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Determinants of the Foreign Exchange Risk Premium in Gulf Cooperation Council Countries

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**Determinants of the Foreign Exchange Risk Premium
in the Gulf Cooperation Council Countries**

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Abstract

This paper analyzes macroeconomic determinants of the foreign exchange risk premium in two
Gulf Cooperation Council (GCC) countries that peg their currencies to the U.S. dollar: Saudi
Arabia and the United Arab Emirates. The analysis is based on the stochastic discount factor
methodology, which imposes a no arbitrage condition on the relationship between the foreign
exchange risk premium and its macroeconomic determinants. Estimation results suggest that
U.S. inflation and consumption growth are important factors driving the risk premium, which
is in line with the standard C-CAPM model. In addition, growth in international oil prices
influences the risk premium, reflecting the important role played by the hydrocarbon sector in
GCC economies. The methodology employed in this paper can be used for forecasting the risk
premium on a monthly basis, which has important practical implications for policymakers
interested in the timely monitoring of risks in the GCC.

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I. INTRODUCTION

Currency stability has been an important part of the macroeconomic policies of most emerging economies worldwide. Since the early work of Hansen and Hodrick (1980) and Fama (1984), various measures of the foreign exchange risk premium, such as the interest parity condition and forward differential, have been used in the literature to quantify downside and upside pressures on a currency. Engel (1996) and Lustig et al. (2008) provide a comprehensive survey of this growing literature, and show that risk premia in currency markets are large and time-varying. However, most of this literature studies countries with a flexible exchange rate regime. Analysis of foreign exchange risk in countries pegging their currencies has been given less attention, since it is widely acknowledged that uncertainty about the future exchange rate is much lower when the currency is pegged to an external anchor. The global financial crisis has changed this perception, as indicated by the increased volatility in prices of forward contracts traded on pegged emerging market currencies.

The aim of this paper is to analyze the relationship between macroeconomic fundamentals and foreign exchange risk in Saudi Arabia and the United Arab Emirates. Both countries have pegged their currencies to the U.S. dollar for more than a decade. During this period, forward contracts traded on currencies of these countries have fluctuated around the peg. Triggered by the global financial crisis, U.S. monetary policy and developments in the oil market, these fluctuations have become much more volatile during the last two years. While the importance of macroeconomic developments in the U.S. for foreign exchange risks in these countries has been widely acknowledged, the quantitative assessment of these factors has not been performed in a rigorous manner in previous work. This study attempts to carry out such an analysis based on theoretical foundations and frontier empirical techniques.

The remainder of this paper is organized as follows. Section 2 reviews the existing approaches for studying foreign exchange risk and introduces the stochastic discount factor (SDF) methodology. Section 3 provides the econometric specification of the model and data description. Section 4 discusses empirical results and shows diagnostics and model specification tests. The final section concludes.

II. THEORETICAL BACKGROUND

A. Review of Methodological Approaches for Modeling Foreign Exchange Risk

The conceptual approaches used in the literature for analyzing foreign exchange risks can be categorized in several groups.[2] The *first* strand of empirical literature implements econometric analysis based on strong theoretical restrictions coming from a two-country asset pricing model.[3] A common problem encountered in these studies is incredible estimates of deep structural parameters of the theoretical models (e.g., the coefficient of relative risk aversion) and the rejection of over-identifying restrictions suggested by the underlying theory. Overall, pricing

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[2] See Cuthbertson and Nitzsche (2005) for a textbook exposition of these approaches.
[3] Examples are Frankel and Engel (1984), Domowitz and Hakkio (1985), Mark (1988), Hodrick (1989), Kaminski and Peruga (1990), Backus et al. (1993), Bekaert (1996), and Bekaert et al. (1997). Engel (1996) provides an exhaustive survey.

theory to date has been notably unsuccessful in producing a risk premium with the prerequisite properties outlined above (see Backus et al., 2001).

The *second* stream of the literature pursued an alternative strategy by adopting a pure time-series approach. Unlike the theoretical models mentioned above, this approach imposes minimal structure on the data. A popular empirical methodology for studying time-series properties of the foreign exchange risk premium is the ARCH framework of Engle (1982) and especially its "in-mean" extension due to Engle et al. (1987). While these studies were more successful in capturing empirical regularities observed in the excess return series, the lack of a theoretical framework makes it difficult to interpret the predictable components of the excess return as a measure of the risk premium (Engel, 1996).

Given the disadvantages associated with both approaches mentioned above, the recent literature is moving towards the *third* approach, which is based on a semi-structural methodology. The cornerstone in these studies is the notion of the stochastic discount factor (SDF), which allows placing some structure on the data sufficient for identifying a foreign exchange risk premium, but otherwise leaves the model largely unconstrained. In our investigation we follow the SDF approach with observable and theoretically-motivated factors to explain the variability of the foreign exchange risk in selected Gulf Cooperation Council (GCC) countries.[4]

B. The Stochastic Discount Factor Approach

Basic concepts

For the rest of the paper, we will be using the following notation: R_t and R_t^* are nominal (gross) returns on risk-free assets (T-bills) between time t and $t+1$ in the domestic and foreign country, respectively; S_t is the domestic price of the foreign currency at time t (an increase in S_t implies depreciation of domestic currency); F_t is a forward contract specifying at date t the exchange of one unit of foreign currency for domestic currency in period $t+1$. The covered interest parity suggests that domestic return should be equal to foreign return adjusted for forward differential:

$$R_t^* = R_t \frac{F_t}{S_t} . \tag{1}$$

No-arbitrage relationship

The stochastic discount factor (SDF) model is based on a generalized asset pricing equation, which states that in the absence of arbitrage opportunities there exists a positive stochastic

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discount factor M_{t+1}, such that for any asset denominated in domestic currency the following relationship holds:[5]

$$1 = E_t[M_{t+1}R_{t+1}], \tag{2}$$

where E_t is an expectations operator with respect to the investor's information set at time t. In the consumption-based capital asset pricing (C-CAPM) model, equation (2) is an outcome of the consumer's utility maximization problem and the stochastic discount factor is given the interpretation of the intertemporal marginal rate of substitution (see Smith and Wickens, 2002).

To extend the fundamental asset pricing relation to the international context, consider returns of a domestic investor on foreign investment holdings:

$$1 = E_t[M_{t+1}R_{t+1}^*]. \tag{3}$$

Substituting the covered parity condition (1) into relationship (3) yields:

$$1 = E_t[M_{t+1}R_{t+1}\frac{F_t}{S_t}]. \tag{4}$$

Under a fixed exchange rate regime, the price of the currency does not change over time ($S_t = S_{t+1}$). If investors trust that the currency will not move, then they set forward rate F_t to the current spot exchange rate S_t ($F_t = S_t$), which implies that equation (4) collapses to equation (2). However, if investors bet that the currency will depreciate (appreciate), they then trade forward contracts above (below) the current exchange rate. This implies the existence of a positive (negative) foreign exchange risk premium $RP_{t+1} = \dfrac{F_t}{S_t}$ in the market, which is time-varying and depends on the SDF M_{t+1}.[6]

Assuming that returns and the discount factor are jointly log-normally distributed, as well as abstracting from credit risk (i.e., r is a risk free rate), equations (2) and (4) can be expressed in logarithmic form as:[7]

$$0 = \log E_t[M_{t+1}] + r_{t+1} = E_t[m_{t+1}] + \frac{1}{2}Var_t[m_{t+1}] + r_{t+1} \tag{5}$$

and

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[5] Suppose P_t is the t period price of a zero-coupon bond, then the relationship between intertemporal prices of bonds is $P_t = E_t[M_{t+1}P_{t+1}]$, which after the division of both sides by P_t, returns equation (2).

[6] A famous example of the foreign exchange forward premium under a peg is the "peso problem" (see, e.g., Rogoff, 1977, Krasker, 1980). According to this literature, a positive risk premium can be generated if investors place a small probability on exchange rate devaluation, which is a very unlikely event *ex-ante*.

[7] The derivation below exploits the moment generating function of a normally distributed variable, according to which if a variable X is normally distributed with mean μ_x and variance σ_x^2, then $E[e^X] = e^{\mu_x + \frac{1}{2}\sigma_x^2}$.

$$0 = \log E_t[M_{t+1} \frac{F_t}{S_t}] + r_{t+1} =$$

$$= E_t[m_{t+1} + rp_{t+1}] + \frac{1}{2} Var_t[m_{t+1}] + \frac{1}{2} Var_t[rp_{t+1}] + Cov_t[m_{t+1}; rp_{t+1}] + r_{t+1}$$

(6)

where lowercase letters denote the logarithmic values of the appropriate variables.

