THE EFFECTS OF INVESTOR CONFIDENCE SHOCKS ON BUSINESS CYCLES

By JAI KEDIA*

This paper extends a quantitative medium-scale New-Keynesian DSGE model with financial intermediaries to account for shocks to investor confidence. Shocks of this nature manifest themselves as per period changes to financial intermediaries' leverage ratios. A Bayesian MCMC approach is utilized to estimate the base and extended model, including shock process parameters, for the U.S. economy using five macroeconomic time series from 1984 through 2019. The estimation results suggest that confidence shocks have a large and sustained effect on the real economy. Overconfidence initially provides a boost to the economy but this effect subsides and then triggers a prolonged recession. In the base model, a decomposition of U.S. output growth into its constituent shocks shows that the effect of negative shocks to capital quality contributed significantly to the financial crisis of 2008. However, this effect is muted in the extended model suggesting that shocks to confidence were important contributors to the output gap during the Great Recession.

KEYWORDS: Applied General Equilibrium Model; Business Cycles; Financial Frictions; Irrationality; Macroeconomics

This paper aims to analyze the macroeconomic effects of irrational changes to investor confidence on the short-run business cycle. The prevalence of overconfidence is well established in the social psychology literature. Its common manifestation is the "better-than-average" effect: when asked to rate their relative skills, people seem to overestimate their ability relative to the average of the group (see: Larwood and Whittaker, 1997; Svenson, 1981; Alicke 1985). Psychological underpinnings for overconfidence are typically attributed to three key factors: an illusion of control over outcomes, large commitments to positive outcomes, and establishing abstract reference points which renders performance comparisons difficult (Weinstein, 1980; Alicke, 1995).

While psychological studies assess subjects' confidence pertaining to things such as motor skills or mortality, this phenomenon is also prevalent with respect to economic decision making (Camerer and Lovallo, 1999). Theoretical and empirical research in behavioral finance has shown that investors and managers exhibit overconfidence. For instance, Malmendier and Tate (2005, 2008, 2015) show that managers and CEOs overestimate the expected returns from investment projects; they overinvest when internal funding is abundant but reduce investment when relying on external funding.

The empirical finance literature also indicates that such overconfidence had an impact

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on the short-run business cycle by exacerbating the financial crisis of 2007-09. Ho, et. al. (2016) show that in the period leading up to the financial crisis, overconfident bank managers were more likely to lower lending standards and increase their leverage, making their institutions more susceptible to the crisis shock. Jlassi, et. al. (2014) claim that overconfidence was the primary factor that triggered and elongated the crisis in the U.S. market. Abbes (2013) demonstrates that market price volatility is positively related to overconfidence bias and that this bias contributed to the financial instability of 2008.

In lieu of the behavioral finance literature, it is possible that the financial crisis was in some part attributable to irrationality or deviations from rational expectations on the part of financial intermediaries. In the past, popular behavioral approaches to explaining macro fluctuations that are unrelated to fundamentals relied on attributing such behavior to "animal spirits"[1] or to agent irrationality (Akerlof and Shiller, 2009). Modern behavioral approaches include macro models that incorporate agent sentiments (Angeletos and La'O, 2013), adaptive learning (Milani, 2007), rational inattention[2], or bounded rationality (Branch and McGough, 2005). However, attempts to model the interaction between financial agents and non-rational expectations have been relatively sparse, albeit illuminating. In an estimated model that combines a medium-scale DSGE model with a financial accelerator and adaptive learning, Rychalovska (2016) shows that the effect of the financial accelerator on the business cycle varies based on how expectations are modeled. In particular, agents' perceptions regarding asset price persistence can significantly amplify the response of real variables to financial shocks. In a calibrated model, Caputo, et. al. (2010) also find that business cycles may be amplified when the financial accelerator is combined with learning. While it may be the case that adaptive learning adds a valuable means of interaction between the financial sector and macro variables, the evidence from the prior literature presented above indicates that it may not be the only behavioral element at play. To my knowledge, there has been no attempt to explicitly account for changes to investor confidence in a theoretical model of the short-run macroeconomy. The research proposed herein attempts to fill this gap and add to the burgeoning macroeconomic literature that aims to incorporate behavioral elements into a model of the short-run economy.

Section I presents a theoretical investigation of how overconfidence in the financial sector might induce banks to increase leverage, causing them to be overexposed to financial shocks. To this end, I begin with the Gertler and Karadi (2011) (henceforth "GK2011") medium-scale monetary DSGE model with financial frictions. Section I.A provides an overview of the equilibrium equations from this model. To provide a theoretical basis for including confidence, the paper follows Malmendier and Tate (2005) where investors do not perceive the true expected rate of return, but instead utilize a *subjective* assessment of what the expected rate of return might be. Mathematically, this is modeled by scaling the objective expected rate of return by a confidence factor. The theory indicates that investors maximizing net worth based on such subjective assessments choose leverage ratios that deviate away from the optimal amount: over-confident

[1]See: Azariadis, 1981; Benhabib and Farmer, 1994; Cass and Shell, 1983; Diamond, 1982; Cooper and John, 1988.
[2]See: Maćkowiak and Wiederholt, 2009, 2015; Alvarez, Lippi, and Paciello, 2016.

investors over-lever their companies. For the purposes of computation, confidence is modeled as a *shock* to capture the impact that exogenous changes to investor confidence have on the short-run macroeconomy.

