Econometrica Supplementary Material

SUPPLEMENT TO "MONETARY POLICY, REDISTRIBUTION, AND RISK PREMIA"

(*Econometrica*, Vol. 90, No. 5, September 2022, 2249–2282)

ROHAN KEKRE
Chicago Booth and NBER

MORITZ LENEL
Princeton

APPENDIX A: PROOFS OF ANALYTICAL RESULTS

A.1. *Proposition 1*

PROOF: MULTIPLYING BOTH SIDES of (14) by a_0^i, integrating over all i, and then using asset market clearing $\int_0^1 a_0^i \omega_0^i \, di = \int_0^1 a_0^i \, di$, we obtain the claimed expression for the risk premium on capital. Differentiating with respect to ϵ_0^m, we have that

$$\frac{d\left[\mathbb{E}_0 \log\left(1+r_1^k\right) - \log\left(1+r_1\right)\right]}{d\epsilon_0^m} = \sigma^2 \frac{d\gamma}{d\epsilon_0^m} = \gamma\sigma^2 \int_0^1 \frac{d\left[a_0^i / \int_0^1 a_0^{i'} \, di'\right]}{d\epsilon_0^m}\left(1-\omega_0^i\right) di,$$

as claimed, where the second equality uses (14) and asset market clearing. *Q.E.D.*

A.2. *Proposition 2*

PROOF: The result for $\frac{dk_0}{d\epsilon_0^m}$ follows from differentiating (16). Now differentiating household i's consumption policy function and (17) and integrating over all i yields

$$\frac{dc_0}{d\epsilon_0^m} = (1-\beta)\left[\frac{dy_0}{d\epsilon_0^m} + \frac{(1-\delta_0)q_0 k_{-1}}{k_0}\chi^x \frac{dk_0}{d\epsilon_0^m}\right],$$

where we have used firms' flow of funds, asset market clearing, and equilibrium investment. Differentiating goods market clearing and using equilibrium investment yields

$$\frac{dy_0}{d\epsilon_0^m} = \frac{dc_0}{d\epsilon_0^m} + q_0\left(1 + \frac{x_0}{k_0}\chi^x\right)\frac{dk_0}{d\epsilon_0^m}.$$

Combining these and using capital accumulation yields the result for $\frac{dc_0}{d\epsilon_0^m}$. *Q.E.D.*

A.3. *Proposition 3*

PROOF: The Taylor rule and Fisher equation imply

$$\frac{d\log P_0}{d\epsilon_0^m} = \frac{1}{\phi}\frac{d\log(1+r_1)}{d\epsilon_0^m} - \frac{1}{\phi}. \tag{A.1}$$

Rohan Kekre: rohan.kekre@chicagobooth.edu
Moritz Lenel: lenel@princeton.edu

Combining with equilibrium labor demand, the production function and a rigid nominal wage in period 0 yield

$$\frac{1}{y_0}\frac{dy_0}{d\epsilon_0^m} = \frac{1-\alpha}{\alpha}\frac{1}{\phi}\frac{d\log(1+r_1)}{d\epsilon_0^m} - \frac{1-\alpha}{\alpha}\frac{1}{\phi}. \tag{A.2}$$

By (15), (18), and (20), it follows that

$$\frac{dk_0}{d\epsilon_0^m} = -\frac{k_0}{1-\alpha+\chi^x}\left[-\gamma\sigma^2\frac{1}{n_0}\operatorname{Cov}^i\left(\frac{dn_0^i}{d\epsilon_0^m}, \omega_0^i\right) + \frac{d\log(1+r_1)}{d\epsilon_0^m}\right], \tag{A.3}$$

where Cov^i denotes a cross-sectional covariance. Combining this with (21), (A.1),

$$\frac{1}{\pi_0}\frac{d\pi_0}{d\epsilon_0^m} = \frac{1}{y_0}\frac{dy_0}{d\epsilon_0^m} \tag{A.4}$$

implied by equilibrium profits, and

$$\frac{1}{q_0}\frac{dq_0}{d\epsilon_0^m} = \chi^x\frac{1}{k_0}\frac{dk_0}{d\epsilon_0^m} \tag{A.5}$$

implied by equilibrium investment, we have that

$$\begin{aligned}
&\operatorname{Cov}^i\left(\frac{dn_0^i}{d\epsilon_0^m}, \omega_0^i\right) \\
&= \frac{1}{1-\gamma\sigma^2(1-\delta_0)\frac{q_0}{n_0}\frac{\chi^x}{1-\alpha+\chi^x}\operatorname{Cov}^i\left(k_{-1}^i, \omega_0^i\right)} \\
&\quad\times\left[-\operatorname{Cov}^i\left(\frac{1+i_{-1}}{P_0}B_{-1}^i, \omega_0^i\right)\left(\frac{1}{\phi}\frac{d\log(1+r_1)}{d\epsilon_0^m} - \frac{1}{\phi}\right)\right. \\
&\quad\left.+\left(\frac{\pi_0}{y_0}\frac{dy_0}{d\epsilon_0^m} - (1-\delta_0)q_0\frac{\chi^x}{1-\alpha+\chi^x}\frac{d\log(1+r_1)}{d\epsilon_0^m}\right)\operatorname{Cov}^i\left(k_{-1}^i, \omega_0^i\right)\right].
\end{aligned} \tag{A.6}$$

Finally, combining (A.3) and (19) yields

$$\begin{aligned}
\frac{dy_0}{d\epsilon_0^m} &= \left[\gamma\sigma^2\operatorname{Cov}^i\left(\frac{dn_0^i}{d\epsilon_0^m}, \omega_0^i\right) - n_0\frac{d\log(1+r_1)}{d\epsilon_0^m}\right] \\
&\quad\times\left(\frac{1+\chi^x\left(1-\beta(1-\delta_0)k_{-1}/k_0\right)}{1-\alpha+\chi^x}\right).
\end{aligned} \tag{A.7}$$

With heterogeneity in γ^i and the assumption that households' initial endowments are consistent with the portfolios (14), we have $\operatorname{Cov}^i(B_{-1}^i, \omega_0^i) < 0$ and $\operatorname{Cov}^i(k_{-1}^i, \omega_0^i) > 0$. Straightforward algebra using the system of equations (A.2), (A.6), and (A.7) then implies

$$\frac{dy_0}{d\epsilon_0^m} < \left.\frac{dy_0}{d\epsilon_0^m}\right|_{\text{RANK}} < 0,$$

$$\mathrm{Cov}^i\left(\frac{dn_0^i}{d\epsilon_0^m}, \omega_0^i\right) < \mathrm{Cov}^i\left(\frac{dn_0^i}{d\epsilon_0^m}, \omega_0^i\right)\bigg|_{\mathrm{RANK}} = 0,$$
$$\frac{d\log(1+r_1)}{d\epsilon_0^m} < \frac{d\log(1+r_1)}{d\epsilon_0^m}\bigg|_{\mathrm{RANK}} \in (0,1),$$

provided that heterogeneity is not too extreme (and thus the initial equilibrium is stable). We can thus conclude from (A.1), (A.3), (A.4), and (A.5) that a monetary tightening generates deflation, a fall in profits, and a fall in the price of capital; that it generates a rise in the risk premium only in the model with heterogeneity; and that the real effects of a monetary shock are amplified in the model with heterogeneity. *Q.E.D.*

A.4. *Proposition 4*

PROOF: For a household up against a portfolio constraint or following a rule-of-thumb, ω_0^i is simply implied by the constraint or rule-of-thumb. For all other households, a Taylor approximation of (13) yields

$$\omega_0^i \approx \frac{1}{\gamma^i(\varsigma^i+\eta^i)} \frac{\mathbb{E}_0^i \log(1+r_1^{k,i}) - \log(1+r_1) + \frac{1}{2}(\varsigma^i+\eta^i)\sigma^2}{\sigma^2}, \tag{A.8}$$

where $\mathbb{E}_0^i$ is the household's subjective expectation and $r_1^{k,i}$ is the return on capital accounting for the idiosyncratic component of its return. Given the distributional assumptions on η^i and ς^i, we have that

$$\begin{aligned} &\mathbb{E}_0^i \log(1+r_1^{k,i}) - \log(1+r_1) + \frac{1}{2}(\varsigma^i+\eta^i)\sigma^2 \\ &\quad = \mathbb{E}_0 \log(1+r_1^{k}) - \log(1+r_1) + \frac{1}{2}\sigma^2, \end{aligned} \tag{A.9}$$

where $\mathbb{E}_0$ denotes the objective expectation and r_1^k the return on capital without idiosyncratic risk (equivalently, aggregating over idiosyncratic risk). Then multiplying both sides of (A.8) by a_0^i, integrating over all unconstrained households, which we denote as $i \notin C$, and using asset market clearing, it is straightforward to show

$$\mathbb{E}_0 \log(1+r_1^{k}) - \log(1+r_1) + \frac{1}{2}\sigma^2 = \gamma\sigma^2,$$

where now

$$\gamma \equiv \left(1 - \frac{\int_{i\notin C} a_0^i(1-\omega_0^i)\, di}{\int_{i\notin C} a_0^i\, di}\right)\left(\int_{i\notin C} \frac{a_0^i}{\int_{i'\notin C} a_0^{i'}\, di'} \frac{1}{\gamma^i(\varsigma^i+\eta^i)}\, di\right)^{-1}.$$

