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In The Middle of the Heat

The GCC countries Between Rising Oil Prices and the Sliding Greenback

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Abstract:

The paper asks two questions. One, what is the size of the effect of the increase in real oil price on competitiveness of the Gulf Cooperation Council (GCC) countries –the real exchange rate is a measure of competitiveness – and two, given recent concerns about the sliding greenback and the consequent income and inflationary problems, would the GCC countries been "better off" had they pegged their currencies to the Euro dollar in 1991? To answer these questions we model and estimate the effect of oil prices on the competitiveness for the GCC then we provide a test statistic to test whether the conditional variance of the model has remained stable under the US dollar peg compared to a counterfactual scenario, where the GCC countries peg their currencies to the Euro dollar in 1991. We find the effect of the increase in the real price of oil on competitiveness of the GCC countries to be small, most of the domestic inflation is imported, and that there is a relatively large variation among the GCC economies with respect to the currency peg. The financial problems the GCC countries face today are not about which currency (or a basket of currencies) they should peg to, but rather about the choice of the monetary arrangement as a whole.

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[1] The views are mine and do not reflect those of the Department of Labor of New Zealand and the Arab Planning Institute. Contacts: weshah.razzak@dol.govt.nz / weshah@api.org.kw and www.razzakw.net . I thank Kazuta Sakamoto for his research assistant.

1. Introduction

The six GCC countries, Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates (UAE) produce about 23 percent of the world's oil and control more than 40 percent of the world's oil reserves. Oil is the main commodity they produce and export. The spot and future prices of oil have been rising because of foreign excess demand, among the main reasons.

Inflationary pressures increased along with recent economic growth. The size of these pressures depend on what index is used. Table 1 reports the averages over the sample from 1970 to 2006 (all data are found in appendix 1). It reports the average GDP deflator and the CPI inflation rates. It also reports the GDP deflator and the CPI inflation rates in 2006 (boldface and in parentheses). Clearly, there is a lot of inflation in 2006 relative to the average, if we take the deflator.[2] Further, we took the average of the CPI and the deflator inflation rates for each country over the period then computed what we call the GCC-wide average inflation, which is 5.5 percent. Figure 1 shows that the deflator in each country is above the average inflation in the GCC countries. The CPI, on the other hand, has been rising slowly and just about equal to the average in 2006.

The GCC incomes grew substantially as a result of the increase in foreign demand and oil prices. This foreign excess demand is expected to persist. Table 1 reports the real GDP growth rates in 2006 (in boldface and in parentheses) and the country's average growth rates over the sample from 1970 to 2006. GDP growth rates in 2006 exceed the average growth rate over the sample, except in the cases of Oman and Saudi Arabia which grew at the average.[3]

Figure 2 is a scatter plot of the GCC GDP growth rate averages and the change in the domestic GDP deflator inflation rate as a proxy for the inflation's deviation from expected inflation. There is a negative relationship with a small correlation coefficient equal to -0.33. This seems to suggest that the dominant shock to the GCC economies has been a supply shock, i.e., perhaps an increase in the production, where oil has the biggest share. Note how Bahrain and Oman seem to differ from the group and how Kuwait seem to be separated from the others.

The GCC countries maintain fixed exchange rate regimes. Recently, the GCC countries have been complaining about the continuous depreciation of the US

[2] The CPI does not include oil prices and construction costs, the GDP deflator does. The correlation between oil price inflation and the GDP deflator inflation is very high in all GCC countries. There is no significant correlation between oil price inflation and the CPI inflation rate. We do not plot or report the data to save space, but we are happy to provide the data on request. Data for the first three quarters show even more inflation.

[3] Kuwait's low average growth over the sample from 1970 to 2006 is due to the inclusion of Gulf War I period when GDP collapsed.

dollar and its effect on domestic inflation, on their currencies, and on their incomes. Figure 3 plots the real and the nominal exchange rates. Figure 4 plots the US price deflator and the domestic price levels. Domestic prices are higher than the US price late in the sample consistent with the appreciation of the real exchange rate. Table 1 also reports the average real depreciation rates and their values in 2006 (boldface and in parentheses). The data suggest that GCC countries experienced large real appreciations in 2006 compared to the sample averages.[4] As a result of the fixed exchange rate regime inflation could be imported from abroad, which we confirm in this paper.[5]

So given the recent increases in incomes, the inflationary pressures and the appreciated real exchange rates, many of the GCC central banks and the business community have been feeling the heat. The Arab Monetary Fund publicly viewed the peg to the US dollar as problematic, and suggested that a peg to another currency or to a basket of currencies might be a way to deal with the heat generated by the sliding greenback and rising oil prices. The Monetary Arab Fund did not consider floating the exchange rates as a good alternative. The head of the Arab Monetary Fund said that the float would be technically challenging to the local expertise. A few GCC central banks, e.g., Bahrain, Saudi Arabia and the UAE, decided not to change their monetary arrangements; given that one would expect these central banks to re-value their currencies.[6]

The primary aim of this paper is to understand these problems. We ask two main questions: first, what is the size of the effect of the rise in the real oil price on the "competitiveness" of the GCC? Second, given these recent concerns about the sliding greenback and the consequences income and inflationary pressures, would the GCC economies have been "better off" had they pegged their currencies to the Euro dollar instead of the US dollar?

We consider the real exchange rate a measure of competitiveness. Our small model consists of four equations for the real exchange rate, real money balances, real output and the price level. We estimate the model and provide an answer to the first question by solving the model and computing the size of the effect of the increase in the real oil price on the real exchange rate.

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[4] See also the IMF press release No. 07/241 on October 29, 2007.

[5] The GCC countries adopted a regime of hard exchange rate peg against the US dollar in 2003. Kuwait pegged its currency to a basket of currencies since March 1975. It switched to a USD dollar peg in January 2003 as a step towards monetary union for the GCC. Kuwait switched to a basket of currencies again in May 2007. The US dollar is suspected to have the highest weight in the basket, but the weights are unknown to the public.

[6] There is a large literature on revaluations of nominal exchange rates under fixed peg systems. Razzak (1995) reports some *real* effects of nominal revaluations in Sub-Saharan Africa. However, these revaluations must be very large in magnitudes and cannot be considered a useful policy recipe.

We are aware of two papers that examine the question of what basket of currencies should the GCC countries peg to, Erbas, et al. (2001) and Abed *et al.* (2003). The first paper considered pegging the GCC currencies to the SDR and found out that while pegging to the SDR improves the stability of the exchange rates between member countries and the SDR countries (UK, Germany, France, and Japan), but not with the US dollar. They found that the results are sensitive to the size of the estimated elasticity of exports and imports to/from the US, the SDR countries and to the rest of the world. They reported that the stability gains from maintaining the peg to the US dollar outweighs the stability gains from switching to the SDR peg. Abed et al. (2003) examined the US dollar peg versus a basket of two currencies: the US and the Euro dollars, and found similar results. They report that a basket-peg regime does not dominate the US dollar peg regime for improving the external stability.

We don't consider a scenario of a basket of currencies because the papers above already examined this issue. Instead, we re-estimate the system using the Euro dollar as the measure of the foreign currency in the model, including the price for oil, thus we report two sets of results one for the US dollar system and one for the Euro dollar. Regarding our second question, "better off" is measured in terms of the conditional variability of the model. In a multivariate setup like ours, the conditional variance of the model is a *function* called the Generalized Variance (Anderson, 1958). Precisely, we compute the Sample Generalized Variance. And, we provide a test statistic to test whether the country variance has changed significantly.

On average (i.e., across the GCC and over the sample period from 1970 to 2006) we found that the effect of the increase in the real price of oil on the real exchange rate in the short run to be small. A doubling of the real price of oil appreciates the real exchange rates (reduce competitiveness) of the GCC countries by about 3 percent on average. For the Euro dollar model, a doubling of the real price of oil measured in Euro dollar appreciates the GCC currencies between 0.30 and 0.70 percent on average. This is smaller than the US dollar effect by a magnitude of 10.

We found large differences among the GCC economies to whether they should peg to the US or the Euro dollar, which might have implications for the monetary union or the optimum currency area. Most importantly, most of the domestic inflation comes, on average, from foreign prices (imported inflation). Rising real oil prices by a 100 percent add about 5 percent to the GDP growth rate on average. We discuss these results and policy implications.

Next, we present our model. In section 3 we derive the test statistic for the conditional variance. Estimation and discussion of the results are in section 4. In Section 5 presents the calculations of the Sample Generalized Variance and the test statistic. Section 6 includes our conclusions.

The model

The actual real exchange rate Q_t is defined as $(S_t P_t^*)/P_t$, where S_t is the nominal exchange rate (the domestic currency price of one unit of foreign currency (i.e., an increase denotes depreciation), P_t^* is the foreign price, and P_t is the domestic price.

There is a great debate in the economic literature about the exchange rate determination; it spans a period of more than forty years. Harrod (1933), Balassa (1964) and Samuelson (1964) show that the real exchange rate is a function of the productivity differential between tradable and non-tradable sector in the home and the foreign country. Messe and Rogoff (1983) argue that the exchange rate is a random walk process. Most asset prices follow a random walk process, which is also consistent with the efficient market hypothesis, e.g., Fama's (1970) influential paper. But, there are also several different theories such as the monetary model and various versions of it, e.g., Mussa (1982, 1986), Frenkel's (1980) real interest rate differential model, and Dornbusch's (1976) overshooting model. Generally speaking, these models suggest the real exchange rate is perhaps a function of real money balances differential (money and inflation effects could be separated), output differential, and the interest rate differential. Then we had another generation of models, where government expenditures are the main determinant of the exchange rate, e.g., Edwards (1989), Froot and Rogoff (1991) and Egert, *et al.* (2004).

It is conceivable that US variables play the most important role in affecting the real exchange rates of the GCC countries. The US government massive expenditures and investments in defense could directly affect the real exchange rate in the GCC countries. In countries that are major exporters of materials (primary commodity and metals) such as New Zealand and Australia, the term of trade seems to play a role in affecting the exchange rate.

To encompass the models of the exchange rate determination, we assume that the real exchange rate has two components: a permanent component Q_t^P and a transitory component Q_t^T (e.g., Meltzer (1993) and Razzak (1995)).

$$1 \quad Q_t = Q_t^P + Q_t^T$$

Further, we let the permanent component be a linear combination of last period actual real exchange rate and a vector of variables X_t, which includes: $(M/P)_t, (M/P)_t^*, TOT, \hat{D}_t$, where M_t is money[7], P_t is the deflator, ToT_t is

[7] The theory does not really say what measure of money. Researchers tried almost all different definitions of money and reported mixed results, but most of the evidence of the 1970s and 1980s models of the exchange rate determination found wrong signs.

the term of trade index and $\hat{d}_t$ is productivity differential in tradable goods, which measures the difference in tradable sector's productivity between each of the GCC and their trading partners, i.e., the US, Europe and Asia). The asterisk denotes the foreign country magnitude.

2 $Q_t^p = \beta Q_{t-1} + (1-\beta) X_t + \varepsilon_{2t}$

Substituting in the actual real exchange rate we get:

3 $Q_t = \beta Q_{t-1} + (1-\beta) X_t + \varepsilon_{3t}$,

Where the error term ε_{3t} include ε_{2t} and Q_t^T . The real exchange rate is a random walk if $\beta = 1$.

Under fixed exchange rate regimes the central bank buys and sells foreign assets to keep the exchange rate fixed so real money balances are give by:

4 $\frac{M_t}{P_t} = \kappa Y_t$

The CPI, $\hat{P}_t$ is a weighted average of the domestic price deflator P_t and the foreign price P_t^* . Non-oil production in the GCC is relatively small so we do not include the price of domestic goods. Average non-oil production as a percent of GDP in GCC in 2002, for example, was about 3.4 percent.

5 $\hat{P}_t = (P_t)^{\gamma_1} * (P_t^* S)^{1-\gamma_1}$

We model real output Y_t as a function of foreign income, Y_t^* (which determines foreign demand), the price of oil $(P_t^O S_t)$, the foreign real interest rate R_t^* and a random disturbance ζ_t that includes uncertainty and other shocks. Note that in a fixed exchange rate regime, where people expect $\Delta s_t^e = 0$ (i.e., the fixed exchange rate to be maintained, thus the expected depreciation to be zero), the domestic interest rate $R_t = R_t^*$. Real interest rates in the GCC countries are not necessarily the same because expected inflation rates might differ. There is a large literature on the relationship between the foreign interest rate and the domestic economy. The foreign interest rate could operate through the effect on the expected real depreciation as we mentioned above; exports and in the case of the GCC, oil; and financial flows. For a discussion and review of this literature see Giovanni and Shambaugh (2006).

