

Uncertainty Shocks in a Model of Effective Demand: Comment*

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ABSTRACT

Basu and Bundick (2017) show an intertemporal preference volatility shock has meaningful effects on real activity in a New Keynesian model with Epstein and Zin (1991) preferences. We show when the distributional weights on current and future utility in the Epstein-Zin time-aggregator do not sum to 1, there is an asymptote in the responses to such a shock with unit intertemporal elasticity of substitution. In the Basu-Bundick model, the intertemporal elasticity of substitution is set near unity and the preference shock only hits current utility, so the sum of the weights differs from 1. We show when we restrict the weights to sum to 1, the asymptote disappears and preference volatility shocks no longer have large effects. We examine several different calibrations and preferences as potential resolutions with varying degrees of success.

Keywords: Stochastic Volatility, Epstein-Zin Preferences, Uncertainty, Economic Activity

JEL Classifications: D81, E32

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1 INTRODUCTION

Basu and Bundick (2017)—denoted BB—build a New Keynesian model with time-varying demand uncertainty to replicate the effects of uncertainty shocks from an estimated VAR. An important contribution of their paper is to show that demand uncertainty shocks can generate meaningful declines in output and positive comovement between consumption and investment.¹ Demand uncertainty is modeled as a stochastic volatility shock to a representative household’s intertemporal preferences within an Epstein and Zin (1991) recursive preference specification. Preference shocks in expected utility settings have become a popular way to model changes in demand. However, the literature offers almost no guidance on how to introduce those shocks with recursive preferences.

We show when a preference shock is introduced in Epstein-Zin preferences and the distributional weights on current and future utility in the time-aggregator do not sum to 1, there is an asymptote in the response to the shock with unit intertemporal elasticity of substitution (IES). In the BB model, the shock only hits current utility, so the sum of the weights differs from 1. As a result, demand uncertainty shocks can generate arbitrarily large declines in real activity as the IES approaches unity from below and arbitrarily large increases as the IES tends to unity from above.²

The standard deviation of the preference shock is set to 0.003 in the BB model to match the volatility of real activity in the data. Given that value, the asymptote only has a meaningful effect on the responses to preference volatility shocks if the IES is near unity. BB set the IES to 0.95, which is close enough to significantly magnify the size of the responses. For example, a one standard deviation preference volatility shock causes output to decline by 0.13% on impact, whereas an IES set to 0.8 would have caused output to decline by only 0.025%. In contrast, an IES set to 1.05 would have caused output to *increase* by 0.14% on impact.³ Despite the importance of the IES, there is no consensus about its value, which ranges from near 0 to 2 in the literature.⁴ In that range, the BB model is able to generate responses to preference volatility shocks with any size and sign.

We show the asymptote disappears with preferences where the weights on current and future utility are restricted to sum to 1. Unlike the BB preferences, the CES time-aggregator over current and future utility in our alternative specification is Cobb-Douglas as the IES approaches unity consistent with Epstein and Zin (1991) and Hansen and Sargent (2008, section 14.3). As a result, the model’s predictions become robust to small changes in the IES. There are also two important economic implications of our alternative preferences. One, demand uncertainty shocks have very small real effects. Two, output and investment increase and they no longer positively comove with consumption. Higher capital adjustment costs, risk-aversion, or price-adjustment costs can attenuate the increases in output and investment. However, only extreme parameter values restore the co-

¹BB complement a large literature on uncertainty shocks (Bachmann et al. (2013), Bloom (2009), Born and Pflafer (2014), Fernández-Villaverde et al. (2015, 2011), Justiniano and Primiceri (2008), and Mumtaz and Zanetti (2013)).

²Albuquerque et al. (2016) add preference shocks to Epstein-Zin preferences the same way as BB, creating a similar asymptote. IES values slightly above (below) unity result in an arbitrarily large positive (negative) equity premium.

³Justiniano and Primiceri (2008) estimate a similar model with several sources of stochastic volatility and find time-varying volatility from a preference shock does not have a meaningful effect on output volatility. Similarly, Richter and Throckmorton (2017) estimate a nonlinear model where uncertainty arises from stochastic volatility as well as the state of the economy. They find a risk premium uncertainty shock reduces real GDP by less than 0.01%.

⁴Hall (1988) argues the empirical evidence supports an IES close to zero. Basu and Kimball (2002) find an IES of about 0.5 and Smets and Wouters (2007) estimate a value of roughly 0.7. In much of the literature, it is common to work with log-preferences (i.e., unit IES). In contrast, Bansal and Yaron (2004) choose an IES of 1.5. They argue earlier empirical work ignored the effect of time-varying volatility, creating downward bias in the estimates of the IES. Similarly, van Binsbergen et al. (2012) estimate a model with Epstein-Zin preferences and obtain an IES of 1.73.

movement and the magnitude of the responses remain much smaller than with the BB preferences.

We examine two potential ways to restore the BB results with a lower IES. One, we retain the BB preferences and increase the steady state standard deviation of the preference shock. In that case, lower IES values generate responses to demand uncertainty shocks with a similar size as BB, but that occurs because the larger standard deviation effectively widens the influence of the asymptote. Two, we modify the preferences to exploit the observational equivalence between preference and disaster risk shocks following Gourio (2012). With an IES very close to 0, disaster risk-type preference shocks can restore the BB results, but our finding is very sensitive to the value of the IES and also requires much higher risk aversion and price-adjustment cost parameter values.

The paper proceeds as follows. [Section 2](#) describes the BB preferences and our alternative specification. [Section 3](#) analytically solves an endowment economy to provide intuition for how the preference specification affects equilibrium dynamics. [Section 4](#) compares the two specifications in the full New Keynesian model. [Section 5](#) discusses two potential resolutions. [Section 6](#) concludes.

