EDHEC-Risk Institute

393-400 promenade des Anglais
06202 Nice Cedex 3
Tel.: +33 (0)4 93 18 32 53
E-mail: research@edhec-risk.com
Web: www.edhec-risk.com

Macroeconomic Risk Management for Oil Stabilization Funds in GCC Countries

September 2009

Bernhard Scherer
Professor of Finance, EDHEC Business School

with the support of
Deutsche Bank

EDHEC BUSINESS SCHOOL

Abstract

The existence of oil stabilization funds as the largest category of sovereign wealth funds relies on oil prices as a main source of macroeconomic risk for oil exporting countries. Given the often contingent spending policies of oil stabilization funds (accumulating wealth when oil prices are rising and spending wealth to support the local economy when GDP is shrinking) it is important to understand the magnitude and relative importance of oil price shocks relative to other sources of macroeconomic risk. Using the Bernanke/Sims approach, we establish oil price innovations as the most important short- and long-term economic drivers of local GDP for GCC (Gulf Cooperation Council) countries. Investment guidelines for oil stabilization funds should therefore stress the necessity to invest in assets with negative correlation to oil price movements to protect the total wealth of an oil-exporting economy. Using a Bayesian VAR, we project the impact of different oil price scenarios on local GDP and hence the likely growth of oil stabilization funds. Under the pessimistic scenario (40% drop in oil prices from their 2009 level and 5% drop in global GDP over two years) a short two year contraction of about 10% per annum (in nominal USD terms) of sovereign wealth fund (SWF) assets is anticipated. In 2011 SWF growth is likely to be back to pre-crisis levels. Under a more optimistic scenario (10% drop in oil prices over two years) SWFs will experience a two-year period of zero growth with strong growth thereafter.

We would like to extend our sincere thanks to Deutsche Bank and acknowledge their support in enabling us to produce this working paper as part of the EDHEC/ Deutsche Bank 'Asset-Liability Management Techniques for Sovereign Wealth Fund Management' research chair.

1. Introduction

Oil (commodity) stabilization funds are the largest and economically most interesting subgroup of sovereign wealth funds (SWF).[1] Driven by the fast accumulation of foreign reserves due to booming oil prices and both (cheap) credit and momentum driven capital flows, SWFs became "institutional" investors in global asset markets.[2] Keen not to repeat the mistakes of the last oil boom in the 70's, oil-exporting countries established SWFs to preserve oil wealth for future generations and/or to smooth consumption. It is a stylized fact that volatile oil revenues are the main source of poor growth for developing countries with limited access to global debt markets. Aghion *et al.* (2006) supply empirical evidence that managing macroeconomic risks increases growth. Hamilton (2008) shows that oil price movements are unpredictable and volatile, with extremely wide confidence intervals.[3] This provides a powerful argument to reduce the volatility of oil related revenues as argued by Ploeg and Poelhekke (2009). Reducing swings in government revenues will itself increase welfare due to the positive impact of consumption smoothing on total welfare. However, the usual routes to consumption smoothing, *i.e.*, borrowing funds or hedging revenue risk, are not available due to limited access to international debt markets (precautionary savings motive) or incomplete markets for oil price hedging instruments (size, liquidity, contract choice).

Negative externalities from oil price volatility will also arise from the impact of oil price movements on real exchange rates ("Dutch disease") as well as the sustainability of fiscal policy. Temporarily overvalued real exchange rates (following short lived oil driven expansions) will render non-oil sectors uncompetitive. Krugman (1988) argues that if there are economies of scale connected with productive experience or with building customer networks (brand, reputation, etc.) long-term growth will be seriously compromised. Affected sectors (agriculture, manufacturing, etc.) might be lost forever as (oil-wealth driven) increases in demand favor local services and the import of consumption goods. Temporarily inflated budgets create entitlement and poor spending quality and will in general ratchet budgets upwards. The difficulty to distinguish between temporary oil price shocks (windfall gain should be saved and not consumed as total wealth did not change) and permanent oil price shocks (oil wealth increases and oil exporters should increase consumption) adds to the problem. Up to the end of 2008 the world was convinced that an oil price of USD140 a barrel reflected a permanent price increase driven by structural demand from emerging markets. This belief was not permanent though.

In general, two ways to diversify an economy away from its vulnerability to oil price shocks are macroeconomic diversification (developing a competitive non-oil sector) and investment diversification (setting up an international SWF). To an economist, macroeconomic diversification runs counter to specialization advantages and takes a long time to implement. Investment diversification (SWF) is faster and easier to implement as the preferred route of self-insurance.[4] Investing money abroad also limits real exchange rate appreciation.[5]

The literature on oil-fuelled SWFs is currently sparse, but developing fast. The first question the literature has been trying to address focuses on resource allocation and intergenerational efficiency and justice, *i.e.*, how should we allocate the proceeds from inherited oil wealth across future generations and how fast should we deplete these resources?[6] Not surprisingly, this part of the literature can be traced back to the cornerstone in modern macroeconomics: the permanent income hypothesis (PIH) by Friedman (1957). The PIH argues that optimal consumption is driven by permanent income, also accounting for future oil revenues (arising from oil resources still in the ground) rather than current income alone.[7] In other words, oil-exporting countries are richer than they seem and should therefore increase consumption to a constant fraction of total wealth (instantaneously) once oil wealth is discovered.

