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Equity Premium and Monetary Policy in a Model with Limited Asset Market Participation

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Abstract:
This short paper shows that a New Keynesian model with limited asset market participation can generate a high risk-premium on unlevered equity relative to short-term risk-free bonds and high variability of equity returns driven by monetary policy shocks with zero persistence.

Keywords: Limited Participation, Monetary Policy, DSGE, Equity Premium
JEL: E32, E44, G12

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1 Introduction

In a basic sticky price model with Ricardian households and real frictions (habits in consumption and capital adjustment costs), monetary policy shocks are key drivers of equity premia only when the persistence of the shock process is counterfactually high (see Wei (2009), among others). In the absence of real frictions, we show that the equity premium can be high, even with zero persistence of the monetary policy shock, in a New Keynesian model with both Ricardian and non-Ricardian households if the share of non-Ricardians is sufficiently high. Ricardians use risk-free government bonds and equity to smooth their consumption and thus have an intertemporal perspective, whereas non-Ricardians who are excluded from financial markets have a static horizon and consume their labor income each period as in the Bilbiie (2008) model.

In our model, price stickiness is necessary for monetary policy shocks to drive the equity premium. Without nominal rigidity, monetary policy shocks lose their importance, as firms adjust prices rather than quantities in response to exogenous shocks. In the case of perfectly flexible prices, firms are neutral toward monetary policy shocks. Similar to Wei (2009), we find that temporary technology shocks contribute little to the equity premium even in a model with household heterogeneity.[1]

To illuminate the workings of our model, we consider a contractionary

[1] We investigate the properties of our model with temporary technology shocks in online appendix C.

monetary policy shock that elevates nominal and real interest rates through the Taylor rule and leads Ricardians to delay their consumption expenditures. Lower demand leads to a decrease in labor demand and production by firms with sticky prices, as they cannot accommodate the decrease in demand by reducing prices. The decline in wages puts downward pressure on non-Ricardians' consumption but creates higher profits (dividends) and yields on the assets held by Ricardians who are the owners' of the firms. Hence, redistribution of income occurs from non-Ricardians to Ricardians. The higher is the concentration of Ricardians (the lower is the share of non-Ricardians) the stronger is the comovement between Ricardian consumption and asset returns giving rise to sizable equity premia and high standard deviation of the return on equity.

We log-linearize our model and provide a closed-form solution for the level of the equity premium. Our model has the salient feature of achieving high equity premia even with an intertemporal elasticity of substitution (IES) close to zero. Havranek et al. (2015) shows that the IES is closer to zero than to one. In this paper, we generate a high equity risk premium with even a small IES coefficient, in contrast to papers with long risks (e.g., Bansal and Yaron (2004)), wherein the IES must be greater than one for the equity premium to be positive and large.

Our paper is closely related to Lansing (2015), who – utilising a model with minimal household heterogeneity like ours and inelastic labor supply – appoints the high concentration of investors (10 percent in his article) as the key explanation for substantial equity premia driven by persistent and highly variable capital-income redistribution shocks. In contrast our model with elastic labour supply requires only lower concentration of asset holders (40 percent) to match equity premium induced by non-persistent and small-size monetary policy shocks.

2 Model

2.1 Households

A share of the households λ has no access to the financial market (see e.g. Bilbiie (2008)). These households cannot smooth their consumption intertemporally through risk-free bonds and shares in equity, and thus, their consumption completely depends on their disposable income in each period. These households are called non-Ricardians (r).

The remaining share of households $1-\lambda$ is Ricardian (optimizers, o) and engages in the intertemporal trade of assets to smooth fluctuations in income.

Each household of either Ricardian or non-Ricardian origin (denoted $i = o, r$) features a utility function that is separable in consumption (C_t^i) and leisure ($1 - N_t^i$):

$$U = \frac{(C_t^i)^{1-\sigma}}{1-\sigma} - \frac{(N_t^i)^{1+\varphi}}{1+\varphi} \tag{1}$$

where $\sigma \neq 1$ is the inverse of the IES (or risk aversion). φ is the inverse of the Frisch labor supply elasticity. Log utility is obtained when $\sigma \to 1$ and $\varphi \to -1$.

Consumption of the two types of households can be aggregated through

$$C_t = \lambda C_t^r + (1-\lambda) C_t^o.$$

The consumption index (C_t) is obtained via standard Dixit-Stiglitz aggregator, which sums up a continuum of goods on the unit interval $[0,1]$ with $\epsilon > 0$ as the elasticity of substitution among goods.

The intertemporal budget constraint of optimizers is given by

$$\begin{aligned} & P_t C_t^o + R_t^{-1} E_t\{B_{t+1}^o\} + V_t^{eq} S_t^o \\ & = (V_t^{eq} + D_t^o) S_{t-1}^o + W_t N_t^o + B_t^o - P_t T_t^o - P_t S^o \end{aligned} \tag{2}$$

where P_t is the price level, B^o denotes the amount of nominal riskless government bonds held by Ricardian households, R_t is the gross nominal interest rate on one-period bonds, and W_t is the nominal wage. S_t^o is the number of shares in firms owned by optimizers. V_t^{eq} and D_t^o denote the nominal value and the dividends on the shares, respectively. T_t^o are lump-sum taxes paid by optimizers, and S^o is a steady state lump-sum tax used to equate steady state consumptions of both types of households ($C = C^o = C^r$). All profits are paid out in the form of dividends, which are received by the optimizer and given by:

$$D_t^o = \frac{D_t}{1-\lambda} = C_t^o - W_t N_t$$

where D_t is the aggregate level of dividends.

Non-Ricardians also maximize utility in equation (1) subject to the budget constraint:

$$C_t^r = W_t N_t.$$

There is a competitive labor market as in Bilbiie (2008). Ricardian and non-Ricardian labor supplies are aggregated through the following equation:

$$N_t = \lambda N_t^r + (1-\lambda) N_t^o$$

where N_t denotes aggregate labor supply. We abstract from government consumption and investment to keep the model simple.

2.2 Firms

Output is produced using a one-to-one production function (abstracting from technology shocks):

$$Y_t(i) = N_t(i).$$

Intermediaries are subject to Calvo-style price setting frictions. The profit maximization problem of an intermediary firm i at time t, which will not be able to reset its price between time t and time $t+k$, can be formulated as

$$\max_{P_t^*} \sum_{k=0}^{\infty} \theta^k Q_{t,t+k} \left[P_t^*(i) Y_{t+k|t}(i) - W_{t+k} N_{t+k}(i) \right] \tag{3}$$

where P_t^* is the optimal reset price at time$-t$, θ is the probability of not resetting the price, and $Q_{t,t+k}$ is the stochastic discount factor defined as

$$Q_{t,t+k} \equiv \beta^k \left(\frac{C_{t+k+1}}{C_{t+k}} \right)^{-\sigma} \frac{P_t}{P_{t+k}}.$$

The profit maximization problem of the intermediary is also subject to the demand schedule for an individual product i:

$$Y_{t+k|t}(i) = \left(\frac{P_t^*(i)}{P_{t+k}} \right)^{-\epsilon} Y_{t+k|t}$$

which can be derived from the cost minimization problem of perfectly competitive firms that bundle intermediary products into a single final product through the Dixit-Stiglitz aggregator.

