Habit Formation and News-driven Business Cycles

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Abstract

This paper demonstrates that, in a standard RBC model, internal consumption habits *alone* are sufficient to generate positive comovements among key macroeconomic aggregates in response to news about future productivity. We highlight *the prospective channel* associated with internal habits, through which the effect of news shocks is transmitted to the present, stimulating current consumption, labor, and investment. Without this channel, other forms of preferences such as external habits fail to generate the positive comovements. The quantitative performance of the model is also discussed. Arguably, we provide a nearly minimal departure from the RBC framework to generate expectation-driven business cycles.

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1 Introduction

The notion of consumption habit formation has been employed in consumer preferences as a fundamental element of macroeconomic models. It has been quite successful at capturing business cycle and asset pricing properties (Abel, 1990; Jermann, 1998; Campbell and Cochrane, 1999; Ljungqvist and Uhlig, 2015) and is currently widely used to generate hump-shaped responses of consumption to exogenous shocks and additional persistence. In particular, the literature on news-driven business cycles has begun to recognize that consumption habit formation is helpful for generating plausible comovements among aggregate variables in response to news about future fundamentals (Christiano et al., 2008). However, conventional wisdom holds that consumption habits are employed only to improve the quantitative performance of news shock comovements (Beaudry and Portier, 2014). Existing studies do not seem to acknowledge the qualitative importance of this preference structure for aggregate comovements, and the mechanism through which habits help to generate news-driven business cycles remains unclear.[1]

This paper attempts to fill this gap by providing comprehensive analysis on whether, and how, habits *alone* can help to produce news-driven business cycles in an otherwise standard real business cycle (RBC) model. To this end, we incorporate internal habits into consumers' preferences where the consumer's period utility is affected by her own past consumption. Our analytical proof shows that in an internal-habit model without any other departure from standard RBC assumptions, news about future technology can generate positive comovements among output, consumption, investment, and hours worked. The result demonstrates the qualitative importance of internal habits for news-driven business cycles. Arguably, we provide a nearly minimal departure from the RBC setting to obtain plausible news shock comovements.

Our analytical demonstration highlights *the prospective channel* through which internal habits help to generate plausible news-driven business cycles. The prospective channel of

[1] The only exception is Wang (2012), who showed by numerical experiments that habits alone can generate positive comovements among consumption and labor in a standard RBC model.

internal habits operates via changes in expected future consumption: When households take future consumption into consideration, the fact that future consumption will eventually increase has a positive effect on the shadow value of wealth. The increase in the shadow value of wealth encourages households to increase their labor supply and is essential for a positive response of hours worked. Without the prospective channel, the plain-vanilla RBC model cannot generate comovements between consumption and labor because consumption and the shadow value of wealth move in the opposite direction. Moreover, the prospective channel introduces a smoothing effect on consumption dynamics, mainly by lowering the household's (local) intertemporal elasticity of substitution (IES). We demonstrate that the (local) level of IES is crucial for the positive comovements between consumption and investment. On the one hand, the IES cannot be too low because a strong consumption-smoothing motive causes a larger (if positive) response of consumption and induces a larger crowding-out effect on investment. If this prospective effect is excessively large, it may crowd out investment. On the other hand, the IES cannot be too high because households may postpone their consumption until the shock actually materializes, and the current response of consumption to a positive news shock can be negative. Thus, to generate plausible comovements among consumption, labor, and investment, the curvature parameter of household preferences, which affects the level of IES and risk aversion, should be carefully chosen. The range of the curvature parameter that generates plausible news shock comovements is derived.

Next, we consider another type of consumption habits named external habits to examine whether the model can still generate news-driven business cycles. Both internal and external habits are commonly used in DSGE models to generate additional persistence in consumption dynamics.[2] The difference is that with external habits, a household's period utility is affected by the aggregate level of past consumption, which consumers consider exogenous. Although external habits also generate a consumption smoothing effect like internal habits, it is achieved mainly through past consumption: A higher level of past consumption increases

[2]See the similar numerical performance of both consumption habits in response to unanticipated shocks in Dennis (2009).

a household's incentive to raise current consumption, making the consumption path more persistent. To distinguish it from the prospective channel of internal habits, we name this the *retrospective channel*. Without the prospective channel, the framework with external habit formation fails to produce a positive response of consumption to favorable news shocks in conjunction with an increase in hours worked. The above comparison between internal and external habit formation highlights the central role of the consumption-smoothing effect via expected future consumption, especially from the perspective of news-driven business cycles.

We further show that this difference between internal and external habits in terms of news shocks persists in a more generalized notion of consumption externalities. Instead of external habits, we consider another notion of consumption externality that incorporates contemporaneous aggregate consumption into the utility function (also known as "keeping up with the Joneses" (KUJ) effect). We prove that a positive TFP news shock cannot generate simultaneous increases in consumption, labor, and investment. Indeed, KUJ preferences introduce a novel channel through which a higher level of contemporaneous social average consumption increases the marginal rate of substitution (MRS) between consumption and labor. Thus, a higher level of consumption has a positive effect on labor supply. However, unlike internal habit formation, the positive effect on labor is static, and the KUJ effect should be large enough to generate positive responses of consumption and hours worked. Moreover, a larger positive response of current consumption causes a larger crowding-out effect on investment, and current investment may decrease without the prospective channel. While the business cycle literature often treats various forms of habits and consumption externalities as interchangeable components for analyzing consumption dynamics, the above result highlights the distinction between internal habits and other types of consumption externalities in the context of news-driven business cycles.

Although our analysis demonstrates the crucial difference between two types of habits regarding news-driven business cycles, it is still unclear whether such difference is still quantitative significant in a medium-scale DSGE model. Existing studies in the news shock literature show that internal habits are among one of the elements that helps to generate the plausible comovements, such as investment adjustment costs, variable capital utilization, and utility function à la Jaimovich and Rebelo (2009) (JR). To this end, we employ both internal and external habits in a medium-scale DSGE model from Schmitt-Grohé and Uribe (2012), which incorporated all of these elements. We conduct Bayesian estimation for both cases, while leaving the other parts of the model unchanged. Our results show that with internal habits, both consumption and hours worked increase after households receive the positive news, whereas under external habits, consumption decreases initially. Furthermore, the estimated model with internal habits has a higher value of the log marginal density than that with external habits, indicating stronger support for the internal habit model. Moreover, we examine the ranges of JR preference parameter and the investment adjustment cost parameter that could generate news shock comovements. We find that the pairs of parameters for news shock comovements are wider in the internal habit model. The above numerical exercise demonstrates that the difference between internal and external habits is still significant in more fruitful quantitative models.

Next, we examine the quantitative performance of the baseline model with internal habits. Our calibrated model shows that although internal habits alone can generate news-driven business cycles, the range of values for the curvature parameter is smaller compared to the commonly used values in the DSGE literature. The limited quantitative performance of our model primarily stems from the absence of additional elements. However, there are various approaches available to address this quantitative limitation. We first explore the inclusion of additional elements that have been utilized in the literature on news-driven business cycles, such as JR preferences and investment adjustment costs. Moreover, this paper provides one novel way to increase the range of the parameter for comovement, that is, to incorporate the KUJ effect into the utility function. We analytically show that both the lower and upper bounds of the curvature parameter increase after introducing the KUJ effect. This is because a higher level of social average consumption increases the marginal rate of transformation between consumption and leisure and causes a further increase in labor supply. A larger positive response of labor causes a higher level of aggregate output and eases the crowding-out of consumption on investment. According to our numerical experiment, one can choose empirically plausible curvature and internal habit parameters for the utility function when the KUJ effect is introduced, and plausible news-driven comovements can still be retained.

Related Literature

Our paper adds to the literature that attempts to imitate empirically plausible news shock comovements among key aggregate variables (Beaudry and Portier, 2007, 2014).[3] These papers incorporate various forms of additional elements to enrich plain-vanilla RBC models, attempting to generate such plausible news shock comovements. Some studies introduce financial frictions to achieve that goal, such as Kobayashi et al.(2012). Kamber et al. (2017) introduce financial constraints a la Jermann and Quadrini (2012). They show that a favorable news shock can relax firms' borrowing constraints. Görtz et al. (2022b) consider a model with a financially constrained banking sector and show that good news about future TFP increases the value of bank equity and relaxes banks' borrowing constraint. Others attempt to introduce a positive substitution channel through which good news about future fundamentals increases the current wage rate (e.g., Gunn and Johri, 2011; Pavlov and Weder, 2013; Chen and Lai, 2015). Another seminal work that is closely related to our paper is Jaimovich and Rebelo (2009), who introduce a specific nonseparable utility function that yields a weaker wealth effect on labor supply. Investment adjustment costs and variable capital utilization are also introduced to enhance the positive substitution effect to achieve news-driven business cycles. Their utility function also incorporates a certain degree of habit formation, but the presence of a weaker income effect and other additional elements makes the role of internal habits obscure. Wang (2012) studies news-driven business cycles from a labor-market approach. He analyzes the effects of various elements such as sticky prices, JR preferences, and internal habits, concluding that that a positive substitution effect on

[3] In this paper, we only list the studies with one-sector models. See the extensive review of the literature on two-sector models in Beaudry and Portier (2014).

labor supply is a necessary condition for a one-sector RBC model to generate news-driven business cycles. In his numerical experiments, he provides the necessary condition for the curvature parameter to generate plausible comovements between consumption and labor. In contrast, we show analytically both the sufficient and necessary conditions for news shock comovements in a simple RBC model with internal habits. From a different perspective of the above papers, our work is among the class of studies that attempt to find a model with the least departure from standard RBC assumptions to generate news-driven business cycles.

Our second contribution is to highlight the qualitative difference between internal and external habits from the news shock perspective. In the business cycle literature, consumer preferences with internal and external habits have similar qualitative features in terms of smoothing consumption dynamics in response to unanticipated shocks. We note the widespread adoption of both types of habit formation in medium-scale DSGE models to generate hump-shaped responses of consumption to exogenous shocks.[4] In particular, the adoption of both habits is common in the news shock literature. Schmitt-Grohé and Uribe (2012), Miyamoto and Nguyen (2020) and Görtz et al. (2022a, 2022b) adopt internal habits, while Leeper et al. (2010) and Faccini and Melosi (2022) employ external habits. Indeed, Dennis (2009) shows in a new Keynesian business cycle model that the two types of consumption habits exhibit similar business cycle characteristics. Both types of habits are also used to capture salient asset pricing features. Abel (1990) introduces a utility functional form with external habits to explain the equity premium puzzle in standard asset pricing models. Campbell and Cochrane (1999) introduce external habits into consumption-based asset pricing models to study the cyclical properties of the risk premium. The applications of both types of habits are vast, and we choose not to enumerate all related theoretical works here.[5]

[4]Some frameworks employ internal habit formation, e.g., Jermann (1998), Carroll et al. (2000), and Christiano et al. (2005), while others employ external habits, such as Smets and Wouters (2007), Ferrara et al. (2021), and Siena (2021).

[5]Nutahara (2010) conducts numerical experiments to compare internal and external habits in a model with investment adjustment costs. Different from his work, our paper provides analytical proof to show

Our paper is also linked with the literature on the application of KUJ preferences.[6] Both external habits (which is also known as "catching up with the Joneses" utility) and KUJ preferences are specific forms of consumption externalities, and studies have been conducted to examine their business cycle and asset pricing properties. Gali (1994) compares external habits (also called "catching up with the Joneses" utility) and KUJ utility and shows that the latter is superior in terms of asset pricing behavior such as the risk premium and risk-free return volatility. Alonso-Carrera et al. (2006) study the welfare implication of habit formation and consumption externalities. Ulph (2014) shows that the KUJ effect leads people to work who would otherwise have chosen not to, and an individual's well-being will be a strictly decreasing function of her wage rate. Klein and Krause (2020) show that the keeping up effect of consumption comparison under KUJ preferences is an important driver of consumer credit dynamics. Their estimated model significantly outperforms a model without consumption externalities. We find that although KUJ preferences alone cannot generate news-driven business cycles, they are helpful to improve the quantitative performance by increasing the marginal rate of transformation between consumption and labor. The notion of KUJ preferences can play a potentially important role in explaining news-driven business cycles.

2 RBC Model with Habit Formation

This section analyzes the effect of a TFP news shock on local dynamics to determine under what conditions the plausible comovements of key aggregate variables can arise. Consider an economy populated by a continuum of households of measure one. The representative

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the differences between two types of habits and highlights the two distinct channels from which news shock comovements could arise. Introducing investment adjustment costs into the model can mute the crowding-out effect of consumption on investment, making the effect of habit formation obscure.

[6]Based on different data sources and econometric techniques, a growing strand of literature finds empirical support for KUJ preferences. These studies include Bertrand and Morse (2016), Drechsel-Grau and Schmid (2014), Agarwal et al. (2021), De Giorgi et al. (2020), and Ravina (2019).

household maximizes the following discounted lifetime utility:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[u\left(h_t\right) - \psi n_t \right], \tag{1}$$

where $\mathbb{E}$ is the expectation operator, β is the time discount factor, ψ is the weight parameter of labor disutility, and n_t is the labor input. For simplicity, we employ indivisible labor from Hansen (1985).[7] Let h_t denote the habit-adjusted consumption (c_t),

$$h_t = c_t - \theta c_{t-1}, \text{ and } 0 < \theta < 1,$$

where θ is the habit parameter.[8] The period utility u is concave and twice differentiable, strictly increasing in consumption ($\frac{\partial u}{\partial h} > 0$ and $\frac{\partial^2 u}{\partial h^2} < 0$), and satisfies Inada conditions ($\lim_{h \to \infty} \frac{\partial u}{\partial h} = 0$ and $\lim_{h \to 0^+} \frac{\partial u}{\partial h} = \infty$). To distinguish from consumption externalities, we call the preference that contains c_{t-1} internal habit formation. The household's relative risk aversion σ is associated with the curvature of the utility function and the (inverse) elasticity of substitution (IES).

The household budget constraint is given by

$$c_t + k_{t+1} - (1-\delta)k_t = w_t n_t + r_t k_t, \tag{2}$$

where k_t is capital used for production at time t, w_t is the wage rate, r_t is the return on capital from time $t-1$ to t, and δ is the constant capital depreciation rate.

[7]For a more general form of preferences with constant Frisch labor elasticity, deriving an analytical solution for the linearized difference system becomes infeasible because we are unable to find the analytical expressions for the eigenvalues of the transition matrix. Instead, we construct a two-period model and show that the main result of this paper still holds for this type of preferences. We thank the editor for raising this point, and the two-period model and its detailed derivations are shown in Appendix C. We also discuss nonseparable preferences when the utility takes the form as in Jaimovich and Rebelo (2009) in Section 5.2.1.

[8]We adopt an additive form of habits, which is widely used in the RBC and news shock literature. There are other forms of habit formation such as multiplicative habits (see Carroll et al., 2000 and Gayle and Khorunzhina, 2018). However, Dennis (2009) demonstrates that multiplicative habits can be regarded as a special case of additive habits after the log-linearization of the Euler equation. As we will show later, our analytical results are derived from the log-linearized dynamic system.

The optimal condition is derived as

$$\frac{\partial u(h_t)}{\partial h_t} - \theta\beta\mathbb{E}_t\left[\frac{\partial u(h_{t+1})}{\partial h_{t+1}}\right] = \lambda_t, \tag{3}$$

$$\psi = \lambda_t w_t, \tag{4}$$

$$\lambda_t = \beta\mathbb{E}_t\left[\lambda_{t+1}(r_{t+1} + 1 - \delta)\right], \tag{5}$$

where λ_t is the Lagrange multiplier of the household budget constraint (2).

The remaining part of the model is fairly standard. We assume a Cobb-Douglas production function

$$y_t = A_t F(k_t, n_t) = A_t k_t^{1-\alpha} n_t^{\alpha},$$

where y_t is output, α is the labor share parameter, and A_t denotes the level of total factor productivity (TFP). Firms hire workers and use physical capital to produce output. Both output and factor markets are fully competitive, which yield the following first-order conditions: $w_t = \alpha y_t/n_t$ and $r_t = (1-\alpha)y_t/k_t$.

The competitive equilibrium of the benchmark model is defined as follows. Taking A_t and k_t as given, the competitive equilibrium is a sequence of endogenous aggregates $\{c_t, n_t, k_{t+1}, y_t\}$ and prices $\{w_t, r_t\}$ such that: (i) the representative household's choice maximizes lifetime utility (1); (ii) firms choose labor and capital inputs to maximize their profits; and (iii) output, labor, and capital (rental) markets clear.

The TFP level is exogenously determined, and the log-linearized TFP (with a "hat") follows an autoregressive process:

$$\hat{a}_t = \rho\hat{a}_{t-1} + \xi_t + \epsilon_{t-l},$$

where ρ is the persistence parameter, ξ_t is the contemporaneous shock to TFP and ϵ_{t-l} is a shock on future TFP level that will materialize l periods later (we simply call it a "news shock" hereafter). Both ξ_t and ϵ_t are independently and normally distributed (*i.i.d.*) with means of zero and variances of σ_ξ^2 and σ_ϵ^2.

Our results are based on the log-linearization model under the first-order approximation. The log-linearized optimality condition for households can be rearranged as

$$\theta\beta\mathbb{E}_t\hat{c}_{t+1} - \left(1+\theta^2\beta\right)\hat{c}_t + \theta\hat{c}_{t-1} = \frac{(1-\theta\beta)(1-\theta)}{\sigma}\hat{\lambda}_t, \tag{6}$$

$$\hat{\lambda}_t + \hat{w}_t = 0, \quad \hat{\lambda}_t - \mathbb{E}_t\hat{\lambda}_{t+1} = \widetilde{\delta}\mathbb{E}_t\hat{r}_{t+1}, \tag{7}$$

where $\tilde{\delta} \equiv 1-(1-\delta)\beta$. Note that the first term of expected consumption on the left-hand side of Eq. (6) represents the prospective channel of internal habits, as a higher level of expected future consumption has a positive effect on the choice of consumption for today. Analogously, the past consumption term captures the retrospective channel of internal habits. Denote $\hat{x}_t = \theta\beta\hat{c}_t - \hat{c}_{t-1}$, and then $\mathbb{E}_t\hat{x}_{t+1} = \theta\beta\mathbb{E}_t\hat{c}_{t+1} - \hat{c}_t$. After combing this with the other contemporaneous relations for the baseline model, the log-linearized system of equations can be written in the following matrix form:

$$z_{t+1} = Jz_t + M\begin{pmatrix}\mathbb{E}_t\hat{a}_{t+1}\\ \hat{a}_t\end{pmatrix}, \tag{8}$$

where $z_{t+1} = \left(\mathbb{E}_t\hat{\lambda}_{t+1}, \mathbb{E}_t\hat{x}_{t+1}, \hat{c}_t, \hat{k}_{t+1}\right)'$,

$$J = \begin{pmatrix} \frac{1-\alpha}{1-\alpha+\alpha\tilde{\delta}} & 0 & 0 & 0\\ \frac{(1-\theta\beta)(1-\theta)}{\sigma} & \theta & 0 & 0\\ 0 & \frac{1}{\theta\beta} & \frac{1}{\theta\beta} & 0\\ \frac{\alpha}{1-\alpha}\frac{\delta}{i_y} & -\frac{\delta c_y}{i_y}\frac{1}{\theta\beta} & -\frac{\delta c_y}{i_y}\frac{1}{\theta\beta} & 1-\delta+\frac{\delta}{i_y} \end{pmatrix}, \quad M = \begin{pmatrix} -\frac{\tilde{\delta}}{1-\alpha+\alpha\tilde{\delta}} & 0\\ 0 & 0\\ 0 & 0\\ 0 & \frac{\delta}{i_y}\frac{1}{1-\alpha} \end{pmatrix},$$

$c_y \equiv 1-(1-\alpha)\beta\delta/\tilde{\delta}$, and $i_y = 1-c_y = (1-\alpha)\delta\beta/\widetilde{\delta}$. After the change of notation, the dynamic system can be rearranged such that J is a lower triangular matrix, which helps to determine the local stability of our model by the following proposition.

