Macroeconomic Dynamics, **22**, 2018, 173–198. Printed in the United States of America.
doi:10.1017/S1365100516000134

ARTICLES

FINANCIAL NEWS, BANKS, AND BUSINESS CYCLES

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In a model where banks face a capital sufficiency requirement, we demonstrate that news about a fall in the expected return on a portfolio of international long bonds held by a bank leads to an immediate and persistent fall in economic activity. Even if the news never materializes, economic activity falls below steady state for several periods, followed by a recovery. The portfolio adjustment induced by the capital sufficiency requirements leads to a rise in loan rates and tighter credit conditions, which trigger the fall in activity. We contribute to the news-shock literature by showing that imperfect signals about future financial returns can create business cycles without relying on the usual suspects—shocks to technology, preferences, or fiscal policy—and to the emerging economy business cycle literature in that disturbances in world financial markets can cause domestic business cycles without shocks to the world interest rate or to country spreads.

Keywords: Expectations-Driven Business Cycles, Financial News Shocks, Financial Intermediation, Business Cycles, Small Open Economy, Capital Adequacy Requirements

1. INTRODUCTION

Can a fall in the expected future return on financial assets influence real economic activity? We explore this question in the context of a small open economy with a banking system that holds an international portfolio of long-term sovereign bonds. Motivated by some key aspects of the recent Eurozone sovereign debt crisis, we model these bond portfolios as offering a stochastic future return with news shocks. When news arrives that expected future return might be lower than previously thought, it causes an immediate fall in the price of a unit of the portfolio. In the presence of a capital sufficiency requirement that imposes constraints on the amount of loans banks can make relative to their equity, banks must adjust their

The authors thank referees and seminar and conference participants at ICRIER, New Delhi, the University of Ottawa, the Conference on Growth and Development, the Asian Meetings of the Econometric Society, and the 2013 meetings of the Society for Computational Economics (CEF 2013). This research was partially supported by a research grant from McMaster University. Address correspondence to: Christopher M. Gunn, Department of Economics, 1125 Colonel By Dr., Ottawa, ON K1S 5B6, Canada; e-mail: chris.gunn@carleton.ca.

 1365-1005/16

balance sheets in response to the erosion of their equity induced by the fall in bond prices. The readjustment induced by the news leads to a sharp rise in the costs of borrowing for producers, who cut back on investment and labor inputs and reduce production. If the news is not eventually realized, expected portfolio returns and bond prices are revised upward, and real variables return to the steady state. If the pessimistic expectations are realized, economic activity remains below the steady state for a prolonged time.

Our model is set up to explore the idea that pessimistic expectations about the future return on international bonds of one country held by banks of another country might itself cause a slowdown in the other country. One might, for example, wonder if the expected fall in return on Greek bonds could influence economic activity in other nations of the Eurozone.[1] Our model takes a quantitative theory approach in describing one such possible transmission effect while abstracting from all the other macroeconomic influences in operation during the Eurozone sovereign debt crisis.

There are two novel elements built into our structure. First, the shock to the domestic economy emerges from changes in expectations of future returns on international financial assets. Second, lending costs to producers rise endogenously through the banking system instead of being assumed to rise, as in many emerging economy business cycle models that follow Neumeyer and Perri (2005). Unlike those models, we do not allow any movement in the interest rate at which banks can borrow on world markets to highlight our mechanism.[2]

We parameterize our model to the Eurozone economy for a number of reasons. First, the Eurozone periphery nations experienced large drops in the price of sovereign debt in recent years. Starting with Greece in mid-2009, interest rates paid by the governments of Ireland and Portugal in 2010 and eventually by Spain and Italy rose sharply. Figure 1 shows the interest rates on ten-year government bonds for Greece, Ireland, Italy, Portugal, and Spain. Second, banks in the Eurozone hold a large amount of sovereign debt of other member nations, including the debt of the "periphery" nations shown in the figure, making them quite vulnerable to capital loss in the face of a decline in the price of these bonds. Guerrieri et al. (2012) report that Euro Area banks' holdings of total "periphery" sovereign debt were 35.2% of gross domestic product (GDP) ending in 2010. Third, because the Eurozone shares a common currency, we can explore the international transmission of shocks without the complications associated with exchange rate movements.

The following article from Bloomburg on October 14, 2011, illustrates the variation in expected future returns for international bondholders:

> Greek bondholders are preparing to lose as much as 60 percent of their investments as European leaders try to impose a solution that reduces the nation's debt burden by enough to end the debt crisis. Everyone is coming to the conclusion that a much deeper restructuring is needed to make Greece in any way sustainable . . . German banks are preparing for losses of as much as 60 percent on their Greek holdings . . . The risk is that creditors balk at forgoing more than the 21 percent initially suggested in a plan crafted in July.

https://doi.org/10.1017/S1365100516000134 Published online by Cambridge University Press

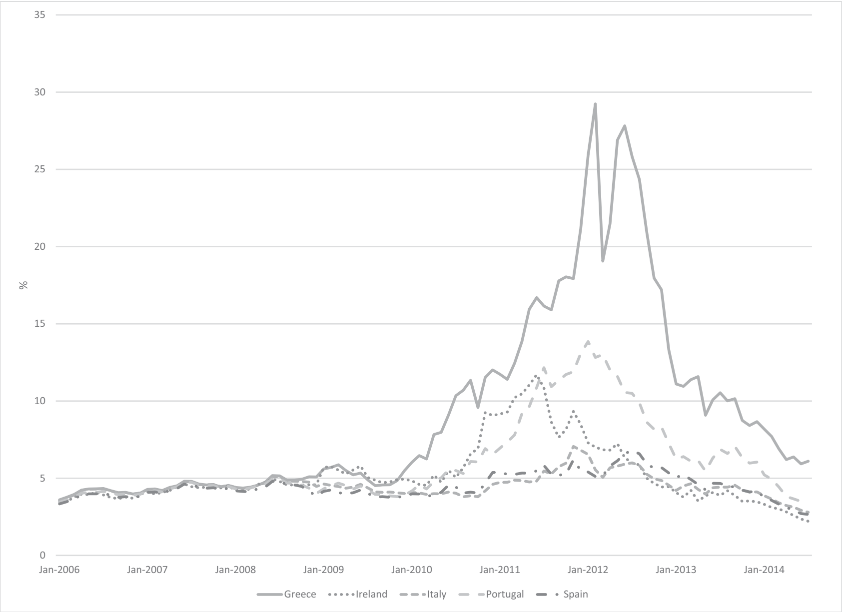

FIGURE 1. Interest rate on ten-year government bond yield. *Source*: OECD.

In order to cut through the messy details of the Eurozone crisis and focus on the international transmission of financial news to domestic real quantities, we model a “representative” portfolio of long sovereign bonds of different maturities originating in the “peripheral nations,” following the work of Hatchondo and Martinez (2009). In this framework, the bond units pay an infinite stream of coupons that decay at a constant rate that governs the average maturity of the portfolio of underlying bonds. The expected return on this portfolio is a function of the rate of decay of coupons. To capture changes in expected returns on the portfolio in a simple way, we model this rate of decay as a stochastic process with news shocks.[3] The stochastic nature of the average duration of the bond portfolio is also consistent with discussion in the press regarding the extent to which restructuring of the debt of various nations in the Eurozone would involve delaying payment of interest or converting shorter maturity debt into longer maturity debt.

Returning to the mechanism of the model, news about a future rise in the rate of decay implies a fall in the expected return, which induces a fall in the price of the portfolio, leading to a capital loss for banks. Because banks face a capital adequacy requirement that imposes restrictions on the amount of loans that they can extend to producers to a multiple of the value of their equity, the shadow price of lending rises, which leads to a higher loan rate and in turn a fall in loans taken by producers, tighter credit conditions, and a drop in investment and hours worked.[4,5]

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Our modeling of the bank capital adequacy requirement follows the literature. For example, banks with capital constraints are studied by Mendoza and Quadrini (2010) (henceforth MQ) in a two-country model. As in our model, banks cannot issue equity in MQ, so they must adjust their deposit and loan portfolios when the price of a fixed capital stock exogenously and unexpectedly falls. MQ does not deal with news shocks.[6]

Our model also builds on the news shock literature popularized by Beaudry and Portier (2004, 2006) where agents receive news about future changes in aggregate TFP [see also Gunn and Johri (2011a) and the references therein]. Kobayashi et al. (2012) and Gortz and Tsoulakas (2013) study the amplification of TFP news due to the presence of leverage-constrained financial intermediaries where, as in this paper, intermediation is also a key mechanism in the transmission of news. News shocks about TFP in an open economy context are studied in Jaimovich and Rebelo (2008) and Beaudry et al. (2011). Unlike these models, we focus on news about the return on a financial variable in a model where bank capital plays a crucial role in transmitting news shocks to the real economy. The focus on financial news as a source of business cycles is shared by Gunn and Johri (2011b, 2013) in fairly different closed economy contexts. Gertler and Karadi (2011) study unrealized news shocks to capital quality in a closed economy monetary model with leverage-constrained banks.[7]

In the next section we present our model. Section 3 discusses how we parameterize the linearized model. Section 4 presents the simulation results, and Section 5 explores the sensitivity of the results to parameter changes. Section 6 concludes.