2.3 Monetary Policy

The monetary policy is described by a simple Taylor rule of the following form:

$$R_t = \Pi_t^{\phi_\pi} exp(\xi_t).$$

$\Pi_t = (P_t - P_{t-1})/P_{t-1}$ stands for the rate of inflation, ϕ_π measures the strength of the reaction of monetary policy to inflation and ξ_t is a monetary policy shock:

$$\xi_t = \rho_\xi \xi_{t-1} + \sigma_\xi \varepsilon_t^\xi$$

where ρ_ξ stands for the persistence of the process ξ and σ_ξ denotes the standard deviation of the i.i.d. shock ε_t^ξ which has zero mean.

2.4 Solution of the model

A summary of the linearized equilibrium conditions is available in online appendix A. The linear solution for output and inflation as a function of the monetary policy shock is provided in Proposition 1. Propositions 2 and 3 describe the linear formulation for the price-dividend ratio and the equity premium, respectively.

Proposition 1 *In the absence of state variables, the model has a closed-form solution for output and inflation as a function of the monetary policy shock:*

$$y_t = A_y \xi_t, \qquad \pi_t = A_\pi \xi_t$$

where $y_t \equiv (Y_t - Y)/Y$ *and* $\pi_t \equiv (\Pi_t - \Pi)/\Pi$ *denote linearized output and inflation, respectively; the absence of the time index stands indicates the steady state. The coefficients* A_y *and* A_π *are defined as*

$$A_y \equiv -\frac{(1-\lambda)(1-\beta\rho_\xi)}{\Gamma(1-\beta\rho_\xi)\sigma - [1-\lambda(1+\varphi)]\rho_\xi(1-\beta\rho_\xi)\sigma + (1-\lambda)(\phi_\pi - \rho_\xi)\kappa(\sigma+\varphi)},$$
$$A_\pi \equiv \frac{\kappa(\sigma+\varphi)A_y}{1-\beta\rho_\xi}, \Gamma \equiv 1-\lambda(1+\varphi) + \frac{(1-\lambda)}{\sigma}\phi_y, \kappa \equiv (1-\theta)(1-\beta\theta)/\theta.$$

For the proof, see online appendix A.

To study the determinacy properties of the model (the next proposition), we set up the IS curve (the combination of the bond Euler equation and market clearing condition):

$$y_t = E_t y_{t+1} - \Gamma^{IS}(dR_t - \pi_{t+1}), \text{ where } \Gamma^{IS} \equiv \frac{1-\lambda}{\sigma[1-\lambda(1+\varphi)]}.$$

dR_t is defined as $R_t - R$. Some combinations of λ and φ have to be avoided (for example, $\lambda = 0.5$ and $\varphi = 1$), as they result an IS curve slope of negative infinity.

Proposition 2 *When $\lambda < \lambda^*$ and/or the labor supply is sufficiently elastic (φ is low)—where λ^* denotes a threshold value of λ—the Taylor principle ($\phi_\pi > 1$) leads to determinacy of the model with the baseline parametrization, and the slope of the IS curve Γ^{IS} is negative.*
When $\lambda > \lambda^*$, the slope of the IS curve is positive, and passive monetary policy ($\phi_\pi < 1$) guarantees determinacy. Taking the baseline parametrization of σ and φ as given, the change in the sign of the IS slope occurs for a high

value of λ, which we consider empirically implausible. Thus, we abstract from cases wherein $\lambda > \lambda^*$. For the proof, see Bilbiie (2008), who employs a similar model.

In line with conventional wisdom, a restrictive monetary shock ($\xi_t > 0$) leads to decreases in output and inflation, i.e., $A_y < 0$ and $A_\pi < 0$, provided that the IS curve has a negative slope ($\lambda < \lambda^*$) and and the Taylor principle is satisfied ($\phi_\pi > 1$).

Proposition 3 *We use the log-linear asset pricing framework of Bansal and Yaron (2004) to derive a closed-form solution for the equity premium. The return on asset i can be written as*

$$rr_{i,t+1} = \kappa_0 + \kappa_1 z_{i,t+1} - z_{i,t} + \Delta d_{i,t+1}$$

where $z_{i,t}$ denotes the asset-specific price-dividend ratio, $\Delta d_{i,t+1}$ is the growth rate of real dividends, and κ_0 and κ_1 are constants. It is possible to show that $\kappa_1 \simeq \beta$. $z_{i,t}$ is a function of the state variable, which is the monetary policy shock ξ_t:

$$z_{i,t} = A_{z0} + A_{z1}\xi_t$$

where A_{z0} is a constant that can be ignored and

$$A_{z1} \equiv \frac{A_c A_y (1-\rho_\xi)}{1-\beta\rho_\xi} - \frac{(1-\rho_\xi) A_y \kappa_{d\xi}}{1-\beta\rho_\xi}$$

where

$$A_c \equiv \frac{1 - \sigma\lambda - \lambda(1+\varphi)}{1-\lambda}.$$

Real dividend growth is given by

$$\Delta d_{t+1} = \kappa_{d\xi} A_y \Delta\xi_{t+1}$$

where $\kappa_{d\xi} \equiv \frac{1-W(1+\sigma+\varphi)}{1-W}$. *For the proof, see online appendix B.*

Proposition 4 *The equity premium is calculated as:* $-cov_t(sdf_{t,t+1}, rr_{i,t+1})$, *where* $sdf_{t,t+1} \equiv -\sigma A_c A_y(\xi_{t+1} - \xi_t)$ *is the linearized stochastic discount factor. Then, the closed-form solution for the equity premium is given by*

$$ep_t = \{\sigma g A_c + (1-g)k_{d\xi}\}\sigma A_c A_y^2 \sigma_\xi^2$$

where $g \equiv \frac{\beta(1-\rho_\xi)}{(1-\beta\rho_\xi)}$. *For the proof, see online appendix B.*

3 Parametrization

We present the parameter values in Table 1. Risk-aversion (σ) is calibrated to 5, which is considered reasonable by Bansal and Yaron (2004), and implies an IES=1/5, which is consistent with the evidence presented by Havranek et al. (2015) that the IES closer to zero rather than to one.

Parameter φ is set to 0.5, which implies that the Frisch elasticity of labor

Table 1: Parametrization

$\sigma = 5$	$\beta = 0.99$	$\phi_\pi = 1.5$
$\epsilon = 6$	$\varphi = 0.5$	$\rho_\xi = 0$
$\theta = 0.845$	$\lambda = 0.6$	$\sigma_\xi = 0.005$

