Business Cycle Implications of Consumption Habit Formation

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Preliminary and Comments Welcome

Outline

Consumption Habits Solve Many Puzzles

- Habits smooth marginal utility (or consumption).
  Explain asset price anomalies

- Important propagation mechanism in DSGE models.
  - Hump-shaped output response to monetary shocks (Christiano, Eichenbaum, and Evans 2005, JPE)
  - Negative response of hours worked to TFP shocks (Francis and Ramey 2005, JME)

Quandary is that Habits Create ...

- Excess smoothness in consumption to technology shocks (Lettau and Uhlig 2000, RED)
- Excess volatility in the current account (Kano 2007, CIRJE-WP)
- True resolution of asset-price anomalies? (Otrok, Ravikumar, and Whiteman 2002, JME)
  Habits solve asset-price anomalies depending on high-frequency fluctuations in consumption, which are insignificant part of actual US data.

Questions remain ...

What does this paper try to do?

- Evaluating the role of habits in business cycle models in a better way.
- Moments relevant and stringent for business cycle analysis.
  - Impulse response functions identified with multivariate vector processes.
  - Identified shocks create fluctuations in output and consumption growth at all frequency range. $\Rightarrow$ Information from IRFs is contaminated by noise not interesting for business cycle analysis
  - We want to extract only low and business-cycle frequency fluctuations generated by identified shocks.
  - **Idea: spectral representation** of IRFs of output and consumption growth to identified permanent and transitory shocks.

What does this paper try to do?

- Why frequency domain?
  1. Can extract fluctuations generated by identified shocks at particular frequency range.
  2. Spectral representation theorem implies that IRFs can be decomposed into orthogonal components frequency-by-frequency.

     $\Rightarrow$ Plotting spectra of IRFs conveys correct shape of likelihood of IRF(cf. Sims and Zha 1999, Econometrica)
  3. Can create a nice statistic for joint test of spectral IRFs at different frequencies: quasi Kolgomorov-Smirnov goodness-of-fit statistic (cf. Cogley and Nason 1995, JEDC)

     $\Rightarrow$ Shape of IRFs really matters for evaluating business cycle models (Vigfusson, last week's presentation)

What does this paper try to do?

- Simulate DSGE models with and without habits.
  - Real business cycle model with capital adjustment costs
  - New Keyensian monetary business cycle (NKMBC) model with Taylor rule

- Bayesian Calibration to measure fit of DSGE models (DeJong, Ingram, and Whiteman 2000 JBES, Geweke 2007)
  - Take into account model uncertainty, i.e., uncertainty in structural parameters, formally with prior distributions
  - Compare theoretical distributions of moments with empirical counterparts estimated by Bayesian posterior simulator
    $\Rightarrow$ Bayesian posterior odd ratio foundation (Geweke 2007)

$$\frac{P(A|Y^0)}{P(B|Y^0)}$$

Tentative Findings

- **No significant role of habits in output growth response at low and business cycle frequencies**
  - to a permanent shock in RBC
  - to a monetary shock in NKMBC
- **Excess smoothness of consumption to a permanent shock in RBC**

Tentative Findings

- **Significant interaction between habits and sticky wages in NKMBC**
  - Good fit of habit-NKMBC to output and consumption growth response to transitory (monetary) shock crucially depends on sticky wages.
  - Without sticky wages, habits lead to the excess smoothness of consumption.

  Without sticky wages, no role of habits in monetary business cycles?