6 $Y_t = f(P_t^O S_t;\ R_t^*;\ Y_t^*; \zeta)$,

Putting all together, the model consists of the following system of equations, where the subscript $i = 1, 2, \ldots 6$ GCC countries, i.e., a panel and lowercase variables denote the natural log.

7 $q_{it} = \alpha_{11} q_{it-1} + (1 - \alpha_{11})[\alpha_{12}(m_{it} - p_{it}) + \alpha_{13}(m_t - p_t)^* + \alpha_{14} ToT_{it} + \alpha_{15}\hat{d}_{it}] + \varepsilon_{7it}$

8 $(m - p)_{it} = \alpha_{21} y_{it} + \varepsilon_{8it}$

9 $\hat{p}_{it} = \alpha_{31}(p_t) + (1 - \alpha_{31})(p_{it}^* + s_{it}) + \varepsilon_{9it}$

10 $y_{it} = \alpha_{41}(p_{it}^o + s_{it}) + \alpha_{42} R_t^* + \alpha_{43} y_t^* + \varepsilon_{10it}$

The model predicts that an increase in domestic real money balances depreciates the real exchange rate $\alpha_{12} > 0$. (positive sign denotes depreciation). The increase in the foreign real money balances due to the central bank sells of foreign reserves for domestic money appreciates the real exchange rate $\alpha_{13} < 0$.

An increase in the term of trade will appreciate the real exchange rate, which is consistent with a voluminous literature showing the appreciation of the real exchange rate, $\alpha_{14} < 0$.

Real government expenditures increases real output and appreciates the real exchange rate as a result of an excess demand for real balances that results in an increase in the real interest rate above the world real interest rate - assuming expectations are unchanged. To restore the equilibrium real exchange rate at its level the central bank buys foreign assets, i.e., increase the money supply). We try both the level of government expenditures and the differential with the US and Europe.

We expect that $\alpha_{15} < 0$, i.e., an increase appreciates the real exchange rate. In the real money balances equation $\alpha_{21} > 0$. Given financial innovations in the GCC countries are not expected to be as high as those in Europe, the US and other advanced countries we expect α_{21} to be greater than one perhaps.

In the real output equation, higher oil prices increase income of the GCC countries because they are major exporters of oil, so α_{41} is expected to be positive. The foreign real interest rate is predicted to have a negative effect on domestic production, $\alpha_{42} < 0$, see Giovanni and Shambaugh (2006). Foreign real output has a positive effect on domestic output, $\alpha_{43} > 0$.

The restriction that domestic money and foreign money coefficients in the exchange rate equation sum to zero will be tested, i.e., $\alpha_{12} + \alpha_{13} = 0$. The restriction in the price equation will also be tested, i.e., α_{31} and $(1 - \alpha_{31})$.

The model is identifiable. It satisfies the rank and order conditions. After we estimate the model above we solve it for the real exchange rate and compute the effect of the real oil price on the real exchange rate.

2. The conditional variability of the system

Pegging the exchange rate to a stable foreign currency or to a basket of currencies aims at providing an anchor. Stability of the currency that a country pegs to is an issue considered by the theory of the Optimum Currency Areas literature (Mundell, 1961). So the second question of this paper arises; could a Euro dollar peg have provided more stability to the GCC economies than the US dollar peg?

Our idea is to test whether the conditional variance of the model, which consists of four equations, has remained constant against the alternative hypothesis that it increased, in both the US dollar peg and Euro dollar peg.

The conditional variance is the variance of the residuals of the model. The residuals of the system in equations 7 to 10 above are distributed multivariate standard normal with a zero mean and a variance – covariance matrix $\sum$. The variance – covariance matrix is symmetric and diagonal $\mathrm{P} \times \mathrm{P}$.

Let a statistic ω, which could have any distribution, measure certain features of the residuals ε such as the variance. If $\omega_\delta (0 < \delta < 1)$ denotes the $(1-\delta)^{th}$ fractile of the distribution of ω then ω_δ satisfies the equation:

$$11 \quad prob \quad (\omega > \omega_\delta) = \delta$$

We define a zone for ω under some common distribution by defining upper and lower critical limits such that ω stays within. In other words, when ω exceeds the critical limits it is considered a significant value (i.e., falling in the tails of the distribution).

For a multivariate normal variable $\varepsilon^T = [\varepsilon_1, \varepsilon_2 \cdots \varepsilon_\mathrm{P}]^T$, where each ε is iid, and if $(1-\delta)$ probability is maintained on each component, then the probability that all variables $\varepsilon_1, \varepsilon_2 \cdots \varepsilon_\mathrm{P}$ are simultaneously falling within the upper and lower critical limits is

$$12 \quad 1 - \varphi = (1-\delta)^\mathrm{P}$$

The probability of falling outside the critical limit is

$$13 \quad \varphi = 1 - (1-\delta)^\mathrm{P}$$

To satisfy a probability of $1-\varphi$ that all variables are falling within the critical limits on one sample when the parameters are the nominal values, δ must be:

14 $$\delta = 1-(1-\varphi)^{1/\mathrm{P}}$$

For a multivariate normal like in the residual matrix above, the variance (of the population) is a *function* called the *Generalized Variance*, which is the determinant of the matrix Σ. The determinant of S^2 is called the *Sample Generalized Variance,* where S^2 is the sample covariance matrix based on sample of size n.[8] Anderson (1958) shows that a convenient statistic for the generalized variance is the following form of the sample generalized variance:

15 $$D_k = (n-1)\mathrm{P}\left[\frac{|S_k^2|}{|\Sigma|}\right]^{1/\mathrm{P}} > 0$$

And $k = 1, 2 \cdots m$.

The matrix S^2 is computed by:

16 $$S_{ij}^2 = \frac{1}{n-1}\sum_{k=1}^{m}(x_{ki}-\bar{x}_i)(x_{kj}-\bar{x}_j)$$

And Σ is approximately:

17 $$\bar{S}^2 = \frac{1}{N-m}\sum_{k=1}^{m}(n-1)\,S_k^2$$

Which is the mean of S^2.

Unfortunately, for P>3, the statistic D_k has no exact distribution so we cannot test for significance. It turned out that we can approximate the distribution by a Γ (Gamma) distribution with two parameters, a shape and a scale parameter, Ganadesikan and Gupta (1970). They showed that the Γ distribution is better approximated when $n = 10$.

The shape parameter is:

18 $$h = \frac{\mathrm{P}(n-\mathrm{P})}{2}$$

[8] Anderson (1958) shows that the determinant of S^2 is proportional to the sum of squares of the volumes of all *parallelopes* formed by using as principle edges P vectors of $\varepsilon_1, \varepsilon_2, \cdots \varepsilon_{\mathrm{P}}$ as one set of end points, and the mean of ε as the other with $\frac{1}{(n-1)^{\mathrm{P}}}$ as the factor of proportionality.

And the scale parameter is:

19 $$A = \frac{P}{2}\left[1 - \frac{(P-1)(P-2)}{2n}\right]^{1/P}$$

To simplify the interpretation of the statistic D_k we transform the Γ distribution into a standard normal by computing the following:

20 $$u_k = G_{h,A}(D_k)$$

Where G is the distribution function of the Gamma distribution with the two parameters above, and then the inverse of u_k

21 $$R(D_k) = \Phi^{-1}(u_k)$$

$R(D_k)$ is distributed standard normal and therefore the values could be $R(D_k) < 0 < R(D_k)$. This should not be confused with a negative variance.

We will compute the statistics $D_k \approx \Gamma_{h,A}$, u_k and $R(D_k) \approx N(0, \mu)$ for the estimated residuals of the model. Then for both the US dollar peg and the Euro dollar peg, we test whether the conditional variance $R(D_k)$ for each country has significantly increased or not. A significant increase implies values of $R(D_k) > \pm 2\sigma$ or > $\pm 3\sigma$. The $\pm 3\sigma$ limits constitute a zone of 0.99730 intervals for the values of $R(D_k)$, which is also true for non-standard normal distribution (Tchebysheff's theorem).

Values of $R(D_k)$ exceeding $\pm 3\sigma$ are considered very significant changes in the conditional variance.[9]

4. Data and estimation

The data we use are annual from 1970 to 2006 when the foreign country is the US, and from 1991 to 2006 when the foreign country is the European Union. All data are in natural logs except the interest rate. Foreign real interest rates are the nominal 90-day rate minus last period inflation rate as a proxy for expected inflation. All data are from the IMF data base. Figures 5 to 12 plot the remaining data.

[9] Razzak (1994) provides a Monte-Carlo experiment to derive the probability distribution for $k = 1, 2 \cdots m$ values of $R(D_k)$ falling beyond the $\pm 3\sigma$ limit. Random variables are generated, 1000 values of $R(D_k)$ and the probabilities are computed.

All the data have trend except the US real interest rate (the 90-day interest rate minus last period inflation as a proxy for expected inflation). Kuwait's GDP (figure 7) has a break during the Gulf War I in 1990. The common unit root tests that we use are not designed to handle breaks in the data; they confuse the break with a unit root. Also, most of the unit root tests have low powers, some relatively different from others. We test the data for unit root using common unit root tests for time series and panel data.[10] We could not reject the hypothesis that the log-level data have unit roots, except for the real interest rate.

Whether the variables in the panel are cointegrated or not is another concern, but we will estimate the regressions in first differences (except for the US real interest rate) for several reasons. First, first differenced regression is approximately the same as fixed effect models and this is precisely what we want to estimate to account for the country-effect i.e., heterogeneity. Second, we are interested in the short-run because the exchange rate and the price of oil are asset prices, which are very persistent (i.e., unit root, near random walk or random walk) so the long run is very long. Typically, when good and asset price inflations are high the lags are short relative to the lags when good and asset inflations are low. Third, to compute the Generalized Sample Variance for the residuals, they have to be I (0), which is guaranteed when we estimate *our* system in first differences because the levels are I (1). Fourth, testing the hypothesis of no cointegration in a panel, and a system of equations, is dicey when N (the number of cross sections) is small (6 observations only) and T (the length of time series sample) is not so long (35 observations at most and in the Euro dollar system is 15 only).

Table 1 reports descriptive statistics for the log-differenced data (except the real interest rates). These are period averages. The average real exchange rate depreciations are between -1 and -3 percent depending on the foreign currency involved. But in 2006 all the currencies appreciated significantly in real terms, up to 13 percent for the UAE. Real money balance grew at rates between 6 to 8 percent on average across the GCC, quite fast compared with Europe and just as high as the US. With exception of Kuwait, which experienced a high rate of growth in the term of trade, most GCC countries' terms of trade grew between 3 and 5 percent on average.

All GCC countries productivity differential with their major trading partners in tradable good sectors are either zero or negatives. Relative to trading partners, the level of productivity in tradable goods in Bahrain increased in the mid 1980s, again in 2000 then flattened; increased right after the 1990s Gulf War I, then flattened in Kuwait; fluctuated wildly in Oman; increased in the 1990s in Qatar

[10] We used the Augmented Dickey- Fuller (1984), Perron (1997), Phillips (1987), Elliott (1991), Levin, Lin and Chu (2002), Im, Pesaran and Shin (2003), Sarno and Taylor (1998) and Taylor and Sarno (1998)). We estimated a variety of specifications (constant, time trend, etc.) and examined a variety of lag structures using different Information Criteria.

then flattened; increased in Saudi Arabia over the 1970s but has been declining since 1980; and finally it has been declining all the way from 1970 in the USE. Kuwait's real GDP has a break during the Gulf War I in 1990/1991.

