What Makes Oil Revenue Funds Effective?

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Abstract

This paper tests the effectiveness of oil revenue funds and their design in oil-producing countries. The empirical results, using monthly data of 27 oil-producing countries (19 with oil revenue funds and 8 without oil revenue funds) over the period from January 1957 to November 2010, show that oil revenue funds are effective in the stabilization of exchange rates. Additionally, in the theoretical model, it is found that funds that follow the expenditure-based accumulation rule can stabilize exchange rates better than funds that follow the revenue-based accumulation rule. However, in the empirical model it is found that funds that follow the revenue-based accumulation rule can stabilize real effective exchange rates better than funds that follow the expenditure-based accumulation rule.

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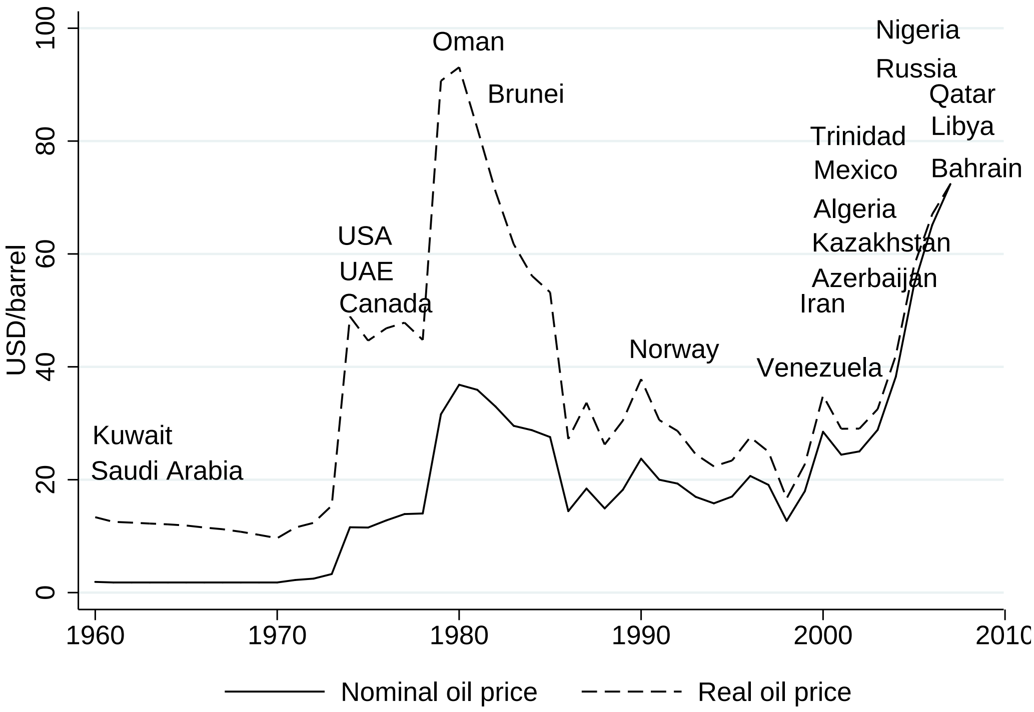
1 Introduction

Resource-rich countries grow at lower rates than resource-poor countries (Sachs and Warner, 2000; Isham et al. 2005; Sala-i-Martin and Subramanian, 2003). This is due to the fact that oil-producing countries suffer from volatile and unpredictable oil revenue movements. However the quality of institutions and governance are also important (Mehlum et al. 2006; Collier and Goderis, 2007). Economists have proposed several solutions for the problems of oil-producing countries with "bad" institutions, including keeping oil in the ground (Stiglitz, 2007), distributing oil revenue among citizens (Morrison, 2007), and keeping oil revenue out of the hands of the government by placing it in a separate fund and committing the government to use this fund in certain ways (Morrison, 2012).

The third solution assumes the establishment of oil revenue funds. This solution has become popular among oil-producing countries, especially after 2000, when oil prices increased (Figure 1.1). In this paper, we try to answer questions "Are oil revenue funds effective?" and "What makes them effective?"

Figure 1.1: The establishment of oil revenue funds and oil prices



Data sources: International Monetary Fund (2011): International Financial Statistics (Edition: December 2011), ESDS International, University of Manchester; and the SWF Institute, available at www.swfinstitute.org.

The efficiency of oil revenue funds is still under debate. In order to answer the question of whether funds are effective or not, we need to clarify which problems those funds can solve.

Many economists have found that oil revenue is associated with the "Dutch disease", which is a negative relationship between the increase in resource revenues and the manufacturing sector (Corden and Neary, 1982). An increase in resource revenues causes the manufacturing sector to decline through the appreciation of the domestic currency. A resource boom brings extra revenue, which causes an increase in demand (mostly of non-tradable goods, such as services) in an economy, increasing domestic prices, and thus real appreciation of domestic currency. This appreciation of domestic currency makes domestic goods less competitive. The solution to this problem may be the sterilization of oil revenue, i.e. taking oil revenue during booms away from spending in a domestic country because it causes real appreciation of the domestic currency. This can be saved and then spent slowly. Oil revenue funds can smooth exchange rates by sterilizing foreign currency when invested abroad (which cuts the link between exchange rates and oil revenues).

