ENDOGENOUS RISK AVERSION IN REAL BUSINESS CYCLE MODELS*

ORHAN TORUL†
Boğaziçi University

November, 2024

Abstract

This paper examines how endogenous risk aversion affects real business cycle (*RBC*) model dynamics. By modeling the coefficient of relative risk aversion as a first-order linear approximation of any non-linear cyclical function of output, I find that procyclical risk aversion increases output volatility and alters labor market dynamics and consumption patterns. The model addresses some limitations of standard *RBC* models, such as insufficient consumption and labor volatility. This study suggests that incorporating time-varying risk attitudes can enhance macroeconomic models' explanatory power, improving their alignment with empirical observations.

Özet

Bu makale, içsel risk tercihinin reel konjonktür dalgalanmaları (*RBC*) modeli dinamiklerini nasıl etkilediğini incelemektedir. Göreceli risk tercih katsayısını, gelirin doğrusal olmayan herhangi döngüsel bir fonksiyonunun birinci dereceden doğrusal bir yaklaşımı olarak modelleyerek, döngüsel risk tercihinin çıktı oynaklığını artırdığını ve işgücü piyasası dinamiklerini ve tüketim kalıplarını değiştirdiğini ortaya koymaktadır. Model, yetersiz tüketim ve çalışma saati volatilitesi gibi standart *RBC* model sınırlamalarını iyileştirmektedir. Böylelikle bu çalışma, zamanla değişen risk tutumlarının makroekonomik modellerin açıklayıcı gücünü artırabileceğini ve ampirik gözlemlerle uyumlarını iyileştirebileceğini önermektedir.

Keywords: Business Cycle Statistics, Real Business Cycles, Time-Varying Risk, Risk Preferences
JEL Classifications: E30, E32, E37, E60, E71

*I am grateful to editor-in-charge Ozan Hatipoğlu and two anonymous reviewers for their comments and suggestions. I gratefully acknowledge the financial support of the Young Scientist Award (BAGEP) of Turkey's Science Academy and Boğaziçi University Research Fund grant number BAP 20050 for the preparation of this manuscript. All remaining errors are mine.

†Address: Boğaziçi University, Department of Economics, 34342 Bebek, Istanbul, Turkey. E-Mail: orhan.torul@bogazici.edu.tr

1 Introduction

The real business cycle (*RBC*) model, a cornerstone of macroeconomic theory since the seminal work of Kydland and Prescott (1982), has traditionally relied on "deep parameters" —fundamental economic characteristics presumed to be invariant across time and states. Among these, the risk aversion coefficient has long been treated as a constant, reflecting an unchanging attitude towards risk among economic agents. This assumption has facilitated model tractability and simplified the analysis of economic fluctuations. However, recent empirical evidence suggests that risk attitudes may be more variable than previously assumed, potentially changing in response to economic conditions.

In this paper, I examine how the predictions of the *RBC* model change if the risk aversion coefficient is not a constant parameter but an endogenous function of output. This question is motivated by a growing body of literature that challenges the assumption of constant risk aversion.[1] These findings raise important questions about the validity of constant risk aversion assumptions in macroeconomic modeling and their implications for our understanding of business cycle dynamics.

Despite these empirical findings, the macroeconomic consequences of time-varying risk aversion remain largely unexplored.[2] This paper aims to contribute to this area by investigating how endogenous, cyclical risk aversion affects the business cycle properties of the *RBC* model. I formulate the risk aversion coefficient as a first-order linear approximation of a non-linear cyclical function of output, allowing for an examination of scenarios ranging from procyclical to countercyclical risk aversion. This approach enables a systematic analysis of how different patterns of time-varying risk aversion might influence key macroeconomic variables and overall economic dynamics.

My approach builds upon previous work that has questioned the constancy of deep parameters in macroeconomic models. For instance, Bai et al. (2012) explored productive demand shocks, while Cho and Cooley (1994) incorporated extensive and intensive labor margins to improve business cycle statistics. Fernandez-Villaverde and Rubio-Ramírez (2007) provided a broader criticism of modeling "structural" parameters as state and time-invariant. My focus on endogenous risk aversion represents a continuation of this line of inquiry, extending the critique to a fundamental aspect of household behavior in *RBC* models.

The paper is structured as follows: First, I present the analytical framework, deriving key equilibrium conditions under endogenous risk aversion. This section provides a detailed exposition of how time-varying risk aversion is incorporated into the standard *RBC* model, highlighting the modifications to household optimization and the resulting changes in equilibrium conditions. I then calibrate the model under three distinct scenarios: a baseline case, a linear disutility specification following Hansen (1985) and Rogerson (1988), and a high risk aversion case. This multi-scenario approach allows for a comprehensive examination of how the effects of endogenous risk aversion might vary under different model specifica-

[1] Studies by Eeckhoudt et al. (1996), Malmendier and Nagel (2011), Bucciol and Zarri (2013), Guiso et al. (2013), Hanaoka et al. (2015), and Mengel et al. (2016) present evidence suggesting that risk aversion is neither time nor state invariant, but rather exhibits persistent patterns of variation.

[2] An exception is the work of Torul (2018), who investigates a scenario where the coefficient of relative risk aversion is stochastic or countercyclical.

tions. For each scenario, I examine steady-state properties, impulse response functions, and business cycle statistics, comparing the results to those of standard *RBC* models and empirical data. This comparative analysis helps to isolate the specific impacts of endogenous risk aversion and to assess its potential to improve the model's fit with observed economic patterns.

My findings indicate that endogenous risk aversion can alter the dynamics of key macroeconomic variables in significant ways. I observe changes in output volatility, labor market dynamics, and the behavior of consumption and investment. Notably, the model with procyclical risk aversion appears to address some known limitations of standard *RBC* models, such as insufficient consumption volatility and excessive investment volatility. These results suggest that incorporating time-varying risk aversion may enhance the explanatory power of *RBC* models and provide new insights into the propagation of economic shocks.

This paper aims to contribute to our understanding of business cycle dynamics by exploring the potential role of time-varying risk attitudes in shaping macroeconomic outcomes. By challenging the assumption of constant risk aversion, it invites a reconsideration of how fundamental economic behaviors are modeled in macroeconomic theory. The results may have implications for how we interpret economic fluctuations and for optimal policy design (Ateşağaoğlu and Torul, 2018). While the focus of this paper is primarily theoretical, the findings point to the importance of further empirical work to estimate the cyclical properties of risk aversion and to test the predictions of models with endogenous risk aversion against historical data.

The rest of the paper is organized as follows: in Section 2, I describe the model environment, in Section 3, I discuss the computational methodology and parametrization, in Section 4, I present the results, and in Section 5 I conclude.

2 Model

This model employs a standard real business cycle (*RBC*) framework with a representative household and firm in a decentralized market economy.[3]

Households

The representative household maximizes its present-discounted lifetime utility subject to a dynamic budget constraint:

$$\max_{\{c_t, n_t, k_{t+1}\}_{t=0}^{\infty}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t [u(c_t) - v(n_t)] \tag{1}$$

subject to

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

[3] Given the absence of government and externalities, the social planner's solution would be identical to the competitive equilibrium, as per the first welfare theorem.

where $\mathbb{E}_0(\cdot)$ denotes the expectations operator (as of period 0), $c > 0$ denotes consumption, $n \in [0,1]$ denotes hours worked (as a fraction of the period), $k > 0$ denotes physical capital, δ denotes depreciation rate, β denotes subjective discount factor, and w and r denote factor prices: real wage, and (net) interest rate, respectively.

The household's preferences are additively separable, with a constant relative risk aversion (*CRRA*) function for consumption and a convex (or linear) disutility function for labor:

$$u(c_t, n_t) = \frac{c_t^{1-\sigma_t} - 1}{1-\sigma_t} - \frac{\psi}{1+\upsilon} n_t^{1+\upsilon} \tag{3}$$

where ψ and υ govern the level and convexity of labor disutility, respectively.

Departing from conventional models, the risk aversion coefficient σ_t is time-varying:[4]

$$\sigma_t = \overline{\sigma} - \gamma(y_t - \overline{y}) \tag{4}$$

where $\overline{\sigma}$ refers to the long-run level of the risk aversion coefficient, $\overline{y}$ denotes the endogenously-determined steady-state level of output, and γ determines the responsiveness of risk aversion to income fluctuations. This formulation allows σ_t to be *countercyclical* ($\gamma > 0$), *procyclical* ($\gamma < 0$), or *acyclical* ($\gamma = 0$).[5]

The household's optimality conditions yield:

$$\psi\, {n_t}^{\upsilon} - {c_t}^{-\sigma_t} w_t = -\gamma\,(1-\alpha)\,\frac{y_t}{n_t}\left(\frac{{c_t}^{1-\sigma_t}\log(c_t)}{\sigma_t - 1} + \frac{{c_t}^{1-\sigma_t} - 1}{(\sigma_t - 1)^2}\right) \tag{5}$$

$$c_t^{-\sigma_t} - \beta\,\mathbb{E}_t\left[{c_{t+1}}^{-\sigma_{t+1}}\,(r_{t+1} - \delta)\right] = -\gamma\,\alpha\,\beta\,\mathbb{E}_t\left[\left(\frac{{c_{t+1}}^{1-\sigma_{t+1}}\log(c_{t+1})}{\sigma_{t+1} - 1} + \frac{{c_{t+1}}^{1-\sigma_{t+1}} - 1}{(\sigma_{t+1} - 1)^2}\right)\frac{y_{t+1}}{k_{t+1}}\right] \tag{6}$$

The left-hand sides of equations (5) and (6) represent standard consumption-leisure and consumption-saving optimality conditions. The right-hand sides introduce novel intratemporal and intertemporal wedges due to the endogenous risk aversion parameter, which vanish when $\gamma = 0$.

