Risk preferences, intertemporal substitution, and business cycle dynamics

Presentation for Sveriges Riksbank, Stockholm

Jim Dolmas
jim.dolmas@dal.frb.org

05/17/11

What does this paper do?

- Study implications of alternative specifications of risk preferences—including non-EU first-order risk aversion—for business cycle behavior.
- Fairly standard business cycle model
    - RBC core of many DSGE models
    - Includes habit formation, capital adjustment costs
- Impact of alternative choices for EIS (including > 1)

Findings

- Risk preferences matter a great deal for welfare
  - Costs as high as 1.3% of lifetime consumption
- Some first moment impact (precautionary capital accumulation, significant under FORA), but no impact on average asset returns.
- Negligible impact on second moments

What *does* matter for second moments?

- EIS matters a great deal
  - In stripped down model(no habits), EIS>1 can lead to $\mathrm{corr}(Y, C) < 0$.
  - Variable labor and nonseparable intratemporal preferences a factor.
- Habits matters, of course.
  - Smaller amplification, low volatility of hours, positive response of hours to negative TFP shock.

Roadmap of talk

550 is the correct CRRA coefficient

Example

Suppose an agent with initial wealth of \$30,000 faces a 0.00477 probability of losing \$55. This is a small risk—the standard deviation of the lottery $\{\tilde{w}; p\} = \{(29945, 30000); (0.00477, 0.99523)\}$, as a percent of mean wealth, is about 0.013%.
Would they pay 45 cents to insure against it?
Yes, if EU/CRRA coefficient is 550.

\$30,000 wealth is hypothetical, but expected loss, probability, price of insurance taken from Cicchetti & Dubin (JPE 1994) phone wire insurance study. 57% of customers bought the insurance.

No, actually 50 is the correct CRRA coefficient

Example

Suppose the agent with wealth equal to \$30,000 faces a 0.245 probability of losing \$182. The standard deviation of this gamble, as percent of mean wealth, is 0.26%.
Would they pay \$55 to insure against it?
Yes, if CRRA coefficient is around 50.

The loss, loss probability, and price of insurance again come from an empirical study: Cohen and Einav's (AER 2007) analysis of the choice of auto insurance deductibles in a large sample of Israeli drivers.

No, really 4 is the correct CRRA coefficient

Example

Suppose the agent, again with initial wealth of $30,000, faces a 7% probability of suffering a $5,000 loss. This represents a gamble with a standard deviation equal to 4.3% of mean wealth.
Would they be willing to pay $500 to insure against it?
Yes, if CRRA coefficient is around 4.

The 7% probability and $5,000 loss are roughly the US average homeowners' multi-peril insurance claim rate and claim intensity for the period 2000–2004. $500 is in the neighborhood of the average 2004 premium.

FORA can fit all three cases

- Allows plausible risk aversion over wide range of gamble sizes.
- Below, specify a two-parameter family of risk preferences. We'll see in a moment what θ and γ represent, but for now, note benchmark FORA calibration I'll use $(\gamma = 0.9, \theta = 1)$ fits all three of the previous examples.

Add leisure, external habit to EZ JME 1990

- Lifetime utility today is a CES aggregate of consumption/leisure composite, and certainty equivalent of lifetime utility from tomorrow on:

$$U_t = [(1-\beta) f_t^{\rho} + \beta \mu_t (U_{t+1})^{\rho}]^{1/\rho}$$

for $\rho \leq 1$, where

$$f_t = (C_t - \phi H_t)^{\psi} (1 - N_t)^{1-\psi}$$

- For $\rho = 0$

$$U_t = f_t^{1-\beta} \mu_t (U_{t+1})^{\beta}$$

Add leisure, external habit to EZ JME 1990

- ρ governs intertemporal substitution, ψ governs allocation of time to work.
  - $\epsilon = 1/(1-\rho)$ is EIS, $\epsilon_c = 1/(1-\psi\rho)$ is EIS in consumption.
- The habit stock is assumed to evolve (externally) according to

$$H_{t+1} = (1-\delta_h)H_t + C_t^a.$$

Certainty equivalent $\mu_t(U_{t+1})$

- Embodies both conventional EZ preferences and FORA. For $\theta \geq 0, \theta \neq 1$
$$\mu_t(U_{t+1}) = (\hat{\mathbb{E}}_t[U_{t+1}^{1-\theta}])^{1/(1-\theta)}$$
or, for $\theta = 1$
$$\mu_t(U_{t+1}) = \exp(\hat{\mathbb{E}}_t[\ln(U_{t+1})])$$
- Ignore the 'hat' over the expectations operator for a moment. Then $\mu_t(\cdot)$ is conventional EZ. θ is CRRA parameter, and $1-\theta = \rho$ gives time-separable EU.
  - Even if $1-\theta \neq \rho$, still CRRA-EU for timeless gambles

First-order risk aversion (FORA)

- What about the $\hat{\mathbb{E}}_t$?
- Our FORA specification is non-linear in probabilities, so can think of as $\hat{\mathbb{E}}_t \neq \mathbb{E}_t$.
- Based on Yaari, Quiggin; applied by EZ to equity premium in Lucas tree economy.