Proposition 1 *The baseline RBC model with internal habit formation exhibits a saddle-path equilibrium if and only if* $0 < \theta < 1$.

Proof: Because J is a lower triangular matrix, we can determine its eigenvalues: $\zeta_1 = \frac{1-\alpha}{1-\alpha+\alpha\tilde{\delta}}$, $\zeta_2 = \theta$, $\zeta_3 = \frac{1}{\theta\beta}$, and $\zeta_4 = 1-\delta+\frac{\delta}{i_y}$. From the above, we can see that $\zeta_1 < 1$, $\zeta_2 < 1$,

$\zeta_3 > 1$ and $\zeta_4 > 1$ when $0 < \theta < 1$. Since our model has two endogenous predetermined variables (c_{t-1} and k_t), the dynamic system exhibits a unique saddle-path equilibrium. $\square$

Next, we examine the effect of a TFP news shock on the local dynamics of aggregate variables. Assuming the economy is in the steady state at time period 0, we analyze the scenario where a positive TFP news shock hits the economy in period 1. Without loss of generality, we focus on the case where the news shock materializes in period 3 ($l = 2$). We follow Blanchard and Kahn (1980) to solve the linearized difference equations (8) that characterizes the model economy and obtain the following solutions for key aggregate variables in period 1:

$$\hat{n}_1 = \eta^N \left(\overline{\sigma}^\lambda - \sigma\right), \tag{9}$$

$$\hat{y}_1 = \alpha \hat{n}_1, \tag{10}$$

$$\hat{\imath}_1 = \eta^I \left(\overline{\sigma}^I - \sigma\right), \tag{11}$$

$$\hat{c}_1 = \eta^C \left(\sigma - \underline{\sigma}^C\right), \tag{12}$$

$$\hat{\lambda}_1 = \eta^\lambda \left(\overline{\sigma}^\lambda - \sigma\right). \tag{13}$$

In the above expressions, $\overline{\sigma}^\lambda > 0$ can be interpreted as the upper bound of σ for the TFP news shock to induce an increase in current labor, $\overline{\sigma}^I > 0$ is the upper bound to cause an increase in current investment, and $\underline{\sigma}^C > 0$ is the lower bound that leads to an increase in consumption. These upper bounds and lower bounds for σ as well as $\eta^\lambda > 0$, $\eta^I > 0$, and $\eta^C > 0$ are all positive and can be expressed as structural parameters.[9]

The above solution indicates that incorporating internal habits into the plain-vanilla RBC model makes it possible to exhibit news-driven business cycles. We discuss the role of internal habits in generating this result in comparison with the scenario when internal habit formation is absent (i.e., $\theta = 0$, where the model becomes a plain-vanilla RBC model).

When $\theta = 0$, the household's first-order condition with respect to consumption is simplified to $\lambda_t = c_t^{-\sigma}$. This implies that the current consumption choice c_t and the shadow value

[9] See the detailed notations in Appendix A.2.

of income λ_t move in opposite directions, so λ_t decreases when c_t increases. According to the labor supply function (4), a decrease in λ_t shifts the labor supply curve upward. Because the physical capital stock is predetermined and the news shock does not affect the current level of TFP, both A_t and k_t are fixed and the labor demand curve remains unchanged. In equilibrium, hours worked in fact decreases. As a result, the model without internal habit formation (and of course, without other departures from standard assumptions) fails to exhibit positive comovements between consumption and hours worked. This result is well documented in the news-driven business cycle literature, e.g., Beaudry and Portier (2007) and Jaimovich and Rebelo (2009).

However, when internal habit formation is present, the prospective channel plays an important role. Specifically, current consumption and hours worked can simultaneously increase in the face of a positive TFP news shock. This is because the shadow value of income λ_t and consumption c_t can simultaneously increase when $\sigma \in (\underline{\sigma}^C, \overline{\sigma}^\lambda)$ (see in Eqs. (12) and (13)). The intuition is that with internal habits, households have greater incentives to smooth their consumption (Lettau and Uhlig, 2000). With this consumption-smoothing motive, a positive news shock causes future consumption to increase even further than in the present. According to Eq. (3), the fact that the households intend to further increase their future consumption has a positive effect on the shadow price of income for today.

Moreover, we can see from the above solutions that whether news about future TFP can exhibit comovements among consumption, hours worked, investment, and output crucially hinges on the choice of the curvature parameter for utility, σ. The following proposition summarizes the condition under which the news-shock comovements arise in the internal habit model.

Proposition 2 *In the canonical RBC model with internal habit formation, there exist curvature parameters for utility σ such that output, investment, consumption, and hours worked exhibit positive comovements in response to a positive TFP news shock. The plausible comovements arise if and only if the curvature parameter satisfies*

$$\sigma \in \left(\underline{\sigma}^C, \overline{\sigma}^I\right).$$

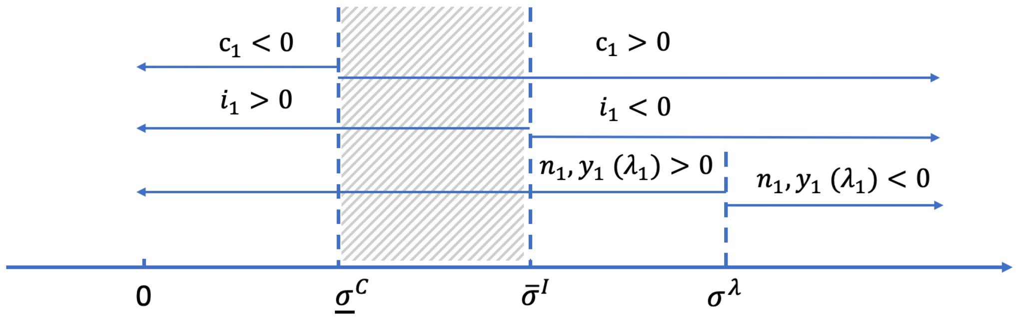


Figure 1: The curvature parameter σ for news-shock comovements. Positive comovements in output, investment, consumption, and hours worked occur when σ falls within the shaded area, i.e., $\sigma \in \left(\underline{\sigma}^C, \overline{\sigma}^I\right)$.

Proof: See the Appendix A.2.

The above proposition guarantees that one can find the appropriate curvature parameter $\sigma \in \left(\underline{\sigma}^C, \overline{\sigma}^I\right)$ so that the current responses of c_t, i_t, and n_t are all positive. Next we elaborate the economic intuitions how these lowerbound and upperbounds of σ's arise.

When a favorable TFP news shock hits the economy, it increases the household's permanent income. Whether an increase in the household's permanent income induces an increase in current consumption ($\hat{c}_1$), however, depends on the curvature parameter for utility (σ). The above proposition implies that the IES cannot be too high (or equivalently, the value of σ cannot be too low); otherwise, it would induce households to postpone their consumption until the good news materializes ($\hat{c}_1 < 0$ in that case). As a result, there is a lower bound for the curvature parameter, $\underline{\sigma}^C$, so that good news about future TFP can generate a positive consumption response.

On the other hand, we derive two upper bounds of σ for the news-driven business cycles. A too high level of σ (or equivalently, a too low level of IES) may induces a larger increase in current consumption $\hat{c}_t$ and a smaller increase in future consumption $E_t\hat{c}_{t+1}$. According to Eq. (6), the shadow value of income $\hat{\lambda}_1$ could be negative and in turn cause a decrease in hours worked. As a result, the curvature parameter σ not exceeding $\overline{\sigma}^\lambda$ guarantees a positive response of $\hat{n}_1$ in response to a favorable TFP news shock (see in Eq. (9)).[10]

Secondly, we find another upper bound $\overline{\sigma}^I$ to guarantee a current increase in investment. This is because a too high value of σ (or equivalently, a too low level of IES) leads to a stronger consumption-smoothing motive and results in a larger response of current consumption. It may crowd out investment. The upper bound of $\overline{\sigma}^I$ shows the minimal degree of IES that guarantees a relatively small crowding-out effect of consumption on investment, and it ensures that a positive TFP news shock does not decrease current investment. Our proof suggests that the condition on σ for a positive response of investment is more binding than that for an increase in the shadow price of income, $\bar{\sigma}^I < \overline{\sigma}^\lambda$. The conditions for σ that exhibits the news shock comovements are depicted in Figure 1. Positive comovements in output, investment, consumption, and hours worked occur when σ falls within the shaded area.

The above proposition shows that in a canonical RBC model with internal habit formation, a news shock on TFP can cause plausible comovements among consumption, investment, output, and hours worked. To the best of our knowledge, this is by far the smallest departure from canonical RBC framework that generates news-driven business cycles. However, the curvature parameter for utility needs to be chosen carefully such that the consumption-smoothing effect on TFP news shock is neither too high nor too low. Our paper is the first attempt to formulate a rigorous proof for such a result.

[10]According to Eq. (7), $\lambda_1 > 0$ induces a decrease in the current real wage. We find several empirical studies to support this result. Chahrour et al. (2023) used structural VAR estimation and found that TFP news shocks lead to a decline in the real wage. They also construct a labor search model in which wages are determined by a cash-flow sharing rule to replicate the observed responses of real wages. Miranda-Agrippino et al. (2022), using monthly patent applications to construct an instrumental variable and the SVAR-IV approach, found that TFP news shocks cause an initial decrease in the real wage. Yang and Zhang (2024) used a structural VAR approach with a novel integration of the proxy variables and obtained similar results.

3 Why Consumption Externalities Alone Cannot Generate Comovements

Since there are two types of habit formation commonly used in the business cycle literature, we explore whether external habits help to generate plausible news-driven business cycles. Our result shows that external habits cannot generate plausible comovements among key aggregate variables in response to a TFP news shock, and this result persists when we consider a generalized notion of consumption externalities such as KUJ preferences. The period utility of households with external habit formation is given by

$$U\left(h_t, X_t, n_t\right) = u(h_t, X_t) - \psi n_t. \tag{14}$$

where X_t is a generic form of consumption externality that is strictly positive and that households take as given. Let us denote the elasticity associated with consumption externalities by $\varepsilon_X = \frac{\partial^2 u}{\partial h_t \partial X_t} X_t / \frac{\partial u}{\partial h_t}$. The preference exhibits positive consumption externality if $\varepsilon_X > 0$. To facilitate further discussion, we instead use the notation $\chi \equiv \frac{\varepsilon_X}{\sigma}$ to represent the effect of the consumption externality.[11]

For comparison, we study the effect of consumption externalities on news shock dynamics when internal habits are absent ($\theta = 0$). We consider two types of consumption externalities commonly used in the business cycle and asset pricing literature. The first considers preferences with external habit formation from Abel (1990), that is, the consumption externality is the lagged average consumption level $X_t = C_{t-1}$. This form of consumption externality is also known as the "catching up with the Joneses effect". The second case in which $X_t = C_t$ denotes the current aggregate consumption level from Gali (1994) and is also known as the KUJ effect. Our task is to determine whether the TFP news shock generates plausible comovements among key aggregate variables. The result is summarized in the following proposition.

[11] Gali (1994) and Alonso-Carrera et al. (2006) employ a more specific form of utility, $U = \frac{h_t^{1-\sigma} X_t^{\chi\sigma}}{1-\sigma} - \psi n_t$, which is among the class of our specification. The relative risk aversion and the consumption externality parameters σ and χ resemble the definition of elasticities that we introduce.

Proposition 3 *News-driven business cycles cannot arise in the canonical RBC model with the household preferences of (14) and with two types of consumption externalities: 1) $X_t = C_{t-1}$ (external habits) and 2) $X_t = C_t$ (KUJ).*

Proof: See the Appendix A.3.

The above proposition highlights the qualitative difference between internal and external habit formation (and consumption externalities) in generating news-driven business cycles. Both internal and external habits are widely used to generate hump-shaped responses of consumption to shocks in medium-scale DSGE models. In the conventional business cycle literature, both are helpful to explain the salient aspects of asset prices, the risk premium, and qualitatively similar consumption persistence. Because of this, they are regarded as interchangeable elements in many cases.[12]

However, our analysis shows that unlike internal habit formation, consumption externalities alone cannot generate news-driven shock comovements. From the perspective of news-driven business cycles, these two elements of consumption persistence have different implications. The key difference is that with internal habit formation, households would take the potential change in future consumption into consideration (i.e., the prospective channel). The fact that households expect a higher level of future consumption is crucial to obtain comovements between current consumption and the shadow value of income. This in turn causes a rightward shift of the labor supply curve and therefore an increase in labor supply. However, the prospective channel is mute in the case of external habits because when a news shock hits the economy, households take the lagged aggregate consumption level C_{t-1} as given, so it cannot help to generate a positive comovement between consumption and labor. Note that the above result can also be applied to another form of external habits in which

[12] Christiano et al. (2005) use a utility function with internal habit formation, while Smets and Wouters (2007) employ a preference with external habit formation. Some studies employ external habits to replace internal habit formation in the utility function to simplify the optimization problem, e.g., Leeper et al. (2010), Ferrara et al. (2021), and Siena (2021).

$h_t = c_t - \theta C_{t-1}$ (e.g., Smets and Wouters, 2007).

Additionally, the preference with the KUJ effect cannot generate comovement either. The reason is as follows. In the case of KUJ preferences, an increase in C_t raises the MRS between labor and habit-adjusted consumption. It has a positive effect on the shadow value of wealth λ_t. It shifts the labor supply curve rightward, so households have greater incentives to increase their labor supply. On the one hand, to generate positive comovements between consumption and hours worked, the KUJ effect on λ_t should be large enough because it is necessary for the news shock to generate an increase in λ_t (without KUJ, there is a negative relation between c_t and λ_t, as explained in Section 2). On the other hand, a larger KUJ effect induces a higher positive response of current consumption and causes a larger crowding-out effect on investment. The proof of Proposition 3 suggests that as long as the KUJ effect causes positive comovements between consumption and labor, the crowding-out effect of consumption on investment is so large that it decreases the current level of investment. Both conditions cannot be satisfied simultaneously to generate comovements among consumption, labor, and investment.

4 Alternative Shocks

This section considers the effect of other types of news shocks commonly studied in business cycle models, specifically news to investment-specific technology (IST) shocks, government spending shocks, and preference shocks (Jaimovich and Rebelo, 2009; Schmitt-Grohé and Uribe, 2012; Guo et al., 2015). We analyze whether news driven business cycles arise under these shocks in our baseline internal habit model. We demonstrate that plausible comovements can arise under an IST news shock with additional conditions satisfied. However, for government spending news shocks and preference news shocks, favorable news fail to cause a simultaneous increase in current consumption, hours worked, and investment, as households tend to reduce their current consumption.

When more shocks are incorporated, the household utility is given by

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[\varrho_t u\left(h_t\right) - \psi n_t\right], \tag{15}$$

where ϱ_t is a multiplicative preference shock that affects household's marginal utility of consumption. The budget constraint is

$$c_t + \frac{k_{t+1} - (1-\delta)k_t}{\nu_t} = w_t n_t + r_t k_t - g_t. \tag{16}$$

Here, ν_t denotes the IST shock, and g_t represents government consumption goods financed by lump-sum taxes.

Analogous to TFP shocks, the alternative shocks mentioned above (in logs) are specified as stationary first-order autoregressive processes:

$$\hat{\varkappa}_t = \rho_\varkappa \hat{\varkappa}_{t-1} + \xi_{\varkappa,t} + \epsilon_{\varkappa,t-l}, \text{ for } \varkappa = \{\varrho, \nu, g\}.$$

Here, $\rho_\varkappa$ is the persistence parameter, $\xi_{\varkappa,t}$ is a contemporaneous shock and $\epsilon_{\varkappa,t-l}$ is a news shock that will materialize l periods later. Both $\xi_{\varkappa,t}$ and $\epsilon_{\varkappa,t-l}$ are *i.i.d.* with means of zero and variances of $\sigma^2_{\xi_\varkappa}$ and $\sigma^2_{\epsilon_\varkappa}$.

4.1 IST News Shocks

We use the same method as in Section 2 to solve for the current variables under an IST news shock. The following proposition summarizes the conditions under which the IST news shock comovements arise in the baseline internal habit model.

Proposition 4 *In the canonical RBC model with internal habit formation, there exist curvature parameters for utility σ such that output, investment, consumption, and hours worked exhibit positive comovements in response to a positive IST news shock. The plausible comovements arise if and only if*

$$\sigma \in \left(\underline{\sigma}_\nu^C, \overline{\sigma}_\nu^I\right) \text{ and } \theta + \delta > 1.$$

Proof: See the Appendix A.4.

Similar to TFP news shocks, IST news can also generate plausible comovements among consumption, investment, output, and hours worked when the value of parameter σ is carefully chosen. This is because favorable shocks of both types are positive supply shocks that increase households' future permanent income. However, for IST news shocks, an additional condition $\theta > 1 - \delta$ needs to be satisfied to ensure that the shadow value of income at time t (λ_t) increases. Intuitively, IST news shocks require a certain degree of habit formation (θ) to generate plausible comovements. The key difference is that TFP shocks can raise both wages and returns on capital, while IST shocks affect the efficiency of investment and hence only the return on capital. A favorable IST shock cannot directly increase the wage rate and, consequently, the firm's labor demand. As discussed in Section 3, an increase in hours worked, primarily induced by an increase in the shadow value of income, is crucial for generating news-driven business cycles. Without this effect on labor demand, the IST news shock requires a larger prospective channel (i.e., a larger value of θ) to increase current labor. Our results align with those studying the effect of IST news shocks in RBC models, such as Jaimovich and Rebelo (2009) and Guo et al. (2015).

