Asset pricing in the frequency domain: theory and empirics

by Ian Dew-Becker and Stefano Giglio

Discussed by Urban Jermann

Contribution

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- Theoretical results: Frequency domain representation for SDF with applications
- Empirical results: Estimation of risk prices by frequency from cross-section, find significantly priced low frequency risk
- Analysis suggests EZ closer to data than Habits

Theory

- Focus on innovations in SDF with time-non-separabilities

$$\Delta E_{t+1} m_{t+1} = \Delta E_{t+1} \sum_{k=0}^{\infty} z_k \cdot x_{t+1+k}$$

with priced variable x_t

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- Assume a vector MA process for state variables

$$x_t = B_1 X_t = B_1 \Gamma(L) \varepsilon_t$$

- $$\Delta E_{t+1} m_{t+1} = -\sum_j \left(\sum_{k=0}^{\infty} \underbrace{z_k}_{\text{Price of risk}} \cdot \underbrace{g_{j,k}}_{\text{Imp rsp.}} \right) \varepsilon_{j,t+1}$$

Result 1

$$\Delta E_{t+1} m_{t+1} = -\sum_j \left(\sum_{k=0}^{\infty} z_k g_{j,k} \right) \varepsilon_{j,t+1}$$
$$= -\sum_j \left(\frac{1}{2\pi} \int_{-\pi}^{\pi} Z(\omega)\, G_j(\omega)\, d\omega \right) \varepsilon_{j,t+1}$$

with

$$Z(\omega) \equiv z_0 + 2 \sum_{k=1}^{\infty} z_k \cos(\omega k)$$
$$G_j(\omega) \equiv \sum_{k=1}^{\infty} g_{j,k} \cos(\omega k)$$

Derivation

- #1: Discrete-time Fourier Transform, and Inverse

$$\tilde{G}_j(\omega) \equiv \sum_{k=0}^{\infty} e^{-i\omega k} g_{j,k}, \text{ and } g_{j,k} = \frac{1}{2\pi} \int_{-\pi}^{\pi} \tilde{G}_j(\omega) e^{-i\omega k} d\omega$$

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- #2: Using fact that $g_{j,k} = 0$, for $k < 0$, and algebra

$$\sum_{k=0}^{\infty} z_k \left(\frac{1}{2\pi}\int_{-\pi}^{\pi} \tilde{G}_j(\omega)\, 2\cos(\omega k)\, d\omega \right)$$

- $\sum_{k=0}^{\infty} z_k g_{j,k} = \frac{1}{2\pi} \int_{-\pi}^{\pi} \tilde{G}_j(\omega) \underbrace{\left[z_0 + \sum_{k=1}^{\infty} z_k 2\cos(\omega k) \right]}_{\equiv Z(\omega)} d\omega,$

  $Z(\omega) \equiv$ 'weighting function'

- #3: A lot more algebra

$$\sum_{k=0}^{\infty} z_k g_{j,k} = \frac{1}{2\pi} \int_{-\pi}^{\pi} G_j(\omega) \underbrace{\left[z_0 + \sum_{k=1}^{\infty} z_k 2\cos(\omega k) \right]}_{\equiv Z(\omega)} d\omega$$

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- Frequency response function: $H(\omega) = |H(w)| \cdot e^{-i\psi(\omega)}$
- Need Inverse "Dew-Becker-Giglio" Transform

$$z_k = \begin{array}{c} \frac{1}{2\pi} \int_{-\pi}^{\pi} Z(\omega)\, d\omega \text{ for } k = 0 \\ \frac{1}{\pi} \int_{-\pi}^{\pi} Z(\omega) \cos(\omega k)\, d\omega \text{ for } k > 0 \end{array}$$

Alternative derivation

- #1: Parseval's theorem

$$\sum_{k=-\infty}^{\infty} z_k g_k = \int_{-\pi}^{\pi} Z(\omega)\,\overline{G(\omega)}d\omega$$

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$$Z(\omega) = \sum_{k=-\infty}^{\infty} z_k e^{-i\omega k}, \ G(\omega) = \sum_{k=-\infty}^{\infty} g_k e^{-i\omega k}$$

- $Z(\omega)$ is complex, because $\sum_{k=0}^{\infty} z_k L^{-k}$

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- Need Inverse D-B-G Transform, split weights