2 RECURSIVE UTILITY AND PREFERENCE SHOCKS

We begin by showing how the preference shock specification in an Epstein and Zin (1991) utility function affects the asymptotic properties of the value function and the household's optimality conditions. In BB, the household chooses sequences of consumption, c_t , and labor, n_t , to maximize

$$U_t^{BB} = [a_t(1 - \beta)u(c_t, n_t)^{(1-\sigma)/\theta} + \beta(E_t[(U_{t+1}^{BB})^{1-\sigma}])^{1/\theta}]^{\theta/(1-\sigma)}, \quad 1 \neq \psi > 0, \quad (1)$$

where $\theta \equiv (1 - \sigma)/(1 - 1/\psi)$, $\sigma \geq 0$ determines the coefficient of relative risk aversion, $\psi \geq 0$ is the intertemporal elasticity of substitution, $\beta \in (0, 1)$ is the subjective discount factor, and E_t is the mathematical expectation operator conditional on information in period t .⁵ The current period consumption-leisure basket is defined as $u(c_t, n_t) = c_t^\eta(1 - n_t)^{1-\eta}$, where η determines the Frisch elasticity of labor supply. The coefficient on current utility, a_t , is a preference shock that follows

$$\begin{aligned} a_t &= (1 - \rho_a) + \rho_a a_{t-1} + \sigma_a^a \varepsilon_t^a, \quad 0 \leq \rho_a < 1, \quad \varepsilon_t^a \sim \mathbb{N}(0, 1), \\ \sigma_t^a &= (1 - \rho_{\sigma^a})\sigma^a + \rho_{\sigma^a}\sigma_{t-1}^a + \sigma^{\sigma^a} \varepsilon_t^{\sigma^a}, \quad 0 \leq \rho_{\sigma^a} < 1, \quad \varepsilon_t^{\sigma^a} \sim \mathbb{N}(0, 1), \end{aligned}$$

The preference shock standard deviation, σ_t^a , follows its own process to introduce time-varying demand uncertainty into the model, where σ_t^a and ε_t^a are uncorrelated. In contrast, the original Epstein and Zin (1991) preference specification does not have an intertemporal preference shock.

Given (1), the stochastic discount factor (SDF) that prices any 1-period asset is given by

$$m_{t,t+1}^{BB} = \beta \left(\frac{a_{t+1}}{a_t} \right) \left(\frac{u(c_{t+1}, n_{t+1})}{u(c_t, n_t)} \right)^{\frac{1-\sigma}{\theta}} \left(\frac{c_t}{c_{t+1}} \right) \left(\frac{(V_{t+1}^{BB})^{1-\sigma}}{E_t[(V_{t+1}^{BB})^{1-\sigma}]} \right)^{1-\frac{1}{\theta}},$$

where V_t^{BB} is the value function that solves the household's constrained optimization problem.

The utility function in (1) is constructed from two components. One, a time aggregator that characterizes preferences over the current consumption-leisure basket and the certainty equivalent of future utility. Two, a risk aggregator that controls preferences for risk over future utility. We focus on the specification of the time aggregator. When $a_t = 1$ for all t , the time aggregator is a

⁵The normalizing constant, $1 - \beta$, on current utility is not in BB, but it is in their code. Whether we include it is immaterial to the equilibrium conditions. However, it simplifies our exposition and appears in Epstein and Zin (1991).

CES function with distributional weights $1 - \beta$ and β , respectively. The CES function then has the typical property that the time aggregator is Cobb-Douglas when the IES equals 1 so (1) becomes

$$U_t^{BB} = u(c_t, n_t)^{1-\beta} (E_t[(U_{t+1}^{BB})^{1-\sigma}])^{\beta/(1-\sigma)}, \quad \psi = 1, \quad a_t = 1 \text{ for all } t. \quad (2)$$

Given the transformation $\mathcal{V}_t^{BB} \equiv \log(U_t^{BB})$, (2) is more familiarly written as

$$\mathcal{V}_t^{BB} = (1 - \beta) \log u(c_t, n_t) + \beta \log(E_t[\exp((1 - \sigma)\mathcal{V}_{t+1}^{BB})]) / (1 - \sigma). \quad (3)$$

However, if $a_t \neq 1$, the distributional weights, $a_t(1 - \beta)$ and β , no longer sum to 1. As a result, preferences are undefined when $\psi = 1$ and have the following properties as the IES approaches 1:⁶

$$\lim_{\psi \rightarrow 1^-} U_t^{BB} = 0 \ (\infty) \text{ for } a_t > 1 \ (< 1) \quad \text{and} \quad \lim_{\psi \rightarrow 1^+} U_t^{BB} = \infty \ (0) \text{ for } a_t > 1 \ (< 1).$$

To remove the asymptote, we propose an alternative to (1), where the distributional weights on current and future utility sum to 1 for all $a_t \in (0, 1/\beta)$. The alternative specification is given by⁷

$$U_t^{ALT} = \begin{cases} [(1 - a_t\beta)u(c_t, n_t)^{(1-\sigma)/\theta} + a_t\beta(E_t[(U_{t+1}^{ALT})^{1-\sigma}])^{1/\theta}]^{\theta/(1-\sigma)} & \text{for } 1 \neq \psi > 0 \\ u(c_t, n_t)^{1-a_t\beta} (E_t[(U_{t+1}^{ALT})^{1-\sigma}])^{a_t\beta/(1-\sigma)} & \text{for } \psi = 1 \end{cases} \quad (4)$$

and the SDF becomes

$$m_{t,t+1}^{ALT} = a_t\beta \left(\frac{1 - a_{t+1}\beta}{1 - a_t\beta} \right) \left(\frac{u(c_{t+1}, n_{t+1})}{u(c_t, n_t)} \right)^{\frac{1-\sigma}{\theta}} \left(\frac{c_t}{c_{t+1}} \right) \left(\frac{(V_{t+1}^{ALT})^{1-\sigma}}{E_t[(V_{t+1}^{ALT})^{1-\sigma}]} \right)^{1-\frac{1}{\theta}}.$$

In sharp contrast with the BB preferences, the alternative specification becomes Cobb-Douglas and is therefore well-defined when the IES equals 1.⁸ The analogous formulation to (3) is given by

$$\mathcal{V}_t^{ALT} = (1 - a_t\beta) \log u(c_t, n_t) + a_t\beta \log(E_t[\exp((1 - \sigma)\mathcal{V}_{t+1}^{ALT})]) / (1 - \sigma). \quad (5)$$

The ‘‘risk-sensitive’’ preferences studied by Hansen and Sargent and others in the context of model uncertainty are not generalizable to preference shocks in the spirit of BB, but they are with (5).

To calibrate the new preference shock, we use expected utility preferences ($\sigma = 1/\psi$) because then the value function does not appear in the SDF. The log-linear SDF in each model is given by

$$\begin{aligned} \hat{m}_{t,t+1}^{BB} &= \hat{a}_{t+1} - \hat{a}_t + (1 - \sigma)(\hat{u}_{t+1} - \hat{u}_t) + \hat{c}_t - \hat{c}_{t+1}, \\ \hat{m}_{t,t+1}^{ALT} &= -(\beta\hat{a}_{t+1} - \hat{a}_t)/(1 - \beta) + (1 - \sigma)(\hat{u}_{t+1} - \hat{u}_t) + \hat{c}_t - \hat{c}_{t+1}, \end{aligned}$$

so we scale the standard deviations of the level and volatility shock by $1 - \beta$ and flip the sign of the shocks. The online appendix shows the two specifications generate nearly identical responses to first moment preference shocks but large differences in the responses to second moment shocks.