Subtracting equation (5) from (6) yields:

$$E_t[rp_{t+1}] + \frac{1}{2} Var_t[rp_{t+1}] = -Cov_t[m_{t+1}; rp_{t+1}].$$

(7)

The above equation has several implications. First, it suggests that the foreign exchange risk premium is a function of its time-varying covariance with SDF. The previous literature mainly focused on the relationship between the variance of the return and its mean and disregarded the covariance term, which is instrumental for the no-arbitrage condition to hold in equilibrium (Smith, Soresen and Wickens, 2003).

Second, the equation suggests that uncertainty about the future exchange rate influences the expected excess returns, and serves as a source for the risk premium. The economic interpretation of the required risk premium is straightforward: the larger the predicted covariance between the future excess returns and the SDF, the lower the risk premium, since the larger expected future excess returns are discounted more heavily.

Modeling the SDF

The previous subsection suggests that the distribution of the SDF is the key element necessary for modeling the risk premium. Therefore, the appropriate specification of the SDF is important for identifying the risk premium.

The literature distinguishes two popular approaches for modeling the SDF. The first approach assumes that the factors driving the SDF are unobservable. The unobservable factors in this literature are extracted using Kalman filtering techniques and are given an ex-post economic interpretation.[8] The advantage of unobservable factor models is that they provide good-fitting results. The disadvantage is an ad-hoc economic interpretation of the unobservable factors as macroeconomic sources of the risk premium (Smith and Wickens, 2002).

The second approach in the literature relies on general equilibrium models of asset pricing and implicitly allows for observable macroeconomic factors to affect the SDF (Smith and Wickens, 2002). In this literature, the SDF is interpreted as an intertemporal marginal rate of substitution from the consumer's utility maximization problem: $M_{t+1} = \beta \frac{U'_{t+1}()}{U'_t()}$. A popular general equilibrium

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[8] Panigirtzouglou (2001) and Benati (2006) provide applications of unobservable factor models in the context of the foreign exchange risk premium.

asset pricing model is a C-CAPM model based on a power utility: $U(C_t) = \frac{C_t^{1-\sigma}}{1-\sigma}$, where C stands for consumption and σ is the relative risk aversion parameter. The logarithm of the SDF under C-CAPM with a power utility function takes the following form:

$$m_{t+1} = \theta - \sigma \Delta c_{t+1},$$ (8)

where $\theta = \log\beta$ is a constant. The interpretation of (8) is that under C-CAPM the risk premium in the foreign exchange market is solely due to consumption risk. Hence, C-CAPM is a single-factor model.

As was mentioned in Balfoussia and Wickens (2007), the C-CAPM is usually expressed in real terms, which implies the existence of a real risk-free rate. However, in practice only a nominal risk-free rate exists, which implies that for empirical estimation purposes C-CAPM has to be rewritten in nominal terms. For this reason, the solution of the intertemporal optimization problem can be rewritten in nominal terms as: $1 = E_t[(\beta \frac{U'_{t+1}(.)}{U'_t(.)})(\frac{P_t}{P_{t+1}})R_{t+1}]$, where P_t is the price level at time t. The nominal discount factor implied by C-CAPM is hence: $M_{t+1} = (\beta \frac{U'_{t+1}(.)}{U'_t(.)})(\frac{P_t}{P_{t+1}})$, which gives rise to a logarithmic expression for the SDF:

$$m_{t+1} = \theta - \sigma \Delta c_{t+1} - \pi_{t+1},$$ (9)

where $\pi t+1$ is the inflation rate.[9] After substituting the SDF specification (9) into the obtained risk premium expression (7) one obtains:

$$E_t[rp_{t+1}] + \frac{1}{2}Var_t[rp_{t+1}] = \sigma Cov_t[\Delta c_{t+1}; rp_{t+1}] + Cov_t[\pi_{t+1}; rp_{t+1}].$$ (10)

Hence, the nominal version of the C-CAPM specification allows one to distinguish between nominal and real macroeconomic determinants of the risk premium (see Hollifield and Yaron, 2000).

The C-CAPM model imposes theoretical restrictions on the risk premium parameters in specification (10). The impact of the conditional covariance with the real factor is assumed to be equal to the relative risk aversion parameter σ, while the nominal factor covariance is assumed to have a complete pass-through. In a more general setup, one can generalize the linear relationship (10), by allowing for multiple factors $z_{i,t+1}$:

$$m_{t+1} = \alpha + \sum_{i=1}^{K} \beta_i z_{i,t+1},$$ (11)

where the impact coefficients β_i are no longer restricted (Smith and Wickens, 2002). This generalization can be applied when the utility function is time non-separable.[10] In fact, Balfoussia

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[9] In the nominal C-CAPM case, m_{t+1} can be interpreted as the inflation-adjusted growth rate of marginal utility.
[10] Smith, Soresen and Wickens (2003) show that specification (1) can be derived for the Epstein and Zin (1989) utility function, in which the β's reflect the deep structural parameters of the model.

and Wickens (2007) show that for the case of the term premium in the U.S. yield curve, C-CAPM restrictions are rejected in favor of the unrestricted specification (11).

Given the generalized SDF specification (11), the no-arbitrage expression for the excess return becomes:

$$E_t[rp_{t+1}] = \beta_1 Var_t[rp_{t+1}] + \sum_{i=2}^{K+1} \beta_i Cov_t[z_{i,t+1}; rp_{t+1}], \qquad (12)$$

where β_i's, $i = 1, 2, \ldots K+1$, are the coefficients of interest to be estimated.[11]

III. ECONOMETRIC METHODOLOGY AND DATA

A. Multivariate GARCH-in-Mean Model

Our aim is to model the distribution of the excess return in the foreign exchange market jointly with the macroeconomic factors, in such a way that the conditional mean of the excess return in period $t+1$ given the information available at time t satisfies the no-arbitrage condition given by equation (12). Since the conditional mean of the excess return depends on time-varying second moments of the joint distribution, we require an econometric specification that allows for a time-varying variance-covariance matrix. A convenient choice in this setting is the multivariate GARCH-in-mean model (see Smith, Soresen and Wickens, 2003).

The general specification of the multivariate GARCH model with mean effects can be written as:

$$\begin{aligned}
\mathbf{y_{t+1}} &= \mu + \mathbf{\Phi vech\{H_t\}} + \mathbf{\varepsilon_{t+1}} \\
\mathbf{\varepsilon_{t+1}} \,|\, \mathbf{I_t} &\sim \mathrm{N}[\mathbf{0, H_{t+1}}] \\
\mathbf{H_{t+1}} &= \mathbf{C'C + A'H_t A + B'\varepsilon_t \varepsilon_t' B}
\end{aligned} \qquad (13)$$

where $\mathbf{y_{t+1}} = \{ER_{t+1}, z_{1,t+1}, \ldots, z_{K,t+1}\}'$ is a vector of excess returns and K (observable) macroeconomic factors used in the estimations, $\mathbf{H_{t+1}}$ is a conditional variance-covariance matrix, $\mathbf{I_t}$ is the information space at time t, and **vech{.}** is a mathematical operator which converts the lower triangular component of a matrix into a vector.

The first equation of the model is restricted to satisfy the no-arbitrage condition (12), which restricts the first row of matrix $\mathbf{\Phi}$ to a vector of β_i's. Since there is no theoretical reason for the conditional means of macroeconomic variables $z_{i,t}$ to be affected by the conditional second moments, the other rows in matrix $\mathbf{\Phi}$ are restricted to zero.

Despite its convenience, the multivariate GARCH-in-mean model is not easy to estimate. First, it is heavily parameterized, which creates computational difficulties and convergence problems.

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[11] Notice that specification (12) also drops the restriction on the coefficient of the variance being $\frac{1}{2}$. Also, the coefficient β in front of the covariance with the consumption factor is no longer interpreted as a coefficient of relative risk aversion.

Second, returns in the financial market are excessively volatile, which affects the conditional variance process. In trying to fit the extreme values in financial returns, the variance process may become unstable and therefore needs to be modeled with special care.

