P_t} h_{jt}^i dj + r_t a_t^i + r_{dt} d_t^i + \frac{R_t B_t^i + M_t^i + T_t}{P_t},$$

where $\gamma(1 - j_t^{i*})$ denotes the total cost of using deposits, and $a_t^i = k_t^i - d_t^i$.

Production. A representative type-j firm hires differentiated labor from households and aggregates them into a homogeneous labor input h_{jt} using the CES

https://doi.org/10.1017/S1365100512000831 Published online by Cambridge University Press

technology

$$h_{jt} = \left(\int_0^1 h^{i\,\frac{\xi-1}{\xi}}_{jt} di \right)^{\frac{\xi}{\xi-1}}, \tag{7}$$

where $\xi \geq 0$ denotes the elasticity of substitution between labor types.[12]

The production technology for type-j output is a CRS function of capital and homogeneous labor: $y_{jt} = f(z_t, k_{jt}, h_{jt})$, where z_t denotes exogenous total factor productivity that is identical across firms and evolves according to $z_t = \kappa_z + \rho_z z_{t-1} + \varepsilon_{zt}$ with $\varepsilon_{zt} \sim N(0, \sigma_z^2)$. Profits of a representative type-j firm are given by

$$P_t y_{jt} + (1 - \delta - r_t)\, P_t k_{jt} - \int_0^1 W^i_{jt} h^i_{jt} di, \tag{8}$$

where P_t is taken as given.

A representative type-j firm chooses k_{jt} and h^i_{jt} $\forall i$ in order to maximize profits (8) subject to (7). A profit-maximizing firm equates the marginal product of each input with its marginal cost:

$$f_{k_j}(z_t, k_{jt}, h_{jt}) = r_t - 1 + \delta, \tag{9}$$

$$f_{h_j}(z_t, k_{jt}, h_{jt}) P_t = \left(\frac{h^i_{jt}}{h_{jt}} \right)^{\frac{1}{\xi}} W^i_{jt}, \ \forall i. \tag{10}$$

Defining the left-hand side of (10) to be firm j's nominal wage index W_{jt} illustrates firm j's demand for type-i's labor,

$$h^i_{jt} = \left(\frac{W_{jt}}{W^i_{jt}} \right)^{\xi} h_{jt}, \tag{11}$$

which is the standard outcome of models with nominal-wage rigidity [e.g., Erceg et al. (2000)].

Financial Intermediaries. Financial intermediaries accept capital deposits from households and frictionlessly lend them to firms. It is assumed that economies of scale exist at the aggregate level and are external to the individual intermediary. Furthermore, it is assumed that capital loans from intermediaries and households are perfect substitutes to the firms. These assumptions result in perfectly competitive deposit and loan markets.

Let the profit function of a representative intermediary be given by

$$r_t d_t - r_{dt} d_t - C(d_t, \bar{d}_t), \tag{12}$$

where d_t denotes real deposits, $\bar{d}_t$ denotes real deposits of the entire intermediary sector, and $C(d_t, \bar{d}_t)$ denotes real operating costs.[13] Let $C(d_t, \bar{d}_t) = \Gamma d_t \bar{d}_t^{\theta}$. It is assumed that the intermediary takes r_t, $r_{dt,}$ and $\bar{d}_t$ as given and chooses d_t to equate marginal costs with benefits:

$$r_{dt} = r_t - \Gamma \bar{d}_t^{\theta}. \tag{13}$$

The cost function of the intermediary exhibits ES for $\theta < 0$, and (13) suggests that the rate of returns on deposits is an increasing function of the aggregate amount of deposits (all else constant).

It should be noted that this description assumes ES at the aggregate level and is at odds with the empirical evidence of ES at the individual-bank level. However, one could arrive at (13) by assuming a single monopoly bank that receives zero profits because of the threat of free entry and therefore uses average-cost pricing.[14] Benhabib and Farmer (1994) note that environments featuring internal increasing returns in production and noncompetitive markets are quantitatively equivalent to environments featuring external increasing returns and competitive markets.[15]

The Monetary Authority. The budget constraint of the monetary authority is $T_t = M_{t+1} - M_t$, where M_{t+1} denotes the aggregate stock of currency (the monetary base) available at the end of period t. The currency base evolves according to $M_t = \mu_t M_t$, where μ_t denotes the gross growth rate. Monetary policy is assumed to be conducted exogenously so that money growth evolves according to $\mu_t = \kappa_\mu + \rho_\mu \mu_{t-1} + \varepsilon_{\mu t}$ with $\varepsilon_{\mu t} \sim N(0, \sigma_\mu^2)$.

2.2. Equilibrium

Household i's Problem. Household i's problem is to maximize (1) subject to (4), (5), (6), and (11) by choosing c_t^i, j_t^{i*}, B_t^i, d_t^i, M_{t+1}^i, k_{t+1}^i, and W_{jt}^i $\forall j$, taking all prices and the state of the economy as given. After some manipulation of the optimal conditions determining j_t^{i*}, B_t^i, and d_t^i, it can be shown that

$$(r_t - r_{dt}) + \frac{\gamma}{2 j_t^{i*} c_t^i} = R_t, \tag{14}$$

where the left (right)-hand side is the opportunity cost of using deposits (currency) to purchase good j_t^{i*}. In particular, recall that the size of the purchase is $c_{jt}^i = 2 j_t^{i*} c_t^i$. The first term on the left-hand side is the foregone interest from depositing this real amount with the intermediary as opposed to direct capital investment, whereas the second term is the check-writing cost. The right-hand side is the foregone interest from using currency as opposed to investing in bonds. This equation confirms the assumption made earlier that the critical good j_t^{i*} is chosen so that the household is indifferent between purchasing this particular good with deposits or currency, because the costs are equal. Therefore, goods indexed with j less (greater) than j_t^{i*} will be purchased with currency (deposits). When (13) is substituted into (14), it can further be shown that

$$\Gamma \bar{d}_t^{\theta} + \frac{\gamma}{2 j_t^{i*} c_t^i} = R_t. \tag{15}$$

https://doi.org/10.1017/S1365100512000831 Published online by Cambridge University Press

This equation suggests that in the presence of ES ($\theta < 0$), there is a negative relationship between aggregate deposits and j_t^{i*} (all else constant). In other words, a larger amount of aggregate deposits decreases the per-deposit cost and makes purchasing a larger portion of goods with deposits more attractive. Because the aggregate amount of deposits is not explicitly chosen by the households, the individual depositing decision becomes susceptible to nonfundamental fluctuations.

