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Chapter 1

Introduction

From the point of view of pricing, hedging as well as medium and long term-term risk and asset management it is clear that, with the increased integration of financial markets of different countries, the majority of assets traded on the world financial markets are exposed to nominal interest rates and exchange rate fluctuations. Existing literature fails to provide an integrated framework, where all these factors play a role in equilibrium. There is a well-established body of literature on the term structure of interest rates in a closed economy. However, a coherent theoretical work has not been presented on the international aspect of the term structure and on the interdependency between the interest rates of different countries and the exchange rate. Mainly this interdependency known as the uncovered interest rate parity has been the main area of research in international finance. Standard economic theory alleges that high interest rates currencies should depreciate, while empirical evidence indicates that these currencies tend to appreciate.

Fama (1984) notes that the current forward foreign exchange rate can be viewed as the expected future spot rate plus a so-called forward risk premium and relates the currency price puzzle to the existence of this time-varying forward "risk premium". He formulates the following conditions to account for the puzzle: the risk premium should be negatively correlated with the expected rate of depreciation of the currency and should have greater variance. Two main issues has been addressed in economic-finance literature.

Several studies attempt to develop a framework that is capable of generating a risk premium with the required properties. Some of these studies adopt an international monetary-economic framework based on a Lucas-type general equilibrium to account for the observed currency puzzle [e.g. Bekaert (1996), Bansal et al. (1995), Canova and Marrinan (1993), Dutton (1993), Macklem (1991), Hodrick (1989), Hodrick and Srivastava (1986)]. One disadvantage of these studies is that they do not provide a tractable theoretical solution for the Fama (1984) puzzle. As a result, it is not clear what the implications of the parameter restrictions of the Fama conditions are for the equilibrium quantities in these models. These models in their general specification, i.e. a standard utility framework, basically rely on the covariance of money and production to account for the currency puzzle. As argued by Engel (1996, 1992), this covariance is not large enough and, therefore, these models cannot provide a plausible explanation for the forward puzzle. As a result they have to allow for an unrealistic large value for the parameter of relative risk aversion to generate a large variation of the forward risk premium.

Based on the results of non-standard utility specifications in the framework of the equity premium puzzle [see Abel (1988, 1990) and Constantinides (1990)], some studies have attempt to use the same preference structure to account for the forward foreign exchange anomaly [e.g. Bekaert (1996)]. The time-nonseparable preference structure, such as habit persistence and/or durability of consumption, and market imperfection, such as the transaction cost function, increases the model's ability to generate more variation in the foreign exchange risk premiums. The price that must be paid in this case is that parsimonious solution for the equilibrium conditions that account for the currency puzzle cannot be obtained. In this case it is difficult to establish the implications of the Fama condition for these models. Furthermore, a large variation of the risk premium is not enough to account for the puzzle, since it is only one of the Fama conditions. The empirical results provided by these studies show that these models cannot account for the Fama conditions.

Recently, some studies adopt a multi-currency affine term structure of interest rate framework to explain the forward puzzle, for instance, Nielsen and Saá-Raquejo (1993), Saá-Raquejo (1994), Ahn (1995), Bansal (1997), Bakshi and Chen (1997)¹, and Backus et al. (2001). The advantage of affine term structure models compared with existing general equilibrium models is that they allow for the nominal interest rates and changes in the log currency price to be linear in the sources of uncertainty. As a result, these models have the flexibility to obtain closed form solution for the covariance of the forward risk premium with the expected depreciation. Most of these studies are based on the pricing kernel approach, with the exception of Bakshi and Chen (1997). Based on the tractable expression obtained in these studies for the Fama covariance, we can observe that the puzzle imposes conditions on affine term structure models that results in an unrealistically large price of risk and/or that they must allow for a positive probability for negative nominal interest rates. The disadvantage of these pricing kernel models is that they do not specify a general equilibrium that supports the ad hoc pricing kernel that is capable of accounting for the puzzle.

In this context, Bakshi and Chen (1997) use a Lucas-type perfect-pooling general equilibrium framework to develop a cross-country affine term-structure of interest rates. They focus, however, on pricing of foreign exchange options and they do not provide an explicit explanation of the currency puzzle in their model. Despite this limitation, their model is capable of obtaining closed-form solution for the expected rate of depreciation of the currency and the forward risk premium. As result we can observe that their model can provide a tractable solution for the currency puzzle, which is completely supported by the general equilibrium conditions of their model. However, due to the separable log-utility preferences, real factors do not affect the nominal quantities in their model and that the expected rate of depreciation and the nominal interest rates dynamics depend only on monetary variables. As a consequence, their model is unable to account for the

¹As a matter of fact Bakshi and Chen (1997) do not really study the currency puzzle, but as argued by themselves, their framework allow them to explain the puzzle.

currency puzzle under plausible parameter values, i.e. parameter values that for instance exclude the probability of negative nominal interest rates.

