

The forward premium puzzle in a model of imperfect information[☆]

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Abstract

This paper studies the forward premium puzzle in a model with imperfect information. The model predicts fixed effects and conditional heteroskedasticity in the forward premium regression and provides a rationale for the evidence in Mayfield and Murphy [Mayfield, E.S., Murphy, R.G. 1992. Interest rate parity and the exchange risk premium, *Economics Letters* 40, 319–324].

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1. Introduction

The forward premium puzzle is the empirical finding that the forward exchange rate is a biased predictor of the future spot exchange rate.¹ Numerous studies have attempted, with limited success, to produce models in which this forward bias is a consequence of risk premia in exchange rate markets. This paper examines the implications for the forward premium of assuming that private agents have imperfect information about the shocks that buffet the economy.

A simple example of an economy in which there is a signal extraction problem is one in which shocks to monetary policy follow a moving average process whose innovations are not publicly observed. This example, which I study in detail, has implications that are qualitatively similar to a more general setting in which there are signal extraction problems with respect to other variables (e.g. dividend flows, government spending) or in which there are interactions between monetary

policy at home and abroad that are imperfectly observed. It is also a realistic assumption as I discuss below.

The main theoretical result of the paper is that the information structure of the model implies conditionally heteroskedastic forecast errors and fixed time- and country-effects in the forward premium regression. These features arise exclusively due to the signal extraction problem and do not require the existence of a positive risk premium. This result provides a rationale for the empirical findings in Mayfield and Murphy (1992), where it is shown that introducing time- and country-fixed effects eliminates most of the forward premium bias. Mayfield and Murphy (1992) justify introducing fixed time- and country-effects in the forward premium regression with the existence of a time-varying risk premium. The present paper provides an alternative explanation that does not rely on fluctuations in risk.

The paper is organized as follows. Section II outlines the theoretical model. Section III presents some results concerning the signal extraction problem, and discusses the theoretical implications of the model for the forward premium regression. Section VI concludes.

2. The model

I use the two-country model with national currencies of Lucas (1982) augmented to incorporate imperfect information about the economy's underlying shocks. This model is the work

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¹ For a survey see Engel (1996).

horse of the literature on time-varying exchange rate risk premia, which facilitates the comparison of my results with previous work. The basic elements of the model are well known so I omit the description of the problems solved by each of the two representative agents to conserve on space and notation.

From the Lucas model I borrow the pricing formulas for the depreciation rate occurring at time $t+1$, ds_{t+1} , and for the forward premium, fp_t , associated with a contract maturing at time $t+1$.² In the perfect pooling equilibrium of the model these are given by the expressions:

$$fp_t = \ln[E_t(\mu_{Y_{M+1}}^{1-\gamma} \mu_{M+1}^{-1})^{-1} E_t(\mu_{Y_{N+1}}^{1-\delta} \mu_{N+1}^{-1})] \quad (1)$$

$$ds_{t+1} = \ln[(\mu_{Y_{M+1}}^{1-\gamma} \mu_{M+1}^{-1})^{-1} \mu_{Y_{N+1}}^{1-\delta} \mu_{N+1}^{-1}]. \quad (2)$$

Here, exchange rates are measured in units of domestic currency per units of foreign currency and a positive ds_{t+1} is a depreciation of the domestic currency. The variables of the domestic country are indexed by M , and those of the foreign country by N . Momentary utility is assumed to be separable in the domestic and foreign good, and to display constant relative risk aversion, with γ and δ being the coefficients of relative risk aversion associated with each good. The variables μ_{Y_i} and μ_i are the gross growth rates of output and money in country i and E_t is the time t expectation operator.

For simplicity of presentation I restrict attention to the case in which μ_M and μ_N are stochastic and assume that output is constant ($\mu_{Y_i}=1$) and set $\gamma=\delta=0$. The later simplification helps to make clear that the results do not rely on the existence of a risk premium.