Most of the RHS variables in equation 7 – 10 such as money, foreign money, the term of trade, oil prices, foreign real interest rate and foreign GDP, could be assumed exogenous. Least Squares method is a reasonable initial estimator, except that the real depreciation rate equation of the *differenced* model includes a lagged dependent variable. Thus, $\text{cov}(\Delta\varepsilon_{7it}, \Delta q_{it-1}) < 0$. Thus, the coefficient α_{11} is biased downward in Lease Squares. We would also expect the other coefficient estimates in the real exchange rate depreciation rate to be biased and inconsistent. For this problem and for robustness, we also report the Generalized Method of Moments (GMM) results. The instruments are several lags of the RHS variables because these variables are the ones that are readily available (see footnote of table 2 for the instruments). These instruments provide reasonably long dynamic. The number of instruments and the length of the lags have well-known disadvantages so we will restrict the number of the instruments to save some degrees-of-freedom. We should interpret the coefficient estimates carefully.[11]

Table 2 reports four regressions.[12] The first two are with respect to the US dollar. The second two are with respect to the Euro dollar. For each case, we report Least Squares and GMM results. The Euro dollar system implies (1) pegging to the Euro dollar and (2) oil is price in Euro dollar rather than US dollar. The samples are different. The effective sample sizes are also different depending on the number of instruments used in the GMM regressions.

Lets begin with the US dollar regression. All estimates are interpreted as *averages over the GCC* countries and over the sample period. The real exchange rate depreciation rate does not seem persistent. The coefficient α_{11} is 0.30 and 0.23 and 0.13 in the Least Squares and the GMM regressions respectively.[13]

Real money balances depreciate the real exchange rate, i.e., the sign is positive, and significant. The size of the coefficient α_{12}, 0.63 (GMM) and 0.66 (Least Squares), which is relatively large. Foreign real money balances appreciate the

[11] For GMM see Wooldrige (2002). We appeal to the facts that the estimator is appropriate when the economic model is not fully specified and that it is a robust estimator because it does not require information about the exact distribution of the error term.

[12] In all regressions, we use a robust Newey-West method to calculate the variance-covariance matrix.

[13] The *level* of the real exchange rate is a random walk, but the depreciation rate is not. The coefficients are statistically significantly different from 1. The p-value of the Wald statistic is zero.

real exchange rate, i.e., the sign is negative, and significant.[14] The coefficient α_{13} is – 0.69 (GMM) and -0.54 (Least Squares). These coefficients sum to zero as some of the exchange rate determination models predict.[15]

The term of trade also appreciates the real exchange rate, the sign of α_{14} is negative, and the coefficient is significant. The size is relatively larger in GMM. It suggests that a one percent increase in the term of trade over last period's value leads the depreciation rate to fall (appreciation) by about ½ percent in GMM and ¼ in Least Squares. This results is consistent with most of the findings in the literature on the effect of the term of trade on the real exchange rate. The GCC has experienced positive term of trade shocks lately because of the increase in the price of oil. More than 70 percent of the GCC exports are oil and gas.[16]

Even though the model has productivity differential in tradable goods only, this variable is significant and has the right sign.[17] An increase in productivity in tradable goods sector at home relative to that of the trading partners appreciates the real exchange rate. It increases the price of non-tradable goods relative to tradable good prices, and it may explain the latest increases in housing prices and services.

The income elasticity of the demand for real money balances is small in the Least Squares regression, 0.21, which is similar to estimates found in the literature for advanced countries. However, it is not different from unity in GMM.[18] This magnitude is higher than the typical short-run elasticity we estimate for advanced countries. Actually, we expected it to be a little larger than unity. But it is clear that the GCC banking system has come a long way. Financial services are very modern and the use of plastic cards and ATM is widespread, which might explain the surprisingly low elasticity.

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[14] Students of the exchange rate know that the literature on the monetary model of the exchange rate determination and the real interest rate differential model of the exchange rate determination is full of empirical studies that show that money has the wrong sign and that the models' restriction do not actually hold.

[15] The Wald statistic's p-values to test this hypothesis are 0.8724 and 0.6828 for GMM and Least Squares respectively.

[16] We tried government expenditures, government expenditures to GDP ratio and the difference between government expenditures in the GCC countries and the US, and Europe. We found the coefficient estimates to be insignificant so we dropped these variables from the regressions.

[17] Productivity in non-tradable good sectors is very difficult to measure. The productivity differential in tradable good sectors between the GCC and their major trading partners such as Europe, Asia and the US, is calculated by the IMF staff.

[18] We test whether $\alpha_{21} = 1$; the Wald statistic's p-value is 0.7938.

The price equation is estimated in an unrestricted form and the restriction is tested. The restriction holds very well in the US dollar regressions. In GMM, the coefficients α_{31} (coefficient of the domestic price) and α_{32} (coefficient of the foreign price) sum to one.[19] The result is self explanatory; on average more than 2/3 of the inflation in the GCC countries is imported from abroad, which is a very consistent feature of fixed foreign exchange rate regimes.

In the final equation, an increase in the real price of oil has a positive effect on output. Remember that these countries are oil producing countries, where oil and gas make up more than 2/3 of their production. Our estimate suggests that a 100 percent increase in the real price of oil at Dubai increases real GDP growth by 5 percent, reasonably high. A one percent increase in the US real interest rate reduces output growth in GCC by about 1 percent. The magnitude seems large. The easy monetary policy in the US, i.e., lower exchange rate and lower interest rate, might explain the expansionary phase in the GCC and the consequent inflationary pressures. The US growth rate of GDP has a significant and large effect on GDP growth in the GCC countries. These results need no further explanation.

Next, we computed the real exchange rate, foreign real money balances, foreign price, real oil price, foreign real interest rate and foreign real GDP in Euro dollar. We re-estimated the model and reported the results in the last four columns of table 2. Foreign real money balances have huge effect on the depreciation rate, several times larger than the effect in the US dollar regressions. The restriction that the coefficients of the domestic and the foreign real money balances sum to zero is rejected by the Wald statistic. The income elasticity of the demand for real money balances is pretty small and significant at the 10 percent level only. Finally, about 90 percent of domestic CPI inflation is imported. The restriction that $\alpha_{31} + \alpha_{32} = 1$ is not rejected.[20]

If these results were to be believable then the GCC countries, on average, would have been experiencing more imported inflation from Europe than under the current US dollar peg. This might be true since the GCC imports more goods and services from Europe than from the US. In both the US dollar and the Euro dollar regressions, the J statistic for the over-identifying restrictions of the instruments is insignificant so the hypothesis of over-identification cannot be rejected.

We solve the model for $\Delta \ln q_t$ and compute the effect of the increase in the real price of oil on the real depreciation rate in the US dollar regression. We found that a 100 increase in real price of oil would appreciate the real exchange rate by

[19] The p-value of the Wald statistic is 0.4343. The restriction also holds in Least Squares; the Wald statistic's p-value is 0.1257.

[20] The p-value of the Wald statistic is 0.7693.

3 percent only. The adverse effect on the competitiveness of the GCC is trivial. For the Euro dollar regression, the effect of the increase in the real price of oil on the real depreciation rate is smaller by a magnitude of 10; a 100 percent increase in the real price of oil measured in Euro dollar would appreciate the real exchange rate by 0.30 percent only. These results indicate that recent increase in the real price of oil has no significant effect on competitiveness on average.

5. Testing the conditional variability of the systems

The system's four equations for Δq, $\Delta(m-p)$, Δp, and Δy have the residuals matrix shown in appendix 2. We have a four-column matrix and six countries stacked. Using Least Square residuals, we have 35 observations for each country (1972-2006) in the US dollar system. For the Euro dollar, we have 15 observation for each country (1992-2006). For GMM we 28 and 11 respectively because of the observations we lose for the instruments. The smallest sample n is 11. Ganadesikan and Gupta (1970) show that a sample of minimum 10 observations is required to precisely estimate the Sample Generalized variance.

Examining the residuals of all four regressions reported in table 2 indicates that all the residuals of the US dollar system are I (0). The residuals of the Euro dollar system are much more difficult to test because of the small sample. The unit root could not be rejected in a few tests.

Figure 13 plots the 6 values of $R(D_k) \sim$ standard normal for the US and the Euro dollar cases from the Least Squares and the GMM regressions. The US dollar test statistics are the light colors and the Euro dollar test statistics are the darker colors. We could use either $\pm 2\sigma$ or $\pm 3\sigma$ as critical upper and lower limits beyond which the static is considered significant and the null hypothesis of stability is rejected.[21]

Both Bahrain and Kuwait are indifferent to whether they peg to the US dollar or the Euro dollar. Oman is much worse off Bahrain and Kuwait under the current US dollar peg than a hypothetical Euro peg. For Least Squares, Saudi Arabia and the UAE are also worse off under the current US dollar peg, but Saudi Arabia is much worse off than the UAE. In GMM, Saudi Arabia and the UAE are equally worse off under the current US dollar peg. The three countries, Oman, Saudi Arabia and the UAE could have been better off pegging to the Euro. Qatar is the only country that is worse off pegging to the Euro. The question is why these countries are so different and segmented is an issue worth studying in future research.

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[21] The conditional variability measure is positive as usual, but our test statistic was converted to a standard normal so there are positive and negative values and should not be confusing.

There is one concern about Kuwait. Kuwait has pegged to a basket of currencies up until 2003, then pegged briefly to the US dollar, and back again to a basket in 2007 as we mentioned earlier. The weight of the US dollar is suspected to dominate all other currencies. The question is whether Kuwait is affecting the results. The statistics in figure 13 seem to suggest that this is not the case because Kuwait's conditional variability is relatively low. Nevertheless, we removed Kuwait from the model and recalculated the statistics. We found no change in the results.

6. Conclusions

We asked two questions: what is the size of the effect of the rise in real oil prices on competitiveness? And, would the GCC countries been better off had they pegged their currencies to the Euro dollar in 1991? We provided a small estimated model for the GCC countries, which consisted of four equations: the real exchange rate, real money balances, real output and the price level. We estimated the model in first differences; used Least Squares and GMM for a panel of the GCC countries; with a fixed effect for both the US dollar peg regime (1970-2006) and a hypothetical Euro- dollar peg regime (1991-2006). We estimated the size of the effect of the rise in oil prices on the real exchange rate and then we provided a test statistic based on the Sample Generalized Variance for the variability of the system under each exchange rate peg, the US and the Euro dollar.

Our estimates suggest that the increase in the real price of oil has a little effect on competitiveness – measured by the real depreciation rate. Further, our estimates suggest that about 2/3 of the domestic CPI inflation in the GCC is imported under the US dollar peg system, and could have been up to 90 percent had the GCC countries pegged their currencies to the Euro dollar. These estimates suggest that the GCC peg to the US dollar is probably less inflationary than the Euro. Foreign real interest rate and foreign output growth have significant and large impacts on the GCC economies. The increase in the real price of oil has a positive and significant impact on GDP growth. None of these results are surprising.

Then we provided a test statistic for the conditional variability of the model. We found that the GCC countries conditional variability differ significantly across member countries. This result was a little surprising. Both Bahrain and Kuwait are indifferent to whether they peg to the US dollar or the Euro dollar. Oman is much worse off than Bahrain and Kuwait under the current US dollar peg. Saudi Arabia and the UAE are the most affected by the peg to the US dollar. It could be argued that these three countries could have been much better off pegging to the Euro dollar. Qatar is the only country that is worse off pegging to the Euro.

To fix the domestic currency to another, *a major and a stable one,* is to provide an anchor to the economy. The same principle applies for a basket, i.e., the currencies must provide stability to the local economy. In the case of the US dollar peg, the GCC monetary policy must inevitably mimic the US monetary policy, i.e., domestic monetary policy is not independent. Problems arise when shocks that affect the foreign economy whose currency is used as the anchor (the US economy) are different from the shocks affecting the domestic economy (the GCC). For example, if the Federal Reserve Bank expects a recession it is expected that they will ease monetary conditions, i.e., lower the interest rate. And when the current account deficit is large the US dollar "could be" left to depreciate until the imbalances are eliminated and equilibrium is restored. Meanwhile, the GCC could be facing a different shock such as soaring oil prices, i.e., boom. Swings in currencies are persistent. In other words, the US dollar may continue to depreciate – if the US government does not intervene – until equilibrium in the current account is re-established. So for the GCC to switch to another currency or a basket of currencies might only be a short-term relief, then what? What will happen when the Euro dollar begins to slide at some point in the future? The GCC countries could continue to peg their currencies to the US dollar and endure the pain, but for how long would they be willing to endure the pain? It certainly depends on their tolerance level, the magnitude of the pain an the damage it might cause etc. Alternatively, they could switch to the Euro or to a basket peg system, but the solution is also a short term one. This is the policy problem.

A more robust resolution to the problem lies in the government(s) choice between domestic price stability or currency stability. The situation today is one where the GCC countries face different economic shocks than the US and their hands are tied behind their backs because the exchange rate is fixed to the US and monetary policy is ineffective and not independent. Inflation is a serious issue that could undermine the GCC economies and most of it is imported because the current monetary arrangement.

