Risk Aversion and the Labor Margin in Dynamic Equilibrium Models

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Coefficient of Relative Risk Aversion

Suppose a household has preferences:

$$E_0 \sum_{t=0}^{\infty} \beta^t u(c_t, l_t),$$

$$u(c_t, l_t) = \frac{c_t^{1-\gamma}}{1-\gamma} - \eta \, l_t$$

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Answer: 0

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What is the household's coefficient of relative risk aversion?

Answer: $\frac{1}{\frac{1}{\gamma} + \frac{1}{\chi}}$

Outline of Presentation

- Define risk aversion rigorously in dynamic equilibrium models
- Derive closed-form expressions
- Show the labor margin has dramatic effects on risk aversion

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See the paper for:

- Epstein-Zin preferences
- internal, external habits
- asset pricing details
- numerical computations

A Household

Household preferences:

$$E_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} u(c_\tau, l_\tau),$$

Flow budget constraint:

$$a_{\tau+1} = (1 + r_\tau)a_\tau + w_\tau l_\tau + d_\tau - c_\tau,$$

No-Ponzi condition:

$$\lim_{T\to\infty} \prod_{\tau=t}^{T} (1 + r_{\tau+1})^{-1} a_{T+1} \geq 0,$$

$\{w_\tau, r_\tau, d_\tau\}$ are exogenous processes, governed by θ_τ

The Value Function

State variables of the household's problem are $(a_t; \theta_t)$.

Let:

$$c_t^* \equiv c^*(a_t; \theta_t),$$

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Value function, Bellman equation:

$$V(a_t; \theta_t) = u(c_t^*, l_t^*) + \beta E_t V(a_{t+1}^*; \theta_{t+1}),$$

where:

$$a_{t+1}^* \equiv (1 + r_t)a_t + w_t l_t^* + d_t - c_t^*.$$

Technical Conditions

Assumption 1. *The function $u(c_t, l_t)$ is increasing in its first argument, decreasing in its second, twice-differentiable, and strictly concave.*

Assumption 2. *The value function $V : X \to \mathbb{R}$ for the household's optimization problem exists and satisfies the Bellman equation*

$$V(a_t;\theta_t) \;=\; \max_{(c_t,l_t)\in\Gamma(a_t;\theta_t)} \; u(c_t,l_t) + \beta E_t V(a_{t+1};\theta_{t+1}).$$

Assumption 3. *For any $(a_t;\theta_t) \in X$, the household's optimal choice (c_t^*, l_t^*) lies in the interior of $\Gamma(a_t;\theta_t)$.*

Assumption 4. *The value function $V(\cdot;\cdot)$ is twice-differentiable. (It then follows that c^*, l^* are differentiable.)*

Assumptions about the Economic Environment

Assumption 5. *The household is* atomistic*.*

Assumption 6. *The household is* representative*.*

Assumption 7. *The model has a* nonstochastic steady state*,*
$x_t = x_{t+k}$ *for* $k = 1, 2, \ldots,$ *and* $x \in \{c, l, a, w, r, d, \theta\}$*.*

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Assumption 7′. *The model has a* balanced growth path *that can be renormalized to a nonstochastic steady state after a suitable change of variables.*

Arrow-Pratt in a Static One-Good Model (Review)

Compare:

$$E\,u(c + \sigma\varepsilon) \quad \text{vs.} \quad u(c - \mu)$$

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$$E\,u(c+\sigma\varepsilon) \approx u(c) + u'(c)\sigma E[\varepsilon] + \frac{1}{2}u''(c)\sigma^2 E[\varepsilon^2],$$

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$$\mu = \frac{-u''(c)}{u'(c)} \frac{\sigma^2}{2}.$$

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Coefficient of absolute risk aversion is defined to be:

$$\lim_{\sigma\to 0} 2\mu(\sigma)/\sigma^2 \;=\; \frac{-u''(c)}{u'(c)}\,.$$

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Note also $(*)$ is equivalent to gambles over income:

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or asset returns:

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Note connection to asset pricing.