Section II describes the data and methodology utilized by the paper. GK2011 attributes the large fall in output during the Great Recession to a sharp negative shock to capital quality. However, the paper does not utilize data to show how large this effect is in comparison to the other shocks present in the model. Since the claim of this paper is that the financial crisis is in some part attributable to investor confidence shocks, it is imperative to assess the impact that the varying shocks had on the economy to gauge which shocks were prevalent and which were not. Consequently, this paper uses a Bayesian MCMC approach to estimate the model using 5 U.S. macroeconomic time series: real GDP, consumption, investment, inflation, and nominal interest rate.

Section III shows the results from the Bayesian estimation. Impulse responses to a negative capital quality shock indicate that capital quality shocks are amplified in a model that includes investor confidence, especially in the quarter of impact. Furthermore, impulse responses to a confidence shock itself demonstrate that over-leveraging may have a large and persistent effect on the short-run business cycle. Investor overconfidence can stimulate the economy and boost consumption in the near term, but leads to depressed output and lowered consumption several periods into the future. Finally, a historical decomposition of the U.S. output gap into its constituent shocks reveals that the effect of capital quality is significantly muted in the presence of confidence shocks. Additionally, in line with Malmendier and Tate (2005), confidence shocks seem to frequently occur in unison with net worth shocks, indicating that investors tend to over-leverage when they have more abundant internal funding and vice-versa.

I. Theoretical Model

A. *Summary of GK2011*

As an overview, GK2011 incorporates a financial sector into a state-of-the-art DSGE model with nominal rigidities. Their model includes several features similar to the benchmark DSGE models of Christiano, Eichenbaum, and Evans (2005) and Smets and Wouters (2007), such as variable capital utilization, investment adjustment costs, habit formation, etc. The model's equilibrium equations are summarized below.

1. Marginal utility of consumption:

$$\varrho_t = (C_t - hC_{t-1})^{-\sigma} - \mathbb{E}_t[\beta h(C_{t+1} - hC_t)^{-\sigma}]$$

   where C_t is consumption, $0 < h < 1$ is the household's degree of habit formation, $0 < \beta < 1$ is the discount factor, and $\sigma > 0$ is the intertemporal elasticity of substitution.

2. Stochastic discount rate:

$$\Lambda_{t,t+1} = \frac{\varrho_{t+1}}{\varrho_t}$$

3. Euler equation:

$$1 = \mathbb{E}_t[\beta R_{t+1} \Lambda_{t,t+1}]$$

where R_{t+1} is the gross real return on one-period bonds from t to $t+1$.

4. Labor market equilibrium:

$$\chi L_t^{\varphi} = \varrho_t W_t$$

where L_t is household's labor supply, W_t is the wage rate, $\chi > 0$ is the relative weight of labor to utility, and $\varphi > 0$ is the inverse Frisch elasticity of labor supply.

5. Growth rate of banks' assets:

$$x_{t,t+i} = \frac{Q_{t+i} S_{t+i}}{Q_t S_t}$$

where $S_{j,t}$ is the amount of shares of non-financial firms that financial firms hold as assets in their balance sheets with Q_t being the price of each share.

6. Growth rate of banks' net worth:

$$z_{t,t+i} = \frac{N_{t+i}}{N_t}$$

where N_t is banks' net worth or equity.

7. Value of banks' capital:

$$\nu_t = \mathbb{E}_t[(1-\theta)\beta\Lambda_{t,t+1}(R_{k,t+1} - R_{t+1}) + \beta\Lambda_{t,t+1}\theta x_{t,t+1}\nu_{t+1}]$$

where $R_{k,t+1}$ is the stochastic return on assets earned by the banker from t to $t+1$ and $0 < \theta < 1$ is bankers' survival rate.

8. Value of banks' net worth:

$$\eta_t = \mathbb{E}_t[(1-\theta) + \beta\Lambda_{t,t+1}\theta z_{t,t+1}\eta_{t+1}]$$

9. Optimal leverage ratio:

$$\phi_t = \frac{\eta_t}{\lambda - \nu_t}$$

where $0 < \lambda < 1$ is the fraction of assets that may be diverted away by bankers.

10. Aggregate capital:

$$Q_t K_{t+1} = \phi_t N_t$$

where K_{t+1} is the capital acquired by intermediate goods producers. This capital is financed by funds obtained from the financial intermediaries.

11. Banks' aggregate net worth:

$$N_t = N_{e,t} + N_{n,t}$$

where $N_{e,t}$ and $N_{n,t}$ is the net worth of existing and new banks respectively.