1 - Arrau and Claesens (1992) are in our view the first to use the term "commodity stabilization fund" in the academic literature. Rozanow (2007) provides a typology of alternative types of sovereign wealth funds.

2 - An SWF usually arises from global imbalances, *i.e.*, a current account surplus is a prerequisite. This puts SWF management both intellectually and institutionally in the neighborhood of central bank reserve management.

3 - Moreover, they will run out at an unknown point in time as resources get depleted and attempts to find new reserves fade.

4 - The excessive accumulation-described in Obstfeld/ and Taylor (2007)-of foreign reserves in the form of central bank reserves or SWF assets is a sign of over-insurance, *i.e.*, non-existence of a collective protection mechanism against balance of payment crises driven by sudden flights or stops as modeled by Jeanne and Rancière (2006).

This requires access to global debt markets to finance current consumption out of future oil revenues. All generations are given an equal increase in consumption, addressing the question of intergenerational fairness. The size of the SWF fund increases continuously until resources are depleted.[8] This is contrary to the current "bird-in-hand" (BIH) rule applied by SWFs in an attempt to learn from the Norwegian model as an example of best practice. The BIH rule entirely ignores the existence of underground wealth until it has surfaced and the revenues from the sale of extracted oil have been added to the SWF. Only interest on the fund is consumed, which leads to a slow increase in consumption, raising concerns about intergenerational fairness. Implicitly, Norway is highly uncertain about its ability to value its underground wealth and therefore prefers to conservatively ignore it, until materialized. While a higher expected return on assets should lead to a faster depletion of resources (oil to equity transformation) as implied by the Hotelling (1931) rule, there is no link between optimal portfolio choice and resource wealth in the PIH model. In other words: investment decisions are exogenous.

The second main question in the literature on SWFs focuses on optimal asset allocation as a response to oil revenue volatility. While investment decisions are modeled directly, the optimal depletion of resources and the optimal level of savings is given exogenously. Optimal asset allocation is an important issue, as Sester and Ziemba (2009) estimate that the SWFs of Abu Dhabi (ADIA), Kuwait (KIA) and Quatar (QIA) lost 40% of their 2007 value at a time when their oil revenues were also down by similar amounts. Gintschel and Scherer (2004, 2008) identified the optimal asset allocation problem for an SWF as an asset allocation problem with non-tradable wealth that bears a strong resemblance to portfolio choice in the presence of human capital, *i.e.*, again the PIH. A country total wealth can be seen as a combination of financial wealth and non-tradable resource (oil) wealth. According to their one-period framework, assets with negative correlation to oil wealth are well suited to improve the efficiency of total wealth for an oil-rich investor. In their empirical implementation they choose sector portfolios with little or negative correlation to oil price changes. Optimal asset allocation decisions must take these correlations into account in order to avoid welfare losses, *i.e.*, sovereign welfare funds should look for an integrated management of financial and resource wealth. Scherer (2009a) introduces resource uncertainty as a form of background risk as well as the impact of optimal oil extraction for an SWF, concluding that uncertainty about the size of a country's oil wealth relative to its total wealth will make it invest less aggressively. Empirically, we should observe that SWFs with larger resource uncertainty should invest less aggressively and vice versa. We would also expect that economies with low reserves relative to financial wealth are less affected by resource uncertainty. He determines an exogenous extraction policy (independent of the evolution of asset returns) and investigates the impact on portfolio choice on the sequence of one period optimization problems. As long as financial wealth is low relative to resource wealth, an SWF will need to invest aggressively to have a meaningful impact on total wealth. Depending on the speed of the optimal extraction policy a maturing SWF will gradually invest less aggressively with less appetite for aggressive hedging or speculative risk taking. Scherer (2009b) extends the previous work by adding a multi-period setting (*i.e.*, an autoregressive data generating process) with return predictability similar to Campbell and Viceira (2002) that allows us to investigate how asset allocation recommendations change as the time horizon becomes larger. This is of particular relevance for SWFs as long-term investors.

All of the reviewed literature on stabilization funds relies on oil prices as a main source of macroeconomic risk for oil exporting countries. Given the often contingent spending policies of oil stabilization funds (accumulate wealth when oil prices are rising and spending wealth to support the local economy when GDP is shrinking), it is important to understand the magnitude and relative importance of oil price shocks relative to that of other sources of macroeconomic risk.

5 - Petro-dollars will not increase domestic money supply, if invested abroad. For US-dollar-pegged oil exporters (GCC countries) inflation will rise to raise real exchange rates, which makes it difficult to develop a non-oil sector.