⁶The distributional weights must sum to 1 when a_t is random but not when it is fixed since there is a transformation of the value function that eliminates the asymptote and leaves the SDF unchanged. See the online appendix for details.

⁷Kollmann (2016) has a time-varying discount factor in a recursive preference setting similar to our formulation.

⁸Rudebusch and Swanson (2012) rewrite Epstein and Zin’s preference specification as $U_t^{RS} = (1 - \beta)v(c_t, n_t) + \beta(E_t[(U_{t+1}^{RS})^{1-\alpha}])^{1/(1-\alpha)}$. That formulation is particularly useful when using utility kernels, v_t , that are additively separable in c_t and n_t . RS and BB preferences are equivalent when $v(c_t, n_t) \equiv u(c_t, n_t)^{(1-\sigma)/\theta}$, $\alpha \equiv 1 - \theta$, and $U_t^{RS} \equiv (U_t^{BB})^{(1-\sigma)/\theta}$. Therefore, the RS reformulation does not eliminate the asymptote that occurs with unit IES.

3 INTUITION

This section presents a simple endowment economy model with an analytical solution to isolate the effect of the preference specification on equilibrium outcomes across IES values. The two specifications, BB and ALT, are given in (1) and (4), respectively, except $\eta = 1$ so labor is inelastically supplied. We assume the household receives a unit endowment in all periods except period 1 and can only save in period 0 at an exogenous rate, r . The preference shock $a_t = 1$ in all periods except period 1, where it equals $a^H = 1 + \Delta$ with probability p and $a^L = 1 - \Delta$ with probability $1 - p$.

Since $V_t = 1$ for $t \geq 2$, the household's problem reduces to choosing c_0^{BB} or c_0^{ALT} to maximize

$$V_0^{BB} = [(1 - \beta)(c_0^{BB})^{(1-\sigma)/\theta} + \beta(E_0[(a_1(1 - \beta)(c_1^{BB})^{(1-\sigma)/\theta} + \beta)^\theta])^{1/\theta}]^{\theta/(1-\sigma)}$$

or

$$V_0^{ALT} = [(1 - \beta)(c_0^{ALT})^{(1-\sigma)/\theta} + \beta(E_0[((1 - a_1\beta)(c_1^{ALT})^{(1-\sigma)/\theta} + a_1\beta)^\theta])^{1/\theta}]^{\theta/(1-\sigma)},$$

subject to $c_1^j = r(1 - c_0^j)$, $j \in \{BB, ALT\}$. The respective equilibrium conditions are given by

$$1 = \beta r E_0 \left[a_1 \left(\frac{c_0^{BB}}{c_1^{BB}} \right)^{1/\psi} \left(\frac{(V_1^{BB})^{1-\sigma}}{E_0[(V_1^{BB})^{1-\sigma}]} \right)^{1-\frac{1}{\theta}} \right] \quad (6)$$

or

$$1 = \beta r E_0 \left[\left(\frac{1 - a_1\beta}{1 - \beta} \right) \left(\frac{c_0^{ALT}}{c_1^{ALT}} \right)^{1/\psi} \left(\frac{(V_1^{ALT})^{1-\sigma}}{E_0[(V_1^{ALT})^{1-\sigma}]} \right)^{1-\frac{1}{\theta}} \right], \quad (7)$$

where $V_1^{BB} = [a_1(1 - \beta)c_1^{(1-\sigma)/\theta} + \beta]^\theta/(1-\sigma)$ and $V_1^{ALT} = [(1 - a_1\beta)c_1^{(1-\sigma)/\theta} + a_1\beta]^\theta/(1-\sigma)$. With one equilibrium condition and one unknown, c_0^j , we use a nonlinear solver to find the exact solution. Without any uncertainty ($a_1 = 1$ for all t), period-0 consumption is given by $\bar{c}_0^j = r/(r + (\beta r)^\psi)$.

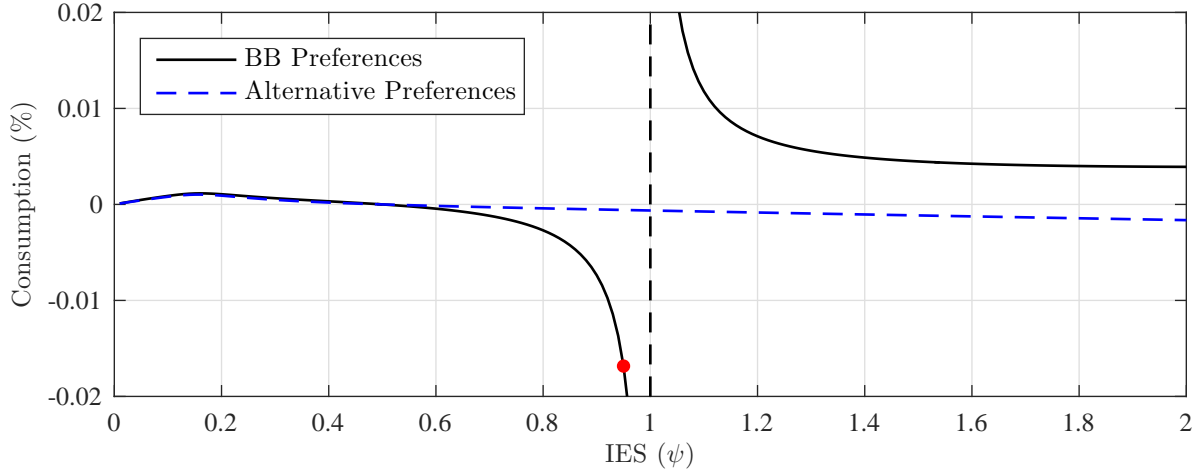


Figure 1: Period-0 consumption as a percent deviation from the no-uncertainty level of period-0 consumption. The circle marker shows the effect of uncertainty when the IES is 0.95 (BB value). The vertical line shows the asymptote.

Figure 1 plots period-0 consumption relative to the no-uncertainty benchmark with the BB and our alternative preference specification across IES values. For this exercise, we set the coefficient of relative risk aversion, σ , to 2, the discount rate, β , to 0.95, the preference shock probability, p , to

0.5, and the amount of uncertainty, Δ , to 0.02. We scale a^H and a^L by $1 - \beta$ for our alternative preferences so the results are almost identical for a deterministic change in a_1 . With expected utility, consumption is certainty equivalent, so both lines cross the horizontal axis when $\psi = 1/\sigma = 0.5$.