4.2 Government Spending Shocks and Preference Shocks

Next, we solve for the current variables under a government spending news shock as well as a change in future preferences. The solutions show that an increase in future government spending leads to increases in current investment, output, and hours worked but a decrease in current consumption. The same responses occur when the economy is hit by positive news about households' consumption preferences.

Intuitively, a government spending news shock generates a negative wealth effect, prompting households to reduce current consumption. As consumption decreases, the marginal utility of consumption rises, leading to an increase in hours worked and, consequently, higher output. Given the decrease in current consumption and the increase in current output, current investment also rises according to the market-clearing condition for consumption goods. Regarding a positive preference news shock, it increases future marginal utility of consumption, causing households to reduce their current consumption. The effects of these two demand shocks are consistent with the standard RBC model without habit formation ($\theta = 0$). The following proposition summarizes the effects of both types of news shocks.

Proposition 5 *In the canonical RBC model with internal habit formation, the plausible comovements cannot arise under a government spending news shock or a consumption preference news shock.*

4.3 Unanticipated TFP shocks

The preceding sections analyzed the effects of various types of news shocks. We now briefly discuss the impact of unanticipated TFP shocks. Following Dennis (2009), we incorporate both internal and external habits into our baseline RBC model and compare the (co)variances of output, consumption, and hours worked in response to unanticipated TFP shocks. The parameter values used are standard in the RBC literature and will be described in Section 5.2.[13] The results on business cycle characteristics are presented in Appendix C.

Consistent with Dennis (2009), our findings show that the business cycle characteristics are broadly similar under both internal and external habit specifications. To further demonstrate this, we also present the impulse responses of key macroeconomic aggregates to a positive unanticipated TFP shock for both specifications (see Appendix C). The quantitative differences between the two are minimal.

[13] The parameter values are identical to those in the baseline model, except for the habit formation parameters (θ) and the IES parameter (σ). The habit parameter $\theta = 0.92$ reflects the mean value estimated in the SGU model for both internal and external habits. The IES parameter (σ) is set to 1, consistent with the majority of studies on unanticipated shocks. The TFP persistence parameter is set to 0.85, aligning with our estimates and values commonly used in the literature.

5 Numerical Results

5.1 Internal Habits v.s. External Habits: A Quantitative Example

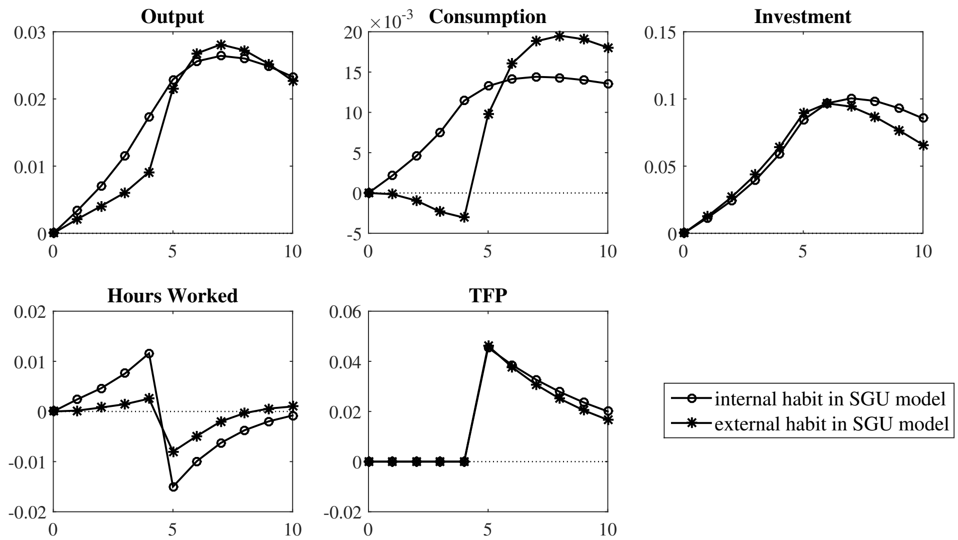
The above sections have demonstrated the distinction between two types of habits regarding news-driven business cycles. However, existing studies in the news shock literature suggest that incorporating additional elements, such as investment adjustment costs, variable capital utilization, and Jaimovich-Rebelo (JR) preferences, into a plain-vanilla RBC model can facilitate the emergence of news-driven business cycles, and internal habit formation is one such element. One potential concern is whether the qualitative difference between internal and external habits in news-driven business cycles has a quantitative impact in a medium-scale DSGE model where these additional elements are already incorporated. In this section, we conduct a quantitative exercise and demonstrate that the difference between internal and external habits is indeed significant.

Specifically, we employ both internal and external habits in a medium-scale DSGE model from Schmitt-Grohé and Uribe (2012). We perform Bayesian estimation for both cases, while leaving the other parts of the model unchanged. We choose their model for two main reasons: first, the model is developed for analyzing the quantitative impact of news shocks on business cycles and aligns well with empirical second moments.[14] Second, the model includes elements such as JR preferences, investment adjustment costs, and capital utilization, all of which facilitate comovement among key macroeconomic aggregates. The utility function takes the following form:

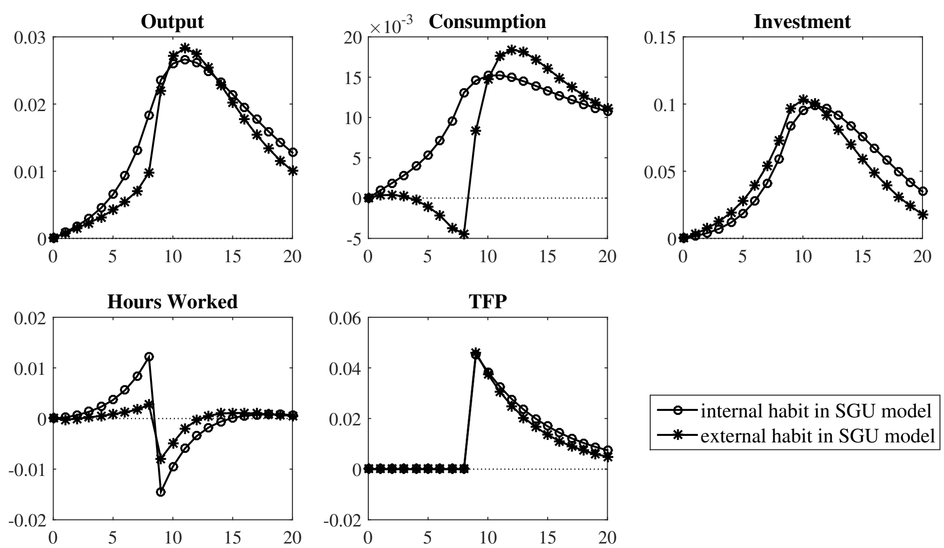
$$U = \frac{(h_t - \psi n_t^{\varphi} s_t)^{1-\sigma} - 1}{1-\sigma}, \quad s_t = h_t^{\gamma} s_{t-1}^{1-\gamma},$$

where $h_t = c_t - \theta c_{t-1}$ under internal habits and $h_t = c_t - \theta C_{t-1}$ under external habits. The calibrated parameter values we use are from Schmitt-Grohé and Uribe (2012). For both cases, we use the same standard prior distributions commonly used in the DSGE literature.

[14] Miyamoto and Nguyen (2020) employs this framework to analyze the expectational effects of news in business cycles using forecast data. Born et al. (2013) and Görtz et al. (2022a) extend the model of Schmitt-Grohé and Uribe (2012) to investigate the fiscal foresight and inventories dynamic respectively.



(a) News shock hits the economy 4 quarters before it materializes



(b) News shock hits the economy 8 quarters before it materializes

Figure 2: Impulse responses of key variables to a positive one-standard deviation news shock on future TFP. Variables are detrended and expressed as percentage deviation from their steady states. In a internal habit model, both consumption and hours worked increase following positive news. In contrast, with external habits, consumption initially decreases.

We provide a detailed description of the estimation model and process in Appendix A.4. The prior distributions and posterior estimation results are reported in Table 1. For both cases, the estimated habit parameters are very close to each other, with a mean of 0.921 for internal habits and 0.922 for external habits. Moreover, the posterior distribution for the persistence and standard deviation of TFP news shocks is similar in both cases. Figure 2 shows the impulse responses to a positive TFP news shock in both scenarios. In Panel (a) and (b), agents receive the news 4 and 8 quarters before it materializes, respectively, as in Schmitt-Grohé and Uribe (2012). And we use the posterior modes as parameter values when plotting the impulse responses. After the news shock materializes, the responses are quite similar in both cases. The key difference occurs before the news shock is realized. Specifically, with internal habits, both consumption and hours worked increase after households receive the positive news, whereas under external habits, consumption decreases initially. Furthermore, the estimated model with internal habits has a higher value of the log marginal density (-1673) than that with external habits (-1713), indicating stronger support for the internal habit model.

We also analyze the differences between internal and external habits in generating news-driven business cycles from other perspectives. In the quantitative framework proposed by Schmitt-Grohé and Uribe (2012), incorporating elements such as JR utility, investment adjustment costs, and variable capital utilization to the plain-vanilla RBC model can generate news-driven business cycles with relative ease. As a result, the estimated model with external habits may also generate comovements. However, depending on whether internal or external habit is considered, the range of parameter values for news shock comovements may differ.

We use the mode estimates in Table 1 and vary the JR income effect parameter (γ) and the investment adjustment cost parameter (κ) to examine whether news shock comovements still arise or not. The ranges of parameters for plausible news shock comovements are shown in Figure 3. The pairs of parameters for the internal habit model that generate comovements are in the region with white circles, and the region of black dots represents the external habit

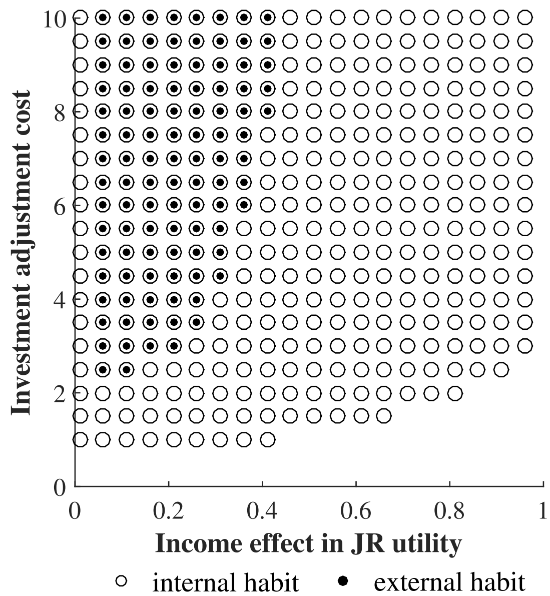


Figure 3: Comovement region in the internal and external habit model with JR preferences and investment adjustment costs. The pairs of parameters for news shock comovements are wider in the internal habit model.

models. The results show that the pairs of parameters for news shock comovements are wider in the internal habit model. Therefore, it is relatively easier for the internal habit model to generate news-driven business cycles than the external habit model.

5.2 Calibration: Baseline Model

This section shows the numerical results of the benchmark RBC model with internal habits only. Specifically, we choose $\alpha = 0.64$, $\beta = 0.985$, $\delta = 0.0125$, and $\theta = 0.85$, as in Jaimovich and Rebelo (2009). Our numerical analysis reveals that TFP news shocks can induce news-driven business cycles for certain values of curvature parameter σ within the range of $(0.24, 0.34)$. However, the values of σ that generate comovements are generally lower than those typically used in the business cycle literature. This finding is consistent with the results obtained by Wang (2012). The limited quantitative performance of our

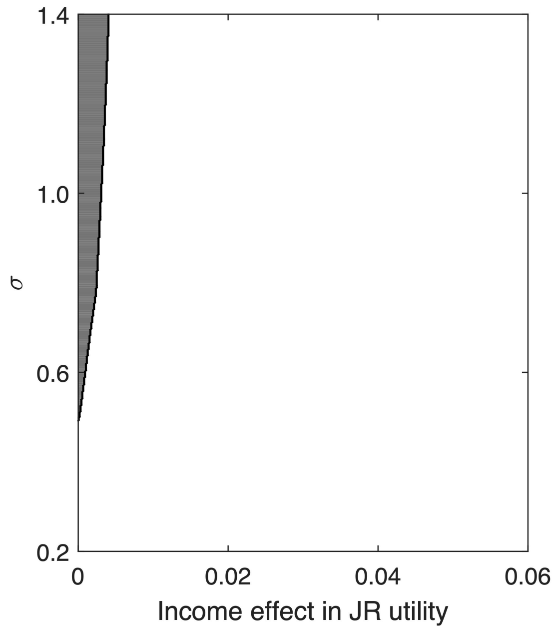


Figure 4: Comovement region in the internal habit model. The model can generate plausible comovements in the dark grey region.

model primarily stems from the absence of additional elements. However, there are various approaches available to address this quantitative limitation. In the subsequent subsections, we initially explore the inclusion of additional elements that have been utilized in the literature on news-driven business cycles, such as JR preferences and investment adjustment costs. Subsequently, we introduce a novel approach to rectify this issue.

5.2.1 The JR Preference and Investment Adjustment Costs

We begin by examining how the inclusion of JR preferences affects the range of the risk aversion parameter σ for the news-driven business cycle. The period utility of the representative household à la Jaimovich and Rebelo (2009) takes the following form:

$$U = \frac{(h_t - \psi n_t X_t)^{1-\sigma}}{1-\sigma}, \text{ and } X_t = h_t^{\gamma} X_t^{1-\gamma}. \tag{17}$$

The left panel of Figure 4 illustrates how the income effect parameter γ affects the range of σ for comovements. The points located in the grey region represent the parameter pairs of

(γ, σ) that can generate news shock comovements. We can see that when γ is very close to zero, the range of σ for comovements becomes wider. In this case, the model would achieve a labor supply schedule with a near-zero wealth effect, which is similar to the preference in Greenwood et al. (1988). It helps to generate an increase in hours worked in response to positive news.

Alternatively, another approach is to incorporate investment adjustment costs into the model. In this case, the household budget constraint is given by

$$c_t + i_t = w_t n_t + r_t k_t, \text{ and } k_{t+1} = (1-\delta)k_t + i_t \left[1 - \varphi\left(\frac{i_t}{i_{t-1}}\right)\right], \tag{18}$$

where $\varphi(\cdot)$ represents the adjustment cost function that satisfies $\varphi(1) = 0, \varphi'(1) = 0$, and $\varphi''(1) = \kappa > 0$. The right panel of Figure 4 illustrates the effect of the investment adjustment cost parameter (κ) on the range of σ for comovements, while maintaining all other settings of the baseline model unchanged. We can see that increasing κ allows us to maintain news shock comovements while selecting a commonly-used value for σ. This is due to the fact that, with investment adjustment costs, agents choose to gradually increase investment to mitigate the costs associated with adjustments. As a result, the model exhibits simultaneous increases in consumption and investment in response to a positive news shock.

5.2.2 The KUJ Preferences

In this section, we introduce a novel approach to expand the range of σ for news shock comovements. We present analytical proofs illustrating how the incorporation of KUJ-type preferences can enhance the value of σ for comovements.[15] The period utility of households with KUJ preferences is given by

$$U(h_t, C_t, n_t) = u(h_t, C_t) - \psi n_t, \tag{19}$$

[15]When consumption externalities are in the form of external habits, the conditions under which the comovements arise do not change because the past consumption channel cannot affect the contemporaneous response of variables to a news shock. Thus, we do not consider the combination of internal and external habits here.

where C_t denotes the aggregate level of consumption at time t. The following proposition shows the necessary and sufficient conditions for news-driven business cycles when the KUJ preferences are incorporated.

Proposition 6 *In the model with internal habit formation and KUJ preferences, the main aggregate variables exhibit comovements in response to a TFP news shock if and only if* $\chi \in (-\infty, 1)$ *and the curvature parameter satisfies*

$$\sigma \in \left(\underline{\sigma}_\chi, \overline{\sigma}_\chi\right),$$

and the lower and upper bounds of $(\underline{\sigma}_\chi, \overline{\sigma}_\chi)$ *that guarantee news-driven business cycles are given by*

$$\underline{\sigma}_\chi \equiv \frac{\left(\mu_3+\mu_4-\rho\right)\mu_4\mu_3}{\frac{\alpha}{1-\alpha}\frac{1}{c_y}\left(\mu_4-\rho\right)\mu_4+\frac{1}{(1-\alpha)\beta+c_y\tilde{\delta}}\left(\mu_3-\rho\right)\mu_3}\frac{\left(1-\theta\beta\right)\left(1-\theta\right)}{\left[1-(1-\theta)\chi\right]\left(\mu_4-\mu_2\right)}>0,$$

and $\bar{\sigma}_\chi (> \underline{\sigma}_\chi)$ *is the greater root of the following quadratic equation*

$$\Gamma(\sigma) = \sigma^2 + s_1'\sigma + s_0' = 0,$$

and μ_1*,* μ_2*,* μ_3*,* μ_4*,* s_0'*, and* s_1' *are short-hand notations for structural parameters.*

Proof: The proof of Proposition 4 is similar to that of Proposition 2. The condition for the range of the KUJ parameter χ is to guarantee a unique saddle-path equilibrium. See the Appendix A.5 for details. □

The above proposition is a generalized version of Proposition 2 with KUJ preferences. The intuition is similar to those we find in Proposition 2. To generate positive responses of current consumption, investment, output, and hours worked, the curvature parameter σ should satisfy the following condition: $\underline{\sigma}_\chi < \sigma < \overline{\sigma}_\chi$. Internal habit formation introduces the prospective channel, and it enhances the household's consumption-smoothing motive, taking as given the curvature parameter σ. In the face of a positive TFP news shock, the total consumption-smoothing effect (from a lower level of σ and the internal habit formation) should be large enough for the TFP news shock to cause an initial increase in consumption.

However, the consumption-smoothing effect cannot be too large because an excessively strong consumption-smoothing motive induces a larger initial increase in consumption and may crowd-out investment. The upper bound of $\overline{\sigma}_\chi$ guarantees that the crowding-out effect on investment is not so large as to prevent current investment from decreasing.

The key finding is that the KUJ parameter χ can affect both the lower and upper bound $(\underline{\sigma}_\chi, \overline{\sigma}_\chi)$. By analyzing the effect of consumption externalities on the range of the curvature parameter for comovements, we find the following proposition.

