Irina Zviadadze: Term structure of risk in expected returns

Discussion by Jaroslav Borovička (NYU)

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A BRIEF HISTORY OF ASSET PRICING

1980s: asset pricing puzzles

- inability of existing macro-based models to fit elementary asset-pricing moments

1990s–2000s: a range of proposed solutions

- long-run risk, habits, disasters, higher moments, ambiguity, heterogeneity, financial frictions, …

2010s: a new puzzle

- which of the many models that fit essentially the same aggregate moments is the ‘right’ description of the underlying risk
- new ways of comparing models to data needed
Matching dynamic responses

- estimate an ‘empirical’ model (VAR) describing the joint dynamics of a vector of macro variables
- identify ‘structural’ shocks from reduced-form disturbances
  - Christiano, Eichenbaum, Evans (2005), …
  - technology, monetary policy, financial conditions, preferences, …
- compare impulse responses to those for analogous shocks in a DSGE model

Asset pricing counterparts

- sensitivity of expected returns at various horizons to identified shocks
- temporal decomposition of risk
Implementation

- A ‘structural’ linear model (Hurwicz (1962))

\[ \Gamma_0 X_t + \Gamma_1 X_{t-1} = \varepsilon_t \quad \varepsilon_t \sim N(0, I) \]

- \( \varepsilon \) are structural shocks: policy interventions, or changes in the economy
- Estimate a VAR

\[ X_t = -\Gamma_0^{-1} \Gamma_1 X_{t-1} + w_t, \quad w_t = \Gamma_0^{-1} \varepsilon_t \]

- Identification assumptions needed to infer \( \Gamma_0^{-1} \) from \( \text{Var}[w_t] \).
Figure 2: Responses to a Neutral Technology Shock: AOB vs. Calvo

VAR 95%     VAR Mean     Alternating Offer Bargaining (AOB)     Calvo Sticky Wages

GDP

Unemployment Rate

Inflation Rate

Federal Funds Rate

Hours

Real Wage

Consumption

Rel. Price Investment

Investment

Capacity Utilization

Job Finding Rate

Vacancies
Cash flows (dividends, consumption) consist of strips with different maturities

- study sensitivity of expected payoffs and expected returns (yields to maturity) of these strips to alternative shocks
- recover the term structure of exposure to shocks and risk prices assigned to these shocks
  - shock-exposure elasticities
  - shock-price elasticities

Borovička, Hansen (also with Hendricks, Scheinkman)

- decomposition of risk premia to contributions of alternative shocks
- comparisons of theoretical models

**This paper**: an empirical implementation (plus much more)
Want to formally compare two models

- an ‘empirical’ model with minimal restrictions (akin a VAR)
- an equilibrium model (e.g., a long-run risk model)

Estimate responses of expected buy-and-hold returns at various horizons to identified shocks

- Assess the term structures of sensitivities of expected returns for alternative shocks
Motivated by reduced-form return forecasting regressions

$$r_{t,t+1} = a + b \log pd_t + w_{r,t+1}$$

- $w_{r,t+1}$ a reduced form shock
- $pd_t$ a function of underlying fundamental sources of risk

$$\log pd_t = q_0 + q_x x_t + q_v v_t + \sigma_{pd} \varepsilon_{pd,t}$$

where $x_t$ is mean consumption growth rate and $v_t$ stochastic variance (both latent)
EMPIRICAL MODEL

\[
\begin{pmatrix}
\log r_{t,t+1} \\
\log g_{t,t+1} \\
x_{t+1}
\end{pmatrix} = G \begin{pmatrix} 1 \\ \log g_t \\ x_t \end{pmatrix} + H_v (v_{t+1} - E_t v_{t+1}) + v_t^{1/2} H \begin{pmatrix} \varepsilon_{g,t+1} \\ \varepsilon_{x,t+1} \\ \varepsilon_{d,t+1} \end{pmatrix}
\]

\[
v_{t+1} = (1 - \varphi_v) + \varphi_v v_t + \sigma_v ((1 - \varphi_v + 2 \varphi_v v_t) / 2)^{1/2} \varepsilon_{v,t+1}
\]

\[
\log pd_t = q_0 + q_x x_t + q_v v_t + \sigma_{pd} \epsilon_{pd,t}
\]

- Implied restriction

\[
\log r_{t,t+1} = \kappa_0 + \kappa_1 \log pd_{t+1} - \log pd_t + \log d_{t,t+1}
\]

- structural shocks \((\varepsilon_{g,t+1}, \varepsilon_{x,t+1}, \varepsilon_{d,t+1}, \varepsilon_{v,t+1})'\)
  - interpretation?