Market Clearing and Definition of Equilibrium. Households face identical elasticities regarding their labor demand (ξ) and firms are perfectly competitive within each industry. The analysis can therefore restrict attention to symmetric labor and goods market equilibria and treat household i as a representative household and firm j as a representative firm (i.e., $W_{jt}^i = W_t$, $h_{jt}^i = h_t$, and $c_t^i = c_t$).

Goods market clearing is

$$y_t = c_t + k_{t+1} - (1-\delta)\,k_t + \Gamma d_t^{1+\theta} + \gamma(1 - j_t^*) + \frac{\phi}{2}\left(\frac{W_t}{\pi W_{t-1}} - 1\right)^2, \quad \textbf{(16)}$$

where $y_t = \int_0^1 (2j) y_{jt} dj$ conforms with composite consumption. Capital market clearing is given by $k_t = \int_0^1 k_t^i di$.

Currency market clearing is $M_t = m_t$. A broader monetary aggregate can be defined as the nominal sum of currency and deposits,

$$\mathrm{M1}_t = M_t + P_t d_t = M_t\left(1 + \frac{P_t d_t}{M_t}\right), \quad \textbf{(17)}$$

where the third equality defines M1 as the product of the currency base and the endogenously determined money multiplier. Zero net supply in the bond market implies $B_t = 0$.

The decision rules and pricing functions can be defined as functions of k_t, W_{t-1}, μ_t, and z_t. When the economy is subject to equilibrium indeterminacy, agents also base their decisions upon a nonfundamental sunspot shock ζ_t. Therefore, for all $\{k_t,\ W_{t-1},\ \mu_t,\ z_t,\ \zeta_t\}$, an equilibrium is defined as a list of prices $\{P_t,\ r_t,\ r_{dt},\ W_t,\ R_t\}$ and allocations $\{k_{t+1},\ M_{t+1},\ h_t,\ c_t,\ j_t^*,\ d_t,\ B_t\}$ such that (i) households maximize (1) subject to (4), (5), and (6), (ii) firms maximize profits (8) subject to (7), (iii) labor demand is determined by (11), (iv) all individual quantities are equal to their respective aggregates (e.g., $d_t = \bar{d}_t$), and (v) the markets for goods (16), currency, bonds, and deposits clear.

2.3. The Flexible Wage Model

The flexible wage (FW) model differs from the RW model in two ways. First, wages are assumed to be perfectly flexible (i.e., $\phi = 0$). The FW model retains the industry structure and substitutability among heterogeneous labor (ξ) to keep the two versions of the model as comparable as possible. Second, only deposits made in the previous period can be used to purchase consumption. This effectively transforms the deposit constraint (5) into a deposits-in-advance constraint, and the depositing decision for next period (d_{t+1}) must now be tracked independent of the capital decision (k_{t+1}). In particular, the budget constraint of the household becomes

$$c_t^i + \frac{M_{t+1}^i}{P_t} + a_{t+1}^i + d_{t+1}^i + \gamma\left(1 - j_t^{i*}\right) \le \int_0^1 \frac{W_{jt}^i}{P_t} h_{jt}^i dj + r_t a_t^i + r_{dt} d_t^i + \frac{R_t B_t^i + M_t^i + T_t}{P_t}, \quad \textbf{(18)}$$

where $k_{t+1}^i = a_{t+1}^i + d_{t+1}^i$. Household i's problem is to maximize (1) subject to (4), (5), (18), and (11) by choosing c_t^i, j_t^{i*}, B_t^i, d_{t+1}^i, M_{t+1}^i, a_{t+1}^i, and h_{jt}^i $\forall j$, taking all prices and the state of the economy as given. All other features of the environment remain unchanged.

3. QUANTITATIVE ANALYSIS

This section begins by detailing the functional forms and model calibration used by the RW and FW models. A search is then conducted for a subset of the parameter space where the model dynamics are indeterminate. The dynamic properties of the models within these indeterminacy zones are then analyzed. This section concludes with a calibration exercise determining the relative sizes of the fundamental and nonfundamental sources of volatility using U.S. data.

3.1. Functional Forms and Calibration

The functional forms and parameter values are determined following the business-cycle literature [e.g., Cooley and Hansen (1989)] and so the resulting steady states of the models match particular long-run properties of the U.S. economy. All parameter values are summarized in Table 1.

A period is one quarter. The discount parameter β is calibrated so that the annual real interest rate is roughly 4%, and the money growth rate ($\mu - 1$) is set to 3% annually. The persistence of money growth shocks (ρ_μ) is set to 0.32 as in Christiano (1991) and Fuerst (1992).

Steady state output is normalized to one, and investment is set to one quarter of steady state output. With a 10% depreciation rate, the capital-stock-to-annual-output ratio is 2.5. The production function is assumed to be $y = zk^\alpha h^{1-\alpha}$, and α is calibrated so that labor's share of national income is roughly two-thirds. The persistence of technology shocks (ρ_z) is set to 0.95 as in Prescott (1986).

The utility function is assumed to be $[c^\eta (1-h)^{1-\eta}]^{1-V}/(1-V)$. The parameter η is calibrated so that a household's average allocation of time to market activity (net of sleep and personal care) is one-third, which is in line with estimates of Ghez and Becker (1975). V is set to 2, which is within the range reported by Neely et al. (2001).

https://doi.org/10.1017/S1365100512000831 Published online by Cambridge University Press

TABLE 1. Calibrated parameter values

Symbol	Description	Value
α	Capital's share	0.3421
β	Discount factor	0.9900
δ	Depreciation rate	0.0241
ς	Consumption's share	0.3783
V	Risk aversion	2
ξ	Labor elasticity	20
ϕ	Wage cost parameter	6.03[a], 0.00[b]
ρ_z	AR coefficient (z)	0.95
ρ_μ	AR coefficient (μ)	0.32
θ	Banking cost parameter	−0.01
γ	Check-clearing cost	8.15×10^{-6}
Γ	Banking cost parameter	1.75×10^{-2}

[a]Value for RW model.
[b]Value for FW model.