Central bankers and monetary economists know that they cannot stabilize both the exchange rate and domestic prices at the same time, one of them must be free to move. The fixed exchange rate regime is a constraint. It imposes a difficult trade-off between currency stability, monetary independence and capital market openness. These three things maybe very difficult to have in the same time, i.e., the well-known *tri-lemma* (Obstfeld, Shambaugh and Taylor, 2004).

It will all depend on the country's preference. (1) If the GCC countries want independent monetary policy and free capital mobility then they cannot fix the exchange rate because it does not allow for a monetary policy independence. (2) If they want to enjoy higher incomes from higher oil prices and currency stability then they have to accept inflation and its consequences. (3) If they want stable domestic inflation then they should let the currency float – an inflation targeting system coupled with a floating exchange rate.[22] Or, they could continue to peg

[22] Economists have not settled the debate on whether inflation targeting is superior to price level targeting. We will not discuss the issue here because its time has not come up yet.

the currency to the US dollar and endure the pain associated with its depreciation and higher domestic inflation until the storm passes by. Pegging to another currency or to a basket of currencies is neither a permanent solution nor the right question to ask.

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Table 1: Descriptive Statistics

Variable	Bahrain		Kuwait		Oman		Qatar		Saudi Arabia		UAE		USA		Europe	
	$\overline{X}$	S	$\overline{X}$	S	$\overline{X}$	S	$\overline{X}$	S	$\overline{X}$	S	$\overline{X}$	S	$\overline{X}$	S	$\overline{X}$	S
Δq (US)[i]	-0.01	0.08	-0.02	0.12	-0.01	0.11	-0.04	0.15	-0.02	0.11	-0.06	0.11	-	-	-	-
	(-0.08)		**(-0.096)**		**(-0.068)**		**(-0.10)**		**(-0.04)**		**(-0.13)**					
Δq (EUR)	-0.007	0.11	-0.03	0.16	-0.01	0.12	-0.03	0.16	-0.01	0.12	-0.02	0.10	-	-	-	-
$\Delta(m-p)$	0.07	0.18	0.05	0.13	0.08	0.13	0.07	0.17	0.08	0.12	0.06	0.23	-	-	-	-
$\Delta(m-p)^*$	-	-	-	-	-	-	-	-	-	-	-	-	0.07	0.16	0.03	0.02
ΔToT	0.02	0.11	0.08	0.27	0.05	0.27	0.03	0.29	0.05	0.25	0.05	0.22	-	-	-	-
$\Delta\hat{d}$	0.00	0.06	-0.04	0.13	0.00	0.10	-0.02	0.10	-0.01	0.08	-0.05	0.08	-	-	-	-
Δy [i]	0.05	0.05	0.02	0.16	0.06	0.07	0.04	0.08	0.04	0.06	0.05	0.07	-	-	-	-
	(0.07)		**(0.05)**		**(0.06)**		**(0.08)**		**(0.04)**		**(0.09)**					
Δs (US)	-0.006	0.02	-0.006	0.03	-0.002	0.03	-0.007	0.02	-0.005	0.02	-0.007	0.02	-	-	-	-
Δs (EUR)	-0.000	0.09	0.000	0.09	0.004	0.10	-0.001	0.09	0.001	0.09	-0.000	0.09	-	-	-	-
Δm	0.11	0.18	0.10	0.09	0.14	0.13	0.15	0.13	0.15	0.15	0.16	0.19	-	-	-	-
Δp	0.05	0.09	0.05	0.12	0.05	0.11	0.07	0.15	0.06	0.12	0.09	0.18	-	-	-	-
	(0.108)		**(0.119)**		**(0.097)**		**(0.132)**		**(0.073)**		**(0.163)**					
$\Delta\hat{p}$	0.04	0.06	0.03	0.06	0.03	0.04	0.06	0.06	0.04	0.07	0.07	0.06	-	-	-	-
	(0.029)		**(0.029)**		**(0.031)**		**(0.112)**		**(0.02)**		**(0.096)**					
Δp^o	-	-	-	-	-	-	-	-	-	-	-	-	0.06	0.32	-	-
Δp^o	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.06	0.23
R^*	-	-	-	-	-	-	-	-	-	-	-	-	0.05	0.026	0.03	0.014
Δy^*	-	-	-	-	-	-	-	-	-	-	-	-	0.03	0.02	0.02	0.01

All data are in natural logs except for the interest rates, asterisks denote the foreign magnitudes. Nominal exchange rate s defined as the domestic price of the foreign currency (USD and Euro alternatively); p is the GDP price deflator (2000=100) ; $\hat{p}$ is the CPI (2000=100); q is the real exchange rate; m is money plus quasi money; ToT is the term of trade (2000=100); $\hat{d}$ is tradable good productivity differential with trading partners; y is real GDP (expenditure side); p^0 is the real price of oil (Dubai), and R^* is the foreign 90-day interest rate. The source of the data is the IMF-IFS and the World Economic Report. $\overline{X}$ denotes the mean and S denotes the standard deviation. The sample is 1970-2006 except for variables involving Europe, where the sample is 1991-2006.

i The numbers in boldface in parentheses are the values in 2006.

Table 2

$$7\ \Delta q_{it} = \alpha_{11}\Delta q_{it-1} + (1-\alpha_{11})[\alpha_{12}\Delta(m_{it} - p_{it}) + \alpha_{13}\Delta(m_t - p_t)^* + \alpha_{14}\Delta ToT_{it} + \alpha_{15}\Delta\hat{d}_{it}] + \Delta\varepsilon_{7it}$$

$$8\ \Delta(m-p)_{it} = \alpha_{21}\Delta y_{it} + \Delta\varepsilon_{8it}$$

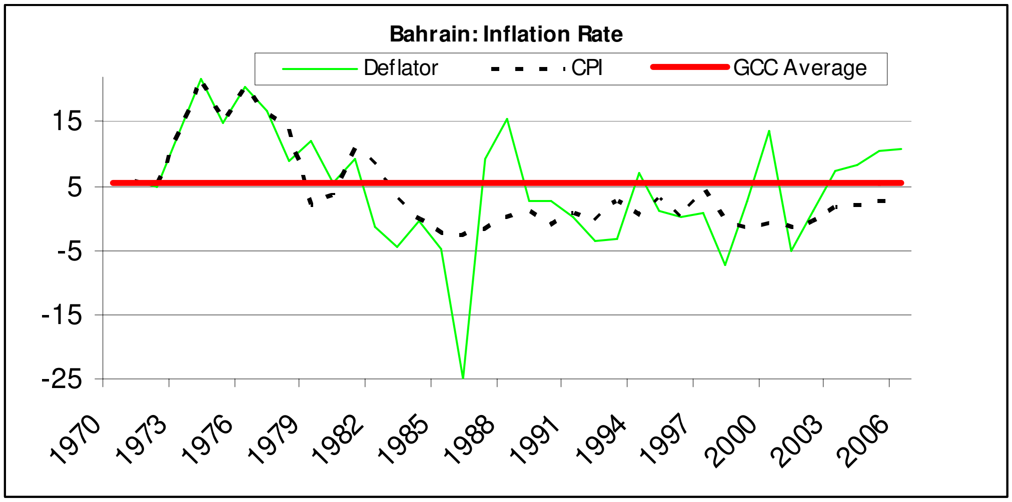
$$9\ \Delta\hat{p}_{it} = \alpha_{31}\Delta p_{it} + \alpha_{32}(\Delta p_t^* + \Delta s) + \Delta\varepsilon_{9it}$$

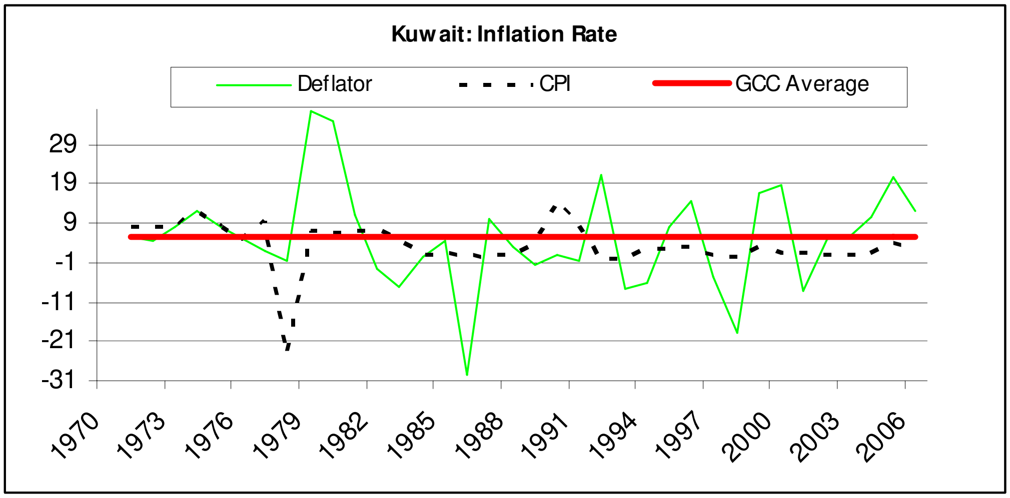
$$10\ \Delta y_{it} = \alpha_{41}\Delta(p_{it}^o + s_{it}) + \alpha_{42}R_t^* + \alpha_{43}\Delta y_t^* + \Delta\varepsilon_{10it}$$

	USD (1970-2006)				Euro (1991-2006)			
	Least Squares		GMM[iii]		Least Squares		GMM[iv]	
Parameters	coefficient	p- value	coefficient	p-value	coefficient	p-value	coefficient	p-value
α_{10}	-0.03	0.0003	-0.01	0.1737	0.01	0.6977	0.03	0.0212
α_{11}	0.30	0.0000	0.13	0.0001	0.23	0.0289	0.02	0.0001
α_{12}	0.66	0.0000	0.63	0.0000	0.93	0.0001	1.60	0.0000
α_{13}	-0.54	0.0848	-0.69	0.0876	-2.20	0.0001	-4.06	0.0000
α_{14}	-0.25	0.0000	-0.52	0.0000	0.004	0.9697	-0.31	0.0004
α_{15}	-0.14	0.1313	-0.35	0.0006	-0.07	0.7717	-1.1	0.0000
α_{20}	0.06	0.0000	0.02	0.1405	0.06	0.0000	0.05	0.0000
α_{21}	0.21	0.0769	1.08	0.0007	0.21	0.0772	0.11	0.1664
α_{30}	0.006	0.2860	-0.01	0.1044	0.01	0.0000	0.01	0.0000
α_{31}	0.15	0.0000	0.39	0.0000	0.07	0.0038	0.09	0.0009
α_{32}	0.70	0.0045	0.74	0.0000	0.03	0.2582	0.89	0.0002
α_{40}	0.02	0.0712	0.03	0.0061	0.05	0.0000	0.05	0.0000
α_{41}	0.06	0.0012	0.05	0.0287	0.01	0.5701	0.04	0.0002
α_{42}	-1.04	0.0003	-1.08	0.0000	-0.94	0.0521	-1.60	0.0000
α_{40}	1.20	0.0002	1.04	0.0007	0.63	0.4074	1.20	0.0004
	4.02E-09[i]		3.74E-09[i] 0.13810[ii]		2.45E-10		9.72E-11 0.1955[ii]	

i-Determinant of the residuals covariance matrix.
ii-J statistic to test for the over-identification of the instruments, distributed.
iii-The instruments are all in first differenced form and include a constant in every equation: eq. (8) [trend, eight lags of the term of trade, four lags of productivity differential, and four lags of government expenditures]; (9) [four lags of foreign real GDP, eight lags of the nominal price of oil, two lags of the nominal spot exchange rate, and four lags of foreign real GDP]; eq. (10) [four lags of the US price level] and eq. (11) [eight lags of the nominal price of oil and eight lags of the nominal exchange rate]. Kernel is Bartlett, Bandwidth fixed equal to 4, no pre-whitening, coefficients iterated after one-step weighting matrix. Convergence achieved after 1 weight matrix and 6 total coefficient iterations.
iv- The instruments: eq. (8) [four lags of the term of trade, four lags of the real money balances, four lags of the foreign real money balances, and four lags of productivity differential]; eq. (9) [four lags of foreign real GDP]; eq. (10) [four lags of domestic price level] and eq. (11) [four lags of the nominal price of oil and four lags of the nominal exchange rate. Kernel is Bartlett. Bandwidth is fixed equal to 3. no pre-whitening, coefficients iterated after one-step weighting matrix. Convergence achieved after 1 weight matrix and 6 total coefficient iterations. The restriction in equation (10) that $\alpha_{31} + \alpha_{32} = 1$ is tested and the Wald statistic P-values are 0.1257, 0.4343, 0.00 and 0.7693 in the four regressions respectively.