12. Existing banks' net worth accumulation:

$$N_{e,t} = \theta z_{t,t-1} N_{t-1} \varepsilon_t^{N_e}$$

where $\varepsilon_t^{N_e}$ is an exogenous shock to existing banks' net worth.

13. New banks' net worth creation:

$$N_{n,t} = \omega Q_t \xi_t K_t$$

where ξ_t is the quality of capital and is governed by the AR(1) process: $\log \xi_t = \rho_\xi \log \xi_{t-1} + \varepsilon_t^{\xi}$. $0 < \omega < 1$ is the proportion of exiting banks' assets that is provided to new banks as "start up" funds.

14. Intermediate firms' production function:

$$Y_{m,t} = A_t (U_t \xi_t K_t)^\alpha L_t^{1-\alpha}$$

where A_t is the total factor productivity which is governed by the AR(1) process: $\log A_t = \rho_a \log A_{t-1} + \varepsilon_t^a$. U_t is the utilization rate of capital and $0 < \alpha < 1$ is the effective share of capital.

15. Optimal capacity utilization rate:

$$U_t^{1+\upsilon} = \frac{P_{m,t} \alpha Y_{m,t}}{b \xi_t K_t}$$

where $P_{m,t}$ is the price of intermediate firms' goods, υ is the elasticity of marginal depreciation with respect to the capital utilization rate, and b is the steady state value of the nominal marginal product of capital.

16. Depreciation rate:

$$\delta(U_t) = \delta_c + \frac{b}{1+\upsilon} U_t^{1+\upsilon}$$

where δ_c is set to maintain a steady state depreciation rate of 0.025.

17. Return to capital:

$$R_{k,t+1} = \frac{P_{m,t} \alpha \frac{Y_{t+1}}{K_{t+1}} + \xi_{t+1}(Q_{t+1} - \delta(U_{t+1}))}{Q_t}$$

where Y_t is the aggregate retail output in the economy.

18. Optimal investment decision:

$$Q_t = 1 + \frac{\eta_i}{2}\left(\frac{I_{n,t} - I_{n,t-1}}{I_{n,t-1} + I_{ss}}\right)^2 + \eta_i\left(\frac{I_{n,t} - I_{n,t-1}}{I_{n,t-1} + I_{ss}}\right)\left(\frac{I_{n,t} + I_{ss}}{I_{n,t-1} + I_{ss}}\right)$$

where $I_{n,t}$ is the new capital created in the economy, I_{ss} is the steady state investment level, and η_i is the inverse elasticity of net investment to the price of capital.

19. Gross investment:

$$I_t = \delta(U_t)\xi_t K_t + I_{n,t}$$

20. Capital accumulation:

$$K_{t+1} = \xi_t K_t + I_{n,t}$$

21. Government expenditure:

$$G_t = G_{ss}\, g_t$$

where G_{ss} is steady state government spending and g_t is an exogenous disturbance that is modeled as the AR(1) process: $\log g_t = \rho_g \log g_{t-1} + \varepsilon_t^g$.

22. Aggregate resource constraint:

$$Y_t = C_t + G_t + I_t + \frac{\eta_i}{2}\left(\frac{I_{n,t} - I_{n,t-1}}{I_{n,t-1} + I_{ss}}\right)^2 (I_{n,t} + I_{ss})$$

23. Price dispersion:

$$D_t = \gamma D_{t-1}\pi_{t-1}^{-\gamma_p\epsilon}\pi_t^{\epsilon} + (1-\gamma)\left(\frac{1 - \gamma\pi_{t-1}^{\gamma_p(1-\gamma)}\pi_t^{\gamma-1}}{1-\gamma}\right)^{-\frac{\epsilon}{1-\gamma}}$$

where π_t is the economy's inflation rate from $t-1$ to t, $0 < \gamma < 1$ is the Calvo probability of firms having to keep prices fixed, $0 < \gamma_p < 1$ is the degree of price indexation, and ϵ is the elasticity of substitution across intermediate firms' products.

24. Retail output:

$$Y_t = \frac{Y_{m,t}}{D_t}$$

25. Pricing equation (1):

$$F_t = Y_t P_{m,t} + \mathbb{E}_t \beta\gamma\Lambda_{t,t+1}\pi_{t+1}^{\epsilon}\pi_t^{-\epsilon\gamma_p}F_{t+1}$$

26. Pricing equation (2):

$$Z_t = Y_t + \mathbb{E}_t \beta \gamma \Lambda_{t,t+1} \pi_{t+1}^{\epsilon-1} \pi_t^{\gamma_p(1-\epsilon)} Z_{t+1}$$

27. Optimal price choice:

$$\pi_t^* = \frac{\epsilon}{\epsilon-1} \frac{F_t}{Z_t} \pi_t$$

28. Price index:

$$\pi_t^{1-\epsilon} = \gamma \pi_{t-1}^{\gamma_p(1-\epsilon)} + (1-\gamma) \pi_t^{*1-\epsilon}$$

29. Fisher equation:

$$i_t = R_{t+1} \mathbb{E}_t \pi_{t+1}$$

30. Taylor rule for interest rate:

$$i_t = i_{t-1}^{\rho_i} \left[\frac{1}{\beta} \pi_t^{\kappa_\pi} \left(P_{m,t} \frac{\epsilon}{\epsilon-1} \right)^{\kappa_y} \right]^{1-\rho_i} \varepsilon_t^i$$

where $0 < \rho_i < 1$ is the interest rate smoothing parameter, κ_π is the inflation weight, κ_y is the output weight, and ε_t^i is an exogenous shock to monetary policy.