Our specification of the variance-covariance process in equation (13) is the so-called BEKK formulation proposed by Engle and Kroner (1995).[12] The BEKK specification guarantees the positive definiteness of the variance-covariance matrix, and still remains quite general in the sense that it does not impose too many restrictions. In particular, the BEKK specification is more general than the constant correlation (CC) model of Bollerslev (1990), which was applied by Wickens and Smith (2001) in modeling foreign exchange risk in the U.S. and the U.K.[13]

B. Data

In our empirical investigation we use data from two GCC countries that peg their currencies to the U.S. dollar: Saudi Arabia and the United Arab Emirates. The reason for selecting these two countries is purely practical: foreign currency forward contracts are not available for sufficiently long periods of time in other GCC countries. We use monthly data covering the period June 1995-February 2010, and the data set contains 177 observations for each series described below. The sources for the data are IMF's International Financial Statistics, U.S. Bureau of Economic Analysis, and Datastream databases. First, we use data on forward and spot exchange rates vis-à-vis the U.S. dollar for each country to estimate the logarithm of the risk premium rp_t for 1-, 2-, 3- and 6-month maturities. The dynamics of risk premiums for each country shown in Figures 1 and 2 displays several interesting features. The risk premium appears to be time-varying in both positive and negative directions, suggesting that there exist driving forces making investors believe that the authorities will either devalue or revalue the currency. Moreover, the fluctuations in the risk premium are comparable across maturities, suggesting that expectations are formed in the same direction regardless of the forecast horizon. This in turn indicates that the market is actively traded, and there is little room to make profits by arbitraging across forward contracts with different maturities.

The volatility of the risk premium in both countries has become particularly large during the 2007-09 period. The risk premium declined by more than 30 basis points and turned negative in 2008 when oil markets were booming and investors were expecting that oil exporting countries would revalue their currencies. At the end of 2008, the risk premium had jumped by more than 60 basis points and turned positive. This increase coincided with cooling oil prices and the unfolding of the global financial crisis, which has changed the sentiment of the investors who started betting on likely devaluation of oil-exporting countries' currencies. Towards the end of our sample,

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[12]Ding and Engle (2001) contains a review of various specifications for the conditional variance-covariance matrix in the multivariate GARCH setup.

[13]The CC model assumes that the conditional correlation coefficient between variables in the system is constant, which implies that the conditional covariance varies over time only as a result of the variation in the conditional variance. Although this assumption is reasonable to impose for the case of the relationship between exchange rates due to the well-documented martingale properties (Bollerslev, 1990), it is too restrictive for the case of the relationship between exchange rates and macroeconomic variables.

market expectations have aligned with the pegged exchange rate and the risk premium has reduced to near zero levels.

Since both countries peg their currencies to the U.S. dollar, importing U.S. monetary policy and aligning their business cycles with that of the U.S., we model the dynamics of the risk premium as a function of U.S. macroeconomic variables as determinants of the SDF. The first two variables are U.S. personal consumption expenditures and the consumer price index. Both variables are in line with the standard C-CAPM formulation. In addition, to account for the oil-export-dependence of these countries, we augment the standard C-CAPM model by introducing oil prices into the SDF specification.

Descriptive statistics of the data are presented in Table 1. The average excess return is always positive in both countries. This empirical observation suggests that, on average, markets expect that the pegged GCC currencies will devalue. This observation is in line with the prediction in the "peso problem" literature (Rogoff, 1977; Krasker, 1980), which argues that a positive risk premium can be generated if investors place a small probability on exchange rate devaluation, which is a very unlikely event *ex-ante*. Like most financial data, the forward differentials exhibit excess skewness and kurtosis. The U.S. inflation rate and consumption growth rates are on average positive, with consumption growth rates on average higher. Oil prices have also grown during the sample period, with average growth rates being higher than both the U.S. inflation and consumption growth rates. In addition, oil prices exhibit much larger variation than inflation and consumption growth rates.

The dynamics of U.S. macroeconomic variables and oil prices presented in Figures 3-5 suggests that they exhibit quite volatile behavior. In particular, oil prices have been growing rapidly during 2008 and have reduced sharply thereafter. Consumption and inflation growth rates were also volatile during the 2008-09 period. Notably, annual growth rates for all three factors (inflation, consumption, and oil) sharply declined in 2009, and then moved up. This simultaneous movement has coincided with large fluctuations in the forward differential in the GCC. In the next section, we explore the linkages between fluctuations in these factors and the GCC risk premium in greater detail.

IV. ESTIMATION RESULTS

A. Empirical Findings

Estimation results of the multivariate GARCH-in-Mean model for Saudi Arabia and the United Arab Emirates are presented in Tables 2 and 3, respectively. The tables consist of two parts: the first block displays parameter estimates from the main equation of the model, while the second block displays parameter estimates of conditional second moments (time-varying variances and covariances). The fit of the model, as measured by the root mean square error, is reported at the bottom of the tables. It suggests that the model tends to fit higher-maturity risk premia relatively better (smaller root mean square error). This finding suggests that the explanatory power of U.S. macroeconomic variables and oil prices for foreign exchange risk in the GCC is higher in the long run (see also Figures 6-7).

B. Determinants of FX Risk Premium

The intercepts in the mean equation associated with excess returns (μ_i) are reported in the first row of the upper panel in Tables 2-3. They are all positive and significant (except for the two-month risk premium equation for the United Arab Emirates), suggesting that after excluding the impact of macroeconomic factors, investors expect that currencies in both countries should on average depreciate (the "peso problem"). This finding implies that market perception contrasts with the view advanced by some experts that the exchange rate in GCC is undervalued (see, e.g., Khan, 2009).

In our analysis, we are primarily interested in the ''in-mean" effects that are captured by the β_i coefficients reported in the fifth to eighth rows of the tables. The coefficients indicate the importance of a particular macroeconomic factor in terms of its contribution in explaining the behavior of the risk premium. We find that both nominal and real factors proxied by the U.S. CPI inflation and consumption growth, respectively, have a significant impact on the risk premium. This finding is in line with the predictions of the C-CAPM model, and implies that by pegging their currencies to the U.S. dollar, Saudi Arabia and the United Arab Emirates import U.S. monetary policy. Fundamental sources of risk in these countries are thus closely connected to macroeconomic developments in the U.S. In other words, foreign exchange risks in these countries are largely dictated by macroeconomic developments in the country to which their currencies are pegged.

Another important factor that investors account for when pricing foreign exchange risks in the GCC is oil price changes. The magnitude of the oil coefficient is lower relative to the ones for inflation and consumption growth, but this can be due to the relatively higher volatility of oil prices (and hence also their conditional covariance with the risk premium) compared to the volatility of inflation and consumption growth.

Figures 6-7 display actual and estimated values of the risk premium for Saudi Arabia and the United Arab Emirates, respectively. The figures suggest that the GARCH-in-Mean model employed in this study fits the actual risk premium relatively well. In particular, it successfully captures the volatility of the risk premium in 2007-09. The fit is slightly better for longer maturities, suggesting that the explanatory power of macroeconomic determinants of the risk premium is relatively higher in the long run.[14]

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[14] In general, the fit of the multivariate GARCH model compares favorably to the fit of a univariate GARCH(1,1) model. The root mean squared error for a univariate GARCH(1,1) model is 1.10, 0.75, 0.69, and 0.61 for 1, 2, 3, and 6 months maturity forward contracts in Saudi Arabia, and 1.01, 0.89, 0.78, and 0.72 for 1, 2, 3, and 6 months maturity forward contracts in United Arab Emirates, respectively. On average, the root mean square error is about 50 percent higher in the case of Saudi Arabia, and about 25 percent higher in United Arab Emirates, suggesting that, in line with the theoretical prediction, macroeconomic fundamentals substantially augment the explanatory power of the model.

C. Diagnostics and Model Specification Tests

After estimating the multivariate GARCH-in-Mean model, we perform specification tests for the presence of serial correlation and any potentially remaining ARCH structure in residuals. Following the approach of Kaminski and Peruga (1990), we apply the Breusch-Godfrey LM test for serial correlation to the standardized residuals $\hat{\varepsilon}_{it} / \hat{h}_{it}$ for each of the equations. In addition, we use the ARCH tests for conditional heteroskedasticity by regressing a residual-variance dependent variable $(\hat{\varepsilon}_{it}^2 - \hat{h}_{it}^2) / \hat{h}_{it}^2$ on $1/\hat{h}_{it}^2$ and up to eight lags of the dependent variable. In both procedures, $\hat{\varepsilon}_{it}^2$ is the squared residual and $\hat{h}_{it}^2$ is the estimate of the conditional variance from our specification defined earlier.

