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Bond risk premia, macroeconomic fundamentals and the exchange rate ☆

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ABSTRACT

We propose a two-country no-arbitrage term-structure model to analyze the joint dynamics of bond yields, macroeconomic variables and the exchange rate. The model allows to understand how exogenous shocks to the exchange rate affect the yield curves, how bond yields co-move in different countries and how the exchange rate is influenced by interest rates, macroeconomic variables and time-varying bond risk premia.

Estimating the model with US and German data, we find that time-varying bond risk premia account for a significant portion of the variability of the exchange rate: apparently, a currency tends to appreciate when investors expect large capital gains on long-term bonds denominated in that currency. A number of other novel empirical findings emerge.

1. Introduction

After the seminal contribution of Ang and Piazzesi (2003), several recent studies have developed no-arbitrage term structure models to determine how macroeconomic variables affect bond prices and bond risk premia. While the vast majority of these studies have analyzed single countries in isolation, to date very little is known about bond pricing in an international setting and how it relates to macroeconomic fundamentals and exchange rate dynamics.

We propose a two-country no-arbitrage term structure model that can be used to tackle a number of largely unaddressed questions about internationally integrated bond markets. For instance, the model allows to assess how exogenous shocks to the exchange rate affect the yield curves, how bond yields co-move in different countries and how time-varying bond risk premia contribute to exchange rate fluctuations, while also controlling for other macroeconomic variables like inflation and output.

On the one hand, a number of studies have investigated the joint dynamics of exchange rates, interest rates and other macroeconomic variables (e.g.: Eichenbaum & Evans, 1995; Grilli & Roubini, 1995, 1996), without taking bond pricing factors and bond risk premia into account. On the other hand, several two-country no-arbitrage term structure models have been proposed to analyse the relation between exchange rates, yield curves and bond risk premia (e.g.: Backus, Foresi, & Telmer, 2001; Bansal, 1997), but in these models all the dynamics are driven by latent variables and macroeconomic variables do not play any role. Our paper aims to bridge these two strands of the literature, providing a unified framework to determine how bond-pricing factors in two different countries are related to each other and to macroeconomic variables and the exchange rate.

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Estimating the model with US and German data, some findings emerge that are robust to various specifications of the model and choices of the sample period. At short horizons changes in short-term interest rates account for approximately 30% of exchange rate fluctuations, while inflation and economic growth have almost no explanatory power. At medium-to-long horizons, the explanatory power of inflation and growth becomes higher (up to 25%), while that of interest rates remains about the same. We find that, even after accounting for macroeconomic variables and for the impact they have on expectations, uncovered interest rate parity does not hold; furthermore, a significant portion of the variability of the exchange rate is accounted for by time-varying bond risk premia (more than 20% at longer horizons). Conducting an impulse response analysis, we find that increases in bond risk premia trigger a reaction of the exchange rate that is similar to the well-known *delayed overshooting* phenomenon caused by increases in policy rates. Delayed overshooting, i.e. persistent currency appreciation after an increase in policy rates, is uncovered by many empirical studies (e.g.: Eichenbaum & Evans, 1995; Grilli & Roubini, 1995, 1996) and it is considered one of the puzzles of international finance, as it contradicts the theoretical prediction (e.g. Dornbusch, 1976) of an immediate overshooting followed by a subsequent currency depreciation. We find that also increases in bond risk premia cause *delayed overshooting*: a currency tends to persistently appreciate when expected excess returns on long-term bonds denominated in that currency rise. As emphasized by Scholl and Uhlig (2006), the *delayed overshooting* puzzle is intimately related to the *forward premium* puzzle, i.e. the empirical regularity that exchange rate fluctuations tend to reinforce rather than attenuate positive return differentials between currencies. According to our estimates, such tendency of high yielding currencies to appreciate, found by many researchers with reference to the short-term (and risk-free) segment of the bond market (e.g.: Engel, 1996; Fama, 1984), seems to extend also to the long-term segment: when investors expect larger capital gains on long-term bonds denominated in a certain currency (in excess of the risk-free rate), that currency tends to appreciate. We also find that, after controlling for macroeconomic variables, there are limited spillovers between bond risk premia in the two countries, with the result that there is low correlation between bond risk premia in Germany and in the US. Finally, we find that exogenous shocks to the exchange rate (those that are not explained by other macroeconomic variables explicitly included in the model) have a negligible impact on the yield curves.