Further details on these conditions or their detailed derivations are beyond the purview of this paper and may be found by perusing GK2011 and its accompanying materials directly.

B. *Modeling Investor Confidence*

Now consider an approach to incorporating confidence into the financial sector of the model summarized above. To begin, consider that banker j maximizes expected terminal wealth as shown in the following rational expectations equation:

$$V_{j,t} = \max \, \mathbb{E}_t \sum_{i=1}^{\infty} m_{t,t+i} [(R_{t+i}^k - R_{t+i}) Q_{t+i} S_{j,t+i} + R_{t+i} N_{j,t+i-1}] \tag{1}$$

where $m_{t,t+i}$ is the banker's stochastic discount factor adjusted for the probability of survival. To incorporate investor confidence, I utilize the technique presented by Malmendier and Tate (2005). I will assume that the banker does not observe the true expected return from investing in goods producing firms; rather the banker utilizes a *subjective* assessment by weighting expected returns by $\zeta_{j,t}$: investor j's confidence at time period t. Now the banker maximizes:

$$V_{j,t} = \max \, \mathbb{E}_t \sum_{i=1}^{\infty} m_{t,t+i} [(\zeta_{j,t} R_{t+i}^k - R_{t+i}) Q_{t+i} S_{j,t+i} + R_{t+i} N_{j,t+i-1}] \tag{2}$$

Clearly, a perfectly rational investor would have $\zeta_t = 1$ for all t. In this model, the assumption of perfectly rational investors is relaxed and the value for ζ is allowed to fluctuate so that the effects of under ($\zeta < 1$) or over ($\zeta > 1$) confidence may be measured. For tractability, I will assume that there is no variation in confidence between individual investors; rather confidence in the market varies at a the financial *sector* level. In any given time period, financial intermediaries as a whole may be under or over confident.

Similar to GK2011, we can solve for the banker's value function as follows:

$$V_{j,t} = \nu_t Q_t S_{j,t} + \eta_t N_{j,t} \tag{3}$$

Note that unlike the GK2011 model, ν_t is now a function of investor confidence. If the banker is overconfident in any given period t, then it follows that $\zeta_t > 1 \implies \nu_t$ is higher in this model than its GK2011 counterpart. Now compute the banker's leverage ratio as:

$$\phi_{j,t} = \frac{\eta_t}{\lambda - \nu_t} \tag{4}$$

Given that ν_t is higher than the baseline model, it is clear from equation (4) that the leverage ratio implied by this model must be higher than the optimal leverage ratio computed by GK2011. As a result of the banker's overconfidence the bank is over-leveraged.

Now that a theoretical basis for the inclusion of investor confidence has been established, for the sake of computational simplicity, the effect of confidence on the leverage ratio may be modeled directly as follows:

$$\phi_{j,t} = \tilde{\zeta}_t \frac{\eta_t}{\lambda - \nu_t} \tag{5}$$

In this updated context, $\tilde{\zeta}_t$ is a source of exogenous variation to investor confidence and may be modeled as the AR(1) process:

$$\log \tilde{\zeta}_t = \rho_\zeta \log \tilde{\zeta}_{t-1} + \varepsilon_t^\zeta \tag{6}$$

Notice that the mean of $\tilde{\zeta}_t$ is zero implying that investors can be over- or under-confident as a result of an exogenous shock to this AR(1) process. As this model is estimated with the help of U.S. macroeconomic data, this allows the data to indicate periods of such confidence swings in U.S. economic history.

II. Data and Methodology

The model presented in section I is estimated via Bayesian MCMC techniques[3] using data for five quarterly macroeconomic U.S. time series as observables: log difference of real GDP, log difference of consumption, log difference of investment, inflation (log difference of GDP deflator), and the federal funds rate. The data spans Q1 1984 through Q4 2019; this roughly matches the modern U.S. macroeconomy with active monetary policy. The model utilizes the following measurement equation:

$$OBS_t = \begin{bmatrix} dlY_t \\ dlC_t \\ dlI_t \\ dlP_t \\ i_t \end{bmatrix} = \begin{bmatrix} y^* \\ y^* \\ y^* \\ \pi^* \\ i^* \end{bmatrix} + \begin{bmatrix} \log Y_t/Y_{t-1} \\ \log C_t/C_{t-1} \\ \log I_t/I_{t-1} \\ \log P_t/P_{t-1} \\ i_t \end{bmatrix}$$

where dl represents 100 times the log difference, y^* is the quarterly trend growth rate common to Y_t, C_t, and I_t, π^* is the steady-state quarterly inflation rate, and i^* is the steady-state quarterly interest rate.