Proposition 7 *In a canonical RBC model with internal habit formation and KUJ preferences, the upper and lower bounds of σ for news-driven business cycles are both increasing in the degree of the KUJ effect, χ.*

Proof: We prove the above comparative statics by calculating the partial derivative of the lower and upper bound of σ with respect to χ by using the expressions

$$\frac{\partial \overline{\sigma}_\chi}{\partial \chi} = -\frac{\frac{\partial \Gamma}{\partial \chi}}{\frac{\partial \Gamma}{\partial \sigma_\chi}} > 0.$$

Additionally, we find that $\frac{\partial \underline{\sigma}_\chi}{\partial \chi} > 0$. This result implies that a larger KUJ effect makes it possible to obtain news-driven business cycles with a smaller IES (measured by the inverse of σ). To further explain why this result arises, we find the following proposition that a larger KUJ effect can increase both the lower and upper bound of $(\underline{\sigma}_\chi, \overline{\sigma}_\chi)$ because a larger value of χ increases the response of the shadow value of income λ_1, taking as given the size of the TFP news shock.

Proposition 8 *In the model with internal habit formation and KUJ preferences, when the news-driven business cycle arises, a larger KUJ effect, (i.e., a higher level of χ) increases the positive response of λ_1.*

Proof: The solution of λ_1 in terms of a TFP news shock is $\hat{\lambda}_1 = \eta_\chi^\lambda \left(\sigma_\chi^\lambda - \sigma\right)$, where the expression for η_χ^λ and σ_χ^λ are given by

$$\eta_\chi^\lambda \equiv -\frac{1}{\varphi_1} \frac{\delta c_y [1-(1-\theta)\chi]\vartheta_2}{i_y(\mu_4 - \rho)} \frac{\mu_1(\mu_3 - \mu_1)}{(\mu_4 - \mu_1)(1-\theta\beta)(1-\theta)\mu_4^2} > 0,$$

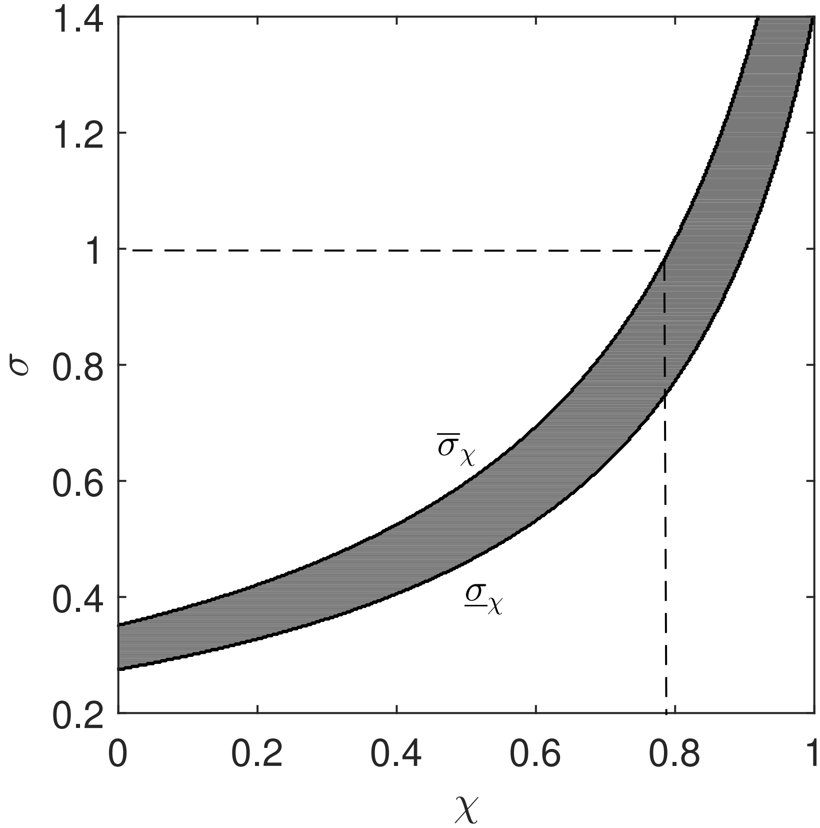


Figure 5: Values of σ for comovements with KUJ preferences. The model can generate plausible comovements in the dark grey region.

$$\sigma_{\chi}^{\lambda} \equiv \left[\frac{(\mu_4 + \mu_3 - \rho)(\mu_4 - \mu_1)}{\mu_3 - \rho} + \mu_3 \right] \frac{(1 - \theta\beta)(1 - \theta)}{\mu_1 (\mu_3 - \mu_1)} \frac{\vartheta_1}{\vartheta_2} \frac{\mu_4^2}{\mu_4[1 - (1 - \theta)\chi] - \theta} > 0,$$

From the above, φ_1, ϑ_1, ϑ_2, c_y and i_y can be expressed by structural parameters. Additionally, μ_1, μ_3, and μ_4 are unaffected by χ. Therefore, it is easy to verify that $\frac{\partial \hat{\lambda}_1}{\partial \chi} = \eta_{\chi}^{\lambda} \frac{\partial \sigma_{\chi}^{\lambda}}{\partial \chi} + (\sigma_{\chi}^{\lambda} - \sigma) \frac{\partial \eta_{\chi}^{\lambda}}{\partial \chi} > 0$. Thus, the coefficient for the solution of λ_1 becomes larger when χ increases. The intuition is that taking as given the increase in the aggregate consumption level, a larger KUJ effect further increases the MRS between consumption and labor. A larger increase in λ_1 encourages the household to supply more labor, so output increases by more. The relaxation of output resources means that the model can endure a larger crowding-out effect of consumption on investment, so the required IES can be lower (or equivalently, a higher level of σ).

To provide a better illustration of the effect of χ on the range $\left(\underline{\sigma}_{\chi}, \overline{\sigma}_{\chi}\right)$, we present a numerical example in Figure 5. In this example, we utilize the same parameter values for α, β, δ, and θ as in the baseline model. We can see that when $\chi = 0$, there exist certain values of σ that lead to the emergence of news-driven business cycles in response to TFP news shocks. However, the values of σ for comovements are lower than those commonly chosen in the business cycle literature. As χ increases, however, both the lower and upper bounds of σ for news-driven business cycles increase. When the value of χ is increased to 0.87, the model can generate plausible news shock comovements when $\sigma = 1$.

6 Concluding Remarks

This paper analytically demonstrates that in a standard RBC framework, internal habits alone can generate positive comovements among consumption, hours worked, investment, and output in response to news about future fundamentals. We highlight the prospective channel of internal habits, through which the effect of news shocks about future is transmitted to the present and impacts current consumption, labor, and investment. This channel distinguishes internal habits from external habits and other forms of consumption externalities. Without the prospective channel, the latter two modifications to consumer preferences cannot generate plausible comovements among key macroeconomic aggregates. Therefore, we advise one to employ internal habits in consumer preferences when designing quantitative dynamic models for the purpose of news-driven business cycles.

We conduct numerical experiments in the Schmitt-Grohé and Uribe (2012) model by substituting internal habits with external habits. The findings from our estimated model show that, unlike internal habits, external habits fail to generate the news-driven business cycle. So the quantitative difference between internal and external habits is substantial. In numerous theoretical works on business cycles, internal habits have become an integral component of DSGE models and are often combined with other elements. One caveat is that when studying the effect of news shocks, the prospective channel of internal habits remains latent in their model environments. If this prospective effect of internal habits were unrecognized, one might overstate the importance of other elements for generating news-driven business cycles. This is especially the case when the curvature parameter chosen is small, as internal habits *alone* can help to generate plausible comovements among macroeconomic aggregates.

Despite this, our numerical exercise shows that without additional elements, the range of the curvature parameter for consumer preferences is below those commonly used in the DSGE literature. We demonstrate that the problem can be resolved by introducing the KUJ effect into the utility function. We discuss other means of extensions that help to increase the range of the parameter for the comovements. The first way is to introduce investment adjustment costs, a commonly used modification we can impose on the supply side.[16] With investment adjustment costs, households on impact gradually increase investment to the realization of a positive news shock to reduce the adjustment cost. The crowding-out effect of consumption on investment is largely dwarfed, so the upper bound constraint of the curvature parameter can be relaxed. However, investment adjustment costs generate a negative response of asset prices to a positive news shock, which contradicts the empirical evidence. The second way is to employ the nonseparable utility function proposed in Jaimovich and Rebelo (2009). The nonseparability between consumption and labor in the preference structure generates a small wealth effect on labor supply, so that a positive news shock causes a larger positive response of labor. However, unlike internal habits, merely introducing nonseparable utility alone cannot generate news-driven business cycles.[17] Arguably, our paper provides nearly the least departure from RBC setting needed to obtain plausible news shock comovements.

[16]See, e.g., Christiano et al. (2008). Nutahara (2010) considers news-driven business cycles in an RBC model with both internal habits and investment adjustment costs. The numerical experiments show that with investment adjustment costs, news shock comovements can be obtained when the curvature parameter is 2, well above the commonly used values of curvature parameters.

[17]In the Appendix, we provide analysis on nonseparable utility functions. The proof is shown in Appendix B.

A Appendix

A.1 Proof of Proposition 1

The log-linearized system of equations can be summarized as follows:

$$\theta\beta\mathbb{E}_t\hat{c}_{t+1} - \left(1+\theta^2\beta\right)\hat{c}_t + \theta\hat{c}_{t-1} = \frac{(1-\theta\beta)(1-\theta)}{\sigma}\hat{\lambda}_t, \tag{A.1}$$

$$\hat{\lambda}_t - \mathbb{E}_t\hat{\lambda}_{t+1} = \widetilde{\delta}\mathbb{E}_t\hat{r}_{t+1},$$

$$\hat{k}_{t+1} = (1-\delta)\hat{k}_t + \delta\hat{\imath}_t,$$

and the contemporaneous relations are

$$\hat{\lambda}_t + \hat{w}_t = 0, \quad \hat{y}_t = \hat{a}_t + (1-\alpha)\hat{k}_t + \alpha\hat{n}_t,$$

$$\hat{w}_t = \hat{y}_t - \hat{n}_t, \ \hat{r}_t = \hat{y}_t - \hat{k}_t, \text{ and } \hat{y}_t = c_y\hat{c}_t + i_y\hat{\imath}_t,$$

Denote $\hat{x}_t = \theta\beta\hat{c}_t - \hat{c}_{t-1}$. After simplification, the system of equations can be rearranged into matrix form as in Eq. (8). Under such arrangement, we can find the eigenvalues of the difference equation system and determine its local stability.

A.2 Proof of Proposition 2

This section shows the proof of Proposition 2. By Eq. (9), we can see that both output ($\hat{y}_1$) and hours worked ($\hat{n}_1$) have positive responses when $\sigma < \overline{\sigma}^\lambda$. This condition, in turn, requires that the shadow value of income ($\hat{\lambda}_1 > 0$) is positive (see in Eq. (13)). Additionally, to ensure an increase in consumption ($\hat{c}_1$), we need $\sigma > \underline{\sigma}^C$ according to Eq. (12). For the TFP news shock to induce an increase in investment ($\hat{\imath}_1 > 0$), it is necessary for $\sigma < \overline{\sigma}^I$. We verify that $\overline{\sigma}^I < \overline{\sigma}^\lambda$, i.e., the upper bound that induces positive investment is more binding. Lastly, we show that $\underline{\sigma}^C < \overline{\sigma}^I$ to guarantee the existence of a curvature parameter σ that generates the news-driven business cycle.

We first solve the linearized system (8) under a favorable TFP news shock and derive the solutions for consumption, labor, investment, and output. Following Blanchard and

Kahn (1980), we solve the simultaneous difference equation system, assuming that the TFP news shock hits the economy in period 1. The following expressions for the main aggregate variables in period 1 are obtained:

$$\hat{\lambda}_1 = \eta^{\lambda}\left(\overline{\sigma}^{\lambda} - \sigma\right), \tag{A.2}$$

$$\hat{c}_1 = \eta^{C}\left(\sigma - \underline{\sigma}^{C}\right), \tag{A.3}$$

$$\hat{n}_1 = \frac{1}{1-\alpha}\hat{\lambda}_1 \equiv \eta^{N}\left(\overline{\sigma}^{\lambda} - \sigma\right), \tag{A.4}$$

$$\hat{\imath}_1 = -\eta_0^{I}(\sigma^2 + s_1\sigma + s_0), \tag{A.5}$$

where $\overline{\sigma}^{\lambda}$, $\underline{\sigma}^{C}$, η^{λ}, η^{N}, η^{C}, and η_0^{I} are positive parameters and take the following form:

$$\overline{\sigma}^{\lambda} = \left[\frac{(\zeta_4+\zeta_3-\rho)(\zeta_4-\zeta_1)}{\zeta_3-\rho} + \zeta_3\right]\frac{\omega_0\kappa_0}{\zeta_1(\zeta_3-\zeta_1)} > 0,$$

$$\underline{\sigma}^{C} = \frac{(\zeta_3+\zeta_4-\rho)\zeta_4\zeta_3}{\frac{\alpha}{1-\alpha}\frac{1}{c_y}(\zeta_4-\rho)\zeta_4 + \frac{1}{(1-\alpha)\beta+c_y\tilde{\delta}}(\zeta_3-\rho)\zeta_3}\frac{(1-\theta\beta)(1-\theta)}{\zeta_4-\zeta_2} > 0,$$

$$\eta^{\lambda} = \frac{\zeta_4-\zeta_1}{\left[\delta c_y\frac{\zeta_3\zeta_4}{\zeta_4-\zeta_2} + \frac{\alpha\sigma\delta(\zeta_3-\zeta_1)}{(1-\theta\beta)(1-\theta)(1-\alpha)}\right]}\frac{\delta c_y}{(\zeta_4-\rho)(\zeta_4-\zeta_2)}\frac{\zeta_1(\zeta_3-\zeta_1)}{(\zeta_4-\zeta_1)\kappa_0} > 0,$$

$$\eta^{N} = \frac{1}{1-\alpha}\eta^{\lambda} > 0,$$

$$\eta^{C} = \frac{\delta}{i_y}\frac{1}{(\zeta_4-\rho)\zeta_4\sigma}\frac{\frac{(\zeta_4-\rho)\zeta_4(1-\zeta_1)}{(\zeta_3-\rho)\zeta_3} + \frac{\delta c_y}{i_y}\frac{\zeta_1}{\zeta_4}}{\frac{\alpha\delta\theta\beta\sigma(\zeta_3-\zeta_1)}{i_y(1-\theta\beta)(1-\theta)(1-\alpha)} + \frac{\delta c_y}{i_y}\frac{\zeta_4}{\zeta_4-\zeta_2}}\frac{1}{1-\alpha} > 0,$$

$$\eta_0^{I} = \frac{\alpha}{1-\alpha}\frac{1}{(1-\theta\beta)(1-\theta)\frac{\zeta_3}{\zeta_3-\zeta_1}c_y + \frac{\alpha}{1-\alpha}\frac{\zeta_4-\zeta_2}{\zeta_4}\sigma}\frac{1}{(\zeta_4-\rho)\kappa_0}\frac{\zeta_1}{\zeta_4}\frac{c_y}{i_y}\frac{(1-\theta\beta)(1-\theta)}{\sigma} > 0.$$

In the above expressions, ζ_1- ζ_4 are eigenvalues for the difference equation system (8), and the other auxiliary variables we introduce are given by

$$\omega_0 = \frac{\tilde{\delta}}{1-\alpha+\alpha\tilde{\delta}},$$

$$\kappa_0 = (1-\theta\beta)(1-\theta)\frac{(1-\alpha)i_y}{\delta}\frac{\zeta_4^2}{\zeta_4-\zeta_2} > 0.$$

For the solution of current investment (A.5), the coefficients s_0 and s_1 take the following form:

$$s_0 \equiv -(1-\theta\beta)(1-\theta)\frac{1-\alpha}{\alpha}\frac{\zeta_3 c_y}{\zeta_3-\zeta_1}\frac{\zeta_4+\zeta_3-\rho}{\zeta_3-\rho}\frac{\omega_0\kappa_0}{\zeta_1} < 0,$$

$$s_1 \equiv \left[(1-\theta\beta)(1-\theta)\frac{1-\alpha}{\alpha}\zeta_3 c_y - \frac{(\zeta_3-\zeta_1)(\zeta_4+\zeta_3-\rho)+\zeta_2(\zeta_4-\rho)}{\zeta_3-\rho}\frac{\omega_0\kappa_0}{\zeta_1}\right]\frac{1}{\zeta_3-\zeta_1}.$$

To determine the range of σ that results in an increase in investment ($\hat{\imath}_1 > 0$), we need to examine the value of two roots for the following quadratic equation.

$$\Omega(\sigma) = \sigma^2 + s_1\sigma + s_0.$$

Let denote $\overline{\sigma}^I$ the larger root and $\underline{\sigma}^I$ the smaller root, the solution for current investment can be rewritten as

$$\hat{\imath}_1 = -\eta_0^I(\sigma^2 + s_1\sigma + s_0) = -\eta_0^I(\overline{\sigma}^I - \sigma)(\underline{\sigma}^I - \sigma) = -\eta_0^I\Omega(\sigma). \tag{A.6}$$

Due to the complex expressions, it is more convenient to find the ranges of $\overline{\sigma}^I$ and $\underline{\sigma}^I$ without examining the expressions of these two roots.

First, we can verify that $\Omega(0) = s_0 < 0$, so the smaller root is negative ($\underline{\sigma}^I < 0$), so we can rearrange the expression of $\hat{\imath}$ as

$$\hat{\imath}_1 = \eta^I(\overline{\sigma}^I - \sigma), \quad \text{where } \eta^I = -\eta_0^I(\underline{\sigma}^I - \sigma) > 0. \tag{A.7}$$

To compare which upper bound ($\overline{\sigma}^\lambda$ or $\overline{\sigma}^I$) is more binding, it is more straightforward if we define an intermediate variable σ_0^I that is smaller than $\overline{\sigma}^\lambda$:

$$\sigma_0^I \equiv \frac{(\zeta_3-\zeta_1)(\zeta_4+\zeta_3-\rho)+\zeta_2(\zeta_4-\rho)}{\zeta_3-\rho}\frac{\omega_0\kappa_0}{\zeta_1(\zeta_3-\zeta_1)} > 0.$$

It is easy to verify that $\sigma_0^I < \overline{\sigma}^\lambda$ and $(\sigma_0^I)^2 + s_1\sigma_0^I + s_0 > 0$. As a result, the larger root, $\overline{\sigma}^I$, lies between 0 and σ^I, and we have $\underline{\sigma}^I < 0 < \bar{\sigma}^I < \sigma_0^I < \overline{\sigma}^\lambda$. Therefore, we have $\Omega(\sigma) < 0$ for $\sigma \in \left(0, \overline{\sigma}^I\right)$. by Eqs. (A.6) and (A.7), we can conclude that the current response of investment is positive when $\sigma \in \left(0, \overline{\sigma}^I\right)$, where $\overline{\sigma}^I$ is the upper bound for the curvature parameter σ to that induces $\hat{\imath} > 0$.