Firms

The representative firm solves a standard optimization problem: it faces a constant returns to scale production technology, and maximizes its profits as a price taker, thereby making zero economic profits. The static optimization of the firm is formally as follows:

$$\max_{\{k_t, n_t\}} e^{z_t} F(k_t, n_t) - w_t n_t - r_t k_t - \delta k_t \tag{7}$$

[4] Note that (4) implies $\sigma_t(\cdot)$ can be considered as a first-order Taylor approximation of a non-linear risk aversion function formulation, hence preserves generality despite its simplicity.

[5] This aligns with Malmendier and Nagel (2011).

where e^z denotes total factor productivity (*TFP*), and k and n denote physical capital and labor demanded by the firm, respectively. *TFP* shock is lognormally distributed and autoregressive of order one, as it is standard in the literature:

$$z_{t+1} = \rho_z z_t + \varepsilon^z_{t+1} \tag{8}$$

where ε^z is normally distributed with zero mean, and a homoskedastic variance σ^2_z, i.e., $\varepsilon^z \sim N(0, \sigma^2_z)$.[6]

Suppose that the firm's production technology takes the Cobb-Douglas form: $F(k,n) = k^\alpha n^{1-\alpha}$. Then, as a result of the price-taking firm's optimal decisions, the real interest rate and wage are determined competitively and are equal to the marginal product of capital and labor, respectively:

$$r_t = e^{z_t} \alpha k_t^{\alpha-1} n_t^{1-\alpha} - \delta \tag{9}$$

$$w_t = e^{z_t} (1-\alpha) k_t^{\alpha} n_t^{-\alpha} \tag{10}$$

Finally, note that the dynamic budget constraint of the household (2) and the factor prices (9) and (10) jointly imply that the aggregate resource constraint has to hold:

$$y_t = e^{z_t} k_t^{\alpha} n_t^{1-\alpha} = c_t + i_t \tag{11}$$

where $i_t = k_{t+1} - (1-\delta) k_t$ denotes investment and $y_t = e^{z_t} k_t^{\alpha} n_t^{1-\alpha}$ denotes output in period t.

The competitive equilibrium of this model economy is defined such that:

- The representative agent maximizes their present-discounted life-time utility (1) subject to the dynamic budget constraint (2) and the transversality condition, and follows the resultant intratemporal and intertemporal decision rules (5) and (6);
- The representative firm maximizes its static profits (7), which results in competitive factor prices in (9) and (10)
- The law of motion for the risk aversion parameter follows (4) and *TFP* shock follows (8);
- The aggregate resource constraint (11) holds.

To explore the business cycle properties of the model, I first compute the deterministic steady state, and then rely on local approximation algorithm around this steady state.

To calculate the deterministic steady state, one can set the variables to their long-run means, and simplify the system of equations as follows:

$$\psi \overline{n}^{\upsilon} - \overline{c}^{-\overline{\sigma}} \overline{w} = -\gamma (1-\alpha) \frac{\overline{y}}{\overline{n}} \left(\frac{\overline{c}^{1-\overline{\sigma}} \log(\overline{c})}{\overline{\sigma}-1} + \frac{\overline{c}^{1-\overline{\sigma}} - 1}{(\overline{\sigma}-1)^2} \right) \tag{12}$$

$$\overline{c}^{-\overline{\sigma}} \left[1 - \beta(\overline{r} - \delta)) \right] = -\gamma \alpha \beta \left[\left(\frac{\overline{c}^{1-\overline{\sigma}} \log(\overline{c})}{\overline{\sigma}-1} + \frac{\overline{c}^{1-\overline{\sigma}} - 1}{(\overline{\sigma}-1)^2} \right) \frac{\overline{y}}{\overline{k}} \right] \tag{13}$$

[6] Note that the steady-state value of the *TFP* shock then satisfies $e^{\overline{z}} = 1$ since $\overline{z} = 0$.

$$\overline{c} + \delta \overline{k} = \overline{y} \tag{14}$$

$$\overline{y} = \overline{k}^{\alpha} \overline{n}^{(1-\alpha)} \tag{15}$$

$$\overline{r} = \alpha \overline{k}^{\alpha-1} \overline{n}^{(1-\alpha)} - \delta \tag{16}$$

$$\overline{w} = (1-\alpha) \overline{k}^{\alpha} \overline{n}^{-\alpha} \tag{17}$$

These six equations uniquely determine the six unknowns of the model: $\overline{k}, \overline{n}, \overline{y}, \overline{c}, \overline{r}$, and $\overline{w}$.

After calculating the deterministic steady state, I derive the decision rules and resultant business cycle statistics around the deterministic steady state using the Schmitt-Grohé and Uribe (2004) local approximation technique.[7]

3 Parametrization and Computation

This study adopts standard parameter estimates for the United States economy, following mainstream macroeconomics literature (e.g., King and Rebelo (1999)). The model period is set to one quarter, with conventional *RBC* parameter values. The quarterly subjective discount rate (β) is set to 0.99, while the share of physical capital in production (α) is 0.36. The quarterly depreciation rate (δ) is assumed to be 0.02. For the total factor productivity, the autoregressive persistence (ρ_z) is set to 0.95, and its shock's standard deviation (σ_z) is 0.007.

Regarding consumption preferences, the baseline steady-state coefficient of risk aversion ($\overline{\sigma}$) is set to 1.50, aligning with Arrow (1999) and common practice in macroeconomic literature.[8] The convexity parameter of labor disutility (υ) is set to 4/3, implying a Frisch elasticity of labor supply of 0.75, as proposed by Chetty et al. (2011) for macroeconomic models. This configuration is termed the *baseline model*.

Two alternative specifications are also explored. The first, termed the *linear disutility model*, sets $\upsilon = 0$, following the "indivisible labor" concept of Hansen (1985) and Rogerson (1988), where the representative household is risk-neutral in labor. The second, the *high risk aversion model*, sets the steady-state coefficient of risk aversion ($\overline{\sigma}$) to 3, to examine the implications for the intertemporal margin as highlighted by Huggett (1993), among others.

In all three models, the level parameter governing labor disutility (ψ) is calibrated to achieve $n = 0.30$ in the acyclical case ($\gamma = 0$), consistent with standard literature. To investigate the role of risk aversion cyclicality, five values of γ are tested across all models: $-3, -1.5, 0, 1.5$, and 3. Positive values represent procyclical risk aversion, negative values represent countercyclical risk aversion, and $\gamma = 0$ represents acyclical risk aversion, equivalent to the benchmark plain-vanilla *RBC* model. Table 1 summarizes the parametrization for all model variants.

[7] Throughout my computations, I use the `MATLAB` add-on `DYNARE` version 6.1.0. For steady-state calculations, I rely on fixed-point iteration: I guess the steady-state level of output, calculate the resultant steady state prediction, and update my prediction with the new result if the initial guess is inaccurate. For business cycle calculations, I rely on `DYNARE`'s in-built third-order local approximation algorithm *à la* Schmitt-Grohé and Uribe (2004).

[8] For further discussion on risk aversion values, see Layard et al. (2008) and Gandelman and Hernández-Murillo (2015).

Table 1: Parameter Sets

	Baseline	Linear Disutility	High Risk Aversion
α	0.36	0.36	0.36
β	0.99	0.99	0.99
δ	0.02	0.02	0.02
ρ_z	0.95	0.95	0.95
σ_z	0.007	0.007	0.007
$\overline{\sigma}$	1.50	1.50	3.00
υ	4/3	0.00	4/3
ψ	14.5429	2.9207	16.4334
γ	$\{-3,-1.5,0,1.5,3\}$	$\{-3,-1.5,0,1.5,3\}$	$\{-3,-1.5,0,1.5,3\}$

4 Results

4.1 Baseline Model

Using the parameter values listed in Table 1's first column, I calculate the baseline economy's steady state through fixed-point iteration, with results reported in Table 2. As the magnitude of γ increases, the steady-state output that equates the long-run value of σ_t to $\overline{\sigma} = 1.5$ also increases. This stems from higher steady-state levels of both production factors, with physical capital showing a notably larger increase (in both level and percentage) compared to labor. These steady-state differences arise from the intertemporal and intratemporal wedges in equations (5) and (6).[9]