Differentiating and again using market clearing, (A.8) for unconstrained households, and (A.9) yields

$$\frac{d\left[\mathbb{E}_0 \log(1+r_1^k) - \log(1+r_1)\right]}{d\epsilon_0^m} = \gamma \left(\frac{\int_0^1 a_0^i \, di}{\int_{i \notin C} a_0^i \omega_0^i \, di} \right) \sigma^2 \int_0^1 \frac{d\left[a_0^i / \int_0^1 a_0^{i'} \, di'\right]}{d\epsilon_0^m} (1-\omega_0^i) \, di.$$

The remaining arguments in Propositions 2 and 3 are unchanged. *Q.E.D.*

A.5. *Proposition 5*

PROOF: We first characterize households' portfolio share in capital in the limit of zero aggregate risk. Up to second order, (13) implies

$$\mathbb{E}_0 \hat{r}_1^k - \hat{r}_1 + \frac{1}{2}\sigma^2 = \gamma^i \delta_{z_1}^{c_1^i} \sigma^2 + o\left(\|\cdot\|^3\right) \tag{A.10}$$

given the first-order approximation of $\hat{c}_1^i$ in terms of the states

$$\hat{c}_1^i = \delta_{z_1}^{c_1^i} \hat{\epsilon}_1^z + \delta_{m_0}^{c_1^i} \hat{\epsilon}_0^m + o\left(\|\cdot\|^2\right)$$

with coefficients $\delta_\cdot^\cdot$. Anticipating the result in Proposition 6, it follows that

$$\delta_{z_1}^{c_1^i} = \frac{\bar{\gamma}}{\gamma^i}. \tag{A.11}$$

Approximating up to first order the period 1 resource constraint and equilibrium wages and profits, the method of undetermined coefficients implies

$$\delta_{z_1}^{c_1^i} = \frac{\bar{w}_1 + \bar{\pi}_1 \bar{k}_0^i}{\bar{c}_1^i}. \tag{A.12}$$

Substituting in (A.11) and rearranging, we can conclude that

$$\frac{\bar{q}_0 \bar{k}_0^i}{\bar{a}_0^i} = \frac{\bar{\pi}_1 \bar{k}_0^i}{(1+\bar{r}_1)\bar{a}_0^i} = \frac{\bar{c}_1^i}{(1+\bar{r}_1)\bar{a}_0^i} \frac{\bar{\gamma}}{\gamma^i} - \frac{\bar{w}_1}{(1+\bar{r}_1)\bar{a}_0^i},$$

where the first equality uses $\bar{q}_0 = \frac{\bar{\pi}_1}{1+\bar{r}_1}$ absent aggregate risk.

We now characterize households' marginal responses to a unit of income in the limit of zero aggregate risk. Differentiating and combining households' optimal portfolio choice condition and period 1 resource constraint yields

$$0 = \mathbb{E}_0 \left(c_1^i\right)^{-\gamma^i} \frac{\gamma^i}{c_1^i} \left(r_1^k - r_1\right) \left((1+r_1) \frac{\partial b_0^i}{\partial n_0^i} + \pi_1 \frac{\partial k_0^i}{\partial n_0^i} \right). \tag{A.13}$$

A second-order approximation then implies

$$0 = \left((1+\bar{r}_1) \overline{\frac{\partial b_0^i}{\partial n_0^i}} + \bar{\pi}_1 \overline{\frac{\partial k_0^i}{\partial n_0^i}} \right) \left(\mathbb{E}_0 \hat{r}_1^k - \hat{r}_1 + \frac{1}{2}\sigma^2 \right)$$

$$- \left((1+\bar{r}_1) \overline{\frac{\partial b_0^i}{\partial n_0^i}} + \bar{\pi}_1 \overline{\frac{\partial k_0^i}{\partial n_0^i}} \right) \frac{\gamma^i + 1}{\bar{c}_1^i} \left(\bar{w}_1 + \bar{\pi}_1 \bar{k}_0^i \right) \sigma^2$$

$$+ \bar{\pi}_1 \overline{\frac{\partial k_0^i}{\partial n_0^i}} \sigma^2 + o\left(\| \cdot \|^3 \right). \tag{A.14}$$

Again anticipating the result in Proposition 6 and using (A.11) and (A.12), it follows from (A.14) that

$$\bar{q}_0 \overline{\frac{\partial k_0^i}{\partial n_0^i}} = \frac{\bar{\gamma}}{\gamma^i} \overline{\frac{\partial a_0^i}{\partial n_0^i}}$$

using $\bar{q}_0 = \frac{\bar{\pi}_1}{1+\bar{r}_0}$ and $\overline{\frac{\partial b_0^i}{\partial n_0^i}} + \bar{q}_0 \overline{\frac{\partial k_0^i}{\partial n_0^i}} = \overline{\frac{\partial a_0^i}{\partial n_0^i}}$. The expression for $\overline{mpr}_0^i \equiv \frac{\bar{q}_0 \overline{\frac{\partial k_0^i}{\partial n_0^i}}}{\overline{\frac{\partial a_0^i}{\partial n_0^i}}}$ follows. *Q.E.D.*

A.6. *Proposition 6*

PROOF: We first derive the result up to second order. Multiplying both sides of (A.10) by $\frac{\bar{c}_1^i}{\gamma^i}$, integrating over all households i, and making use of the market clearing conditions, which imply that

$$\int_0^1 \bar{c}_1^i \, di = \int_0^1 \left(\bar{w}_1 + \bar{\pi}_1 \bar{k}_0^i \right) di,$$

we obtain

$$\mathbb{E}_0 \hat{r}_1^k - \hat{r}_1 + \frac{1}{2}\sigma^2 = \left(\frac{\bar{c}_1^i}{\int_0^1 \bar{c}_1^{i'} \, di'} \frac{1}{\gamma^i} \right)^{-1} \sigma^2 + o\left(\| \cdot \|^3 \right), \tag{A.15}$$

defining $\bar{\gamma}$ as in the claim.

We now derive the result up to third order. The third-order approximation of optimal portfolio choice for household i is

$$\begin{aligned} &\mathbb{E}_0 \hat{r}_1^k - \hat{r}_1 + \frac{1}{2}\sigma^2 \\ &\quad = \gamma^i \delta_{z_1}^{c_1^i} \sigma^2 + \left[\gamma^i \left(\delta_{m_0}^{c_1^i} \bar{\gamma} + \delta_{m_0 z_1}^{c_1^i} \right) - \left(\gamma^i \right)^2 \delta_{m_0}^{c_1^i} \delta_{z_1}^{c_1^i} + \gamma^i \delta_{z_1}^{c_1^i} \delta_{m_0}^{r_1} - \bar{\gamma} \delta_{m_0}^{r_1} \right] \hat{\epsilon}_0^m \sigma^2 + o\left(\| \cdot \|^4 \right). \end{aligned}$$

given the second-order expansion of $\hat{c}_1^i$ in terms of the underlying states

$$\hat{c}_1^i = \delta_{m_0}^{c_1^i} \hat{\epsilon}_0^m + \delta_{z_1}^{c_1^i} \hat{\epsilon}_1^z + \frac{1}{2} \delta_{m_0^2}^{c_1^i} \left(\hat{\epsilon}_0^m \right)^2 + \delta_{m_0 z_1}^{c_1^i} \hat{\epsilon}_0^m \hat{\epsilon}_1^z + \frac{1}{2} \delta_{z_1^2}^{c_1^i} \left(\hat{\epsilon}_1^z \right)^2 + \frac{1}{2} \delta_{\sigma^2}^{c_1^i} \sigma^2 + o\left(\| \cdot \|^3 \right).$$