Both test statistics have χ^2 distribution with the corresponding degrees of freedom. The p-values from the LM and ARCH tests are displayed in Table 4. Overall, the validity of our specifications is confirmed, since the null hypothesis of no serial correlation cannot be rejected at the 5% confidence level in most cases. Similarly, the hypothesis of no remaining ARCH effects in residuals cannot be rejected for most residuals in at least one of the specifications (four or eight lags).

V. Conclusions

This paper provides the first empirical evidence on the relationship between U.S. macroeconomic variables, international oil prices and foreign exchange risk in GCC countries. The analysis is performed using the stochastic discount factor methodology, which imposes a no-arbitrage relationship on the risk premium and its theoretically-grounded macroeconomic determinants.

The estimation results suggest that macroeconomic developments in the U.S. constitute important sources of foreign exchange risk in the GCC. This result holds for risk premia calculated for four maturities: 1 month, 2 months, 3 months, and 6 months. Both nominal and real factors proxied by U.S. CPI inflation and consumption growth play important roles in explaining the variability in the foreign exchange risk premium, as measured by the forward differential in the foreign exchange market. These findings are in line with the standard C-CAPM model and correspond to the evidence garnered from advanced economies (Hollifield and Yaron, 2001; Lustig and Verdelhan, 2007) and emerging markets with flexible exchange rate regimes (see, e.g., Kocenda and Poghosyan, 2009).

We also find evidence on the importance of international oil prices for pricing foreign exchange risk in the GCC, where the dependence of these economies on oil revenues has been very high historically. The GARCH-in-Mean model used in this paper fits the actual risk premium quite well, including the high volatility episode of 2007-09. This suggests that it can also be employed for timely monitoring of foreign exchange risks in the GCC.

Overall, and in line with theoretical predictions, we find that the inclusion of U.S. macroeconomic determinants and oil prices as explanatory variables substantially improves the fit of the multivariate model relative to the univariate model. After accounting for the impact of these fundamental factors, the risk premium remains positive as indicated by significant positive intercepts in all specifications (except for 2 months forward rates in the United Arab Emirates).

This finding is in line with the "peso problem" literature pioneered by Rogoff (1977) and Krasker (1980), according to which a positive risk premium can exist even in pegged exchange rate regime countries, if investors place a small probability on the possibility of exchange rate devaluation (a very unlikely event *ex-ante*). This finding reiterates the importance of understanding the fundamental drivers of the foreign exchange risk premium in GCC countries with a pegged exchange rate regime.

Table 1: Descriptive Statistics

		Mean	Median	St. Dev.	Skewness	Kurtosis
Saudi Arabia forward differential	1 month	0.0398	0.0313	0.0849	-1.3289	8.4120
	2 months	0.0262	0.0257	0.0583	-1.0528	6.2063
	3 months	0.0225	0.0200	0.0527	-0.9841	6.1883
	6 months	0.0186	0.0142	0.0471	-0.7289	4.2171
United Arab Emirates forward differential	1 month	0.0094	0.0191	0.0771	-4.0136	23.4586
	2 months	0.0028	0.0123	0.0641	-3.5330	18.6136
	3 months	0.0012	0.0100	0.0596	-3.3337	18.0216
	6 months	0.0001	0.0075	0.0499	-3.5513	18.4195
U.S. consumption growth rates		0.4103	0.4348	0.4078	-0.7120	1.9990
U.S. inflation		0.2037	0.1918	0.3100	-1.7666	12.1770
Oil price changes		0.8418	1.5741	11.0766	-0.5489	1.2293

Table 2: Estimation Results: Saudi Arabia

	1m risk premium		2m risk premium		3m risk premium		6m risk premium	
	coeff.	p-value	coeff.	p-value	coeff.	p-value	coeff.	p-value
I. Parameters in the main equation								
Intercepts (mean equation)								
RP	1.6084	0.0000	0.6069	0.0000	0.8040	0.0000	1.3607	0.0000
INFL	0.0009	0.0000	0.0011	0.0000	0.0005	0.0054	0.0004	0.0239
CONS	0.0044	0.0000	0.0041	0.0000	0.0034	0.0000	0.0036	0.0000
OIL	-0.0027	0.6979	-0.0142	0.0367	-0.0113	0.1271	-0.0474	0.0000
"In-Mean" effects								
Var(RP)	0.9477	0.0000	-0.2070	0.4977	119.2389	0.0000	100.0375	0.0000
Cov(INFL,RP)	4991.9203	0.0000	3320.8196	0.0000	4903.7611	0.0000	4565.1824	0.0000
Cov(CONS,RP)	4818.3882	0.0000	4090.8770	0.0000	5383.9066	0.0000	5099.9143	0.0000
Cov(OIL,RP)	988.0946	0.0000	726.8777	0.0000	556.2510	0.0000	1812.6873	0.0000
II. Parameters in the conditional moment equation								
Conditional variance-covariance matrix								
Var(RP)	0.1906	0.0000	-0.0236	0.0000	0.8868	0.0000	0.8698	0.0000
Cov(INFL,RP)	4.6755	0.0000	-0.1382	0.5014	-0.1382	0.0379	-0.0805	0.0000
Cov(CONS,RP)	0.8975	0.0000	-0.1271	0.2268	-0.4113	0.0942	-0.1042	0.0000
Cov(OIL,RP)	-0.1227	0.0000	-0.0722	0.0011	-0.0033	0.6981	0.0225	0.0000
Var(INFL)	0.7738	0.0000	0.1574	0.0000	0.8971	0.0000	0.7317	0.0000
Cov(CONS,INFL)	0.1372	0.0000	0.3985	0.0000	-0.2960	0.0000	-0.4491	0.0000
Cov(OIL,INFL)	0.0016	0.0000	-0.0050	0.5594	-0.0032	0.0000	0.0023	0.0000
Var(CONS)	0.6343	0.0000	0.8916	0.0000	-0.1090	0.0000	-0.3043	0.0000
Cov(OIL,CONS)	0.0065	0.0000	-0.0100	0.0341	0.0162	0.0000	-0.0022	0.1785
Var(OIL)	0.9379	0.0000	0.1282	0.0000	-0.1582	0.0000	0.7758	0.0000
Shocks (residual errors)								
Var(ER)	0.2787	0.0000	1.3235	0.0000	0.1357	0.0000	0.0812	0.0000
Cov(INFL,ER)	0.9165	0.0513	8.4174	0.0000	-0.0161	0.8407	0.0186	0.6628
Cov(IP,ER)	0.0910	0.8374	-0.7477	0.1187	0.2877	0.0013	-0.0094	0.8050
Cov(M,ER)	0.0128	0.3860	0.0575	0.0001	0.0062	0.0315	0.0002	0.7987
Var(INFL)	0.1025	0.0000	-0.0108	0.0154	0.1775	0.0000	0.2442	0.0000
Cov(IP,INFL)	-0.0002	0.0008	0.0111	0.0087	0.1232	0.0000	-0.0905	0.0000
Cov(M,INFL)	0.0029	0.0000	0.0031	0.0000	-0.0010	0.0929	0.0050	0.0000
Var(IP)	0.0517	0.0000	-0.0039	0.2817	-0.0207	0.0009	0.0041	0.6416
Cov(M,IP)	-0.0125	0.0000	-0.0093	0.0000	-0.0005	0.3452	-0.0068	0.0000
Var(M)	0.0484	0.0000	0.0416	0.0000	0.0310	0.0000	0.0470	0.0000
Constant terms								
Var(ER)	0.0133	0.0000	-0.0035	0.1462	-0.0048	0.0151	0.0115	0.0000
Cov(INFL,ER)	-0.0539	0.0000	0.0019	0.7538	0.0042	0.0000	0.0038	0.0000
Cov(IP,ER)	-0.0040	0.1734	-0.0045	0.1203	-0.0025	0.1130	-0.0044	0.0000
Cov(M,ER)	-0.0130	0.0000	-0.0049	0.0000	-0.0110	0.0000	-0.0059	0.0000
Var(INFL)	0.0006	0.0000	0.0004	0.2948	0.0003	0.0005	-0.0004	0.0005
Cov(IP,INFL)	0.0003	0.0110	0.0016	0.0000	-0.0005	0.0000	0.0001	0.5655
Cov(M,INFL)	0.0001	0.0346	0.0015	0.0000	0.0016	0.0000	0.0015	0.0000
Var(IP)	0.0025	0.0000	-0.0012	0.0000	-0.0031	0.0000	0.0003	0.2852
Cov(M,IP)	0.0000	0.8609	0.0015	0.0000	0.0022	0.0000	0.0039	0.0000
Var(M)	0.0409	0.0000	0.1159	0.0000	0.1184	0.0000	0.0763	0.0000
Root mean square error	**0.8568**		**0.5294**		**0.3771**		**0.2655**	

Notes: RP=risk premium; CONS=consumption; INFL = inflation; OIL = oil prices.