2. MODEL

The economy consists of an infinitely lived household, an infinitely lived bank, and an infinitely lived entrepreneur operating as a competitive firm that produces a single good used for consumption or investment. The domestic bank uses funds from the household, as well as its own equity, to finance domestic loans to the entrepreneur, as well as international loans in the form of long bonds. The bank also has access to an international risk-free asset. For simplicity, our notation anticipates market clearing, so that we do not distinguish between quantities on the two sides of the markets unless necessary.

2.1. Household

The household has preferences defined over consumption C_t and hours worked N_t with expected lifetime utility defined as

$$\mathcal{U} = E_0 \sum_{t=0}^{\infty} \beta^t U(C_t, N_t), \tag{1}$$

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where β is the household's subjective discount factor and where $U(C_t, N_t)$ is given by $U(C_t, N_t) = \ln C_t - \chi N_t$.

The household enters into each period with financial assets A_t, held as deposits with the domestic bank, where they earn the risk-free net interest rate r_t^a. Each period it is endowed with a unit of time that can be allocated between nonmarket leisure and market hours worked at the firm for wage rate w_t.

The household's period-t budget constraint is given by

$$C_t + A_{t+1} = (1 + r_t^a)A_t + w_t N_t. \tag{2}$$

The household's problem is to choose contingent sequences of C_t, N_t, and A_{t+1} to maximize (1) subject to (2), yielding the respective first-order conditions

$$u_C(C_t, N_t) = \lambda_t^h, \tag{3}$$

$$-u_N(C_t, N_t) = \lambda_t^h w_t, \tag{4}$$

$$\lambda_t^h = \beta(1 + r_{t+1}^a)E_t\lambda_{t+1}^h, \tag{5}$$

where λ_t^h refers to the Lagrange multiplier on (2).

2.2. Entrepreneur

The entrepreneur has preferences defined over consumption Π_t, with expected lifetime utility defined as

$$\mathcal{U}^e = E_0 \sum_{t=0}^{\infty} \beta^{et} U^e(\Pi_t), \tag{6}$$

where β^e is the entrepreneur's subjective discount factor, and where $U^e(\Pi_t)$ is given by $U^e(\Pi_t) = \ln \Pi_t$.

The entrepreneur produces output Y_t using a constant-returns-to-scale technology given by

$$Y_t = N_t^{\alpha} K_t^{1-\alpha}, \tag{7}$$

where N_t is total hours hired in the competitive labor market at wage w_t and K_t is the stock of capital held by the entrepreneur.

The entrepreneur accumulates capital according to

$$K_{t+1} = (1-\delta)K_t + I_t\left[1 - S\left(\frac{I_t}{I_{t-1}}\right)\right], \tag{8}$$

where I_t is investment purchased from the goods market, $S(\cdot)$ are investment adjustment costs as in Christiano et al. (2005), and $S(1) = S'(1) = 0$ and $S''(1) > 0$. We assume that $S(\frac{I_t}{I_{t-1}})$ is given by $S(\frac{I_t}{I_{t-1}}) = \frac{\psi_i}{2}(\frac{I_t}{I_{t-1}} - 1)^2$, where the parameter $\psi_i = S''(1)$.

The entrepreneur has access to a one-period intertemporal loan L_{t+1} from the bank, with associated noncontingent interest rate r_{t+1}^l. In addition, it faces

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a working capital constraint forcing it to pay its wage bill $w_t N_t$ in advance of production, requiring it to access a within-period loan J_t from the the bank, so that it faces the working capital constraint

$$J_t = w_t N_t. \tag{9}$$

There is no interest rate associated with the within-period loan.[8]

The entrepreneur's budget constraint is then given by

$$\Pi_t + I_t = L_{t+1} + Y_t - w_t N_t - (1 + r_t^l) L_t. \tag{10}$$

There is limited enforceability of both the intertemporal and intratemporal loan contracts, in that the entrepreneur can decide to default after realizing its revenues but before repaying the intratemporal loan. Following Jermann and Quadrini (2012), in case of default, the bank can recover the liquidation value of the entrepreneur's assets; however, this liquidation value is uncertain. In particular, with probability ζ, the bank can recover $q_t K_{t+1}$, where q_t is the market price of capital, but with probability $1 - \zeta$, it recovers zero. Thus, as in Jermann and Quadrini (2012), the entrepreneur faces the enforceability constraint

$$\zeta \left(q_t K_{t+1} - L_{t+1} \right) \geq J_t. \tag{11}$$

We assume, as in Iacoviello (2015), that entrepreneurs discount the future more heavily than either households or bankers, soh that the entrepreneur will always borrow as much as possible, causing this constraint to bind.

The entrepreneur's problem is to choose contingent sequences of Π_t N_t, I_t, L_{t+1}, K_{t+1}, and J_t to maximize current and expected future profits,

$$E_t \sum_{s=0}^{\infty} \beta^{e t+s} U^e(\Pi_{t+s}), \tag{12}$$

subject to the capital accumulation equation (8), the working capital constraint (9), the budget constraint (10), and the enforcement constraint (11), taking all prices and interest rates as given. The entrepreneur's problem yields the first-order conditions[9]

$$U^{e\prime}(\Pi_t) = \lambda_t^e, \tag{13}$$

$$\left(1 + \frac{1}{\zeta} \frac{\xi_t}{\lambda_t^e}\right) w_t = \alpha \frac{Y_t}{N_t}, \tag{14}$$

$$1 = q_t \left[1 - S\left(\frac{I_t}{I_{t-1}}\right) - S'\left(\frac{I_t}{I_{t-1}}\right) \frac{I_t}{I_{t-1}} \right] + \beta^e E_t \frac{\lambda_{t+1}^e}{\lambda_t^e} q_{t+1} S'\left(\frac{I_{t+1}}{I_t}\right) \left(\frac{I_{t+1}}{I_t}\right)^2, \tag{15}$$

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$$1 - \frac{\xi_t}{\lambda_t^e} = \beta^e (1 + r_{t+1}^l) E_t \frac{\lambda_{t+1}^e}{\lambda_t^e}, \quad (16)$$

$$1 - \frac{\xi_t}{\lambda_t^e} = \frac{1}{q_t} \beta^e E_t \frac{\lambda_{t+1}^e}{\lambda_t^e} \left[(1-\alpha) \frac{Y_{t+1}}{K_{t+1}} + q_{t+1}(1-\delta) \right], \quad (17)$$

where λ_t^e and ξ_t are the Lagrange multipliers on the budget constraint (10) and the enforcement constraint (11), respectively.

For later reference, it is helpful to understand how a rise in the loan rate r_{t+1}^l leads to a drop in investment and hours worked. Combining (16) and (17) gives

$$(1 + r_{t+1}^l) E_t \frac{\lambda_{t+1}^e}{\lambda_t^e} = \frac{1}{q_t} E_t \frac{\lambda_{t+1}^e}{\lambda_t^e} \left[(1-\alpha) \frac{Y_{t+1}}{K_{t+1}} + q_{t+1}(1-\delta) \right], \quad (18)$$

where it is clear that with all else equal, on impact a rise in the loan rate r_{t+1}^l decreases the entrepreneur's desired level of capital next period, and thus reduces its demand for investment. From the investment first-order condition (15), the drop in current investment drives down the price of capital q_t, effectively tightening the enforceability constraint (11), driving up the shadow value of the constraint ξ_t, and thus decreasing the demand for labor through (14) as the entrepreneur's ability to gain working capital financing gets squeezed out by the drop in the value of its assets.

2.3. Bank

As discussed earlier, banks operate on both domestic and international markets. We describe the structure and pricing of the international long bonds first before describing the bank and its problem.

International long bonds. In order to capture the idea that international bond prices are determined on the international market, we work with a risk-neutral foreign investor who can borrow B_t^f at the constant world interest rate r^w and purchase units of a composite portfolio of long duration government bonds with an uncertain return. This portfolio resembles a bond mutual fund where quarterly interest payments by the underlying bonds can be reinvested in additional units of the fund or consumed if desired.