Making use of (A.11) substantially simplifies this to

$$\mathbb{E}_0 \hat{r}_1^k - \hat{r}_1 + \frac{1}{2}\sigma^2 = \gamma^i \delta_{z_1}^{c_1^i} \sigma^2 + \gamma^i \delta_{m_0 z_1}^{c_1^i} \hat{\epsilon}_0^m \sigma^2 + o\left(\| \cdot \|^4 \right). \tag{A.16}$$

Again multiplying both sides by $\frac{\bar{c}_1^i}{\gamma^i}$, integrating over all households i, and making use of the market clearing conditions, we obtain

$$\mathbb{E}_0\hat{r}_1^k - \hat{r}_1 + \frac{1}{2}\sigma^2 = \bar{\gamma}\sigma^2 + \frac{\bar{\gamma}}{\int_0^1 \bar{c}_1^i\,di}\left(\int_0^1 \bar{c}_1^i\delta_{m_0 z_1}^{c_1^i}\,di\right)\hat{\epsilon}_0^m\sigma^2 + o\big(\|\cdot\|^4\big).$$

It remains to further characterize the coefficient on $\hat{\epsilon}_0^m\sigma^2$ in closed form. Taking a second-order approximation of the period 1 resource constraint and equilibrium wages and profits, the method of undetermined coefficients implies

$$\bar{c}_1^i\delta_{m_0 z_1}^{c_1^i} + \bar{c}_1^i\delta_{m_0}^{c_1^i}\delta_{z_1}^{c_1^i} = \alpha\bar{w}_1\delta_{m_0}^{k_0} + \bar{\pi}_1\delta_{m_0}^{k_0^i} - (1-\alpha)\bar{\pi}_1\bar{k}_0^i\delta_{m_0}^{k_0}. \tag{A.17}$$

It follows that

$$\int_0^1 \bar{c}_1^i\delta_{m_0 z_1}^{c_1^i}\,di = -\int_0^1 \bar{c}_1^i\delta_{m_0}^{c_1^i}\delta_{z_1}^{c_1^i}\,di + \bar{\pi}_1\int_0^1 \delta_{m_0}^{k_0^i}\,di,$$

using market clearing and the definition of equilibrium wages and profits.[1] Further using a first-order approximation to capital claims market clearing and goods market clearing implies

$$\int_0^1 \bar{c}_1^i\delta_{m_0 z_1}^{c_1^i}\,di = \int_0^1 \bar{c}_1^i\delta_{m_0}^{c_1^i}\big(1-\delta_{z_1}^{c_1^i}\big)\,di = \int_0^1 \bar{c}_1^i\delta_{m_0}^{c_1^i}\left(1-\frac{\bar{\gamma}}{\gamma^i}\right)di,$$

where the second equality uses (A.11). Recall from Proposition 5 that $\overline{mpr}_0^i \equiv \frac{\bar{\gamma}}{\gamma^i}$. Since the definition of $\bar{\gamma}$ implies

$$\int_0^1 \bar{c}_1^i\delta_{m_0}^{c_1^i}\left(1-\frac{\bar{\gamma}}{\gamma^i}\right)di = \int_0^1\left(\bar{c}_1^i\delta_{m_0}^{c_1^i} - \frac{\bar{c}_1^i}{\int_0^1 \bar{c}_1^{i'}\,di'}\int_0^1 \bar{c}_1^{i'}\delta_{m_0}^{c_1^{i'}}\,di'\right)\left(1-\frac{\bar{\gamma}}{\gamma^i}\right)di$$

and

$$\overline{\frac{d\left[c_1^i/\int_0^1 c_1^{i'}\right]}{d\epsilon_0^m}} = \frac{1}{\int_0^1 \bar{c}_1^{i'}\,di'}\left(\bar{c}_1^i\delta_{m_0}^{c_1^i} - \frac{\bar{c}_1^i}{\int_0^1 \bar{c}_1^{i'}\,di'}\int_0^1 \bar{c}_1^{i'}\delta_{m_0}^{c_1^{i'}}\,di'\right),$$

we obtain the coefficient on $\hat{\epsilon}_0^m\sigma^2$ given in the claim. *Q.E.D.*

[1] We linearize rather than log-linearize with respect to $\{k_0^i, b_0^i, a_0^i\}$ since these may be negative.

TABLE A.I

ROBUSTNESS OF 1 SD MONETARY SHOCK ON RETURNS AND COMPONENTS.

	1-Year Treasury Yield (pp)	Real Stock Return (pp)	Share Future Excess Return News (%)
Baseline	−0.22	1.92	59%
Number of lags in VAR			
4	−0.21	1.85	52%
5	−0.22	1.79	54%
7	−0.23	1.86	62%
8	−0.23	1.90	56%
Sample periods			
VAR: 1/91–6/12, IV: 1/91–6/12	−0.14	1.51	36%
VAR: 7/79–6/12, IV: 1/91–9/01	−0.21	3.07	49%
VAR: 7/79–6/12, IV: 10/01–6/12	−0.17	−2.08	37%
Variable added to VAR			
Excess bond premium	−0.21	2.21	83%
Mortgage spread	−0.24	1.53	54%
3-month commercial paper spread	−0.20	2.13	65%
5-year Treasury rate	−0.17	1.61	78%
10-year Treasury rate	−0.17	1.56	76%
Term spread	−0.21	2.04	64%
Relative bill rate	−0.18	2.55	70%
Change in 3-month Treasury rate	−0.19	2.25	65%
3-month ahead FF as IV	−0.21	2.21	65%

Note: Series for the Gilchrist and Zakrajsek (2012) excess bond premium, mortgage spread, 3-month commercial paper spread, 5-year Treasury rate, and 10-year Treasury rate are taken from the data set provided by Gertler and Karadi (2015). The term spread (10-year Treasury rate less 1-month Treasury yield), relative bill rate (difference between the 3-month Treasury rate and its 12-month moving average), and change in the 3-month Treasury rate are constructed using CRSP.

APPENDIX B: EMPIRICAL APPENDIX

B.1. *The Effect of Monetary Shocks*

B.1.1. *Robustness to Details of the Estimation Approach*

We first demonstrate that the broad messages of our baseline estimates of the effects of a monetary policy shock in Section 3.1 are robust to details of the estimation.

Given a monetary policy shock, Table A.I summarizes the impact effect on the 1-year Treasury yield, the impact effect on the real S&P 500 return (implied by the real rate and excess return), and the share of the latter accounted for by news about future excess returns in the Campbell–Shiller decomposition (26). First, we find that the baseline results using 6 lags in the VAR are little affected if 4–8 lags are used instead. Second, we find that the results are broadly robust to using the same January 1991–June 2012 period for both the VAR and IV regressions, or limiting the analysis of monetary policy shocks to the first half of the IV sample alone (January 1991–September 2001). The expansionary monetary policy shock lowers the stock market when using the second half of the IV sample alone (October 2001–June 2012), but we note that the instrument is weak over this subsample (having a first-stage F statistic of 4.7, not shown). Third, we find that news about future excess returns tends to be, if anything, even more important when adding other variables included in the analyses of Bernanke and Kuttner (2005) and Gertler and Karadi (2015) on which we build. Finally, we find similar results when using as the instrument the 3-month ahead Fed Funds futures contract instead of the current contract.

TABLE A.II

TESTS OF INVERTIBILITY ASSUMED IN THE VAR.

	1-yr Treasury	CPI	Industrial Production	1-mo Real Rate	1-mo Excess Return	Dividend/Price
SW [2018] test	0.45	0.61	0.97	0.80	0.68	0.76
Granger test	0.07	0.16	0.88	0.13	0.41	0.93

Note: The first row is the bootstrapped p-value for the null hypothesis that the SVAR-IV and LP-IV impulse responses are the same 1, 13, 25, and 37 months after shock, using the test statistic provided in Stock and Watson (2018). We construct the variance matrix needed for this statistic using the 10,000 iterations of the wild bootstrap used to construct confidence intervals for our SVAR-IV estimates in the main text. The second row is the p-value for the null hypothesis that the coefficients on 6 lags of the instrument are jointly equal to zero when added to the VAR.

B.1.2. *Testing Invertibility and Comparing SVAR-IV and LP-IV*

We now demonstrate that the assumption of invertibility implicit in our SVAR-IV is validated by statistical tests suggested in the literature.