6 - See also Reisen (2008). Related questions are: Should the proceeds be invested in financial assets (saved for consumption by future generations)? Should the proceeds be invested in real domestic assets or in human capital? While interesting, they belong in mainstream development economics.

7 - See also Collier *et al.* (2009) on the management of resource revenues in developing economies.

8 - If access to global debt markets is not given Arrau and Claesens (1992) developed a precautionary savings model applied to oil exporters. Their model, however, never received traction in the SWF discussion as their suggested size for an SWF (*i.e.*, the level of precautionary savings) is less than one month of oil exports.

Under these conditions, direct hedging (using oil price derivatives) or indirect hedging (using anti-correlated assets) of oil price risks is seen a substitute of limiting fluctuations in local GDP.

This paper calculates the impact of oil price shocks versus global GDP shocks on oil-exporting countries. We use the GCC (Gulf Cooperation Council) countries as they are home to some of the largest oil stabilization funds in the world. We also use Norway as a "control" country. Norway is also a small open economy but it provides more sector diversification and revenue diversification, with only 50% of exports arising from oil and gas (80% for the GCC on average). Do oil price shocks in both types of countries necessitate the same type of macroeconomic risk management? In section 2 we investigate the impact of oil price shocks as well as global GDP shocks on the GDP of oil-exporting countries, using a structural vector autoregressive model (SVAR). We are interested in both contemporaneous correlation (how sensitive is local GDP to movements in oil prices or global GDP?) and long-term variance decomposition (how much of the forecast error in local GDP can be attributed to oil price or global GDP shocks?). As mentioned above, this is particularly important for the risk management of oil stabilization funds. If local GDP is driven mainly by oil price shocks (even after adjusting for changes in global growth), oil stabilization funds are well advised to invest in assets that exhibit negative correlation with oil price movements. If not, the term oil stabilization fund will be a misnomer, as hedging demand against oil price shocks will be zero. Risk management for oil stabilization funds will instead become a stand-alone asset allocation problem. If global GDP was a driving force of local GDP there would be limited need for oil stabilization funds as the economy itself provides stabilization. Repeating this exercise across countries of different economic integration (GCC versus Norway) with the world economy allows us further to assess whether oil sensitive investments are equally important for all oil-exporting countries. Section 3 uses the VAR methodology in section 2 to provide a framework for conditional forecasts (conditional on projected oil prices and or global growth) for GDP in GCC countries. Again, given the conditional nature of oil stabilization funds, periods of negative growth ahead will dry up additional funding for oil stabilization funds and trigger withdrawals approximately of the size of negative GDP growth. This allows us to project the likely growth rates of stabilization funds in the years ahead. Section 4 concludes.

2 Oil Prices and Macroeconomic Risks

2.1 Data and Methodology

For each country in our sample (GCC countries: United Arab Emirates, Bahrain, Saudi Arabia, Qatar, Kuwait, Norway), we estimate a VAR in standard form using a parsimonious set of three variables: oil prices, g7 GDP (as a proxy for global GDP), and local GDP. We also limit ourselves to a VAR (1) model to save degrees of freedom for statistical tests. This is a deliberate choice arising from the limited number of observations (28 annual data points per country for the time period 1980 to 2008). All data are in log levels given the exponential growth in these time series. We also decided against differencing in our VAR, following Fuller (1976), Sims (1980) and Hamilton (1994) as we do not want to throw away information with respect to the co-movement of the variables involved. After all, we want to determine relationships (that provide insight into what risk management framework oil stabilization funds should choose), not coefficient estimates. All variables are nominal and expressed in USD. This reflects the fact that SWFs are usually managed very conservatively and similar to central bank reserves (arising from the same global imbalances).[9] Hence, we argue, in accordance with Rozanow (2007) that stabilization funds focus on nominal returns in the reserve currency (US dollar) and not on real returns in domestic currency, given that their assets are a substitute for oil, which is also priced in the reserve currency. All data come from the WEO database. Oil prices are an equally weighted mixture of three different (Brent, Dubai and West Texas Intermediate) oil qualities.

9 - This led the World Bank, BIS and ECB to a joint seminar on Central Bank Reserve management and SWF management in November 2008 in Frankfurt.

2.2 Estimation Strategy and Results

All variables are tested to be non-stationary and follow an I(1) process.[10] Next, we test for co-integration for each country separately. More precisely, we test for the existence of at least one co-integrating vector between oil, global (G7) and local GDP. Following the critique by Podivinsky (1998) on the robustness of the Johansen trace test in small samples, a Bartlett correction as derived in Johansen (2002) is employed for two alternative models. The results can be seen in figure 1.[11] Model 1 allows for linear trends in the data (due to technical progress in these "developing" countries) and in the co-integrating relationship (trends do not exactly cancel out). Model 2 allows for linear trends in the data only. With the exception of Saudi Arabia there is little evidence of cointegration. It is not surprising that Saudi Arabia seems to be more co-integrated with the world economy, given its status of having the largest proven oil reserves in the world and a heavily oil dependent infrastructure where oil accounts for about 75% of government revenues and 81% of exports, as documented in Fasano and Iqbal (2003). However, even in the case of Saudi Arabia, we would prefer to work with a VAR in levels as a VAR in levels will be robust to the number of unit roots in the system, which is the main reason for its widespread use in applied macro-econometrics.[12]

Figure 1: Johansen co-integration test. We report the results for the small sample adjusted Johansen trace test statistic. Statistical significance or the lack of it is documented by p-values in brackets.