To model the long bonds in a tractable way, we follow the approach of Hatchondo and Martinez (2009) in assuming that in each period a unit of the bond portfolio provides an infinite stream of future coupons that decline at a stochastic rate δ_{gt}. The accumulated sum of past bond units purchased (and reinvested coupons), B_t^g, then summarizes the accumulated debt claims in a single state variable and captures the number of coupons to be received in period t. As discussed by Hatchondo and Martinez (2009), this particular coupon structure is a tractable way of approximating the debt-portfolio dynamics of a portfolio of zero-coupon bonds of different maturities, where the proportion of bonds with a given maturity

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declines geometrically with maturity. As such, the rate of decrease of the coupon payment, δ_{gt}, is associated with the average duration of the portfolio and thus can be tied down to the observed duration in the data if desired. By making the average duration of the portfolio stochastic, we are able to capture not only duration changes such as those that occur during restructuring of debt, but also, importantly, the expected future return of the bond holder, without having to model sovereign default.

The number of coupons received can then be captured by the accumulation equation

$$B_{t+1}^{g} = I_t^g + \left\{(1-\delta_{gt})I_{t-1}^{g} + \left[(1-\delta_{gt-1})^2 I_{t-2}^{g} + ...\right]\right\}, \tag{19}$$

which we can write as

$$B_{t+1}^{g} = (1-\delta_{gt})B_t^g + I_t^g, \tag{20}$$

where the new purchases of bond units are I_t^g, and each unit is a promise to pay a potentially stochastic stream $(1-\delta_{gt})^{s-1}$ of units each future period $t+s$, where $s \geq 1$.

The current profit of the foreign investor may be written as

$$\pi_t^f = B_{t+1}^f - q_t^g I_t^g - (1+r^w)B_t^f + B_t^g, \tag{21}$$

where q_t^g is the price of the long-duration bond.

Assuming that the foreign investor discounts future income at the rate β^f, the first-order conditions associated with the profit maximization problem are given by

$$1 = \beta^f(1+r^w) \tag{22}$$

and

$$q_t^g = \beta^f E_t[1 + q_{t+1}^g(1-\delta_{gt+1})]. \tag{23}$$

Combining, these conditions gives us a relationship between the world interest rate and the price of the government bond portfolio,

$$q_t^g = E_t \frac{1}{1+r^w}[1 + q_{t+1}^g(1-\delta_{gt+1})]. \tag{24}$$

Bank's problem. The representative bank has preferences defined over sequences of consumption D_t with expected lifetime utility defined as

$$\mathcal{U}^b = E_0 \sum_{t=0}^{\infty} \beta^{b^t} v(D_t), \tag{25}$$

where $\beta^b < \beta$ is the bank's subjective discount factor, and where $v(D_t)$ is given as $v(D_t) = \ln D_t$.[10]

Each period the bank makes one-period loans L_{t+1} to the domestic entrepreneur at the risk-free rate r_{t+1}^l, and within-period working capital loans J_t to the entrepreneur (with no associated interest rate as discussed earlier). In addition it

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buys, at the price q_t^g, I_t^b units of a portfolio of long-duration bonds, issued by various governments. As with the foreign investor, it is convenient to think of these purchases in terms of a composite portfolio of government bonds of different maturities, similar to a bond mutual fund. The bank's accumulated coupon receipts from owning units of the government bond portfolio, B_t^b, follow a process analogous to that of the foreign investor,

$$B_{t+1}^b = (1 - \delta_{gt})B_t^b + I_t^b. \tag{26}$$

The bank finances its intertemporal lending with one-period deposits from the household, A_{t+1}, at a risk-free interest rate r_{t+1}^a, as well as its own end-of-period equity V_{t+1}. Additionally, the bank can trade international one-period bonds, B_t^w, with associated exogenous risk-free world net interest rate r^w. The bank's end-of-period equity, V_{t+1}, is then defined as

$$V_{t+1} = L_{t+1} + q_t^g B_{t+1}^b - A_{t+1} - B_{t+1}^w. \tag{27}$$

We follow Kollmann et al. (2011) in assuming that the bank faces a capital requirement in the form of a penalty Φ_t for deviating from some desired bank capital ratio, $\frac{V_{t+1}}{L_{t+1}} = \gamma$. The value of this ratio may come from several sources. There may exist regulations that limit banks from lending more than a certain multiple of their equity. In addition, credit rating agencies use this type of information in deciding the riskiness of bank debt; the closer this ratio is to a predefined minimum, the lower the rating, which in turn leads to higher borrowing costs. There may also be costs associated with developing and marketing products that move loans off the bank balance sheet. Without modeling the specific details of this process, we simply wish to capture the idea that it is costly to move away from the desired ratio.

Letting $x_t = V_{t+1} - \gamma L_{t+1}$ be the deviation from the optimal capital ratio, we assume that $\Phi_t = \Phi(x_t)$ is defined as a convex adjustment cost with properties $\Phi(0) = 0$, $\Phi''(0) > 0$, as in Kollmann et al. (2011). In particular, we assume that $\Phi(x_t)$ follows $\Phi(x_t) = \phi_1 x_t + \frac{\phi_2}{2} x_t^2$, where the parameter $\phi_2 = \Phi''(0)$ and the parameter $\phi_1 = \Phi'(0)$ is pinned down by the model steady state.

The bank's budget constraint is given by

$$\begin{aligned} D_t + q_t^g I_t^b + L_{t+1} = {} & A_{t+1} + B_{t+1}^w + B_t^b + (1 + r_t^l)L_t - (1 + r_t^a)A_t \\ & -(1 + r^w)B_t^w - \Phi_t - \Psi_t^b - \Psi_t^w, \end{aligned} \tag{28}$$

where B_t^b evolves according to (26), and where Ψ_t^b and Ψ_t^w are adjustment costs on the international bonds B_t^b and B_t^w necessary to close the small open economy. We assume $\Psi_t^b = \Psi^b(B_t^b)$ and $\Psi_t^w = \Psi^w(B_t^w)$ follow $\Psi^b(B_t^b) = \frac{\psi_b}{2}(B_t^b - \bar{B}^b)^2$ and $\Psi^w(B_t^w) = \frac{\psi_w}{2}(B_t^w - \bar{B}^w)^2$ respectively, where the parameter $\psi_b = \Psi^{b''}(0) > 0$, the parameter $\psi_w = \Psi^{w''}(0) > 0$ and where a bar above a variable denotes a steady-state value.[11] Note that because there is no interest rate or cost for the bank

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associated with the within-period loans, these loans do now show up in the budget constraint written as net period flows as in the preceding.

The bank operatives competitively, taking prices as given to maximize (25) subject to (28), yielding the first-order conditions

$$\lambda_t^b = v'(D_t) \tag{29}$$

$$\lambda_t^b[1 + \Phi'(x_t)] = \beta^b(1 + r_{t+1}^a)E_t\lambda_{t+1}^b \tag{30}$$

$$\lambda_t^b[1 + (1 - \gamma)\Phi'(x_t)] = \beta^b(1 + r_{t+1}^l)E_t\lambda_{t+1}^b \tag{31}$$

$$\lambda_t^b q_t^g[1 + \Phi'(x_t)] = \beta^b E_t\lambda_{t+1}^b\left[1 + q_{t+1}^g(1 - \delta_{gt+1}) - \Psi^{b\prime}(B_{t+1}^b)\right] \tag{32}$$

$$\lambda_t^b[1 + \Phi'(x_t)] = \beta^b E_t\lambda_{t+1}^b\left[1 + r^w + \Psi^{w\prime}(B_{t+1}^w)\right], \tag{33}$$

where λ_t^b is the Lagrange multiplier on (28).

For future reference, it is helpful to illustrate how a fall in the the value of the government bond portfolio q_t^g leads to a rise in the domestic loan rate r_{t+1}^l. Note that a fall in q_t^g directly reduces bank equity V_{t+1} and thus excess capital x_t for given quantities of borrowing and lending. Because a fall in excess capital is costly for the bank, it will, as a result, reduce its borrowing relatively to its lending to limit the impact on excess capital, funding the shortfall by foregoing current consumption, which is also costly for the bank because of the curvature in its preferences. In equilibrium the bank will adjust on all of these margins so as to satisfy the efficiency conditions listed in the preceding, and the movements in r_{t+1}^l, r_{t+1}^a and q_t^g will reflect the bank's indifference to these levers of adjustment at the margin. Combining (30) and (31) we can see that

$$\frac{1 + r_{t+1}^l}{1 + r_{t+1}^a} = \frac{1 + (1 - \gamma)\Phi'(x_t)}{1 + \Phi'(x_t)}, \tag{34}$$

where the loan rate is determined by the severity of the capital requirement, γ, and the slope of the adjustment cost. In the absence of the capital requirement, banks would face no costs of lending to the entrepreneur and would act as a frictionless conduit of funds. As a result, variation in the price of government debt, while affecting bank capital, would have little impact on the borrowing costs. In the presence of a capital requirement however, (34) reflects the asymmetric impact of loans and deposits on the bank's capital requirement. The impact on the capital ratio of a marginal reduction in deposits is larger than that of an increase in loans because the former only affects the numerator whereas the latter affects both numerator and denominator in the same direction. As as a result, in equilibrium the loan rate r_{t+1}^l must rise relative to the deposit rate r_{t+1}^a in order to leave the bank indifferent between these two margins of adjustment.