The GK2011 model is not linearized and this non-linear model is estimated directly using computational software. The challenge with this approach is the burdensome computational capacity required by the process. As a result, some structural parameters are calibrated to the same values utilized by GK2011. These parameters are presented in Table 1.

The remaining parameters are estimated using a standard Bayesian MCMC procedure. First, the mode of the posterior distribution is estimated by maximizing the log of the posterior function; the posterior is computed as the product of the prior information of non-calibrated parameters and the likelihood of the data described above. The priors for the selected parameters are set based on standard choices in the empirical macro literature and may be found in Table 2. Secondly, a Metropolis-Hastings computational algorithm is utilized to map a complete posterior distribution for all estimated parameters and to calculate the marginal likelihood of the model. This process is first utilized to estimate the GK2011 base model and is then used to estimate the extended model which includes confidence (henceforth referred to as 'K2021'). The estimated posterior means are used to compute IRFs to the various shocks within the model as well as to break down historical output gaps into its constituent shocks over time. The results from these analyses are presented in the following section.

[3]See An and Schorfheide (2007), Fernández-Villaverde (2010), and Herbst and Schorfheide (2015) for an overview of Bayesian MCMC estimation methods pertaining to DSGE models.

Parameter	Value	Details
β	0.99	Discount rate
σ	1	Intertemporal elasticity of substitution
φ	0.276	Inverse Frisch elasticity of labor supply
θ	0.972	Bankers' survival rate
α	0.33	Effective share of capital
υ	7.2	Elasticity of marginal depreciation wrt utilization rate
η_i	1.728	Elasticity of investment adjustment costs
ε	4.167	Elasticity of goods substitution
$\bar{\delta}$	0.025	Steady state depreciation rate
$\bar{\phi}$	4	Steady state leverage ratio
$\bar{R}^k - \bar{R}$	0.0025	Steady state market premium
$\bar{L}$	1/3	Steady state labor supply
G/Y	0.2	Steady state government spending ratio

TABLE 1—CALIBRATED PARAMETERS

III. Results

A. *Parameter Estimates*

Table 2 provides the mean, 10, and 90 percentiles of the posterior distribution of the parameters obtained from the Metropolis-Hastings procedure described above. The trend of output growth is estimated at 0.65 for GK2011 and 0.28 for K2021, which are higher and lower respectively than the corresponding estimate from Smets and Wouters (2007) of 0.43. This difference is because the K2021 model relies more heavily on large and persistent shocks to fit macroeconomic data as compared to GK2011. The estimated annual steady state inflation rate is roughly the same for both models and is estimated to be 2.5 to 2.8%. An interesting observation from the estimation is that the GK2011 model relies on a high degree of price indexation (0.997) to fit the data. On the other hand, K2021 provides a more reasonable value for price indexation (0.46), and instead relies on a higher value of price stickiness (0.91). Note that both estimates of price indexation are higher than the value of 0.24 computed by Smets and Wouters (2007) but the K2021 value is much closer than GK2011.

In regard to the shock process parameters, the K2021 model estimates shock processes that are more persistent than their GK2011 counterparts. Especially with regard to the capital quality shock, the K2021 model estimates a much larger persistence of 0.48 compared to the GK2011 estimate of 0.05. Additionally, the results demonstrate the importance of including the confidence shock as it has an estimated persistence of 0.61 (among the highest) and a deviation of 0.08 (twice as high as the capital quality shock). Technology shocks have similar persistence across the two models but have a significantly higher deviation of 0.35 in K2021 compared to only 0.06 in GK2011. Government spending shocks are highly persistent across both models. Deviations for