With the BB preferences, the relationship between period-0 consumption and the IES features an asymptote at unit IES. As the IES tends to 1, the effect of uncertainty is magnified. When the IES is slightly below unity, uncertainty leads to arbitrarily large declines in consumption, whereas an IES slightly above unity generates the opposite result. With our alternative preferences there is no asymptote, so the results are robust to small changes in the IES. The predictions from the two specifications are very similar when $\psi < 1/\sigma$ (i.e., $\psi < 0.5$ with $\sigma = 2$). In that case, the household prefers a late resolution of uncertainty. In the more typical region of the parameter space where the household prefers an early resolution of uncertainty, the predictions of the two specifications quickly diverge. Unlike the BB preferences, the alternative specification induces precautionary behavior in response to uncertainty and the effect on consumption is small, regardless of the IES.

To better understand what is driving the results in [figure 1](#), we rewrite (6) and (7) as

$$1 = \tilde{\beta}^j r (c_0^j / c_1^j)^{1/\psi},$$

where $\tilde{\beta}^j$ is an *augmented* discount factor due to the combination of recursive preferences and preference uncertainty. Defining $W_1^j \equiv (V_1^j)^{1/\psi - \sigma}$, the augmented discount factor is given by

$$\tilde{\beta}^j \equiv \beta \times \underbrace{\frac{E_0[W_1^j]}{(E_0[(W_1^j)^{\theta/(\theta-1)}])^{(\theta-1)/\theta}}}_{\text{Risk Aversion Term}} \times \underbrace{\left(1 + \frac{\text{cov}_0(\tilde{a}_1^j, W_1^j)}{E_0[W_1^j]}\right)}_{\text{Covariance Term}}, \quad (8)$$

where $\tilde{a}_1^{BB} = a_1$ and $\tilde{a}_1^{ALT} = (1 - a_1\beta)/(1 - \beta)$. Although the last two terms depend on the value of period-1 consumption, the online appendix shows the effect is small. For simplicity, we evaluate $\tilde{\beta}^j$ at $c_1^j = \beta r / (1 + \beta)$, which is the no-uncertainty level of period-1 consumption when $\psi = 1$. With expected utility preferences (i.e., $\sigma = 1/\psi$), the value function drops out of the equilibrium condition in (6) or (7). As a result, $\tilde{\beta}^j = \beta$ and the asymptote disappears. In this case, whether one uses the BB or our alternative preference specification is inconsequential for equilibrium outcomes.

[Figure 2](#) plots the decomposition of the augmented discount factor shown in (8). Comparing the vertical scales in the top left and top right panels reveals the variation in the augmented discount factor is mainly due to the covariance term and not the risk-aversion term. Looking at the bottom left panel, we can trace the source of the asymptote to the covariance between a_1 and V_1^{BB} . In contrast, with our alternative preferences the covariance is always negative and modestly sized.

We conclude this section by showing two comparative statics that are useful for understanding the results from the BB model in the next section. [Figure 3](#) shows the effect of increasing risk-aversion (left panel) and the amount of uncertainty (right panel). A higher risk aversion parameter boosts the response of consumption for all values of the IES, so the domain in which the asymptote affects the responses is larger. Therefore, it is possible to lower the IES away from 1 and still generate the same consumption response by increasing risk aversion. Since $W_1^{BB} \equiv (V_1^{BB})^{1/\psi - \sigma}$, a higher σ increases the covariance term in the augmented discount factor. Higher uncertainty expands the influence of the asymptote in a similar way by increasing the covariance term. With our alternative preferences that eliminate the asymptote, higher uncertainty and risk aversion also increase the consumption response, but the magnitude is small compared to the BB preferences.⁹

⁹The online appendix presents two other toy models, which provide further intuition for the interested reader.

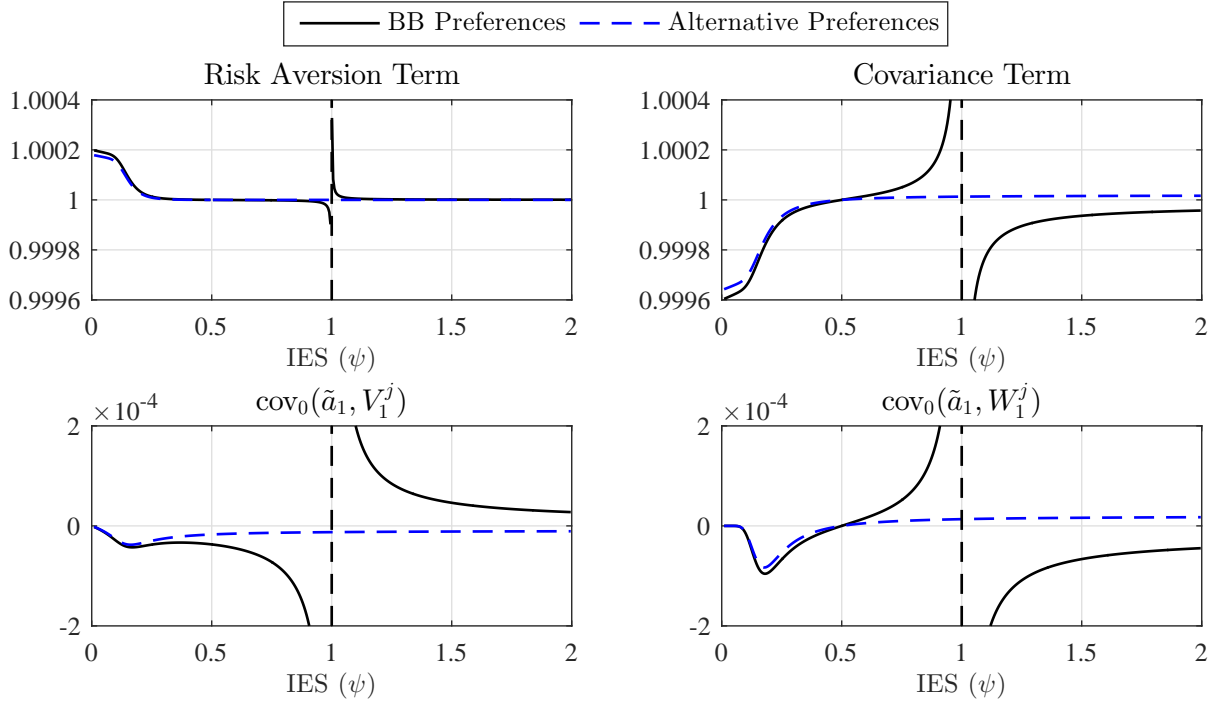


Figure 2: Key terms in the decomposition of the augmented discount factor given in (8), where $j \in \{BB, ALT\}$.