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2.4. Stochastic Process δ_{gt}

As discussed earlier, δ_{gt} refers to the average maturity of the bond portfolio held by the bank in period t. It also refers to the rate at which future coupon payments will decline. A rise in δ_{gt} implies that the expected future returns from holding the bond will fall, which will induce, in turn, a fall in the price of the bond to compensate future bond holders for this lower payment. We model δ_{gt} as an exogenous process in which $1 - \delta_{gt}$ evolves according to the stationary AR(1) process

$$\ln(1 - \delta_{gt}) = \rho \ln(1 - \delta_{gt-1}) + \mu_t, \tag{35}$$

where $\rho < 1$ and μ_t is an exogenous period-t innovation, which we will define further hereafter.

Our representation of news shocks is standard and follows Christiano et al. (2008). We provide for news about δ_{gt} by defining the innovation μ_t in equation (35) as

$$\mu_t = \epsilon_{t-p}^{p} + \varepsilon_t, \tag{36}$$

where ϵ_{t-p}^{p} is a news shock that agents receive in period $t - p$ about the innovation μ_t, and ε_t is an unanticipated contemporaneous shock to μ_t. The news shock ϵ_t^p has properties $E\epsilon_t^p = 0$ and standard deviation σ_{ϵ^p}, and the contemporaneous shock ε_t has properties $E\varepsilon_t = 0$ and standard deviation σ_{ε_x}. The shocks ϵ_t^p and ε_t are uncorrelated over time and with each other.

2.5. Equilibrium

Equilibrium in this economy is defined by contingent sequences of C_t, N_t, Π_t, I_t, Y_t J_t, D_t, I_t^b, A_{t+1}, K_{t+1}, L_{t+1}, B_{t+1}^w, B_{t+1}^b, w_t, r_{t+1}^a, r_{t+1}^l, q_t^g, and q_t that satisfy the following conditions: (i) the allocations solve the household's, entrepreneur's, and bank's problems, taking prices as given, and (ii) all markets clear. Note that we have included neither the foreign investors' decisions nor the aggregate supply of international long bonds as part of the equilibrium, because they are assumed to be formed outside the model and are simply taken as given by domestic agents in the small open economy.

The aggregate resource constraint for the economy is given by

$$Y_t = C_t^{\text{tot}} + I_t + \text{NX}_t + \Gamma_t, \tag{37}$$

where C_t^{tot} is total aggregate consumption, given by

$$C_t^{\text{tot}} = C_t + D_t + \Pi_t, \tag{38}$$

NX_t is net exports, given by

$$\text{NX}_t = (q_t^g I_t - B_t^b) - [B_{t+1}^w - (1 + r^w)B_t^w], \tag{39}$$

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and Γ_t is a collection of adjustment costs, given by

$$\Gamma_t = \Phi_t + \Psi_t^b + \Psi_t^w. \quad \textbf{(40)}$$

3. PARAMETERIZATION

In this section we present an illustrative calibration that we will use in the next section for our simulation analysis. Because we think of the mechanisms that we highlight as being potentially operative in various Eurozone countries (albeit to differing degrees), we do not attempt to base our parameterization on any one country. Rather, we think about a prototypical or "amalgamated" Eurozone country with characteristics close to the Eurozone average. We assign values to parameters using typical values established in the literature modeling Eurozone economies, or where there is a lack of precedent, we choose the parameters to match relevant steady state quantities in the model economy with analogous quantities in the data. Finally, we solve the model by using standard methods to linearize the nonlinear system about the unique steady state.

Beginning with the standard parameters, we set the household's subjective rate of time discount, β, to 0.99, labor's share in production, α, to 0.7, and depreciation of physical capital, δ, to 0.025, all based on Smets and Wouters (2003), who construct a dynamic stochastic general equilibrium (DSGE) model of the Eurozone. We set the entrepreneur's rate of time discount, β^e, to 0.94, based on Mendoza and Quadrini (2010) and Iacoviello (2015), and the investment adjustment cost parameter, ψ_i, to 6.962 from the value estimated by Smets and Wouters (2003) for the Eurozone.

We follow Jermann and Quadrini (2012) in using the domestic-loans-to-GDP ratio to pin down the enforcement constraint parameter ζ. Kollmann et al. (2011) report domestic loans to nonfinancial firms as a proportion of (annualized) GDP for the Eurozone of 0.9 for the first decade of the 2000s. Using this value in our model yields a value for ζ of 0.104. Jermann and Quadrini (2012) calibrate a value of 0.1634 for this parameter for the United States.

The remaining parameters apply to the bank. We set the bank's subjective discount factor β^b to 0.97, consistent with Guerrieri et al. (2012), who use 0.96, and Gerali et al. (2010), who use 0.975.

In the steady state, we target the depreciation rate on government bonds, δ_g, to match the average duration of bonds seen in the Eurozone periphery. According to Contessi (2012), Portugal, Italy, Spain, and Greece had a weighted maturity as of December 31, 2011 of between 5 and 10 years, so we use 7.5 years for the model to target in steady state. Following Hatchondo and Martinez (2009), the duration in quarters can be calculated from $D = (1 + r^g)/(\delta_g + r^g)$, where D refers to the duration and r^g to the implied constant yield on government debt from the formula $r^g = (1/q^g) - \delta_g$. This gives us a value of $\delta_g = 0.023$. In our simulations we wish to consider only the case of a one-time shock to the average maturity δ_g

TABLE 1. Model parameterization

Parameter	Value
β	0.99
α	0.7
δ	0.025
β^e	0.94
ψ_i	6.962
ζ	0.104
β^b	0.97
δ_g	0.023
ρ	0
γ	0.08
ϕ_2	0.25
$q^g B^b / Y_{\text{ann}}$	0.352
B^w / Y_{ann}	2
ψ_w	0.00042
ψ_b	0.00042

as a conservative illustration with no persistence, and thus we choose $\rho = 0$ for the persistence of the stochastic process for $1 - \delta_t$.

We set the capital sufficiency requirement γ to 8% based on the so-called Basel II documents and explore the impact of changing this number. Kollmann et al. (2011) use a value of 5%, whereas Gerali et al. (2010) and Guerrieri et al. (2012) use values of 9% and 10%, respectively. Turning to ϕ_2, which governs the adjustment cost of deviating from the steady state capital-to-loan ratio, we set the baseline value to 0.25 as in Kollmann et al. (2011), whereas Mendoza and Quadrini (2010) work with a value of 0.1. We also show the impact of changing this parameter on the model results.

We set steady state bank holdings of sovereign debt as a fraction of (annualized) GDP, $\frac{q^g B^b}{Y_{\text{ann}}}$, based on Guerrieri et al. (2012), who report Eurozone banks' holdings of total peripheral Eurozone sovereign debt of 35.2% of GDP ending in 2010. From here, we set borrowing of international risk-free bonds as a fraction of (annualized) GDP, $\frac{B^w}{Y_{\text{ann}}}$, to 200% to target a steady state consumption-to-GDP ratio $\frac{C}{Y}$ of 0.6, as reported by Smets and Wouters (2003) for the Eurozone. The bonds held by the foreign investor do not interact with the domestic economy, so they are not included in the model. For the adjustment costs associated with the bank changing its stock of international assets, B^w and B^b, we set both, ψ_w and ψ_b, equal to 0.00042, the value determined in [Uribe and Yue (2006)] for the same form of adjustment costs. Table 1 summarizes the parameterization.

4. RESULTS

In this section we explore impulse responses of the calibrated model to shocks to the mean duration of the bond portfolio which governs the expected future return.