Stock and Watson (2018) propose a Hausman-type test statistic of the null hypothesis that invertibility is satisfied by comparing the impulse response at horizon h for a given variable under the SVAR-IV and LP-IV. We implement the LP-IV by projecting each outcome variable h months ahead on the 1-year Treasury yield, instrumenting for the latter using the Fed Funds futures surprise also used in our baseline SVAR-IV.[2] The first row of Table A.II summarizes the p-value for this test in our setting jointly applied at horizons $h \in \{1, 13, 25, 37\}$ for each variable, demonstrating that we cannot reject the null at standard significance levels.

Stock and Watson (2018) also recommend the use of the complementary Granger causality test in Forni and Gambetti (2014): if invertibility is satisfied, lagged values of the instrument should not have predictive power given the variables included in the VAR. We include 6 lags of our instrument in the VAR and construct an F statistic associated with the null hypothesis that these coefficients are jointly zero for each variable in the VAR. We again cannot reject the null at standard significance levels.

B.1.3. *Adding Relative Wealth Responses to the VAR*

We finally augment our VAR with two measures of the relative wealth of agents with heterogeneous exposures to capital. The wealth of agents more exposed to the stock market rises on impact of a monetary easing, consistent with the model mechanisms.

We construct the relative wealth measures using monthly data on the returns of hedge funds and mutual funds through which households invest. In each case, we have an unbalanced panel of data on returns r_{ft} and assets A_{ft} for funds indexed by f and months in time indexed by t; the data sources are described further below. For each fund, we project the time-series of its monthly return on the S&P 500 return relative to the 1-month Treasury return. The estimated coefficient is the fund's estimated beta β_f. We sort funds by their beta, compute the median fund beta β_{p50}, and then define the average monthly return (weighted by the prior month's assets) for funds with a beta above or below the me-

[2]Following Stock and Watson (2018), to make this specification comparable with the SVAR-IV and further improve the precision of estimates, we include 6 lags of each of the variables included in the VAR as controls. Moreover, given the serial correlation of the instrument discussed in Ramey (2016) and Stock and Watson (2018), we include a lag of the instrument as an additional control.

dian, r_t^{high} and r_t^{low}, respectively. Finally, we define the relative total return index relative to an initial date 0 as

$$\text{relwealth}_t = \sum_{s=0}^{t} r_s^{\text{high}} - \sum_{s=0}^{t} r_s^{\text{low}}.$$

This is a measure of the relative wealth of a household that continually reinvests in high beta funds versus a household that continually reinvests in low beta funds. We obtain one such measure for hedge funds and another for mutual funds.

Our source of hedge fund data is the Lipper TASS database from June 1990 through June 2012. Following Getmansky, Lee, and Lo (2015), we focus on funds that provide monthly data; we define the monthly fund return as the ratio of its NAV to its prior month NAV if these measures are available, and as the self-reported return if they are not; we only keep observations for which the monthly fund return is between -100 and 200; and we only keep observations for which the monthly fund return is not equal to the last two observations. We further only keep observations with reported estimated assets that are not equal to the previous observation, and only keep funds with at least 120 observations meeting the criteria described above. We are left with 733 hedge funds in the sample.

Our source of mutual fund data is the CRSP Survivorship-Bias-Free Mutual Fund database from June 1990 through June 2012. We keep only observations with non-missing returns and prior period total net assets, and funds with at least 120 observations meeting these criteria. We are left with 13,011 mutual funds in the sample.

Having constructed the relative wealth measures in this way, we add both to our VAR. We estimate the VAR and the IV regressions using the January 1991–June 2012 period. Figure A.1 displays the estimated responses of both relative wealth measures to a monetary easing that results in a roughly $0.2pp$ decline in the 1-year Treasury yield; the estimated responses of the other variables in the VAR are similar to the baseline results presented in the main text and are thus excluded for brevity. In both cases, a household (continually re)invested in high beta funds would experience an increase in relative wealth on impact of a monetary easing, after which its wealth share would decline.[3] This result is not mechanical: while the hedge funds and mutual funds are sorted based on their unconditional betas over the sample period, these measures of relative reported returns do not otherwise use any information on market returns, and their conditional response to a monetary easing need not have exhibited the same qualitative pattern as the excess S&P 500 return—but they do.

B.2. *Micro Moments From the SCF*

B.2.1. *Construction of Household Portfolios*

We now provide supplemental details on our measurement of household portfolios using the 2016 SCF described in Section 3.3. We proceed in three steps.

First, to the SCF data we add an estimate of defined benefit pension wealth for each household, since this is not included in the SCF measure of net worth. We use the estimates of Sabelhaus and Henriques Volz (2019).

[3]The larger response of the relative wealth measure using mutual funds is consistent with the fact that we estimate a larger dispersion in betas in the sample of mutual funds than hedge funds.

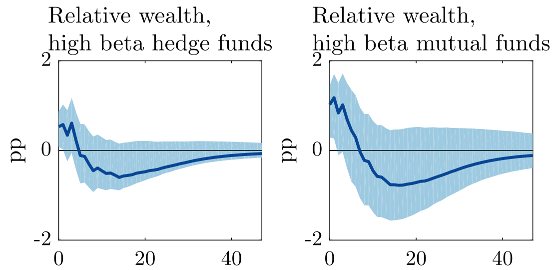

FIGURE A.1.—Effects of a 1 SD monetary shock on relative wealth measures. *Notes*: See the notes accompanying Figure 1 in the main text.

Second, we proceed by line item to allocate how much household wealth is in directly held claims on capital, indirect claims on capital through business equity, or nominal claims. Direct claims on capital are nonfinancial assets (vehicles, primary residence, residential real estate excluding the primary residence, nonresidential real estate, and other miscellaneous nonfinancial assets). Indirect claims on capital through business equity come in two forms: publicly traded stocks or privately-owned businesses. We assume the following line items reported in the SCF summary extract include stocks:[4] stock mutual funds, other mutual funds, and directly held stocks, all of which we assume are fully invested in stocks; combination mutual funds, 50% of which we assume are invested in stocks; and savings accounts that may be invested in stocks and are included in transaction accounts (such as 529 or state-sponsored education accounts), other managed assets, and quasi-liquid retirement assets, for which we use the self-reported fraction of these accounts invested in stocks. We assume the remaining portion of these line items not invested in stocks, as well as all other line items not mentioned above, are purely nominal assets or liabilities.

Third, we account for households' leverage via indirect claims on capital. In particular, if household i owns \$1 in equity in a firm with leverage lev^i, then we assign the household $Qk^i = \text{lev}^i$ and $B^i = 1 - \text{lev}^i$. We assume that the leverage of publicly traded stocks and private businesses owned by household i are

$$\text{lev}^i_{\text{public}} = \text{lev}_{\text{public}} \epsilon^i,$$
$$\text{lev}^i_{\text{private}} = \text{lev}_{\text{private}} \epsilon^i,$$

respectively, where the idiosyncratic component ϵ^i is drawn from a $\Gamma(\theta^{-1}, \theta)$ distribution having mean one. $\text{lev}_{\text{public}}$ thus reflects the aggregate leverage of the household sector in publicly traded stocks; $\text{lev}_{\text{private}}$ reflects the aggregate leverage of the household sector in private businesses; and θ controls the dispersion of household leverage in these claims. The Γ distribution is right-skewed, which accords well with the literature studying portfolio and return heterogeneity discussed further below.

We use the Financial Accounts (FA) to discipline $\text{lev}_{\text{public}}$ and $\text{lev}_{\text{private}}$. $\text{lev}_{\text{public}}$ equals the net leverage of the consolidated nonfinancial corporate sector (FA Table S.5.a) and financial business sector (FA Table S.6.a), net of the central bank (FA Table S.61.a), government DB pension funds (FA Tables L.119.b and L.120.b), all defined contribution

[4]Our approach here follows the construction of the EQUITY variable in the summary extract.

(DC) pension funds (FA Tables L.118.c, L.119.c, and L.120.c), and mutual funds (FA Table L.122).[5] $\text{lev}_{\text{private}}$ equals the net leverage of the consolidated nonfinancial noncorporate sector (FA Table S.4.a) and nonprofit sector (FA Table B.101.n). We compute net leverage by dividing the aggregate position in capital by net equity issued to other sectors. Capital is given by total assets net of nominal assets and equity assets. Net equity issued to other sectors is given by equity liabilities plus net worth net of equity assets. Using the Q2 2019 release of the FA, the resulting measures of 2016 leverage we obtain are $\text{lev}_{\text{public}} = 1.6$ and $\text{lev}_{\text{private}} = 1.1$.