- latent variables \(x_t, v_t \implies \text{estimate using ML}\)
LONG-RUN RISK MODEL (BANSAL, YARON (2004))

Exogenous dynamics

\[
\begin{align*}
\log g_{t,t+1} &= g + x_t + \gamma_g v_t^{1/2} \varepsilon_{g,t+1} \\
\log d_{t,t+1} &= d + \mu_x x_t + \gamma_d v_t^{1/2} \varepsilon_{d,t+1} \\
x_{t+1} &= \varphi_x x_t + \gamma_x v_t^{1/2} \varepsilon_{x,t+1} \\
v_{t+1} &= (1 - \varphi_v) + \varphi_v v_t + \sigma_v ((1 - \varphi_v + 2 \varphi_v v_t) / 2)^{1/2} \varepsilon_{v,t+1}
\end{align*}
\]

Preferences

\[
V_t = \left[ (1 - \beta) C_t^{1-\rho} + \beta \left( E_t \left[ V_{t+1}^{1-\gamma} \right] \right) \right]^{1-\rho} \left[ \frac{1-\rho}{1-\gamma} \right]^{1-\rho}
\]

Equilibrium price-dividend ratio and returns

\[
\begin{align*}
\log pd_t &= q_0 + q_x x_t + q_v v_t \\
\log r_{t,t+1} &= \log r + r_x x_t + r_v v_t + r_{\varepsilon x} v_t^{1/2} \varepsilon_{v,t+1} + r_{\varepsilon d} v_t^{1/2} \varepsilon_{d,t+1} + r_{\varepsilon v} v_{t+1}
\end{align*}
\]
INCREMENTAL EXPECTED RETURNS

Construct $\tau$-period buy-and-hold returns

$$ r_{t,t+\tau} = \prod_{s=1}^{\tau} r_{t+s-1,r+s} $$

Compare the expected return with a counterfactual

$$ \text{IEER} (r_{t,t+\tau}, \varepsilon_{v,t+1}) = E_t [r_{t,t+\tau} \mid \mathcal{F}_t, \tilde{v}_{t+1} = v_{t+1} + \Delta v] - E_t [r_{t,t+\tau}] $$

- sensitivity of expected returns to $\varepsilon_{v,t+1}$ across alternative horizons
  - using stock returns across horizons instead of returns on strips
  - returns on strips can perhaps be reconstructed (if needed)
Term Structure of Expected Returns

Panel A. Bansal and Yaron (2004)

Panel B. Wachter (2013)

Panel C. Drechsler and Yaron (2011)

The red lines correspond to theoretical term structures of expected buy-and-hold returns, that is as implied by the original calibrations of Bansal and Yaron (2004), Wachter (2013), and Drechsler and Yaron (2011). The solid blue lines correspond to empirical term structures of expected buy-and-hold returns, that is as implied by the estimated empirical models. Vertical bars indicate 95% credible intervals for the estimated term structures of expected returns. Panel A represents the economic environment of Bansal and Yaron (2004). Panel B represents the economic environment of Wachter (2013). Panel C represents the economic environment of Drechsler and Yaron (2011). Quarterly.
The red dashed lines correspond to the theoretical term structures of risk. The blue solid lines correspond to the empirical term structure of risk. Vertical bars indicate 95% credible intervals for the estimated term structures of risk. The incremental expected returns are scaled by the unconditional standard deviation of the one-period stock returns. Quarterly.
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Term structure of risk in expected stock returns.