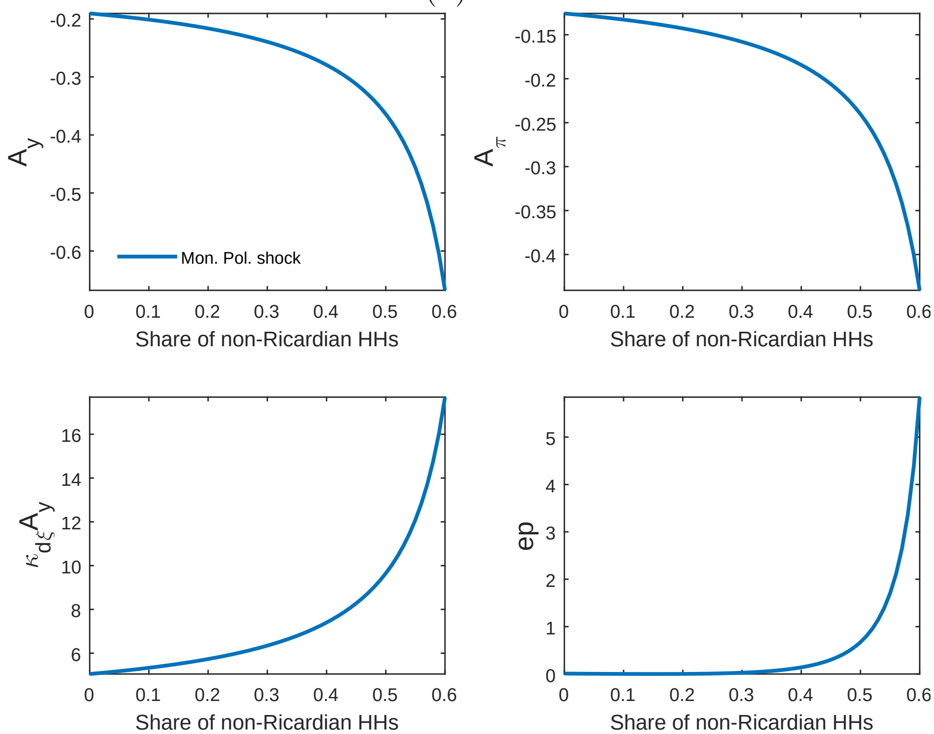
supply is 2. When technology is set to unity in the steady state ($A = 1$), the steady-state equality of consumption for each type implies that the same hours are worked by both types ($N^o = N^r = N$) in this state.

The elasticity of substitution among intermediary goods (ε) is set to six, implying a markup of 20 percent that is standard in the literature. The Calvo parameter of price adjustment is 0.845, which implies that the average duration of a price spell is approximately four quarters. For simplicity, we consider a Taylor rule that focuses only on inflation with a standard coefficient of 1.5. The share of non-Ricardian households is set to 0.6, as in the work of De Graeve et al. (2010). The persistence and standard deviation of the monetary policy shock are set to 0 and 0.005, respectively, in line with the monetary business cycle literature.

4 Results

Figure 1 displays the sensitivity of output, inflation, the growth rate of dividends and the equity premium to share of non-Ricardian households. On each graph, $\lambda = 0$ delivers the standard representative agent model (only Ricardian households), where the equity premium is zero (see the right bot-

Figure 1: Sensitivity of A_y, A_π, $\kappa_{d\xi}A_y$ and the equity premium (ep) to the share of non-Ricardian households (λ)



Notes: A_π is annualized. The ep is measured as an annualized percentage. Values of λ higher than 0.6 are excluded, as they deliver implausibly high equity premia and are not in line with empirical evidence.

tom panel, ep). The sensitivity of output, inflation and the growth rate of dividends to a monetary policy shock (see the subplots denoted A_y, A_π and $\kappa_{d\xi}A_y$, respectively) increases with the share of non-Ricardian households in the population. This can be explained as follows. Consider a contractionary monetary policy shock increasing real interest rates and curbing Ricardian expenditures. The higher the share of non-Ricardians the more negative the slope of the IS curve (Γ^{IS}) and the more successful monetary policy is in curtailing aggregate demand through rises in the real interest rate. In our model it is the nominal price rigidity which establishes the link between non-Ricardians' demand and real interest rates. With sticky prices, the monetary tightening also leads to decreases in labor demand, marginal costs (real wages) and, thus the wage income of non-Ricardians but increases in profits, endogenously redistributing income from non-Ricardians to Ricardians. The stronger the redistribution, the more concentrated the ownership of capital, that is, the lower is the share of Ricardians whose consumption is susceptible to changes in dividend income[2] and to asset returns that positively co-move with the growth rate of dividends. As a result, a positive connection emerges between the share of non-Ricardians and the equity premium. With sufficiently high share of non-Ricardians ($\lambda = 0.6$) we achieve large equity premium ($ep = 5.9$ percent) and a high standard deviation of equity returns (25.71 percent) which are close to the 6.33 and 19.42 percent

[2]The dividend income of Ricardians is increasing in the share of non-Ricardian households for given level of aggregate dividends ($D_t^o = D_t/(1-\lambda)$).

reported, respectively, by Bansal and Yaron (2004) for the market portfolio using post-war US data (both in annualised terms).

5 Conclusion

Monetary policy shocks are important drivers of the equity premium when they cause redistribution of income and risky assets are concentrated in the hands of relatively few investors whose consumption strongly covaries with asset returns. Unlike technology shocks in other papers, our result does not require real friction such as capital with adjustment costs. Future research should address a larger class of moments in more general environments (models with several shocks and types of friction).

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6 Online Appendix A

6.1 Summary of loglinear equilibrium conditions

This section provides a linear solution to the model.

The loglinear equilibrium conditions are detailed below and are, in fact, similar to those in Bilbiie (2008) and Gali et al. (2007) with the following small departures.

Bilbiie (2008) removes steady-state profits using a fixed cost which we omit. The inclusion of this fixed cost in our model would marginally affect the slope of the IS curve and our results.

We differ from Gali et al. (2007) to the extent that we exclude capital with adjustment costs and government sector and the IES is not constrained to be one in our paper. Our exclusion of capital facilitates analytical solution and the identification of the channels that contribute to the high equity premium.

The intratemporal conditions for type $i = r, o$:

$$w_t = \sigma c_t^i + \varphi n_t^i$$

which can be aggregated to

$$w_t = \sigma c_t + \varphi n_t$$

using

$$c_t = \lambda c_t^r + (1-\lambda) c_t^o$$

$$n_t = \lambda n_t^r + (1-\lambda) n_t^o.$$

The budget constraint of the non-Ricardian household is:

$$c_t^r = w_t + n_t^r$$

The intertemporal Euler equation of Ricardians is given by:

$$\sigma(c_t^o - E_t c_{t+1}^o) = -(dR_t - E_t \pi_{t+1})$$

The production function reads as:

$$y_t = a_t + n_t$$

The aggregate resource constraint (market clearing) is:

$$y_t = c_t$$

The New Keynesian Phillips curve (NKPC) is given by

$$\pi_t = \beta E_t \pi_{t+1} + \kappa mc_t$$

where mc_t stands for the real marginal cost and κ is the slope of NKPC. The system is closed by adding a linear Taylor rule of the form (here we are more general than the paper and include a response to the output-gap as well)

$$dR_t = \phi_\pi \pi_t + \phi_y y_t + \xi_t$$

The model can be solved using the method of undetermined coefficients. Let us postulate that output and inflation is given as a linear function of the monetary policy shock:

$$y_t = A_y \xi_t = y_\xi \xi_t$$

$$\pi_t = A_\pi \xi_t = \pi_\xi \xi_t$$

where $A_y = y_\xi$ and $A_\pi = \pi_\xi$ are coefficients to be determined.