The parameter ξ is calibrated so that the average mark-up of type i labor is 5%, as in postwar U.S. data [see Christiano et al. (2005)]. In the RW model, the cost parameter governing nominal wage changes (ϕ) corresponds to an average wage duration of three quarters.[16] The FW model assumes $\phi = 0$.

The three remaining parameters define the costs of managing deposits (Γ and θ) and check writing (γ). Because θ is central to indeterminacy, it is analyzed separately later. Given a value for θ, the parameters Γ and γ are determined so that the model's steady state matches the U.S. deposit–currency ratio and the value added of the financial intermediation sector. The deposit–currency ratio is defined as dP/M and set to 7. This ratio is close to the postwar minimum, considering that two-thirds to three-fourths of the U.S. currency base is held abroad [see Porter and Judson (1996)], and is similar to the measure considered by Freeman and Kydland (2000) and Dressler (2007). Value added is defined as total banking costs per unit of output, $[\Gamma d^{1+\theta} + \gamma(1 - j^*)]/y$, and serves as a proxy for the size of the intermediation sector. Diaz-Gimenez et al. (1992) compute the value added from "banking and credit agencies other than banks" to be 1.8 to 2.7% of GNP for the years 1970 to 1989 (see Sensitivity Analysis). More recent data from the NIPA reports the value added as a percentage of real GDP for *all depository institutions* to lie within the range 2.5 to 2.9 for the years 1987 to 1997. Although these value-added measures have remained relatively constant, it is not clear how much value added should be exhibited by the simple intermediaries considered here. This information will therefore serve as an upper bound for the size of the financial intermediary sector.

3.2. Economies of Scale and Indeterminacy

Although a concave cost function is necessary for banks to exhibit ES in textbook models of banking [e.g., Freixas and Rochet (1997)], it may not be sufficient

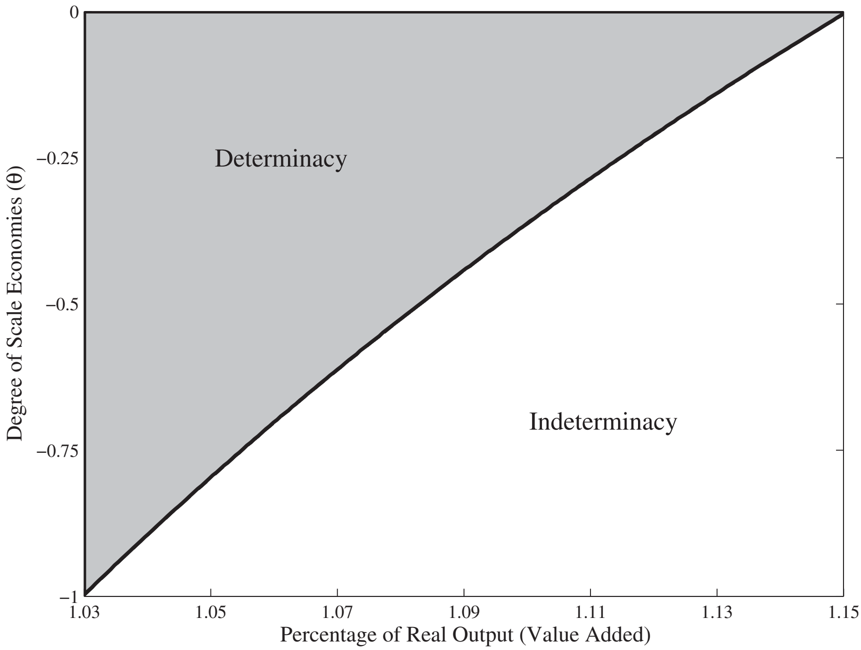

FIGURE 1. Pairs of value added and θ that deliver indeterminate and determinate equilibria for the FW and RW models.

for indeterminacy in quantitative models, because the banking sector is small relative to the aggregate economy. The equilibrium properties of the RW and FW models over values of θ and the value added of the intermediary sector are illustrated in Figure 1. The solid line separates the zones of the parameter space, resulting in determinate and indeterminate equilibria for both models.[17] Although the models differ with respect to nominal wage rigidity and the timing of the deposit decision, these features of the environment have no influence on the ability of ES in the intermediary to exhibit indeterminacy. As the size of the intermediation sector increases in either model, the minimum (absolute value) of θ required for indeterminacy decreases.[18]

The ability of the models to deliver equilibrium indeterminacy given small degrees of ES stems from the multiple means of payment (cash and deposits), which are endogenously chosen by the household. As (13) and (15) suggest, separation between cash goods and deposit goods is directly determined by the respective rates of return, and the return on deposits is directly determined by the return on capital and the cost of intermediation. Therefore, small changes in the rate of return on deposits deliver relatively larger changes in the proportion of consumption purchased with cash versus deposits, and further deliver changes in aggregate prices and the rest of the economy. In the literature focusing on increasing returns in production, models sometimes require excessive parameter

https://doi.org/10.1017/S1365100512000831 Published online by Cambridge University Press

values for the production sector of the model to deliver indeterminacy. Our source of indeterminacy is rooted in the choice between substitutable means of purchasing production, which is decidedly different from the production process itself. As the figure indicates, determinacy in the models considered here is more tenuous.

Taking the amounts of ES and value added required for indeterminacy from the figure, the quantitative analysis proceeds with a conservative degree of ES for both versions of the model: $\theta = -0.01$. With this degree of ES, the minimum value added that delivers indeterminacy is approximately 1.15%. This amount of value added is used with θ and the previously specified deposit–currency ratio to calibrate γ and Γ, which are reported in Table 1.

3.3. Model Results

The models are solved following the methodology of Lubik and Schorfheide (2003). When a model exhibits indeterminacy, the rational expectations forecast errors of the agents can be decomposed into influences from the fundamental and nonfundamental shocks. Although the nonfundamental shock is interpreted as a reduced-form sunspot shock, an additional assumption is needed to identify the transmission of the fundamental shocks on the forecast errors uniquely. The analysis considers both identification schemes proposed by Lubik and Schorfheide: *orthogonality* and *continuity*. Under orthogonality, the influences of the fundamental and nonfundamental shocks are uniquely identified by assuming that they are orthogonal to each other. Under continuity, the fundamental shocks are identified by imposing the requirement that their influence on the endogenous forecast errors does not abruptly change when the economy transitions from regions of determinacy to indeterminacy. The benefit of the continuity assumption is that because the chosen degree of ES in the model lies close to the boundary between determinacy and indeterminacy, the determinate dynamics of the model in response to fundamentals is preserved under indeterminacy. Considering both identification schemes allows the analysis to assess the effect of the sunspot shock on the economy, as well as how ES in banking influences the impact of the fundamental shocks.