Panel A. IER for the variance risk $v$

Panel B. IER for the variance risk $v^*$

Panel C. IER for the jump in variance $z$

Trending volatility with jumps

The red dashed lines correspond to the theoretical term structures of risk. The blue solid lines correspond to the empirical term structure of risk. Vertical bars indicate 95% credible intervals for the estimated term structures of risk. The incremental expected returns are scaled by the unconditional standard deviation of the one-period stock returns. Quarterly.
1. Are the alternative models that different?
2. Matching jointly responses of expected returns and expected cash flows
3. Imposing other types of restrictions
4. What are the structural shocks?
Empirical model motivated by predictability of returns using price-dividend ratio

- In each model, the price-dividend ratio is a function of different state variables.
- These latent variables must have similar paths to explain the same path of the price-dividend ratio.

Structural models differ, because

- they impose different parametric restrictions
- they imply different mappings between fundamentals and returns

This paper provides a useful way of discriminating among these mappings.
Panels A, B, C display quarterly observations of consumption growth, log stock returns, and log price-dividend ratio, respectively. Panel D displays the mean path of the stochastic variance factor (dashed blue line) with the 95% credible interval (thin solid lines) and the mean path of the expected consumption growth (dashed red line) with the 95% credible interval (thin solid lines). Sample period: second quarter of 1947 to fourth quarter of 2015. Grey bars are the NBER recessions. Quarterly.
Panels A, B, C display quarterly observations of consumption growth, log stock returns, and log price-dividend ratio, respectively. Panel D displays consumption disaster risk (blue lines), jump risk in stock returns (red lines). A brown line corresponds to the estimated jump intensity, the dashed lines correspond to the 95% credible interval. Sample period: second quarter of 1947 to fourth quarter of 2015. Grey bars are the NBER recessions.
Panels A, B, C display quarterly observations of consumption growth, log stock returns, and log price-dividend ratio, respectively. Panel D displays the mean path of the stochastic variance factor (dashed brown line) with the 95% credible interval (thin brown lines), right axes, and the mean path of the variance factor (dashed red line) with the 95% credible interval (thin red lines), left axes. Self exciting jumps (blue bars) are displayed on Panel D, left axes. Sample period: second quarter of 1947 to fourth quarter of 2015. Grey bars are the NBER recessions. Quarterly.
One of central tensions in asset pricing models is to square

- predictability of returns
- predictability of fundamentals (e.g., consumption)

The paper focuses solely on returns.

- Why not add responses of expected cash flows to the analysis?
- Assess joint fit.
  - shock-exposure and shock-price elasticities
IMPOSING OTHER TYPES OF RESTRICTIONS

Methodology in the paper

- prescribe one-period dynamics
- extrapolate into future
- economically interesting restrictions may not be one-period relations

**Blanchard, Quah (1989):** imposing long-run restrictions

- can impose which shocks have long-run impact on returns
- e.g., technology yes, monetary policy no (real vs nominal?)

Empirical implementation of identifying *martingale components* of cash flows and SDFs

- Hansen, Scheinkman (2009), Borovička, Hansen, Scheinkman (2016)
- conditions not as simple as in Blanchard, Quah (1989) due to lack of additivity of level returns
WHAT ARE THE STRUCTURAL SHOCKS?

The models treat as structural shocks those directly affecting

- consumption growth
- probability of disasters
- stochastic volatility

Are these interesting structural shocks in the sense of Hurwicz (1962)?

- Do they correspond to interesting independent innovations in policy, technology and other fundamental forces?
- E.g., consumption can move for many reasons, and each of those reasons can have a very different propagation through consumption dynamics?
- Old problem going back to the Cowles Commission (1950s) and Frisch (1930s).
What does the paper achieve?

- Substantial progress in empirical implementation of using term structure of expected returns as a source of information for asset-pricing models.
- Methodology that treats various types of innovations (normal, gamma mixture, jumps)
- Applications to relevant quantitative models

What else to do?

- Joint cash flow and return term structure
- Sharper interpretation of the role of latent variables