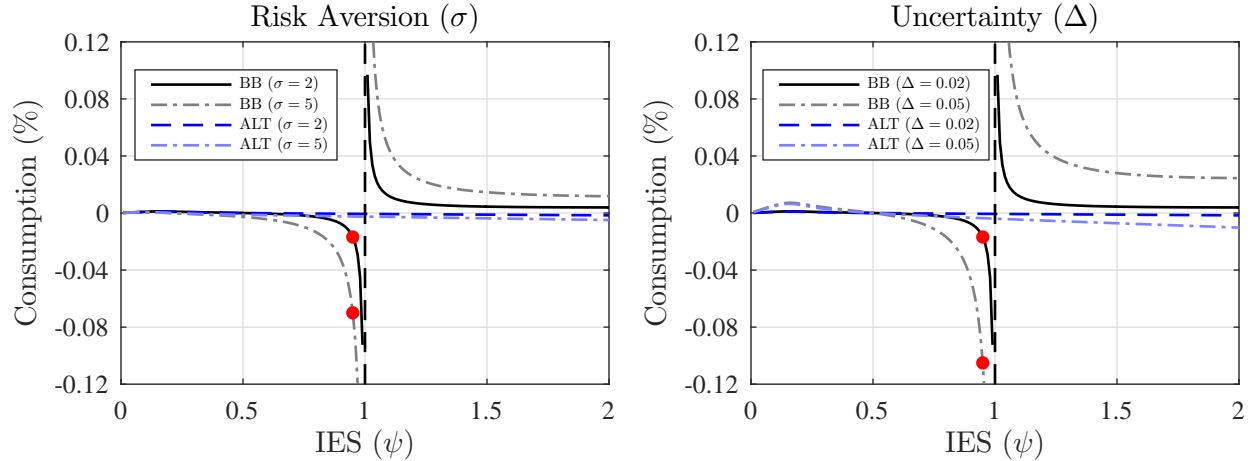


Figure 3: Period-0 consumption as a percent deviation from the no-uncertainty level of period-0 consumption. The circle marker shows the effect of uncertainty when the IES is 0.95 (BB value). The vertical line shows the asymptote.

4 PREFERENCE SHOCKS IN THE BB NEW KEYNESIAN MODEL

This section conducts the same analysis as section 3 with the full BB model. With the qualitative results unchanged, we focus on the quantitative effects of the different preferences. We also examine the comovement problem between output, consumption, and investment—a key issue in BB.

Figure 4 plots the impact effect on output, consumption, and investment from a one standard deviation increase in the level (top panels) and volatility (bottom panels) of a_t with the BB preferences and our alternative specification. The circle markers show the impact effect when the IES equals 0.95—the value in BB. Aside from the preferences, the model is identical to the BB model.

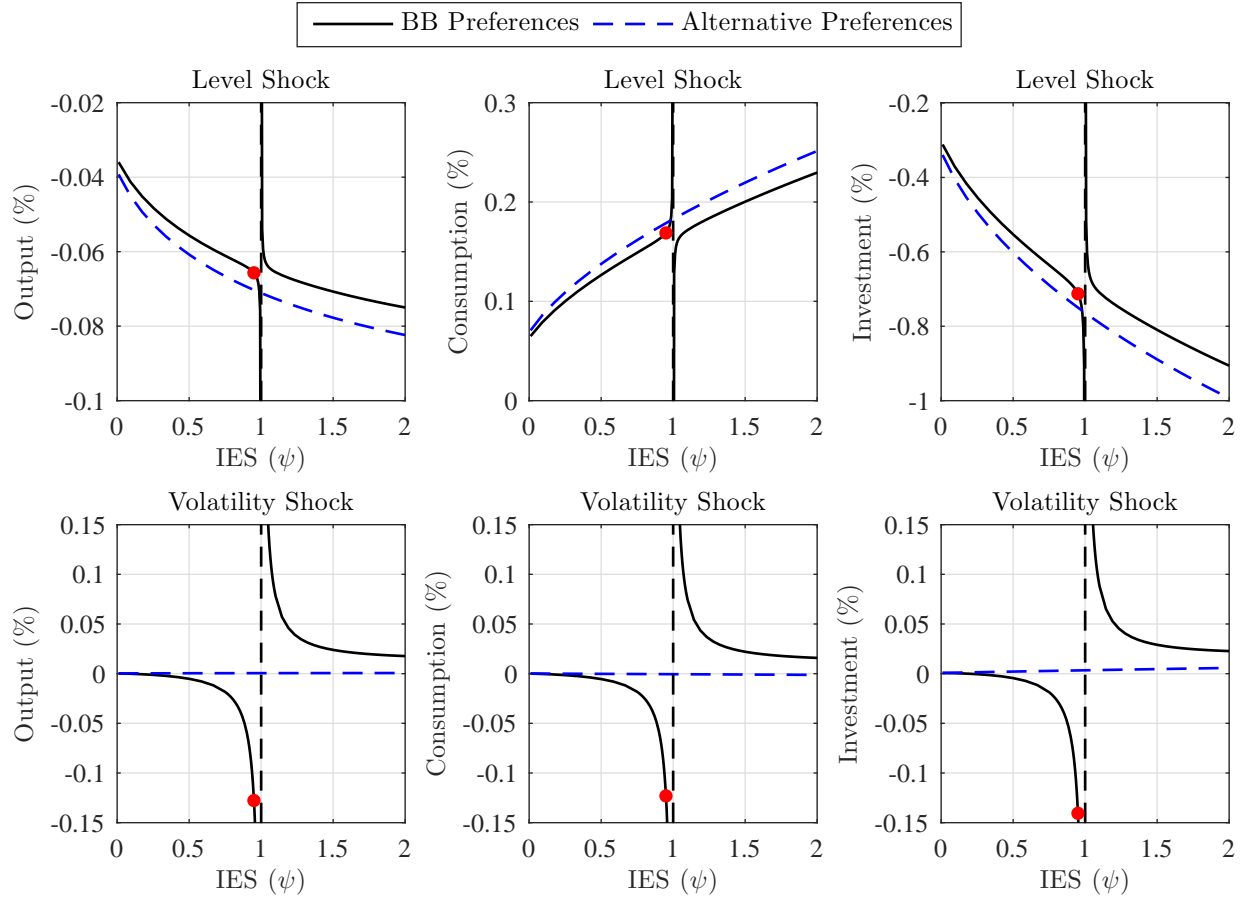
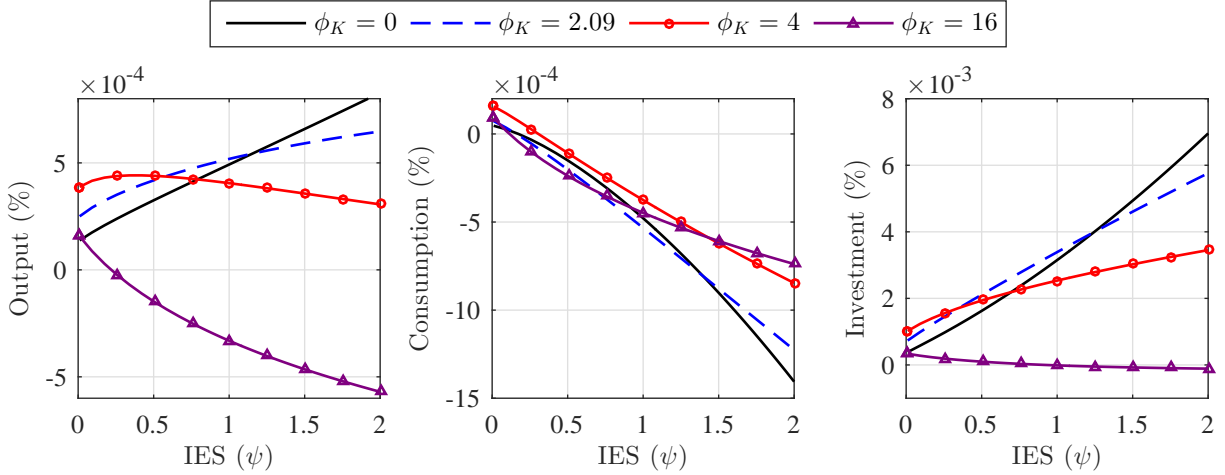