To focus the analysis, this section compares the impulse responses from only monetary and sunspot shocks. Although TFP shocks will be important for the calibration portion of the analysis, the impulse responses from a TFP innovation in this environment do not differ drastically from those in standard DSGE environments.

Rigid Wage Model. The response to positive (1%) monetary and sunspot shocks for the RW model is illustrated in Figure 2. First consider a monetary shock under continuity, which is depicted by the dashed line. An injection of currency increases the inflation rate and makes deposits more attractive than currency (i.e., j_t^* decreases). The increase in deposits results in a further increase in prices because of more currency being used to purchase less consumption. The decline in real wages due to nominal rigidity increases labor demand and all other real aggregates. In the period following the shock, inflation decreases, but prices

https://doi.org/10.1017/S1365100512000831 Published online by Cambridge University Press

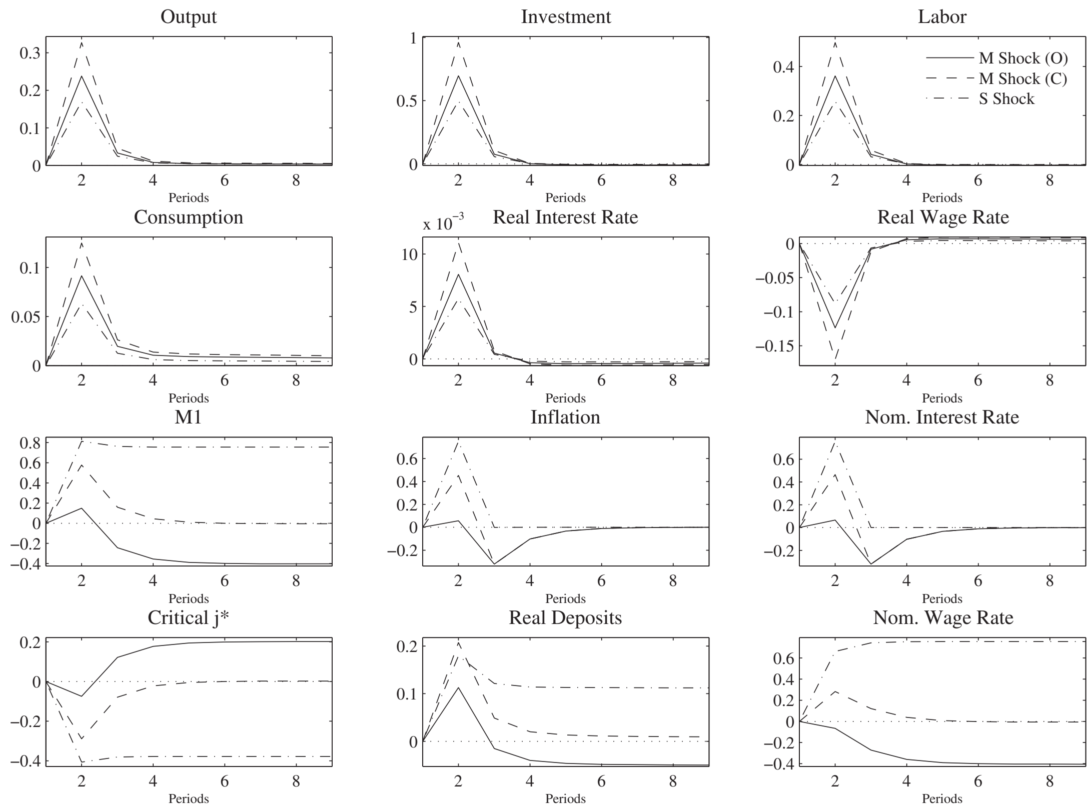

FIGURE 2. Impulse responses to a 1% increase in the monetary base (M Shock) and the reduced-form sunspot shock (S Shock) in the model with nominal wage rigidity (RW model). The Y-axes denote percentage changes from steady state. Impulse responses calculated under the orthogonality (continuity) assumption are denoted by O (C).

remain above steady state, along with the portion of consumption purchased with deposits (i.e., j_t^* remains below steady state). Real wages remain below steady state, so real aggregates remain above. Eventually, the paths of prices and nominal wages align, so real aggregates return to steady state.

Under orthogonality, the initial impact of a monetary shock is qualitatively similar to the impact under continuity. Movements in prices, M1, and j_t^* all illustrate that deposits become more attractive. However, because the orthogonality assumption implies that there is no impact of the change in deposits on the forecast errors (which would otherwise be observed because of a nonfundamental shock), the initial impact of a monetary shock is diminished. In the following period, prices decline below steady state, resulting in currency becoming more attractive. As households choose to hold fewer deposits, the net return to deposits declines. This results in a persistent shift away from deposits, illustrated by the persistent increase in j_t^* and the persistent decrease in M1, but the amount of total capital received by firms shows no persistent changes, because the direct and indirect loan markets offset each other. Therefore, the persistence is apparent in nominal variables, whereas the real economy again returns to steady state once nominal wages and prices align.

The final set of responses in Figure 2 illustrates the impact of the sunspot shock. The real impact of a sunspot shock is approximately one-half the size of a monetary shock under continuity and three-quarters the size under orthogonality. These responses appear qualitatively similar because monetary and sunspot shocks both impact the household's portfolio choice of cash and deposits. A sunspot shock induces an increase in deposits because of an anticipated decrease in deposit costs, resulting in deposits dominating currency for a larger portion of consumption purchases. The increase in deposits delivers an increase in M1 and prices. The resulting decline in real wages increases the demand for labor and further results in increases in all other real aggregates. In the following period, the increase in deposits keeps the net return high and delivers persistence in deposits, M1, and j_t^*. Although nominal aggregates continue to remain far from steady state, nominal wages and prices eventually align, so the real economy converges to its initial state.