We derive general formulae for a class of RBC models when proving Proposition 2, and the RBC model with both internal habit formation and the KUJ effect is one case in this class. The model with internal habit formation is a special case when $\chi = 0$, so the general formulae we derived above can be still used.

A.3 Proof of Proposition 3

This section shows the detailed proof of Proposition 3. We demonstrate the proof in two parts. First, we show that the preference that exhibits external habit formation (or "catching up with the Joneses effect") cannot generate news-driven business cycles. Second, we prove that news-driven business cycles cannot arise when $X_t = C_t$, i.e., the KUJ effect in Gali (1994).

A.3.1 External habits

This section shows the main steps of proving that news-driven business cycles cannot arise when $X_t = C_{t-1}$. We can use similar steps to show that news-driven business cycles cannot arise when external habit formation ($h_t = c_t - \theta C_{t-1}$) is present.

In the case of $X_t = C_{t-1}$, if we combine the first-order conditions with respect to c_t and n_t, we have the following expression:

$$\frac{-\partial U(c_t, C_{t-1}, n_t)/\partial n_t}{\partial F/\partial n_t} = \frac{\partial U(c_t, C_{t-1}, n_t)}{\partial c_t}.$$

Due to the separability and concavity of the utility function, we know that $-\partial U(c_t, C_{t-1}, n_t)/\partial n_t$ is a function n_t and is increasing in n_t. The denominator on the left-hand side is the marginal product of labor, and due to the diminishing marginal product of labor, $\partial F/\partial n_t$ is decreasing in n_t. As a result, the left-hand side of the expression is increasing in n_t. Additionally, in the above equation, C_{t-1} and k_t are predetermined variables, and A_t remains unchanged in the current period; we can verify that $\frac{\partial c_t}{\partial n_t} < 0$. This implies that consumption and hours worked cannot increase simultaneously in response to a positive TFP news shock. □

A.3.2 Keeping up with the Joneses effect

Define $\epsilon_{CC} = -\frac{c_t \partial^2 u/\partial(c_t)^2}{\partial u/\partial c_t}\Big|_{c_t=C_t=\bar{c}} > 0$ and $\epsilon_X = \frac{c_t \partial^2 u/\partial c_t \partial C_t}{\partial u/\partial c_t}\Big|_{c_t=C_t=\bar{c}}$. These notations are introduced for the purpose of log-linearization. Due to the empirical evidence in the literature, we focus on the case when the preference exhibits the KUJ effect, i.e., $\epsilon_X > 0$.

The (log-linearized) optimality conditions for the household are given by

$$\hat{\lambda}_t = (\epsilon_X - \epsilon_{CC})\,\hat{c}_t, \tag{A.8}$$

$$\hat{n}_t = \frac{1}{1-\alpha}\hat{a}_t + \frac{\epsilon_X - \epsilon_{CC}}{1-\alpha}\hat{c}_t + \hat{k}_t. \tag{A.9}$$

Suppose that a news shock hits the economy at time 1 and that it will materialize after l periods. For the TFP news shock, the technological level and physical capital in the present ($\hat{a}_t$ and $\hat{k}_t$) are unchanged. According to Eq. (A.9), the comovement between $\hat{c}_t$ and $\hat{n}_t$ requires that $\epsilon_X - \epsilon_{CC} > 0$.

After rearrangement, we derive the log-linearized dynamic system in the following matrix form:

$$\begin{pmatrix} \mathbb{E}_t\hat{\lambda}_{t+1} \\ \hat{k}_{t+1} \end{pmatrix} = \begin{pmatrix} m_1 & 0 \\ J_{21} & m_2 \end{pmatrix} \begin{pmatrix} \hat{\lambda}_t \\ \hat{k}_t \end{pmatrix} + \begin{pmatrix} 0 & \vartheta_{12} \\ \vartheta_{21} & 0 \end{pmatrix} \begin{pmatrix} \hat{a}_t \\ \mathbb{E}_t\hat{a}_{t+1} \end{pmatrix},$$

where

$$m_1 = \frac{1-\alpha}{1-\alpha+\alpha\tilde{\delta}} < 1, \quad m_2 = 1-\delta+\frac{\delta}{i_y} > 1,$$

$$J_{21} = \left(\frac{\alpha}{1-\alpha} - \frac{c_y}{\epsilon_X - \epsilon_{CC}}\right)\frac{\delta}{i_y},$$

$$\vartheta_{12} = -\frac{\tilde{\delta}}{1-\alpha+\alpha\tilde{\delta}}, \quad \vartheta_{21} = \frac{\delta}{(1-\alpha)\,i_y}.$$

From the above, we can solve for the shadow price of wealth λ_t in period 1 in terms of the TFP news shock:

$$\hat{\lambda}_1 = -\frac{\epsilon_X - \epsilon_{CC} + 1 - \alpha + \alpha\tilde{\delta}}{\alpha(\epsilon_X - \epsilon_{CC}) - (1-\alpha)\,c_y}\frac{(1-\alpha)(1-\beta+\alpha\beta\delta)}{\left(1-\alpha+\alpha\tilde{\delta}\right)^2}\frac{1}{(m_2-\rho)\,m_2}.$$

We can find the following necessary condition for generating a positive response of $\hat{\lambda}_1$

$$\epsilon_{CC} < \epsilon_X < \epsilon_{CC} + \frac{1-\alpha}{\alpha}c_y.$$

Thus, we find the following condition for comovements in consumption and labor.

Lemma 1 *With the contemporaneous social average consumption in the utility function, a news-driven TFP shock induces comovements in consumption, hours worked and output, but not investment, if and only if the preference exhibits the KUJ effect ($\epsilon_X > 0$) and*

$$\epsilon_{CC} < \epsilon_X < \epsilon_{CC} + \frac{1-\alpha}{\alpha} c_y.$$

However, we solve for investment in the present and find that

$$\hat{\imath}_1 = \left(\frac{\alpha}{1-\alpha} - \frac{c_y}{\epsilon_X - \epsilon_{CC}} \right) \frac{1}{i_y} \hat{\lambda}_1.$$

We can verify that investment moves in the opposite direction if $\epsilon_X < \epsilon_{CC} + \frac{1-\alpha}{\alpha} c_y$, and therefore, $\hat{\imath}_1$ and $\hat{\lambda}_1$ cannot simultaneously increase if the condition in Lemma 1 is satisfied. $\square$

A.4 Proof of Proposition 4 and 5

This section outlines the main steps for solving the key macroeconomic aggregates in the linearized dynamic system with three alternative shocks: IST shocks, government spending shocks, and preference shocks. When these shocks are included, the log-linearized system of equations can be written in the following form:

$$z_{t+1} = J_\nu z_t + M_\varrho \begin{pmatrix} \mathbb{E}_t \hat{\varrho}_{t+1} \\ \hat{\varrho}_t \end{pmatrix} + M_\nu \begin{pmatrix} \mathbb{E}_t \hat{\nu}_{t+1} \\ \hat{\nu}_t \end{pmatrix} + M_g \hat{g}_t, \tag{A.10}$$

where $z_{t+1} = \left(\mathbb{E}_t \hat{\lambda}_{t+1}, \mathbb{E}_t \hat{x}_{t+1}, \hat{c}_t, \hat{k}_{t+1} \right)'$,

$$J_\nu = \begin{pmatrix} \frac{1-\alpha}{1-\alpha+\alpha\tilde{\tilde{\delta}}} & 0 & 0 & 0 \\ \frac{(1-\theta\beta)(1-\theta)}{\sigma} & \theta & 0 & 0 \\ 0 & \frac{1}{\theta\beta} & \frac{1}{\theta\beta} & 0 \\ \frac{\alpha}{1-\alpha}\frac{\delta}{i_y} & -\frac{\delta c_y}{i_y}\frac{1}{\theta\beta} & -\frac{\delta c'_y}{i_y}\frac{1}{\theta\beta} & 1-\delta+\frac{\delta}{i_y} \end{pmatrix},$$

$$M_{\varrho}=\begin{pmatrix} 0 & 0 \\ \frac{(1-\theta)\theta\beta}{\sigma} & -\frac{1-\theta}{\sigma} \\ 0 & 0 \\ 0 & 0 \end{pmatrix},\ M_{\nu}=\begin{pmatrix} \frac{(1-\alpha)\left(1-\tilde{\delta}\right)}{1-\alpha+\alpha\tilde{\delta}} & -\frac{1-\alpha}{1-\alpha+\alpha\tilde{\delta}} \\ 0 & 0 \\ 0 & 0 \\ 0 & \delta \end{pmatrix},\ \text{and}\ M_{g}=\begin{pmatrix} 0 \\ 0 \\ 0 \\ -\frac{\delta g_y}{i_y} \end{pmatrix},$$

$c_y' \equiv 1-(1-\alpha)\,\beta\frac{\delta}{\tilde{\delta}}-g_y$, $i_y=1-c_y-g_y=(1-\alpha)\,\delta\beta/\widetilde{\delta}$, and g_y denotes the steady-state ratio of government purchases to output. The matrix J_ν has a similar form as in the baseline case. Besides, the eigenvalues of the matrix J_ν are the same as the baseline matrix (ζ_1 - ζ_4). As a result, the aforementioned system has a saddle path when $0<\theta<1$. Analogous to our analysis of TFP news shocks, we focus on the case when news shocks materialize in period 3 ($l=2$).

A.4.1 IST News Shocks

We first analyze the effect of IST news shocks. Assuming that the IST news shock hits the economy in period 1, we solve the linearized system under a favorable IST news shock and derive the solutions for consumption, labor, investment, and output. The following expressions for the main aggregate variables in period 1 are obtained:

$$\hat{c}_1^{\nu}=\eta_{\nu}^{C}\left(\sigma-\underline{\sigma}_{\nu}^{C}\right), \tag{A.11}$$

$$\hat{n}_1^{\nu}=\frac{1}{1-\alpha}\hat{\lambda}_1^{\nu}, \tag{A.12}$$

$$\hat{y}_1^{\nu}=\frac{\alpha}{1-\alpha}\hat{\lambda}_1^{\nu}, \tag{A.13}$$

$$\hat{\lambda}_1^{\nu}=\eta_{\nu}^{\lambda}\left(\bar{\sigma}_{\nu}^{\lambda}-\sigma\right), \tag{A.14}$$

$$\hat{i}_1^{\nu}=-\eta_{\nu,0}^{I}\left(\sigma^2+s_1^{\nu}\sigma+s_0^{\nu}\right). \tag{A.15}$$

In the above expressions, $\underline{\sigma}_{\nu}^{C}$, $\bar{\sigma}_{\nu}^{\lambda}$, η_{ν}^{C}, η_{ν}^{λ}, and $\eta_{\nu,0}^{I}$ take the following form:

$$\underline{\sigma}_{\nu}^{C}=\frac{\Psi}{\Theta}\frac{(1-\theta\beta)\,(1-\theta)\,\zeta_3\zeta_4 c_y'}{\zeta_4-\zeta_2},$$

$$\bar{\sigma}_\nu^\lambda = \frac{(1-\theta\beta)(1-\theta)\zeta_3\zeta_4}{\Theta}\left[\frac{(\theta+\delta-1)(\zeta_4-\rho_\nu)}{\zeta_3-\mu_1}\Xi + \frac{c_y'}{\zeta_4-\zeta_2}\Psi\right],$$

$$\eta_\nu^\lambda = \frac{\Theta}{\Xi}\frac{1}{(1-\theta\beta)(1-\theta)}\frac{\zeta_3-\zeta_1}{\zeta_3^2\zeta_4^2(\zeta_3-\rho_\nu)(\zeta_4-\rho_\nu)},$$

$$\eta_\nu^C = \frac{\Theta}{\Xi}\frac{1}{\zeta_3\zeta_4^2(\zeta_3-\rho_\nu)(\zeta_4-\rho_\nu)\sigma},$$

$$\eta_{\nu,0}^I = \frac{1}{i_y}\frac{\alpha}{1-\alpha}\frac{\zeta_3-\zeta_1}{(1-\theta\beta)(1-\theta)\zeta_3}\eta_\nu^C,$$

where the above auxiliary variables we introduce are given by

$$\Theta = \upsilon\zeta_3(\zeta_3-\rho_\nu) + \frac{\alpha}{1-\alpha}(\theta+\delta-1)\zeta_4(\zeta_4-\rho_\nu),$$

$$\Xi = \frac{c_y'\zeta_4}{\zeta_4-\zeta_2} + \frac{\alpha\beta\theta\sigma(\zeta_3-\zeta_1)}{(1-\alpha)(1-\theta\beta)(1-\theta)},$$

$$\Psi = \frac{(\theta+\delta-1)\zeta_4(\zeta_4-\rho_\nu)-(\zeta_1+\delta-1)\zeta_3(\zeta_3-\rho_\nu)}{\zeta_4-\zeta_3},$$

$$\upsilon = \delta - \frac{\alpha+(1-\alpha)i_y}{1-\alpha}(\zeta_1+\delta-1).$$

We determine the sign of the above coefficients to examine the conditions under which news driven business cycles arise. It is obvious that $\Xi > 0$. Also, we can further prove that $\Psi > 0$ and $\upsilon > 0$ when $\theta+\delta-1 > 0$ for any positive values of ζ_1 and θ. Specifically, the numerator and denominator of Ψ are both positive (negative) when $\zeta_1 < (>)\theta$.

Next, we prove that $\upsilon > 0$. Because the sign of $\zeta_1+\delta-1$ is uncertain, we consider two cases. *(a)* If $\zeta_1+\delta-1 \leq 0$, it is easy to see that $\upsilon > 0$;*(b)* If $\zeta_1+\delta-1 > 0$, we still have $\upsilon > 0$ because $\upsilon = \delta - \frac{\alpha+(1-\alpha)i_y}{1-\alpha}(\zeta_1+\delta-1) > \delta - \frac{\zeta_1+\delta-1}{1-\alpha} = \frac{\alpha}{1-\alpha}\frac{(1-\delta)[1-(1-\alpha\delta)\beta]}{1-\alpha+\alpha\delta} > 0$. If $\upsilon > 0$, it is easy to verify that $\Theta > 0$. Thus, we can conclude that $\underline{\sigma}_\nu^C > 0$, $\bar{\sigma}_\nu^\lambda > 0$, $\eta_{\nu,0}^I > 0$, $\eta_\nu^C > 0$, and $\eta_\nu^\lambda > 0$ are all positive when $\Theta > 0$, $\Xi > 0$, and $\Psi > 0$. The above result implies that current consumption, hours worked and output increase under a positive IST news shock when $\sigma \in (\underline{\sigma}_\nu^C, \bar{\sigma}_\nu^\lambda)$.

Finally, we examine solution of current investment (A.15), the coefficients of s_0^ν and s_1^ν take the following form:

$$s_0^\nu = -\frac{\Psi}{\Theta}\frac{1-\alpha}{\alpha}\frac{(1-\theta\beta)^2(1-\theta)^2\zeta_3^2c_y^2\zeta_4}{(\zeta_3-\zeta_1)(\zeta_4-\zeta_2)} < 0,$$

$$s_1^\nu = -\frac{1-\alpha}{\alpha}\frac{(1-\theta\beta)(1-\theta)\zeta_3}{\zeta_3-\zeta_1}\left[\frac{\alpha}{1-\alpha}\frac{\zeta_4(\zeta_3-\zeta_1)}{\Theta}\left(\frac{(\theta+\delta-1)(\zeta_4-\rho_z)}{\zeta_3-\zeta_1}\Xi + \frac{c_y'}{\zeta_4-\zeta_2}\Psi\right) - c_y'\right].$$

We use the similar method in Section A.2 to determine the range of σ that results in an increase in investment ($\hat{i}_1^\nu$). We examine two roots for the following quadratic equation:

$$\Delta(\sigma) = \sigma^2 + s_1^\nu \sigma + s_0^\nu.$$

Let denote $\bar{\sigma}_\nu^I$ the larger root and $\underline{\sigma}_\nu^I$ the smaller root. First, we can verify that $\Delta(0) = s_0^\nu < 0$, so the smaller root is negative ($\underline{\sigma}_\nu^I < 0$). By verifying $\Delta(\underline{\sigma}_\nu^C) < 0$ and $\Delta(\bar{\sigma}_\nu^\lambda) > 0$, we can further determine the range of the larger root $\bar{\sigma}_\nu^I \in (\underline{\sigma}_\nu^C, \bar{\sigma}_\nu^\lambda)$, and we have $\underline{\sigma}_\nu^C < \bar{\sigma}_\nu^I < \bar{\sigma}_\nu^\lambda$. To conclude, the current response of investment is positive ($\hat{i}_1^\nu > 0$) when $\sigma \in (0, \bar{\sigma}_\nu^I)$.

A.4.2 Government Spending Shocks and Preference Shocks

We can also express current consumption, investment, output, and hours worked when facing a government spending news shock:

$$\hat{c}_1^g = -\frac{\eta_g^C}{\sigma}, \quad \hat{n}_1^g = \frac{\eta_g^N}{\sigma}, \quad \hat{y}_1^g = \alpha \hat{n}_1^g, \quad \hat{i}_1^g = \frac{\eta_g^I}{\sigma},$$

where η_g^N, η_g^I, and η_g^C are positive parameters and take the following form:

$$\eta_g^C = \frac{1}{\frac{c_y\zeta_4}{(\zeta_4-\zeta_2)(\zeta_4-\zeta_1)\sigma} + \frac{\alpha}{1-\alpha}\frac{\theta\beta}{(1-\theta\beta)(1-\theta)}\frac{\zeta_3-\zeta_1}{\zeta_4-\zeta_1}}\frac{g_y}{\zeta_4^2(\zeta_4-\rho_g)},$$

$$\eta_g^N = \frac{\sigma(\zeta_3-\zeta_1)}{(1-\alpha)(1-\theta\beta)(1-\theta)\zeta_3}\eta_g^C, \quad \eta_g^I = \frac{\alpha\sigma(\zeta_3-\zeta_1)}{i_y(1-\alpha)(1-\theta\beta)(1-\theta)\zeta_3}\eta_g^C + \frac{c_y'}{i_y}\eta_g^C,$$

It is easy to verify that $\eta_g^C > 0$, $\eta_g^N > 0$, and $\eta_g^I > 0$. So we have $\hat{c}_1^g < 0$, $\hat{n}_1^g > 0$, $\hat{y}_1^g > 0$, and $\hat{i}_1^g > 0$.