Figure 1


Bahrain: Inflation Rate
Deflator
CPI
GCC Average
15
5
-5
-15
-25
1970
1973
1976
1979
1982
1985
1988
1991
1994
1997
2000
2003
2006


Kuwait: Inflation Rate
Deflator
CPI
GCC Average
29
19
9
-1
-11
-21
-31
1970
1973
1976
1979
1982
1985
1988
1991
1994
1997
2000
2003
2006

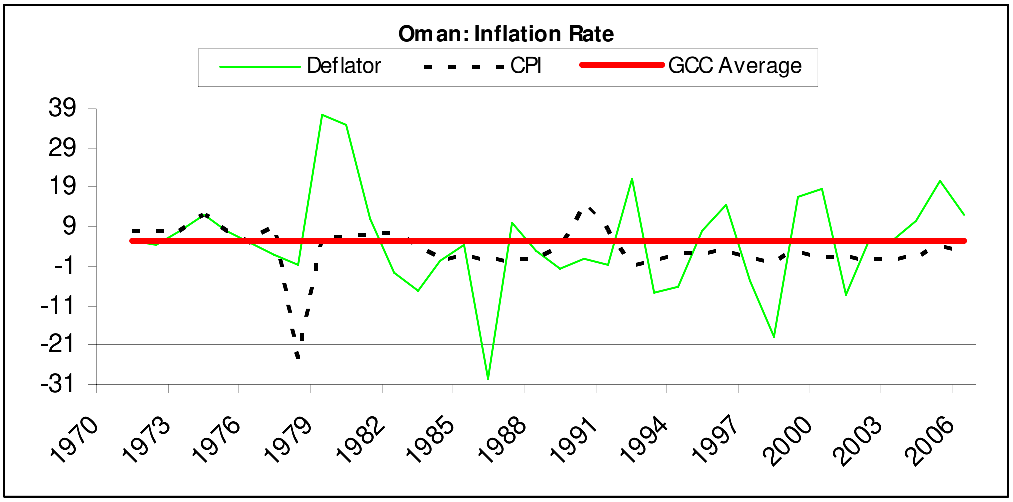
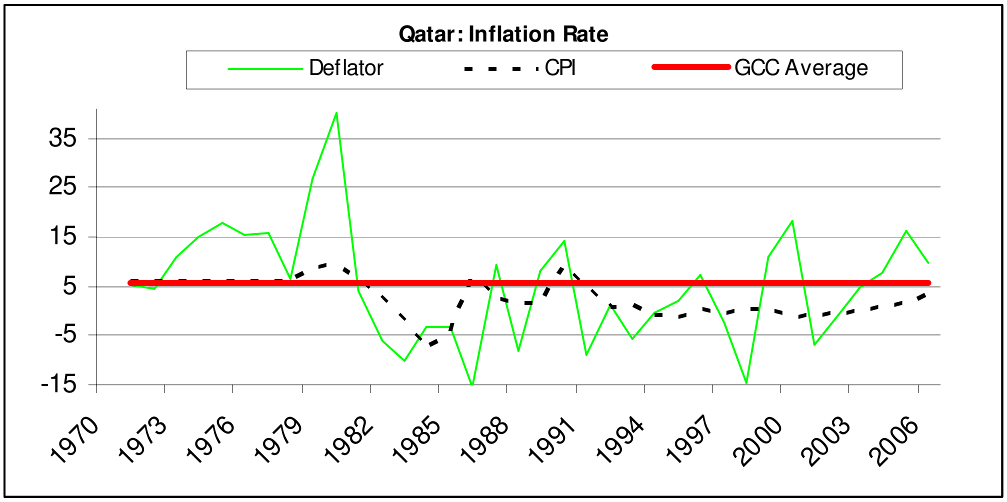
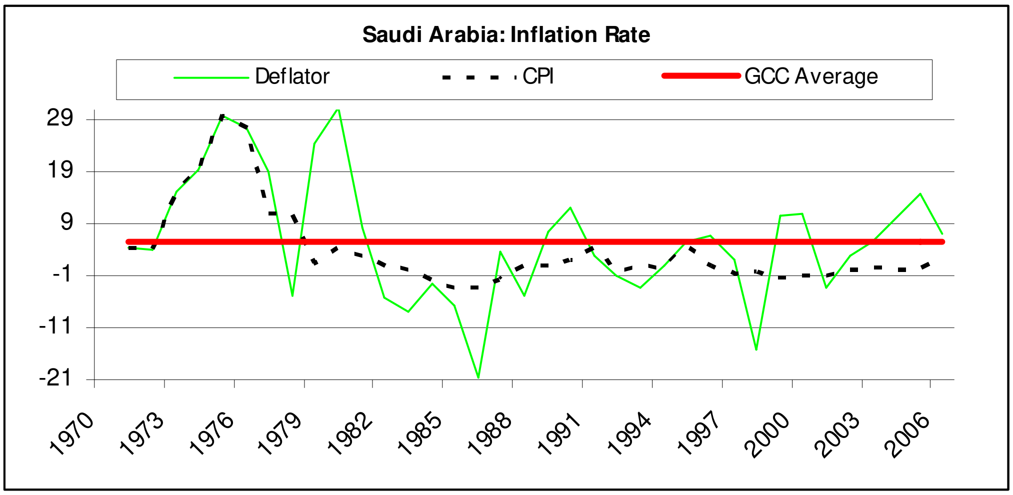
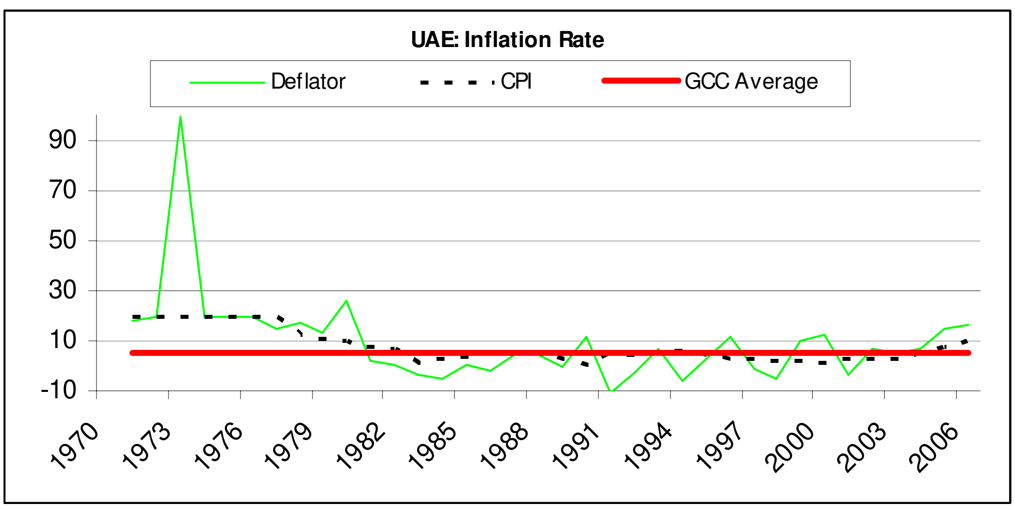

Oman: Inflation Rate
Deflator
CPI
GCC Average
39
29
19
9
-1
-11
-21
-31
1970
1973
1976
1979
1982
1985
1988
1991
1994
1997
2000
2003
2006

Figure 1 – Continued







We sum of the CPI and the GDP deflator for each country and take the average then we average across the six GCC countries.

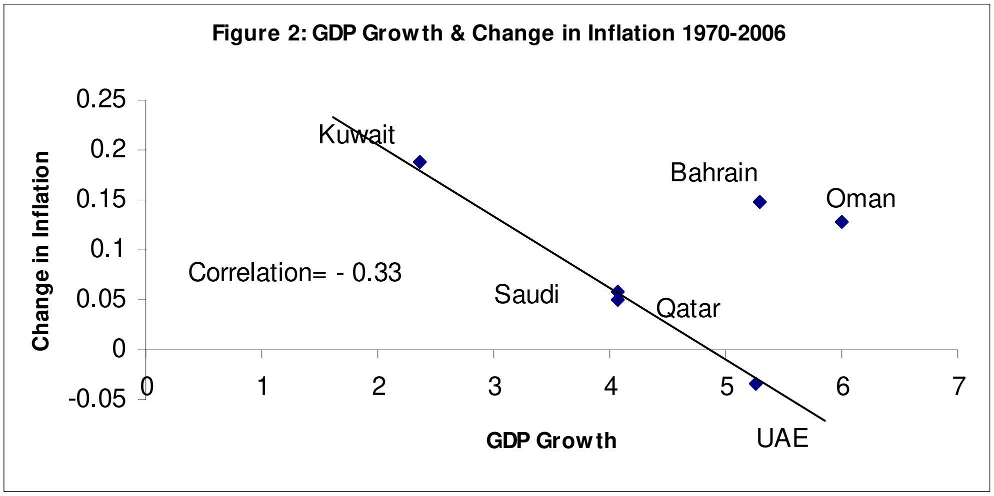


Figure 2: GDP Growth & Change in Inflation 1970-2006
Change in Inflation
0.25
0.2
0.15
0.1
0.05
0
-0.05
0
1
2
3
4
5
6
7
GDP Growth
Kuwait
Bahrain
Oman
Correlation= - 0.33
Saudi
Qatar
UAE