Table 3: Estimation Results: The United Arab Emirates

	1m risk premium		2m risk premium		3m risk premium		6m risk premium	
	coeff.	p-value	coeff.	p-value	coeff.	p-value	coeff.	p-value
I. Parameters in the main equation								
Intercepts (mean equation)								
RP	0.0693	0.0000	-0.0086	0.0000	0.2073	0.0000	0.0091	0.0000
INFL	0.0015	0.0000	0.0019	0.0000	0.0015	0.0000	0.0015	0.0000
CONS	0.0047	0.0000	0.0040	0.0000	0.0055	0.0000	0.0050	0.0000
OIL	0.0203	0.0000	0.0167	0.0044	-0.0024	0.7301	0.0162	0.0360
"In-Mean" effects								
Var(RP)	-0.0428	0.8544	-0.6440	0.0015	-2.1476	0.0000	-2.2501	0.0000
Cov(INFL,RP)	5280.0502	0.0000	2968.3936	0.0000	6279.0415	0.0000	3352.8689	0.0000
Cov(CONS,RP)	6018.1184	0.0000	3121.9490	0.0000	6491.7826	0.0000	4099.6392	0.0000
Cov(OIL,RP)	825.9285	0.0000	831.4431	0.0000	741.1312	0.0000	772.8378	0.0000
II. Parameters in the conditional moment equation								
Conditional variance-covariance matrix								
Var(RP)	0.0487	0.0000	0.4955	0.0000	-0.0299	0.0000	0.0468	0.0000
Cov(INFL,RP)	0.0377	0.2543	0.3081	0.0000	-1.1367	0.0000	0.2280	0.0000
Cov(CONS,RP)	-0.4177	0.0000	-0.1730	0.0153	-0.2809	0.0003	-0.1155	0.0000
Cov(OIL,RP)	0.0120	0.0000	0.0023	0.2029	0.0154	0.0000	-0.0047	0.0000
Var(INFL)	0.0269	0.0000	0.9075	0.0000	-0.1589	0.0173	0.7945	0.0000
Cov(CONS,INFL)	0.0354	0.0000	-0.0178	0.5999	0.3446	0.0000	-0.3003	0.0000
Cov(OIL,INFL)	-0.0096	0.0000	-0.0194	0.0000	0.0028	0.0907	-0.0141	0.0000
Var(CONS)	-0.7841	0.0000	0.0041	0.9262	0.9893	0.0000	-0.9425	0.0000
Cov(OIL,CONS)	-0.0072	0.0000	-0.0315	0.0000	0.0005	0.0000	0.0046	0.0000
Var(OIL)	0.0436	0.0000	0.0799	0.0325	0.9253	0.0000	-0.8699	0.0000
Shocks (residual errors)								
Var(ER)	1.0545	0.0000	1.0090	0.0000	0.7955	0.0000	1.4922	0.0000
Cov(INFL,ER)	0.1240	0.4177	-0.1024	0.0946	-6.7777	0.0000	-0.1190	0.1345
Cov(IP,ER)	1.4971	0.0000	0.1677	0.0023	3.8540	0.0000	-0.0639	0.2086
Cov(M,ER)	0.1784	0.0000	-0.0138	0.0000	-0.0324	0.0000	0.0009	0.6548
Var(INFL)	-0.0008	0.6238	-0.0785	0.0000	-0.0127	0.0000	-0.0160	0.0000
Cov(IP,INFL)	0.0653	0.0000	0.0427	0.0000	-0.0446	0.0000	-0.0513	0.0000
Cov(M,INFL)	0.0014	0.0000	0.0036	0.0000	-0.0003	0.3929	-0.0031	0.0000
Var(IP)	-0.0514	0.0000	-0.0129	0.0704	0.0347	0.0000	0.0229	0.0000
Cov(M,IP)	-0.0034	0.0000	-0.0118	0.0000	-0.0036	0.0000	-0.0064	0.0000
Var(M)	0.0195	0.0000	0.0316	0.0000	0.0400	0.0000	0.0484	0.0000
Constant terms								
Var(ER)	0.0000	0.9985	0.0000	0.9967	0.0000	0.9902	0.0000	0.9963
Cov(INFL,ER)	-0.0021	0.0000	-0.0001	0.8997	-0.0001	0.8088	-0.0001	0.8212
Cov(IP,ER)	-0.0021	0.0000	0.0001	0.6390	0.0002	0.8016	-0.0001	0.8405
Cov(M,ER)	-0.0002	0.0000	0.0002	0.0000	-0.0023	0.0000	-0.0008	0.0000
Var(INFL)	0.0013	0.0000	-0.0001	0.7005	0.0001	0.7965	-0.0005	0.0419
Cov(IP,INFL)	0.0015	0.0000	0.0000	0.9246	-0.0003	0.2902	0.0004	0.5217
Cov(M,INFL)	0.0016	0.0000	0.0015	0.0000	0.0024	0.0000	0.0019	0.0000
Var(IP)	0.0007	0.0007	-0.0006	0.5381	0.0002	0.0042	0.0003	0.3586
Cov(M,IP)	0.0016	0.0000	0.0017	0.0000	0.0002	0.0000	0.0018	0.0000
Var(M)	0.1147	0.0000	0.1097	0.0000	0.0441	0.0000	0.0607	0.0000
Root mean square error	**0.8177**		**0.8658**		**0.5669**		**0.4300**	

Notes: RP=risk premium; CONS=consumption; INFL = inflation; OIL = oil prices.

Table 4: Specification Tests

Saudi Arabia				
1 month	Forward premium	Inflation	Consumption	Oil prices
LM4	0.0357	0.5668	0.7441	0.3812
LM8	0.1079	0.3015	0.6922	0.5911
ARCH4	0.0013	0.0000	0.0053	0.0369
ARCH8	0.0194	0.0002	0.0132	0.1056
2 months	Forward premium	Inflation	Consumption	Oil prices
LM4	0.9609	0.4046	0.4050	0.4698
LM8	0.0396	0.4154	0.1470	0.6798
ARCH4	0.0171	0.0000	0.6215	0.0550
ARCH8	0.1655	0.0011	0.4250	0.1316
3 months	Forward premium	Inflation	Consumption	Oil prices
LM4	0.6590	0.3195	0.6232	0.4381
LM8	0.7542	0.6815	0.5843	0.6324
ARCH4	0.0022	0.0001	0.0000	0.1745
ARCH8	0.0326	0.0005	0.0001	0.2090
6 months	Forward premium	Inflation	Consumption	Oil prices
LM4	0.0000	0.8418	0.8854	0.6993
LM8	0.0000	0.2115	0.9934	0.8783
ARCH4	0.0000	0.0035	0.0010	0.4853
ARCH8	0.0000	0.0321	0.0046	0.5606

Notes: reported are p-values from the test on remaining serial correlation (null hypothesis: no serial correlation) and conditional heteroscedasticity (null hypothesis: no ARCH effects in residuals).