DSGE models

- RBC: Christiano and Eichenbaum (1992,AER) and Cogley and Nason (1995,AER)
  - Permanent technology shock and transitory government spending shock
  - Linear disutility of labor
  - Extended with internal habits
- New Keynesian-MBC: Christiano, Eichenbaum, and Evans (2005, JPE)
  - Nominal rigidities: sticky prices and wages
  - Real rigidities: investment adjustment costs, habit formation, capacity utilization
  - Taylor-type monetary policy rule
  - Permanent technology

RBC: consumption habits

- Period utility is

$$U(c_t, c_{t-1}, n_t) = \ln(c_t - hc_{t-1}) + v(1 - n_t), \quad h \in (0, 1)$$

- Household garners utility given internal habits.
- $MU(c_t) = (c_t - hc_{t-1})^{-1} - \beta h E_t(c_{t+1} - hc_t)^{-1}$.
- Household discount factor $\beta \in (0, 1)$.

RBC: technology

- Cobb-Douglas technology $Y_t = K_t^{\psi}(N_t A_t)^{1-\psi}$.
- TFP is random walk (with drift)

$$\ln(A_t/A_{t-1}) = \alpha + \epsilon_t, \quad \alpha > 0,\ \epsilon_t \sim N(0, \sigma_\epsilon^2)$$

- Investment adjustment costs

$$K_{t+1} = (1-\delta)K_t + \left[1 - \mathcal{S}(\frac{X_t}{\alpha X_{t-1}})\right] X_t, \qquad (1)$$

where $\mathcal{S}(1) = \mathcal{S}'(1) = 0$, and $\mathcal{S}''(1) = \omega > 0$.

RBC: leisure, government, and market structure

- Rogerson (1988) indivisible labor supply $\Rightarrow$ linear labor disutility

$$v(1 - n_t) = -\zeta n_t$$

- Transitory AR(1) government spending shock, g_t
- Government budget balance period by period.
- Complete and perfectly competitive markets

NKMBC: preference and technology

- From RBC model, keep internal consumption habits, investment adjustment costs, drop g_t shock.
- Alter labor disutility to $-n_t^{1+\frac{1}{\gamma}}/(1+\frac{1}{\gamma})$
- Money in utility: $\ln M_t/P_t$
- Add capacity utilization, u_t, to create capital service, $K_t = u_t\mathcal{K}_t$, at cost $a(u_t)\mathcal{K}_t$ to household, where $a(1) = 0$ and $a''(1)/a'(1) = 0.01$ without uncertainty.

NKMBC: Calvo staggered price and wage mechanisms

- Monopolistic competition in goods and labor markets.
- Firms (households) unable to update their price (wage) index to lagged aggregate price (wage) inflation $\Rightarrow$ full indexation.
- Firm updates price at prob $\mu_p \in (0, 1)$, faces price elasticity $\chi > 0$
- Household updates wage at prob $\mu_w \in (0, 1)$, faces wage elasticity $\theta > 1$.

NKMBC: monetary policy

- Interest rate-smoothing Taylor rule

$$R_t = \rho_R R_{t-1} + (1-\rho_R)(R^* + a_\pi E_t \pi_{t+1} + a_y y_t) + v_t, \quad v_t \sim N(0, \sigma_v^2)$$

Empirical s-IRFs of $\Delta \ln Y$ and $\Delta \ln C$

- On 1954Q1-2002Q4 sample, estimate
  1. VARs for RBC: $[\Delta \ln Z_t, \ln N_t], Z = \{Y, C\}$
  2. VARs for NKMBC: $[\Delta \ln Z_t, \Delta \ln P_t], Z = \{Y, C\}$
  3. Identify IRFs with long-run restrictions $\Rightarrow$ Y (or C) responds only to TFP shock in the long run
- SMAs with permanent and transitory shocks $\epsilon_{p,t}$ and $\epsilon_{s,t}$ with unit variances

$$\Delta \ln Z_t = \sum_{k=0}^{\infty} \Gamma_k^p \epsilon_{p,t} + \sum_{k=0}^{\infty} \Gamma_k^s \epsilon_{s,t}$$