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Welfare loss from μ:

$$V_1(a_t; \theta_t)\,\frac{\mu}{(1 + r_t)}$$

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Welfare loss from μ:

$$\beta E_t V_1(a^*_{t+1}; \theta_{t+1})\, \mu.$$

Loss from σ:

$$\beta E_t V_{11}(a^*_{t+1}; \theta_{t+1})\frac{\sigma^2}{2}.$$

Coefficient of Absolute Risk Aversion

Proposition 1. *The household's coefficient of absolute risk aversion at* $(a_t; \theta_t)$ *is given by:*

$$\frac{-E_t V_{11}(a^*_{t+1}; \theta_{t+1})}{E_t V_1(a^*_{t+1}; \theta_{t+1})}.$$

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Evaluated at the nonstochastic steady state, this simplifies to:

$$\frac{-V_{11}(a; \theta)}{V_1(a; \theta)}.$$

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Solve for V_1 and V_{11}

Benveniste-Scheinkman:

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Differentiate $(*)$ to get:

$$V_{11}(a_t;\theta_t) \;=\; (1+r_t)\left[u_{11}(c_t^*, l_t^*)\,\frac{\partial c_t^*}{\partial a_t} \;+\; u_{12}(c_t^*, l_t^*)\,\frac{\partial l_t^*}{\partial a_t}\right].$$

Solve for $\partial l_t^* / \partial a_t$ and $\partial c_t^* / \partial a_t$

Household intratemporal optimality: $-u_2(c_t^*, l_t^*) \;=\; w_t\, u_1(c_t^*, l_t^*)$.

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$$\frac{\partial l_t^*}{\partial a_t} = -\lambda_t \frac{\partial c_t^*}{\partial a_t},$$

$$\lambda_t \equiv \frac{w_t u_{11}(c_t^*, l_t^*) + u_{12}(c_t^*, l_t^*)}{u_{22}(c_t^*, l_t^*) + w_t u_{12}(c_t^*, l_t^*)}.$$

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Use Euler equation and budget constraint to derive:

$$\frac{\partial c_t^*}{\partial a_t} = \frac{r}{1 + w\lambda}.$$

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Proposition 2. *The household's coefficient of absolute risk aversion in Proposition 1, evaluated at steady state, satisfies:*

$$\frac{-V_{11}(a;\theta)}{V_1(a;\theta)} \;=\; \frac{-u_{11}+\lambda u_{12}}{u_1}\;\frac{r}{1+w\lambda}\,.$$

Relative Risk Aversion

Consider Arrow-Pratt gamble of general size A_t:

$$a_{t+1} = (1 + r_t)a_t + w_t l_t + d_t - c_t + A_t \sigma \varepsilon_{t+1},$$

vs.

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Risk aversion coefficient for this gamble:

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A natural benchmark for A_t is household wealth at time t.

Household Wealth

In DSGE framework, household wealth has more than one component:

- present value of labor income, $w_t l_t$
- present value of net transfers, d_t
- present value of leisure, $w_t(\bar{l} - l_t)$?

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Leisure, in particular, can be hard to define, e.g.,

$$u(c_t, l_t) = \frac{c_t^{1-\gamma}}{1-\gamma} - \eta \frac{l_t^{1+\chi}}{1+\chi}$$

and $\bar{l}$ is arbitrary.

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Different definitions of household wealth lead to different definitions of relative risk aversion.

Two Coefficients of Relative Risk Aversion

Definition 1. *The consumption-based coefficient of relative risk aversion is given by* $(*)$, *with* $A_t \equiv (1 + r_t)^{-1} E_t \sum_{\tau=t}^{\infty} m_{t,\tau} c_\tau^*$.

In steady state:

$$\frac{-A\, V_{11}(a;\theta)}{V_1(a;\theta)} = \frac{-u_{11} + \lambda u_{12}}{u_1} \frac{c}{1 + w\lambda}.$$

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Definition 2. *The consumption-and-leisure-based coefficient of relative risk aversion is given by* $(*)$, *with*
$\tilde{A}_t \equiv (1+r_t)^{-1} E_t \sum_{\tau=t}^{\infty} m_{t,\tau} \left(c_\tau^* + w_\tau(\bar{l} - l_\tau^*)\right)$.

In steady state:

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Example 1

Utility kernel:

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$$= \frac{1}{\frac{1}{\gamma} + \frac{1}{\chi}}$$