Government expenditure depends on oil revenue and budgeting is very difficult when government revenue is volatile and unpredictable. An increase in government expenditure causes the appreciation of domestic currency. The government faces a budget deficit when oil prices are low. Saving revenue in funds should reduce expenditure during oil booms and thus help to avoid appreciation of domestic currency. This also reduces the need for loans to cover budget deficits during low oil prices because budget deficit can be covered by a fund. Oil revenue funds can smooth government expenditure, cutting the link between the government expenditure and oil revenues.

An efficient fund must be able to delink exchange rates/government expenditures from oil revenues. The existing literature provide contradictory results of the efficiency of funds. Many authors who have studied the efficiency of funds in different countries came to the conclusion that the rules, which oil revenue funds follow, matter (Crain and Devlin, 2003; Fasano-Filho, 2000; Engel and Valdes, 2000; Bjerkholt and Niculescu, 2004; Humphreys and Sandbu, 2007; Devlin and Lewin, 2005). But there is a lack of evidence as to which rules make funds more efficient.

This paper shows the effectiveness of funds in the reduction of the correlation between oil revenues and exchange rates, and which funds' rules are important. These results can be useful for countries that are considering the establishment of an oil revenue fund, or already have such funds and want to make them more effective in the stabilization of an economy.

This paper is structured as follows. Section 1.1 of the current paper provides an introduction and background on oil revenues, how they are generated, and what the problems associated with oil revenues. Section 1.2 provides a definition of funds and explains their objectives and rules. Section 2 provides a review of existing literature studying the effectiveness of funds (section 2.1) and the effect of oil revenue on exchange rates (section 2.2). A simple theoretical model is developed in section 3. This model explains how an oil revenue fund affects exchange rates and shows the effects of funds under different rules. Based on findings of the theoretical model, we developed an empirical model (section 4). Using monthly data from 27 oil-producing countries with funds (19) and without funds (8), we tested the effectiveness of the funds and the importance of their rules. Using results of unit root and cointegration tests (individual and panel), we provide country-by-country and panel estimations. The results list the rules that make funds effective. Conclusions are in section 5. The main contributions of this paper are in section 4.

1.1 Oil revenue

Before explaining the research, background on oil revenue and oil revenue funds is provided. Before we analyze oil revenue funds, we must first explain where oil revenue comes from, how it is accumulated, and the problems associated with oil revenues. Oil revenue is revenue accumulated from taxes on oil and the privatization of oil-related properties.

Oil is deposited in a country and belongs to the government. Countries usually do not produce their own oil, but rather allow investors to explore and produce it. Oil production involves the following problems: oil extraction and exploration require significant investment, the amount and quality of oil reserves are unpredictable, and oil is an exhaustible resource. Investment in the oil industry is quite risky; nevertheless, oil companies can diversify their risk by working with many different projects, which is why oil-producing countries allow oil companies to work on their territory.

Even though oil production involves substantial investments, oil brings enormously high economic rent. Governments must be sure to receive an appropriate share of economic rent from oil. Apart from the usual taxes, such as corporate taxes, profit taxes, value-added taxes, etc., governments impose other taxes on oil. Countries can apply special taxes on oil producers to receive compensation for the extraction of oil that belongs to that country. Oil producers must pay part of the economic rent to the owner of the oil by way of special oil taxes. Revenue from oil often significantly exceeds the cost of production, consequently creating high economic rent. Taxes on oil determine how this rent is shared between the country and the investor.

Oil production involves different geographical, political and financial risks (Revenue Watch Institute, Date unknown). These risks can be compensated by lower taxes. The greater the risk, the lower taxes must be to attract investors. Investors should be able to cover the supply price of investment (cost of exploration, development and production, the cost of capital, risk premium) and taxes. Taxes can be greater when oil price and/or oil production are greater and when the supply price of investment is lower. Investors are risk averse - they prefer less risky projects and require a risk premium for more risky projects. Thus, taxes on riskier projects should be smaller. Risk can not only be commercial but also political; thus, politically unstable countries must offer more favourable taxes. Governments share the risk of revenue from oil with investors (Table 1.1).

Investors may choose to invest only if they receive enough compensation for significant investments that are required prior to oil production and risks associated with oil production. Countries face a trade-off between receiving economic rent and sustaining foreign investment in the oil industry (Oyinlola,

