

# Estimation and simulation of risk premia in equity and foreign exchange markets

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## Abstract

There is substantial evidence to reject constant-risk-premia financial models. While time-varying risk premia are often mentioned as an alternative, the literature has yet to produce an example that accounts for the important time-series properties of asset returns. We inquire whether mean-variance optimization models can do so. We model asset risk with an absolute-error version of the ARCH-in-mean hypothesis and model hedging motives that derive from variation in future real income and inflation to account for agent heterogeneity. We consider a three-country-and-two-asset world. Our model predicts values for five excess returns relative to the US bill rate. We use a systems approach to estimate the model parameters and then simulate the estimated model to determine if it can account for the important time-series properties of risk premia. © 2000 Elsevier Science Ltd. All rights reserved.

*Keywords:* Time-varying risk premium; Mean-variance optimization; Hedging; Foreign exchange

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## 1. Introduction

The evidence is substantial to reject models of financial markets that imply that constant risk premia are imbedded in asset prices. While a widely suggested alternative is a risk premium that varies through time, the literature has yet to produce a model with time-varying risk premia that accounts for the important time-series properties of asset returns. The purpose of this paper is to determine whether mean-variance optimization models can do so.

We confine our attention to models where agents choose a portfolio that maximizes

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a function that is increasing in expected wealth and decreasing in the variance of wealth. Kim (1995) discusses the place of these models in financial theory. We focus on the mean-variance optimization (MVO) model because it is simple and because we believe that variation in wealth is a better proxy for risk than variation in consumption flows especially when aggregate data are employed.

Much of the recent work with MVO models traces back to Frankel (1982) which assumes that the covariance matrix of asset returns is constant through time. Frankel shows, and others have since confirmed, that constant-covariance MVO models can **not** explain the variation in excess returns observed in the data. More recent studies have assumed that the return-error covariance matrix is time-varying and generated by an ARCH or GARCH process. Examples include Engel and Rodrigues (1989), Giovannini and Jorion (1989), Ng (1991), and Thomas and Wickens (1993). None of these studies has successfully explained the large variation observed in excess returns.

We make several modifications to the standard MVO model. First, we model asset risk with a version of the ARCH-in-mean hypothesis in which return-error variances depend on the absolute value of lagged residuals. This modification implies that the first partial derivatives of the return-error variance with respect to lagged errors are constant rather than increasing in the size of the error and can potentially increase the effect of medium and small errors on risk.

Second, we model the dependence of real wealth on non-portfolio real income and inflation. Optimizing agents adjust their portfolios to hedge risk associated with variation in real income and inflation, and we inquire whether allowing for this hedging motive can improve the empirical performance of the model.

Third, we consider a three-country-and-two-asset world with bills<sup>1</sup> and equity issued in each country so that agents can hold six assets.<sup>2</sup> Using the US bill rate as the reference rate, our model explains five risk premia: the expected excess return on equity in each country and the expected excess return on German and Rest-of-the-World bills. The international nature of financial markets suggests that agents of different countries face many common sources of risk. We thus expect more precise estimates of risk premia from a study that simultaneously models risk premia in several countries.

While agents of each country are the same *ex ante*, our model is not a representative-agent model in the standard sense of the term. The time series behavior of real wealth differs across countries because agents value wealth in their own currency and because they face different income and inflation processes. Agents in our model trade assets.

Engel (1994) sets out a version of the Solnik (1974) model which also has agents from several countries. Because it ignores real income flows and assumes that price

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<sup>1</sup> We call these assets “bills” rather than “bonds” because they have fixed nominal one-period returns. However, our empirical measure of the supply of “bills” includes all treasury securities. We discuss these issues further in the data section of the paper.

<sup>2</sup> Smith (1992), Thomas and Wickens (1993), and Engel (1994) test versions of the international capital asset pricing model with bills and equities.

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