When facing a preference news shock, we can express the current variables as follows

$$\hat{c}_1^\varrho = -\frac{\eta_\varrho^C}{\sigma}, \quad \hat{n}_1^\varrho = \frac{\eta_\varrho^N}{\sigma}, \quad \hat{y}_1^\varrho = \alpha \hat{n}_1^\varrho, \quad \hat{i}_1^\varrho = \frac{\eta_\varrho^I}{\sigma},$$

where η_ϱ^C, η_ϱ^I, and η_ϱ^N are short-hand notations for structural parameters and take the following form:

$$\eta_\varrho^C = \frac{1}{\frac{c_y\zeta_4}{(\zeta_4-\zeta_2)(\zeta_4-\mu_1)} + \frac{\alpha}{1-\alpha}\frac{\theta\beta\sigma}{(1-\theta\beta)(1-\theta)}\frac{\zeta_3-\zeta_1}{\zeta_4-\zeta_1}}\frac{(1-\theta)c_y'}{\zeta_4(\zeta_4-\zeta_2)(\zeta_4-\rho_\varrho)},$$

$$\eta_{\varrho}^{N}=\frac{\sigma\left(\zeta_{3}-\zeta_{1}\right)}{\left(1-\alpha\right)\left(1-\theta\beta\right)\left(1-\theta\right)\zeta_{3}}\eta_{\varrho}^{C},\quad \eta_{\varrho}^{I}=\frac{1}{i_{y}}\frac{\alpha}{1-\alpha}\frac{\sigma\left(\zeta_{3}-\zeta_{1}\right)}{\left(1-\theta\beta\right)\left(1-\theta\right)\zeta_{3}}\eta_{\varrho}^{C}+\frac{c_{y}'}{i_{y}}\eta_{\varrho}^{C}.$$

It is easy to verify that $\eta_{\varrho}^{C}>0$, $\eta_{\varrho}^{N}>0$, and $\eta_{\varrho}^{I}>0$. So we have $\hat{c}_{1}^{\varrho}<0$, $\hat{n}_{1}^{\varrho}>0$, $\hat{y}_{1}^{\varrho}>0$, and $\hat{i}_{1}^{\varrho}>0$.

The solutions show that an increase in future government spending leads to increases in current investment, output, and hours worked but a decrease in current consumption. The same responses occur when the economy is hit by a positive news about households' consumption preferences.

A.5 Bayesian estimation for SGU (2012) model with both internal and external habits

The model proposed by Schmitt-Grohé and Uribe (2012) incorporates a wide range of frictions, including JR utility, habit formation, investment adjustment costs, and variable capital utilization. This medium-scale model has demonstrated its success in explaining the behavior of business cycles observed in macroeconomic data. The model features two sources of non-stationarity shocks: nonstationary neutral technological shock and nonstationary investment-specific technological shock. Additionally, there are other shocks in the model, such as stationary neutral technological shock, stationary investment-specific technological shock, government spending shock, preference shock, and wage-markup shock. These exogenous shocks follow AR(1) processes and are influenced by unanticipated shocks as well as two news shocks with anticipation horizons of 4 and 8, respectively.

We compare the internal and external habit formation within a full model of Schmitt-Grohé and Uribe (2012). We use the calibrated parameters reported in Schmitt-Grohé and Uribe (2012), and assign priors to the parameters as reported in Table 1, following standard Bayesian estimation in the DSGE literature. We follow Schmitt-Grohé and Uribe (2012) and incorporate the observed variables of seven time series, including the growth rates of per capita real GDP, real consumption, real investment, real government expenditure, total factor productivity, hours worked and the relative price of investment. Employing these priors and the sample data spanning from 1955:Q2 to 2006:Q4, we obtain posterior parameter estimates by running 2 chains with 200,000 draws each using the Metropolis-Hastings algorithm. The reported posterior parameters represent the mean values. In Table 1, φ is the Frisch labor elasticity parameter, γ is the income effect parameter for JR preferences, and κ is the parameter for investment adjustment costs.

A.6 Proof of Proposition 4

We first log-linearize the system of equations and simplify the dynamic system. In equilibrium, we have $c_t = C_t$. Thus, the dynamic system can be rearranged as

$$\theta\beta[1-(1-\theta)\chi]\mathbb{E}_t\hat{c}_{t+1} - \left[1+\theta^2\beta-(1-\theta)\chi\right]\hat{c}_t + \theta\hat{c}_{t-1} = \frac{(1-\theta\beta)(1-\theta)}{\sigma}\hat{\lambda}_t, \tag{A.16}$$

$$\hat{\lambda}_t - \mathbb{E}_t\hat{\lambda}_{t+1} = \widetilde{\delta}\mathbb{E}_t\hat{r}_{t+1},$$

$$\hat{k}_{t+1} = (1-\delta)\hat{k}_t + \delta\hat{\imath}_t.$$

The contemporaneous relations are determined by

$$\hat{\lambda}_t + \hat{w}_t = 0, \quad \hat{y}_t = \hat{a}_t + (1-\alpha)\hat{k}_t + \alpha\hat{n}_t,$$

$$\hat{w}_t = \hat{y}_t - \hat{n}_t, \ \hat{r}_t = \hat{y}_t - \hat{k}_t, \text{ and } \hat{y}_t = c_y\hat{c}_t + i_y\hat{\imath}_t.$$

Let us denote $\hat{x}_t = \theta\beta\hat{c}_t - \hat{c}_{t-1}$, and then $\mathbb{E}_t\hat{x}_{t+1} = \theta\beta\mathbb{E}_t\hat{c}_{t+1} - \hat{c}_t$. The above log-linearized system can be written in the form

$$z_{t+1} = J_\chi z_t + M_\chi \begin{pmatrix} \mathbb{E}_t\hat{a}_{t+1} \\ \hat{a}_t \end{pmatrix}, \tag{A.17}$$

where $z_{t+1} = \left(\mathbb{E}_t\hat{\lambda}_{t+1}, \mathbb{E}_t\hat{x}_{t+1}, \hat{c}_t, \hat{k}_{t+1}\right)'$,

$$J_\chi = \begin{pmatrix} \frac{1-\alpha}{1-\alpha+\alpha\tilde{\delta}} & 0 & 0 & 0 \\ \frac{(1-\theta\beta)(1-\theta)}{\sigma[1-(1-\theta)\chi]} & \frac{\theta}{1-(1-\theta)\chi} & 0 & 0 \\ 0 & \frac{1}{\theta\beta} & \frac{1}{\theta\beta} & 0 \\ \frac{\alpha}{1-\alpha}\frac{\delta}{i_y} & -\frac{\delta c_y}{i_y}\frac{1}{\theta\beta} & -\frac{\delta c_y}{i_y}\frac{1}{\theta\beta} & 1-\delta+\frac{\delta}{i_y} \end{pmatrix}, \text{ and } M_\chi = \begin{pmatrix} -\frac{\tilde{\delta}}{1-\alpha+\alpha\tilde{\delta}} & 0 \\ 0 & 0 \\ 0 & 0 \\ 0 & \frac{\delta}{i_y}\frac{1}{1-\alpha} \end{pmatrix}.$$

Because J_χ is a lower triangular matrix, we can determine its eigenvalues: $\mu_1 = \frac{1-\alpha}{1-\alpha+\alpha\tilde{\delta}}$, $\mu_2 = \frac{\theta}{1-(1-\theta)\chi}$, $\mu_3 = \frac{1}{\theta\beta}$, and $\mu_4 = 1-\delta+\frac{\delta}{i_y}$. From the above, we see that $\mu_1 < 1$, $\mu_3 > 1$ and $\mu_4 > 1$. Since our model has two predetermined variables, the dynamic system always exhibits a unique saddle-path equilibrium if $|\mu_2| < 1$, which is equivalent to $\chi \in (-\infty, 1) \cup \left(\frac{1+\theta}{1-\theta}, \infty\right)$.

Without loss of generality, let us assume that a positive TFP news shock hits the economy in period 1 and will materialize in period 3. We follow Blanchard and Kahn (1980) to solve the simultaneous difference equation system (A.17) and obtain the expressions for the main aggregate variables in period 1:

$$\hat{\lambda}_1 = \eta_\chi^\lambda \left(\sigma_\chi^\lambda - \sigma\right), \tag{A.18}$$

$$\hat{i}_1 = -\eta_\chi^I \Gamma\left(\sigma\right),$$

$$\hat{c}_1 = \eta_\chi^c \left(\sigma - \underline{\sigma}_\chi\right),$$

$$\hat{y}_1 = \frac{\alpha}{1-\alpha}\hat{\lambda}_1, \text{ and } \hat{n}_1 = \frac{1}{1-\alpha}\hat{\lambda}_1.$$

From the above, the expressions of σ_χ^λ, σ_χ^I, $\underline{\sigma}_\chi$, η_χ^λ, η_χ^I, and η_χ^c are short-hand notations for structural parameters, which are given by

$$\sigma_\chi^\lambda \equiv \left[\frac{\left(\mu_4+\mu_3-\rho\right)\left(\mu_4-\mu_1\right)}{\mu_3-\rho}+\mu_3\right]\frac{\omega_1\kappa_1}{\mu_1\left(\mu_3-\mu_1\right)},$$

$$\sigma_\chi^I \equiv \frac{\left(\mu_3-\mu_1\right)\left(\mu_4+\mu_3-\rho\right)+\mu_2\left(\mu_4-\rho\right)}{\mu_3-\rho}\frac{\omega_1\kappa_1}{\mu_1\left(\mu_3-\mu_1\right)},$$

$$\underline{\sigma}_\chi \equiv \frac{\left(\mu_3+\mu_4-\rho\right)\mu_4\mu_3}{\frac{\alpha}{1-\alpha}\frac{1}{c_y}\left(\mu_4-\rho\right)\mu_4+\frac{1}{(1-\alpha)\beta+c_y\tilde{\delta}}\left(\mu_3-\rho\right)\mu_3}\frac{\left(1-\theta\beta\right)\left(1-\theta\right)}{\left[1-(1-\theta)\chi\right]\left(\mu_4-\mu_2\right)},$$

$$\eta_\chi^\lambda \equiv -\frac{1}{\varphi_1}\frac{\delta c_y}{i_y\left(\mu_4-\rho\right)\left(\mu_4-\mu_2\right)}\frac{\mu_1\left(\mu_3-\mu_1\right)}{\left(\mu_4-\mu_1\right)\kappa_1},$$

$$\eta_\chi^I \equiv \frac{\alpha}{1-\alpha}\frac{1}{\frac{(1-\theta\beta)(1-\theta)}{1-(1-\theta)\chi}\frac{\mu_3}{\mu_3-\mu_1}c_y+\frac{\alpha}{1-\alpha}\frac{\mu_4-\mu_2}{\mu_4}\sigma}\frac{1}{\left(\mu_4-\rho\right)\kappa_1}\frac{\mu_1}{\mu_4}\frac{c_y}{i_y}\frac{\left(1-\theta\beta\right)\left(1-\theta\right)}{\sigma\left[1-(1-\theta)\chi\right]},$$

$$\eta_\chi^c \equiv \frac{1}{1-\alpha}\frac{\delta}{i_y}\frac{1}{\left(\mu_4-\rho\right)\mu_4\sigma}\frac{\frac{(\mu_4-\rho)\mu_4(1-\mu_1)}{(\mu_3-\rho)\mu_3}+\frac{\delta c_y}{i_y}\frac{\mu_1}{\mu_4}}{\frac{\alpha\delta(\mu_3-\mu_1)\theta\beta\sigma[1-(1-\theta)\chi]}{i_y(1-\alpha)(1-\theta\beta)(1-\theta)}+\frac{\delta c_y}{i_y}\frac{\mu_4}{\mu_4-\mu_2}},$$

where

$$\omega_1 = \frac{\tilde{\delta}}{1-\alpha+\alpha\tilde{\delta}} > 0,$$

$$\kappa_1 \equiv \frac{(1-\theta\beta)(1-\theta)}{1-(1-\theta)\chi}\frac{i_y(1-\alpha)}{\delta}\frac{\mu_4^2}{\mu_4-\mu_2},$$

$$\varphi_1 = -\left[\frac{\delta c_y}{i_y}\frac{\mu_3\mu_4}{\mu_4-\mu_2}+\frac{\alpha\delta(\mu_3-\mu_1)\sigma[1-(1-\theta)\chi]}{i_y(1-\alpha)(1-\theta\beta)(1-\theta)}\right]\frac{1}{\mu_4-\mu_1}.$$

The quadratic function $\Gamma(\cdot)$ in the solution for the current response of investment is defined as

$$\Gamma(\sigma) = \sigma^2 + s_1'\sigma + s_0',$$

where

$$s_0' \equiv -\frac{(1-\theta\beta)(1-\theta)}{1-(1-\theta)\chi}\frac{1-\alpha}{\alpha}\frac{\mu_3 c_y}{\mu_3-\mu_1}\frac{\mu_4+\mu_3-\rho}{\mu_3-\rho}\frac{\omega_1\kappa_1}{\mu_1},$$

$$s_1' \equiv \left[\frac{(1-\theta\beta)(1-\theta)}{1-(1-\theta)\chi}\frac{1-\alpha}{\alpha}\mu_3 c_y - \frac{(\mu_3-\mu_1)(\mu_4+\mu_3-\rho)+\mu_2(\mu_4-\rho)}{\mu_3-\rho}\frac{\omega_1\kappa_1}{\mu_1}\right]\frac{1}{\mu_3-\mu_1},$$

We consider two cases $\chi \in (-\infty, 1)$ and $\chi \in \left(\frac{1+\theta}{1-\theta}, \infty\right)$ separately.

Case 1: $\chi \in (-\infty, 1)$.

We find that $\kappa_1 > 0$, $\varphi_1 < 0$, $\sigma_\chi^\lambda > 0$, $\sigma_\chi^I > 0$, $\underline{\sigma}_\chi > 0$, $\eta_\chi^\lambda > 0$, $\eta_\chi^I > 0$, $\eta_\chi^c > 0$ and $s_0' < 0$. Thus, we can further obtain the following inequalities: $\sigma_\chi^I < \sigma_\chi^\lambda$, and $\Gamma(0) = s_0' < 0$ and $\Gamma\left(\sigma_\chi^I\right) > 0$. As a result, there exists a root, denoted as $\overline{\sigma}_\chi$, lying between 0 and σ_χ^I such that $\Gamma(\overline{\sigma}_\chi) = 0$. Therefore, we have $\Gamma(\sigma) < 0$ for all $\sigma \in (0, \overline{\sigma}_\chi)$.

Case 2: $\chi \in \left(\frac{1+\theta}{1-\theta}, \infty\right)$.

We can verify that $\kappa_1 < 0$, $\sigma_\chi^\lambda < 0$, $\underline{\sigma}_\chi > 0$ and $s_0' < 0$. Thus, the sufficient and necessary condition for $\hat{c}_1 > 0$ is $\eta_\chi^c > 0$, from which we obtain the range of $0 < \sigma < \bar{\sigma}_\chi^c$ for comovements. The upper bound is given by

$$\bar{\sigma}_\chi^c \equiv -\frac{1-\alpha}{\alpha}\frac{\mu_3}{\mu_3-\mu_1}\frac{c_y\mu_4}{\mu_4-\mu_2}\frac{(1-\theta\beta)(1-\theta)}{1-(1-\theta)\chi} > 0.$$

However, we verify that $\eta_\chi^I < 0$ when $0 < \sigma < \bar{\sigma}_\chi^c$. We can further demonstrate that $\Gamma(0) = s_0' < 0$ and $\Gamma\left(\bar{\sigma}_\chi^c\right) < 0$. As a result, the response of investment to a positive news shock $\hat{\imath}_1$ is always negative when σ lies between 0 and $\bar{\sigma}_\chi^c$, and the comovement between consumption and investment does not occur in case 2.

A.7 Proof of Proposition 5

This section shows the proof of Proposition 5. The lower and upper bounds of the curvature parameter for news-driven business cycles that we find in Proposition 3 are functions of χ.

$$\Gamma(\sigma;\chi) = \sigma^2 + s_1'(\chi)\,\sigma + s_0'(\chi)\,,$$

We define $\vartheta_1 = \frac{\tilde{\delta}}{1-\alpha+\alpha\tilde{\delta}}$, $\vartheta_2 = \frac{\delta}{i_y}\frac{1}{1-\alpha}$. The partial derivatives of s_1' and s_0' are given by

$$s_1'(\chi) = \left[\frac{1-\alpha}{\alpha}\mu_3 c_y + \frac{\mu_4-\rho}{\mu_3-\rho}\frac{\vartheta_1}{\vartheta_2}\frac{\mu_4^2}{\mu_1} - \frac{(\mu_3-\mu_1)(\mu_4+\mu_3-\rho)+\mu_4(\mu_4-\rho)}{(\mu_3-\rho)(\mu_4-\mu_2)}\frac{\vartheta_1\mu_4^2}{\vartheta_2\mu_1}\right]\frac{(1-\theta\beta)(1-\theta)\mu_2}{\theta(\mu_3-\mu_1)}$$

$$s_0'(\chi) = -\frac{1-\alpha}{\alpha}\frac{\mu_3 c_y}{\mu_3-\mu_1}\frac{\mu_4+\mu_3-\rho}{\mu_3-\rho}\frac{\vartheta_1\mu_4^2}{\vartheta_2\mu_1}\left[\frac{(1-\theta\beta)(1-\theta)}{\theta}\right]^2\frac{\mu_2^2}{\mu_4-\mu_2}$$

$$\frac{\partial s_1'(\chi)}{\partial\chi} = \left[\frac{s_1'}{\mu_2} - \frac{(\mu_3-\mu_1)(\mu_4+\mu_3-\rho)+\mu_4(\mu_4-\rho)}{\mu_3-\rho}\frac{\vartheta_1\mu_4^2}{\vartheta_2\mu_1}\frac{1}{(\mu_4-\mu_2)^2}\right]\frac{\partial\mu_2}{\partial\chi}$$

$$\begin{aligned}
\frac{\partial s_0'(\chi)}{\partial\chi} &= -\frac{1-\alpha}{\alpha}\frac{\mu_3 c_y}{\mu_3-\mu_1}\frac{\mu_4+\mu_3-\rho}{\mu_3-\rho}\frac{\vartheta_1\mu_4^2}{\vartheta_2\mu_1}\left[\frac{(1-\theta\beta)(1-\theta)}{\theta}\right]^2\frac{\mu_2(2\mu_4-\mu_2)}{(\mu_4-\mu_2)^2}\frac{\partial\mu_2}{\partial\chi}\\
&= s_0'\left[\frac{\mu_4}{\mu_2(\mu_4-\mu_2)} + \frac{1}{\mu_2}\right]\frac{\partial\mu_2}{\partial\chi}
\end{aligned}$$

$$\begin{aligned}
\frac{\partial\Gamma}{\partial\chi} &= \frac{\partial s_1'}{\partial\chi}\overline{\sigma}_\chi + \frac{\partial s_0'}{\partial\chi}\\
&= \left\{\frac{s_1'\overline{\sigma}_\chi + s_0'}{\mu_2} + \frac{\mu_4 s_0'}{\mu_2(\mu_4-\mu_2)} - \frac{(\mu_3-\mu_1)(\mu_4+\mu_3-\rho)+\mu_4(\mu_4-\rho)}{(\mu_3-\rho)(\mu_4-\mu_2)^2}\frac{\vartheta_1\mu_4^2}{\vartheta_2\mu_1}\overline{\sigma}_\chi\right\}\frac{\partial\mu_2}{\partial\chi}\\
&= -\left\{\frac{\overline{\sigma}_\chi^2}{\mu_2} + \frac{(\mu_3-\mu_1)(\mu_4+\mu_3-\rho)+\mu_4(\mu_4-\rho)}{(\mu_3-\rho)(\mu_4-\mu_2)^2}\frac{\vartheta_1\mu_4^2}{\vartheta_2\mu_1}\overline{\sigma}_\chi - \frac{\mu_4}{\mu_2(\mu_4-\mu_2)}s_0'\right\}\frac{\partial\mu_2}{\partial\chi} < 0
\end{aligned}$$

$$\frac{\partial\Gamma}{\partial\overline{\sigma}_\chi} = 2\overline{\sigma}_\chi + s_1' = \overline{\sigma}_\chi - \frac{s_0'}{\overline{\sigma}_\chi} > 0.$$

B Nonseparable Preference and Income Effect

The results we present in the main body of the paper are based on the assumption of the utility function being separable between consumption and hours worked. This section complements our analysis by considering a nonseparable utility function. We first prove that nonseparable utility without internal habit formation cannot generate news-driven business cycles.