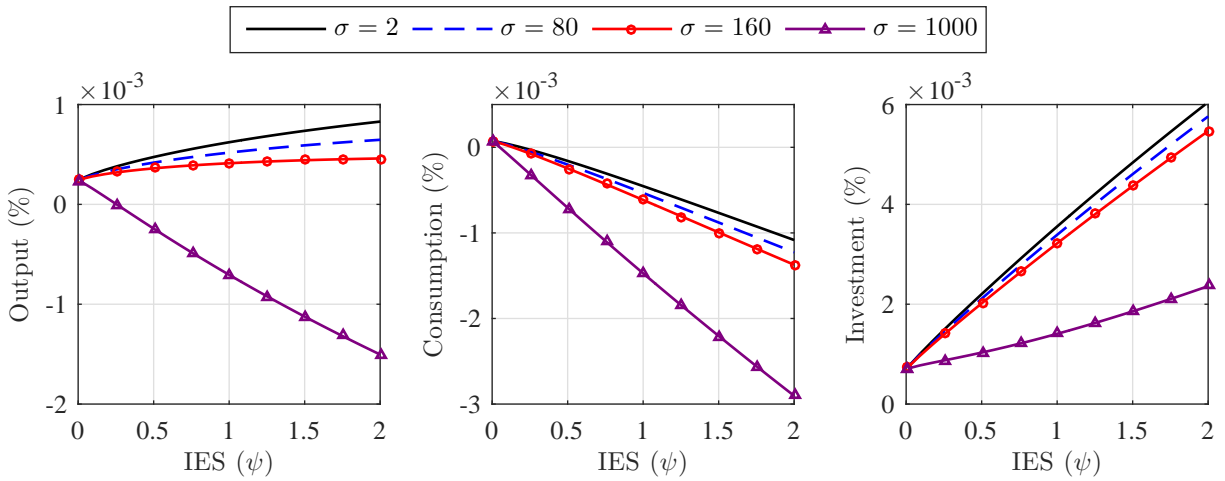
Figure 4: Impact effect on output, consumption, and investment from a 1 standard deviation increase in the level and volatility of the intertemporal preference shock. The circle markers show the impact when the IES is 0.95 (BB value).

The impact effects of the level shock are very similar for the BB preferences and our alternative specification for most values of the IES. When the household becomes more impatient, consumption increases and investment decreases on impact. The BB preferences show an asymptote appears in the responses of all three variables when the IES equals 1, but it only has a meaningful effect on the responses if the IES is very close to 1. In response to a volatility shock, the asymptote also appears when the IES equals 1, but it affects the responses for a wider range of IES values. For example, there is almost no effect on output when the IES is less than 0.5, whereas output decreases by about 0.015% (0.025%, 0.06%, 0.13%) when it equals 0.7 (0.8, 0.9, 0.95). By setting the IES equal to 0.99, the model is able to generate an enormous 0.68% decline in output. When the IES is alternatively set to 1.05, output instead rises on impact by 0.14%. In short, small changes in the IES lead to very different conclusions, so the model can produce any effect of demand uncertainty.

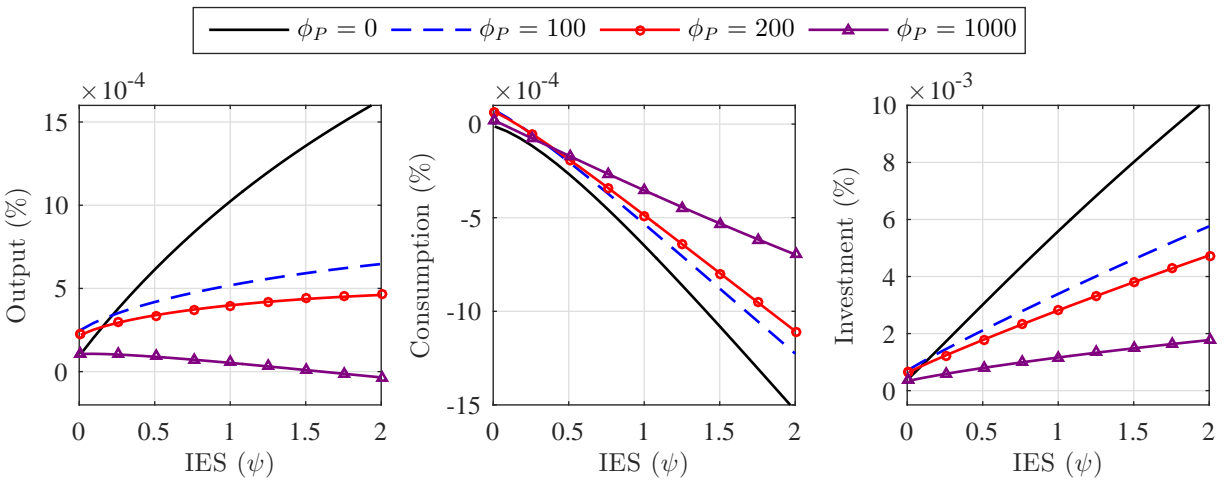
The asymptote never appears with our alternative preferences, so small changes in the IES no longer significantly alter the responses to demand uncertainty shocks. There are also two key economic implications from removing the asymptote. One, the impact of a demand uncertainty shock is no longer economically significant. Output, consumption, and investment all change by less than 0.005% in response to a one standard deviation increase in uncertainty. Two, higher uncertainty increases output and investment and causes consumption to fall, contrary to VAR evidence. The comovement problem arises because higher uncertainty creates an increase in precautionary sav-



(a) Impact responses as a function of the capital adjustment cost parameter (ϕ_K).