6.2 Proof of Proposition 1. Derivation of $A_\pi = \pi_\xi$

The NKPC is given by

$$\begin{aligned}
\pi_t &= \beta E_t \pi_{t+1} + \kappa m c_t \\
&= \beta E_t \pi_{t+1} + \kappa(\sigma c_t + \varphi n_t - a_t) \\
&= \beta E_t \pi_{t+1} + \kappa(\sigma y_t + \varphi n_t + \varphi a_t - \varphi a_t - a_t) \\
&= \beta E_t \pi_{t+1} + \kappa[(\sigma + \varphi) y_t - (1 + \varphi) a_t].
\end{aligned}$$

For the rest of the derivation we can ignore the technology shock (a_t).

Let us first rewrite the New Keynesian Phillips curve as function of the monetary policy shock:

$$\begin{aligned}\pi_t &= \beta\pi_\xi\rho_\xi\xi_t + \kappa(\sigma+\varphi)A_y\xi_t \\ &= \{\beta\pi_\xi\rho_\xi + \kappa(\sigma+\varphi)A_y\}\,\xi_t\end{aligned}$$

where A_y is calculated below.

Matching coefficients:

$$\pi_\xi = \beta\pi_\xi\rho_\xi + \kappa(\sigma+\varphi)y_\xi$$

$$\pi_\xi = \frac{\kappa(\sigma+\varphi)y_\xi}{1-\beta\rho_\xi}$$

or in the empirically relevant case of $\rho_\xi = 0$:

$$\pi_\xi = \kappa(\sigma+\varphi)y_\xi$$

6.3 Proof of Proposition 1. Derivation of $A_y = y_\xi$

The separate labor supply decision of non-Ricardian households is given by the following linear intratemporal condition:

$$\sigma c_t^r + \varphi n_t^r = w_t$$

which we express for n_t^r as:

$$n_t^r = \varphi^{-1}(w_t - \sigma c_t^r)$$

which we substitute in for n_t^r in the loglinear budget constraint of non-Ricardians and also making use of the aggregate intratemporal condition:

$$c_t^r = w_t + n_t^r$$

and

$$\sigma c_t^r + \varphi n_t^r = w_t$$

$$c_t^r = [w_t] + \varphi^{-1}([w_t] - \sigma c_t^r)$$

and also

$$c_t^r = [\sigma c_t + \varphi n_t] + \varphi^{-1}([\sigma c_t + \varphi n_t] - \sigma c_t^r)$$

and then express it for c_t^r as:

$$c_t^r \left(1 + \frac{\sigma}{\varphi}\right) = \sigma c_t + \varphi n_t + \varphi^{-1} (\sigma c_t + \varphi n_t)$$

and also

$$c_t^r \left(1 + \frac{\sigma}{\varphi}\right) = \sigma \left(1 + \frac{1}{\varphi}\right) c_t + (1 + \varphi) n_t$$

Then it follows that the consumption of non-Ricardians is a function of the aggreagate variables of the model:

$$c_t^r = \frac{\sigma\left(1+\frac{1}{\varphi}\right)}{1+\frac{\sigma}{\varphi}} c_t + \frac{(1+\varphi)}{1+\frac{\sigma}{\varphi}} n_t$$

which can be alternatively written as:

$$c_t^r = \frac{\sigma\,(1+\varphi)}{\varphi+\sigma} c_t + \frac{(1+\varphi)\varphi}{\varphi+\sigma} n_t$$

which can also be expressed as:

$$c_t^r - E_t c_{t+1}^r = \frac{\sigma\,(1+\varphi)}{\varphi+\sigma}(c_t - E_t c_{t+1}) + \frac{(1+\varphi)\varphi}{\varphi+\sigma}(n_t - E_t n_{t+1}) \qquad (4)$$

Then recall

$$c_t - E_t c_{t+1} = \lambda(c_t^r - E_t c_{t+1}^r) + (1-\lambda)(c_t^o - E_t c_{t+1}^o)$$

Then using equation (4) leads to:

$$c_t - E_t c_{t+1} = \frac{\lambda\sigma\,(1+\varphi)}{\varphi+\sigma}(c_t - E_t c_{t+1}) + \frac{\lambda(1+\varphi)\varphi}{\varphi+\sigma}(n_t - E_t n_{t+1}) + (1-\lambda)(c_t^o - E_t c_{t+1}^o)$$

Recall Ricardian Euler equation:

$$\sigma(c_t^o - E_t c_{t+1}^o) = -(dR_t - E_t \pi_{t+1})$$

where $dR_t = R_t - R$ is deviation of the nominal interest from its steady-state. The Ricardian Euler equation can be inserted into the previous equation to obtain:

$$\begin{aligned} c_t - E_t c_{t+1} = & \frac{\lambda\sigma\,(1+\varphi)}{\varphi+\sigma}(c_t - E_t c_{t+1}) + \frac{\lambda(1+\varphi)\varphi}{\varphi+\sigma}(n_t - E_t n_{t+1}) \\ & - \frac{(1-\lambda)}{\sigma}(dR_t - E_t \pi_{t+1}) \end{aligned}$$

Using the market clearing and the production function we obtain:

$$\begin{aligned} y_t - E_t y_{t+1} = & \frac{\lambda\sigma\,(1+\varphi)}{\varphi+\sigma}(y_t - E_t y_{t+1}) + \frac{\lambda(1+\varphi)\varphi}{\varphi+\sigma}(y_t - E_t y_{t+1}) \\ & - \frac{\lambda(1+\varphi)\varphi}{\varphi+\sigma}(a_t - E_t a_{t+1}) - \frac{(1-\lambda)}{\sigma}(dR_t - E_t \pi_{t+1}) \end{aligned}$$

Then

$$\begin{aligned} y_t - E_t y_{t+1} = & \frac{(\lambda\sigma + \lambda\varphi)\,(1+\varphi)}{\varphi+\sigma}(y_t - E_t y_{t+1}) \\ & - \frac{\lambda(1+\varphi)\varphi}{\varphi+\sigma}(a_t - E_t a_{t+1}) - \frac{(1-\lambda)}{\sigma}(dR_t - E_t \pi_{t+1}) \end{aligned}$$

The previous one can be rewritten as (after inserting the Taylor rule for dR_t—here we are more general than in the main paper and include response to the output gap as well i.e. $\phi_y y_t$)

$$\left[1 - \frac{\lambda(\varphi+\sigma)\,(1+\varphi)}{\varphi+\sigma}\right](y_t - E_t y_{t+1})$$
$$= -\frac{\lambda(1+\varphi)\varphi}{\varphi+\sigma}(a_t - E_t a_{t+1}) - \frac{(1-\lambda)}{\sigma}(\phi_\pi \pi_t + \phi_y y_t + \xi_t - E_t \pi_{t+1})$$

Then it follows that

$$\left[\frac{(\varphi+\sigma) - \lambda(\varphi+\sigma)\,(1+\varphi) + (\varphi+\sigma)\frac{(1-\lambda)}{\sigma}\phi_y}{\varphi+\sigma}\right] y_t = \left[\frac{(\varphi+\sigma) - \lambda(\varphi+\sigma)\,(1+\varphi)}{\varphi+\sigma}\right] E_t y_{t+1}$$
$$-\frac{\lambda(1+\varphi)\varphi}{\varphi+\sigma}(a_t - E_t a_{t+1}) - \frac{(1-\lambda)}{\sigma}(\phi_\pi \pi_t + \xi_t - E_t \pi_{t+1})$$

