

# Chapter 13

## Reevaluating Factor Models: Feature Extraction of the Factor Zoo

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### **ABSTRACT**

*Since the introduction of CAPM in the 1960s, the asset pricing literature has documented hundreds of characteristics that capture the cross-sectional variation in stock returns. Traditionally, multifactor models seek a multidimensional representation of common risks; this approach entails selecting a small number of representative characteristics from a set of candidate characteristics that, together, explain most of the cross-sectional variation in stock returns. Characteristics-based long-short portfolios are partially loaded on the true underlying risk factors and are at best noisy proxies for true latent factors. However, the expansive list of potential characteristics, along with developments in the field of dimensionality reduction, offers us an opportunity to seek better approximations of the unobservable latent risk factors. A recent stream of literature has investigated how to appropriately extract relevant features from the “factor zoo” while incorporating information from the expansive list of factors. This chapter aims to summarize this novel paradigm in factor modeling.*

### **INTRODUCTION**

The essence of asset pricing boils down to one central question: Why do different assets earn different returns? Much of the investment literature produced over the last four decades has been dedicated to addressing this question. The risk-return tradeoff applied by investors and academics alike has proven to be a good starting point to understanding this issue. Synonymous to the English phrase “there is no such thing as a free lunch”, this fundamental assumption has been extensively explored and is widely accepted in investment circles. In order to make higher returns, investors must take risky positions and

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to avoid risky investments, they must settle for lower expected returns. However, measuring risk is an extremely challenging problem empirically and is still very much an issue of debate in asset pricing.

## Measuring Common Risk

A simple measure of risk is the volatility in the assets returns because it signals uncertain future returns. Consider a simplistic assumption that assets with more volatile returns are riskier and investors would rather have positions in less volatile assets than highly volatile ones (for a given level of average returns). This is to say that investors would only accept higher volatility in returns if the average returns were higher. Another important assumption is that investors can choose to invest from a variety of correlated assets and can hold diversified portfolios. These two assumptions combined are key to how we measure risk.

It is important at this point to establish what is meant by risk and what type of risks are interesting. The risks in an investment can be divided into two broad classes: idiosyncratic risk and systematic risk. This distinction is important when allowing for diversification because, idiosyncratic or unsystematic risk is the risk faced by a firm and can be managed through effective diversification. For example, an investor can choose to invest in fossil fuels and renewables and hence have a position in the energy sector. Moreover, such diversification could be across industries and asset classes. In a market where the market participants are well diversified, the idiosyncratic risk should not bother the investors much, and hence, will not be priced.

Systematic risk, however, is faced by the overall market and all market participants are exposed to such risks. As a result, the systematic risk is priced (i.e. the investors demand compensation for this risk because they are unable to diversify this risk). This is the risk that factor models are concerned about: the undiversifiable risk that affects the overall market. This chapter focuses on this (priced) systematic risk and its approximation using factor models.

A good approach proposed by Cochrane (2001) is the Stochastic Discount Factor (SDF) approach, which sums up the problem of measuring common risk effectively. This states that there exists a Stochastic Discount Factor (SDF) that explains the cross-sectional return differential in equity returns.

SDF elegantly sums up asset pricing in two equations:

$$P_t = E(m_{t+1}x_{t+1}) \quad (1)$$

$$m_{t+1} = f(\text{data}, \text{parameters}) \quad (2)$$

where  $P_t$  is the price at time  $t$ ,  $m_{t+1}$  is the stochastic discount factor, and  $x_{t+1}$  is the payoff at period  $t+1$ .

The SDF can be estimated as a general function of data and estimated parameters. Traditionally, linear multifactor models have been used to approximate the SDF, where factors are approximated using characteristic sorted stock portfolios. Additionally, modern deep learning models have introduced less restrictive approaches that can accommodate higher dimensional inputs and incorporate flexible functional forms. Recent literature in asset pricing has proposed theoretically motivated deep learning models to approximate the SDF and show promising results in the form of consistent SDF functional forms and a many-fold increase in prediction accuracy. It is clear that these models are doing a much

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