Flexible Wage Model. The responses to positive (1%) monetary and sunspot shocks for the FW model are illustrated in Figure 3. As in the RW model, these three responses are qualitatively similar. However, the channels through which the monetary and sunspot shocks impact this flexible-price economy are different from those in the RW model, because it is the *persistence* of the monetary shocks that delivers the impact, whereas the purely transient sunspot shocks influence a forward-looking depositing decision.[19]

The impulse responses of a monetary shock under continuity closely follow those from standard cash-in-advance models. In a textbook cash-in-advance economy, an increase in inflation induced by a monetary shock makes households substitute from consumption (*cash goods*) to investment and leisure (*credit goods*). Although consumption is not entirely purchased with currency in this environment,

https://doi.org/10.1017/S1365100512000831 Published online by Cambridge University Press

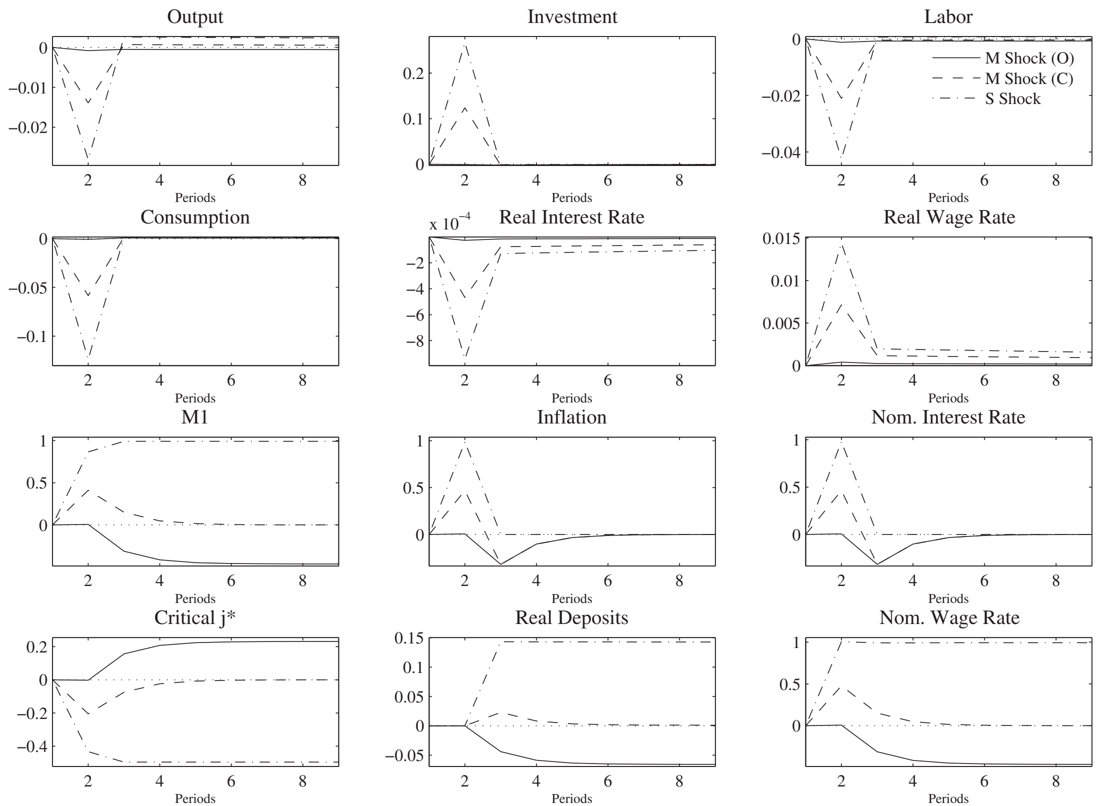

FIGURE 3. Impulse responses to a one percent increase in the monetary base (M Shock) and the reduced-form sunspot shock (S Shock) in the model with flexible wages (FW model). The Y-axes denote percentage changes from steady state. Impulse responses calculated under the orthogonality (continuity) assumption are denoted with O (C).

a similar substitution prevails, and total consumption and labor both decrease, whereas investment increases. Not only is there an initial decrease in total consumption, but also there is a decrease in the portion purchased with currency (i.e., j_t^* decreases). In the period following the shock, the new deposit decision reverses the inflation created by the monetary shock and all real variables return roughly to their preshock levels. The real impulse responses of a monetary shock under orthogonality are qualitatively similar to those under continuity, only smaller in magnitude again because of the inability of the deposit decision to influence the forecast errors.

In contrast to the RW model, the sunspot shock in the FW model has the largest impact on the economy. Because households cannot immediately adjust their deposit holdings upon the arrival of a sunspot shock, they choose to increase investment in order to have more deposits next period. This result, combined with the decline in consumption and labor, resembles the *cash good* versus *credit good* substitution depicted in the response to a monetary response under continuity. Not only is consumption declining immediately after the arrival of the sunspot shock, but also the decline in j_t^* indicates that the portion of consumption purchased with currency is declining. These decisions both deliver upward pressure on prices, which initially increases the inflation rate. In the following period, the change in deposits goes into effect and a new portfolio of cash goods and deposit goods is attained. Note that because a larger amount of deposits requires a larger amount of investment, the new deposit decision results in a slight increase in output above steady state, which persists for several periods.

In comparing these results with the RW model in Figure 2, it is important to note the different avenues through which a sunspot shock is impacting the economy. In the RW model, the sunspot shock directly impacts the nominal variables, and the real effects are due to the presence of nominal wage rigidity. In the FW model, the sunspot shock has roughly the same impact on nominal variables as in the RW model, but the real effects are due to the forward-looking behavior of the depositing decision and the impact it has on investment. Although it is interesting to note that both versions of the model qualitatively display almost identical nominal responses to a sunspot shock, the differences in nominal frictions and deposit timing deliver real responses that are qualitative opposites.

Fundamental and Nonfundamental Volatility: A Calibration Exercise. The analysis has thus far compared the impact of fundamental and nonfundamental shocks without considering their relative size. Empirically speaking, if the nonfundamental shocks are small relative to the fundamental shocks, then what is the motivation for considering them? This issue is addressed here via a calibrating exercise that determines the shock volatilities such that the predicted volatilities of key macroeconomic aggregates from the model match those of postwar U.S. data.