Accordingly the previous expression is rewritten as:

$$\left[\frac{(\varphi+\sigma)[1 - \lambda\,(1+\varphi) + \frac{(1-\lambda)}{\sigma}\phi_y]}{\varphi+\sigma}\right] y_t = \left[\frac{(\varphi+\sigma)[1 - \lambda\,(1+\varphi)]}{\varphi+\sigma}\right] E_t y_{t+1}$$
$$-\frac{\lambda(1+\varphi)\varphi}{\varphi+\sigma}(a_t - E_t a_{t+1}) - \frac{(1-\lambda)}{\sigma}(\phi_\pi \pi_t + \xi_t - E_t \pi_{t+1})$$

Then

$$[1 - \lambda\,(1+\varphi) + \frac{(1-\lambda)}{\sigma}\phi_y] y_t = [1 - \lambda\,(1+\varphi)] E_t y_{t+1}$$
$$-\frac{\lambda(1+\varphi)\varphi}{\varphi+\sigma}(a_t - E_t a_{t+1}) - \frac{(1-\lambda)}{\sigma}(\phi_\pi \pi_t + \xi_t - E_t \pi_{t+1})$$

Let us define

$$\Gamma \equiv 1 - \lambda\,(1+\varphi) + \frac{(1-\lambda)}{\sigma}\phi_y$$

Using this definition the previous equation is written as:

$$
\begin{aligned}
y_t = & \frac{[1-\lambda(1+\varphi)]}{\Gamma} y_\xi \rho_\xi \xi_t \\
& - \frac{\lambda(1+\varphi)\varphi}{\Gamma(\varphi+\sigma)}(a_t - E_t a_{t+1}) - \frac{(1-\lambda)}{\Gamma\sigma}(\phi_\pi \pi_t + \xi_t - \pi_\xi \rho_\xi \xi_t)
\end{aligned}
$$

From now, we can ignore the technology part as our focus is the monetary policy shock. Thus, we obtain

$$
y_t = \frac{[1-\lambda(1+\varphi)]}{\Gamma} y_\xi \rho_\xi \xi_t - \frac{(1-\lambda)}{\sigma\Gamma}(\phi_\pi \pi_\xi \xi_t + \xi_t - \pi_\xi \rho_\xi \xi_t)
$$

The previous can be expressed as

$$
y_t = \frac{[1-\lambda(1+\varphi)]}{\Gamma} y_\xi \rho_\xi \xi_t - \frac{(1-\lambda)}{\sigma\Gamma}(\phi_\pi - \rho_\xi)\pi_\xi \xi_t - \frac{(1-\lambda)}{\sigma\Gamma}\xi_t
$$

or written in the form of

$$
y_t = \frac{[1-\lambda(1+\varphi)]}{\Gamma} y_\xi \rho_\xi \xi_t - \frac{(1-\lambda)}{\sigma\Gamma}(\phi_\pi - \rho_\xi)\frac{\kappa(\sigma+\varphi)y_\xi}{1-\beta\rho_\xi}\xi_t - \frac{(1-\lambda)}{\sigma\Gamma}\xi_t
$$

$$
y_t = \left[\frac{[1-\lambda(1+\varphi)]}{\Gamma} y_\xi \rho_\xi - \frac{(1-\lambda)}{\sigma\Gamma}(\phi_\pi - \rho_\xi)\frac{\kappa(\sigma+\varphi)y_\xi}{1-\beta\rho_\xi} - \frac{(1-\lambda)}{\sigma\Gamma}\right]\xi_t
$$

$$
y_\xi \left\{1 - \frac{[1-\lambda(1+\varphi)]\rho_\xi}{\Gamma} + \frac{(1-\lambda)(\phi_\pi - \rho_\xi)}{\sigma\Gamma}\frac{\kappa(\sigma+\varphi)}{1-\beta\rho_\xi}\right\} = -\frac{(1-\lambda)}{\sigma\Gamma}
$$

$$
y_\xi \left\{\frac{\Gamma(1-\beta\rho_\xi)\sigma}{\sigma\Gamma(1-\beta\rho_\xi)} - \frac{[1-\lambda(1+\varphi)]\rho_\xi(1-\beta\rho_\xi)\sigma}{\sigma\Gamma(1-\beta\rho_\xi)} + \frac{(1-\lambda)(\phi_\pi - \rho_\xi)\kappa(\sigma+\varphi)}{\sigma\Gamma(1-\beta\rho_\xi)}\right\} = -\frac{(1-\lambda)}{\sigma\Gamma}
$$

Then

$$y_\xi \left\{ \frac{\Gamma(1-\beta\rho_\xi)\sigma - [1-\lambda(1+\varphi)]\rho_\xi(1-\beta\rho_\xi)\sigma + (1-\lambda)(\phi_\pi - \rho_\xi)\kappa(\sigma+\varphi)}{\sigma\Gamma(1-\beta\rho_\xi)} \right\} = -\frac{(1-\lambda)}{\sigma\Gamma}$$

Then

$$y_\xi = -\frac{(1-\lambda)(1-\beta\rho_\xi)}{\Gamma(1-\beta\rho_\xi)\sigma - [1-\lambda(1+\varphi)]\rho_\xi(1-\beta\rho_\xi)\sigma + (1-\lambda)(\phi_\pi - \rho_\xi)\kappa(\sigma+\varphi)}$$

which is the same as in proposition 1.

7 Online Appendix B

This appendix provides a loglinear solution to the price-dividend ratio and the equity premium.

7.1 Proof of Proposition 3

We provide details on the derivation of A_{z1}, A_c and $\kappa_{d\xi}$ in Proposition 3.

The loglinear version of the stochastic discount factor is given by:

$$sdf_{t,t+1} = -\sigma \Delta c^o_{t+1}$$

In order to establish connection between Ricardian consumption and aggregate variables we use consumption aggregator of the two types:

$$
\begin{aligned}
c_t^o &= \frac{c_t - \lambda c_t^r}{1-\lambda} = \frac{c_t}{1-\lambda} - \frac{\lambda}{1-\lambda} c_t^r \\
&= \frac{c_t}{1-\lambda} - \frac{\lambda}{1-\lambda}(w_t + n_t) \\
&= \frac{c_t}{1-\lambda} - \frac{\lambda}{1-\lambda}(\sigma c_t + (1+\varphi) n_t) \\
&= \frac{1-\sigma\lambda}{1-\lambda} c_t - \frac{\lambda(1+\varphi)}{1-\lambda} n_t
\end{aligned}
$$

Then it follows that

$$
\Delta c_{t+1}^o = \frac{1-\sigma\lambda - \lambda(1+\varphi)}{1-\lambda} \Delta y_{t+1}
$$

Thus, the sdf can be expressed as:

$$
\begin{aligned}
sdf_{t,t+1} &= -\sigma \Delta c_{t+1}^o = -\sigma \left\{ \frac{1-\sigma\lambda - \lambda(1+\varphi)}{1-\lambda} \right\} \Delta y_{t+1} \\
&= -\sigma A_c A_y (\xi_{t+1} - \xi_t) \\
\text{where } A_c &\equiv \frac{1-\sigma\lambda - \lambda(1+\varphi)}{1-\lambda} \\
E_t sdf_{t,t+1} &= \sigma A_c A_y (1-\rho_\xi) \xi_t
\end{aligned}
$$

where $A_y = y_\xi$ is derived in appendix A.