With these measures of aggregate leverage alone, we can decompose the \$104,721bn in total U.S. household net worth ($\sum_i A^i$) into \$11,228bn in nominal claims ($\sum_i B^i$) and \$93,492bn in capital ($\sum_i Qk^i$).[6]

We finally use recent evidence on the heterogeneity in households' expected returns on wealth to discipline θ. Using granular data on the portfolios of the universe of Swedish households, Bach, Calvet, and Sodini (2020) construct household-specific measures of expected excess returns. Over the 2000–2007 period, the cross-sectional standard deviation in expected excess returns on gross assets was 31% of the expected excess returns of the global market.[7] We choose $\theta = 1.05$ so that the implied cross-sectional standard deviation in leverage on assets in our SCF sample equals 31% of the aggregate leverage in public equities estimated above ($\text{lev}_{\text{public}} = 1.6$). The fact that a positive value of θ is needed to match the evidence on return heterogeneity is consistent with broader results from the literature that households in fact do not hold identical, diversified equity portfolios.[8] Nonetheless, even when $\theta \to 0$, there is heterogeneity in capital portfolio shares (and thus expected returns) because of households' heterogeneous portfolios across nominal claims, capital, and equity.

B.2.2. *Application to the 2007–2009 SCF Panel*

Using the 2007–2009 SCF panel, we can apply the exact same methodology as described in the prior subsection to characterize households' portfolios and sort them into three groups as of 2007. In this subsection, we follow these households over the next 2 years using this survey's unique panel structure, demonstrating that the evolution of portfolios is broadly consistent with the mechanisms in our model.

Rows 1–4 of Table A.III summarize households by group as of 2007. The moments are quite consistent with the 2016 counterparts in Table II in the main text.

Row 5 reports the change in the aggregate wealth share of households in each group between 2007 and 2009. The key message is that *a* households experienced a decline in their wealth share over these 2 years, consistent with the decline in risky asset prices over the 2007–2009 period and the fact that these households were levered in such claims. The

[5]We exclude the central bank and government DB pension funds because we model these as part of the government sector (the latter consistent with our interpretation of DB pensions in footnote 24). We exclude DC pension funds and mutual funds because these are pass-through entities whose assets have already been folded into that of households using our approach described so far.

[6]We have validated that this aggregate balance sheet is consistent with market clearing in nominal claims after accounting for the balance sheets of the government and rest of the world.

[7]In their Table 8, these authors report a cross-sectional standard deviation in expected excess returns of 1.81%. In their section I.D, they report a long-run (1983–2016) average of the global market excess return of 5.8%. The ratio between these is 31%. We use this evidence because of the absence of comparable data in the United States with exhaustive coverage of households' wealth.

[8]It is also consistent with some households investing in equity through levered investment intermediaries such as hedge funds and private equity, which cannot be identified in the SCF.

TABLE A.III

HETEROGENEITY AND PERSISTENCE IN THE 2007–2009 SCF PANEL.

		Group (g)		
		a	b	c
1	Share households	4%	35%	61%
2	$\sum_{i\in g} W_{2007}\ell^i_{2007}/\sum_i W_{2007}\ell^i_{2007}$	4%	21%	75%
3	$\sum_{i\in g} A^i_{2007}/\sum_i A^i_{2007}$	16%	63%	20%
4	$\sum_{i\in g} Q_{2007}k^i_{2007}/\sum_{i\in g} A^i_{2007}$	1.9	0.6	1.2
5	$\sum_{i\in g} A^i_{2009}/\sum_i A^i_{2009} - \sum_{i\in g} A^i_{2007}/\sum_i A^i_{2007}$	−1.7%	−0.6%	+2.2%
6	$\sum_{i\in g} Q_{2009}k^i_{2009}/\sum_{i\in g} A^i_{2009}$	1.8	0.5	1.2

Note: Observations are weighted by SCF sample weights. Construction of capital and bond positions implicit in business equity use $\text{lev}_{\text{public},2007} = 1.4$, $\text{lev}_{\text{public},2009} = 1.3$, $\text{lev}_{\text{private},2007} = 1.1$, and $\text{lev}_{\text{private},2009} = 1.2$ obtained using the Financial Accounts for 2007 and 2009. θ is calibrated so that expected return heterogeneity in 2007 is as in Bach, Calvet, and Sodini (2020), and ϵ^i is assumed the same in 2007 and 2009 for each household.

redistribution away from a households on impact of a decline in the price of capital is indeed a key mechanism at play in the quantitative model.

Row 6 reports the aggregate capital portfolio share in 2009 by group. The key message is that it is very close to its counterpart in 2007; portfolio heterogeneity across groups is quite persistent. This holds even within each group: at the individual household level, projecting the capital portfolio share in 2009 on a constant and its 2007 value implies a coefficient of 0.94 on the latter.[9] This is consistent with the permanent differences in risk tolerance across households in the quantitative model.

We note that the redistribution away from a households and the persistence in capital portfolio shares holds even if we exclude all assets and liabilities involving vehicles and housing, thereby focusing on capital held in business equity alone.

APPENDIX C: INFINITE HORIZON ENVIRONMENT

C.1. *Environment*

We now outline in more detail the environment studied in Section 3.

Households. The unit measure of households is now organized into three groups $i \in \{a, b, c\}$ with measures $\{\lambda^i\}$ such that $\sum_i \lambda^i = 1$. Household ι in group $i(\iota)$ is comprised of a continuum of members $j \in [0, 1]$ supplying a differentiated variety of labor, with full consumption insurance within the household. The household has Epstein–Zin preferences

$$v^\iota_t = \left((1-\beta)\left(c^\iota_t \Phi\left(\int_0^1 \ell^\iota_t(j)\,dj/\bar{\ell}^\iota_t\right)\right)^{1-1/\psi} + \beta\mathbb{E}_t\left[\left(v^\iota_{t+1}\right)^{1-\gamma^{i(\iota)}}\right]^{\frac{1-1/\psi}{1-\gamma^{i(\iota)}}}\right)^{\frac{1}{1-1/\psi}},$$

where $\bar{\ell}^\iota_t$ denotes the household's labor endowment. In equilibrium, the representative household of each group will hold a unitary labor endowment, so that these preferences simplify to (27) as given in the main text. Assuming that the household was alive the

[9]As portfolio shares can become very large when net worth is close to zero, we run this regression only on (the more than 97% of) households with a 2007 capital portfolio share between -10 and 10.

previous period, it faces the resource constraint

$$
\begin{aligned}
& P_t c_t^\iota + B_t^\iota + Q_t k_t^\iota + Q_t^{\bar{\ell},i(\iota)} \bar{\ell}_t^\iota \\
& \quad \le (1-\tau) \int_0^1 W_t(j) \ell_t^\iota(j)\, dj - \int_0^1 AC_t^W(j)\, dj \\
& \qquad + (1+i_{t-1}) B_{t-1}^\iota + \big(\Pi_t + (1-\delta) Q_t\big) k_{t-1}^\iota \exp(\varphi_t) + Q_t^{\bar{\ell},i(\iota)} \bar{\ell}_{t-1}^\iota + T_t^\iota,
\end{aligned}
$$

where the cost of setting the wage for member j is (29), and $Q_t^{\bar{\ell},i}$ is the price of the labor endowment for households in group i. It will be convenient to define the household's share of its group's aggregate financial wealth inclusive of labor endowment,

$$
\mu_t^\iota = \frac{(1+i_{t-1}) B_{t-1}^\iota + \big(\Pi_t + (1-\delta) Q_t\big) k_{t-1}^\iota \exp(\varphi_t) + Q_t^{\bar{\ell},i(\iota)} \bar{\ell}_{t-1}^\iota}{\displaystyle\int_{\iota' := i(\iota') = i(\iota)} \big[(1+i_{t-1}) B_{t-1}^{\iota'} + \big(\Pi_t + (1-\delta) Q_t\big) k_{t-1}^{\iota'} \exp(\varphi_t) + Q_t^{\bar{\ell},i(\iota')} \bar{\ell}_{t-1}^{\iota'}\big]\, d\iota'}.
$$

Finally, households further face the capital constraint (30). In our calibration, this constraint will (almost always) only bind for c households.