The empirical targets chosen to calibrate the exogenous volatilities are the standard deviations of real GDP, the monetary base, and M1 over the range from 1959:1 to 2007:4. Although the choice of real GDP volatility is central to

TABLE 2. Calibration of fundamental and nonfundamental variances

Pre 84/Post 84	$\sigma_z \times 1000$	$\sigma_\mu \times 1000$	$\sigma_\zeta \times 1000$
RW model[a]	11.0/6.5	5.1/7.7	13.8/19.6
RW model[b]	11.0/6.5	5.1/7.7	14.7/21.0
FW model[a]	11.4/7.1	5.2/7.8	10.5/15.5
FW model[b]	11.4/7.1	5.2/7.8	10.9/16.6

[a]Model solved assuming continuity.
[b]Model solved assuming orthogonality.

identifying exogenous TFP, the other two targets were chosen to best identify the exogenous monetary and nonfundamental shocks. Because the model is without durable goods, fiscal policies, and international sectors, real GDP is defined to be the sum of nondurable consumption, services, and investment.[20] In addition, because of the Great Moderation and the widely known observation that variability in real output growth and inflation has significantly declined since the mid-1980s, the calibration exercise uses 1984:1 as a break date.[21]

The standard deviations of real GDP, the monetary base, and M1 are 1.93, 0.83, and 1.62 prior to 1984, and 1.19, 1.24, and 2.31 afterward. Although the decline in the variability of real GDP as defined here coincides with the observation of the Great Moderation, the variability of the monetary base and M1 increases over the break date.

The calibration exercise uses numerous simulations of the model economy to determine the standard deviations of exogenous TFP (σ_z), exogenous monetary growth (σ_μ), and the exogenous nonfundamental shock (σ_ζ) that minimizes the squared distance between the empirical volatilities and the respective predicted volatilities from the model.[22] The results are detailed in Table 2. The calibrated TFP volatility is quite similar across the RW and FW models, and is stable across the continuity versus orthogonality solution assumptions. In addition, the decline in TFP volatility across the 1984 break date is again consistent with observations on the Great Moderation. The calibrated monetary growth volatility is similar to the TFP volatility in that the measure is stable across the two models and solution assumptions, but increases across the 1984 break date. This is a direct result of the increase in monetary base volatility observed over the break date in the data. The main purpose of this exercise, however, is to see how these fundamental sources of volatility compare to the nonfundamental source. First, with the exception of the FW model data prior to 1984, the nonfundamental volatility is the largest of the three sources. Second, the orthogonality assumption slightly increases the nonfundamental volatility because of the dampened impact of exogenous monetary growth volatility, as seen in Figures 2 and 3. Third, the increase in the nonfundamental source of volatility over the 1984 break date far surpasses the increase in exogenous monetary growth volatility and is the largest source of volatility over all model versions and solution assumptions. These results

https://doi.org/10.1017/S1365100512000831 Published online by Cambridge University Press

TABLE 3. Economies of scale estimates

Data	θ	R^2
1959:1–2007:4	−0.8666 (0.3139)	0.42
1959:1–1979:1	−5.6641 (2.5143)	0.57
1984:1–2007:4	−0.3024 (0.1574)	0.36

Note: Standard errors in parentheses.

suggest not only that economic volatility from nonfundamental sources is just as large as the economic volatility from fundamental sources, but also that the nonfundamental source has increased in the latter portion of postwar U.S. data. It should be noted that all calibration results reported in the table achieved the targeted volatility moments within 0.0002.

Sensitivity Analysis. A sensitivity analysis was performed on the degree of ES in the intermediary sector (θ) and the value added of the intermediary sector. To get a sense of θ from the data, taking the log of (13) gives

$$\log (r_t - r_{dt}) = \log (\Gamma) + \theta \log (d_t)\,, \qquad \textbf{(19)}$$

where the left-hand side is the logged spread between real lending and deposit rates, and the right-hand side is the log-linearized version of the marginal intermediary cost. Estimating (19) over postwar U.S. data gives values of θ reported in Table 3.[23] For the full data sample, θ is estimated to be −0.87 and is significantly less than zero. The point estimate is lower in the earlier subsample (−5.66), but not significantly different from the full-sample estimate at the 95% confidence level. The estimate in the later subsample is significantly higher than the full-sample estimate (−0.30), but still significantly less than zero at the 90% confidence level.[24] Although this simple exercise is far from concrete evidence supporting ES in the financial intermediary sector, it supports the conservative choice of $\theta = -0.01$ used throughout the analysis and provides a less arbitrary value of θ to be considered.

The impulse responses illustrated in Figures 2 and 3 were compared with the model results using $\theta = -0.87$, as well as a minimum amount of value added () which accommodates the higher degree of ES. When the impulse responses of the models with these alternative parameter choices were compared with the benchmark results, the maximum differences across all impulse responses were 0.0075 and 0.0059% for the RW and FW models, respectively. The small change in the impulse responses from differing degrees of ES is due to the intermediary sector representing a small part of the overall economy in terms of value added. This exercise suggests that only a minimal amount of ES is required to make the economy susceptible to sunspot shocks. Once this amount of ES is met, there is little additional quantitative effect from surpassing it.

https://doi.org/10.1017/S1365100512000831 Published online by Cambridge University Press

4. CONCLUSION

This paper quantitatively assesses the economic effects of indeterminacy resulting from ES in the financial intermediation sector. A monetary model with multiple media of exchange features financial intermediaries that exhibit economies of scale through decreasing marginal costs to managing deposits, and is assessed with and without nominal wage rigidity and different timing assumptions on the use of deposits. With the size of the financial intermediary sector calibrated to match U.S. data, the analysis suggests that indeterminacy arises for small degrees of ES in the intermediary sector, and the resulting confidence shocks can qualitatively mimic monetary shocks. A calibration exercise concludes that U.S. economic volatility from nonfundamental sources has increased over time, whereas volatility from fundamental sources has decreased.