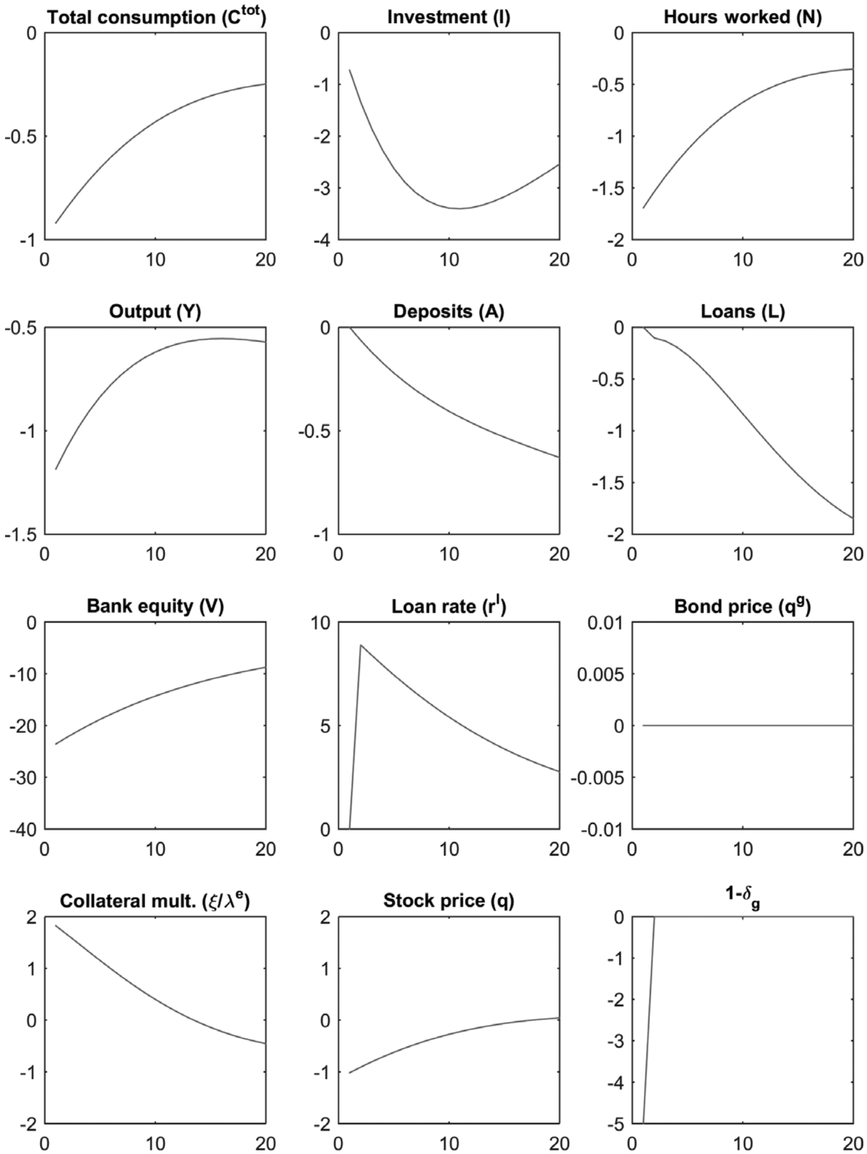

FIGURE 2. Contemporaneous fall in $1 - \delta_g$ (% deviation from steady state).

More precisely, we hit the model with a 5% fall in $1 - \delta_{gt}$. To help illustrate the mechanics of the model, we first begin with a contemporaneous shock before moving on to look at anticipated changes in returns using news shocks.

4.1. Contemporaneous Shock to $1 - \delta_{gt}$

Figure 2 displays the response of the model economy to a 5% fall in $1 - \delta_{gt}$ in period 1. The shock process has zero persistence, so as indicated in the last panel of Figure 2, $1 - \delta_{gt}$ returns to its steady state value in period 2. As can be seen from the figure, in response to this one-time shock, total consumption, investment, hours worked, and output all drop immediately. Moreover, the loan rate rises while the quantity of loans falls, indicating a fall in the quantity of loans demanded by the entrepreneur in response to the higher cost of credit. Note that in this case, the price of government bonds, q_t^g, is unaffected by a contemporaneous fall in $1 - \delta_{gt}$, so that the recession in domestic variables is not accompanied by a fall in bond prices (rise in yield) as was seen during the Eurozone crisis.

The initial impact of the shock works through the bank's budget constraint as an unanticipated drop in the bank's return on its government bond portfolio. Faced with this unanticipated drop in return, the bank has several levers to reorganize its portfolio of assets and liabilities, all of which are costly to use. The key changes are displayed in Figure 2—the bank lowers the amount of loans made and it slightly increases deposits taken from the household. In addition, it reduces its consumption somewhat and allows equity to fall relative to loans to a ratio below the steady-state level. The consumption-smoothing motive entices it to spread the impact through time, willingly reducing its end-of-period equity in order to pull future consumption into the present. As discussed earlier, the cost to the bank in terms of capital ratio penalties of adjusting loans relative to borrowing causes the loan rate r_{t+1}^l to rise immediately, and the rise in the loan rate in turn leads to a decrease in both investment and labor and a drop in the price of capital (stock prices) as described earlier in the model section.

Figure 3 shows the composition of total consumption between household, bank, and entrepreneurial consumption. Although household consumption drops only slightly, both bank and entrepreneurial consumption drop significantly as these agents trade off current consumption to adjust to the shock.[12]

Although the model response to the contemporaneous shock exhibits some patterns that are consistent with the ongoing Euro area sovereign debt crisis episode, the lack of movement in bond prices is not. We will see in the next section that the introduction of anticipated shocks to $1 - \delta_g$ "solves" this problem.

4.2. Anticipated Decrease in $1 - \delta_g$

Figure 4 shows the response of the model economy to a news shock in period 1 according to which $1 - \delta_g$ will fall by 5% in period 8, and then in period 8 $1 - \delta_g$ to an actual fall by 5%. As can be seen from the figure, in response to the news shock, consumption, investment, hours worked, and output all drop immediately on arrival of the news and persistently stay below steady state for all periods shown in the figure. As in the case of the contemporaneous shock, the loan rate rises as befor,e but now bond prices immediately tumble, implying a *rise* in the yield on government bonds, which is consistent with observations from the Eurozone.

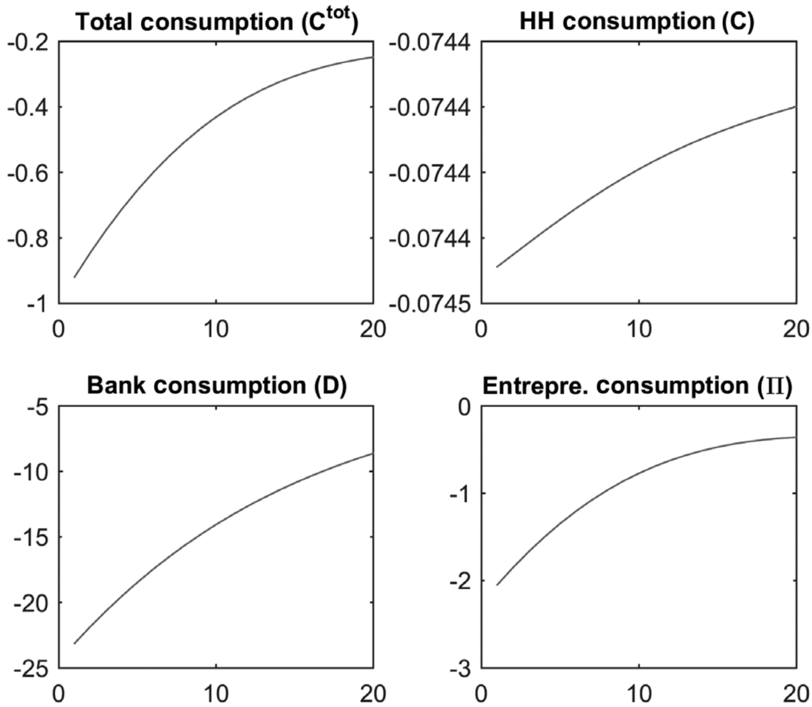

FIGURE 3. Contemporaneous fall in $1 - \delta_g$ (% deviation from steady state). Response of consumption components.

In contrast to the case of the contemporaneous shock, where the impact effect of the shock operated through the unanticipated drop in the return on the bank's government bond portfolio (with no change in the price of this portfolio), now the primary impact effect operates through the drop in the price of this bond portfolio, q_t^g, as agents anticipate a fall in the future return. Note that in the bank's bond portfolio first-order condition (32), the price of the bond in the next period, q_{t+1}^g, is on the right-hand side of the equation, reflecting the positive market value of the bond unit in the next period, because it will continue to pay coupons into the future. Iterating this equation into the future for eight periods then reveals that the price today depends on the expected value of δ_g for all periods leading up to and including period 8. Thus the news that $1 - \delta_g$ will decrease in period 8 immediately reduces the price of the long bond in period 1 as compensation to the potential investor for this expected loss.[13] The fall in bond prices drives up the loan rate, r_{t+1}^l, and the rise in the loan rate again in turn leads to a decrease in both investment and labor and a drop in stock prices, as described earlier in the model section.

