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Multifactor models and their consistency with the ICAPM ☆

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ABSTRACT

Can any multifactor model be interpreted as a variant of the Intertemporal CAPM (ICAPM)? The ICAPM places restrictions on time-series and cross-sectional behavior of state variables and factors. If a state variable forecasts positive (negative) changes in investment opportunities in time-series regressions, its innovation should earn a positive (negative) risk price in the cross-sectional test of the respective multifactor model. Second, the market (covariance) price of risk must be economically plausible as an estimate of the coefficient of relative risk aversion (RRA). We apply our ICAPM criteria to eight popular multifactor models and the results show that most models do not satisfy the ICAPM restrictions. Specifically, the "hedging" risk prices have the wrong sign and the estimates of RRA are not economically plausible. Overall, the Fama and French (1993) and Carhart (1997) models perform the best in consistently meeting the ICAPM restrictions. The remaining models, which represent some of the most relevant examples presented in the empirical asset pricing literature, can still empirically explain the size, value, and momentum anomalies, but they are generally inconsistent with the ICAPM.

1. Introduction

Explaining the dispersion in average excess returns in the cross-section of stocks has been one of the most important topics in the asset pricing literature. The inability of the Sharpe (1964)–Lintner (1965) CAPM to price portfolios sorted on size, book-to-market, momentum, and other stock characteristics has led to so-called size, value, and momentum anomalies (Fama and French, 1992, 1993, 1996, among others). In response, several multifactor models seeking to explain these various anomalies have emerged in the literature. Typically, these models include factors in addition to the market return whose betas help match the dispersion in excess portfolio returns observed in the cross-section. Many of these multifactor models have been justified as empirical applications of the Intertemporal CAPM (ICAPM) (Merton, 1973), leading Fama (1991) to interpret the ICAPM as a "fishing license" to the extent that authors claim it provides a theoretical background for relatively ad hoc risk factors in their models. However, Cochrane (2005, Chapter 9) notes that although the ICAPM does not directly identify the "state variables" underlying the risk

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factors, there are some restrictions that these state variables must satisfy. According to Merton, the state variables relate to changes in the investment opportunity set, which implies that they should forecast the distribution of future aggregate stock returns. Moreover, the innovations in these state variables should be priced factors in the cross-section.

We examine the restrictions associated with the ICAPM that prevent it from being a "fishing license" for any multifactor model that seeks to explain the cross-section of stock returns. We identify three main conditions that a multifactor model must meet to be justifiable by the ICAPM and find that most multifactor models in the literature do not satisfy these restrictions.

First, the candidates for ICAPM state variables must forecast the first or second moments of aggregate stock returns. We assess the forecasting power of each variable by conducting time-series long-horizon regressions.

Second, if a given state variable forecasts positive expected aggregate returns, its innovation (the risk factor) should earn a positive risk price in cross-sectional tests, while state variables that forecast negative expected aggregate returns should earn a negative risk price. Risk premiums with opposite signs should accrue to innovations to state variables that forecast market volatility. Thus, it is not enough that the candidate state variables forecast future aggregate expected returns or the volatility of returns, the corresponding factors should also be priced in the cross-section with the correct sign. The intuition for this result is simple. An asset that covaries positively with innovations to the state variable also covaries positively with future expected returns. It does not provide a hedge for reinvestment risk because it offers lower returns when aggregate returns are expected to be lower. Hence, a risk-averse rational investor will require a positive risk premium to invest in such an asset, implying a positive price of risk for the factor. A similar argument applies to assets that covary with innovations to market volatility.

The third restriction associated with the ICAPM is that the market (covariance) price of risk estimated from the cross-sectional tests must be economically plausible as an estimate of the coefficient of relative risk aversion (RRA) of the representative investor.

Most of the empirical literature on the ICAPM uses state variables from the predictability literature (short-term interest rates, bond yields, and aggregate financial ratios) in order to meet the first ICAPM restriction that the state variables should forecast expected market returns. Yet, authors largely neglect the other constraints of the ICAPM: that the market price of risk corresponds to the risk aversion of the representative investor and especially that there must be consistency between the "hedging" factor risk prices and the corresponding slopes from the predictive regressions.

In Campbell (1996), the risk prices associated with the vector autoregressive (VAR) state variables that forecast market returns are constrained in the sense that they are linked with the estimated slopes from the VAR. However, Campbell only tests a specific parametrization with Epstein-Zin preferences and a VAR to estimate market discount rate news. This paper extends this work, focusing on whether commonly used empirical factor models satisfy the consistency between time-series slopes and cross-sectional risk prices to be justifiable as ICAPM applications. Our work is also related to Lewellen, Nagel, and Shanken (2010) and Lewellen and Nagel (2006), who advocate that cross-sectional tests of asset pricing models in general, and the conditional CAPM in particular, should impose the models' theoretical restrictions on the factor risk prices.

We apply our ICAPM criteria to eight multifactor models, tested over 25 portfolios sorted on size and book-to-market (SBM25) and 25 portfolios sorted on size and momentum (SM25). We include the market return in the set of testing assets, which enables us to merge the cross-sectional literature on the ICAPM with the literature on the time-series aggregate risk-return trade-off. Hence, we have a total of 16 empirical tests in the cross-section: eight models and two sets of portfolios.

Table 1 summarizes the main results regarding the multifactor models satisfying the ICAPM criteria. When investment opportunities are driven by changing expected market returns, our results show that only two models—the Fama and French (1993) three-factor model tested over SBM25, and the Carhart (1997) model tested

Table 1
Consistency of multifactor models with the ICAPM.

This table reports the consistency of the factor risk prices from multifactor models with the ICAPM criteria. The criteria are associated with the magnitude of the market risk price (or risk-aversion coefficient) (γ), and the consistency in sign of the risk prices of the hedging factors with the corresponding predictive slopes over the excess market return (γ_z,E(r)) and the market variance (γ_z,$\sigma^2(r)$). The multifactor models are Hahn and Lee (2006) (HL), Petkova (2006) (P), Campbell and Vuolteenaho (2004) (CV), Koijen, Lustig, and Van Nieuwerburgh (2010) (KLVN), Fama and French (1993) (FF3), Carhart (1997) (C), Pástor and Stambaugh (2003) (PS), and the Fama and French (1993) five-factor model (FF5). The testing assets in the cross-sectional tests are the 25 size/book-to-market portfolios (SBM25, Panel A), and 25 size/momentum portfolios (SM25, Panel B). A "✓" indicates that the ICAPM criteria are satisfied.

	γ	γ_z, E(r)	γ_z, $\sigma^2(r)$
Panel A: SBM25			
HL	×	×	×
P	×	×	×
CV	×	×	×
KLVN	×	✓	×
FF3	✓	✓	✓
C	✓	✓	×
PS	×	✓	×
FF5	×	×	✓
Panel B: SM25			
HL	✓	×	×
P	×	×	×
CV	×	×	×
KLVN	×	×	×
FF3	×	×	×
C	✓	✓	×
PS	×	×	×
FF5	×	×	×