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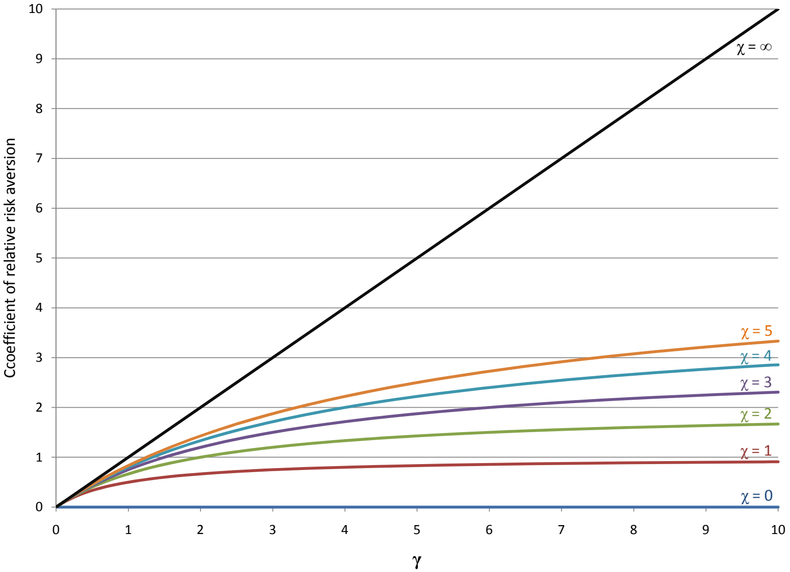

Ccoefficient of relative risk aversion
γ
χ = ∞
χ = 5
χ = 4
χ = 3
χ = 2
χ = 1
χ = 0
0
1
2
3
4
5
6
7
8
9
10

Risk Aversion Away from the Steady State

Utility:

$$u(c_t, l_t) = \frac{c_t^{1-\gamma}}{1-\gamma} - \eta \frac{l_t^{1+\chi}}{1+\chi} \qquad \gamma = 2,\ \chi = 1.5$$

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Plus standard RBC model, solved numerically:

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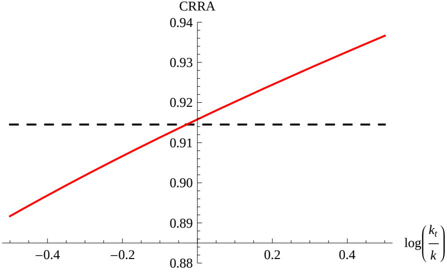
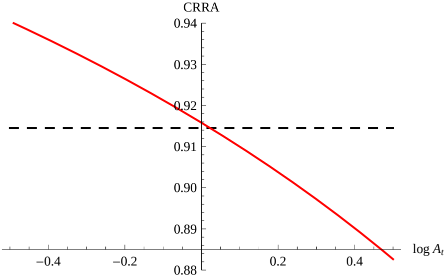
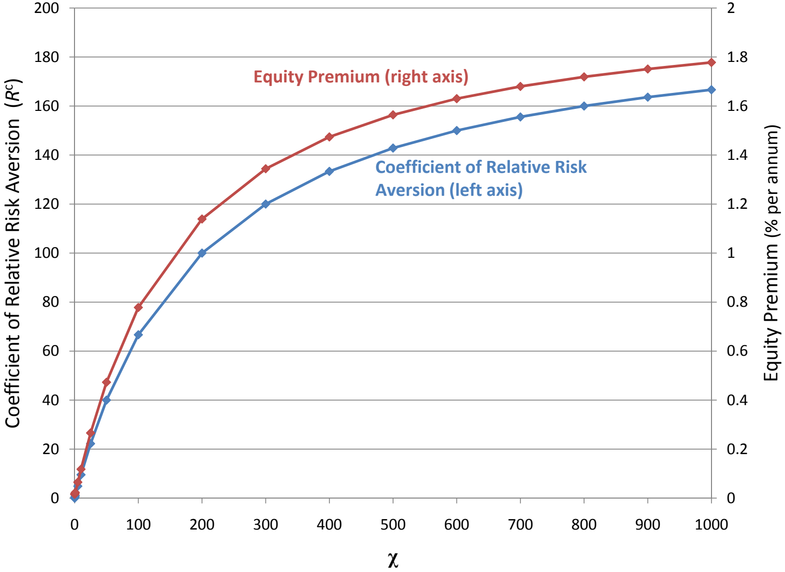




Risk Aversion and the Equity Premium ($\gamma = 200$)



Conclusions

1. The labor margin has dramatic effects on risk aversion
2. Risk aversion is the right concept for asset pricing, $E_t m_{t+1} p_{t+1}$
3. Arrow-Pratt risk neutrality holds for any u with $u_{11} u_{22} - u_{12}^2 = 0$
4. Risk aversion and the intertemporal elasticity of substitution are nonreciprocal when there is labor in the model
5. Simple, closed-form expressions for risk aversion in DSGE models with:
   - expected utility preferences
   - Epstein-Zin preferences
   - external or internal habits
   - valid away from steady state