Table 2: Steady State of the Baseline Economy

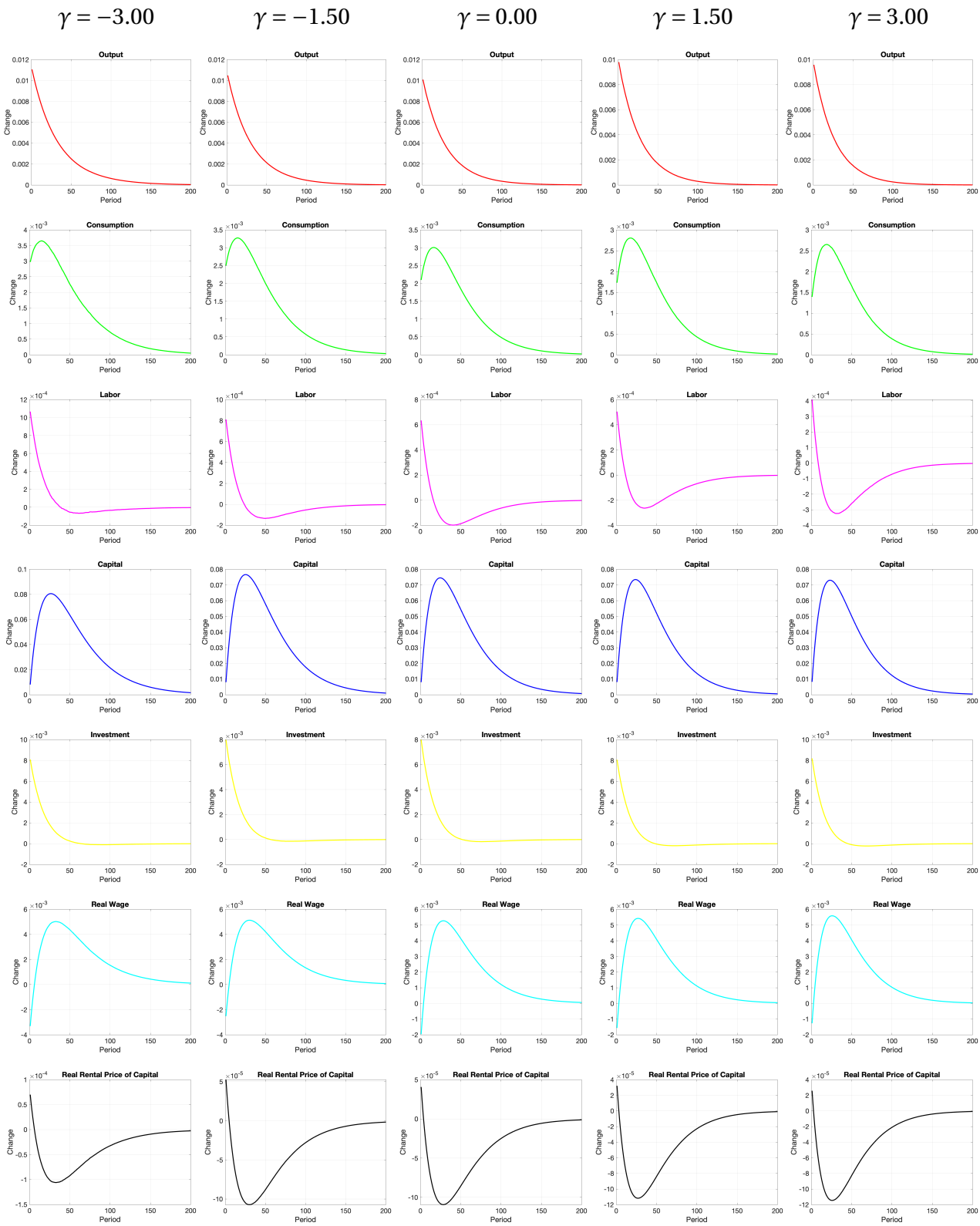
γ	$\overline{y}$	$\overline{c}$	$\overline{k}$	$\overline{i}$	$\overline{n}$	$\overline{y/n}$	$\overline{r}$	$\overline{w}$
-3.00	1.1989	0.9152	14.1862	0.2837	0.2987	4.0143	0.0104	2.5691
-1.50	1.2057	0.9187	14.3499	0.2870	0.2994	4.0274	0.0102	2.5775
0.00	1.2115	0.9217	14.4897	0.2898	0.3000	4.0385	0.0101	2.5846
1.50	1.2166	0.9244	14.6117	0.2922	0.3005	4.0481	0.0100	2.5908
3.00	1.2210	0.9266	14.7196	0.2944	0.3010	4.0566	0.0099	2.5962

Before examining the impact of time-varying risk aversion on business cycle statistics, I analyze the impulse response functions (*IRFs*) of the model's endogenous variables, presented in Figure 1. These *IRFs* show the 200-quarter responses of key variables from their steady-state values following a one-standard-deviation positive total factor productivity shock. Each column depicts the *IRFs* for a specific γ value.

The first row of Figure 1 reveals that a highly procyclical σ (i.e., $\gamma = -3$) yields the largest initial output increase, which decays most slowly over time. To understand this phenomenon, I focus on the responses of production factors, capital and labor. The fourth row shows that capital responses remain relatively consistent across γ values. In contrast, the third row demonstrates significant variations in labor responses. A procyclical σ leads to larger initial increases in labor that decay slowly, while a countercyclical σ (shown in the last column) results in moderate initial jumps that turn negative within five years before oscillating

[9] Note that as long as $\gamma \neq 0$, the endogeneity of the risk aversion coefficient alters the representative household's optimal decision rules.

Figure 1: Impulse-Response Functions with Baseline Parameters



back to zero. Other endogenous variables exhibit less variation across σ's cyclicality compared to labor. Investment *IRFs* show negligible changes across γ values, while consumption *IRFs* display similar patterns but with different magnitudes. Factor prices (real wage and real rental price of capital) show the most pronounced initial variations with procyclical σ and the largest oscillations with countercyclical σ, mirroring the labor response patterns. These findings suggest that labor, consumption, and factor prices are the most likely candidates to drive variations in business cycle statistics.

Table 3 presents the business cycle properties of the baseline model.[10] The table displays standard deviation, relative (to output) standard deviation, lagged, contemporaneous, and lead correlations with output, and autocorrelation functions (*ACF*) for various variables.[11] The output rows in Table 3 indicate that while output's standard deviation increases with σ's procyclicality, other output statistics remain relatively stable across γ values. Capital statistics show little variation, whereas labor exhibits considerable changes in both absolute and relative standard deviation as γ changes. Higher σ procyclicality leads to greater labor variation and stronger positive contemporaneous and lead correlations with output. Consumption displays similar patterns, but with increased lagged (rather than lead) correlations as procyclicality increases.

A key limitation of *RBC* models is their inability to generate sufficient consumption volatility due to households' consumption smoothing behavior. This, combined with intratemporal decisions affecting optimal labor supply, also constrains labor volatility. Moreover, the standard *RBC* model ($\gamma = 0$) overestimates investment volatility and underestimates factor price volatility. The procyclicality of σ helps mitigate these discrepancies. Table 3 thus demonstrates that a procyclical risk aversion coefficient could help align model predictions more closely with empirical data.

4.2 Linear Disutility Model

Next, I examine the role of risk aversion cyclicality in the linear disutility model using the parameter values from Table 1's second column. Table 4 presents the steady states of this model economy. Notably, the acyclical σ case yields identical steady state values to the baseline model in Table 2. This equivalence results from recalibrating the disutility level parameter to $\psi = 2.9207$, ensuring the steady-state labor level remains at $n = 0.3$.[12]

As in the baseline case, Table 4 shows that higher σ values generate higher steady-state output levels, primarily driven by increased steady-state capital, with minimal changes in labor across γ values. However, the variation in steady-state output and other endogenous variables over γ is more pronounced under the linear disutility parameter set compared to the baseline scenario.

[10] In calculating business cycle statistics, I follow common practice in the literature: I take the natural logarithm of series of interest, apply the Hodrick-Prescott filter with smoothing parameter $\lambda = 1600$ to the log series, and then construct the (detrended) residual series to calculate relevant descriptive statistics.

[11] For comparison, U.S. business cycle statistics by King and Rebelo (1999) are provided in Table A.1.

[12] When $\gamma = 0$, the model reverts to the plain-vanilla *RBC* model. In this setting, the steady-state interest rate equals $\overline{r} = 1/\beta - 1 + \delta$ due to the intertemporal margin (i.e., the *Euler equation*). Given n's recalibration to 0.3, identical $\overline{r}$ values necessitate identical capital stock levels, resulting in identical steady states.