Relative to the literature on news shocks about expected future changes in TFP, one may ask why our model exhibits co-movement in response to news about our

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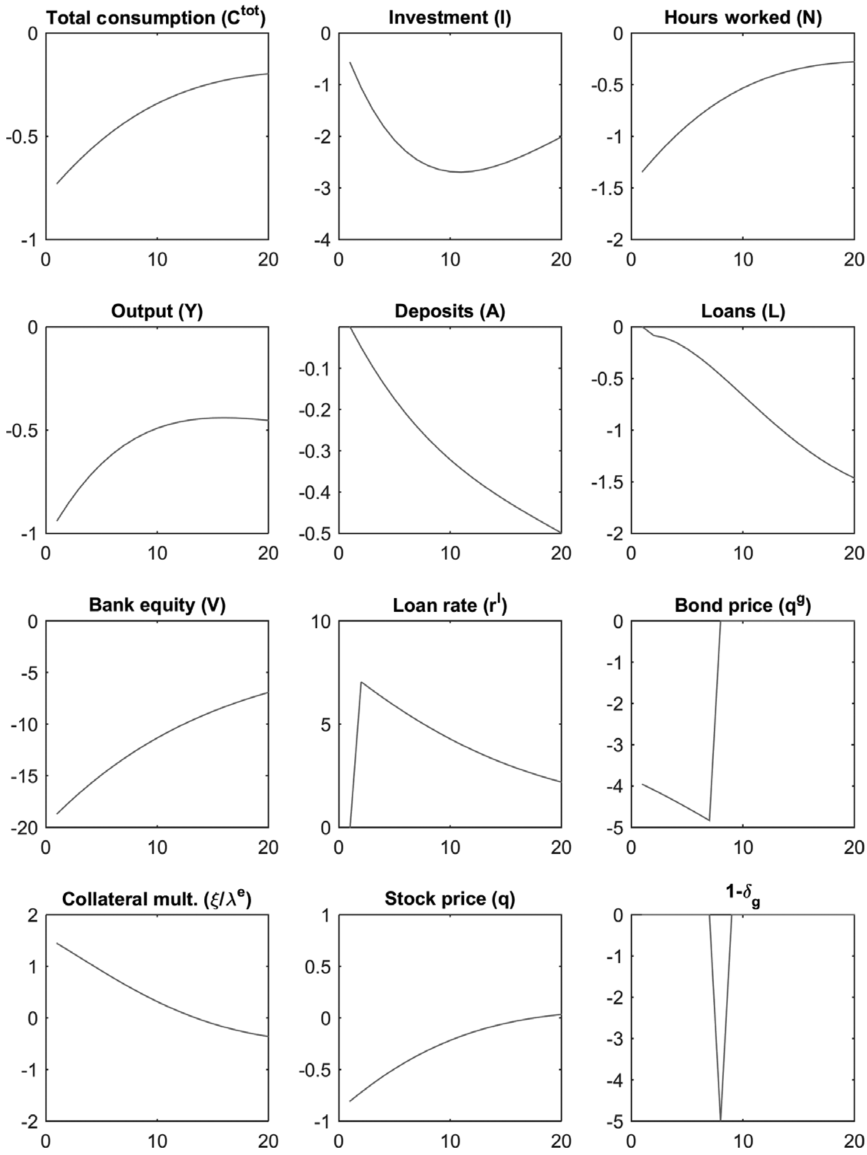

FIGURE 4. News about fall in $1-\delta_g$, shock *realized* (% deviation from steady state).

shock with standard preferences, in contrast to many models of TFP news that require special forms of preferences to eliminate or weaken the effect of wealth on leisure. Unlike the case of TFP news, financial news shocks such as ours simply do not have the same large wealth effects unleashed by changes in TFP, and as a result there is no significant impact on labor supply. Recall that a TFP shock is like

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"manna from heaven": agents know that they will receive additional consumption goods in the future even if they do nothing different. This unleashes large wealth effects, which under standard preferences typically result in a contraction in labor supply and as a result an equilibrium response of hours worked that negatively co-moves with consumption. In contrast, the main mechanism by which hours are influenced in our model is that entrepreneurs wish to hire less labor. Labor demand falls because the shadow price of working capital loans rises when bank capital is lost. Essentially, we view this as tighter credit conditions causing firms to borrow less and hence reducing their labor input.

4.3. Unrealized Expectations

Although investors' expectations about a fall in the return on their portfolio are sometimes realized, often they are not. A fall in the expected future return through a shock to $1-\delta_g$ occurs because the future stream of expected payments is postponed. In the Eurozone crisis, investor expectations regarding a fall in future payments from the Greek government were realized due both to revaluation of the amount of debt to be repaid and to postponement of the maturity date. Similar expectations regarding other nations' debt have so far proved false. The news shock methodology is interesting in this situation because it allows us to analyze the macroeconomic implications of news that fails to materialize. Although too stark to be realistic, we find the following exercise to be quite helpful in interpreting current events in the Eurozone. In period 1 agents receive the news that $1-\delta_g$ will fall in period 8 by 5%. In period 8, an exactly ofsetting contemporaneous shock to δ_g renders the news false. As a result, all the actions taken by agents in response to the fall in bond prices need to be reversed and the economy slowly recovers from the recession. Figure 5 displays the response of the model economy for the unrealized news shock case. Because agents receive the same news in period 1 as in the realized shock case, their responses are exactly the same up through period 7: the immediate rise in the yield on government debt is transmitted into a rise in loan rates and a recession. In period 8 the pessimism proves to be unfounded and there is an immediate spike in government bond prices. The spike in bond prices causes an immediate increase in bank capital, which allows the bank to reverse earlier portfolio decisions. Lending rates fall below their steady state levels and aggregate quantities and stock prices rise above steady state levels as the economy rebuilds its capital stock. We find this exercise particularly interesting because the recession occurs in the absence of any actual delay in coupon payments thus can be seen as an example of a recession induced purely by changes in expectations about future returns on bond portfolios.

5. SENSITIVITY TO KEY PARAMETERS

In this section we explore the sensitivity of our model results to variations in three key parameters: γ, ϕ_2, and ϕ_i. As can be seen from Figures 6–8, although the

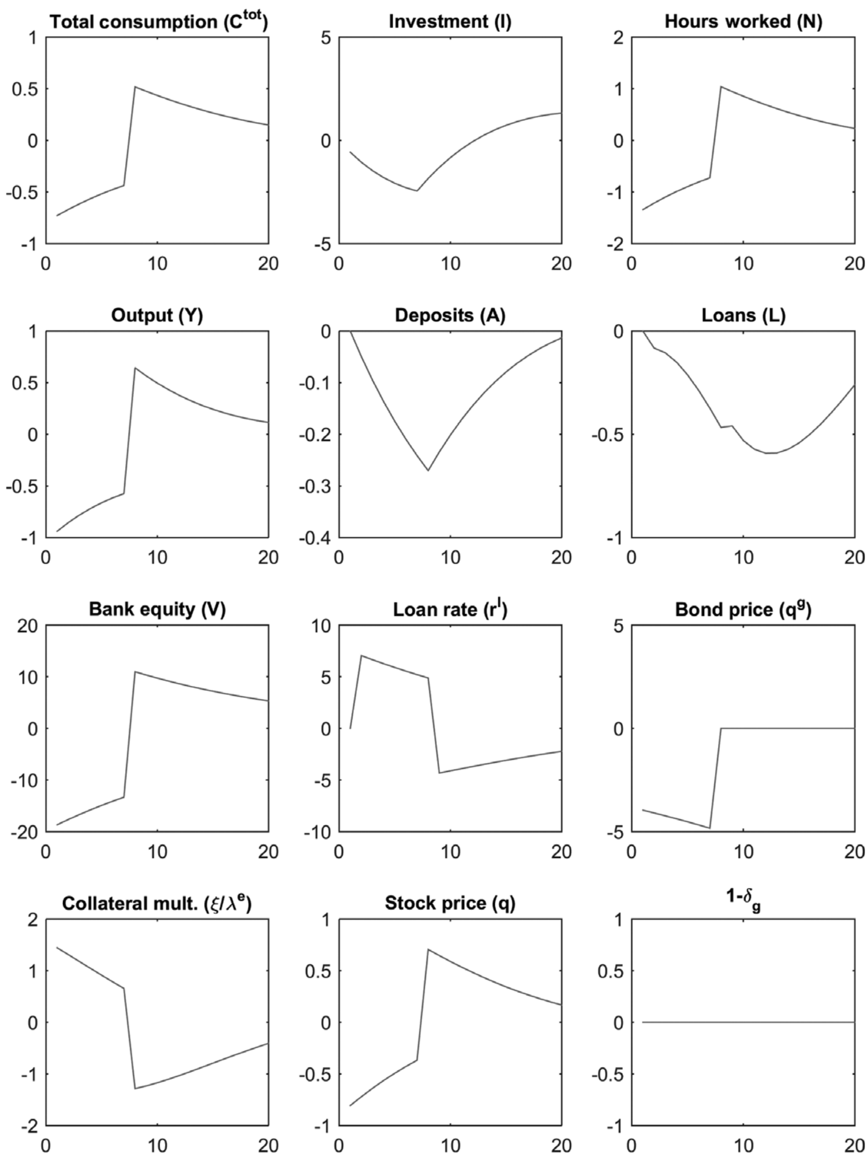

FIGURE 5. News about fall in $1 - \delta_g$, shock *unrealized* (% deviation from steady state).