Supply-Side. A union represents each labor variety j across households. Each period, it chooses $W_t(j)$, $\ell_t(j)$ to maximize the utilitarian social welfare of union members subject to the allocation rule

$$
\ell_t^\iota(j) = \frac{\bar{\ell}_t^\iota}{\displaystyle\int_{\iota' := i(\iota') = i(\iota)} \bar{\ell}_t^{\iota'}\, d\iota'} \phi^{i(\iota)} \ell_t(j).
$$

That is, within group i, labor is allocated across households in proportion to their labor endowments. The labor packer combines varieties supplied by the union, earning profits each period (33) given (32). The representative producer hires ℓ_t units of the labor aggregator in period t and combines it with $k_{t-1}\exp(\varphi_t)$ units of capital rented from households. It further uses $(\frac{k_t}{k_{t-1}\exp(\varphi_t)})^{\chi^x} x_t$ units of the consumption good to produce x_t new capital goods, where it again takes k_t as given. It thus earns profits

$$
\Pi_t k_{t-1} \exp(\varphi_t) = P_t (z_t \ell_t)^{1-\alpha} \big(k_{t-1} \exp(\varphi_t)\big)^\alpha - W_t \ell_t + Q_t x_t - P_t \left(\frac{k_t}{k_{t-1} \exp(\varphi_t)}\right)^{\chi^x} x_t.
$$

Productivity follows (34).

Policy. The government follows a standard Taylor rule (37) where monetary policy shocks m_t follow (38). The government sets $\tau = -\frac{1}{\epsilon - 1}$ and the transfers

$$
T_t^\iota = \int_0^1 AC_t^W(j)\, dj + \tau \int_0^1 W_t(j) \ell_t^\iota(j)\, dj + \mu_t^\iota \nu^{i(\iota)} \big((1+i_{t-1}) B_{t-1}^g - B_t^g\big).
$$

Within group i, the government rebates the proceeds from its bond market trading in proportion to households' wealth.[10] As described in the main text, the government further collects the wealth of dying households and endows it to newborns.

Market Clearing. Market clearing in goods each period is now

$$\int_0^1 c_t^\iota \, d\iota + \left(\frac{k_t}{k_{t-1}\exp(\varphi_t)}\right)^{\chi^x} x_t = (z_t \ell_t)^{1-\alpha}\big(k_{t-1}\exp(\varphi_t)\big)^\alpha,$$

in labor is

$$\left[\int_0^1 \ell_t(j)^{(\epsilon-1)/\epsilon} \, dj\right]^{\epsilon/(\epsilon-1)} = \ell_t,$$

in the capital rental market is

$$\int_0^1 k_{t-1}^\iota \, d\iota = k_{t-1},$$

in the capital claims market is

$$(1-\delta)\int_0^1 k_{t-1}^\iota \exp(\varphi_t)\, d\iota + x_t = \int_0^1 k_t^\iota \, d\iota,$$

in bonds is

$$\int_0^1 B_t^\iota \, d\iota + B_t^g = 0,$$

and in the labor endowment is

$$\int_{\iota : = i(\iota) = a} \bar{\ell}_t^\iota \, d\iota = 1, \qquad \int_{\iota : = i(\iota) = b} \bar{\ell}_t^\iota \, d\iota = 1, \qquad \int_{\iota : = i(\iota) = c} \bar{\ell}_t^\iota \, d\iota = 1.$$

Equilibrium. Given initial states $\{W_{-1}, \{B_{-1}^\iota, k_{-1}^\iota\}, i_{-1}, z_0, \varphi_0, p_0, m_0\}$ and the stochastic processes (34)–(38), the equilibrium naturally generalizes Definition 1. Since labor varieties and unions j are symmetric, $\ell_t(j) = \ell_t$ and going forward we drop j.

C.2. *Aggregation Into Representative Households*

Within each group of households $i \in \{a, b, c\}$, we can then prove the homogeneity of households' policies in wealth, implying a representative household of each group.

PROPOSITION 1: *Households' optimal policies satisfy*

$$v_t^\iota = \mu_t^\iota v_t^{i(\iota)}, \qquad c_t^\iota = \mu_t^\iota c_t^{i(\iota)}, \qquad B_t^\iota = \mu_t^\iota B_t^{i(\iota)}, \qquad k_t^\iota = \mu_t^\iota k_t^{i(\iota)}, \qquad \bar{\ell}_t^\iota = \mu_t^\iota,$$

[10] We assume, however, that households do not internalize the dependence of their rebate on their wealth in their decisions, preserving the neutrality of government participation in the bond market.

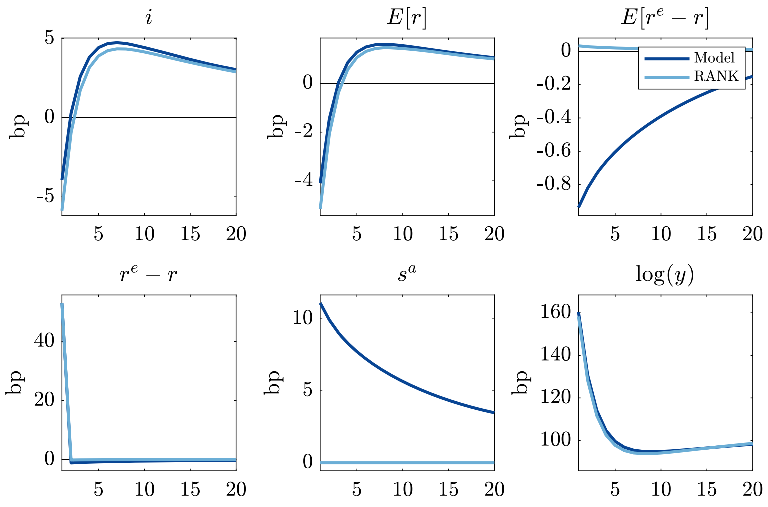

FIGURE A.2.—Responses to positive productivity shock. *Notes*: See the notes accompanying Figure 2 in the main text.

where the variables with an $i \in \{a, b, c\}$ superscript correspond to those of a representative household endowed with aggregate group-specific wealth. Furthermore, the evolution of wealth shares is identical across households in a given group, conditional on surviving through the next period:

$$\frac{\mu_{t+1}^{\iota}}{\mu_t^{\iota}} = \mu_{t,t+1}^{i(\iota)}. \tag{A.18}$$

This result follows from households' ability to trade labor endowments with other households in the same group, the assumed labor allocation rule, the assumed lump-sum transfers, and the assumed endowments. We exclude the proof for brevity.

C.3. *Rescaled Economy*

The results of the prior subsection allow us to summarize the equilibrium in terms of the first-order conditions of the three representative households $i \in \{a, b, c\}$, their resource constraints, and the market clearing conditions. Scaling by the price level P_t and permanent level of productivity z_t, we obtain a stationary transformation of the economy, which we can numerically solve over the state variables

$$\left\{ \frac{k_{t-1}}{z_{t-1}\exp(\epsilon_t^z)}, \frac{W_{t-1}}{P_t z_{t-1}\exp(\epsilon_t^z)}, s_t^a, s_t^c, p_t, m_t \right\},$$

where s_t^i denotes the financial wealth share of group i.

APPENDIX D: ADDITIONAL QUANTITATIVE RESULTS

D.1. *Impulse Responses to Other Shocks*

We now characterize the impulse responses to other shocks in Section 3.

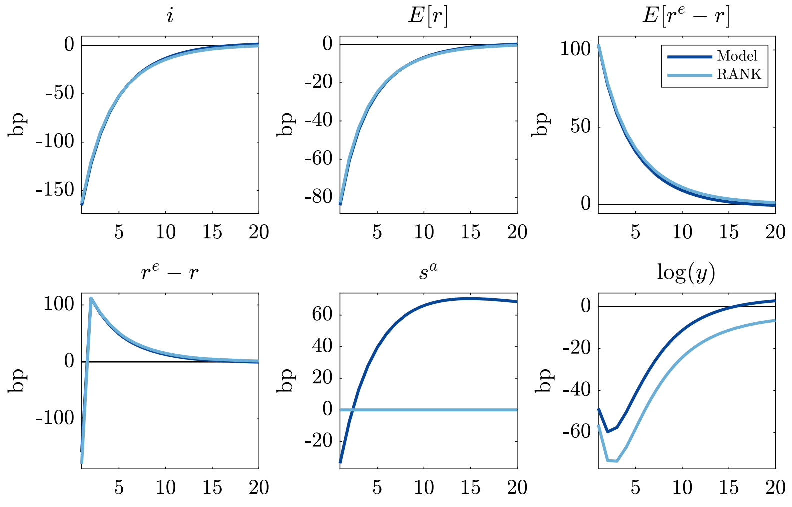

FIGURE A.3.—Responses to positive disaster probability shock. *Notes*: See the notes accompanying Figure 2 in the main text.