Table 3: Business Cycle Statistics of the Baseline Economy

$\gamma = -3.00$														
	Std.	Rel. Std.	$x(-5)$	$x(-4)$	$x(-3)$	$x(-2)$	$x(-1)$	$x(0)$	$x(+1)$	$x(+2)$	$x(+3)$	$x(+4)$	$x(+5)$	ACF
y	0.0125	1.0000	-0.0080	0.1196	0.2753	0.4784	0.7256	1.0000	0.7256	0.4784	0.2753	0.1196	-0.0080	0.7253
c	0.0046	0.3698	-0.1282	-0.0014	0.1623	0.3825	0.6559	0.9707	0.7707	0.5766	0.4057	0.2668	0.1460	0.7547
i	0.0389	3.0982	0.0401	0.1652	0.3150	0.5084	0.7409	0.9952	0.6961	0.4324	0.2200	0.0598	-0.0681	0.7200
k	0.0027	0.2153	-0.5183	-0.4601	-0.3595	-0.2052	0.0129	0.2993	0.4942	0.6088	0.6600	0.6641	0.6309	0.9569
n	0.0049	0.3938	0.0551	0.1770	0.3244	0.5156	0.7425	0.9900	0.6861	0.4203	0.2054	0.0454	-0.0794	0.7201
y/n	0.0077	0.6126	-0.0485	0.0814	0.2409	0.4495	0.7072	0.9959	0.7434	0.5107	0.3174	0.1660	0.0380	0.7319
r	0.0001	0.0092	0.2953	0.3875	0.4850	0.6001	0.7205	0.8287	0.4404	0.1269	-0.1071	-0.2651	-0.3715	0.7615
w	0.0021	0.1680	-0.2954	-0.3879	-0.4854	-0.6004	-0.7208	-0.8289	-0.4402	-0.1263	0.1077	0.2659	0.3727	0.7615
$\gamma = -1.50$														
	Std.	Rel. Std.	$x(-5)$	$x(-4)$	$x(-3)$	$x(-2)$	$x(-1)$	$x(0)$	$x(+1)$	$x(+2)$	$x(+3)$	$x(+4)$	$x(+5)$	ACF
y	0.0118	1.0000	-0.0097	0.1187	0.2746	0.4773	0.7252	1.0000	0.7252	0.4773	0.2746	0.1187	-0.0097	0.7250
c	0.0039	0.3301	-0.1545	-0.0264	0.1386	0.3605	0.6392	0.9614	0.7764	0.5925	0.4291	0.2938	0.1727	0.7624
i	0.0378	3.2119	0.0396	0.1651	0.3149	0.5080	0.7408	0.9951	0.6952	0.4308	0.2184	0.0582	-0.0702	0.7195
k	0.0026	0.2230	-0.5178	-0.4595	-0.3587	-0.2043	0.0141	0.3010	0.4959	0.6102	0.6610	0.6645	0.6306	0.9568
n	0.0037	0.3159	0.0820	0.2040	0.3478	0.5317	0.7503	0.9851	0.6657	0.3889	0.1692	0.0069	-0.1193	0.7187
y/n	0.0081	0.6909	-0.0515	0.0785	0.2384	0.4477	0.7066	0.9969	0.7453	0.5130	0.3200	0.1686	0.0406	0.7322
r	0.0001	0.0081	0.3537	0.4345	0.5130	0.5994	0.6832	0.7447	0.3461	0.0300	-0.1993	-0.3501	-0.4477	0.7893
w	0.0018	0.1488	-0.3534	-0.4346	-0.5131	-0.5994	-0.6834	-0.7448	-0.3459	-0.0296	0.1997	0.3507	0.4487	0.7892
$\gamma = 0.00$														
	Std.	Rel. Std.	$x(-5)$	$x(-4)$	$x(-3)$	$x(-2)$	$x(-1)$	$x(0)$	$x(+1)$	$x(+2)$	$x(+3)$	$x(+4)$	$x(+5)$	ACF
y	0.0112	1.0000	-0.0108	0.1181	0.2740	0.4766	0.7250	1.0000	0.7250	0.4766	0.2740	0.1181	-0.0108	0.7247
c	0.0033	0.2911	-0.1869	-0.0585	0.1074	0.3308	0.6146	0.9445	0.7806	0.6113	0.4584	0.3284	0.2083	0.7738
i	0.0375	3.3320	0.0397	0.1654	0.3150	0.5079	0.7407	0.9949	0.6943	0.4293	0.2169	0.0565	-0.0719	0.7192
k	0.0026	0.2311	-0.5171	-0.4586	-0.3577	-0.2031	0.0155	0.3026	0.4975	0.6114	0.6618	0.6647	0.6303	0.9567
n	0.0029	0.2592	0.1170	0.2374	0.3756	0.5493	0.7550	0.9715	0.6351	0.3468	0.1222	-0.0417	-0.1680	0.7197
y/n	0.0084	0.7507	-0.0548	0.0753	0.2354	0.4453	0.7050	0.9966	0.7464	0.5152	0.3229	0.1717	0.0437	0.7326
r	0.0001	0.0074	0.4041	0.4717	0.5298	0.5865	0.6324	0.6467	0.2464	-0.0652	-0.2855	-0.4260	-0.5125	0.8207
w	0.0016	0.1381	-0.4037	-0.4716	-0.5298	-0.5865	-0.6326	-0.6470	-0.2465	0.0654	0.2857	0.4264	0.5131	0.8204
$\gamma = 1.50$														
	Std.	Rel. Std.	$x(-5)$	$x(-4)$	$x(-3)$	$x(-2)$	$x(-1)$	$x(0)$	$x(+1)$	$x(+2)$	$x(+3)$	$x(+4)$	$x(+5)$	ACF
y	0.0109	1.0000	-0.0115	0.1176	0.2736	0.4761	0.7248	1.0000	0.7248	0.4761	0.2736	0.1176	-0.0115	0.7245
c	0.0028	0.2534	-0.2276	-0.1003	0.0654	0.2897	0.5778	0.9155	0.7809	0.6326	0.4945	0.3725	0.2550	0.7905
i	0.0375	3.4555	0.0400	0.1657	0.3152	0.5079	0.7406	0.9945	0.6933	0.4279	0.2153	0.0549	-0.0735	0.7188
k	0.0026	0.2395	-0.5162	-0.4576	-0.3565	-0.2017	0.0170	0.3043	0.4989	0.6126	0.6625	0.6649	0.6300	0.9567
n	0.0024	0.2172	0.1612	0.2777	0.4073	0.5670	0.7541	0.9452	0.5907	0.2910	0.0621	-0.1022	-0.2267	0.7248
y/n	0.0087	0.7978	-0.0583	0.0718	0.2320	0.4425	0.7031	0.9960	0.7476	0.5176	0.3260	0.1752	0.0473	0.7332
r	0.0001	0.0071	0.4442	0.4978	0.5358	0.5642	0.5737	0.5439	0.1493	-0.1524	-0.3605	-0.4889	-0.5630	0.8513
w	0.0014	0.1329	-0.4437	-0.4977	-0.5359	-0.5643	-0.5742	-0.5446	-0.1497	0.1524	0.3605	0.4891	0.5636	0.8509
$\gamma = 3.00$														
	Std.	Rel. Std.	$x(-5)$	$x(-4)$	$x(-3)$	$x(-2)$	$x(-1)$	$x(0)$	$x(+1)$	$x(+2)$	$x(+3)$	$x(+4)$	$x(+5)$	ACF
y	0.0106	1.0000	-0.0121	0.1171	0.2732	0.4757	0.7246	1.0000	0.7246	0.4757	0.2732	0.1171	-0.0121	0.7243
c	0.0023	0.2179	-0.2796	-0.1556	0.0077	0.2307	0.5211	0.8653	0.7724	0.6549	0.5383	0.4288	0.3165	0.8151
i	0.0379	3.5816	0.0406	0.1662	0.3155	0.5080	0.7406	0.9942	0.6923	0.4265	0.2137	0.0533	-0.0751	0.7185
k	0.0026	0.2481	-0.5153	-0.4566	-0.3553	-0.2004	0.0185	0.3059	0.5004	0.6137	0.6631	0.6651	0.6297	0.9566
n	0.0020	0.1869	0.2134	0.3234	0.4410	0.5819	0.7440	0.9019	0.5297	0.2202	-0.0113	-0.1741	-0.2944	0.7361
y/n	0.0088	0.8353	-0.0623	0.0679	0.2284	0.4394	0.7010	0.9953	0.7489	0.5203	0.3296	0.1792	0.0514	0.7339
r	0.0001	0.0070	0.4733	0.5137	0.5336	0.5368	0.5144	0.4464	0.0621	-0.2267	-0.4212	-0.5371	-0.5992	0.8776
w	0.0014	0.1318	-0.4729	-0.5138	-0.5339	-0.5373	-0.5152	-0.4474	-0.0627	0.2266	0.4212	0.5374	0.5998	0.8770

Figure 2: Impulse-Response Functions with Linear Disutility ($\upsilon = 0$)