Let us consider a model with the utility $u(c_t, n_t)$ assumed to be strictly increasing in consumption c_t and decreasing in hours worked n_t, concave and $\mathcal{C}^2$, i.e., $u_c > 0$, $u_n < 0$, $u_{cc} < 0$, $u_{nn} < 0$ and $u_{cc}u_{nn} - u_{cn}u_{nc} > 0$. Consumption and leisure are normal goods, i.e., $u_n u_{cn} - u_c u_{nn} \geqslant 0$ and $u_n u_{cc} - u_c u_{cn} \geqslant 0$. We can derive the following result.

Proposition 9 *The model with nonseparable utility and without internal habit formation cannot generate news-driven business cycles under TFP news shocks.*

Proof: The optimal conditions for consumption and labor change correspondingly as

$$u_c = \lambda_t, \tag{B.1}$$

$$-u_n = (1-\alpha)\lambda_t \frac{y_t}{n_t}, \tag{B.2}$$

and all the other conditions remain unchanged. Specifically, the log-linearized equations for the optimal consumption choice and labor supply decision are

$$\varepsilon_{cc}\widehat{c}_t + \varepsilon_{cn}\widehat{n}_t = \widehat{\lambda}_t,$$

$$\varepsilon_{nc}\widehat{c}_t + (1+\varepsilon_{nn})\widehat{n}_t = \widehat{\lambda}_t + \widehat{y}_t,$$

where $\varepsilon_{cc} = \frac{u_{cc}c}{u_c} < 0$, $\varepsilon_{cn} = \frac{u_{cn}n}{u_c}$, $\varepsilon_{nc} = \frac{u_{nc}c}{u_n}$, $\varepsilon_{nn} = \frac{u_{nn}n}{u_n} > 0$. The concavity condition implies that $\varepsilon_{nn} - \varepsilon_{nc}\frac{\varepsilon_{cn}}{\varepsilon_{cc}} > 0$, and the normality conditions induce $\varepsilon_{nn} - \varepsilon_{cn} \geqslant 0$ and $\varepsilon_{cc} - \varepsilon_{nc} \leqslant 0$.

$$(1-\alpha+\varepsilon_{nn}-\varepsilon_{cn})\widehat{n}_t = (\varepsilon_{cc}-\varepsilon_{nc})\widehat{c}_t + \hat{a}_t + (1-\alpha)\hat{k}_t.$$

Comovements between consumption and laobor require that $1-\alpha+\varepsilon_{nn}-\varepsilon_{cn}$ and $\varepsilon_{cc}-\varepsilon_{nc}$ take the same sign. However, from the normality conditions, we know that $1-\alpha+\varepsilon_{nn}-\varepsilon_{cn} > 0$ and $\varepsilon_{cc}-\varepsilon_{nc} \leqslant 0$, which implies that $\widehat{c}_t$ and $\widehat{n}_t$ always move in opposite directions.

C General Form of Labor Disutility

This section discusses whether the main result of the paper still holds for a more general form of preferences with constant Frisch labor elasticity. However, once we incorporate such household preferences, deriving an analytical solution for the linearized difference system becomes infeasible because the system of equations becomes more complex. We cannot rearrange the system in such a way that that the transition matrix J is upper triangular (as in Eq. (8)), preventing us from obtaining analytical expressions for the eigenvalues.[18]

Because of that, we construct a two-period model to investigate how the TFP news shock affects the household's current consumption, saving, and labor supply decisions. We find that the main result of our paper still holds in this two-period model. That is, internal consumption habits alone can generate simultaneous increases in consumption, hours worked, and investment. Whether such comovement arises depend on the choices of the IES parameter σ. Furthermore, we find that the elasticity of labor supply can affect the range of σ for news shock comovements. The lower bound of σ decreases and the upper bound of σ increases as we increase the Frisch labor elasticity. Finally, we examine the numerical results of our baseline model with a standard labor disutility and show that these results are consistent with the theoretical analysis.

[18]We attempted several approaches to simplify the baseline model in the hope of obtaining analytical expressions for the eigenvalues of the transition matrix, but all were unsuccessful. First, we considered two extreme cases: one where the physical capital depreciation rate is 0, and the other where it is 1. Second, instead of incorporating internal consumption habits, we introduce anticipated future social average consumption ($E_t C_{t+1}$) into the preferences. This replacement simplifies the benchmark model by reducing the fourth-order difference equation system to a third-order system, while retaining the prospective channel of internal habits. However, none of these simplifications enabled us to derive an analytical expression for the eigenvalues of the transition matrix.

C.1 A Two-Period Model

The household utility function is given by

$$U(c_1, c_2, l_1, l_2) = \frac{c_1^{1-\sigma}}{1-\sigma} - \psi \frac{l_1^{1+\frac{1}{\epsilon}}}{1+\frac{1}{\epsilon}} + \beta \left[\frac{(c_2 - \theta c_1)^{1-\sigma}}{1-\sigma} - \psi \frac{l_2^{1+\frac{1}{\epsilon}}}{1+\frac{1}{\epsilon}} \right],$$

and her lifetime budget constraint is given by

$$c_1 + \frac{c_2}{R} = w_1 l_1 + \frac{w_2 l_2}{R}, \tag{C.1}$$

where R is gross interest rate, w_1 and w_2 are wages, and these prices are exogenous. The optimality conditions are given by

$$c_1^{-\sigma} - \beta\theta \left(c_2 - \theta c_1\right)^{-\sigma} = \lambda, \tag{C.2}$$

$$\beta \left(c_2 - \theta c_1\right)^{-\sigma} = \frac{1}{R}\lambda, \tag{C.3}$$

$$\psi l_1^{\frac{1}{\epsilon}} = \lambda w_1, \tag{C.4}$$

$$\psi \beta l_2^{\frac{1}{\epsilon}} = \frac{1}{R}\lambda w_2, \tag{C.5}$$

where λ is the Lagrange multiplier of the budget constraint. After rearrangement, we eliminate λ to obtain the following system of equations with budget constraint (C.1):

$$\frac{c_2}{c_1} = \left[\beta \left(R + \theta\right)\right]^{\frac{1}{\sigma}} + \theta, \tag{C.6}$$

$$\left(\frac{l_1}{l_2}\right)^{\frac{1}{\epsilon}} = \beta R \frac{w_1}{w_2}, \tag{C.7}$$

$$\psi l_2^{\frac{1}{\epsilon}} \left(c_2 - \theta c_1\right)^{\sigma} = w_2. \tag{C.8}$$

We linearize the above optimality conditions of (c_1, c_2, l_1, l_2) around their initial values and assume that a small TFP news shock $(\hat{A})$ simultaneously affects the return on saving (R) and the second-period wage (w_2):

$$\hat{R} = \hat{A}, \quad \hat{w}_2 = \hat{A},$$

where variables with hats denote log-deviations from their initial values. Under this arrangement, we obtain a parsimonious model without production, which can still be used to study the effect of a TFP news shock (A) on current consumption (c_1), hours worked (l_1), and saving $(k = w_1 l_1 - c_1)$.

C.2 Effect of TFP News Shock

Now, we study the effect of a small TFP news shock on first-period consumption and labor. Before proceeding, we make some assumptions regarding the choice of parameters and exogenous prices in the model. First, we assume that $\beta(R+\theta) = 1$, which implies $c_2 = (1+\theta)c_1$ according to (C.6). In this case, second-period consumption increases proportionately by a factor of θ, accounting for the effect of habit formation. Second, we assume that the wage ratio for the two periods satisfies the following condition: $\frac{w_2}{w_1} = \beta R$ to guarantee that the hours worked are the same in both periods, i.e., $l_1 = l_2$ (see Eq. (C.7)). The above parameterization also guarantees that the choices of σ and ϵ have no effect on the initial values of endogenous choices, and it helps to facilitate the derivation of conditions for news shock comovements.

C.2.1 Condition for $\hat{c}_1 > 0$

First, we derive the condition for σ that guarantees a positive response of first-period consumption to a favorable TFP news shock. By linearizing Eqs. (C.6), (C.7) and (C.8):

$$\hat{c}_2 = \hat{c}_1 + \frac{1}{\sigma}\frac{c_2 - \theta c_1}{c_2}\frac{R}{R+\theta}\hat{A}, \tag{C.9}$$

$$\hat{l}_1 = \hat{l}_2, \tag{C.10}$$

$$\frac{1}{\epsilon}\hat{l}_2 + \sigma\frac{c_2}{c_2 - \theta c_1}\hat{c}_2 - \theta\sigma\frac{c_1}{c_2 - \theta c_1}\hat{c}_1 = \hat{A}. \tag{C.11}$$

By linearizing the lifetime budget (C.1):

$$c_1\hat{c}_1 + \frac{c_2}{R}(\hat{c}_2 - \hat{A}) = w_1 l_1 \hat{l}_1 + \frac{w_2 l_2}{R}\hat{l}_2 = (w_1 l_1 + \frac{w_2 l_2}{R})\hat{l}_1. \tag{C.12}$$

The second equality follows from (C.10). Substituting (C.11) into (C.12) eliminates $\hat{l_2}$:

$$c_1\hat{c}_1 + \frac{c_2}{R}(\hat{c}_2 - \hat{A}) = (w_1 l_1 + \frac{w_2 l_2}{R})\epsilon(-\sigma\frac{c_2}{c_2 - \theta c_1}\hat{c}_2 + \theta\sigma\frac{c_1}{c_2 - \theta c_1}\hat{c}_1 + \hat{A}). \tag{C.13}$$

Then, substituting (C.9) into the above expression eliminates $\hat{c}_2$:

$$(\sigma\epsilon + 1)\left(1 + \frac{1+\theta}{R}\right)\hat{c}_1 = \left[(1 + \frac{1+\theta}{R})\epsilon\frac{\theta}{R+\theta} - \frac{1+\theta}{R}\left(\frac{1}{\sigma}\frac{1}{1+\theta}\frac{R}{R+\theta} - 1\right)\right]\hat{A}. \tag{C.14}$$

The above arrangement employs the condition of $c_2 = (1+\theta)c_1$. By Eq. (C.14), we can see that the following inequality must be satisfied to guarantee a positive response of $\hat{c}_1$ to a favorable news shock $\hat{A}$:

$$\left(1+\frac{1+\theta}{R}\right)\epsilon\frac{\theta}{R+\theta}-\frac{1+\theta}{R}\left(\frac{1}{\sigma}\frac{1}{1+\theta}\frac{R}{R+\theta}-1\right)>0.$$

After rearrangement and by using the expression of $R = \frac{1}{\beta} - \theta$ to eliminate R, we have

$$\sigma > \frac{1-\beta\theta}{1+\theta+(1+\beta)\,\theta\epsilon} \equiv \underline{\sigma}. \tag{C.15}$$

For $\hat{c}_1 > 0$, the IES parameter σ cannot be too low. Also, we find that $\frac{\partial\sigma}{\partial\epsilon} < 0$, so the lower bound $\underline{\sigma}$ is decreasing in ϵ. It means that a higher level of ϵ induces a smaller value of the lower bound of σ.

C.2.2 Condition for $\hat{l}_1 > 0$

Next we examine the effect of $\hat{A}$ on first-period labor $\hat{l}_1$. Substituting (C.9) into (C.12) eliminates $\hat{c}_2$:

$$c_1\hat{c}_1+\frac{c_2}{R}\hat{c}_1+\frac{1}{\sigma}\frac{c_2-\theta c_1}{R+\theta}\hat{A}-\frac{c_2}{R}\hat{A}=(w_1l_1+\frac{w_2l_2}{R})\hat{l}_1. \tag{C.16}$$

Then substituting (C.9) into (C.11) eliminate $\hat{c}_2$:

$$\hat{c}_1=\frac{1}{\sigma}\frac{\theta}{R+\theta}\hat{A}-\frac{1}{\epsilon\sigma}\hat{l}_1. \tag{C.17}$$

Substituting C.17 into (C.16) eliminates $\hat{c}_1$, and we have:

$$(\frac{1}{\sigma\epsilon}+1)\left(1+\frac{1+\theta}{R}\right)\hat{l}_1=\frac{1+\theta}{R}\left(\frac{1}{\sigma}-1\right)\hat{A}$$

The above arrangement uses $c_2 = (1+\theta)c_1$. To guarantee a positive response of $\hat{l}_1$ to a favorable news shock $\hat{A}$, we need

$$\sigma < 1 \tag{C.18}$$

to be satisfied. The solution of $\hat{l}_1$ is given by:

$$\hat{l}_1=\frac{\left(\frac{1}{\sigma}-1\right)}{(\frac{1}{\sigma\epsilon}+1)\left(1+\frac{1+\theta}{R}\right)}\frac{1+\theta}{R}\hat{A}. \tag{C.19}$$

C.2.3 Condition for $\hat{k} > 0$

Finally, we examine the condition under which a favorable shock on $\hat{A}$ causes an increase in saving $\hat{k}$. By linearizing the definition of saving, we have:

$$k\hat{k} = w_1 l_1 \hat{l}_1 - c_1 \hat{c}_1. \tag{C.20}$$

Substituting (C.17) into the above expression eliminates $\hat{c}_1$:

$$k\hat{k} = w_1 l_1 \hat{l}_1 - c_1 \left(\frac{1}{\sigma} \frac{\theta}{R+\theta} \hat{A} - \frac{1}{\sigma\epsilon} \hat{l}_1 \right)$$

Then substituting the solution of $\hat{l}_1$ (C.19) into the above expression to eliminate $\hat{l}_1$:

$$k\hat{k} = \left[\left(w_1 l_1 + \frac{1}{\sigma\epsilon} c_1 \right) \frac{\left(\frac{1}{\sigma} - 1\right)}{\left(\frac{1}{\sigma\epsilon} + 1\right)\left(1 + \frac{1+\theta}{R}\right)} \frac{1+\theta}{R} - \frac{1}{\sigma} \frac{\theta}{R+\theta} c_1 \right] \hat{A} \tag{C.21}$$

Here we can use the parameterization conditions of $l_1 = l_2$, $\frac{w_2}{w_1} = \beta R$, and $c_2 = (1+\theta)c_1$ to further simplify the above expression. After simplifying Eq. (C.21), we have:

$$\frac{\theta}{R}\hat{k} = \left[\left(\frac{R+\theta}{R} + \frac{1}{\sigma\epsilon} \right) \frac{\left(\frac{1}{\sigma} - 1\right)}{\left(\frac{1}{\sigma\epsilon} + 1\right)\left(1 + \frac{1+\theta}{R}\right)} \frac{1+\theta}{R} \hat{A} - \frac{1}{\sigma} \frac{\theta}{R+\theta} \right] \hat{A} \tag{C.22}$$

The condition for $\hat{k} > 0$ is given by

$$-\frac{(1+\theta)(R+\theta)^2}{R}\sigma^2 - \left[(1+\theta)(R+\theta)\frac{1}{\epsilon} - \frac{(1+\theta)(R+\theta)^2}{R} + \theta\left(R+1+\theta\right) \right] \sigma + \frac{R}{\epsilon} > 0. \tag{C.23}$$

Define the following quadratic function of σ:

$$F(\sigma) = -\frac{(1+\theta)(R+\theta)^2}{R}\sigma^2 - \left[(1+\theta)(R+\theta)\frac{1}{\epsilon} - \frac{(1+\theta)(R+\theta)^2}{R} + \theta\left(R+1+\theta\right) \right] \sigma + \frac{R}{\epsilon}. \tag{C.24}$$

Since $F(0) = \frac{R}{\epsilon} > 0$ and $F(1) = -\theta(1+R+\theta)(\frac{1}{\epsilon}+1) < 0$, we can conclude that the larger root of $F(\sigma) = 0$, denoted as $\bar{\sigma}$, lies between 0 and 1. Also, for $\sigma \in (0, \bar{\sigma})$, we have $F(\sigma) > 0$. Thus, for $\hat{k} > 0$, the value of σ should not be larger than $\bar{\sigma}$.

Above all, for a positive TFP news shock to cause simultaneous increases in current consumption, hours worked, and investment, the value of σ should be

$$\underline{\sigma} < \sigma < \bar{\sigma}. \tag{C.25}$$

Furthermore, we find that

$$\frac{\partial F}{\partial \sigma} = -\frac{(1+\theta)(R+\theta)^2}{R}\sigma - \frac{R}{\sigma\epsilon} < 0, \tag{C.26}$$

$$\frac{\partial F}{\partial \epsilon} = -\frac{1}{\epsilon^2}[R - (1+\theta)(R+\theta)\sigma]. \tag{C.27}$$

Now we verify that $\frac{\partial F}{\partial \epsilon}|_{\sigma=\bar{\sigma}} > 0$. By Eq. (C.27), we can find $\sigma^* = \frac{R}{(1+\theta)(R+\theta)} \in (0,1)$ such that $\frac{\partial F}{\partial \epsilon} = 0$. Also, for $\sigma > \sigma^*$, we have $\frac{\partial F}{\partial \epsilon} > 0$.