Habits versus Epstein-Zin

- CRRA

$$E_{t+1}m_{t+1} = -\alpha E_{t+1}\Delta c_{t+1}$$

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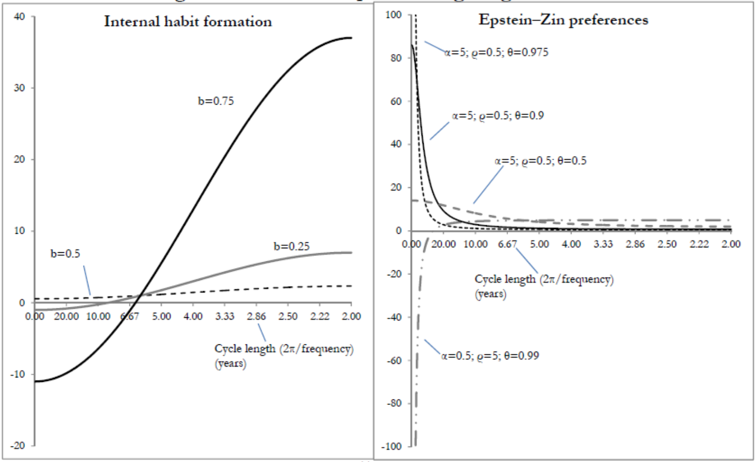
- $$E_{t+1} m_{t+1} \approx -\alpha \left[\begin{array}{c} \left(b (1-b)^{-2} + 1 \right) E_{t+1} \Delta c_{t+1} \\ -b (1-b)^{-2} E_{t+1} \Delta c_{t+2} \end{array} \right]$$

Figure 2. Theoretical spectral weighting functions



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- External habits, only innovations in Δc_{t+1}, spectrum is flat

$$\exp\left(m_{t+1}\right) = \beta \frac{\left(C_{t+1} - b\bar{C}_t\right)^{-\alpha}}{\left(C_t - b\bar{C}_{t-1}\right)^{-\alpha}}$$

Epstein-Zin

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&= -\left(\rho + (a-\rho)\,\frac{1}{1-\theta}\right) \Delta E_{t+1} c_{t+1} \\
&= -\left(.5 + (5-.5)\,\frac{1}{.025}\right) \Delta E_{t+1} c_{t+1} \\
&= -\left[180\right] \Delta E_{t+1} c_{t+1}
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Estimates of spectral weighting functions

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\begin{aligned}
Z^U(\omega) &= q_1 \sum_{j=1}^{\infty} \theta^j \cos(\omega j) + q_2 + q_3 \cos(\omega) \\
\text{EZ} &: \quad q_1, q_2 > 0,\ q_3 = 0 \\
\text{Internal Habit} &: \quad q_3 < 0,\ q_2 > 0,\ q_3 = 0
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- Bandpass basis

$$
Z^{BP}(\omega) = q_1 Z^{(\infty,32\text{quarters})} + q_2 Z^{(32,6)} + q_3 Z^{(6,2)}
$$

- Apply Inverse Transform

$$
\begin{aligned}
\Delta E_{t+1} m_{t+1} &= -\bar{q}' \left(\sum_{j=0}^{\infty} \underbrace{H_j^{U,BP}}_{\text{Freq.func.}} B_1 \Phi^j \right) \underbrace{(X_{t+1} - \Phi X_t)}_{\text{VAR state var.}} \\
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\end{aligned}
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$$= -\bar{q}' u_{t+1}$$

- Moment conditions

$$E\left(R_{i,t} - R^f_{t-1}\right) = -E\left(-\bar{q}' u_{t+1}, r_{i,t} - r^f_{t-1}\right)$$

Results

Portfolios:		FF25					
Basis:		Bandpass	t-stat		Utility (0.975)	t-stat	
Consumption growth	q1	269	2.47	**	555.47	1.66	*
	q2	-431	-1.17		-442.65	-0.44	
	q3	138	0.33		616.12	0.32	

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- Epstein-Zin Risk Aversion coefficient implied by Utility basis

$$q_1 = (\alpha - \rho)\, 2$$

$$\text{Risk Aversion: } \alpha = \frac{555.47}{2} + \rho > 277.7$$

Other comments

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- Cross-section: Drivers of results, and literature (ex: Parker and Julliard (2005), Hansen, Heaton, Lee & Roussanov (2007))

Conclusion

Nice paper!