Also Dong (2006) and Chabi-Yo and Yang (2007) have recently studied the behavior of internationally integrated bond markets in a no-arbitrage framework with macroeconomic variables. We adopt a modelling strategy which is substantially different from theirs. While they take the domestic and the foreign pricing kernel as exogenously given and derive implied currency depreciation endogenously, our model features an exogenous process for currency depreciation and an endogenous foreign pricing kernel. This approach has several advantages. First, it overcomes the well-known mismatch between model-implied and actual exchange rate found when the depreciation process is derived endogenously. This mismatch is commonly attributed to the fact that a predominant portion of exchange rate movements is independent of interest rate movements (e.g.: Constantinides, 1992; Leippold & Wu, 2007; Lothian & Wu, 2002). The inability to produce a realistic endogenous currency depreciation process is also found by Dong (2006) and Chabi-Yo and Yang (2007), notwithstanding the fact that they explicitly consider other macroeconomic factors beyond interest rates: both papers find that large variations in the exchange rate remain unexplained by a model with endogenous currency depreciation, even after accounting for inflation and output dynamics in the domestic and foreign country. Instead, in our model there is a perfect match between the data and the model-implied exchange rate. Furthermore, we allow the exchange rate to be affected by exogenous shocks, which can capture important factors not explicitly included in the model, such as current account imbalances (e.g.: Hooper & Morton, 1978). Despite having an endogenous foreign pricing kernel, our model is still able to fit very well both the domestic and the foreign yield curve. Hence, a more realistic modelling of currency depreciation does not come at the expense of pricing accuracy. Another important advantage of our modelling strategy is that it allows to measure the feedback effect of currency depreciation on the yield curves: for example, one can estimate impulse-response functions to assess how exogenous currency shocks are transmitted to domestic and foreign yield curves and to risk premia. Finally, while in a model with endogenous currency depreciation one has to resort to approximate numerical procedures to estimate impulse responses and variance decompositions for the exchange rate (see also Diez de los Rios, 2009), our model allows for exact analytical computation of these quantities.

Although other studies previously recognized that bond returns do not necessarily span returns in the foreign exchange market and explicitly introduced exchange rate factors orthogonal to bond market factors (e.g.: Brandt & Santa-Clara, 2002; Graveline, 2006; Leippold & Wu, 2007), our study is the first to extend Ang and Piazzesi's (2003) methodology to a two-country setting with exogenous currency depreciation. Ang and Piazzesi (2003) have inaugurated a prolific literature which uses modern no-arbitrage pricing models to analyze the relation between the yield curve and macroeconomic fundamentals: some examples are Ang, Dong, and Piazzesi (2007), Ang, Piazzesi, and Wei (2006), Gallmeyer, Hollifield, and Zin (2005), Hördal, Tristani, and Vestin (2006) and Rudebusch and Wu (2004); for a survey, we refer the reader to Diebold, Piazzesi, and Rudebusch (2005). Earlier studies investigating the relation between the yield curve and macroeconomic variables, like Fama (1990), Mishkin (1990), Estrella and Mishkin (1995) and Evans and Marshall (2007) did not consider no-arbitrage relations among yields and did not model bond pricing. As a consequence, they were able to make predictions only about the yields explicitly analyzed (typically no more than three), they did not rule out theoretical inconsistencies due to the presence of arbitrage opportunities along the yield curve and, more importantly, they made no predictions about risk premia and their dynamics. For these reasons, the more recent studies we mentioned above have proposed to enrich macro-finance models with rigorous asset pricing relations, imposing no-arbitrage constraints on bond prices. Our methodological contributions to this literature are in the following directions: we propose a general setting for two-country no-arbitrage macro-finance models, refining the canonical form proposed by Pericoli and Taboga (2008) for the single-country case; in particular, we add further identification restrictions to their canonical form, addressing the lack of identification pointed out by Hamilton and Wu (2010); we show how to introduce an exogenous process for currency depreciation in a setting with both observable and unobservable variables and we derive a new set of pricing equations which extend the Riccati equations usually found in discrete-time single-country models of the term-structure; we develop an OLS-based estimation method that affords considerable simplifications over