These results warrant some discussion. First, although not directly adding to the controversy in the empirical literature on ES in intermediation, the analysis suggests that the degree of ES required to give rise to equilibrium indeterminacy can be small and therefore difficult to estimate accurately. The stability of the quantitative results with respect to the degree of ES (i.e., the value of θ) unfortunately makes this model unsuitable for precisely estimating θ. The results nevertheless suggest that belief-induced shocks to financial intermediation can have large effects. Second, although the simple calibration exercise performed here suggests that nonfundamental sources of economic volatility can be relatively large, it is not clear whether or not this conclusion would hold up in a model with a larger variety of fundamental shocks (e.g., preference shocks, cost-push shocks, investment shocks). Finally, the recent financial crisis in the United States has undoubtedly increased the interest in studying the effects of self-fulfilling expectations on the economy.[25] The predicted responses of the RW model to a negative sunspot shock are in line with the observed declines in the U.S. economy. One possible extension of the model is to increase the role of banking through bank-dependent firms or holders of collateral needed to acquire loans. In the latter case, extrinsic uncertainty could then have an impact on the value of collateral and might have a persistent impact on the credit structure of the economy. These research directions are currently being explored.

NOTES

1. A few examples are Cass and Shell (1983), Benhabib and Farmer (1994), and Farmer and Guo (1994). See Farmer (1999) for an overview of the literature.

2. Other supporting analyses are by Berger and Mester (1997), Hughes et al. (2001), and Bossone and Lee (2004).

3. The endogenous distinction between narrow and broad monetary aggregates has also been explored by Ireland (1994).

4. This intuition is almost exactly the same as that laid out in the productive externality literature [e.g., Benhabib and Farmer (1994)], where household optimism (pessimism) of market returns to labor induces higher (lower) employment and wages.

5. This choice of nominal wage rigidity follows the conclusion of Christiano et al. (2005) that this rigidity is the key friction linking nominal shocks to the real economy.

6. Although the timing assumption on deposits and whether or not nominal frictions are considered deliver four models to consider, the models explored here are most relevant to the present topic. In particular, an environment with perfectly flexible prices and currently chosen deposits being used to purchase current consumption allows households to almost completely assuage any impact of a monetary shock, resulting in neither monetary or sunspot shocks having any real impact. In addition, an environment with nominal wage rigidity and only previously chosen deposits being used to purchase consumption results in a bifurcation even when the intermediary sector does not exhibit ES. Although interesting, this version of the model is beyond the scope of the present analysis.

7. The degree of increasing returns to scale in production needed for indeterminacy in models with one productive sector [e.g., Farmer and Guo (1994) and Gali (1994)] far exceeds the empirical estimates of Basu and Fernald (1997). Wen (1998) shows that the degree can be much smaller when applied to capital utilization. Furthermore, Farmer (1999) shows that indeterminacy arises in cash-in-advance economies only when households exhibit weak degrees of intertemporal substitution. See Benhabib and Farmer (1999) for an overview of these issues.

8. For example, actual Federal Reserve policy operations allow the effective interest rate to move around a predetermined target. Such a policy prevents the effective rate from straying outside of some specified range, but does not predetermine the rate within this range. This policy therefore accommodates indeterminacy by not predetermining the returns to deposits.

9. It should be noted that (2) is equivalent to a standard CES-type Armington aggregate of differentiated goods, where the goods are perfect complements and weighted according to their index number j. This simplifying expression was also used by Freeman and Kydland (2000) and Dressler (2007).

10. It is also the case that (2) delivers $\int_0^1 c^i_{jt}\partial j = c^i_t$.

11. Although j_t^* is simply posited in this environment, it can be derived from a general version of the environment. These details are contained in a technical appendix available on the authors' web sites.

12. One could establish an equivalent environment where an additional production sector aggregates labor and sells homogeneous labor units to good-producing firms as in Erceg et al. (2000). Firms here are allowed to hire heterogeneous labor to streamline the environment.

13. It is assumed for simplicity that intermediaries have no minimum reserve requirements. Requiring fractional reserves does not change any of the results. Furthermore, note that because processing costs are passed on to households in equation (6), γ does not appear in (12).

14. This cost structure is a variant of Cooper and Corbae (2002). The key difference is that this cost structure allows local indeterminacy around a unique steady state as opposed to multiple steady states.

15. We wish to thank an anonymous referee for bringing this to our attention.

16. See Chugh (2006) for a mapping from Rotemberg-style costs to Calvo-style rigidity.

17. This exercise uses values of θ and value added (used along with a specified deposit–currency ratio to calibrate Γ and γ) distributed over a fine grid. The model is solved for each point in this space, and the resulting eigenvalues are used to determine whether the resulting equilibrium is determinate or indeterminate.

18. It should be noted that the amount of value added at the point where the indeterminacy zone reaches $\theta = 0$ is the maximum amount allowable before the model calibration delivers a negative value for either γ or Γ. Because the deposit–currency ratio is fixed, there exists a negative relationship between the size of the intermediary and the parameters delivering value added.

19. As in the textbook cash-in-advance model, purely transient monetary shocks have no quantitative impact on this economy.

20. The data for output were constructed as the sum of (i) Real Personal Consumption Expenditures: Nondurable Goods (PCNDGC96) and Services (PCESVC96) and (ii) Real Gross Private Domestic Investment (GDPIC96). The data for the monetary base were the currency component of M1 (CURRSL), whereas M1 was defined to be the currency component of M1 plus demand deposits (CURRDD). All data are seasonally adjusted and available from the Federal Reserve of St. Louis database for the range from 1959:1 to 2007:4. Monthly data were made quarterly by taking monthly averages, and trends were removed using the HP filter.

21. Although no contribution is made to the Great Moderation literature in particular, the choice of the break date helps to assess how these relative volatilities have changed throughout the postwar U.S. economy.

22. The calibration exercise is very similar to a simulated method of moments exercise, but with an identity matrix replacing an inverted variance–covariance matrix.

23. The spread between lending and deposit rates was taken to be the spread between the prime lending rate (series name: MPRIME) and the 3-month Tbill rate (series name: TB3MS), whereas real deposits were defined as the sum of M1: demand deposits and M1: other checkable deposits (series names: DD.US and OCD.US) deflated by the GDP deflator (series name: GDPDEF). The annualized interest rate data were transformed into gross, monthly rates, and trends were removed from all variables using the HP filter. All monthly data were transformed to quarterly by taking three-month averages. The data sample from 1959:1 to 2007:4 is available from the Board of Governors of the Federal Reserve System. Considering up to two lagged dependent variables was sufficient to render white noise residuals for all cases.