	UNITED ARAB EMIRATES	BAHRAIN	SAUDI ARABIA	QATAR	KUWAIT	NORWAY
Model 1	31.26	31.28	46.54	39.31	20.27	18.01
	(0.38)	(0.434)	(0.019)	(0.10)	(0.93)	(0.57)
Model 2	25.42	28.96	37.54	30.48	18.01	28.34
	(0.15)	(0.06)	(0.06)	(0.051)	(0.57)	(0.074)

Once the unrestricted VAR(1) in standard form is estimated, we save the residuals in a 3×1 vector, e_t, for each observation period. While we don't know the true 3×1 residual vector, ε_t, for the accompanying VAR in primitive form, we can assume them to be orthogonal, *i.e.*, representing true shocks (after dynamic and contemporaneous effects have been removed). We use the approach by Bernanke (1986) and Sims (1986) imposing some structure on the relationship between the residuals in primitive and standard form. We conjecture that

(1)
$$e_t = B^{-1}\varepsilon_t, B^{-1} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ \beta_{oil} & \beta_{g7} & 1 \end{bmatrix}$$

This particular ordering implies that oil prices and global GDP react only to their own shocks, while local GDP is contemporaneously affected by both oil prices and global GDP shocks. Let Σ_{ee} be the variance covariance matrix of the residuals in a standard VAR (1), we can then estimate β_{g7}, β_{oil},oil by maximizing

(2)
$$\frac{n}{2}\left(\log\left|B^{-1}\right|^2\right) - \frac{n}{2} trace\left(B^{-1}\Sigma_{ee}B^{-1T}\right)$$

with respect to β_{g7}, β_{oil}. The results are given in figure 2.

10 - See appendix A1 for the results.

11 - All calculations have been performed with RAT 7.0

12 - The variance decomposition of forecast errors shows a very similar picture for VAR in levels versus VAR in differences for our data set. This is a clear indication that co-integration analysis does not add much here.

Figure 2: Identification of contemporaneous sensitivities using a Bernanke/Sims structural VAR. Estimates of contemporaneous beta are given together with the respective t-value. While the distribution of the above t-test is non-standard, higher t-values still can be interpreted as evidence for a significant relationship. Statistical significance at the 10%, 5% and 1% levels is denoted by *,**,***.

	UNITED ARAB EMIRATES	BAHRAIN	SAUDI ARABIA	QATAR	KUWAIT	NORWAY
β_{g7}	-0.288	-0.084	0.071	0.128	0.130	1.383
	(-1.219)	(-0.443)	(0.209)	(0.462)	(0.218)	(9.950)***
β_{oil}	0.478	0.332	0.300	0.453	0.433	0.142
	(10.277)***	(7.691)***	(5.103)***	(7.125)***	(3.504)***	(4.353)***

None of the GCC countries shows a strong statistical relationship with global GDP. This is further evidence of weak global integration of the GCC economies, *i.e.*, there has been limited success in creating more diversified export earnings.[13] In other words, the non-oil sector is not developed enough to diversify the economy away from the importance of oil revenues. This is in stark contrast to Norway (our non-GCC "control" country), which is heavily exposed to global GDP. All oil exporters show positive and significant exposure to oil prices of the same magnitude. The exception is again Norway, which only exhibits half the exposure of GCC countries.[14]

While contemporaneous correlations show the immediate impact of oil price shocks, they do not reveal any longer-term impact. Given our restrictions in (1), we have identified the VAR (1) model and can now calculate the variance decompositions without having to rely on ordering dependent Cholesky decompositions. Without imposing our restrictions, we would not be able to identify impulse response functions or variance error decomposition. The results are shown in figure 3. Our data show a rich interaction between the involved variables. This is particularly true at the longer (ten-year) forecast horizon. For Saudi Arabia (the most influential member of OPEC, with a heavily oil dependent economy), the ten-year forecast error variance amounts to 70% arising from oil price shocks, up from 48% for the one-year forecast error variance.

Figure 3: Bernanke-Sims variance decomposition. N-year forecast error in local GDP as a function of shocks in local GDP, g7 GDP and oil prices.