		Prior			Posterior			GK2011		
Parameter	Description	Dist.	Mean	Dev.	Mean	10%	90%	Mean	10%	90%
h	Habit formation	Beta	0.70	0.10	0.63	0.62	0.63	0.75	0.75	0.76
γ	Calvo	Beta	0.50	0.15	0.91	0.90	0.91	0.85	0.84	0.87
γ_p	Price Indexation	Uniform	0.50	-	0.46	0.44	0.47	0.997	0.993	1.000
κ_π	Taylor rule	Normal	1.50	0.25	1.17	1.16	1.19	1.42	1.41	1.43
κ_y	Taylor rule	Normal	0.125	0.0625	0.17	0.16	0.18	0.15	0.15	0.16
y^*	Output trend	Normal	0.40	0.10	0.28	0.26	0.30	0.65	0.63	0.66
π^*	Inflation trend	Normal	0.60	0.10	0.69	0.67	0.72	0.63	0.61	0.65
i^*	Interest rate trend	Normal	0.75	0.10	0.87	0.86	0.88	0.64	0.64	0.65
ρ_a	Tech. shock persistence	Beta	0.50	0.20	0.24	0.21	0.27	0.30	0.25	0.34
ρ_i	Monetary policy shock persistence	Beta	0.50	0.20	0.62	0.59	0.66	0.49	0.46	0.52
ρ_g	Govt. spending shock persistence	Beta	0.50	0.20	0.997	0.995	1.000	0.90	0.87	0.93
ρ_ξ	Capital quality shock persistence	Beta	0.50	0.20	0.48	0.45	0.52	0.05	0.03	0.06
ρ_ζ	Confidence shock persistence	Beta	0.50	0.20	0.61	0.60	0.62	-	-	-
σ_a	Tech. shock deviation	Gamma^{-1}	0.30	1.00	0.35	0.33	0.36	0.06	0.05	0.08
σ_i	Monetary policy shock deviation	Gamma^{-1}	0.30	1.00	0.04	0.04	0.04	0.04	0.04	0.04
σ_g	Govt. spending shock deviation	Gamma^{-1}	0.30	1.00	0.04	0.04	0.04	0.04	0.04	0.05
σ_N	Net worth shock deviation	Gamma^{-1}	0.30	1.00	0.12	0.11	0.14	0.15	0.13	0.16
σ_ξ	Capital quality shock deviation	Gamma^{-1}	0.30	1.00	0.04	0.04	0.04	0.04	0.04	0.05
σ_ζ	Confidence shock deviation	Gamma^{-1}	0.30	1.00	0.08	0.07	0.10	-	-	-

TABLE 2—POSTERIOR DISTRIBUTION OF STRUCTURAL PARAMETERS AND SHOCK PROCESSES

monetary policy, government spending, and net worth shocks are also similar for both models.

B. Impulse Responses

This paper is primarily concerned with the effects of two shocks: capital quality and confidence. In this section, impulse responses to both these shocks are discussed, beginning with capital quality. Figure 1 shows the comparative impulse responses of output, consumption, investment, inflation, and nominal interest rate to a one-period, 1 standard deviation, negative shock to capital quality. As expected, the economy enters a prolonged recession following the shock in both models. The output falls, first due to a large decrease in investment, followed by a large and sustained decrease in consumption. The economic recovery is driven by investment, which rises above steady state roughly 3 years after the initial shock. However, even the increased investment level cannot compensate for the decline in consumption and as a result, the economy stays below steady state even at a horizon of 10 years following the shock.

It is interesting to note that the magnitude of the capital quality shock is *amplified* in the K2021 model. In this manner, the results corroborate findings from Rychalovska (2016) that effects of financial shocks may be amplified under the presence of behavioral elements. The recession caused in the economy described by K2021 is roughly twice as large although the effect dissipates in approximately the same time. Again, this is due to the fact that including confidence into the model requires the use of larger and more persistent shocks to fit the data. Consumption is also significantly lower as a result of the shock in K2021 than it is in GK2011 and investment is more volatile. Inflation rises

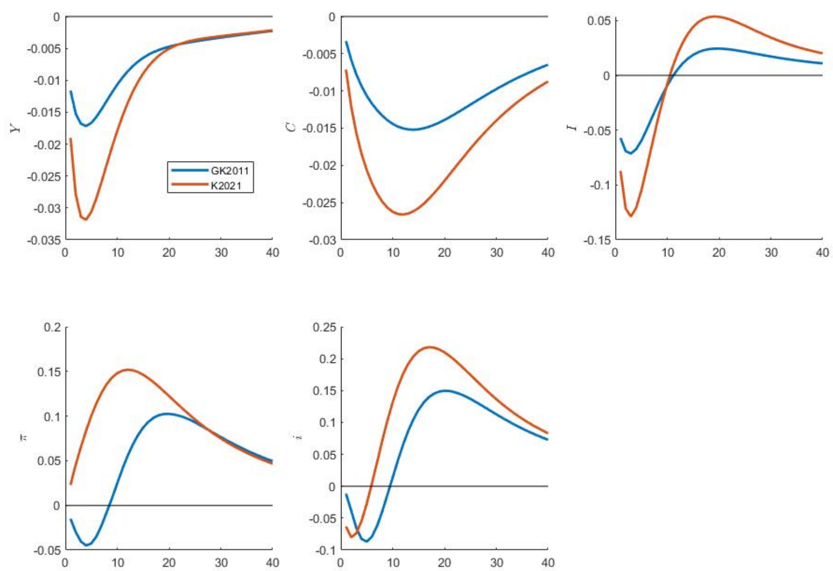

FIGURE 1. IMPULSE RESPONSES TO A NEGATIVE CAPITAL QUALITY SHOCK

higher in the K2021 model and unlike GK2011, the economy does not go through an initial deflationary episode.

Figure 2 shows the impulse responses of output, consumption, investment, inflation, and nominal interest rate to a one-period, 1 standard deviation, positive shock to investor confidence, i.e. 1 standard deviation "overconfidence" among financial intermediaries. Note that in the period of impact, investor overconfidence is able to stimulate the economy above its steady state, driven largely by increased investments. However, this boost is short-lived as the positive effects of over-leveraging dissipate roughly 2 years after the point of impact as the economy tries to curtail its initial period of over-investing.