24. The data were split at 1979:1 because of a change in Federal Reserve policy that changed many business-cycle correlations [see Gavin and Kydland (1999)]. The latter half of the sample was analyzed without the volatile period 1979:2–1983:4 because of the nonborrowed reserves targeting experiment by the Fed.

25. Recent work considering indeterminacy through financial frictions and their impact on the economy has been done by Liu and Wang (2010), Benhabib and Wang (2011), and others.

REFERENCES

Basu, Susanto and John G. Fernald (1997) Returns to scale in U.S. production: Estimates and implications. *Journal of Political Economy* 105, 249–283.

Benhabib, Jess and Roger E. A. Farmer (1994) Indeterminacy and increasing returns. *Journal of Economic Theory* 63(1), 19–41.

Benhabib, Jess and Roger E. A. Farmer (1999) Indeterminacy and sunspots in macroeconomics. In John B. Taylor and Michael Woodford (eds.), *Handbook of Macroeconomics*, vol. 1, Ch. 6, pp. 387–448. New York: North-Holland.

Benhabib, Jess and Pengfei Wang (2011) Financial Constraints, Endogenous Markups, and Self-fulfilling Equilibria. NBER working paper 18074, National Bureau of Economic Research, Cambridge, MA.

Berger, Allen N. and Loretta J. Mester (1997) Inside the Black Box: What explains differences in the efficiencies of financial institutions? *Journal of Banking and Finance*, 21(7), 895–947.

Bossone, Biagio and Jong-Kun Lee (2004) In finance, size matters: The "systemic scale economies" hypothesis. *IMF Staff Papers* 51, 19–46.

Carlstrom, Charles T. and Timothy S. Fuerst (2001) Real indeterminacy in monetary models with nominal interest rate distortions. *Review of Economic Dynamics* 4, 767–789.

Cass, David and Karl Shell (1983) Do sunspots matter? *Journal of Political Economy* 91(2), 193–227.

Christiano, Lawrence J. (1991) Modeling the liquidity effect of a monetary shock. *Federal Reserve Bank of Minneapolis Quarterly Review* 15(1), 3–34.

Christiano, Lawrence J., Martin Eichenbaum, and Charles Evans (2005) Nominal rigidities and the dynamic effects of a shock to monetary policy. *Journal of Political Economy* 113(1), 1–45.

Chugh, Sanjay K. (2006) Optimal fiscal and monetary policy with sticky wages and sticky prices. *Review of Economic Dynamics* 9, 683–714.

Cooley, Thomas F. and Gary D. Hansen (1989) The inflation tax in a real business cycle model. *American Economic Review* 79(4), 733–748.

Cooper, Russell and Dean Corbae (2002) Financial collapse: A lesson from the Great Depression. *Journal of Economic Theory* 107(2), 159–190.

Diaz-Gimenez, Javier, Edward C. Prescott, Terry Fitzgerald, and Fernando Alvarez (1992) Banking in computable general equilibrium models. *Journal of Economic Dynamics and Control* 16(3–4), 533–559.

Dressler, Scott J. (2007) The cyclical effects of monetary policy regimes. *International Economic Review* 48(2), 551–573.

Dressler, Scott J. (2011) Economies of scale in banking, indeterminacy, and monetary policy. *Economic Inquiry* 49(1), 158–193.

Erceg, Christopher J., Dale W. Henderson, Andrew T. Levin (2000) Optimal monetary policy with staggered wage and price contracts. *Journal of Monetary Economics* 46, 281–313.

Farmer, Roger E. A. (1999) *The Macroeconomics of Self-Fulfilling Prophecies*. Cambridge, MA: MIT Press.

Farmer, Roger E. A. and Jang-Ting Guo (1994) Real business cycles and the animal spirits hypothesis. *Journal of Political Economy* 63(1), 42–72.

Freeman, Scott and Finn E. Kydland (2000) Monetary aggregates and output. *American Economic Review* 90(5), 1125–1135.

Freixas, Xavier and Jean-Charles Rochet (1997) *Microeconomics of Banking*. Cambridge, MA: MIT Press.

Fuerst, Timothy S. (1992) Liquidity, loanable funds, and real activity. *Journal of Monetary Economics* 29(1), 3–24.

Gali, Jordi (1994) Monopolistic competition, business cycles and the composition of aggregate demand. *Journal of Economic Theory* 63, 73–96.

Gavin, William T. and Finn E. Kydland (1999) Endogenous money supply and the business cycle. *Review of Economic Dynamics* 2(2), 347–69.

Ghez, Gilbert and Gary S. Becker (1975) *The Allocation of Time and Goods over the Life Cycle*. New York: Columbia University Press.

Hughes, Joseph P. and Loretta J. Mester (1998) Bank capitalization and cost: Evidence of scale economies in risk management and signaling. *Review of Economics and Statistics* 80, 314–325.

Hughes, Joseph P., Loretta J. Mester, and Choon-Geol Moon (2001) Are scale economies in banking elusive or illusive? Evidence obtained by incorporating capital structure and risk-taking into models of bank production. *Journal of Banking and Finance* 25(12), 2169–2208.

Ireland, Peter N. (1994) Money and growth: An alternative approach. *American Economic Review* 84(1), 47–65.

Liu, Zheng and Pengfei Wang (2010) Indeterminate Credit Cycles. Working paper series 2010-22, Federal Reserve Bank of San Francisco.

Lubik, Thomas A. and Frank Schorfheide (2003) Computing sunspot equilibria in linear rational expectations models. *Journal of Economic Dynamics and Control* 28(2), 273–285.

Neely, Christopher J., Amlan Roy, and Charles H. Whiteman (2001) Risk aversion versus intertemporal substitution. *Journal of Business and Economic Statistics* 19(4), 395–403.

Porter, Richard D. and Ruth A. Judson (1996) The location of U.S. currency: How much is abroad? *Federal Reserve Bulletin* 82(10), 883–903.

Prescott, Edward C. (1986) Theory ahead of business cycle measurement. *Federal Reserve Bank of Minneapolis Quarterly Review* (Fall), 9–22.

Rotemberg, Julio J. (1982) Sticky prices in the United States. *Journal of Political Economy* 90(6), 1187–1211.

Wen, Yi (1998) Capacity utilization under increasing returns to scale. *Journal of Economic Theory* 81(1), 7–36.