Real dividends of Ricardians are given by:

$$
D_t^o = C_t^o - W_t N_t
$$

which can be rewritten in terms of aggregate variables:

$$\begin{aligned}\frac{D_t}{1-\lambda} &= \frac{C_t - \lambda C_t^r}{1-\lambda} - W_t N_t \\ &= \frac{C_t - \lambda W_t N_t}{1-\lambda} - W_t N_t \\ &= \frac{C_t - \lambda W_t N_t}{1-\lambda} - \frac{(1-\lambda) W_t N_t}{1-\lambda} \\ &= \frac{C_t - W_t N_t}{1-\lambda}\end{aligned}$$

Hence, we obtain

$$D_t = C_t - W_t N_t$$

The previous one can be linearised as:

$$Dd_t = Cc_t - WNw_t - WNn_t \tag{5}$$

or using

$$Y = C = N$$

we can rewrite equation (5) as:

$$\begin{aligned}d_t &= \frac{C}{(1-W)C} c_t - \frac{WN}{(1-W)N} w_t - \frac{WN}{(1-W)N} n_t \\ &= \frac{1}{1-W} c_t - \frac{W}{1-W} w_t - \frac{W}{1-W} n_t\end{aligned}$$

Using the aggregate intratemporal condition:

$$\begin{aligned} d_t &= \frac{1}{1-W}c_t - \frac{W}{1-W}(\sigma c_t + \varphi n_t) - \frac{W}{1-W}n_t \\ &= \frac{1-W(1+\sigma+\varphi)}{1-W}y_t \end{aligned}$$

Recall from the main text that the return on asset i is given by:

$$rr_{i,t+1} = \beta A_{z1}\xi_{t+1} - A_{z1}\xi_t + \Delta d_{i,t+1} \tag{6}$$

where real dividends can be expressed as:

$$d_t = \kappa_{d\xi} A_y \xi_t$$

After linearising the asset Euler equation and taking expectations we obtain (using $E_t\xi_{t+1} = \rho_\xi \xi_t$):

$$\begin{aligned} 0 &= E_t rr_{i,t+1} + E_t sdf_{t,t+1} \\ &= (\beta\rho_\xi - 1)A_{z1}\xi_t - (1-\rho_\xi)\kappa_{d\xi}A_y\xi_t + A_c A_y(1-\rho_\xi)\xi_t \end{aligned}$$

Therefore, in order for the previous expression to be equal to zero the sum of the coefficients multiplying ξ_t has to satisfy:

$$A_{z1} = \frac{A_c A_y(1-\rho_\xi)}{1-\beta\rho_\xi} - \frac{(1-\rho_\xi)A_y\kappa_{d\xi}}{1-\beta\rho_\xi}.$$

Hence the return on equity can be written, using equation (6), as:

$$rr_{i,t+1} = -\frac{\beta(1-\rho_\xi)\kappa_{d\xi}A_y}{(1-\beta\rho_\xi)}\xi_{t+1} + \frac{\beta\sigma A_c A_y(1-\rho_\xi)}{(1-\beta\rho_\xi)}\xi_{t+1}$$
$$[-A_{z1}\xi_t] + \kappa_{d\xi}A_y\Delta\xi_{t+1}$$

where $[A_{z1}\xi_t]$ is not of interest from the point of view of the equity premium, EP (see the conditional covariance term below).

Let us introduce the notation $g \equiv \frac{\beta(1-\rho_\xi)}{(1-\beta\rho_\xi)}$ to rewrite the previous equation as:

$$rr_{i,t+1} = -\kappa_{d\xi}A_y g\xi_{t+1} + \sigma A_c A_y g\xi_{t+1}$$
$$[-A_{z1}\xi_t] + \kappa_{d\xi}A_y(\xi_{t+1} - \xi_t),$$

which is the same as the expression in proposition 3.

7.2 Proof of Proposition 4.

We provide details on the derivation of ep in proposition 4.

The equity premium is given by the conditional covariance between the linear stochastic discount factor and real return on asset i:

$$ep_t = -cov_t(-\sigma A_c A_y\xi_{t+1} + \sigma A_c A_y\xi_t, rr_{i,t+1})$$

where

$$rr_{i,t+1} = -\kappa_{d\xi} A_y g \xi_{t+1} + \sigma A_c A_y g \xi_{t+1}$$
$$[-A_{z1}\xi_t] + \kappa_{d\xi} A_y (\xi_{t+1} - \xi_t)$$

The covariance leads to the following terms:

$$\begin{aligned} ep_t &= \{-\sigma \kappa_{d\xi} A_c A_y^2 g + \sigma^2 A_c^2 A_y^2 g + \sigma A_c \kappa_{d\xi} A_y^2\} \sigma_\xi^2 \\ &= \{-\sigma \kappa_{d\xi} g A_c + \sigma^2 A_c^2 g + \sigma \kappa_{d\xi} A_c\} A_y^2 \sigma_\xi^2 \\ &= \{\sigma g A_c + (1-g)\kappa_{d\xi}\} \sigma A_c A_y^2 \sigma_\xi^2 \end{aligned}$$

which is the same as the expression in proposition 4.

8 Online Appendix C—Technology shocks

In case of technology shocks the guesses for the coefficients are:

$$y_t = A_y a_t = y_a a_t$$
$$\pi_t = A_\pi a_t = \pi_a a_t$$

where $A_y = y_a$ and $A_\pi = \pi_a$ are coefficients to be determined.

8.1 Expression for $A_\pi = y_\pi$ and $A_y = y_a$ (technology shock)

Recall

$$[1-\lambda\,(1+\varphi)+\frac{(1-\lambda)}{\sigma}\phi_y]y_t=[1-\lambda\,(1+\varphi)]E_t y_{t+1}$$
$$-\frac{\lambda(1+\varphi)\varphi}{\varphi+\sigma}(a_t-E_t a_{t+1})-\frac{(1-\lambda)}{\sigma}(\phi_\pi\pi_t+\xi_t-E_t\pi_{t+1})$$

where we can omit monetary policy shock when discussing the technology shock:

$$[1-\lambda\,(1+\varphi)+\frac{(1-\lambda)}{\sigma}\phi_y]y_t=[1-\lambda\,(1+\varphi)]y_a\rho_a a_t$$
$$-\frac{\lambda(1+\varphi)\varphi}{\varphi+\sigma}(1-\rho_a)a_t-\frac{(1-\lambda)}{\sigma}(\phi_\pi\pi_a a_t-\pi_a\rho_a a_t)$$

Then

$$[1-\lambda\,(1+\varphi)+\frac{(1-\lambda)}{\sigma}\phi_y]y_t=[1-\lambda\,(1+\varphi)]y_a\rho_a a_t$$
$$-\frac{\lambda(1+\varphi)\varphi}{\varphi+\sigma}(1-\rho_a)a_t-\frac{(1-\lambda)}{\sigma}(\phi_\pi-\rho_a)\pi_a a_t$$