Empirical s-IRFs of $\Delta \ln Y$ and $\Delta \ln C$

- Spectral representation of IRF(q) at frequency $\lambda \in [0, \pi]$

$$S_{\Delta Z}(\lambda) = (2\pi)^{-1} \sum_{k=0}^{q} \sum_{l=0}^{q} \Gamma_k^p \Gamma_l^p \exp(-ik\lambda) \exp(il\lambda)$$
$$+ (2\pi)^{-1} \sum_{k=0}^{q} \sum_{l=0}^{q} \Gamma_k^s \Gamma_l^s \exp(-ik\lambda) \exp(il\lambda)$$

- Setting $q = 20$ in this presentation.
- Alternative interpretation: frequency decomposition of FEVDs
- $S_{\Delta Z}(0)$ goes back to standard FEVDs of $\ln Z_t$ at 20 period forecast horizon.

Empirical s-IRFs of $\Delta \ln Y$ and $\Delta \ln C$

- Priors for Markov-chain Monte Carlo (MCMC) are VAR estimates
- Generate $\mathcal{J}$ posterior draws.
- VAR posteriors generate empirical, $\mathcal{E}$, s-IRF distributions of $\Delta \ln Z_t$ w.r.t. permanent and transitory shocks.
- How close is each posterior draw of s-IRFs to the sample estimate counterpart? quasi Kolmogorov-Smirnov statistic (QKS) (Cogley and Nason 1995, Dzhaparidze 1986)
- Calculate QKSs for posterior draws of empirical s-IRFs and construct empirical (posterior) distribution of QKS

DSGE model solution

- Construct optimality and equilibrium conditions
- Stochastically detrend and linearize.
- Solve linearized RBC and NKMBC models with Sims' (2002) algorithm.

DSGE model parameters

- Calibrate RBC and NKMBC models.
  1. with and without consumption habits
  2. RBC models driven by TFP and g shocks
  3. NKMBC models driven by TFP and v shocks

     $\Rightarrow$ theoretical long-run restrictions.
  4. NKMBC models with and without stick price and wage.
- Sources of priors previous DSGE model studies and other aggregate data.
- Draw vectors of length $\mathcal{J} = 5000$ for parameters.

Theoretical s-IRFs distributions

- Create $\mathcal{J}$ synthetic samples of length $T = 196$ from linearized solution of DSGE models given priors of parameters.
- Estimate VARs on the synthetic samples.
- VARs provide $\mathcal{T}$ s-IRF distributions.
- Construct $\mathcal{T}$ distributions of QKS using synthetic s-IRFs and the sample estimate counterpart.

Measuring fit of DSGE models to the data

- Gauge fit of $\mathcal{E}$ and $\mathcal{T}$ s-IRF distributions
- Present median s-IRFs across ensemble of $\mathcal{E}$ and $\mathcal{T}$.
- Non-parametric density plot of s-IRFs for low and business-cycle frequencies
- Measure overlap of $\mathcal{E}$ and $\mathcal{T}$ distributions of QKS
- Non-parametric density plot of QKS for low and business-cycle frequencies
- Credible interval criteria (CICs) (DeJong, Ingram, and Whiteman, 1992): $CIC > 0.3$ means good fit