The United Arab Emirates				
1 month	Forward premium	Inflation	Consumption	Oil prices
LM4	0.5568	0.5446	0.7488	0.5658
LM8	0.4301	0.3378	0.8526	0.7518
ARCH4	0.7996	0.0000	0.0094	0.2668
ARCH8	0.3530	0.0001	0.0360	0.2762
2 months	Forward premium	Inflation	Consumption	Oil prices
LM4	0.0106	0.4365	0.5398	0.6140
LM8	0.6664	0.3975	0.4718	0.7792
ARCH4	0.9496	0.0000	0.4923	0.5929
ARCH8	0.9605	0.0001	0.5322	0.5024
3 months	Forward premium	Inflation	Consumption	Oil prices
LM4	0.6999	0.5239	0.6931	0.7393
LM8	0.8427	0.3572	0.8962	0.8819
ARCH4	0.6985	0.0000	0.0507	0.4576
ARCH8	0.2911	0.0003	0.1151	0.3993
6 months	Forward premium	Inflation	Consumption	Oil prices
LM4	0.1219	0.4864	0.7818	0.7717
LM8	0.5161	0.3474	0.6118	0.9253
ARCH4	0.0000	0.0000	0.1524	0.8215
ARCH8	0.0000	0.0001	0.2564	0.6487

Notes: reported are p-values from the test on remaining serial correlation (null hypothesis: no serial correlation) and conditional heteroscedasticity (null hypothesis: no ARCH effects in residuals).

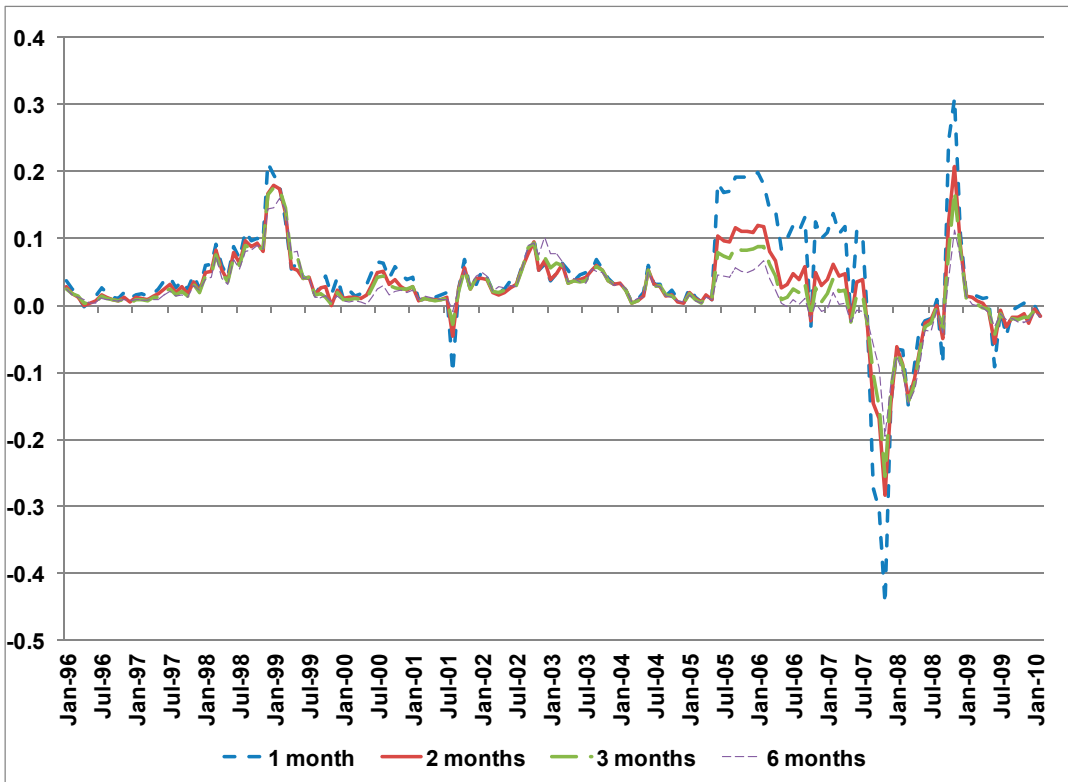**Figure 1: Foreign Exchange Forward Differential in Saudi Arabia (in percent)**

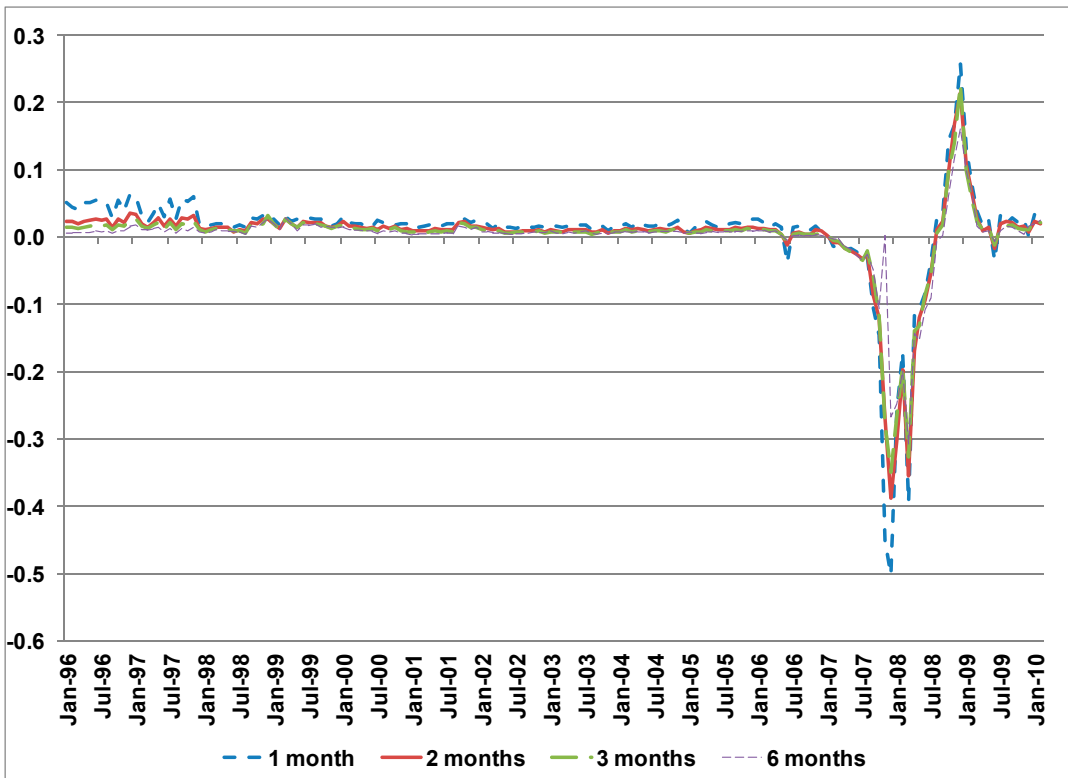**Figure 2: Foreign Exchange Forward Differential in the United Arab Emirates (in percent)**

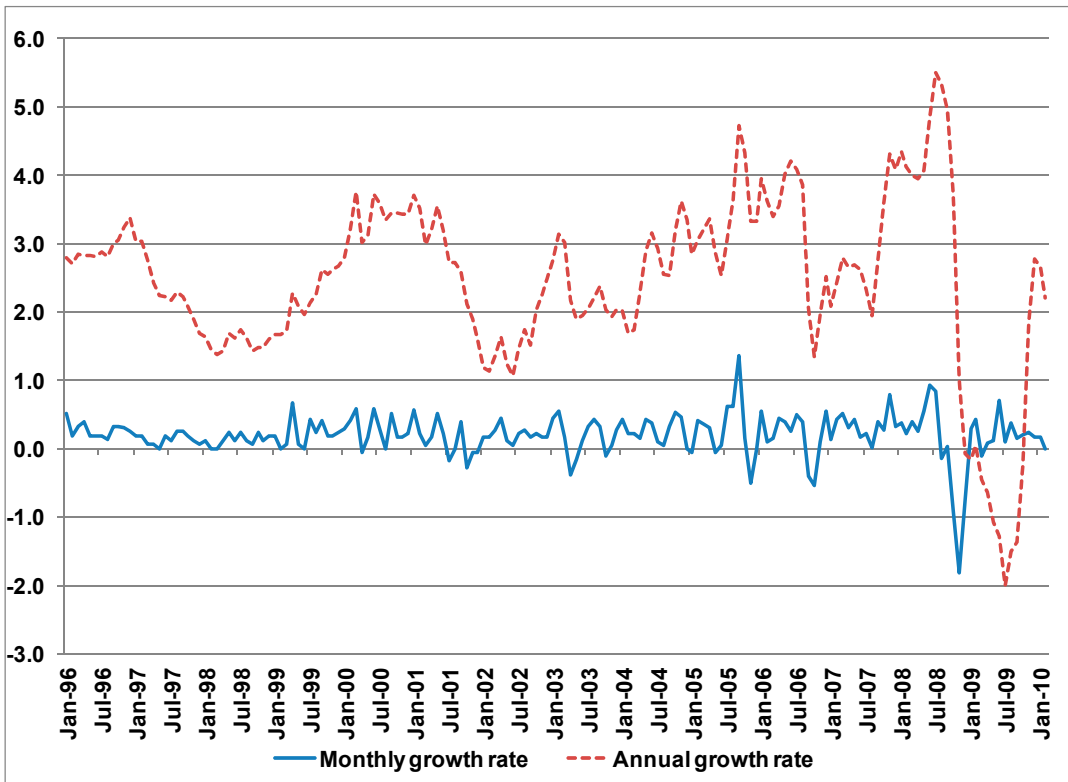**Figure 3: U.S. CPI Inflation (percent change)**