First-order risk aversion (FORA)

- Generalizes the following two-state case: Imagine r.v. w that takes on two values, $w_L < w_H$, with probabilities p and $1-p$. For $0 < \gamma \leq 1$, Yaari's certainty equivalent is

$$\hat{\mathbb{E}}(w) = p^{\gamma} w_L + (1 - p^{\gamma}) w_H$$

- Effectively, over-weights worse outcome when $\gamma < 1$
- In our context, this gives

$$\mu(U) = [p^{\gamma} U_L^{1-\theta} + (1 - p^{\gamma}) U_H^{1-\theta}]^{1/(1-\theta)}$$

Standard RBC model with capital adjustment costs

- Representative firm hires labor and capital from households to produce output according to

$$Y_t = A_t K_t^{\alpha} N_t^{1-\alpha}$$

- Output divided between consumption, gross investment

$$Y_t \geq C_t + X_t$$

- Households' capital stocks following

$$K_{t+1} = (1 - \delta_k) K_t + K_t g(X_t / K_t)$$

Standard RBC model with capital adjustment costs

- Adjustment cost function takes following form (as in Jermann, JME 1998):

$$g(z) = (b_0/b_2)z^{b_2} - b_1$$

where $b_0, b_1, b_2 \geq 0$ and $b_2 \leq 1$.

Equilibrium decision rules

- Equilibrium consists of a value function & decision rules that satisfy intratemporal FOC, intertemporal FOC (Euler equation), and Bellman equation.
  - External habit $\Rightarrow$ Impose $c = c^a$ after taking FOCs
- Really only need to find two maps: $v(a, k, h)$ and $N(a, k, h)$. Everything else can be derived from these.
- Use Chebyshev collocation method described by Caldara, Fernandez-Villaverde, Rubio-Ramirez & Yao to approximate $v(a, k, h)$ and $N(a, k, h)$.

Approximations

- Assume TFP process $\{a_t\}$ generated by finite state Markov chain
- Treat decision rules as vector-valued functions at each (k, h): $N_i(k, h) = N(a_i, k, h)$
- Then approximate as tensor product of Chebyshev polynomials in k, h:

$$N_i(k, h) \approx \sum_{l=0}^{O_k} \sum_{m=0}^{O_h} D_N^i(l, m) T_l(\iota(k)) T_m(\iota(h)) \equiv \mathcal{N}(k, h; D_N^i)$$

$$v_i(k, h) \approx \sum_{l=0}^{O_k} \sum_{m=0}^{O_h} D_v^i(l, m) T_l(\iota(k)) T_m(\iota(h)) \equiv \mathcal{V}(k, h; D_v^i)$$

Calibration is mostly—OK, sort of—standard

	Value	Remarks
Technology parameters:		
α	0.4	Standard
δ_k	0.0127	10% annual
η	1.0045	1.8 % annual
Habit formation parameters:		
ϕ	0.5	Habit strength
δ_h	1	$h_t = c_{t-1}$
Capital adjustment cost function:		
b_0	0.1312	$g(\bar{z}) = \bar{z}, Dg(\bar{z}) = 1$
b_1	0.0172	$g(\bar{z}) = \bar{z}, Dg(\bar{z}) = 1$
b_2	0.5	Q elasticity of $z = 2$

Some indirect settings

- β and ψ set to target $\bar{N}$ and s_c. Depend on EIS, whether habit/no-habit

	Value	Remarks
If habits & adjustment costs:		
ψ	0.2075	$\bar{N} = 0.3$
$\beta\,(\epsilon = 0.5/\epsilon = 15)$	0.9927/0.9910	$\bar{k}$ s.t. $s_c = 0.73$
If no habit or adjustment costs:		
ψ	0.3427	$\bar{N} = 0.3$
$\beta\,(\epsilon = 0.5/\epsilon = 15)$	0.9933/0.9904	$\bar{k}$ s.t. $s_c = 0.73$

Markov chain for TFP

- Approximate an AR(1) with persistence 0.95 and residual standard deviation of 0.07 (Cooley & Prescott)
- Use Rouwenhorst's method to approximate with 9-state Markov chain (See Kopecky & Suen, RED 2010 for advantages of Rouwenhorst's method, compared to, say Tauchen's)
- Last step is set mean level of TFP such that deterministic s.s. output is one.

Several objects of interest

- First moments:
  - Precautionary accumulation (stochastic s.s. k versus deterministic s.s. k);
  - Average returns on physical capital, hypothetical riskless asset
- Second moments:
  - Standard volatility measures (absolute, relative to y, relative to TFP)
  - Impulse responses
- Welfare cost of volatility
  - Number of ways one could calculate this

Common features of the numerical experiments

- Two EIS settings, $\epsilon = 0.5$ and $\epsilon = 15$ (corresponds to ϵ_c's around 3/4 and 1.5)
- Given EIS, three cases for risk preferences
  - EU: $\gamma = 1$, $\theta = 1/\epsilon$
  - 'High CRRA': $\gamma = 1$, $\theta = 100$ (like Tallarini)
  - FORA: $\gamma = 0.9$, $\theta = 1$
- Except for impulse responses, use same draw of 10,100 disturbances for all runs; discard first 100 observations.
- Standard deviations and correlations are for HP-filtered model data
- Impulse responses calculated similar to Caldara et al.