Figure 3: Log Real and Nominal Exchange Rates

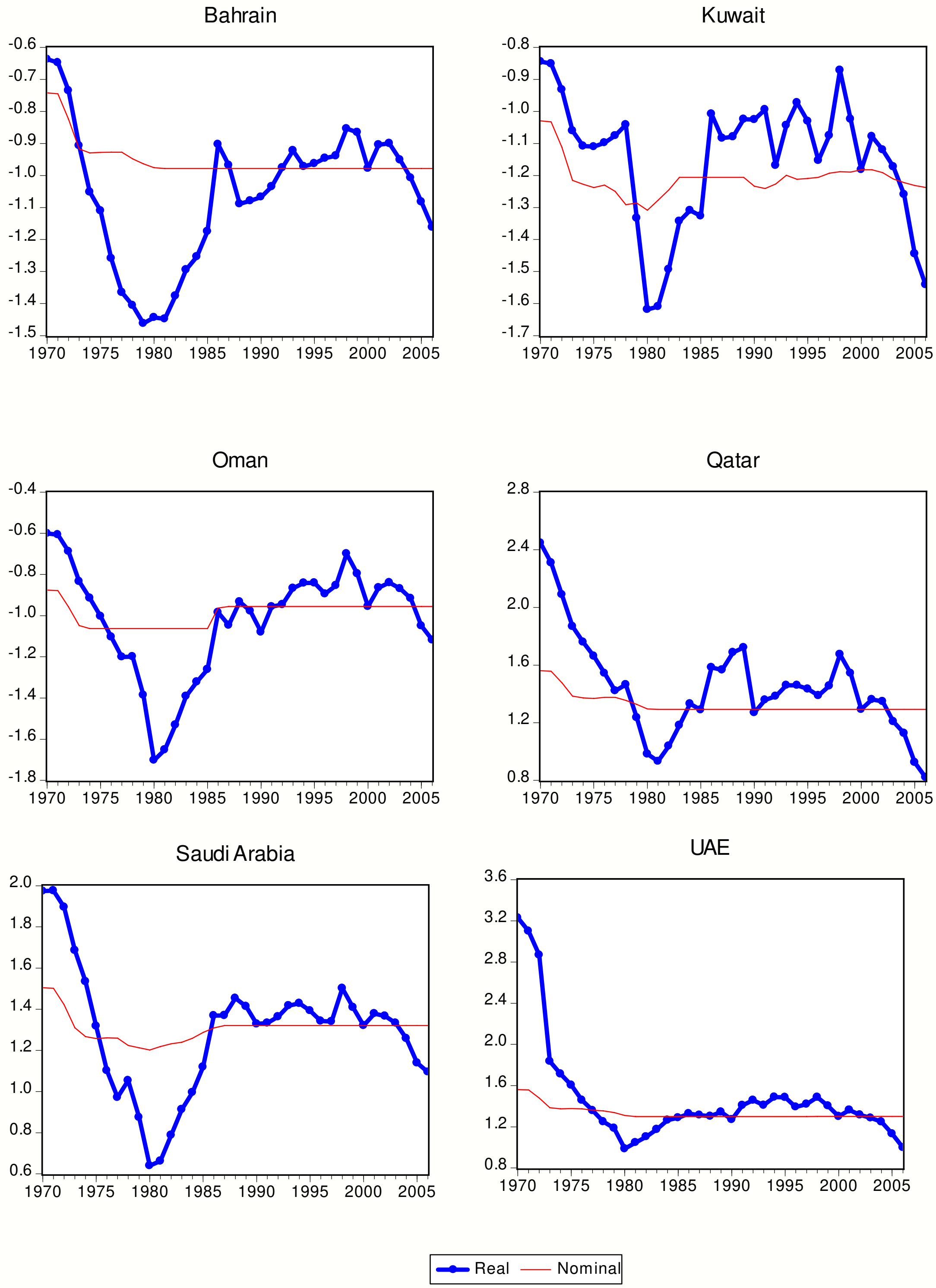


Figure 4: US and GCC Log Price Deflator

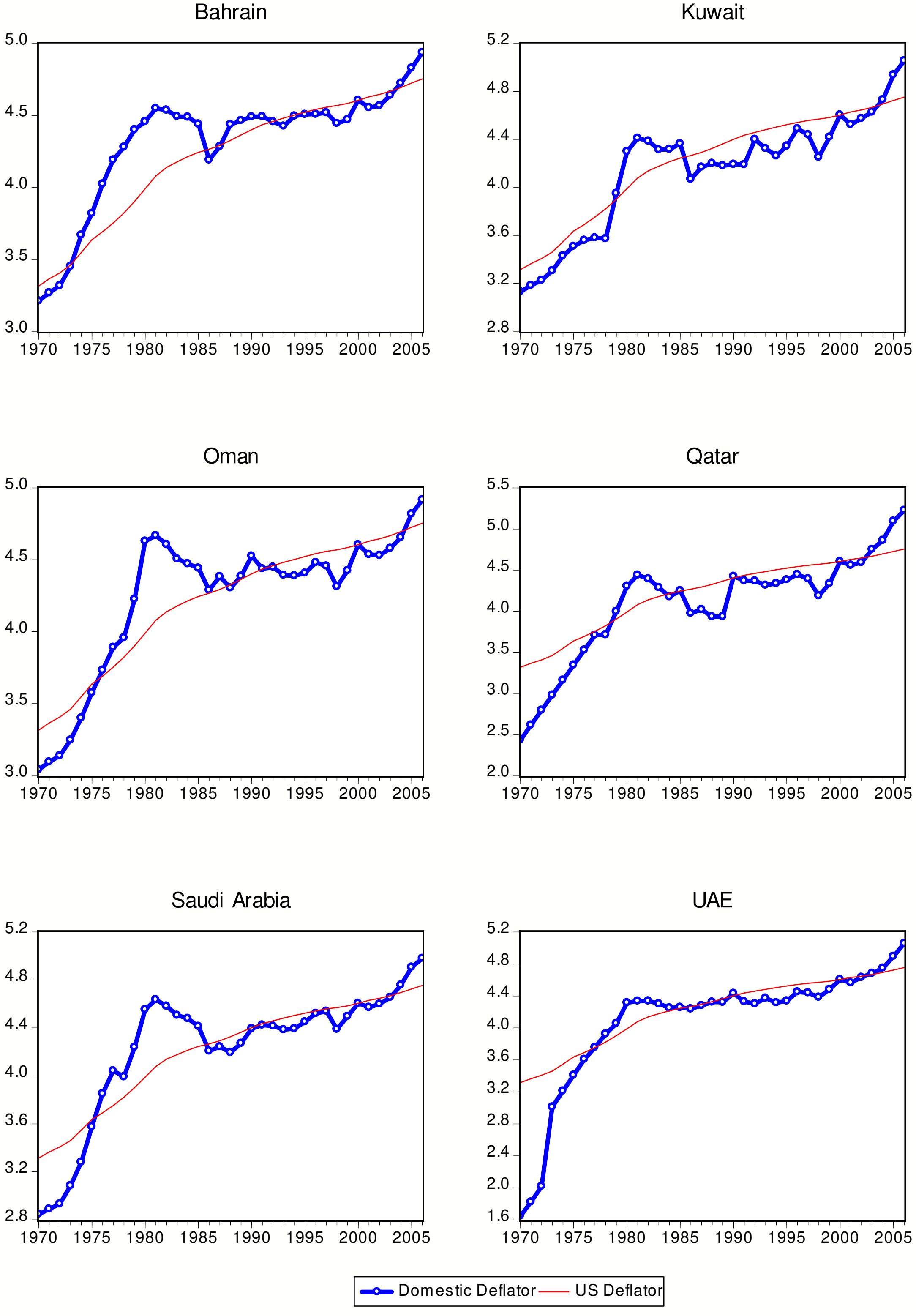


Figure 5: Log Real Money Balances

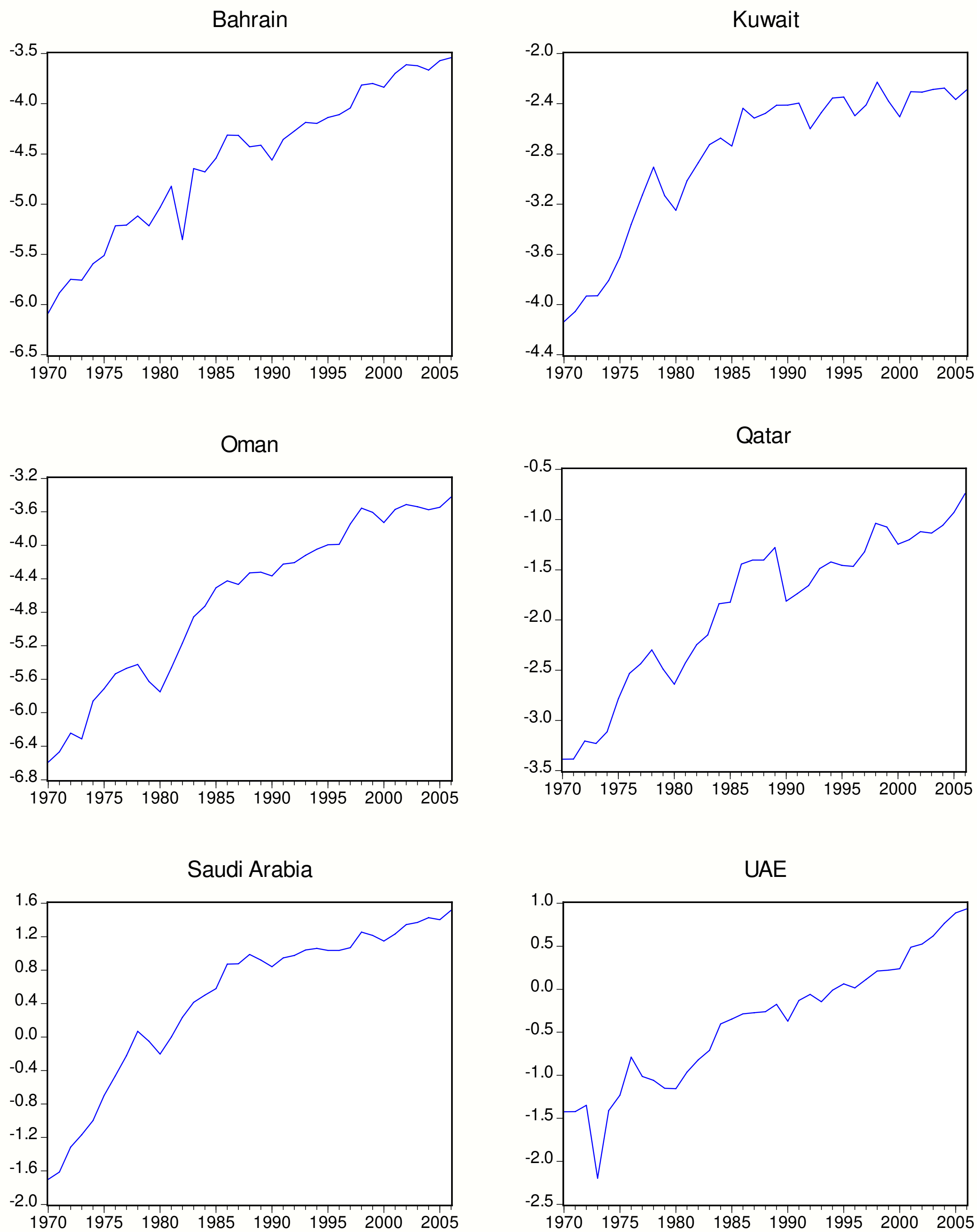



Figure 6: Log Term of Trade
Bahrain
Kuwait
Oman
Qatar
Saudi Arabia
UAE
1970
1975
1980
1985
1990
1995
2000
2005