(b) Impact responses as a function of the coefficient of relative risk aversion (σ).



(c) Impact responses as a function of the price adjustment cost parameter (ϕ_P).

Figure 5: Impact effect on output, consumption, and investment from a 1 standard deviation preference volatility shock with our alternative preferences. In each panel, the dashed line shows the response with the parameter value in BB.

ings (reducing consumption) as well as an increase in precautionary labor supply (raising output).

The above analysis compares equilibrium outcomes under the BB preferences to our alternative specification that removes the asymptote, but that exercise does not provide a complete comparison because we used the BB parameters that are chosen to fit the data conditional on their preferences. To see the range of possible predictions under our alternative preferences, [figure 5](#) shows the effect of a 1 standard deviation preference volatility shock as a function of the capital adjustment cost parameter (ϕ_K), coefficient of relative risk aversion (σ), and price adjustment cost parameter (ϕ_P).¹⁰ In each case, a larger parameter value attenuates the counterfactual increases in output and investment, especially with a larger IES. If ϕ_K is sufficiently large, the dynamics in the model approach those in a model with fixed capital, so investment becomes constant and output moves one-for-one with consumption. A higher σ makes households more sensitive to changes in volatility, as shown in [section 3](#). A larger ϕ_P raises the volatility of the price markup and makes households more sensitive to the nominal interest rate. Even with implausible values for those parameters, higher uncertainty typically raises investment, regardless of the IES. Also, the impact on output is much smaller than with the BB preferences, even with parameters that address the comovement problem.

5 POTENTIAL RESOLUTIONS

This section examines potential ways to obtain larger responses to preference volatility shocks and positive comovement between output, consumption, and investment when the IES is far below 1.

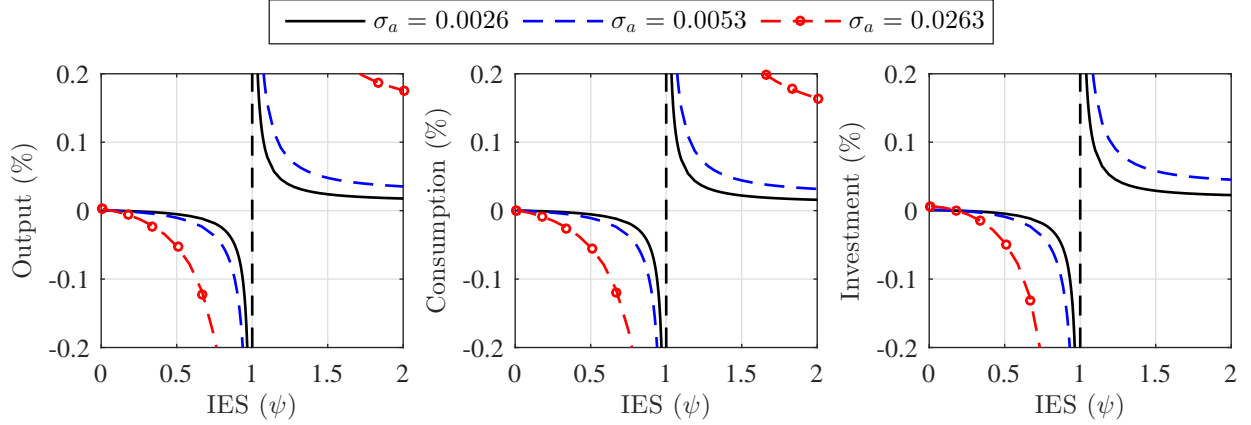
5.1 LARGER SHOCKS As shown in [section 3](#), one way to create larger responses of real activity to a volatility shock when the IES is farther below 1 is by raising the steady state standard deviation of the preference shock, σ_a . [Figure 6](#) reproduces [figure 4](#) with different values of σ_a . With the BB preferences, it is possible to achieve a 0.13% decline in output on impact—the value BB report—when ψ is (0.95, 0.90, 0.67) by setting σ_a to (0.0026, 0.0053, 0.0263), respectively. Thus, an IES close to the value estimated by Smets and Wouters (2007) requires a shock standard deviation that is roughly an order of magnitude larger than the value in BB. Also, if we increase risk aversion from $\sigma = 80$ to $\sigma = 100$, double the Rotemberg price adjustment cost parameter from $\phi_P = 100$ to $\phi_P = 200$, and rerun the BB impulse response matching exercise, then [table I](#) shows the model is able to match both the decline in output and the volatilities in the data when the IES is 0.5 and σ_a is doubled to 0.005. With our alternative preferences the same volatility shock has very little real effect, regardless of σ_a . Consistent with the discussion in [section 3](#), we are able to reproduce the BB results with a lower IES because larger values of σ and σ_a widen the influence of the asymptote.

5.2 DISASTER RISK Gourio (2012) develops a model with time-varying disaster risk, which enters through a combination of permanent and transitory shocks to productivity and a depreciation shock to capital. According to Proposition 3 (p. 2746), if the preference shock in (1) directly hits u_t , then an increase in the probability of a disaster and a positive shock to household preferences are observationally equivalent. In that case, the recursive structure for intertemporal utility becomes

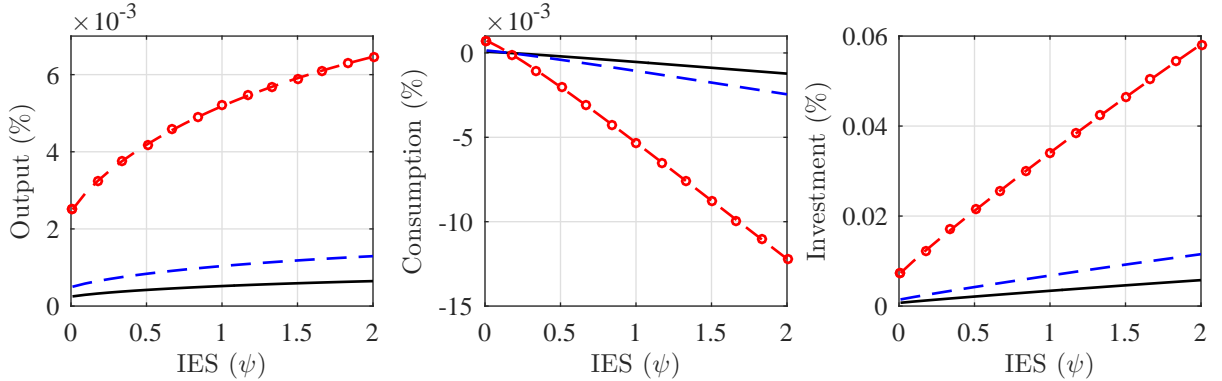
$$U_t^{BB} = [(1 - \beta)(a_t^d u(c_t, n_t))^{(1-\sigma)/\theta} + \beta(E_t[(U_{t+1}^{BB})^{1-\sigma}])^{1/\theta}]^{\theta/(1-\sigma)}.$$