	Step										
Country	1	2	3	4	5	6	7	8	9	10	Source
NORWAY	67.72	67.27	66.93	66.64	66.40	66.19	65.99	65.81	65.65	65.49	*g7*
	13.55	14.55	15.23	15.71	16.07	16.35	16.59	16.79	16.96	17.12	*oil*
	18.73	18.18	17.85	17.65	17.53	17.46	17.42	17.40	17.39	17.39	*gdp*
KUWAIT	0.12	0.62	1.42	2.46	3.67	5.00	6.41	7.90	9.42	10.98	*g7*
	30.80	40.22	47.99	53.97	58.39	61.55	63.74	65.19	66.06	66.49	*oil*
	69.08	59.16	50.59	43.57	37.94	33.45	29.84	26.92	24.52	22.53	*gdp*
QATAR	0.27	1.20	2.77	4.90	7.52	10.52	13.80	17.26	20.80	24.35	*g7*
	64.52	55.74	49.45	44.97	41.70	39.24	37.32	35.75	34.43	33.28	*oil*
	35.21	43.06	47.78	50.13	50.78	50.23	48.88	46.99	44.77	42.36	*gdp*
SAUDI ARABIA	0.08	0.53	1.24	2.16	3.23	4.41	5.63	6.86	8.07	9.24	*g7*
	48.48	50.33	52.78	55.54	58.38	61.13	63.68	65.96	67.92	69.56	*oil*
	51.44	49.14	45.98	42.30	38.39	34.46	30.69	27.18	24.00	21.20	*gdp*
BAHRAIN	0.22	0.37	0.75	1.26	1.90	2.65	3.49	4.41	5.41	6.48	*g7*
	68.12	77.74	80.83	82.09	82.57	82.62	82.39	81.97	81.41	80.73	*oil*
	31.65	21.90	18.42	16.64	15.53	14.74	14.12	13.61	13.18	12.79	*gdp*
UAE	1.12	0.58	0.45	0.66	1.13	1.85	2.76	3.83	5.05	6.38	*g7*
	78.18	82.05	84.76	86.62	87.84	88.54	88.82	88.75	88.39	87.78	*oil*
	20.70	17.36	14.78	12.72	11.03	9.62	8.42	7.42	6.56	5.85 g	*dp*

13 - See Auty (2001).
14 - Simple OLS regressions of log changes in local GDP against log changes in global GDP and oil prices provide almost identical coefficient estimates with an average 2 R of about 60%. See Appendix B2.

With the exception of Qatar, smaller GCC countries are even more greatly impacted by oil price shocks. This is in stark contrast to Norway, where there is little difference between long and short variance decompositions and oil price shocks contribute only to about 17% of the forecast error in local GDP. Oil price innovations are the most important short- and long-term economic drivers of local GDP.

3. Projected Growth of Oil Stabilization Funds

In this section we forecast the likely growth of GCC oil stabilization funds. This is of great interest to asset management companies, of whom these funds are often clients, to economists who want to gauge the influences of SWF investment activities on exchange rates and bond markets, or to regulators who fear that political objectives hidden behind these funds might override economic principles. Given the lack of information on GCC stabilization funds available from official sources, we draw on our parsimonious vector autoregressive model developed in the previous section to forecast the impact of projected oil prices for 2009. This contrasts with papers that apply a more subjective and model-free framework as in Setser and Ziemba (2009). It also guarantees consistency among all our forecasts across both countries and time. For forecasting purposes we employ a Bayesian VAR (BVAR) with lag one, as described in Litterman (1986) specifying normal prior distributions given by

(3) $$\beta_i \sim N(1, w)$$

(4) $$\beta_j \sim N\left(0, w\frac{\hat{\sigma}_i}{\hat{\sigma}_j}\right)$$

where β_i in (3) denotes the three autoregressive regression coefficients, while β_j in (4) represents the remaining coefficients. We on set only one hyper-parameter *w* (representing the tightness of our beliefs) whereas $\hat{\sigma}_i$ is the estimated standard error of a univariate auto-regression on equation *i*. Equation (4) scales by standard errors to account for different magnitudes of measurement. Given that we have little data, we attach a high level of uncertainty to our prior coefficient choice in order not to overrule the data. Having estimated the above BVAR (1), we are ready to calculate conditional forecasts, *i.e.*, forecasts that are conditioned on future values of endogenous variables. In our case, we fix GDP growth and oil price changes for two years. By setting values for endogenous variables, we create a forecast error (unconstrained forecast minus prefixed value) imposing linear constraints on innovations. Assuming normally distributed innovations, we generate 5,000 draws (paths) from the constrained distributions to calculate the uncertainty around our forecast.

We investigate two scenarios. Under scenario I (pessimistic) we assume a 40% drop in oil prices over two years and a 5% drop in global GDP over the same period. Scenario II (optimistic) assumes a 10% drop in oil prices and a 5% drop in global GDP over the same two-year period. The results from conditional forecasts from a BVAR (1), with $\omega = 0.2$ can be found in figures 4 and 5. What do these results mean for the accumulation of assets by oil stabilization funds? Let us assume that a local GDP growth rate of less than 7% (the IMF estimate for inflation in GCC countries in 2008) is unacceptable for the political leaders in the respective counties. In this case we will see a substantial depletion of assets in all GCC countries (with the exception of Qatar) in the five years to come. However, assuming only a modest 10% drop in oil prices from end of 2008 (!) levels (around USD90 a barrel), which at the time of writing (September 2009) is entirely plausible (around USD75 a barrel), our model tells us that GCC economies will quickly return to their fast growth of recent years once oil prices recover (see figure 5).