Let

$$\Gamma\equiv 1-\lambda\,(1+\varphi)+\frac{(1-\lambda)}{\sigma}\phi_y$$

and we can also make use of the expression derived from NKPC:

$$A_\pi = y_\pi \equiv \frac{\kappa[(\sigma+\varphi)y_a - (1+\varphi)]}{1-\beta\rho_a}$$

$$\begin{aligned}\Gamma y_t &= [1-\lambda\,(1+\varphi)]y_a\rho_a a_t \\ &- \frac{\lambda(1+\varphi)\varphi}{\varphi+\sigma}(1-\rho_a)a_t - \frac{(1-\lambda)}{\sigma}(\phi_\pi-\rho_a)\frac{\kappa[(\sigma+\varphi)y_a-(1+\varphi)]}{1-\beta\rho_a}a_t\end{aligned}$$

Then

$$\begin{aligned}y_t = &\frac{[1-\lambda\,(1+\varphi)]}{\Gamma}y_a\rho_a a_t - \frac{(1-\lambda)}{\sigma\Gamma}(\phi_\pi-\rho_a)\frac{\kappa(\sigma+\varphi)y_a}{1-\beta\rho_a}a_t \\ &+ \frac{(1-\lambda)}{\sigma\Gamma}(\phi_\pi-\rho_a)\frac{\kappa(1+\varphi)}{1-\beta\rho_a}a_t \\ &- \frac{\lambda(1+\varphi)\varphi}{\Gamma(\varphi+\sigma)}(1-\rho_a)a_t\end{aligned}$$

Matching coeffs:

$$\begin{aligned}y_a = &\frac{[1-\lambda\,(1+\varphi)]}{\Gamma}y_a\rho_a - \frac{(1-\lambda)}{\sigma\Gamma}(\phi_\pi-\rho_a)\frac{\kappa(\sigma+\varphi)y_a}{1-\beta\rho_a} \\ &+ \frac{(1-\lambda)}{\sigma\Gamma}(\phi_\pi-\rho_a)\frac{\kappa(1+\varphi)}{1-\beta\rho_a}a_t \\ &- \frac{\lambda(1+\varphi)\varphi}{\Gamma(\varphi+\sigma)}(1-\rho_a)\end{aligned}$$

$$y_a\left\{1-\frac{[1-\lambda\,(1+\varphi)]\rho_a}{\Gamma}+\frac{(1-\lambda)(\phi_\pi-\rho_a)}{\sigma\Gamma}\frac{\kappa(\sigma+\varphi)}{1-\beta\rho_a}\right\}$$
$$=\left\{\frac{(1-\lambda)}{\sigma\Gamma}(\phi_\pi-\rho_a)\frac{\kappa(1+\varphi)}{1-\beta\rho_a}-\frac{\lambda(1+\varphi)\varphi}{\Gamma(\varphi+\sigma)}(1-\rho_a)\right\}a_t$$

$$y_a\left\{\frac{\Gamma(1-\beta\rho_a)\sigma}{\Gamma(1-\beta\rho_a)}-\frac{[1-\lambda\,(1+\varphi)]\rho_a(1-\beta\rho_a)\sigma}{\Gamma(1-\beta\rho_a)}+\frac{(1-\lambda)(\phi_\pi-\rho_a)\kappa(\sigma+\varphi)}{\sigma\Gamma(1-\beta\rho_a)}\right\}$$
$$=\left\{\frac{(1-\lambda)(\phi_\pi-\rho_a)\kappa(1+\varphi)}{\sigma\Gamma(1-\beta\rho_a)}-\frac{\lambda(1+\varphi)\varphi(1-\rho_a)}{\Gamma(\varphi+\sigma)}\right\}a_t$$

Then

$$y_a\left\{\frac{\Gamma(1-\beta\rho_a)\sigma-[1-\lambda\,(1+\varphi)]\rho_a(1-\beta\rho_a)\sigma+(1-\lambda)(\phi_\pi-\rho_a)\kappa(\sigma+\varphi)}{\sigma\Gamma(1-\beta\rho_a)}\right\}$$
$$=\left\{\frac{(1-\lambda)(\phi_\pi-\rho_a)\kappa(1+\varphi)}{\sigma\Gamma(1-\beta\rho_a)}-\frac{\lambda(1+\varphi)\varphi(1-\rho_a)}{\Gamma(\varphi+\sigma)}\right\}a_t$$

or

$$y_a\left\{\frac{\Gamma(1-\beta\rho_a)\sigma-[1-\lambda\,(1+\varphi)]\rho_a(1-\beta\rho_a)\sigma+(1-\lambda)(\phi_\pi-\rho_a)\kappa(\sigma+\varphi)}{\sigma\Gamma(1-\beta\rho_a)}\right\}$$
$$=\left\{\frac{(1-\lambda)(\phi_\pi-\rho_a)\kappa(1+\varphi)(\varphi+\sigma)}{\sigma\Gamma(1-\beta\rho_a)(\varphi+\sigma)}-\frac{\sigma\lambda(1+\varphi)\varphi(1-\rho_a)(1-\beta\rho_a)}{\sigma\Gamma(\varphi+\sigma)(1-\beta\rho_a)}\right\}a_t$$

Then the method of undetermined coefficients yields:

$$y_t=y_aa_t=A_ya_t$$

where

$$y_a = \frac{(1-\lambda)(\phi_\pi - \rho_a)\kappa(1+\varphi)(\varphi+\sigma) - \sigma\lambda(1+\varphi)\varphi(1-\rho_a)(1-\beta\rho_a)}{\{\Gamma(1-\beta\rho_a)\sigma - [1-\lambda(1+\varphi)]\rho_a(1-\beta\rho_a)\sigma + (1-\lambda)(\phi_\pi-\rho_a)\kappa(\sigma+\varphi)\}(\varphi+\sigma)}$$

8.2 Derivations for the equity premium

This appendix provides a loglinear solution to the equity premium in case of technology shocks.

$$\begin{aligned}
c_t^o &= \frac{c_t - \lambda c_t^r}{1-\lambda} = \frac{c_t}{1-\lambda} - \frac{\lambda}{1-\lambda}c_t^r \\
&= \frac{c_t}{1-\lambda} - \frac{\lambda}{1-\lambda}(w_t + n_t) \\
&= \frac{c_t}{1-\lambda} - \frac{\lambda}{1-\lambda}(\sigma c_t + (1+\varphi)n_t) \\
&= \frac{1-\sigma\lambda}{1-\lambda}y_t - \frac{\lambda(1+\varphi)}{1-\lambda}(n_t + a_t) + \frac{\lambda(1+\varphi)}{1-\lambda}a_t \\
&= \frac{1-\sigma\lambda-\lambda(1+\varphi)}{1-\lambda}y_t + \frac{\lambda(1+\varphi)}{1-\lambda}a_t
\end{aligned}$$

where the fourth line made use of the market clearing and the production function.