In Figure A.2, we summarize the effects of a two-standard deviation increase in productivity in both the model and counterfactual RANK economies. In the first row, the first panel demonstrates that the central bank following a standard Taylor rule will cut the nominal interest rate (in response to the price deflation induced by this shock). The second and third panels demonstrate that the expected real interest rate and the expected excess returns on capital decline following the shock. The first two panels of the second row demonstrate that redistribution drives the decline in the risk premium in our model: as in the case of a negative monetary policy shock, realized excess returns on capital are substantially positive on impact, and this raises the wealth share of high MPR a households who hold levered claims on capital. The third panel in this row demonstrates that output rises, as expected. The difference between the output responses in the model and RANK is minimal, arising from the endogenous tightening of monetary policy in the model in response to the stimulus from lower risk premia.

In Figure A.3, we summarize the effects of a two standard deviation increase in disaster risk in both the model and RANK economies. In the first row, the first panel demonstrates that the central bank following a standard Taylor rule will cut the nominal interest rate (again in response to the price deflation induced by this shock, reflecting the increase in precautionary saving). The second panel demonstrates that the expected real interest rate declines following the shock. The third panel demonstrates that expected excess returns rise following the shock, reflecting both the persistent increase in the quantity of risk and transitory redistribution of wealth away from the relatively risk tolerant. The latter is absent in the RANK economy. The first two panels in the second row rationalize the dynamics of the wealth distribution in the model with heterogeneity: realized excess returns on capital are negative on impact and positive in the quarters which follow, so a households lose in relative wealth on impact but then recoup these losses. The final panel demonstrates that output falls on impact of the increase in uncertainty—despite the fact that the households' intertemporal elasticity of substitution is less than one. This is consistent with the effects of uncertainty shocks in New Keynesian models and it is for this reason that the model-implied equity premium is countercyclical.

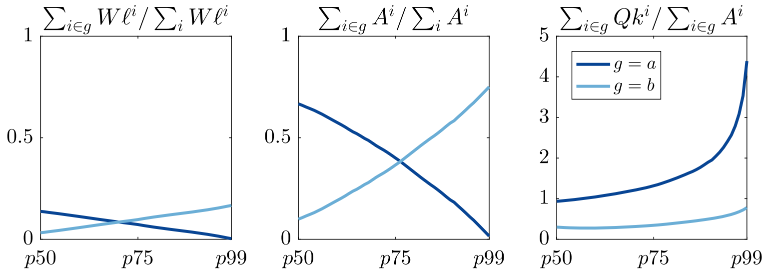

FIGURE A.4.—Alternative cutoff in the capital portfolio share. *Notes*: observations are weighted by SCF sample weights. Targets in the baseline calibration use a 90th percentile cutoff in the capital portfolio share.

D.2. *Alternative Calibration of Wealth and Leverage*

We now present the results in an alternative calibration in which a households hold a smaller fraction of the economy's wealth but are more levered, and thus have a higher MPR. Because these forces offset in determining the effects of a monetary policy shock on the risk premium, the net effects are comparable to our baseline results.

Formally, we change the cutoff in the capital portfolio share between group a and b agents. Figure A.4 summarizes the fraction of labor income, fraction of wealth, and ratio of aggregate capital to wealth for groups a and b as we vary the cutoff (the moments for c households are unaffected). As is evident, a higher cutoff means that group a households are more levered, but conversely have a lower share of total wealth. Our baseline calibration employed a cutoff at the 90th percentile.

In this subsection, we instead employ a cutoff at the 99th percentile. The targeted moments are the right-most points in Figure A.4: a agents are now only 0.4% of agents, earn even less labor income than that, own 2% of wealth, and have a capital portfolio share of 4.4; b agents meanwhile earn 17% of labor income, own 75% of wealth, and have a capital portfolio share of 0.8. These targets mean that we can interpret our a agents as capturing highly levered sectors such as security broker-dealers and hedge funds, which issue nominal claims to households (the asset-rich b and asset-poor c) to hold capital. Indeed, the estimates in He and Krishnamurthy (2013) imply that these sectors own 3% of U.S. wealth and have leverage of 4.5, comparable to the 2% wealth share and capital portfolio share of 4.4 obtained here.

Given these new targets, we maintain the same externally set parameters as in Table IV except that we set $\lambda^a = 0.4\%$; $\lambda^b = 39.6\%$; $\phi^a = 0$ (so a agents do not supply any labor, consistent with their interpretation as levered institutions); $\phi^b = 17\%/\lambda^b$; and $\nu^a = 2\%/\lambda^a$. We further set the death probability to $\xi = 4\%$ so that the solution is numerically stable given a agents' high targeted capital portfolio share. We maintain the same targets as in Table V except that we target the higher capital portfolio share and lower wealth share of a agents. The results are reported in Table A.IV. We calibrate a agents to be more risk tolerant than in the baseline.

Figure A.5 compares the effects of a monetary policy shock in this environment to a counterfactual RANK economy in which $\gamma^i = 18$ for all groups. Table A.V presents the Campbell–Shiller decomposition of the stock market return following the shock. As is evident, it remains the case that a substantial share of the stock market return is due to news about future excess returns. And again, the impact effect on output is roughly 1.3 times larger than in the RANK economy.

TABLE A.IV

TARGETED MOMENTS AND CALIBRATED PARAMETERS, ALTERNATIVE CALIBRATION.

	Description	Value	Moment	Target	Model
σ^z	std. dev. prod.	0.55%	$\sigma(\Delta \log c)$	0.5%	0.6%
χ^x	capital adj cost	3.5	$\sigma(\Delta \log x)$	2.1%	2.0%
β	discount factor	0.984	$4r_{+1}$	1.3%	1.1%
γ^b	RRA b	21	$4[r^e_{+1} - r_{+1}]$	7.3%	7.3%
σ^p	std. dev. log dis. prob.	0.47	$\sigma(4\mathbb{E}r_{+1})$	2.2%	2.2%
ρ^p	persist. log dis. prob.	0.8	$\rho(4\mathbb{E}r_{+1})$	0.79	0.74
γ^a	RRA a	2.5	qk^a/a^a	4.4	4.8
$\underline{k}$	lower bound k^i	10	qk^c/a^c	1.1	1.0
$\xi\bar{s}^a$	newborn endowment a	0%	$\lambda^a a^a / \sum_i \lambda^i a^i$	2%	3%
$\xi\bar{s}^c$	newborn endowment c	0.9%	$\lambda^c a^c / \sum_i \lambda^i a^i$	23%	24%
b^g	real value govt bonds	-2.7	$-\sum_i \lambda^i b^i / \sum_i \lambda^i a^i$	-10%	-10%

Note: See the notes accompanying Table V in the main text. The disutilities of labor $\{\bar{\theta}^a, \bar{\theta}^b, \bar{\theta}^c\}$ are jointly set to $\{0.00, 2.47, 0.44\}$ so that the average labor wedge is zero for each group and $\ell = 1$.

D.3. *Alternative Microfoundation of Portfolio Heterogeneity*

We now present the results in an alternative environment that microfounds differences in portfolios and MPRs without differences in risk aversion. Instead, we assume households experience idiosyncratic returns on capital, and the volatility of these returns differs across groups, consistent with one of the alternative forms of heterogeneity considered in Section 2.5. Our quantitative results are again robust.

Formally, we assume that households' choice of capital k^i_t in period t is subject to an idiosyncratic quality shock at $t+1$, turning into $\epsilon^i_{t+1} k^i_t$ units of capital, which can be rented in the spot market to firms. The quality shock is an *iid* shock from a lognormal distribution,

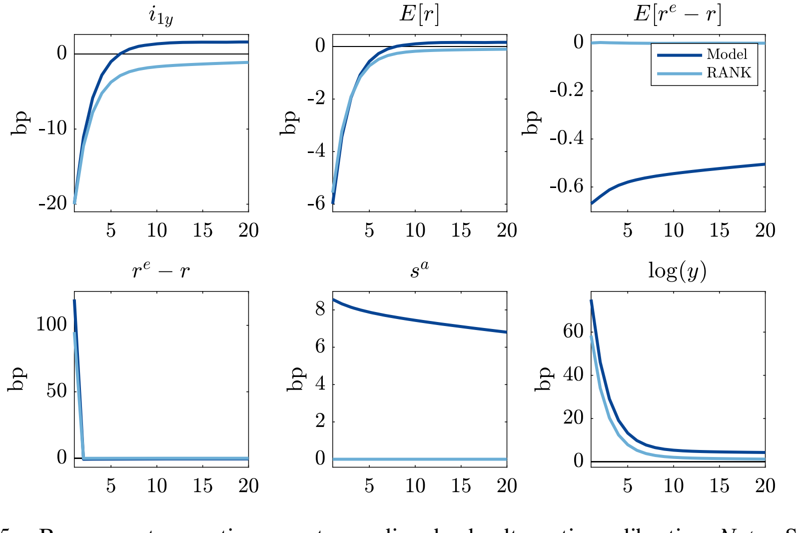

FIGURE A.5.—Responses to negative monetary policy shock, alternative calibration. *Notes*: See the notes accompanying Figure 2 in the main text.