results do change with the parameters, the story told in the previous section remains intact for a fairly wide range of parameter values. Not surprisingly, as Figures 6 and 7 show, both γ, the capital requirements ratio, and ϕ_2, the adjustment cost on excess capital parameter, are key parameters for transmitting the news shock about bond returns into real activity, and in general the depth of the recession

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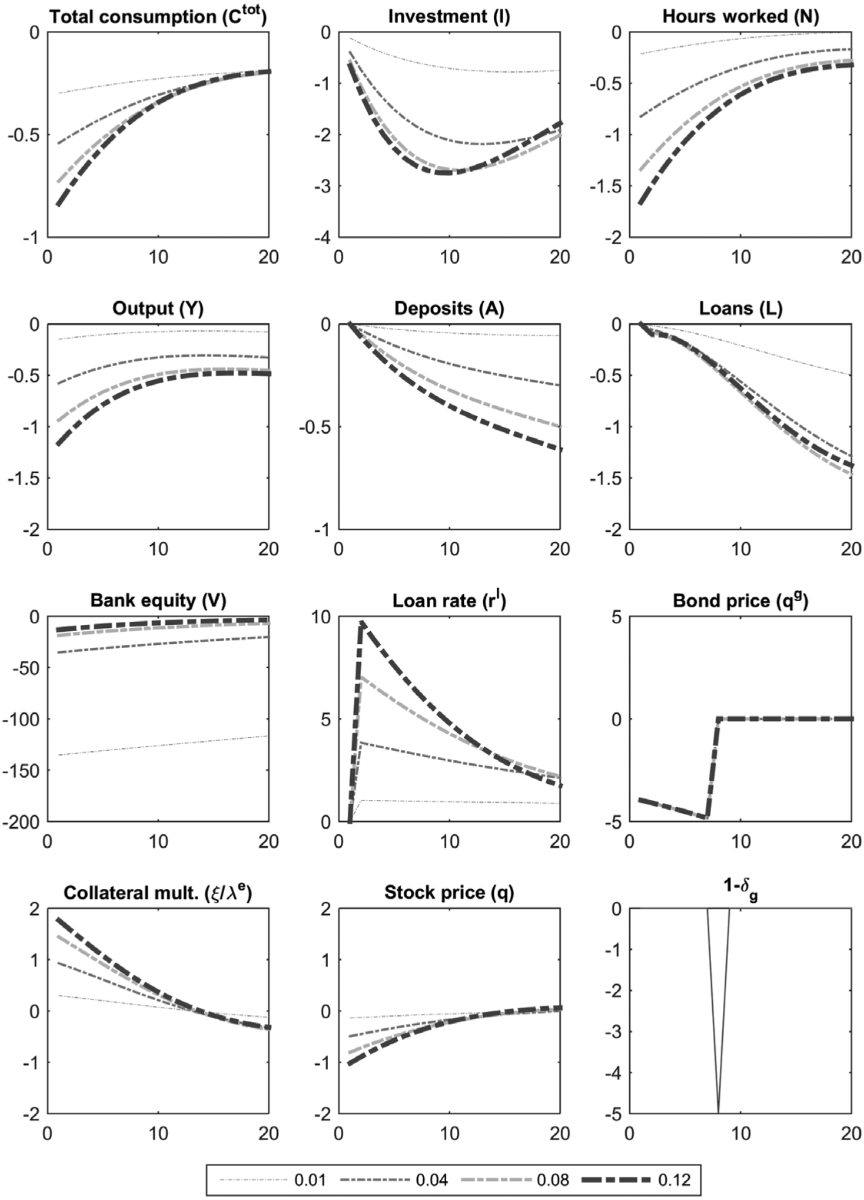

FIGURE 6. News about fall in $1 - \delta_g$, shock realized: γ sensitivity (% deviation from steady state).

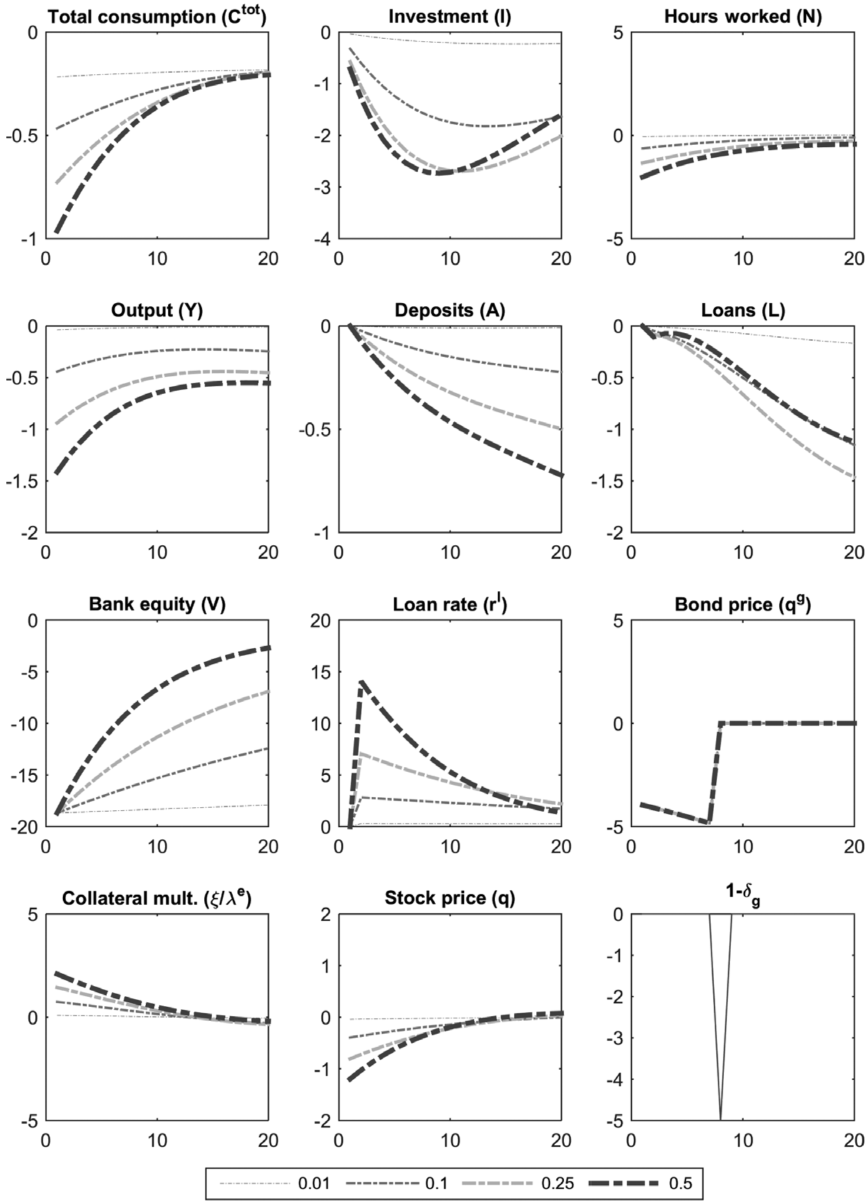

FIGURE 7. News about fall in $1-\delta_g$, shock realized: ϕ_2 sensitivity (% deviation from steady state).