After the initial boost wanes, the economy enters a prolonged recession. While the output does not fall as sharply as it rose during impact, the duration of the recession far exceeds the duration of the initial boom. The slump in GDP is associated with a prolonged decrease in consumption. Output does not return to its steady state value until roughly 8 years after the initial shock. The effects on consumption are more prolonged than output, staying below steady state 10 years past the the original shock. In this manner, the results seem to agree with prior literature; a situation where over-leveraged agents are forced to rapidly deleverage due to economic conditions can lower aggregate demand, triggering a recession (see Eggertsson and Krugman, 2012).

The magnitude of the effect on the economy is not as high as the effect of a capital quality shock in the K2021 model; however, the magnitude is comparable in scale to the effect of a capital quality shock in GK2011. Note that the impulse responses match

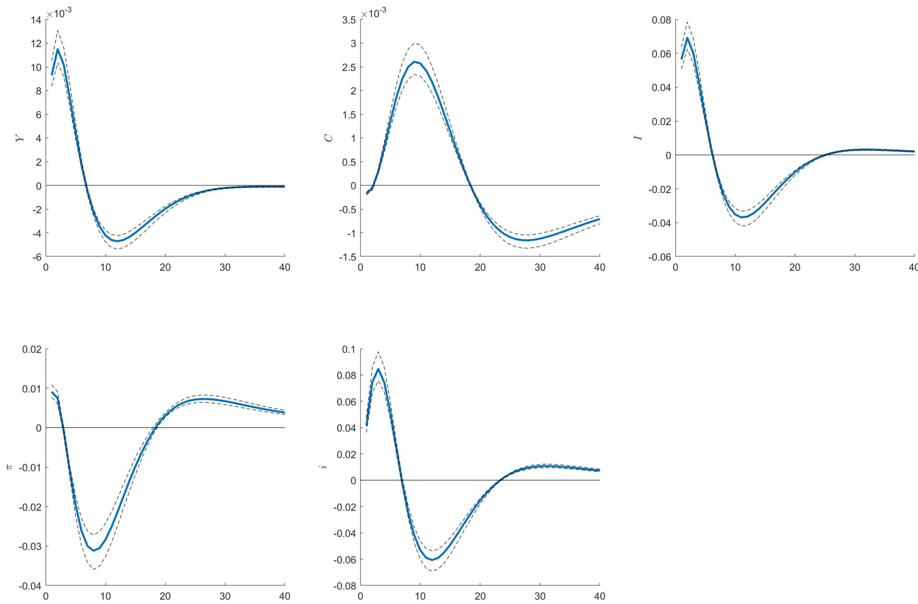

FIGURE 2. IMPULSE RESPONSES TO AN OVERCONFIDENCE SHOCK

several facts of the mid-2000's U.S. economy: a few years of an economic boom corresponding with high increases in the leverage ratios of financial institutions followed by the financial crash of the 2008 Great Recession.

C. Shock Decomposition

Figure 3 shows the historical decomposition of U.S. output growth into its constituent shocks from 1990 to 2019. Panel (a) shows the decomposition for the GK2011 model while panel (b) shows the same decomposition for K2021 so that it is possible to compare the sources of U.S. recessions across the two models. Both models show a brief but volatile period of economic activity in the mid 90's and also demonstrate the large and elongated recessions associated with the dot-com bubble bursting in the early 2000's and the housing crash of 2007.

It is interesting to note that the overall volatility of the U.S. economy is estimated to be much higher in the K2021 model: there are large shocks to the economy, both positive and negative, especially in times of great economic uncertainty such as the Great Recession. Another observation is that while both models attribute the 2001 recession to net worth and technology shocks, GK2011 highlights net worth while K2021 highlights technology as the primary force behind the recession: a more reasonable finding as this episode was primarily caused by the dot-com bubble burst.