Figure 4: Projected GDP growth for GCC countries and Norway (40% drop in oil prices and GDP growth of -5%). Calculations are based on a Bayesian VAR conditional on a 40% drop in oil prices (over the next two years from end of 2008 levels) and a 5% contraction in g7 GDP (also over the next two years). The projected growth path is accompanied by upper and lower limits (one standard deviation) using 5,000 MC simulations.

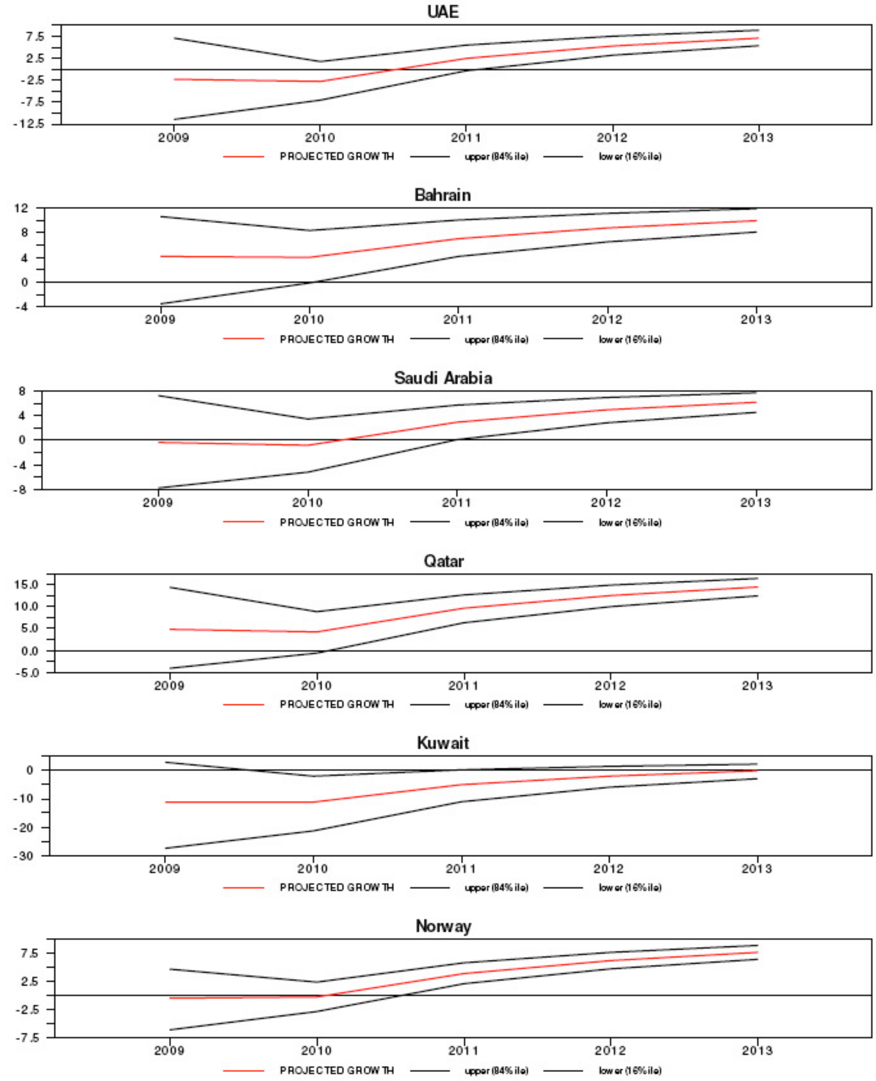
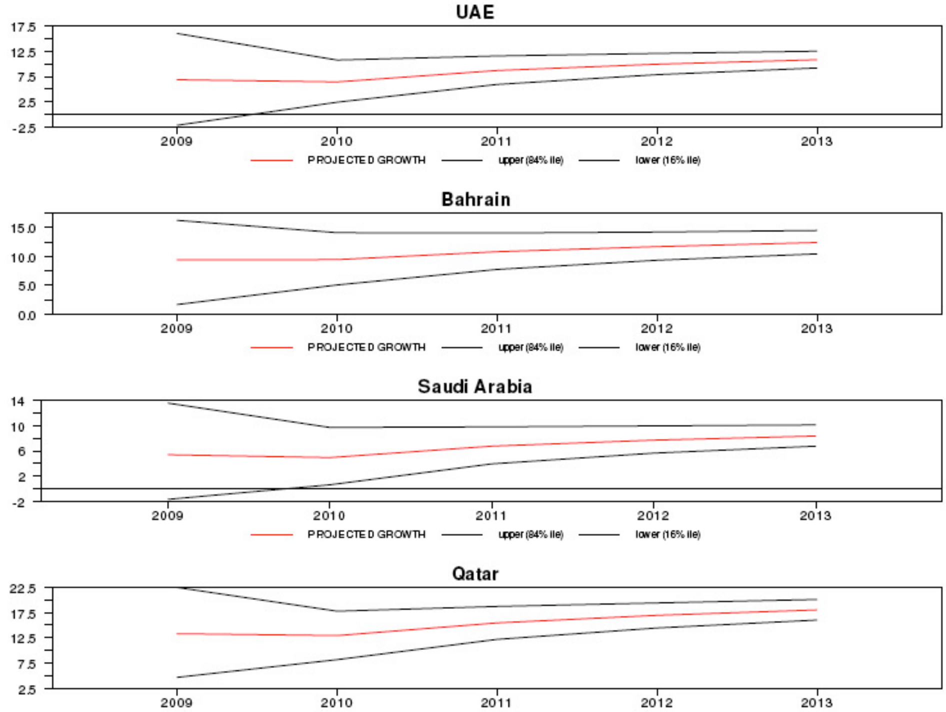
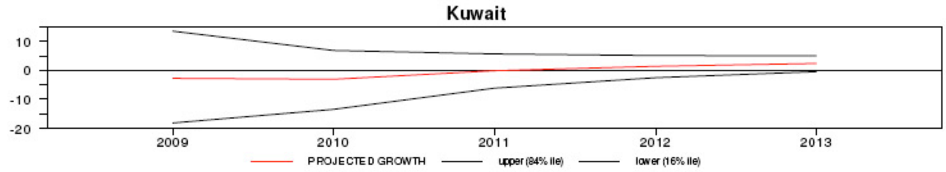
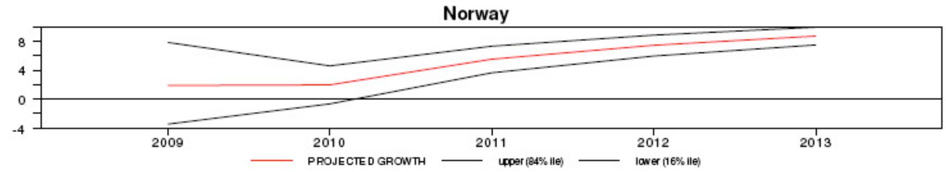


