

# Simulation-based multiple testing for many non-nested multivariate models

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# Motivation and Results

- Growing problem of model specification: Harvey et al. (2016) documents over 300 asset pricing factor models since 1964
- This paper: multivariate extensions of tests for simple and multiple non-nested alternatives
- The test statistic is pivotal under normality and asymptotically pivotal otherwise, even when the design matrix is rank-deficient  $\rightarrow$  MC  $p$ -values
- Simulation results: the test shows good size and power properties
- We test prominent asset pricing model against both simple and multiple non-nested alternatives

- Artificial regression:

$$Y = X_0\theta_0 + \sum_{k=1}^K P_{X_k} P_{X_0} Y A_k + U = \tilde{X}\Pi + U \quad (1)$$

- Test  $H_0 : A_1 = \dots = A_K = 0_{n \times n}$  using Wilk's lambda  $\Lambda = |\hat{U}'\hat{U}|/|\hat{U}'_0\hat{U}_0|$ , where  $\hat{U}'\hat{U}$  and  $\hat{U}'_0\hat{U}_0$  are the unrestricted and restricted SSE
- Uniform mixed linear restrictions:  $R\Pi = L$ , where  $R = [0_{n \times K_0} \quad I_n \dots I_n]$ ,  $L = 0_{n \times n}$
- Conditioning on  $\tilde{X}$ ,  $\Lambda$  follows the same distribution as the ratio

$$|W'M(\tilde{X})W|/|W'M_0W|. \quad (2)$$

where  $W$  has a known distribution, with  $U = WJ'$  and  $\Sigma = JJ'$ .  $M(\tilde{X}) = I_T - \tilde{X}\tilde{X}^+$ , and  $M_0 = M(\tilde{X}) + \tilde{X}(\tilde{X}'\tilde{X})^+R' \left[ R(\tilde{X}'\tilde{X})^+R' \right]^{-1} R\tilde{X}^+$ , with  $\tilde{X}^+$  being the Moore-Penrose inverse of  $\tilde{X}$ .

- Simple alternative: Fama and French (2015) five-factor model vs. Pástor and Stambaugh (2003)
  - For most time periods, we reject the Fama and French (2015) model in favour of Pástor and Stambaugh (2003) (monthly data)
- Multiple alternatives: Fama and French (2015) five-factor model vs. three liquidity- and consumption-based asset pricing models: Pástor and Stambaugh (2003), Lettau and Ludvigson (2001), Lustig and Van Nieuwerburgh (2005)
  - For most time periods, we cannot reject the Fama and French (2015) model (quarterly data)