Figure 7: Log Real GDP

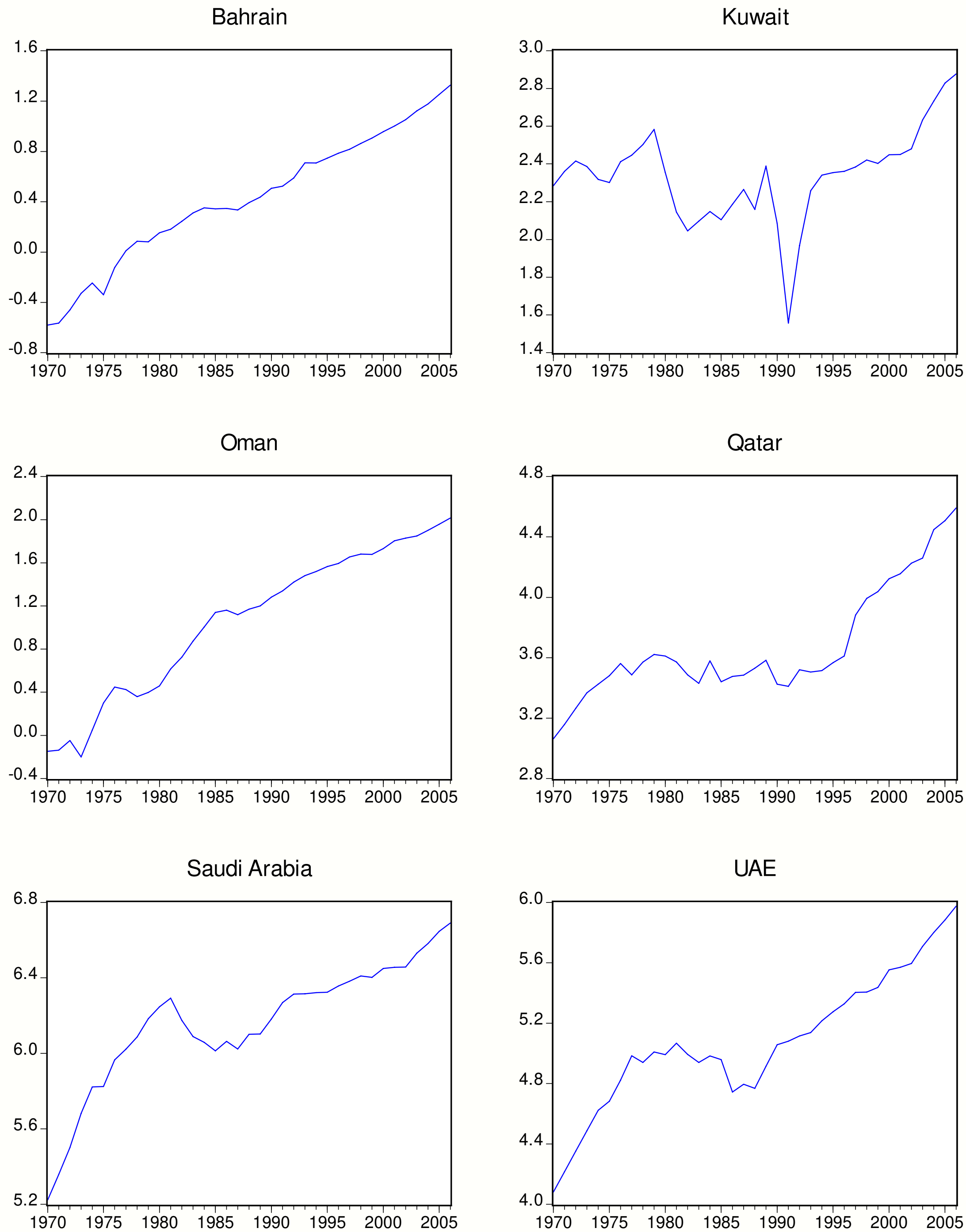


Figure 8: Log Price of Oil

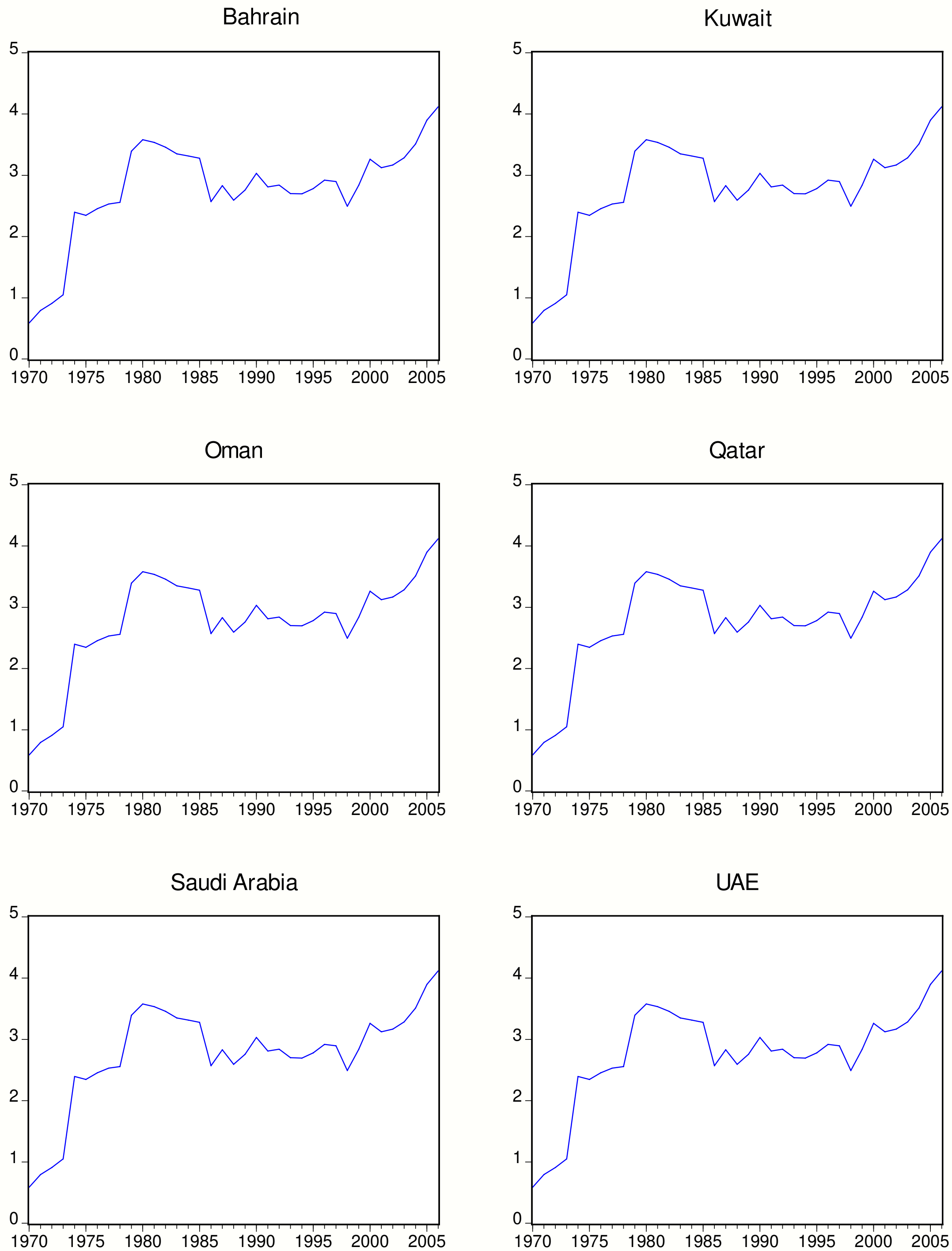


Figure 9: Log GDP Deflator

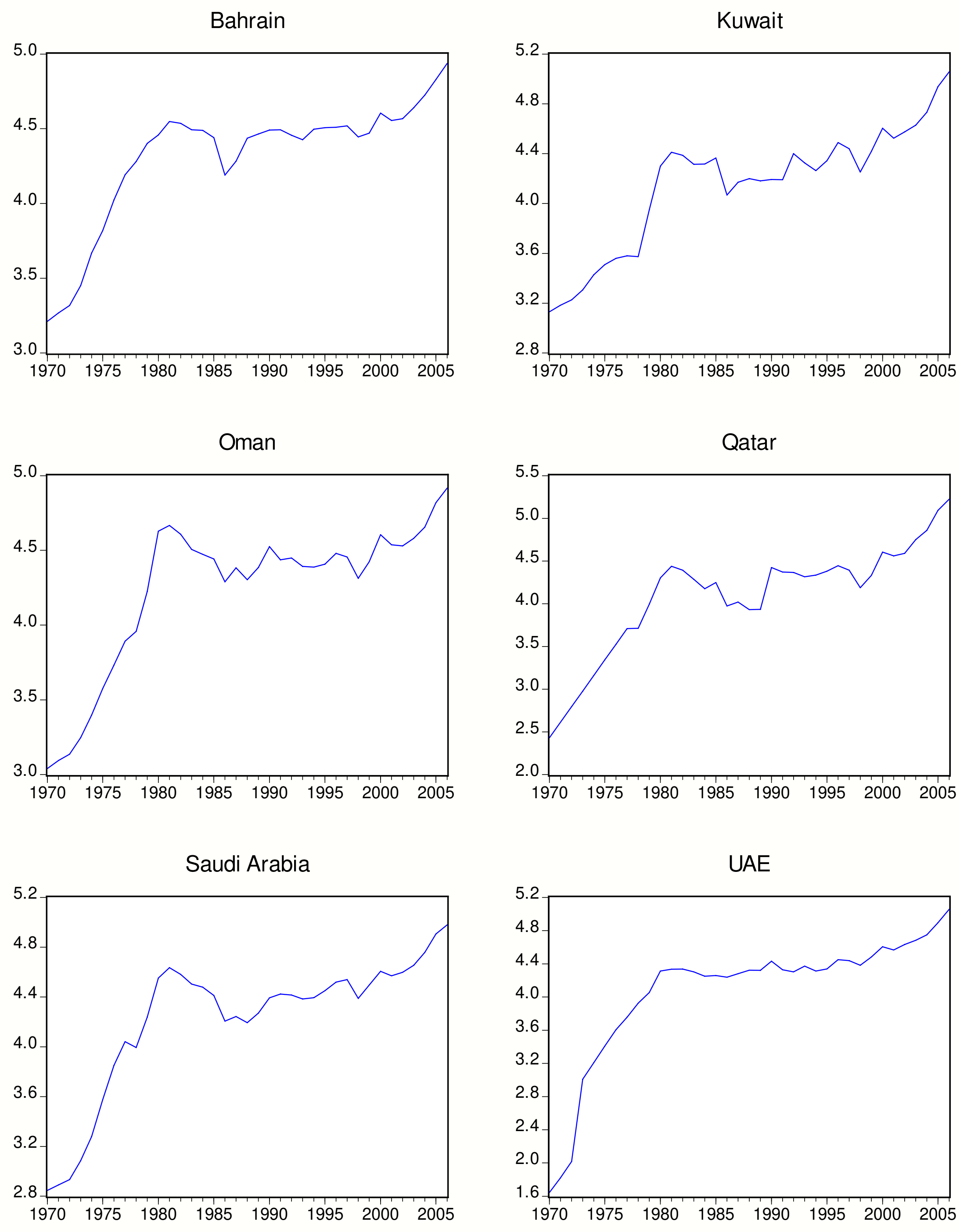
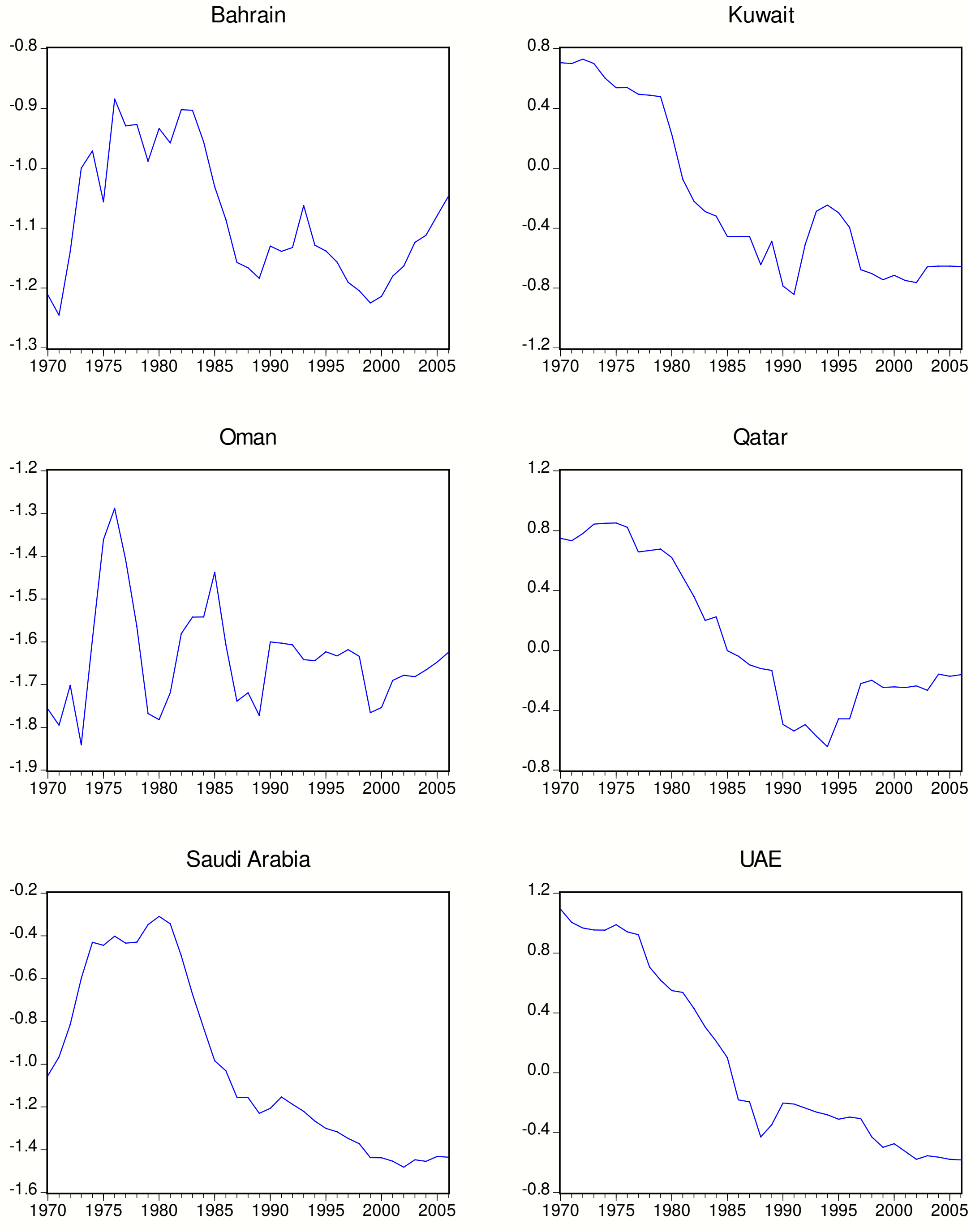