Figure 5. Projected GDP growth for GCC countries and Norway (10% drop in oil prices and GDP growth of -5%). Calculations are based on a Bayesian VAR conditional on a 10% drop in oil prices (over the next two years from end of 2008 levels) and a 5% contraction in g7 GDP (also over the next two years). The projected growth path is accompanied by upper and lower limits (one standard deviation) using 5,000 MC simulations.







4. Summary

We establish oil price innovations as the most important short- and long-term economic drivers of local GDP for GCC countries. Investment guidelines for oil stabilization funds should therefore stress the necessity to invest in assets with negative correlation to oil price movements to protect the total wealth of an oil-exporting economy. Using a Bayesian VAR, we project the impact of different oil price scenarios on local GDP and hence the likely growth of oil stabilization funds. Under the pessimistic scenario (40% drop in oil prices from their 2009 level and 5% drop in global GDP over two years) a short two-year contraction of about 10% per annum (in nominal USD terms) of SWF assets is anticipated. In 2011 SWF growth is likely to be back to pre-crisis levels. Under a more optimistic scenario (10% drop in oil prices over two years), oil stabilization funds are likely to experience a two-year period of zero growth with strong growth thereafter.

References

• Aghion P., P. Bacchetta and R. Ranciere (2006), Exchange Rate Volatility and Productivity Growth: The Role of Financial Development, Working Paper 12117, National Bureau of Economic Research, Cambridge, MA.

• Arrau P. and S. Claesens (1992), Commodity Stabilization Funds, World Bank Working Paper Series.

• Auty R. (2001), The Political State and the Management of Mineral Rent in Capital Surplus Countries: Botswana and Saudi Arabia, *Resources Policy*, 27, p77-86.

• Bernanke B. (1986), Alternative Explanations of the Money Income Correlation, Carnegie Rochester Conference Series on Public 25, p49-100.

• Campbell J. and L. Viceira (2002), *Strategic Asset Allocation*, Oxford University Press.

• Collier P, F. Ploeg, M. Spence and A. Venables (2009), Managing Resource Revenues in Developing Countries, OxCarre Research Paper No. 2009-15.

• Fasano U. and Z. Iqbal (2003), GCC Countries – From Oil Dependence to Diversification, IMF.

• Friedman M. (1957), *A Theory of the Consumption Function*, Princeton University Press.

• Fuller W. (1976), *Introduction to Statistical Time Series*, Wiley.

• Gintschell A. and B. Scherer (2004), Optimal Asset Allocation for Sovereign Wealth Funds, working paper, Deutsche Asset Management.

• — (2008), Optimal Asset Allocation for Sovereign Wealth Funds, *Journal of Asset Management*, 9, p215-238.