Figure 1: s-IRF of $\Delta \ln Y$ to P-Shock: RBC

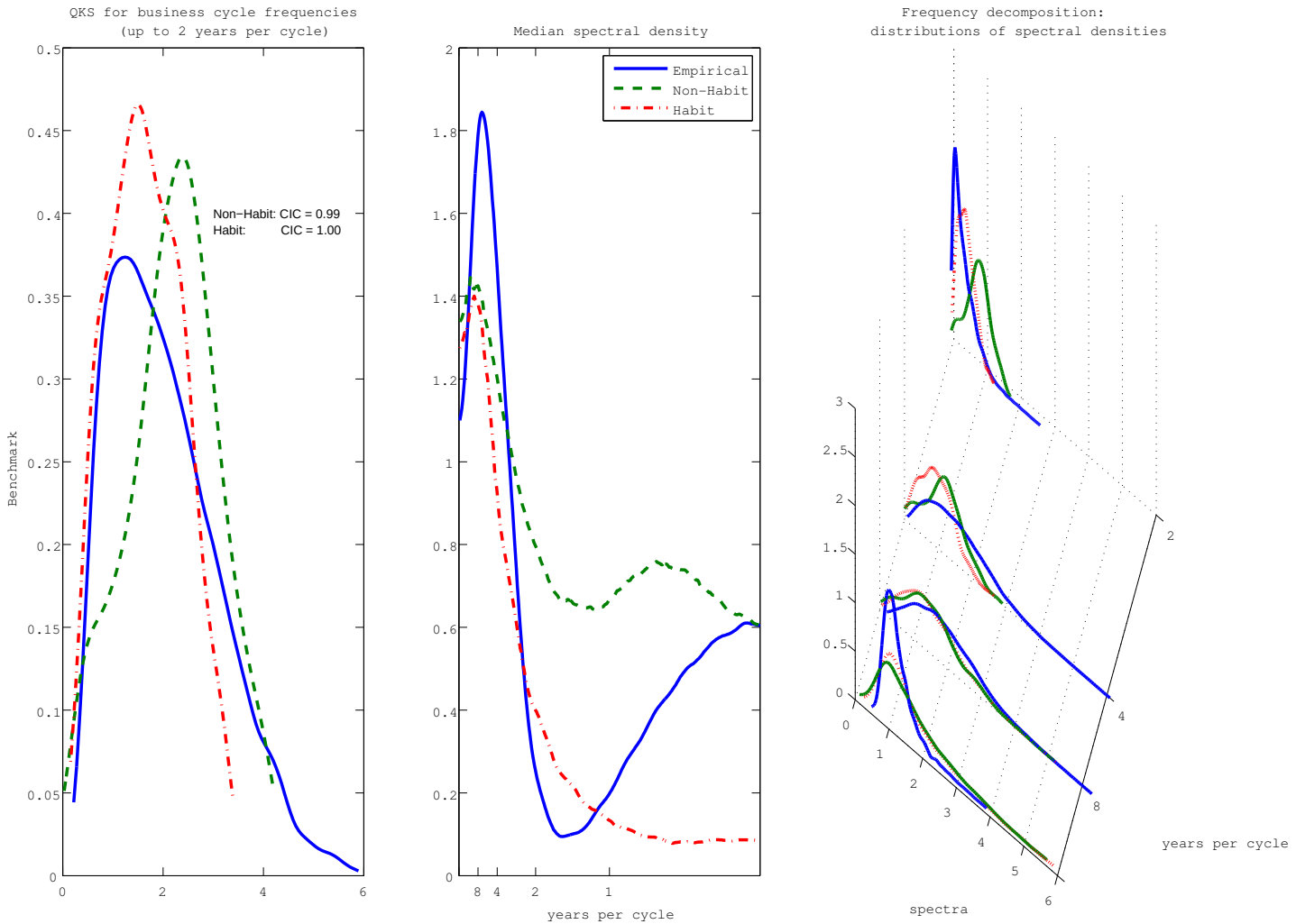


Figure 2: s-IRF of $\Delta \ln C$ to P-Shock: RBC

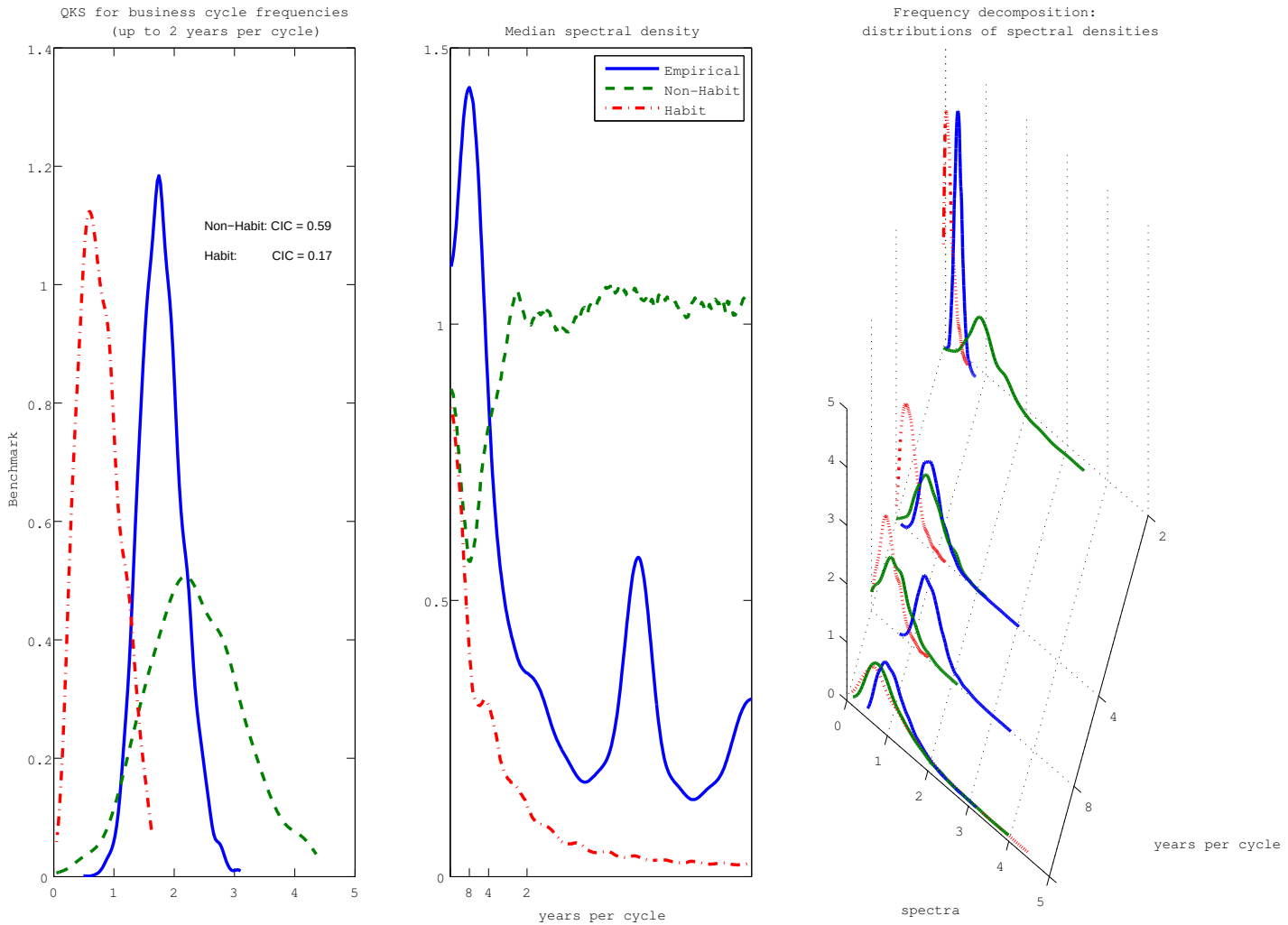