Money growth is subject to both persistent shocks (with an innovation ϵ_i) and to transitory shocks (v_i). Transitory shocks to country i 's money supply do not affect (but may be correlated with) country j 's current money growth. Country j 's money supply can potentially respond to persistent disturbances to money growth in country i . The process describing money creation in country M is:

$$\ln \mu_{Mt} = \ln \mu_M + h_{M0} \epsilon_{Mt} + h_{M1} \epsilon_{Mt-1} + h_{M2} \epsilon_{Mt-2} + v_{Mt}, \quad (3)$$

where $\ln \mu_M$ is the mean growth rate of money. I assume that country N follows a similar monetary policy rule. This money growth rule is motivated by the work of [Christiano et al. \(1998\)](#). These authors argue that the stochastic processes for the growth rates of the monetary base and $M1$ for the US can be well approximated by moving averages of order 2. The leading assumption of the paper is:

Assumption. The shocks ϵ_{it}, v_{it} cannot be perfectly inferred from the signals μ_{it} , $i=M, N$. Except for the shocks ϵ_{it}, v_{it} , all other information is common knowledge.

Under the stated assumption the representative agent infers the underlying shocks ϵ_{it}, v_{it} , from the sequence of signals

$\{\mu_{js}\}_{s=1}^t$. Since information is symmetric all private agents receive the same signals, and use the same information to update the conditional distribution function needed to evaluate Eq. (1). Attesting to the plausibility of the stated assumption are the efforts of the empirical literature that tries to identify monetary shocks (surveys to the literature include [Canova, 1995](#); [Leeper et al., 1996](#); and [Christiano et al., 1999](#)).

3. The signal extraction problem

In this section I show how agents construct and update their conditional expectations given the assumption about information. In deriving the conditional distribution of future growth rates of money, agents use all the information available in a way that is consistent with the rational expectations paradigm.

Agents filter information by means of the Kalman filter (the discussion here draws on [Hamilton, 1994](#), Chapter 13; and [Anderson and Moore, 1979](#)). The Kalman filtering technique is especially useful because of its recursive representation. To obtain this recursive representation rewrite Eq. (3) with the more general notation:

$$y_t = x + H' \xi_t + v_t,$$

with

$$H' = \begin{bmatrix} h_{M0} & h_{M1} & h_{M2} & 0 & 0 & 0 \\ 0 & 0 & 0 & h_{N0} & h_{N1} & h_{N2} \end{bmatrix},$$

$$\xi_t' = [\epsilon_{Mt} \ \epsilon_{Mt-1} \ \epsilon_{Mt-2} \ \epsilon_{Nt} \ \epsilon_{Nt-1} \ \epsilon_{Nt-2}],$$

$$v_t' = [v_{Mt} \ v_{Nt}],$$

$$x = \begin{bmatrix} \ln \mu_M \\ \ln \mu_N \end{bmatrix}, \quad y_t = \begin{bmatrix} \ln \mu_{Mt} \\ \ln \mu_{Nt} \end{bmatrix}$$

and

$$\xi_{t+1} = F \xi_t + \eta_{t+1},$$

$$\eta_{t+1} = [\epsilon_{Mt+1} \ 0 \ 0 \ \epsilon_{Nt+1} \ 0 \ 0]',$$

where F is defined implicitly and has all its eigenvalues inside the unit circle, and primes denote transposition. The innovations in the economy obey the following restrictions: (i) $(v_{Mt+1}, v_{Nt+1}) \sim N(0, R)$, R is positive definite, and v_t is uncorrelated with v_τ , $\tau \neq t$; (ii) $(\epsilon_{Mt+1}, \epsilon_{Nt+1}) \sim N(0, \tilde{Q})$, $\tilde{Q}$ is related to $Q = E(\eta_t \eta_t')$ in an obvious way, and η_t is uncorrelated with η_τ , $\tau \neq t$.

Let $\Omega_t = \{(\mu_{j,i})_{i=1}^t, j=M, N\}$ be the information set at time t . All relevant information to the agents as of time t is contained in Ω_t . The following system of equations gives the expectation of y_{t+1} conditional on Ω_t , denoted by $\hat{y}_{t+1|t}$:

$$\hat{y}_{t+1|t} = x + H' \hat{\xi}_{t+1|t}, \quad (4)$$

$$\hat{\xi}_{t+1|t} = F \hat{\xi}_{t|t-1} + F P_{t|t-1} H (H' P_{t|t-1} H + R)^{-1} (y_t - x - H' \hat{\xi}_{t|t-1}). \quad (5)$$

² See Lucas' eq. (4.5) for the nominal exchange rate, and eqs. (4.17) and (4.18) for the nominal interest rates, and the fact that covered interest parity holds in this model.

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