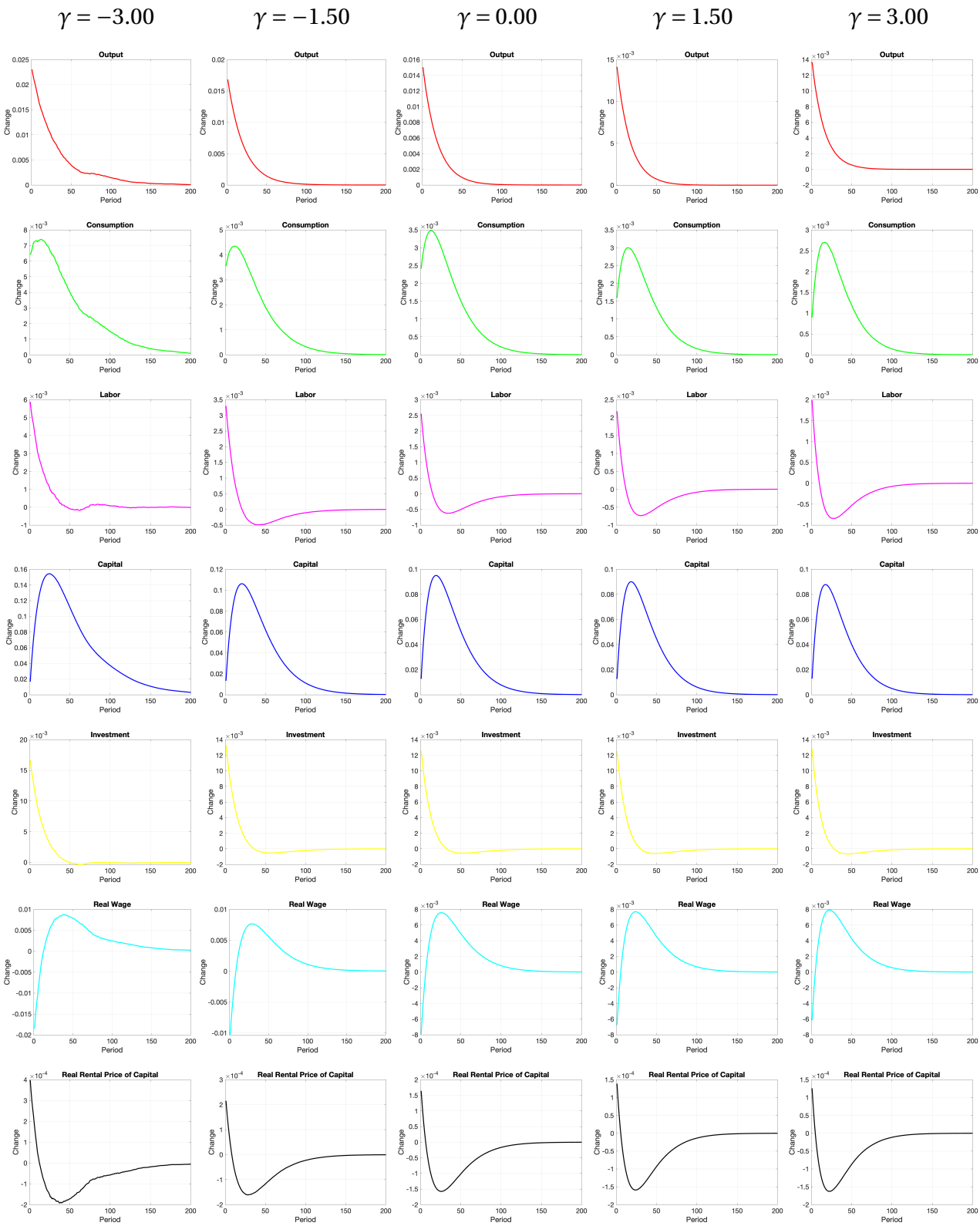


Figure 2 illustrates the *IRFs* of this model to a total factor productivity shock. The first row reveals that output's on-impact response varies significantly across γ values: a highly procyclical σ ($\gamma = -3$) generates about 150% larger initial output increase, decaying much more slowly compared to the highly countercyclical σ ($\gamma = 3$) case. The disparity in immediate jumps across γ values primarily stems from labor responses, while capital responses contribute to slower decay under the procyclical scenario.

Consumption *IRFs* also show considerable variation across γ values, with the peak jump for $\gamma = -3$ being almost triple that for $\gamma = 3$.[13] Investment and factor prices exhibit notable variation over σ's cyclicality as well. These findings indicate that the Hansen-Rogerson parametrization amplifies the variation of *IRFs* across γ values.

Table 4: Steady State of the Linear Disutility Model

γ	$\overline{y}$	$\overline{c}$	$\overline{k}$	$\overline{i}$	$\overline{n}$	$\overline{y/n}$	$\overline{r}$	$\overline{w}$
-3.00	1.1921	0.9104	14.0887	0.2818	0.2972	4.0115	0.0105	2.5674
-1.50	1.2032	0.9168	14.3160	0.2863	0.2988	4.0269	0.0103	2.5772
0.00	1.2115	0.9217	14.4897	0.2898	0.3000	4.0385	0.0101	2.5846
1.50	1.2183	0.9257	14.6297	0.2926	0.3010	4.0478	0.0100	2.5906
3.00	1.2239	0.9289	14.7466	0.2949	0.3018	4.0555	0.0099	2.5955

[13] The heightened disparities of *IRFs* over γ between the baseline and linear disutility models can be attributed to the Hansen-Rogerson parametrization's intratemporal implications on household responses to shocks. In the plain-vanilla *RBC* model, the intratemporal margin dictates that $\psi n_t^{\upsilon} c_t^{\sigma} = w_t$. When $\upsilon = 0$, a wage shock is absorbed solely by consumption response, whereas when $\upsilon > 0$, the shock is handled by joint responses in consumption and hours worked. Consequently, the convexity of disutility over hours worked amplifies economic responses, generating more pronounced magnitudes under the Hansen-Rogerson parameter set.

Table 5: Business Cycle Statistics of the Linear Disutility Model

$\gamma = -\mathbf{3.00}$														
	Std.	Rel. Std.	$x(-5)$	$x(-4)$	$x(-3)$	$x(-2)$	$x(-1)$	$x(0)$	$x(+1)$	$x(+2)$	$x(+3)$	$x(+4)$	$x(+5)$	ACF
y	0.0272	1.0000	-0.0004	0.1195	0.2740	0.4841	0.7269	1.0000	0.7269	0.4841	0.2740	0.1195	-0.0004	0.7263
c	0.0105	0.3875	-0.1146	0.0028	0.1633	0.3904	0.6564	0.9656	0.7661	0.5765	0.3971	0.2599	0.1486	0.7553
i	0.0861	3.1686	0.0511	0.1689	0.3164	0.5160	0.7399	0.9918	0.6911	0.4331	0.2140	0.0553	-0.0653	0.7170
k	0.0058	0.2130	-0.5150	-0.4579	-0.3589	-0.2050	0.0114	0.2955	0.4897	0.6051	0.6558	0.6603	0.6302	0.9577
n	0.0283	1.0427	0.0498	0.1644	0.3117	0.5139	0.7390	0.9899	0.6944	0.4384	0.2180	0.0607	-0.0564	0.7223
y/n	0.0038	0.1396	-0.3707	-0.3610	-0.3470	-0.3366	-0.2702	-0.1733	0.0601	0.2220	0.3488	0.4089	0.4167	0.8218
r	0.0006	0.0210	0.1572	0.2627	0.3935	0.5677	0.7551	0.9528	0.6110	0.3235	0.0872	-0.0749	-0.1881	0.7276
w	0.0103	0.3786	-0.1574	-0.2637	-0.3948	-0.5688	-0.7562	-0.9545	-0.6111	-0.3229	-0.0867	0.0762	0.1904	0.7263
$\gamma = -\mathbf{1.50}$														
	Std.	Rel. Std.	$x(-5)$	$x(-4)$	$x(-3)$	$x(-2)$	$x(-1)$	$x(0)$	$x(+1)$	$x(+2)$	$x(+3)$	$x(+4)$	$x(+5)$	ACF
y	0.0190	1.0000	-0.0134	0.1131	0.2687	0.4729	0.7221	1.0000	0.7221	0.4729	0.2687	0.1131	-0.0134	0.7218
c	0.0056	0.2955	-0.1777	-0.0535	0.1109	0.3356	0.6176	0.9477	0.7755	0.6021	0.4441	0.3127	0.1956	0.7676
i	0.0638	3.3560	0.0354	0.1594	0.3087	0.5031	0.7368	0.9942	0.6911	0.4259	0.2125	0.0526	-0.0741	0.7157
k	0.0044	0.2297	-0.5196	-0.4626	-0.3628	-0.2085	0.0107	0.2998	0.4955	0.6097	0.6596	0.6620	0.6274	0.9562
n	0.0152	0.7976	0.0729	0.1937	0.3384	0.5251	0.7467	0.9869	0.6667	0.3902	0.1700	0.0084	-0.1162	0.7158
y/n	0.0047	0.2487	-0.2876	-0.1665	-0.0045	0.2179	0.5090	0.8559	0.7653	0.6502	0.5351	0.4279	0.3189	0.8139
r	0.0003	0.0168	0.2118	0.3174	0.4361	0.5826	0.7465	0.9102	0.5370	0.2294	-0.0050	-0.1674	-0.2824	0.7332
w	0.0059	0.3101	-0.2113	-0.3176	-0.4363	-0.5826	-0.7468	-0.9107	-0.5370	-0.2289	0.0052	0.1680	0.2837	0.7328
$\gamma = \mathbf{0.00}$														
	Std.	Rel. Std.	$x(-5)$	$x(-4)$	$x(-3)$	$x(-2)$	$x(-1)$	$x(0)$	$x(+1)$	$x(+2)$	$x(+3)$	$x(+4)$	$x(+5)$	ACF
y	0.0168	1.0000	-0.0184	0.1096	0.2654	0.4691	0.7203	1.0000	0.7203	0.4691	0.2654	0.1096	-0.0184	0.7201
c	0.0039	0.2341	-0.2450	-0.1213	0.0432	0.2690	0.5604	0.9055	0.7771	0.6340	0.4987	0.3791	0.2643	0.7922
i	0.0595	3.5475	0.0312	0.1563	0.3055	0.4995	0.7351	0.9940	0.6892	0.4219	0.2089	0.0491	-0.0786	0.7141
k	0.0041	0.2421	-0.5200	-0.4635	-0.3639	-0.2095	0.0106	0.3015	0.4977	0.6114	0.6604	0.6616	0.6254	0.9556
n	0.0117	0.6982	0.0969	0.2180	0.3584	0.5367	0.7500	0.9770	0.6409	0.3530	0.1294	-0.0335	-0.1590	0.7145
y/n	0.0059	0.3511	-0.2450	-0.1213	0.0432	0.2690	0.5604	0.9055	0.7771	0.6340	0.4987	0.3791	0.2643	0.7922
r	0.0003	0.0152	0.2536	0.3546	0.4622	0.5904	0.7326	0.8664	0.4773	0.1608	-0.0736	-0.2333	-0.3446	0.7452
w	0.0047	0.2822	-0.2528	-0.3545	-0.4621	-0.5902	-0.7327	-0.8667	-0.4775	-0.1606	0.0735	0.2335	0.3455	0.7449
$\gamma = \mathbf{1.50}$														
	Std.	Rel. Std.	$x(-5)$	$x(-4)$	$x(-3)$	$x(-2)$	$x(-1)$	$x(0)$	$x(+1)$	$x(+2)$	$x(+3)$	$x(+4)$	$x(+5)$	ACF
y	0.0156	1.0000	-0.0214	0.1069	0.2626	0.4665	0.7189	1.0000	0.7189	0.4665	0.2626	0.1069	-0.0214	0.7187
c	0.0029	0.1832	-0.3343	-0.2178	-0.0593	0.1619	0.4553	0.8096	0.7548	0.6660	0.5689	0.4716	0.3665	0.8361
i	0.0584	3.7353	0.0292	0.1542	0.3033	0.4973	0.7338	0.9937	0.6871	0.4185	0.2054	0.0456	-0.0820	0.7126
k	0.0040	0.2540	-0.5197	-0.4635	-0.3641	-0.2096	0.0111	0.3032	0.4996	0.6128	0.6609	0.6610	0.6236	0.9553
n	0.0100	0.6427	0.1221	0.2414	0.3770	0.5474	0.7506	0.9634	0.6137	0.3172	0.0902	-0.0730	-0.1975	0.7154
y/n	0.0065	0.4180	-0.2390	-0.1155	0.0487	0.2745	0.5660	0.9111	0.7763	0.6284	0.4898	0.3683	0.2528	0.7879
r	0.0002	0.0144	0.2882	0.3832	0.4805	0.5931	0.7148	0.8222	0.4231	0.1026	-0.1306	-0.2865	-0.3924	0.7585
w	0.0042	0.2696	-0.2873	-0.3830	-0.4803	-0.5929	-0.7150	-0.8227	-0.4235	-0.1027	0.1302	0.2863	0.3930	0.7581
$\gamma = \mathbf{3.00}$														
	Std.	Rel. Std.	$x(-5)$	$x(-4)$	$x(-3)$	$x(-2)$	$x(-1)$	$x(0)$	$x(+1)$	$x(+2)$	$x(+3)$	$x(+4)$	$x(+5)$	ACF
y	0.0151	1.0000	-0.0239	0.1041	0.2597	0.4640	0.7174	1.0000	0.7174	0.4640	0.2597	0.1041	-0.0239	0.7171
c	0.0022	0.1443	-0.4479	-0.3538	-0.2183	-0.0221	0.2491	0.5890	0.6592	0.6672	0.6398	0.5860	0.5059	0.9042
i	0.0591	3.9240	0.0276	0.1522	0.3011	0.4954	0.7325	0.9935	0.6849	0.4152	0.2015	0.0419	-0.0850	0.7110
k	0.0040	0.2658	-0.5191	-0.4634	-0.3642	-0.2096	0.0115	0.3048	0.5014	0.6140	0.6612	0.6602	0.6218	0.9549
n	0.0093	0.6153	0.1461	0.2625	0.3931	0.5561	0.7490	0.9481	0.5863	0.2828	0.0530	-0.1098	-0.2318	0.7173
y/n	0.0069	0.4602	-0.2473	-0.1248	0.0388	0.2647	0.5575	0.9052	0.7748	0.6301	0.4937	0.3734	0.2585	0.7900
r	0.0002	0.0142	0.3151	0.4040	0.4924	0.5922	0.6966	0.7821	0.3766	0.0546	-0.1765	-0.3281	-0.4282	0.7707
w	0.0040	0.2667	-0.3141	-0.4039	-0.4924	-0.5922	-0.6972	-0.7831	-0.3774	-0.0550	0.1760	0.3279	0.4287	0.7702