Figure 3: s-IRF of $\Delta \ln Y$ to T-Shock: NKMBCs

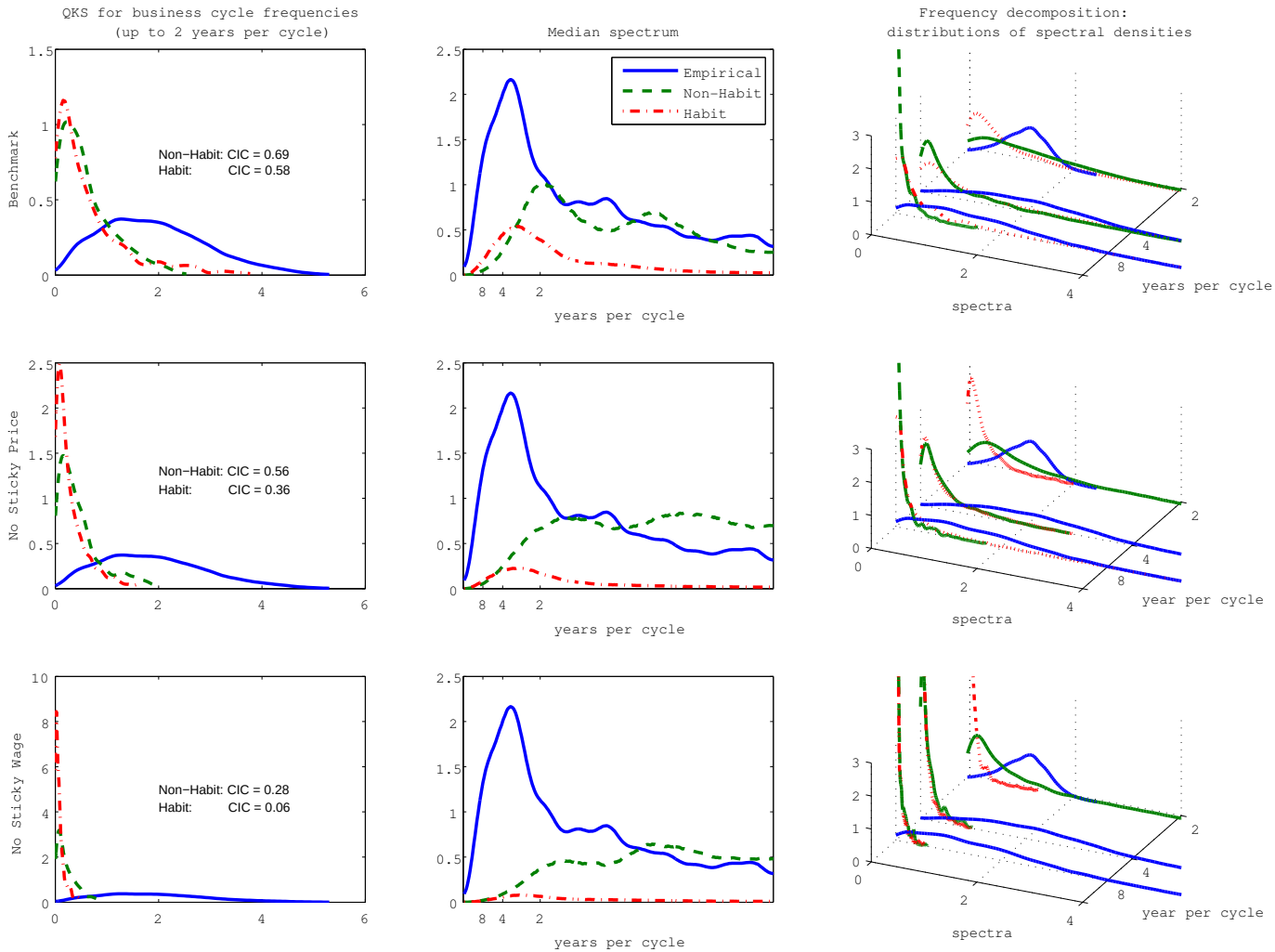
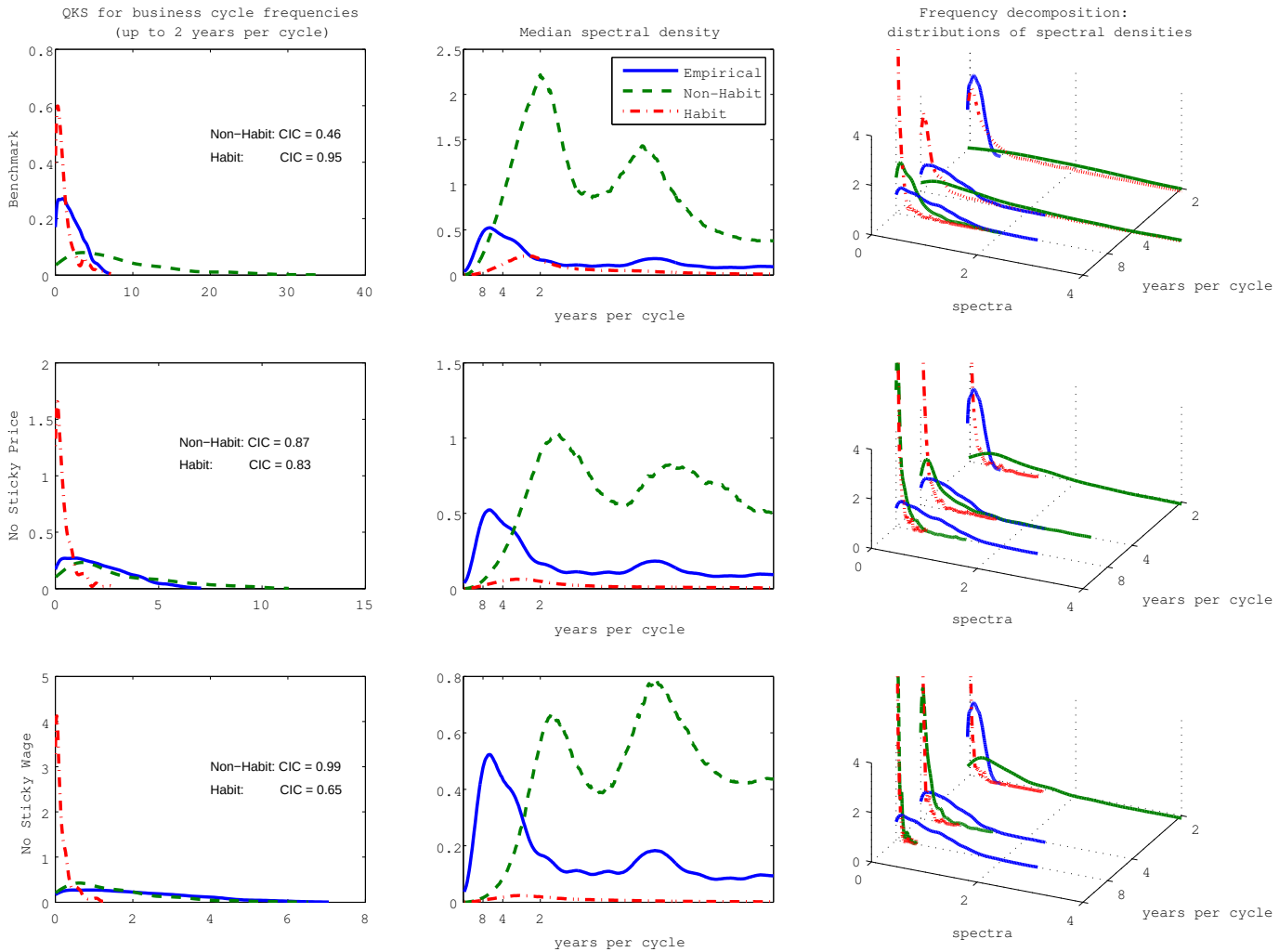


Figure 4: s-IRF of $\Delta \ln C$ to T-Shock: NKMBCs



Conclusion

- New and better statistics for evaluating DSGE models w.r.t. IRFs in frequency domain
- Habits seem to matter little in RBC model as a business cycle DGP
- Excess smoothness of consumption
- Without sticky wages, no role of habits in monetary business cycles.
- Habits likely to interact with nominal rigidities in labor market for generating good fit to business cycle moments.