Next, we show $\bar{\sigma} > \sigma^*$ by substituting σ^* into $F(\cdot)$:

$$F(\sigma^*) = \frac{(R+\theta+1)\theta^2}{(1+\theta)(R+\theta)} > 0.$$

Since $F(\bar{\sigma}) = 0$ and $F(\sigma)$ is decreasing in $\sigma \in (0,1)$, so we have $\bar{\sigma} > \sigma^*$. Thus, $\frac{\partial F}{\partial \epsilon}|_{\sigma=\bar{\sigma}} > 0$.

Finally, we can find how the value of ϵ affect the upper bound $\bar{\sigma}$ by

$$\frac{d\bar{\sigma}}{d\epsilon} = -\frac{\partial F}{\partial \epsilon} \Big/ \frac{\partial F}{\partial \sigma}\Bigg|_{\sigma=\bar{\sigma}} > 0. \tag{C.28}$$

The above two-period model highlights the role of internal consumption habits in generating news-driven business cycles. Without habits ($\theta = 0$), the lower bound $\overline{\sigma} = 1$ (see in Eq. (C.15)), and the TFP news shock cannot generate simultaneous increases in consumption and hours worked. In this case, the shadow value of income and current consumption always move in the opposite direction (see Eq. (C.2) when $\theta = 0$). So an increase in the shadow value of income (λ) is crucial for plausible news shock comovements. Moreover, the simplified model helps us analyze how the labor elasticity affects the conditions under which news shock comovement arises.

C.3 Numerical Results

This section shows the numerical result of our model with a general form of labor disutility. We use the utility function $U(h_t, n_t) = \frac{h_t^{1-\sigma}}{1-\sigma} - \psi\frac{n_t^{1+\frac{1}{\epsilon}}}{1+\frac{1}{\epsilon}}$, while keeping the other parts of the model remain unchanged. We choose the baseline parameterization and vary the Frisch elasticity parameter (ϵ) to examine the values of the IES parameter (σ) that generate news

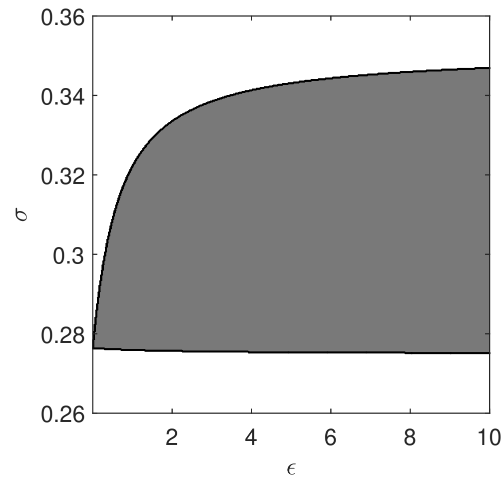


Figure C.1: Value of σ for news shock comovements under different values of Frisch labor elasticity

shock comovements. The shaded area of Figure C.1 shows the range of σ that leads to increases in output, consumption, hours worked, and investment. Our baseline model is an extreme case with a very large value of Frisch labor elasticity. We observe that for any value of ϵ, we can find appropriate values of σ that generate news driven business cycles, so our main results persist. Moreover, the range of σ expands as the Frisch labor elasticity increases, consistant with the result we obtain in the two-period model.

D Numerical Results for Unanticipated TFP Shocks

Table C.1 shows the (co)variances of output, consumption, hours worked, and interest rates for unanticipated TFP shocks. Figure C.1 presents the responses of macroeconomic aggregates to a positive unanticipated TFP shock under both internal and external habits.

Table D.1: Business cycle statistics: the RBC model with unanticipated TFP shocks

Moments	Internal habit	External habit
Relative standard deviations to output		
σ_c/σ_y	0.39	0.47
σ_i/σ_y	5.77	5.68
σ_n/σ_y	0.75	0.71
Contemporaneous correlations with output		
corr(c, y)	0.35	0.38
corr(i, y)	0.95	0.92
corr(n, y)	0.81	0.85
Autocorrelations		
corr(y_t, y_{t-1})	0.84	0.85
corr(c_t, c_{t-1})	0.99	0.99
corr(i_t, i_{t-1})	0.82	0.83
corr(n_t, n_{t-1})	0.80	0.79

References

[1] Abel, A.B., 1990. Asset prices under habit formation and catching up with the Joneses. American Economic Review, 80(2), pp.38-42.

[2] Agarwal, S., Qian, W. and Zou, X., 2021. Thy neighbor's misfortune: Peer effect on consumption. American Economic Journal: Economic Policy, 13(2), pp.1-25.

[3] Alonso-Carrera, J., Caballé, J. and Raurich, X., 2006. Welfare implications of the interaction between habits and consumption externalities. International Economic Review, 47(2), pp.557-571.

[4] Beaudry, P. and Portier, F., 2007. When can changes in expectations cause business cycle fluctuations in neo-classical settings?. Journal of Economic Theory, 135, pp.458-477.

[5] Beaudry, P. and Portier, F., 2014. News-driven business cycles: Insights and challenges. Journal of Economic Literature, 52(4), pp.993-1074.

[6] Bertrand, M. and Morse, A., 2016. Trickle-down consumption. Review of Economics and Statistics, 98(5), pp.863-879.

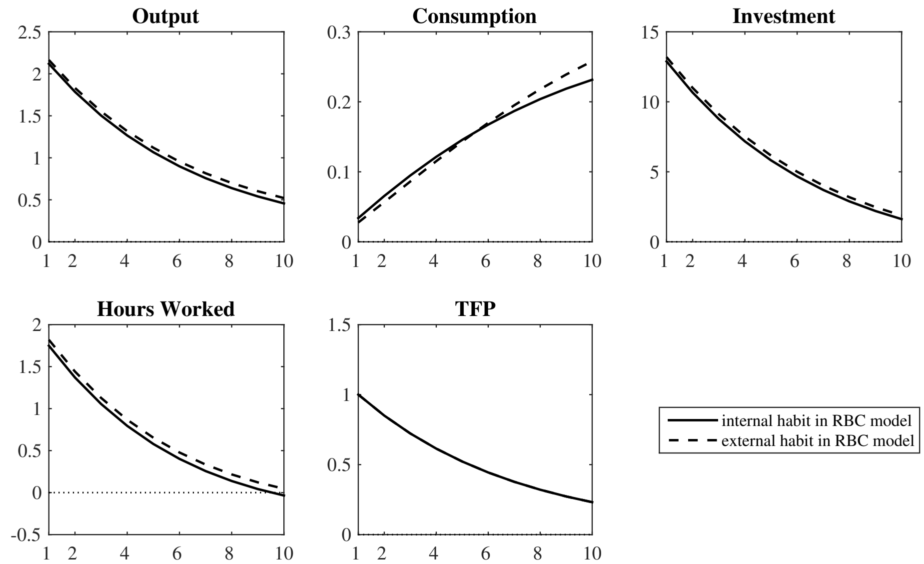


Figure D.1: Impulse responses of an unanticipated TFP shock: internal v.s. external habits

[7] Blanchard, O.J. and Kahn, C.M., 1980. The solution of linear difference models under rational expectations. Econometrica: Journal of the Econometric Society, pp.1305-1311.

[8] Born, B., Peter, A. and Pfeifer, J., 2013. Fiscal news and macroeconomic volatility. Journal of Economic Dynamics and Control, 37(12), pp.2582-2601.

[9] Campbell, J.Y. and Cochrane, J.H., 1999. By force of habit: A consumption-based explanation of aggregate stock market behavior. Journal of Political Economy, 107(2), pp.205-251.

[10] Carroll, C.D., Overland, J. and Weil, D.N., 2000. Saving and growth with habit formation. American Economic Review, 90(3), pp.341-355.

[11] Chahrour, R., Chugh, S.K. and Potter, T., 2023. Anticipated productivity and the labor market. Quantitative Economics, 14(3), pp.897-934.

[12] Chen, K. and Lai, C., 2015. On-the-Job Learning and news-driven business cycles. Journal of Money, Credit and Banking, 47 (2/3), pp.261-294.

[13] Christiano, L.J., Eichenbaum, M. and Evans, C.L., 2005. Nominal rigidities and the dynamic effects of a shock to monetary policy. Journal of Political Economy, 113(1), pp.1-45.

[14] Christiano, L.J., Ilut, C.L., Motto, R. and Rostagno, M., 2008. Monetary policy and stock market boom-bust cycles. Working paper.

[15] De Giorgi, G., Frederiksen, A. and Pistaferri, L., 2020. Consumption network effects. The Review of Economic Studies, 87(1), pp.130-163.

[16] Dennis, R., 2009. Consumption habits in a new Keynesian business cycle model. Journal of Money, Credit and Banking, 41(5), pp.1015-1030.

[17] Drechsel-Grau, M. and Schmid, K.D., 2014. Consumption-savings decisions under upward-looking comparisons. Journal of Economic Behavior and Organization, 106, pp.254-268.

[18] Faccini, R. and Melosi, L., 2022. Pigouvian cycles. American Economic Journal: Macroeconomics, 14(2), pp.281-318.

[19] Ferrara, L., Metelli, L., Natoli, F. and Siena, D., 2021. Questioning the puzzle: fiscal policy, real exchange rate and inflation. Journal of International Economics, 133, No.103524.

[20] Gali, J., 1994. Keeping up with the Joneses: Consumption externalities, portfolio choice, and asset prices. Journal of Money, Credit and Banking, 26(1), pp.1-8.

[21] Gayle, W. R. and Khorunzhina, N., 2018. Micro-level estimation of optimal consumption choice with intertemporal nonseparability in preferences and measurement errors. Journal of Business & Economic Statistics, 36(2), pp.227-238.

[22] Görtz, C., Gunn, C. and Lubik, T. A., 2022(a). Is there news in inventories?. Journal of Monetary Economics, 126, pp.87-104.

[23] Görtz, C., Tsoukalas, J. D. and Zanetti F., 2022(b). News shocks under financial frictions. American Economic Journal: Macroeconomics, 14(4), pp.210-243.

[24] Greenwood, J., Hercowitz, Z. and Huffman, G.W., 1988. Investment, capacity utilization, and the real business cycle. American Economic Review, 78(3), pp.402-417.

[25] Gunn, C. M. and Johri, A., 2011. News and knowledge capital. Review of Economic Dynamics, 14 (1), pp.92-101.

[26] Hansen, G.D., 1985. Indivisible labor and the business cycle. Journal of Monetary Economics, 16(3), pp.309-327.

[27] Jaimovich, N. and Rebelo, S., 2009. Can news about the future drive the business cycle?. American Economic Review, 99(4), pp.1097-1118.

[28] Jermann, U.J., 1998. Asset pricing in production economies. Journal of Monetary Economics, 41(2), pp.257-275.

[29] Jermann, U. and Quadrini, V., 2012. Macroeconomic effects of financial shocks. American Economic Review, 102(1), pp.238-271.

[30] Kamber, G., Theodoridis, K. and Thoenissen, C., 2017. News-driven business cycles in small open economies. Journal of International Economics, 105, pp.77-89.

[31] Klein, M. and Krause, C., 2020. Income redistribution, consumer credit, and keeping up with the riches. Journal of Money, Credit and Banking, 52(8), pp.1937-1971.

[32] Kobayashi, K., Nakajima, T. and Inaba, M., 2012. Collateral constraint and news-driven cycles. Macroeconomic Dynamics, 16(5), pp.752-776.

[33] Leeper, E.M., Walker, T.B. and Yang, S.C.S., 2010. Government investment and fiscal stimulus. Journal of Monetary Economics, 57(8), pp.1000-1012.

[34] Lettau, M. and Uhlig, H., 2000. Can habit formation be reconciled with business cycle facts?. Review of Economic Dynamics, 3(1), pp.79-99.

[35] Ljungqvist, L. and Uhlig, H., 2015. Comment on the Campbell-Cochrane habit model. Journal of Political Economy, 123(5), pp.1201-1213.

[36] Miranda-Agrippino, S., Hacioglu Hoke, S. and Bluwstein, K., 2022. When creativity strikes: news shocks and business cycle fluctuations. Working Paper.

[37] Miyamoto, W. and Nguyen, T. L., 2020. The expectational effects of news in business cycles: Evidence from forecast data. Journal of Monetary Economics, 116, pp.184-200.

[38] Nutahara, K., 2010. Internal and external habits and news-driven business cycles. Economics Letters, 107(2), pp.300-303.

[39] Pavlov, O. and Weder, M., 2013. Countercyclical markups and news-driven business cycles. Review of Economic Dynamics, 16 (2), pp.371-382.

[40] Ravina, E., 2019. Habit persistence and keeping up with the Joneses: evidence from micro data. Working Paper.

[41] Schmitt-Grohé, S. and Uribe, M., 2012. What's news in business cycles. Econometrica, 80(6), pp.2733-2764.

[42] Siena, D., 2021. The euro area periphery and imbalances: Is it an anticipation story?. Review of Economic Dynamics, 40, pp.278-308.

[43] Smets, F. and Wouters, R., 2007. Shocks and frictions in US business cycles: A Bayesian DSGE approach. American Economic review, 97(3), pp.586-606.

[44] Ulph, D., 2014. Keeping up with the Joneses: Who loses out?. Economics Letters, 125(3), pp.400-403.

[45] Wang, P., 2012. Understanding expectation-driven fluctuations: A labor-market approach. Journal of Money, Credit and Banking, 44(2-3), pp.487-506.

[46] Yang, Y. and Zhang, R., 2024. Combining proxies and narrative sign restrictions: Revisiting the effects of technology shocks. Working Paper.

Table D.2: Prior and posterior distribution

	Prior distribution			Posterior distribution					
				Internal habit formation			*External habit formation*		
Parameter	Distribution	Mean	Std. dev.	Mean	5%	95%	Mean	5%	95%
θ	Beta	0.5000	0.2000	0.9209	0.8956	0.9446	0.9217	0.9013	0.9430
φ	Normal	4.0000	1.0000	5.3585	4.4614	6.2148	3.7355	2.0260	5.3996
γ	Uniform	0.5000	0.2887	0.0021	0.0000	0.0039	0.9700	0.9547	0.9861
κ	Gamma	4.0000	1.0000	7.9249	6.3163	9.4930	8.5838	6.5322	10.6675
δ_2/δ_1	Inv. Gamma	1.0000	1.0000	0.5040	0.3421	0.6528	0.6036	0.4023	0.8034
ρ_{xg}	Beta	0.5000	0.2000	0.4484	0.1800	0.7165	0.4402	0.1676	0.7083
ρ_z	Beta	0.5000	0.2000	0.8530	0.7952	0.9124	0.8053	0.7151	0.8971
σ_z^0	Inv. Gamma	0.1000	2.0000	0.7189	0.6542	0.7815	0.6842	0.6101	0.7731
σ_z^4	Inv. Gamma	0.1000	2.0000	0.0661	0.0256	0.1081	0.0884	0.0231	0.1683
σ_z^8	Inv. Gamma	0.1000	2.0000	0.0679	0.0280	0.1124	0.0972	0.0222	0.1855
ρ_{μ^a}	Beta	0.5000	0.2000	0.4784	0.3835	0.5662	0.4737	0.3788	0.5640
$\sigma_{\mu^a}^0$	Inv. Gamma	0.1000	2.0000	0.0824	0.0250	0.1466	0.2641	0.0660	0.3718
$\sigma_{\mu^a}^4$	Inv. Gamma	0.1000	2.0000	0.2237	0.0690	0.3671	0.0952	0.0236	0.1918
$\sigma_{\mu^a}^8$	Inv. Gamma	0.1000	2.0000	0.2014	0.0315	0.3500	0.1441	0.0265	0.3283
ρ_g	Beta	0.5000	0.2000	0.9399	0.9155	0.9638	0.9454	0.9188	0.9732
σ_g^0	Inv. Gamma	0.1000	2.0000	1.0779	0.9811	1.1612	0.4820	0.0270	1.1130
σ_g^4	Inv. Gamma	0.1000	2.0000	0.0691	0.0257	0.1115	0.7082	0.0295	1.1328
σ_g^8	Inv. Gamma	0.1000	2.0000	0.0731	0.0316	0.1274	0.0885	0.0230	0.1651
ρ_{μ^x}	Beta	0.5000	0.2000	0.8790	0.8122	0.9534	0.8137	0.6622	0.9576
$\sigma_{\mu^x}^0$	Inv. Gamma	0.1000	2.0000	0.1015	0.0443	0.1619	0.0799	0.0249	0.1441
$\sigma_{\mu^x}^4$	Inv. Gamma	0.1000	2.0000	0.0528	0.0255	0.0806	0.0770	0.0243	0.1371
$\sigma_{\mu^x}^8$	Inv. Gamma	0.1000	2.0000	0.0578	0.0254	0.0895	0.0784	0.0239	0.1386
ρ_μ	Beta	0.5000	0.2000	0.9629	0.9434	0.9851	0.9798	0.9647	0.9960
σ_μ^0	Inv. Gamma	0.1000	2.0000	0.0734	0.0254	0.1273	0.0896	0.0232	0.1585
σ_μ^4	Inv. Gamma	0.1000	2.0000	5.6988	4.9624	6.5091	13.4818	9.8529	17.0941
σ_μ^8	Inv. Gamma	0.1000	2.0000	0.1216	0.0197	0.2777	0.0871	0.0219	0.1677
ρ_ς	Beta	0.5000	0.2000	0.1977	0.0727	0.3236	0.4821	0.3250	0.6414
σ_ς^0	Inv. Gamma	0.1000	2.0000	0.0827	0.0278	0.1528	0.0808	0.0245	0.1487
σ_ς^4	Inv. Gamma	0.1000	2.0000	0.0764	0.0252	0.1246	0.0977	0.0231	0.1924
σ_ς^8	Inv. Gamma	0.1000	2.0000	6.9728	4.7240	8.9752	7.0465	5.6348	8.4367
ρ_{z^I}	Beta	0.5000	0.2000	0.6344	0.5426	0.7382	0.6010	0.4616	0.7392
$\sigma_{z^I}^0$	Inv. Gamma	0.1000	2.0000	9.5536	6.8231	11.9900	10.5417	6.9846	13.9827
$\sigma_{z^I}^4$	Inv. Gamma	0.1000	2.0000	0.1005	0.0232	0.2098	0.0829	0.0238	0.1541
$\sigma_{z^I}^8$	Inv. Gamma	0.1000	2.0000	0.0588	0.0283	0.0885	0.0903	0.0230	0.1641
$\sigma_{g^y}^{me}$	Uniform	0.5000	0.2887	0.6096	0.5643	0.6589	0.6043	0.5559	0.6527
	Log marginal density				-1673			-1713	