Table 5 presents the business cycle statistics of the linear disutility model. The output rows show that the standard deviation of output again increases with the procyclicality of σ. Conversely, the standard deviation of capital decreases with σ's procyclicality, which differs notably from the baseline case. Labor's standard deviation under $\sigma = -3$ closely matches that of output, aligning better with actual U.S. data. Furthermore, labor's standard deviation, as well as its contemporaneous and lead correlations with output, increase with σ's procyclicality. The business cycle properties of consumption also exhibit similarities with the baseline case: both consumption variation and its lagged correlations with output increase with σ's procyclicality. Additionally, procyclical σ generates more accurate contemporaneous correlations with output in terms of goodness of fit with the data. The procyclicality of σ also improves the accuracy of rela-

tive volatility for investment and factor prices, limiting investment volatility overshooting and factor price undershooting. Overall, Table 5 demonstrates that σ's procyclicality enhances the *RBC* model's goodness of fit, with the linear disutility model outperforming the baseline model in matching empirical data.

4.3 High Risk Aversion Model

To examine the high risk aversion scenario, I employ the parameter values listed in the third column of Table 1. Table 6 presents the resulting steady-state values under this parametrization. The acyclical σ model economy remains identical to its previous two counterparts, as labor is recalibrated to maintain the same steady-state value of $n = 0.3$. Consistent with earlier findings, the steady-state values of model variables (except for $\overline{r}$) increase with γ, albeit at a slower rate compared to the baseline case. This slower rate of change can be attributed to the nature of this utility function class, where the coefficient of relative risk aversion is the multiplicative inverse of the elasticity of intertemporal substitution. Consequently, changes in γ induce less pronounced changes in the steady-state values of the model's endogenous variables.

Table 6: Steady State of the High Risk Aversion Model

γ	$\overline{y}$	$\overline{c}$	$\overline{k}$	$\overline{i}$	$\overline{n}$	$\overline{y/n}$	$\overline{r}$	$\overline{w}$
-3.00	1.2029	0.9179	14.2484	0.2850	0.2995	4.0167	0.0104	2.5707
-1.50	1.2153	0.9234	14.5958	0.2919	0.3002	4.0480	0.0100	2.5907
0.00	1.2115	0.9217	14.4897	0.2898	0.3000	4.0385	0.0101	2.5846
1.50	1.2153	0.9234	14.5958	0.2919	0.3002	4.0480	0.0100	2.5907
3.00	1.2189	0.9250	14.6940	0.2939	0.3005	4.0567	0.0099	2.5963

Figure 3 illustrates the *IRFs* of model variables under the high risk aversion environment. Given that higher risk aversion increases the concavity of the utility function, thereby inducing more conservative responses, the *IRFs* in this parametrization are more moderate compared to the baseline scenario. Furthermore, the variation of IRFs across γ values is less pronounced, with the notable exception of labor. For labor, both the on-impact variations and subsequent oscillations remain substantial.

Table 7 presents the business cycle statistics of the high risk aversion model. Consistent with the previous two models, lower γ values correspond to higher output volatility. However, due to the moderating influence of higher risk aversion (and lower intertemporal substitution), these variations are less extreme compared to the baseline scenario. Similar to the baseline case, capital volatility remains relatively stable across γ values, while the volatility of labor, consumption, and factor prices increases with the procyclicality of σ.

Although the high risk aversion model generates many patterns shared by the previous two models, its business cycle predictions are not as accurate as those of the Hansen-Rogerson parametrization. This suggests that while the cyclicality of risk aversion continues to play a significant role in shaping business cycle dynamics, the overall level of risk aversion can impact the model's ability to match empirical data.

Figure 3: Impulse-Response Functions with High Risk Aversion ($\overline{\sigma} = 3$)

$\gamma = -3.00$ $\gamma = -1.50$ $\gamma = 0.00$ $\gamma = 1.50$ $\gamma = 3.00$