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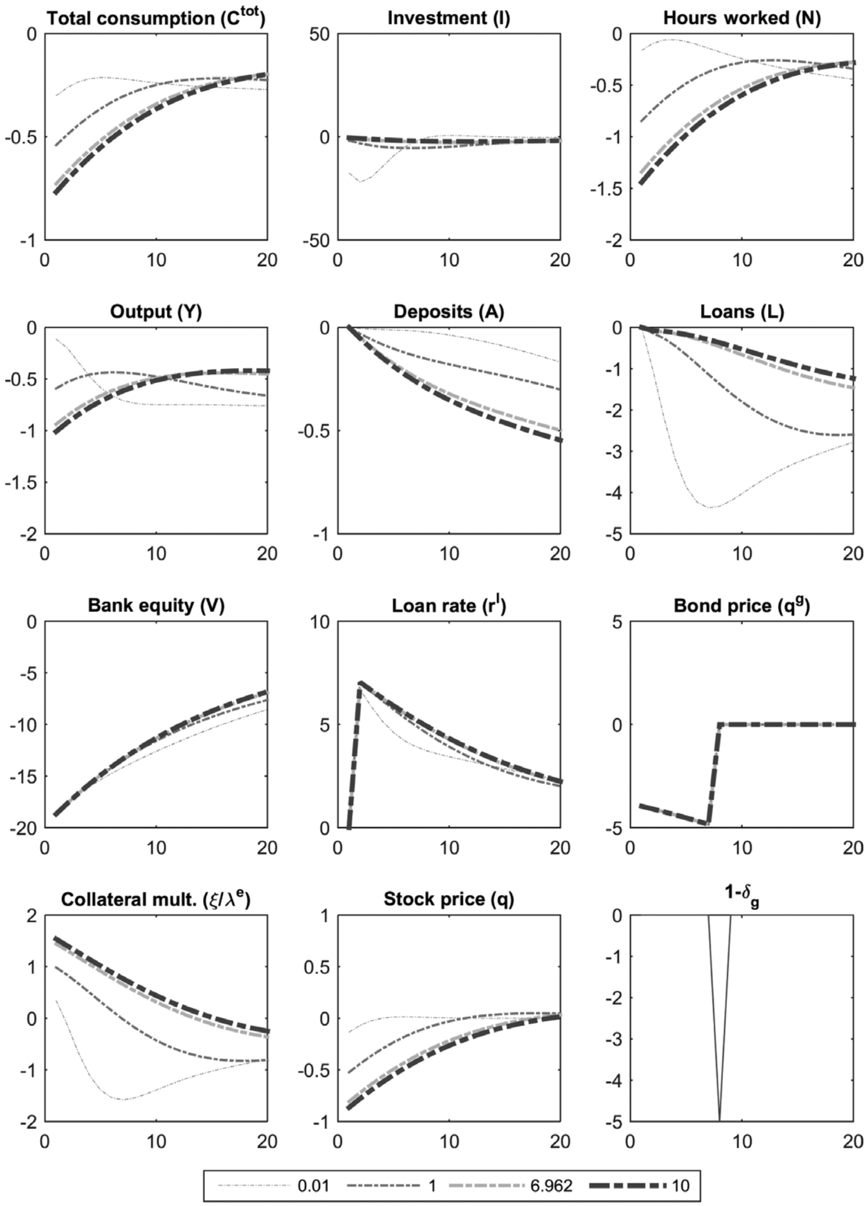

FIGURE 8. News about fall in $1 - \delta_g$, shock realized: ψ_i sensitivity (% deviation from steady state).

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falls as these two parameters are reduced. As ϕ_2 approaches zero, the bank faces no penalty for deviating from the capital requirement, and thus again there is no rise in the lending rate charged to the entrepreneur and no impact on the demand for labor. Figure 8 shows that ψ_i, the investment adjustment cost parameter, also plays a key role, yet in a different way than the previous two. Whereas γ and ϕ_2 primarily control the extent to which the change in the value of the sovereign bond portfolio impacts the cost of domestic credit, ψ_i impacts the extent to which both investment and the demand for labor respond to this change in the cost of domestic credit. Indeed, as the figure shows, as ψ_i approaches zero (0.01), the response of hours worked diminishes markedly, despite a larger initial drop in investment.

6. CONCLUSION

Can the mere anticipation of a fall in bond-portfolio returns curtail economic activity? We build a model that answers the question in the affirmative. Our small open economy model delivers a fall in output, consumption, investment, and hours as well as in the amount of loans made by the banking system in conjunction with a rise in the loan rate purely in anticipation of a future postponement of coupon payments on units of a portfolio of infinitely lived international sovereign debt. When news arrives that the future stream of coupon payments starting eight quarters later will be delayed (in a discounted sense), this causes expected returns to be revised downward, and investors immediately cause the portfolio price to fall to compensate them for the lower return. The fall in bond prices imposes a capital loss on bondholders, including those in the banking system, causing a loss of bank capital. In the presence of a need to satisfy some desired ratio of bank capital to loans, banks must adjust their optimal mix of loans, deposits, sovereign bond holdings, and consumption. This causes interest rates on private loans to rise, which, along with the tighter credit conditions induced by the fall in the price of capital, induces a big fall in private loans. The fall in economic activity occurs in advance of any actual change in coupon payments and may occur even if the pessimistic expectations are later unfulfilled.

Our paper contributes to several recent literatures, including studies that emphasize the role of banking capital in economic fluctuations, the emerging economy business cycle literature, and the news shock literature. Whereas most studies of news shocks focus on news about total factor productivity or fiscal policy, we extend these ideas to the financial sphere and study the impact of news about a change in the expected return on a portfolio of sovereign bonds. Relative to the business cycle literature with a banking system, the presence of long-maturity bonds is unusual and essential to the story, as is the presence of news shocks as a driving force. In addition, the model develops a novel source of external financial shocks relative to the small open economy business cycle literature. Many emerging-economy business cycle models generate fluctuations based on shocks to the world interest rate or the country-specific interest rate at which the economy can borrow, whereas in our model the cost of borrowing from the rest of the world is held constant, whereas private domestic loan rates move endogenously.

NOTES

1. Cyprus is one such example (we thank the referee for making this suggestion). We note too that other nations in the Eurozone may have experienced the contractionary force illustrated by our model whether or not they actually experienced a recession.

2. Although our model is related to emerging-economy business cycle models in which a rise in the exogenous interest rate faced by a small open economy induces a domestic recession [see Uribe and Yue (2006), Garcia-Cicco et al. (2010), Chang and Fernandez (2013), and Minetti and Peng (2013), for example], in our model the relevant private cost of borrowing is determined by local demand and supply factors in the market for domestic credit.

3. This is in contrast to the typical dynamic stochastic general equilibrium (DSGE) model with government debt, where bonds mature in one period. In that setting, if agents anticipate future declines in the return of some bond several periods out, then there is no need for them to react in the bond market until the period immediately before the actual change is expected to occur, because these assets do not yet exist as part of bond portfolios. See Kollmann et al. (2011) for an illustration of this. In contrast, in our case of a portfolio of long bonds, when news arrives today about the change in future returns, the price of the long bonds will plunge immediately in order to compensate buyers, and existing bondholders will be forced to take a capital loss immediately. because these long bonds are part of existing loan portfolios.

4. In practice, government debt held by banks was included in equity. As a result, a fall in government bond prices lowered bank equity without lowering risk-weighted loans. As discussed in more detail in the model section that follows, the bank uses all available margins (adjusting dividends, deposits, and loans) to limit the costs associated with departing from the desired ratio of loans to equity.

5. Iacoviello (2015) shows how one can alternatively think of this constraint as a standard collateral constraint on bank loans.

6. Kollmann et al. (2011) study the impact of exogenous loan defaults by entrepreneurs on the international transmission of business cycles in a model of global banking with capital requirements. Capital constraints are also important in Iacoviello (2015), where bank capital is reduced by making one group of households exogenously default on their loans in a closed-economy model without news shocks. See also Gerali et al. (2010) and Aliaga-Diaz and Olivero (2012).

7. In order to focus on the issues at hand, we have omitted a discussion of anticipated fiscal policy, which is relevant but also better understood. See, for example, Leeper and Walker (2011).

8. See Jermann and Quadrini (2012), Bianchi and Mendoza (2013), and Iacoviello (2015) for models with working capital loans without an associated interest rate.

9. For notational simplicity, we have omitted notation allowing for multiple entrepreneurs that both produce capital and buy and sell capital from and to each other in capital markets. Such a framework yields the result that at the optimum, the market price of capital equals each entrepreneur's internal shadow value of new capital, a result that we used earlier to replace the Lagrange multiplier on (8) with the market price for new capital q_t. It is easy to show that q_t is also the price of a share of a firm traded in the stock market in a suitable modified model. In the discussion of the results we will refer to q_t as the stock price.

10. It is quite common to model banks as agents with concave preferences. See Guerrieri et al. (2012), Kollman (2013), and references within.

11. Small open economy models typically only require an adjustment cost on the international bond (or similar alternative mechanism) to close the small open economy and prevent a unit root on the international bond [see Schmitt-Grohe and Uribe (2003)]. Because in our model there are two international assets, we require adjustment costs on both household assets to prevent *two* unit roots on

the two international bonds. The form of the adjustment costs that we use here on each asset follows that on the single international asset in Uribe and Yue (2006).

12. Under alternative nonseparable preference specifications such as those used in Gunn (2015), household consumption drops into line with hours worked.

13. As might be expected, if the model only contains one-period bonds (which can be modeled here with $\delta_g = 1$), we end up with a result similar to the finding of Kollmann et al. (2011) that anticipated changes in the return on the bond have no real impact in a one-period bond model economy. Note that in their model the change in returns was the result of default by borrowers. Results from that 1-period bond economy are available from the authors upon request.

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