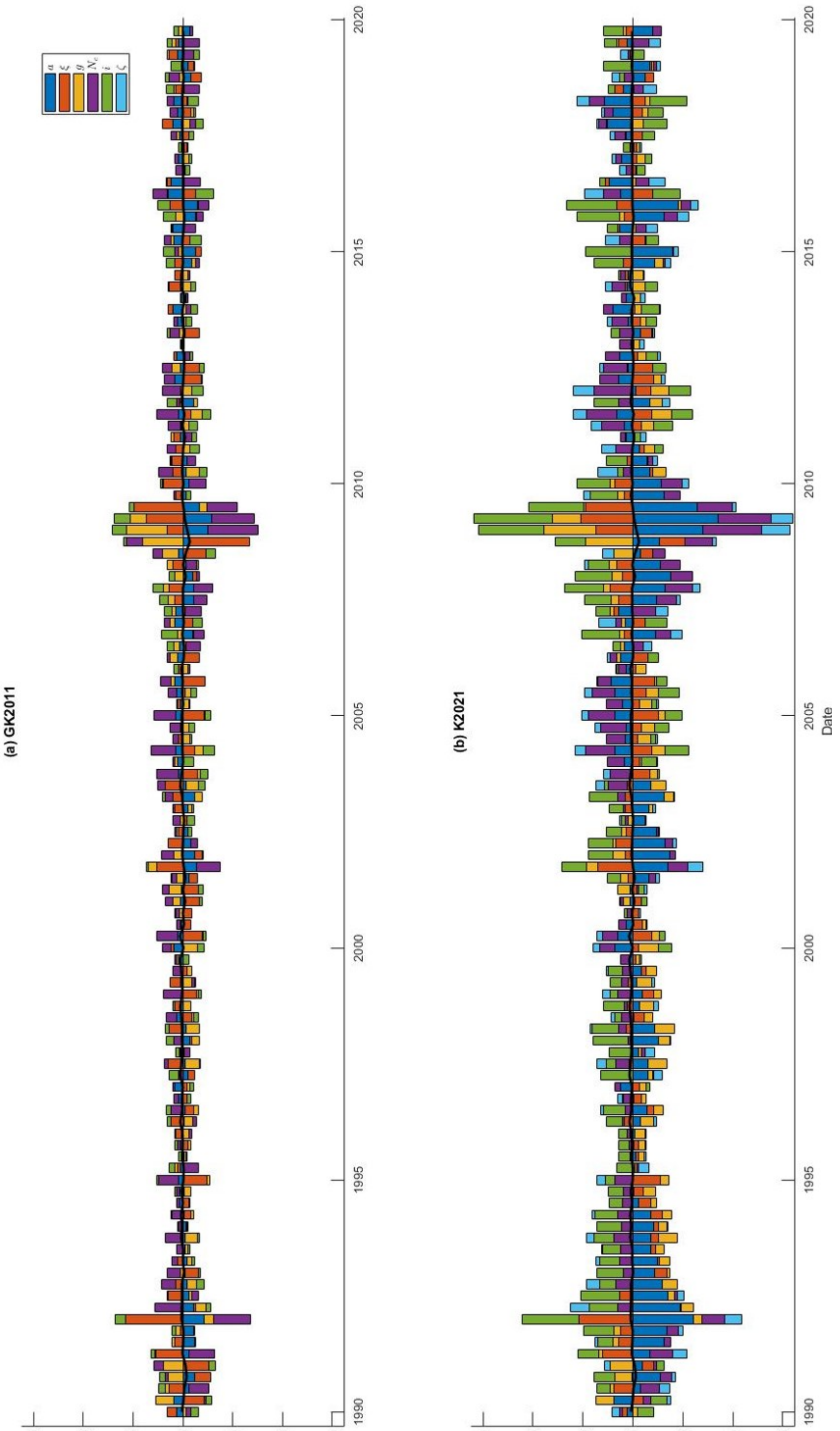

FIGURE 3. HISTORICAL SHOCK DECOMPOSITION OF U.S. OUTPUT GROWTH

The most interesting comparison between the models arises during the Great Recession. The estimated GK2011 model confirms its authors' claim that the recession was caused primarily by a large negative shock to capital quality, at least during the initial phase of the crisis. However, the K2021 model shows that in the presence of shocks to confidence, negative shocks to capital quality do not play as large a role. In fact, the majority of the recession could be attributed to other factors such as technology, net worth, and confidence, especially after the initial phase of the crisis.

Another noteworthy observation is that the historical decomposition seems to confirm Malmendier and Tate (2005)'s microevidence in a macro setting: investor confidence seems to be high at times when they have abundant internal funding. In our model, an investor's internal funding is represented by net worth. Notice from panel (b) in Figure 3 that shocks to net worth are routinely paired with shocks to investor confidence in the same direction. This association is particularly stark in the mid 2000's, a period that is characterized by large increases to leverage ratios in the financial sector. K2021 shows that this period is marked by sustained positive shocks to investors' net worth, coupled with a prolonged period of overconfidence marked by leverage ratios higher than their steady state. This result has also been noted by other papers in the finance literature, as previously discussed in the introduction to this paper.

IV. Concluding Remarks

This paper has built on prior work that incorporates a financial sector into a DSGE framework by providing an avenue for changes in investor confidence to affect the business cycle. The results confirm prior work in the field of finance by demonstrating that suboptimal leveraging by financial intermediaries can have a large and sustained effect on the economy and that the financial crisis of 2008-09 is partly attributable to such leveraging. At the least, the paper provides some evidence that irrational microbehavior can have macro consequences, highlighting the need for more business cycle research to include behavioral elements.

Nevertheless, the models estimated herein are stylized and should be nuanced further. The addition of confidence simply as a shock may be regarded as ad-hoc. In the future, it may be prudent to include an endogenous measure of confidence that can interact with other measures of the financial sector, particularly investor net worth. In the absence of a structural measure, there is always a concern that the effects being attributed to confidence may actually be capturing the effects of an omitted variable such as changes in financial regulations that makes it easier or harder for banks to leverage. The interactions between the financial sector shocks in this model are also fertile ground for future research.

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