Thus, the sdf can be expressed as:

$$
\begin{aligned}
sdf_{t,t+1} &= -\sigma \Delta c^o_{t+1} = -\sigma \left\{ \frac{1-\sigma\lambda-\lambda(1+\varphi)}{1-\lambda} \right\} \Delta y_{t+1} - \sigma \frac{\lambda(1+\varphi)}{1-\lambda} \Delta a_{t+1} \\
&= -\sigma A_a A_y (a_{t+1} - a_t) - \sigma A_b (a_{t+1} - a_t) \\
\text{where } A_a &\equiv \frac{1-\sigma\lambda-\lambda(1+\varphi)}{1-\lambda} \text{ and } A_b \equiv \frac{\lambda(1+\varphi)}{1-\lambda} \\
&= -\sigma (A_a A_y + A_b)(a_{t+1} - a_t) \\
E_t\{sdf_{t,t+1}\} &= \sigma (A_a A_y + A_b)(1-\rho_a) a_t
\end{aligned}
$$

Using the aggregate intratemporal condition we can writen real dividends in linear form as:

$$
\begin{aligned}
d_t = &\frac{1}{1-W} c_t - \frac{W}{1-W} (\sigma c_t + \varphi(n_t + a_t)) \\
&+ \frac{W}{1-W} \varphi a_t - \frac{W}{1-W} (n_t + a_t) + \frac{W}{1-W} a_t \\
= &\frac{1-W(1+\sigma+\varphi)}{1-W} y_t + \frac{W(1+\varphi)}{1-W} a_t
\end{aligned}
$$

Let

$$
\kappa_{d1} \equiv \frac{1-W(1+\sigma+\varphi)}{1-W}, \kappa_{d2} \equiv \frac{W(1+\varphi)}{1-W}
$$

Then in case of A shock

$$
\Delta d_{t+1} = (\kappa_{d1} A_y + \kappa_{d2}) \Delta a_{t+1}
$$

Recall that the return can be expressed as:

$$rr_{i,t+1} = \beta A_{i,2} a_{t+1} - A_{i,2} a_t + \Delta d_{t+1}$$

$$0 = E_t rr_{i,t+1} + E_t m_{t+1} = (\beta\rho_a - 1) A_{i,2} a_t - (1 - \rho_a)(\kappa_{d1} A_y + \kappa_{d2}) a_t$$
$$+ \sigma(A_a A_y + A_b)(1 - \rho_a) a_t$$

To solve for the coefficient $A_{i,2}$ we require:

$$A_{i,2} = \frac{\sigma(A_a A_y + A_b)(1 - \rho_a)}{1 - \beta\rho_a} - \frac{(1 - \rho_a)(\kappa_{d1} A_y + \kappa_{d2})}{1 - \beta\rho_a}$$

Using $A_{i,2}$ the return on equity is written as:

$$rr_{i,t+1} = \frac{\beta\sigma(A_a A_y + A_b)(1 - \rho_a)}{1 - \beta\rho_a} a_{t+1} - \frac{\beta(1 - \rho_a)(\kappa_{d1} A_y + \kappa_{d2})}{1 - \beta\rho_a} a_{t+1}$$
$$[-A_{i,2} a_t] + (\kappa_{d1} A_y + \kappa_{d2})(a_{t+1} - a_t)$$

where the term in [] is not of importance from the point of view of the calculation of the equity premium.

The previous one can also be written as:

$$rr_{i,t+1} = g\sigma(A_a A_y + A_b)a_{t+1} - g(\kappa_{d1}A_y + \kappa_{d2})a_{t+1}$$

$$[-A_{i,2}a_t] + (\kappa_{d1}A_y + \kappa_{d2})(a_{t+1} - a_t)$$

$$\text{where } g \equiv \frac{\beta(1-\rho_a)}{(1-\beta\rho_a)}$$

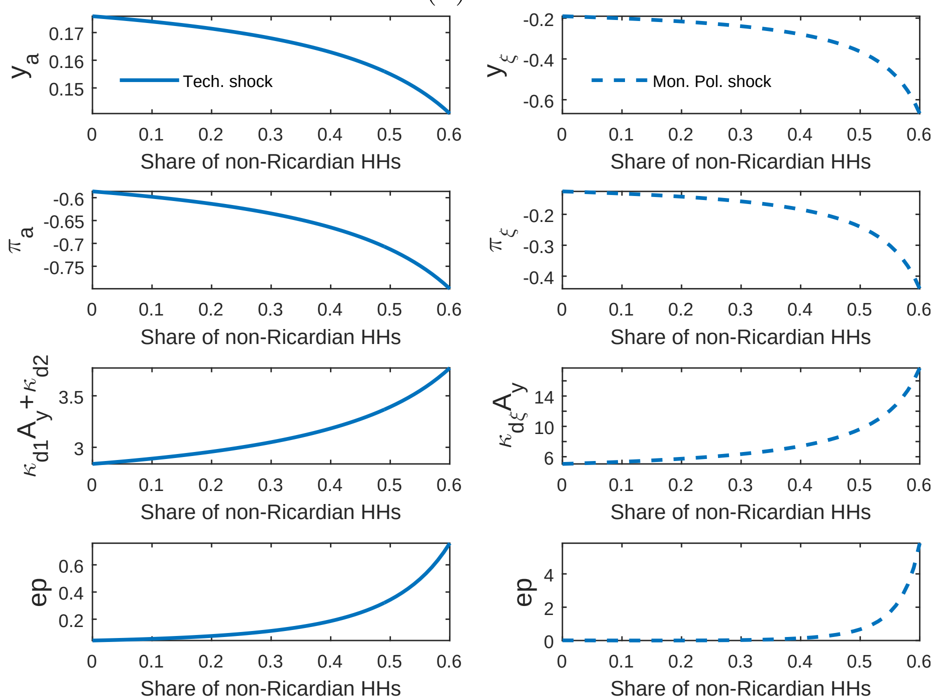
Then the equity premium is given by the conditional covariance between the stochastic discount factor and the return on equity:

$$\begin{aligned} ep_t &= -cov_t(-\sigma(A_a A_y + A_b)a_{t+1}, rr_{i,t+1}) \\ &= \{g\sigma^2(A_a A_y + A_b)^2 - g(\kappa_{d1}A_y + \kappa_{d2})\sigma(A_a A_y + A_b) \\ &+ \sigma(A_a A_y + A_b)(\kappa_{d1}A_y + \kappa_{d2})\}\sigma_a^2 \end{aligned}$$

8.3 Comparison of the model in case of technology and monetary shocks

The third row of Figure 2 shows the sensitivity of dividends to technology shocks is lower than in case of monetary shocks. To understand this recall profits which can be written in linear form as $(1 - mc_t)y_t = (1 - w_t + a_t)y_t$ where we used the fact that $mc_t = w_t - a_t$. Different from the workings of a restrictive monetary shock, a contractionary technology shock will in fact lead to a rise in marginal costs and reduction in profits limiting the ability of the model to account for high equity premium. The latter effect is

Figure 2: Comparison of model features in case of A and M shocks. Sensitivity of y_a, y_ξ, π_a, π_ξ, $\kappa_{d\xi}A_y$, $\kappa_{d1}A_y + \kappa_{d2}$ and the equity premium (ep) to the share of non-Ricardian households (λ)



Notes: A_π is annualized. The ep is measured as an annualized percentage. Values of λ higher than 0.6 are excluded, as they deliver implausibly high equity premia and are not in line with empirical evidence.

attenuated by a higher share of non-Ricardians resulting in smaller decrease of the output (see y_a on the graph). The bottom panels of the figure show that the equity premium (expressed as annualised percent) is small in case of technology shock even when the share of non-Ricardian households is high.

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