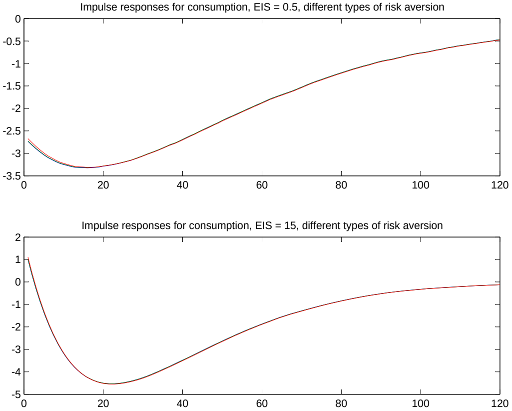
First, no habits or adjustment costs

- First moment implications

	$\epsilon = 0.50$		
	$\%(k/\bar{k})$	R^e	R^f
EU, $\theta = 1/\epsilon, \gamma = 1$	-0.0675	5.2054	5.2019
High CRRA, $\theta = 100, \gamma = 1$	0.7372	5.1614	5.2063
FORA, $\theta = 1, \gamma = 0.9$	1.4267	5.1560	5.2019

	$\epsilon = 15$		
	$\%(k/\bar{k})$	R^e	R^f
EU, $\theta = 1/\epsilon, \gamma = 1$	-0.0386	5.2037	5.2007
High CRRA, $\theta = 100, \gamma = 1$	0.5568	5.1711	5.1965
FORA, $\theta = 1, \gamma = 0.9$	0.8359	5.1560	5.2007

This picture kills a couple birds with one stone



Other points from stripped-down model

- High EIS case makes you wonder what "long-run risk" folks will find when they incorporate production with variable work effort
- Complementarity between consumption and leisure is important for strange behavior when EIS high (can check approximate impulse response for mu_c)
- Amplification on order of 1.4–1.8 (ratio $\sigma(y)/\sigma(a)$)
- Welfare cost of volatility:
  - EU nil
  - High CRRA roughly 0.3–0.4% of lifetime consumption
  - FORA 1.1–1.3%.

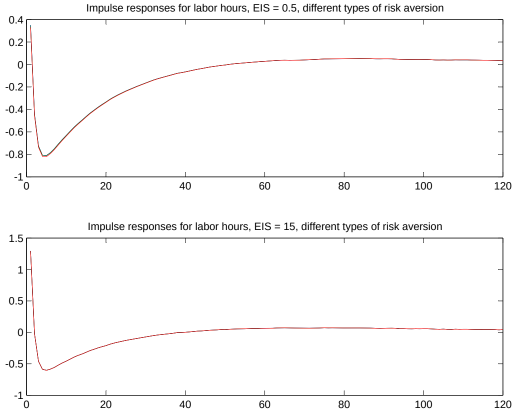
Habits matter, not much else does

- Adding habit & capital adjustment cost changes results substantitially, but conditional on presence of habit neither risk preferences nor EIS matter that much.
- First moments:
    - Less precautionary capital accumulation, none in higher EIS case
    - Significantly, average equity premium still minute, doesn't vary significantly with either risk preferences or EIS choice
    - That's a sharp contrast to Jermann (fixed labor model)

Second moments with habits & adjustment costs

- Compared to stripped-down model, behavior of labor hours is key difference
- Hours are significantly less volatile, less highly correlated with output
  - $100\sigma(\ln(N))$ now 0.1–0.2, was 0.6–1.3
  - $\mathrm{corr}(\ln(N), \ln(Y))$ now 0.1–0.6, was basically 1.0
  - Impulse responses have hours up at impact in response to negative shock
- 2nd moments still virtually identical across risk preference specifications

Odd hours behavior in model with habits



Other points from the full model

- Hours jump maybe not that surprising, given need to maintain $c_t > \phi c_{t-1}$. (See Graham, JnlMacro 2008)
- Lower hours volatility means much less amplification $(\sigma(Y)/\sigma(a) \approx 1)$
- Welfare costs: Similar orders of magnitude as before
  - EU ≈ 0
  - High CRRA $\approx 0.3\%$ of consumption
  - FORA $\approx 1.3\%$

Conclusions

- Risk preferences don't matter for dynamics
  - Caveat: Not exhaustive. What about disappointment aversion? (Campanale, Castro, Clementi RED 2010)
- EIS matters a great deal
  - And elastic labor, intratemporal preferences play important role
- Volatility potentially very costly
  - Question: What's the correct thought experiment? (Compare current results w/earlier version)