Monthly growth rate · · · Annual growth rate

Figure 4: U.S. Consumption (percent change)

Monthly growth rate · · · Annual growth rate
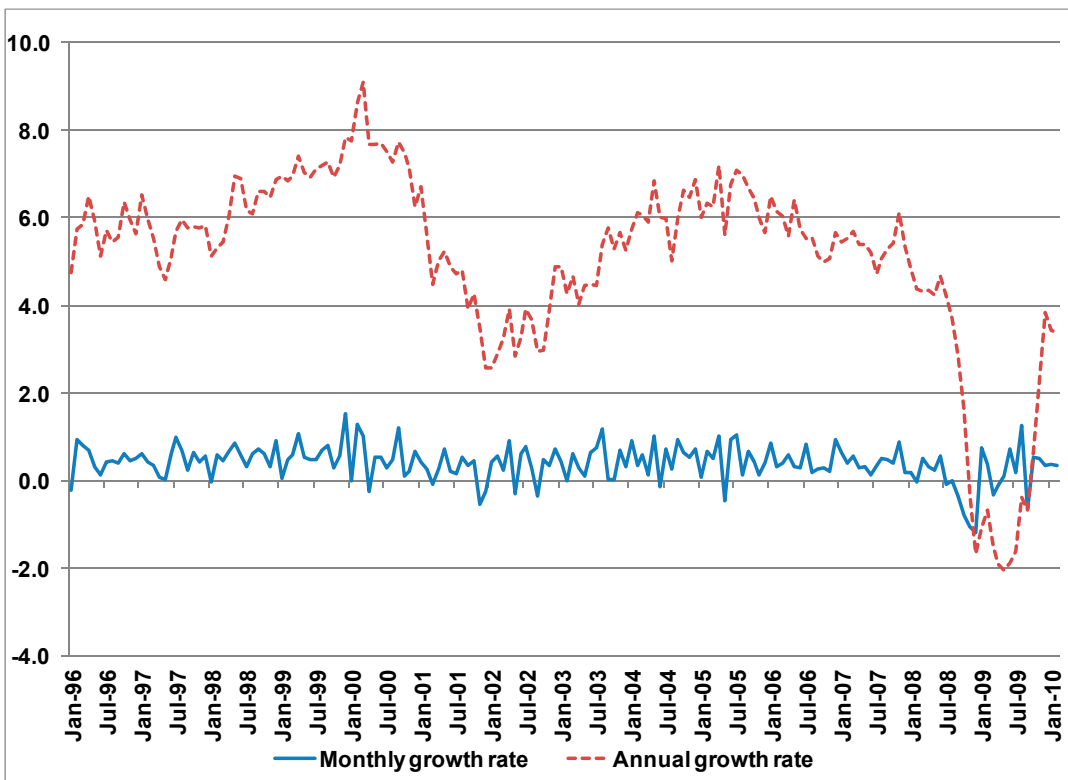
Figure 4: Nominal Oil Prices (percent change)
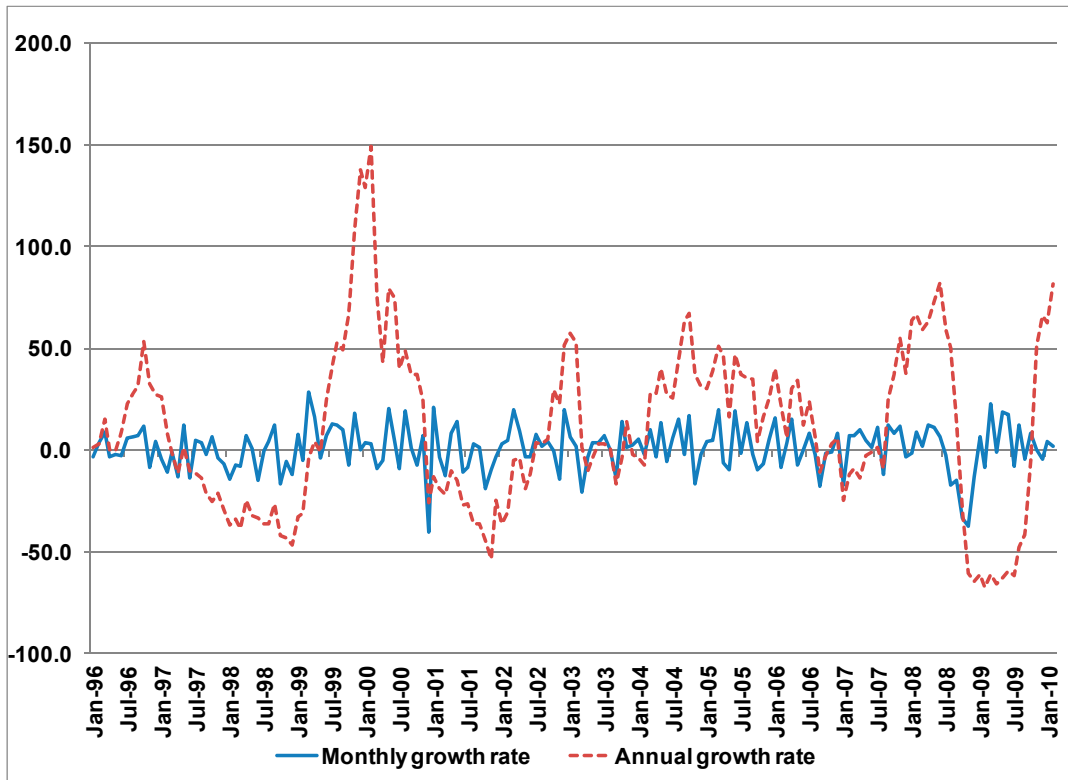
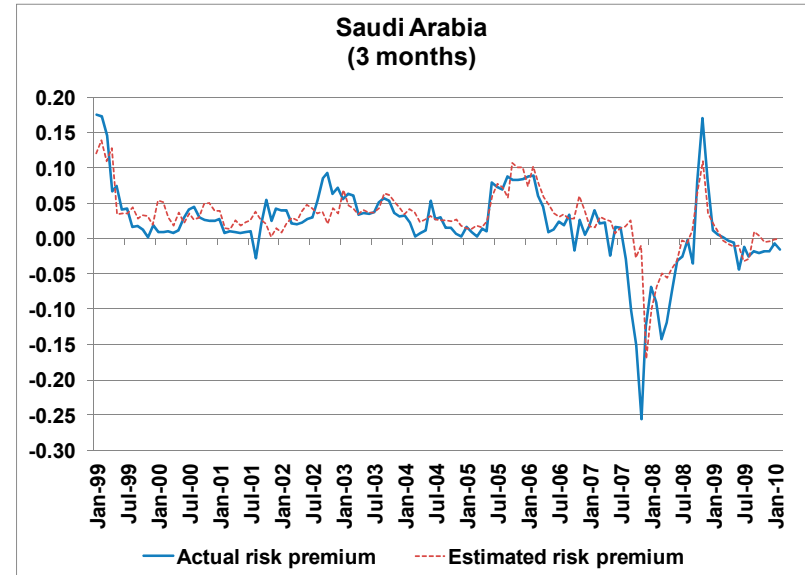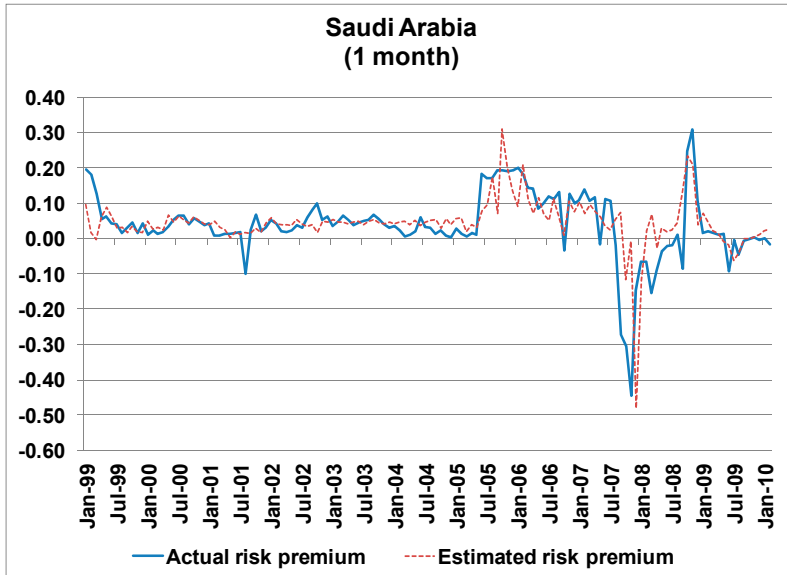**Figure 6: Actual and Estimated Foreign Exchange Risk Premium in Saudi Arabia (in percent)**
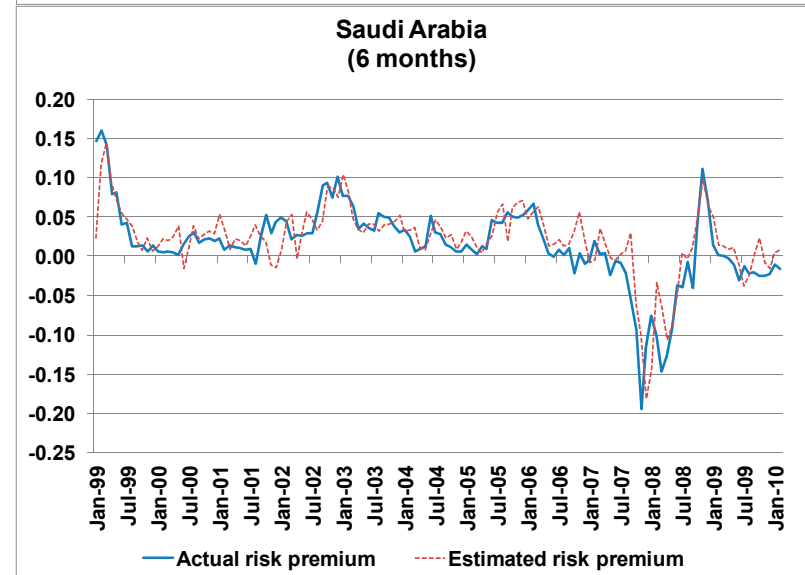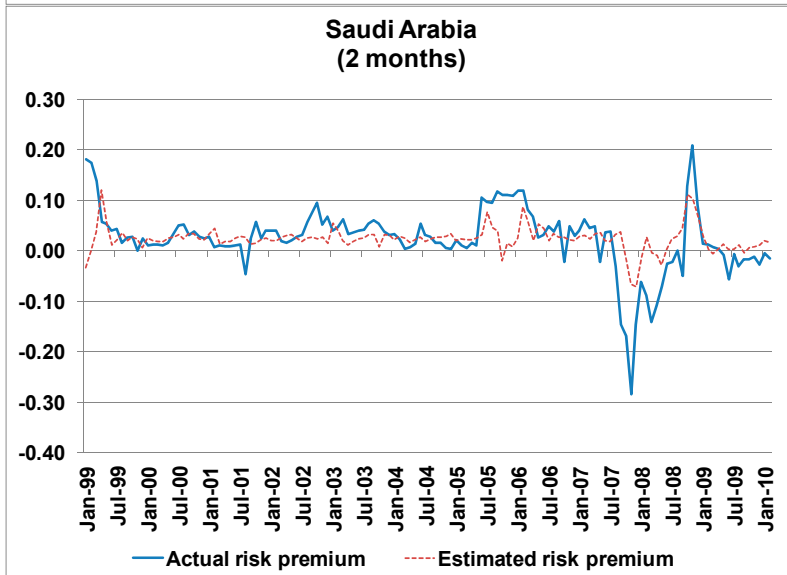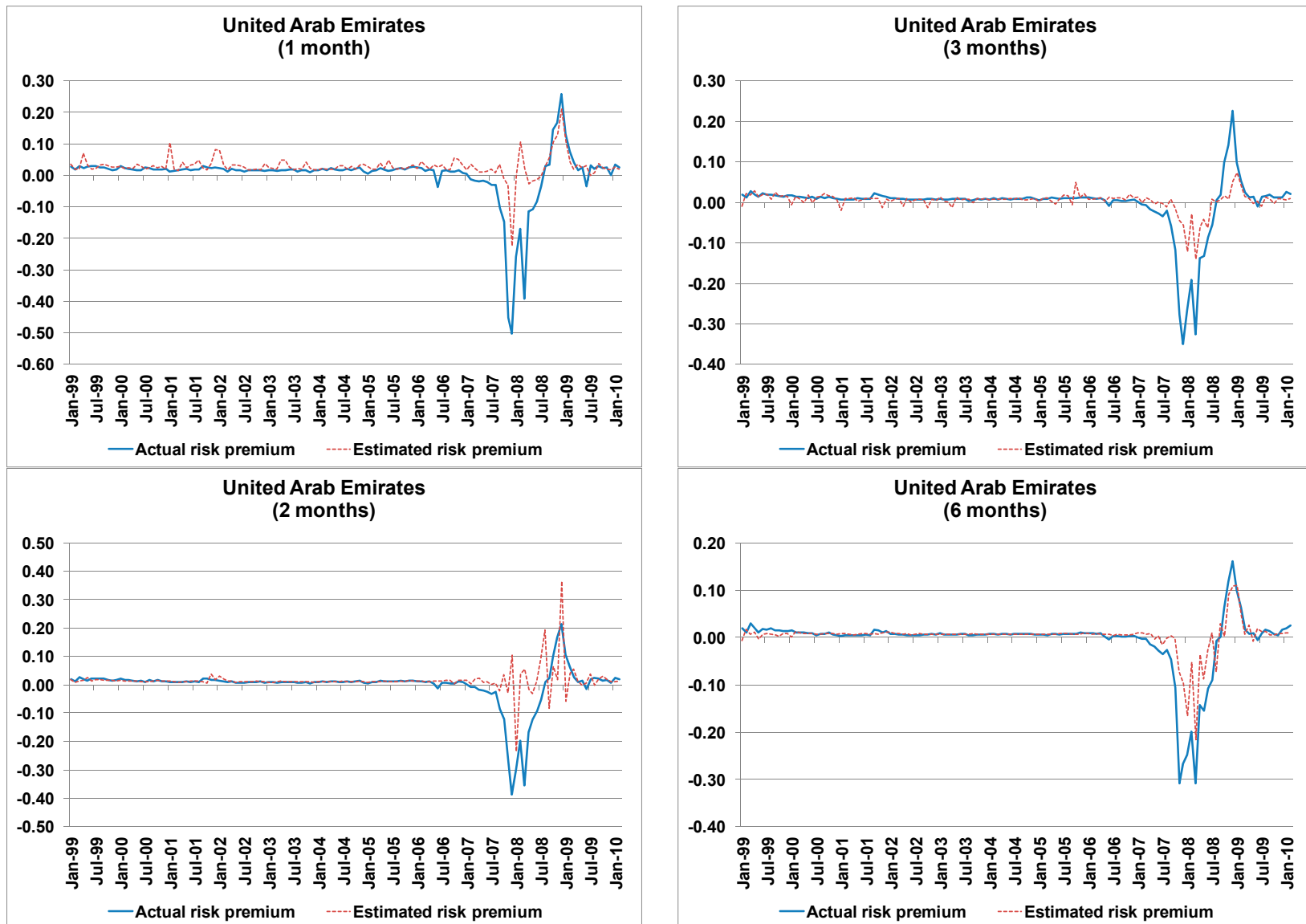
Figure 7: Actual and Estimated Foreign Exchange Risk Premium in the United Arab Emirates (in percent)

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