The objective of this study is, therefore, to develop a two-country general equilibrium affine term-structure model of interest rates that is capable of accounting for the currency puzzle in a tractable manner and with plausible parameter values. To achieve this objective we apply techniques developed in the finance literature, which build on Merton's (1973) intertemporal asset-pricing model, and use a concept of general equilibrium developed in Cox, Ingersoll, and Ross, henceforth CIR, (1985a,b). Finally, we also use techniques of monetary theory, such as portfolio and transaction demand for money and monetary endogeneity, to allow for money to play an integrated role in the economy.

The main contribution of our theoretical model with respect to existing general equilibrium models and affine term structure models of the forward premium puzzle is that we provide a tractable general equilibrium explanation of the puzzle. This explanation is based on financial-economic considerations, with plausible parameter values (i.e. we exclude the possibility of negative interest rates) and without allowing for market imperfections. We show that the existing puzzle, i.e. the negative covariance between the forward risk premium and the expected rate of depreciation, is a direct result of asymmetric response of money and production growth to real shocks across countries, which leads to asymmetric impact on equity and bond returns across countries.

In this context our model extends existing literature on multi-currency affine term structure models and economic models of the currency puzzle in several important ways. First, our term structure model provides a financial-economic explanation of this puzzle. Most affine term structure studies of the forward exchange rate anomaly apply a pricing kernel approach that accounts for the currency puzzle under rather technical and ad-hoc conditions [e.g. Nielsen and Saá-Raquejo (1993), Saá-Raquejo (1994), Ahn (1995), and Backus et al. (2001)]. As argued by Backus et al. (2001), the currency anomaly imposes conditions on affine models, such that they either allow for negative nominal interest rates or the effects of one or more factors on pricing kernels must differ across

currencies. It is not clear from these studies whether these conditions are supported by a general equilibrium, where the interest rates and currency prices and their dynamics are determined endogenously in equilibrium. The advantage of our framework is that it provides a realistic explanation of the currency puzzle, where the expressions for the expected exchange rate and forward foreign exchange 'risk' premium are fully supported by the equilibrium conditions in the two-country world economy. Therefore, the conditions imposed by the anomaly can be confronted with the underlying financial-economic aspects of the two-country affine term structure model.

Second, another distinguishing feature is that money plays an integral role in this two-country world economy. In existing general equilibrium monetary models of the forward premium puzzle, separability in the utility function results inevitable in a segmented and dichotomous economy, in which the real and monetary economy are completely detached from each other [e.g. Bekaert (1996) and Bakshi and Chen (1997)]. In our analysis, separability in the utility does not preclude an integrated economy. Money is incorporated in this economy by allowing the representative agents to hold money both for transaction purposes as for portfolio considerations and by allowing endogeneity in the money supply processes. This combination allows for an integration of the financial, real, and monetary markets in the economy. As a result, despite the separable log-utility preferences, monetary and real quantities play a crucial role in explaining the currency puzzle. In addition, the endogenously determined inflation process is correlated with the exchange rate process and as such plays an important role together with the exchange rate in restoring equilibrium. This feature of our model is an extension of the Lucas-type perfect-pooling equilibrium term structure model developed by Bakshi and Chen (1997), which is capable of explaining the puzzle based only on monetary quantities and money only serves for cash-transaction purposes. Furthermore, inflation do not play a role in their model.

Third, existing multi-currency term structure models explain the puzzle through the factor-risk differentials [Backus et al. (1993), Nielsen and Saá-Raquejo (1993), Saá-

Raquejo (1994), Ahn (1995), and Backus et al. (2001)]. To account for the anomaly these models must either allow for a positive probability of negative nominal interest rates or adopt a framework with only one or more common state variables. The latter leads to correlation structure for the cross-country term structures that is from a financial-economic standpoint implausible. In either case these conditions put a large burden on the factor-risk in order to equalize the market price of risk (i.e. excess return per unit of risk) across countries. As a result these models must allow for unrealistic volatility values. As argued by Backus et al. (2001), the implications for risk premiums are strongly counterfactual. Since our model is based on a risk premium approach we provide an explanation of the currency puzzle that is not only based on factor-risk differentials on the equity and bond markets, but also on expected rate of return differentials on these markets. This allow us to explain the puzzle with realistic factor-risk values, whereby we exclude the possibility of negative interest rates or unrealistic correlation structure. In addition the market price of risk required to account for the anomaly provides realistic risk compensation in equilibrium.

The outline of this study is the following. In Chapter 2 we provide a theoretical review of optimization models of the forward risk premium. Chapter 3 contains a description of the two-country monetary-production economy in continuous time. We examine in Chapter 4 the equilibrium conditions for the price of money, exchange rate, and the nominal and real interest rate in a simplified two-country world economy. This economy is characterized by an i.i.d. production process and money supply process. Chapter 5 presents a more complex economy that is characterized by stochastic nominal interest rates. We derive the equilibrium bond pricing formula and present closed-form expressions for the expected exchange rates and the forward 'risk' premium that accounts for the currency puzzle. In Chapter 6 we presents the results of our empirical analysis. Chapter 7 concludes.