• Hamilton J.D. (1994), *Time Series Analysis*, Princeton University Press.

• –. (2008), Understanding Crude Oil Prices, NBER Working Papers 14492, National Bureau of Economic Research.

• Hotelling H. (1931), The Economics of Exhaustible Resources, *Journal of Political Economy*, 39, p137-175.

• Jeanne O. and R. Rancière (2006), The Optimal Level of International Reserves for Emerging Market Countries: Formulas and Applications, IMF Working paper.

• Johansen S. (2002), A Small Sample Correction for the Test of Cointegrating Rank in the Vector Autoregressive Model, *Econometrica*, 70, p1929-1961.

• Krugman P. (1988), Deindustrialization, Reindustrialization, and the Real Exchange Rate, NBER Working Papers 2586, National Bureau of Economic Research.

• Litterman B. (1986), Forecasting with Bayesian Vector Autoregression, *Journal of Business and Economic Statistics*, 4, p. 25-38.

• Obstfeld M. and A. Taylor (2007), *Financial Stability, the Trilemma and International Reserves*, University of California, Berkeley.

• Phillips P. and P. Perron (1988), Testing for a Unit Root in Economic Time Series, *Biometrika*, 65, p335-346.

• Ploeg F. and S. Poelhekke (2009), Volatility and the Natural Resource Curse, Oxford Economic Papers, forthcoming.

• Podivinsky J. (1998), Testing Misspecified Cointegrating Relationships, *Economics Letters*, 60, p1-9.

• Reisen H. (2008), How to Spend It? Deutsche Bank Research Note 28.

• Rozanow A. (2007), Sovereign Wealth Funds: Defining Liabilities, State Street Research.

• Scherer B. (2009a), Portfolio Choice for Oil Based Sovereign Wealth Funds, forthcoming in: BIS/World Bank/ECB conference proceedings on SAA for Central Banks and Sovereign Wealth Funds.

• –. (2009b), A Note on Portfolio Choice for Oil Based Sovereign Wealth Funds, forthcoming in: *Journal of Financial Markets and Portfolio Management.*

• Sester B. and R. Ziemba (2009), GCC Sovereign Funds – Reversal of Fortune, Center for Geo-economic Studies, Working Paper.

• Sims C. (1980), Macroeconomics and Reality, *Econometrica*, 48, p1-48.

• –. (1986), Are Forecasting Models Usable for Policy Analysis, Federal Reserve Bank of St. Louis Quarterly Review, Winter.

Appendix A1: Unit Root Tests.

We use the Phillips and Perron (1988) test to test for unit roots in the investigated time series. According to the results below all times series are non-stationary in log(levels). With first differencing, all series become stationary with high statistical significance, even though our data set shows a limited set of observations.

Figure 6: Phillips and Perron unit root test. The table provides value for the Phillips and Perron unit root test with two lags for both trend and no trend in the underlying process. 1%, 5% and 10% significance levels are marked, ***, **,*.

	Log (level)		Difference of Log (level)	
	no trend	trend	no trend	Trend
UNITED ARAB EMIRATES	0.416	-0.122	-4.188***	-7.051***
BAHRAIN	1.930	-0.095	-3.354**	-4.476***
SAUDI ARABIA	-1.241	-1.012	-2.406	-4.742***
QATAR	0.927	-0.662	-3.404**	-7.644***
KUWAIT	-0.106	-1.705	-4.365***	-5.313***
NORWAY	1.422	-1.463	3.382**	-3.716**
OIL	0.210	-0.279	-5.089***	-7.040***
G7	-1.015	-1.377	-3.217*	-3.324**

Appendix A2: OLS Sensitivities

Instead of running a dynamic regression on log levels, we can run a standard OLS regression using contemporaneous log changes.

(5)
$$\log\left(\frac{gdp_t}{gdp_{t-1}}\right) = \beta_0 + \beta_{g7}\log\left(\frac{g7_t}{g7_{t-1}}\right) + \beta_{oil}\log\left(\frac{oil_t}{oil_{t-1}}\right) + \varepsilon_t$$

Figure 7: OLS regression coefficients for first log differences. Estimates of contemporaneous beta for regression are given together with their respective t-values.

	UNITED ARAB EMIRATES	BAHRAIN	SAUDI ARABIA	QATAR	KUWAIT	NORWAY
β_0	0.010	0.037	-0.020	0.854	-0.013	-0.010
	(0.454)	(1.816)	(-0.729)	(8.121)	(-0.259)	(-0.681)
β_{g7}	-0.102	-0.130	0.171	0.327	0.424	1.226
	(-0.345)	(-0.464)	(0.455)	(0.228)	(0.597)	(6.265)
β_{oil}	0.511	0.285	0.388	1.052	0.495	0.147
	(8.920)	(5.224)	(5.312)	(3.773)	(3.582)	(3.865)
R^2	0.768	0.538	0.532	0.365	0.339	0.655