TABLE A.V

DECOMPOSITION AFTER MONETARY SHOCK, ALTERNATIVE CALIBRATION.

% Real Stock Return	Data [90% CI]	Model	RANK
Dividend growth news	33% [−13%, 71%]	50%	65%
− Future real rate news	8% [−6%, 21%]	13%	35%
−Future excess return news	59% [19%,108%]	37%	0%

Note: See the notes accompanying Table A.V in the main text.

the variance of which is the group-specific parameter η^i:

$$\log \epsilon^i_{t+1} \sim N\left(-\frac{1}{2}\eta^i, \eta^i\right).$$

In equilibrium, this affects households' portfolio choice, but since the quality shock has a mean value of one the representative household still holds k^i_t units of capital and none of the supply-side conditions or aggregate resource constraints are affected.[11]

To rationalize their high leverage, a households are now calibrated to be those with the smallest volatility of idiosyncratic returns; equivalently, they have the highest risk-adjusted returns. Formally, we maintain the same externally set parameters as in Table IV and set $\eta^a = 0$. We then recalibrate the parameters in Table A.VI assuming that households share the same level of risk aversion γ calibrated to match the level of the equity premium, and calibrating η^b and $\underline{k}$ to match households' capital portfolio shares. Taken together, this environment builds on a large literature on entrepreneurship in macroeconomic models emphasizing idiosyncratic risk and entrepreneurs as those with relatively good investment ideas.

TABLE A.VI

TARGETED MOMENTS AND CALIBRATED PARAMETERS, IDIOSYNCRATIC RISK.

	Description	Value	Moment	Target	Model
σ^z	std. dev. prod.	0.55%	$\sigma(\Delta \log c)$	0.5%	0.5%
χ^x	capital adj cost	3.5	$\sigma(\Delta \log x)$	2.1%	2.1%
β	discount factor	0.98	$4r_{+1}$	1.3%	1.4%
$\gamma^a = \gamma^b = \gamma^c$	RRA	11	$4[r^e_{+1} - r_{+1}]$	7.3%	7.4%
σ^p	std. dev. log dis. prob.	1.20	$\sigma(4\mathbb{E}r_{+1})$	2.2%	2.2%
ρ^p	persist. log dis. prob.	0.8	$\rho(4\mathbb{E}r_{+1})$	0.79	0.70
η^b	idio. risk b	0.001	qk^a/a^a	2.0	2.5
$\underline{k}$	lower bound k^i	10	qk^c/a^c	1.1	0.9
$\xi\bar{s}^a$	newborn endowment a	−0.02%	$\lambda^a a^a / \sum_i \lambda^i a^i$	18%	22%
$\xi\bar{s}^c$	newborn endowment c	−0.15%	$\lambda^c a^c / \sum_i \lambda^i a^i$	23%	24%
b^g	real value govt bonds	−2.6	$-\sum_i \lambda^i b^i / \sum_i \lambda^i a^i$	−10%	−10%

Note: See the notes accompanying Table V in the main text. The disutilities of labor $\{\bar{\theta}^a, \bar{\theta}^b, \bar{\theta}^c\}$ are jointly set to $\{0.64, 2.89, 0.43\}$ so that the average labor wedge is zero for each group and $\ell = 1$.

[11] As described earlier in this Appendix, to obtain aggregation within groups we allow households to trade a claim on a labor endowment with other households in the same group. So that the valuation of the labor endowment behaves similarly as in the model with heterogeneity in risk aversion, we also assume the idiosyncratic quality shock applies to the labor endowment claim.

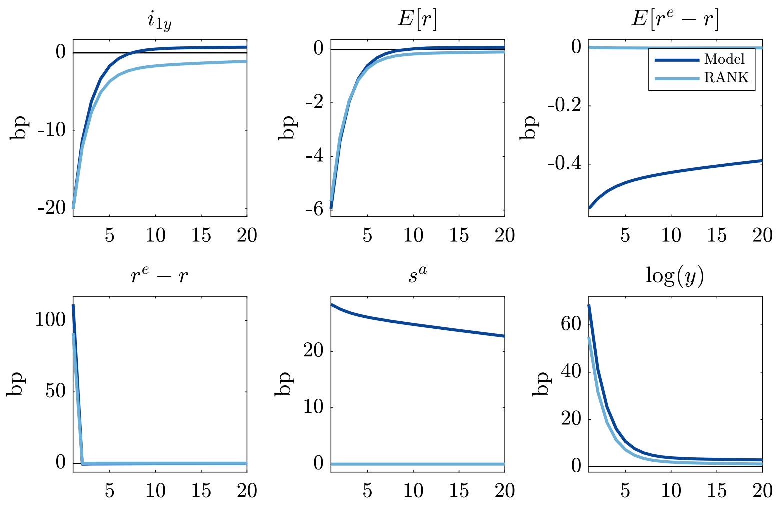

FIGURE A.6.—responses to negative monetary policy shock, idiosyncratic risk. *Notes*: See the notes accompanying Figure 2 in the main text.

TABLE A.VII

DECOMPOSITION AFTER MONETARY SHOCK, IDIOSYNCRATIC RISK.

% Real Stock Return	Data [90% CI]	Model	RANK
Dividend growth news	33% [−13%, 71%]	51%	65%
– Future real rate news	8% [−6%, 21%]	20%	35%
– Future excess return news	59% [19%,108%]	28%	1%

Note: See the notes accompanying Table A.V in the main text.

Figure A.6 compares the effects of a monetary policy shock in this environment to a counterfactual RANK economy in which η^i is identical across groups. Table A.VII presents the Campbell–Shiller decomposition of the stock market return following the shock. It remains the case that a substantial share of the stock market return is due to news about future excess returns. And again, the impact effect on output is roughly 1.3 times larger than in the RANK economy.

REFERENCES

BACH, LAURENT, LAURENT E. CALVET, AND PAOLO SODINI (2020): "Rich Pickings? Risk, Return, and Skill in Household Wealth," *American Economic Review*, 110, 2703–2747. [11,12]

BERNANKE, BEN S., AND KENNETH N. KUTTNER (2005): "What Explains the Stock Market's Reaction to Federal Reserve Policy?" *Journal of Finance*, 60, 1221–1257. [7]

FORNI, MARIO, AND LUCA GAMBETTI (2014): "Sufficient Information in Structural VARs," *Journal of Monetary Economics*, 66, 124–136. [8]

GERTLER, MARK, AND PETER KARADI (2015): "Monetary Policy Surprises, Credit Costs, and Economic Activity," *American Economic Journal: Macroeconomics*, 7, 44–76. [7]

GETMANSKY, MILA, PETER A. LEE, AND ANDREW W. LO (2015): "Hedge Funds: A Dynamic Industry in Transition," *Annual Review of Financial Economics*, 7, 483–577. [9]

GILCHRIST, SIMON, AND EGON ZAKRAJSEK (2012): "Credit Spreads and Business Cycle Fluctuations," *American Economic Review*, 102, 1692–1720. [7]

HE, ZHIGUO, AND ARVIND KRISHNAMURTHY (2013): "Intermediary Asset Pricing," *American Economic Review*, 2, 732–770. [17]

RAMEY, VALERIE A. (2016): "Macroeconomic Shocks and Their Propagation," in *Handbook of Macroeconomics*, Vol. 2A, 71–162. [8]

SABELHAUS, JOHN, AND ALICE HENRIQUES VOLZ (2019): "Are Disappearing Employer Pensions Contributing to Rising Wealth Inequality?" Working paper. [9]

STOCK, JAMES H., AND MARK W. WATSON (2018): "Identification and Estimation of Dynamic Causal Effects in Macroeconomics Using External Instruments," *The Economic Journal*, 128, 917–948. [8]

Co-editor Charles I. Jones handled this manuscript.

Manuscript received 15 January, 2020; final version accepted 1 May, 2022; available online 19 May, 2022.