Figure 10: Log Productivity Differential



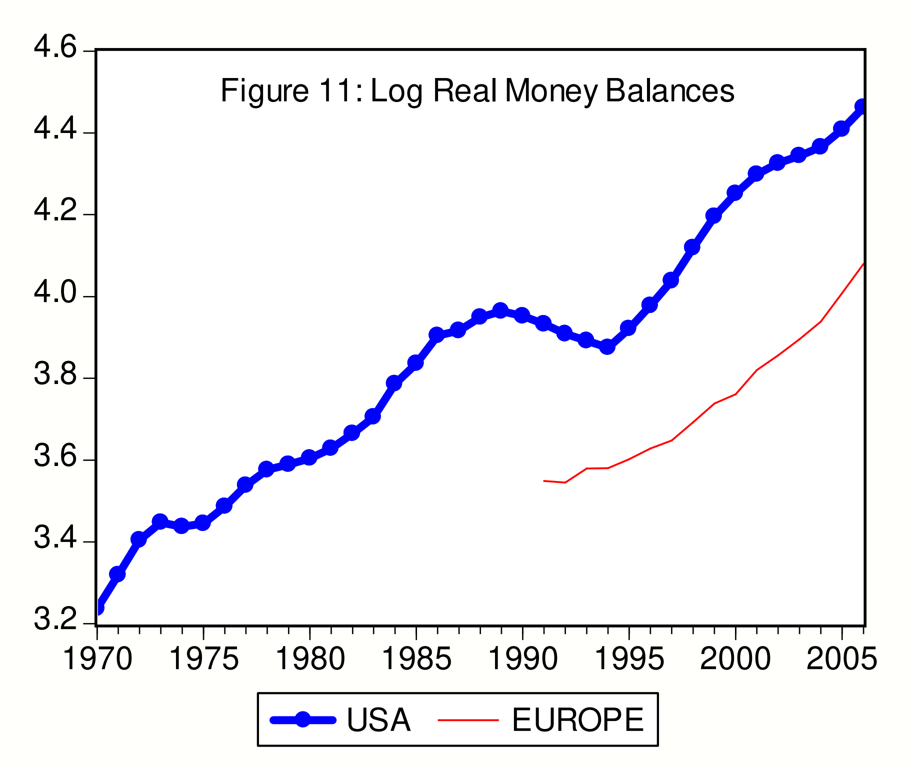


Figure 11: Log Real Money Balances
4.6
4.4
4.2
4.0
3.8
3.6
3.4
3.2
1970
1975
1980
1985
1990
1995
2000
2005
USA
EUROPE

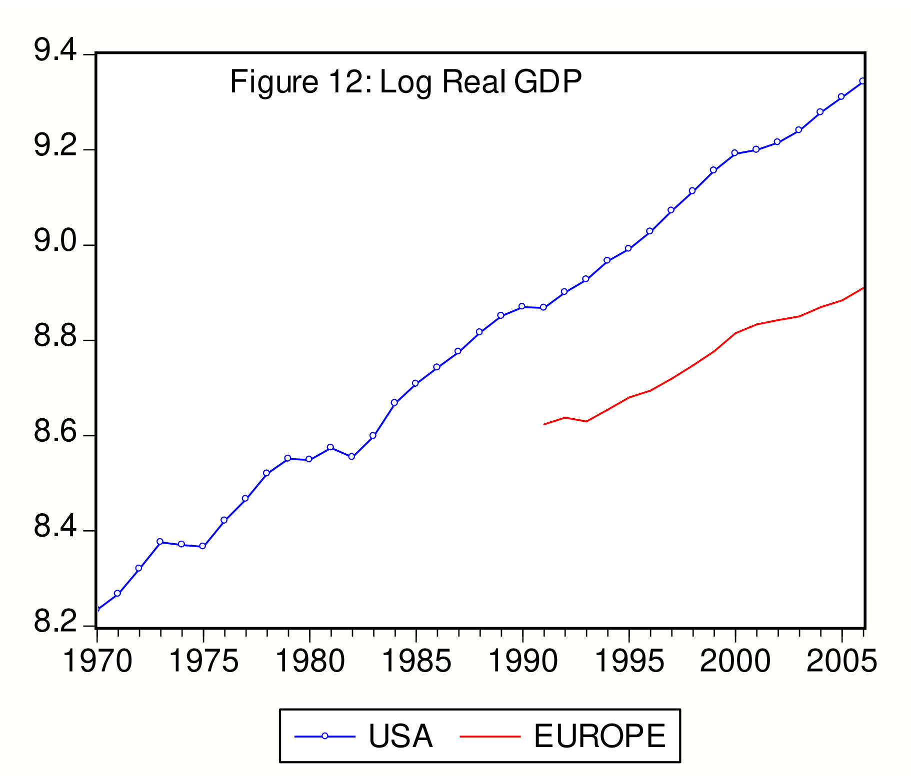
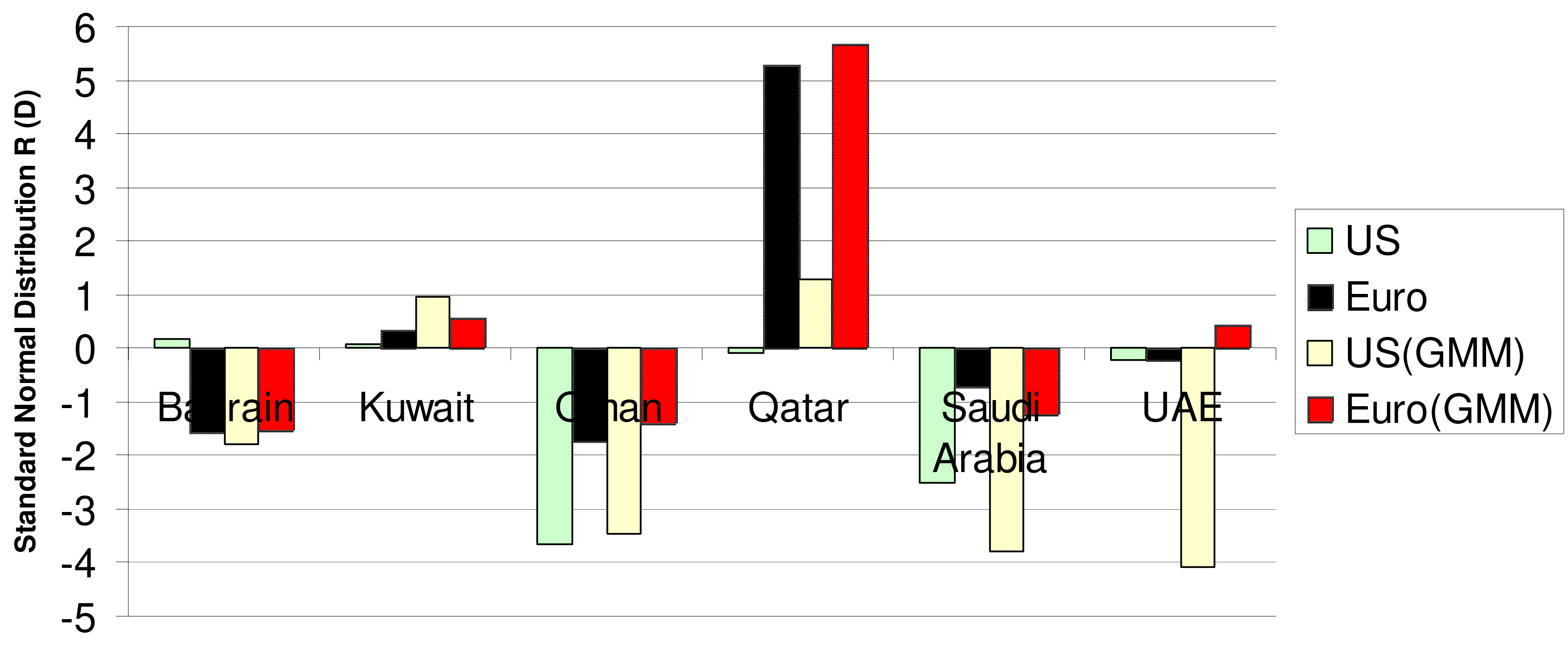


Figure 12: Log Real GDP
9.4
9.2
9.0
8.8
8.6
8.4
8.2
1970
1975
1980
1985
1990
1995
2000
2005
USA
EUROPE

Figure 13: Test Statistic for Sample Generalized Variance



Appendix 1: Data

Variable	
s	Nominal exchange rate defined as the domestic price of a unit of a foreign currency (increase means depreciation)
p	Domestic GDP deflator (2000=100)
p^*	Foreign GDP deflator (2000=100)
$\hat{p}$	Domestic CPI (2000=100)
q	$s+p^*-p$
m	Domestic money plus quasi money
m^*	Foreign money plus quasi money
tot	Term of trade index (2000=100)
$\hat{d}$	Tradable good productivity differential with the GCC trading partners
y	Domestic expenditure side real GDP (production side GDP is not available)
y^*	Foreign expenditure side real GDP
p^o	Dubai price of oil in US dollars deflated by the last period CPI
R^*	The 90-day real interest rate measured by the 90-day rate minus last period inflation rate as a proxy for expected inflation

Source: IMF database, IMF-IFS and the World Economic Report. Data are available upon request.

Appendix 2: Residuals Matrix

$$[BAH]\begin{bmatrix}\Delta q\\ \varepsilon_1\\ \vdots\\ \varepsilon_{35}\end{bmatrix}\begin{bmatrix}\Delta(m-p)\\ \varepsilon_1\\ \vdots\\ \varepsilon_{35}\end{bmatrix}\begin{bmatrix}\Delta p\\ \varepsilon_1\\ \vdots\\ \varepsilon_{35}\end{bmatrix}\begin{bmatrix}\Delta y\\ \varepsilon_1\\ \vdots\\ \varepsilon_{35}\end{bmatrix}$$

$$[KWT]\begin{bmatrix}\Delta q\\ \varepsilon_1\\ \vdots\\ \varepsilon_{35}\end{bmatrix}\begin{bmatrix}\Delta(m-p)\\ \varepsilon_1\\ \vdots\\ \varepsilon_{35}\end{bmatrix}\begin{bmatrix}\Delta p\\ \varepsilon_1\\ \vdots\\ \varepsilon_{35}\end{bmatrix}\begin{bmatrix}\Delta y\\ \varepsilon_1\\ \vdots\\ \varepsilon_{35}\end{bmatrix}$$

$$[OMN]\begin{bmatrix}\Delta q\\ \varepsilon_1\\ \vdots\\ \varepsilon_{35}\end{bmatrix}\begin{bmatrix}\Delta(m-p)\\ \varepsilon_1\\ \vdots\\ \varepsilon_{35}\end{bmatrix}\begin{bmatrix}\Delta p\\ \varepsilon_1\\ \vdots\\ \varepsilon_{35}\end{bmatrix}\begin{bmatrix}\Delta y\\ \varepsilon_1\\ \vdots\\ \varepsilon_{35}\end{bmatrix}$$

$$[QTR]\begin{bmatrix}\Delta q\\ \varepsilon_1\\ \vdots\\ \varepsilon_{35}\end{bmatrix}\begin{bmatrix}\Delta(m-p)\\ \varepsilon_1\\ \vdots\\ \varepsilon_{35}\end{bmatrix}\begin{bmatrix}\Delta p\\ \varepsilon_1\\ \vdots\\ \varepsilon_{35}\end{bmatrix}\begin{bmatrix}\Delta y\\ \varepsilon_1\\ \vdots\\ \varepsilon_{35}\end{bmatrix}$$

$$[SAD]\begin{bmatrix}\Delta q\\ \varepsilon_1\\ \vdots\\ \varepsilon_{35}\end{bmatrix}\begin{bmatrix}\Delta(m-p)\\ \varepsilon_1\\ \vdots\\ \varepsilon_{35}\end{bmatrix}\begin{bmatrix}\Delta p\\ \varepsilon_1\\ \vdots\\ \varepsilon_{35}\end{bmatrix}\begin{bmatrix}\Delta y\\ \varepsilon_1\\ \vdots\\ \varepsilon_{35}\end{bmatrix}$$

$$[UAE]\begin{bmatrix}\Delta q\\ \varepsilon_1\\ \vdots\\ \varepsilon_{35}\end{bmatrix}\begin{bmatrix}\Delta(m-p)\\ \varepsilon_1\\ \vdots\\ \varepsilon_{35}\end{bmatrix}\begin{bmatrix}\Delta p\\ \varepsilon_1\\ \vdots\\ \varepsilon_{35}\end{bmatrix}\begin{bmatrix}\Delta y\\ \varepsilon_1\\ \vdots\\ \varepsilon_{35}\end{bmatrix}$$