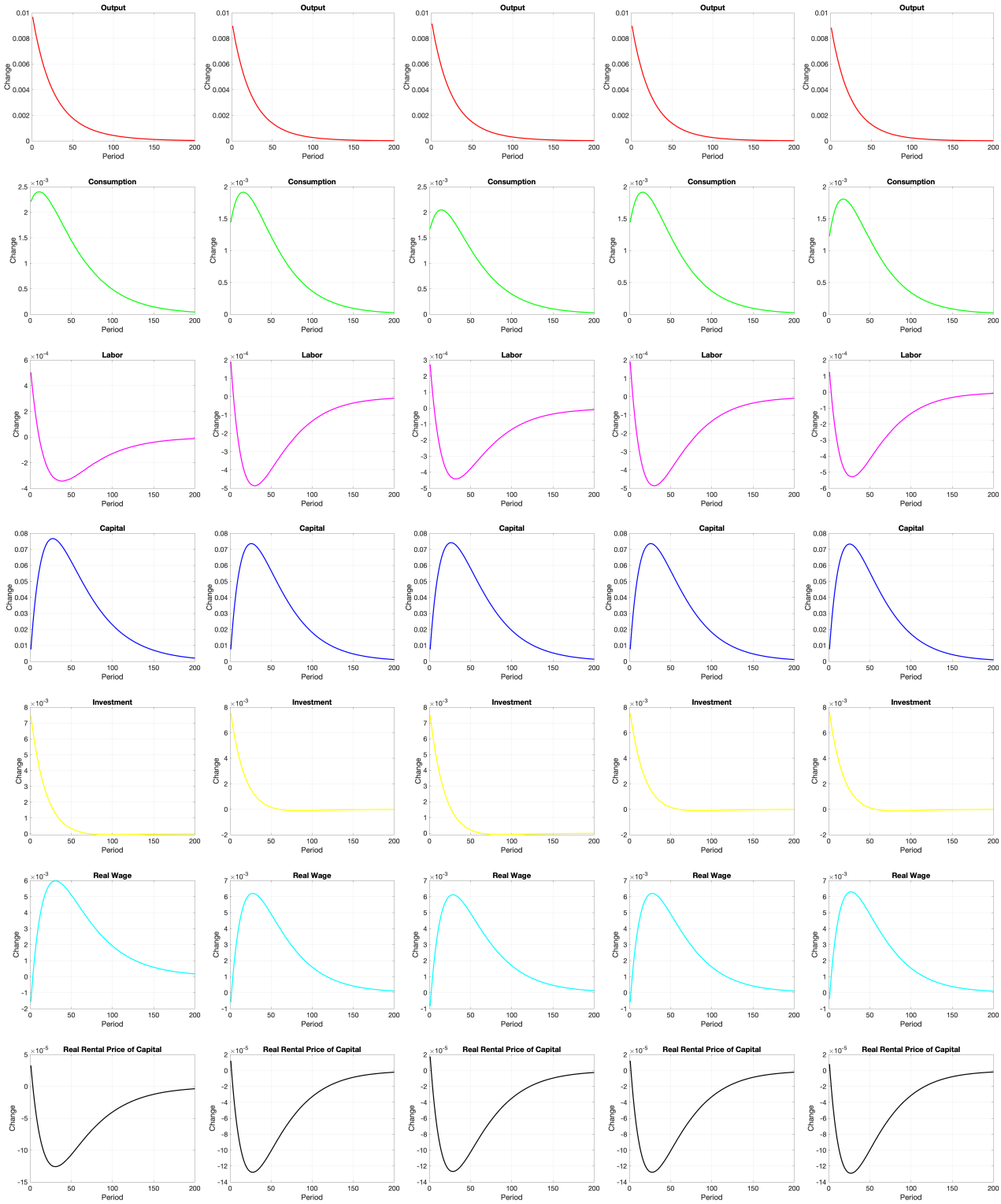


Table 7: Business Cycle Statistics of the High Risk Aversion Model

$\gamma = -3.00$														
	Std.	Rel. Std.	$x(-5)$	$x(-4)$	$x(-3)$	$x(-2)$	$x(-1)$	$x(0)$	$x(+1)$	$x(+2)$	$x(+3)$	$x(+4)$	$x(+5)$	ACF
y	0.0109	1.0000	-0.0120	0.1160	0.2719	0.4750	0.7238	1.0000	0.7238	0.4750	0.2719	0.1160	-0.0120	0.7235
c	0.0033	0.3065	-0.1167	0.0115	0.1748	0.3936	0.6668	0.9801	0.7641	0.5582	0.3811	0.2388	0.1156	0.7441
i	0.0356	3.2757	0.0212	0.1474	0.2993	0.4962	0.7350	0.9977	0.7053	0.4459	0.2363	0.0774	-0.0507	0.7204
k	0.0025	0.2280	-0.5347	-0.4814	-0.3849	-0.2338	-0.0170	0.2706	0.4685	0.5874	0.6436	0.6529	0.6249	0.9570
n	0.0024	0.2229	0.1641	0.2778	0.4072	0.5690	0.7551	0.9471	0.5963	0.3005	0.0713	-0.0929	-0.2149	0.7281
y/n	0.0086	0.7921	-0.0614	0.0683	0.2286	0.4395	0.7012	0.9959	0.7459	0.5151	0.3231	0.1727	0.0453	0.7309
r	0.0001	0.0072	0.4414	0.4994	0.5448	0.5833	0.6026	0.5846	0.1938	-0.1076	-0.3200	-0.4539	-0.5330	0.8481
w	0.0014	0.1323	-0.4413	-0.4997	-0.5451	-0.5835	-0.6028	-0.5846	-0.1934	0.1084	0.3208	0.4548	0.5342	0.8480
$\gamma = -1.50$														
	Std.	Rel. Std.	$x(-5)$	$x(-4)$	$x(-3)$	$x(-2)$	$x(-1)$	$x(0)$	$x(+1)$	$x(+2)$	$x(+3)$	$x(+4)$	$x(+5)$	ACF
y	0.0100	1.0000	-0.0136	0.1150	0.2710	0.4739	0.7234	1.0000	0.7234	0.4739	0.2710	0.1150	-0.0136	0.7231
c	0.0022	0.2204	-0.1808	-0.0520	0.1138	0.3372	0.6219	0.9525	0.7755	0.5967	0.4386	0.3062	0.1852	0.7632
i	0.0351	3.5204	0.0210	0.1474	0.2991	0.4958	0.7346	0.9972	0.7040	0.4439	0.2343	0.0753	-0.0531	0.7198
k	0.0024	0.2447	-0.5336	-0.4802	-0.3836	-0.2323	-0.0153	0.2726	0.4705	0.5889	0.6447	0.6533	0.6245	0.9569
n	0.0012	0.1239	0.3848	0.4613	0.5291	0.5974	0.6591	0.6911	0.2955	-0.0169	-0.2397	-0.3856	-0.4805	0.8136
y/n	0.0091	0.9188	-0.0667	0.0631	0.2236	0.4353	0.6985	0.9952	0.7475	0.5182	0.3273	0.1773	0.0500	0.7314
r	0.0001	0.0067	0.5277	0.5427	0.5289	0.4849	0.3998	0.2577	-0.0876	-0.3388	-0.5021	-0.5934	-0.6332	0.9266
w	0.0012	0.1244	-0.5276	-0.5430	-0.5293	-0.4853	-0.4004	-0.2582	0.0875	0.3392	0.5027	0.5941	0.6341	0.9263
$\gamma = 0.00$														
	Std.	Rel. Std.	$x(-5)$	$x(-4)$	$x(-3)$	$x(-2)$	$x(-1)$	$x(0)$	$x(+1)$	$x(+2)$	$x(+3)$	$x(+4)$	$x(+5)$	ACF
y	0.0102	1.0000	-0.0132	0.1153	0.2712	0.4742	0.7235	1.0000	0.7235	0.4742	0.2712	0.1153	-0.0132	0.7232
c	0.0025	0.2484	-0.1553	-0.0263	0.1389	0.3607	0.6415	0.9657	0.7723	0.5819	0.4158	0.2791	0.1568	0.7548
i	0.0351	3.4388	0.0210	0.1474	0.2991	0.4959	0.7347	0.9973	0.7044	0.4445	0.2349	0.0760	-0.0524	0.7200
k	0.0024	0.2391	-0.5340	-0.4806	-0.3840	-0.2328	-0.0158	0.2720	0.4699	0.5885	0.6444	0.6532	0.6246	0.9569
n	0.0015	0.1460	0.3009	0.3962	0.4928	0.6034	0.7210	0.8231	0.4344	0.1192	-0.1131	-0.2715	-0.3813	0.7693
y/n	0.0090	0.8837	-0.0647	0.0651	0.2256	0.4370	0.6996	0.9956	0.7469	0.5169	0.3257	0.1754	0.0481	0.7312
r	0.0001	0.0067	0.5094	0.5376	0.5413	0.5211	0.4660	0.3588	-0.0050	-0.2749	-0.4552	-0.5604	-0.6126	0.9068
w	0.0013	0.1241	-0.5092	-0.5378	-0.5415	-0.5214	-0.4664	-0.3591	0.0051	0.2754	0.4557	0.5611	0.6135	0.9065
$\gamma = 1.50$														
	Std.	Rel. Std.	$x(-5)$	$x(-4)$	$x(-3)$	$x(-2)$	$x(-1)$	$x(0)$	$x(+1)$	$x(+2)$	$x(+3)$	$x(+4)$	$x(+5)$	ACF
y	0.0100	1.0000	-0.0136	0.1150	0.2710	0.4739	0.7234	1.0000	0.7234	0.4739	0.2710	0.1150	-0.0136	0.7231
c	0.0022	0.2204	-0.1808	-0.0520	0.1138	0.3372	0.6219	0.9525	0.7755	0.5967	0.4386	0.3062	0.1852	0.7632
i	0.0351	3.5204	0.0210	0.1474	0.2991	0.4958	0.7346	0.9972	0.7040	0.4439	0.2343	0.0753	-0.0531	0.7198
k	0.0024	0.2447	-0.5336	-0.4802	-0.3836	-0.2323	-0.0153	0.2726	0.4705	0.5889	0.6447	0.6533	0.6245	0.9569
n	0.0012	0.1239	0.3848	0.4613	0.5291	0.5974	0.6591	0.6911	0.2955	-0.0169	-0.2397	-0.3856	-0.4805	0.8136
y/n	0.0091	0.9188	-0.0667	0.0631	0.2236	0.4353	0.6985	0.9952	0.7475	0.5182	0.3273	0.1773	0.0500	0.7314
r	0.0001	0.0067	0.5277	0.5427	0.5289	0.4849	0.3998	0.2577	-0.0876	-0.3388	-0.5021	-0.5934	-0.6332	0.9266
w	0.0012	0.1244	-0.5276	-0.5430	-0.5293	-0.4853	-0.4004	-0.2582	0.0875	0.3392	0.5027	0.5941	0.6341	0.9263
$\gamma = 3.00$														
	Std.	Rel. Std.	$x(-5)$	$x(-4)$	$x(-3)$	$x(-2)$	$x(-1)$	$x(0)$	$x(+1)$	$x(+2)$	$x(+3)$	$x(+4)$	$x(+5)$	ACF
y	0.0098	1.0000	-0.0140	0.1148	0.2707	0.4737	0.7232	1.0000	0.7232	0.4737	0.2707	0.1148	-0.0140	0.7230
c	0.0019	0.1933	-0.2126	-0.0847	0.0812	0.3060	0.5947	0.9322	0.7768	0.6137	0.4664	0.3400	0.2213	0.7750
i	0.0352	3.6022	0.0212	0.1475	0.2991	0.4957	0.7345	0.9970	0.7035	0.4433	0.2336	0.0746	-0.0537	0.7196
k	0.0024	0.2503	-0.5333	-0.4798	-0.3832	-0.2318	-0.0147	0.2732	0.4710	0.5894	0.6449	0.6533	0.6244	0.9569
n	0.0011	0.1118	0.4602	0.5116	0.5437	0.5612	0.5571	0.5090	0.1252	-0.1684	-0.3695	-0.4942	-0.5675	0.8678
y/n	0.0093	0.9480	-0.0690	0.0608	0.2215	0.4335	0.6972	0.9948	0.7482	0.5196	0.3293	0.1795	0.0523	0.7318
r	0.0001	0.0068	0.5384	0.5422	0.5140	0.4506	0.3414	0.1715	-0.1553	-0.3888	-0.5368	-0.6156	-0.6446	0.9402
w	0.0012	0.1264	-0.5385	-0.5426	-0.5146	-0.4512	-0.3421	-0.1722	0.1552	0.3893	0.5375	0.6164	0.6456	0.9399

5 Conclusions

This paper explores the implications of endogenizing the coefficient of relative risk aversion within a standard real business cycle (*RBC*) model. By formulating the risk aversion coefficient as a first-order linear approximation of a non-linear cyclical function of output, this paper provides novel insights into how cyclical risk aversion affects the dynamics of key macroeconomic variables.