The asymptote no longer appears with unit IES because a_t^d revalues the current consumption-leisure basket instead of the distributional weights. However, $a_t^d = (a_t^{BB})^{1-1/\psi}$, so the volatility of

¹⁰In addition to providing further sensitivity analysis on the parameters, the online appendix shows the implications of a Smets and Wouters (2007) risk premium shock and additively separable preferences in consumption and leisure.



(a) Impact responses with the BB preferences.



(b) Impact responses with our alternative preferences.

Figure 6: Impact effect on output, consumption, and investment from a 1 standard deviation preference volatility shock. All of the parameters except the IES and preference shock standard deviation are set to the values in BB.

Moment	Unconditional Volatility			Stochastic Volatility		
	Data	Larger Shock	Disaster Risk	Data	Larger Shock	Disaster Risk
Output	1.1	0.9	1.1	0.4	0.2	0.2
Consumption	0.7	0.7	0.7	0.2	0.1	0.1
Investment	3.8	4.7	4.7	1.6	1.0	0.9

Table I: Standard deviations with the BB preferences (%). The data sample is 1986-2014. The model-based statistics reflect the average from repeated simulations with the same length as the data. Stochastic volatility is measured by the standard deviation of the time-series of 5-year rolling standard deviations. These procedures follow table 2 from BB.

a_t^d is much larger when ψ is near zero.¹¹ Therefore, we reran the BB impulse response matching exercise with the IES set to 0.05. As table I shows, we were able to restore the BB results with disaster risk preferences. However, with such a low IES, we had to more than double the risk-aversion parameter from 80 to 200 and triple the Rotemberg price adjustment cost parameter from 100 to 300. The algorithm also increased the capital adjustment cost parameter from 2.09 to 9.86.

¹¹Also, the disaster risk specification is not observationally equivalent to the preference shock specification in the expected utility limit. Thus, the model has different predictions than preference shocks in an expected utility setting.

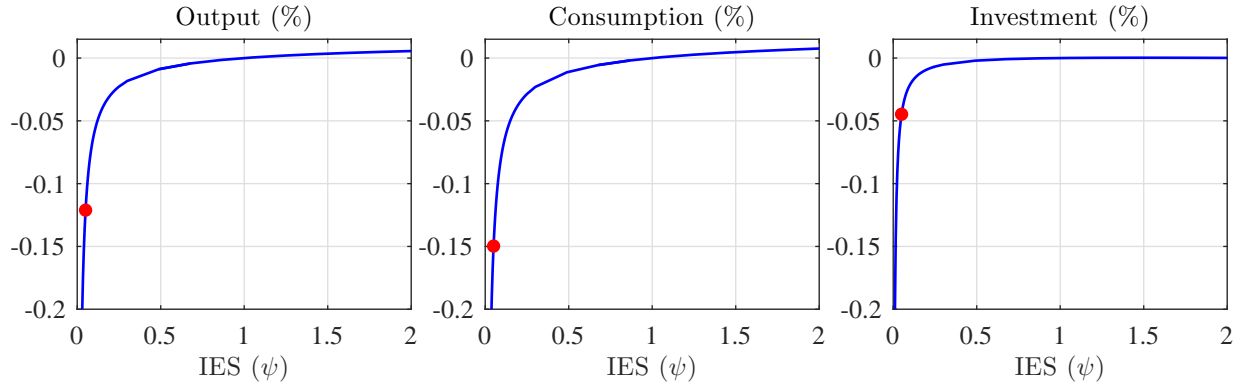


Figure 7: Impact effect on output, consumption, and investment from a 1 standard deviation preference volatility shock under the disaster risk preferences. The circle markers show the impact effect when the IES equals 0.05—a value that achieves similar responses as the original BB specification. All other parameters are re-estimated with the BB method.

To get a broader sense of how the IES affects the response of real activity, [figure 7](#) reproduces [figure 4](#) with disaster risk preferences. There are two key points. One, the responses are continuous for positive IES values, so there is no longer a discrete jump in the impact effect at unit IES. However, the predictions of the model are still very sensitive to the IES. For example, doubling the IES from 0.05 to 0.1 causes the impact effect on output to decline from 0.12% to 0.06%, and an IES of 0.5 causes output to decrease less than 0.01%. The sensitivity to the IES is similar to what we reported with the BB preferences. Two, there is no economic effect at unit IES, as stressed by [Gourio \(2012\)](#). Therefore, the responses to a volatility shock are quite different from the BB preferences, which generated the largest effects of volatility shocks when the IES was near unity.¹²

6 CONCLUSION

Since the financial crisis, aggregate demand shocks driven by changes in intertemporal preferences have become commonplace in macroeconomists' toolkits. Intertemporal uncertainty shocks in combination with recursive preferences are much less common. Our paper highlights that the novel findings in BB rest on an—until now—undetected asymptote. We suggest a simple alternative specification that removes the asymptote and provides predictions that are robust to small changes in the IES. Under this specification, preference volatility shocks have negligible effects on macro aggregates for plausible parameterizations. The question is whether it is possible to rationalize the asymptote. Providing an axiomatic account of the BB preferences is beyond the scope of this paper. However, we point out two puzzling features. The covariance between the preference shock and the value function changes sign at an IES of 1 and it is very large when the IES is near 1, so small changes in relative discounting have big effects on the level of utility.¹³ Therefore, we believe the uncertainty puzzle—why models struggle to generate sizeable movements in economic activity in response to changes in uncertainty, in contrast to the empirical evidence—remains.

¹²Another alternative is a risk premium volatility shock, which creates positive comovement between consumption and investment and thus slightly larger responses than a preference volatility shock with our alternative preferences.

¹³Recursive preferences are cardinal in that outcomes depend on the level of utility or “intensity” of preference.

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