This analysis demonstrates that endogenous risk aversion significantly impacts model predictions across various parametrizations. I consistently find that procyclical risk aversion (lower γ values) corresponds to higher output volatility, suggesting that when economic agents become less risk-averse during expansions and more risk-averse during contractions, it amplifies the economy's response to shocks.

Labor market dynamics prove particularly sensitive to risk aversion cyclicality. In both baseline and linear disutility models, labor volatility and its correlation with output increase as risk aversion becomes more procyclical. This could help explain observed labor market fluctuations that standard *RBC* models struggle to capture.

Furthermore, procyclical risk aversion tends to increase consumption volatility and strengthen its lagged correlations with output, aligning better with empirical observations. Importantly, it helps mitigate common discrepancies between *RBC* model predictions and empirical data, such as overshooting investment volatility and undershooting factor price volatility.

The high risk aversion scenario demonstrates that while risk aversion cyclicality continues to influence business cycle dynamics, the overall risk aversion level can moderate these effects, underscoring the complex interplay between risk aversion's level and cyclicality in shaping macroeconomic outcomes.

This paper makes a valuable contribution by being the first to systematically investigate how endogenous risk aversion affects the business cycle properties of the *RBC* model. The findings suggest that incorporating time-varying, cyclical risk aversion into macroeconomic models could substantially improve their explanatory power.

For future research, rigorous estimation of the risk aversion coefficient and its cyclical properties is crucial. Extensions to more complex models incorporating nominal rigidities, financial frictions, or heterogeneous agents could provide richer insights. Additionally, exploring the implications of cyclical risk aversion for policy design and welfare analysis represents a promising avenue for investigation (Ateşağaoğlu and Torul, 2018).

In conclusion, by demonstrating the potential significance of endogenous, cyclical risk aversion for business cycle dynamics, this paper aims to enhance our understanding of macroeconomic fluctuations and paves the way for research that could further bridge the gap between theoretical models and empirical observations.

References

Arrow, K. J. (1999). Discounting, Morality, and Gaming. *Discounting and Intergenerational Equity*, pages 13–21.

Ateşağaoğlu, O. E. and Torul, O. (2018). Optimal ramsey taxation with endogenous risk aversion. *Economics Letters*, 171:87 – 92.

Bai, Y., Rios-Rull, J.-V., and Storesletten, K. (2012). Demand shocks as productivity shocks. *Federal Reserve Board of Minneapolis*.

Bucciol, A. and Zarri, L. (2013). Financial risk aversion and personal life history. *Mimeo*.

Chetty, R., Guren, A., Manoli, D., and Weber, A. (2011). Are Micro and Macro Labor Supply Elasticities Consistent? A Review of Evidence on the Intensive and Extensive Margins. *American Economic Review*, 101(3):471–75.

Cho, J.-O. and Cooley, T. F. (1994). Employment and hours over the business cycle. *Journal of Economic Dynamics and Control*, 18(2):411–432.

Eeckhoudt, L., Gollier, C., and Schlesinger, H. (1996). Changes in background risk and risk taking behavior. *Econometrica: Journal of the Econometric Society*, pages 683–689.

Fernandez-Villaverde, J. and Rubio-Ramírez, J. F. (2007). Estimating Macroeconomic Models: A Likelihood Approach. *Review of Economic Studies*, 74(4):1059–1087.

Gandelman, N. and Hernández-Murillo, R. (2015). Risk Aversion at the Country Level. *Federal Reserve Bank of St. Louis Research Paper Series Review*, 97(1):53–66.

Guiso, L., Sapienza, P., and Zingales, L. (2013). Time varying risk aversion. Technical report, National Bureau of Economic Research.

Hanaoka, C., Shigeoka, H., and Watanabe, Y. (2015). Do risk preferences change? evidence from panel data before and after the great east japan earthquake. Working Paper 21400, National Bureau of Economic Research.

Hansen, G. D. (1985). Indivisible Labor and the Business Cycle. *Journal of Monetary Economics*, 16(3):309–327.

Huggett, M. (1993). The Risk-Free Rate in Heterogeneous-Agent Incomplete-Insurance Economies. *Journal of Economic Dynamics and Control*, 17(5):953–969.

King, R. G. and Rebelo, S. T. (1999). Resuscitating Real Business Cycles. *Handbook of Macroeconomics*, 1:927–1007.

Kydland, F. E. and Prescott, E. C. (1982). Time to Build and Aggregate Fluctuations. *Econometrica*, pages 1345–1370.

Layard, R., Mayraz, G., and Nickell, S. (2008). The Marginal Utility of Income. *Journal of Public Economics*, 92(8):1846–1857.

Malmendier, U. and Nagel, S. (2011). Depression babies: do macroeconomic experiences affect risk taking? *The Quarterly Journal of Economics*, 126(1):373–416.

Mengel, F., Tsakas, E., and Vostroknutov, A. (2016). Past experience of uncertainty affects risk aversion. *Experimental Economics*, 19(1):151–176.

Rogerson, R. (1988). Indivisible Labor, Lotteries and Equilibrium. *Journal of Monetary Economics*, 21(1):3–16.

Schmitt-Grohé, S. and Uribe, M. (2004). Solving Dynamic General Equilibrium Models Using a Second-Order Approximation to the Policy Function. *Journal of Economic Dynamics and Control*, 28(4):755–775.

Torul, O. (2018). On the business cycle implications of alternative risk aversion formulations. *Central Bank Review*, 18(2):41 – 50.

Appendix

A Appendix Tables and Figures

Table A.1: Business Cycle Statistics for the U.S. Economy

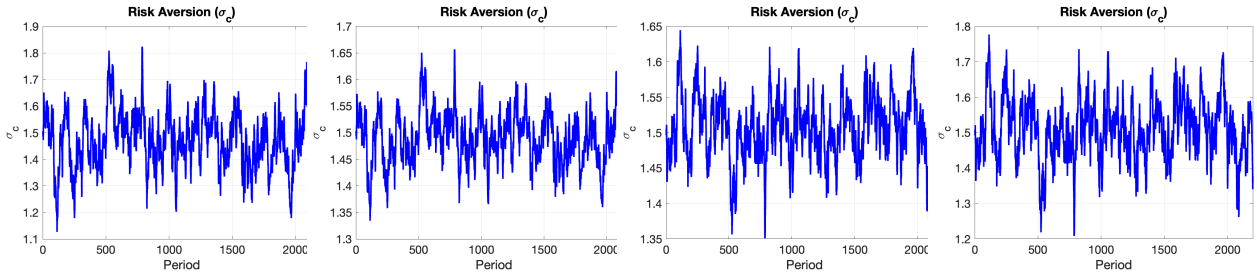
	y	c	n	y/n	I	w	r	z
Std. D (%)	1.81	1.35	1.79	1.02	5.30	0.68	0.30	0.54
Relative Std. D.	1.00	0.74	0.99	0.56	2.93	0.38	0.16	0.52
Corr(y)	1.00	0.88	0.88	0.55	0.80	0.12	-0.35	0.78
Autocorrelation	0.84	0.80	0.88	0.74	0.87	0.66	0.60	0.74

Notes: Based on King and Rebelo (1999)

Figure A.1: Simulations of the Risk Aversion Coefficient σ_t

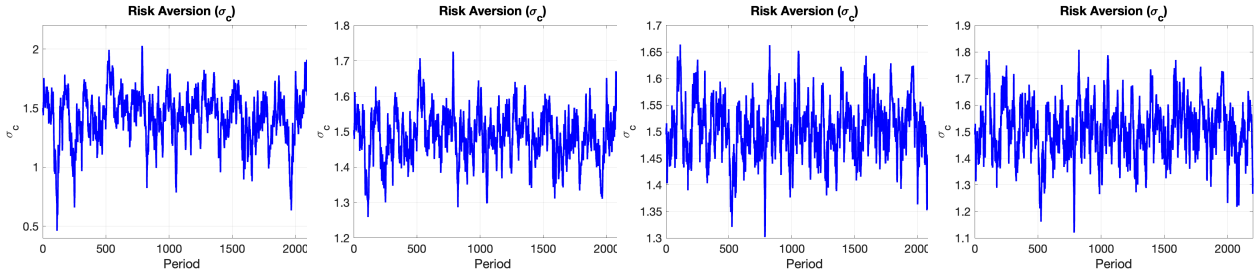
Baseline Simulations

$\gamma = -3.00$ $\gamma = -1.50$ $\gamma = 1.50$ $\gamma = 3.00$



Linear Disutility Simulations

$\gamma = -3.00$ $\gamma = -1.50$ $\gamma = 1.50$ $\gamma = 3.00$



High Risk Aversion Simulations

$\gamma = -3.00$ $\gamma = -1.50$ $\gamma = 1.50$ $\gamma = 3.00$