Figure 1.2: Oil production cycle

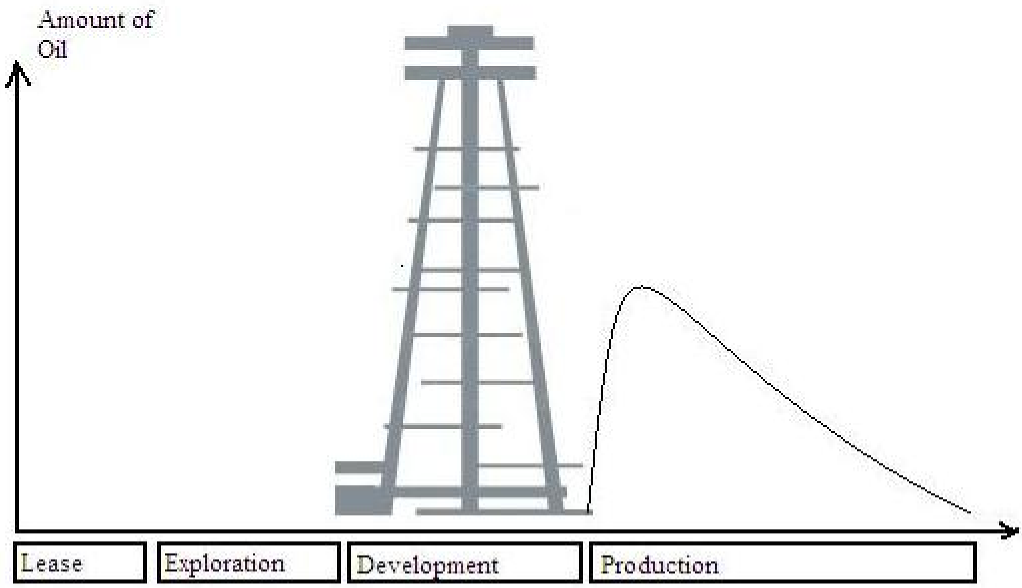


Table 1.1: Tax bases

Basis	Oil producer	Government
Fixed-fee	Risky	Ensures revenue even if project turns out to be not profitable.
Product-based	Risky	Ensures that government receives at least a minimum payment regardless of the production cost.
Profit-based	Reduced uncertainty for oil producers	Gets more revenue from more profitable projects.
Revenue-based	Reduced risk when oil prices are low	Gets higher revenue when oil prices are high.

2008).

Generally, the process of oil production involves: exploration, development, extraction and processing of the oil (Figure 1.2).

The difficulties in taxing oil are unknown stock and variable quality of oil. Oil production requires exploration and development costs. The variety of oil quality comes from different concentration levels of the oil in deposits, as well as different costs of extraction. Also, extracted oil varies in quality due to the accompaniment of other elements and thus requires further processing. Due to imperfect information about the quality and reserves of oil and the high volatility of its price, governments impose a variety of taxes on oil. There are different taxes paid at different stages of oil production, most taxes are paid during the production stage.

Most common taxes on oil are royalties, profit taxes, resource rent taxes, production sharing, fixed fees and bonuses. Royalties tax provides early revenue and is easy to administer. Royalties tax does not depend on the profitability of the project. An investor only decides to invest if the profit is greater than the royalties tax. If the tax is independent from the cost of production, the burden is the same for low and high cost projects. They can also be based on the volume of production or on the value of

Table 1.2: Progressive taxes

Base	Advantage
Progressive with volume produced	Higher taxes from greater projects (projects that turned out to have greater oil reserves)
Progressive with oil price	Higher taxes when oil price is greater
Progressive with profit	Higher taxes for highly profitable projects (extra profit)

Resource rent taxes are direct taxes on economic rent. A disadvantage of these taxes is that the government might not receive revenue for less-profitable projects.

The R-factor based system is an investment payback ratio, the government share increases with the payback ratio. This system is common in Production Sharing Agreements (PSAs). PSA is an alternative to regular taxation. PSA is a long term contract between a government and an oil producer. The government and oil producers agree on the government's share of profit. They are attractive to investors because PSAs are flexible for each project. Design of PSAs differs a lot. They are not as simple as they look, because of deductible production cost. Since PSAs are an ex-ante agreements and investors have more information about the future profitability of a project than the government, the production share might be inappropriate for the government.

Fixed fees and bonuses are one-time payments, which can be fixed or auctioned. Fixed fees and bonuses have the following advantages for governments: very early payment and easy to administer. Auctions are usually used as a way to allocate exploration rights among companies. Auctions are attractive, but may receive low bids in countries with political risk.

Oil producers can be exempted from duties. Exemption from duties makes projects very attractive to investors because project development involves substantial imports. Also, many countries choose to exempt imported capital goods and imported inputs for mineral extraction from value-added tax.

While corporate income taxes are not special taxes for oil producers, oil producers might have to pay at a higher rate than non-oil producers or they might not be allowed to be exempt from withholdings such as dividends or interest. Also it is important to determine what can be included in deductible costs.

Countries use different combinations of taxes. Taxation of oil varies a lot among different countries (Sarma and Naresh, 2001). Each tax can be ranked on policy neutrality to investment (efficiency), investor risk (stability, project risk), government risk (loss, flexibility, delay) and implementation (design, administration, tax credit) using a scale from +3/-3 (Table 1.3) according to Baunsgaard (2001). Tordo (2007) characterizes oil taxation: how flexible, how neutral, and how stable. He also notes that investment is affected not only by taxes but also by the stability of fiscal policy.

Oil revenue is associated with several problems: oil is exhaustible resource, oil reserves are uncertain and oil prices are volatile (Baunsgaard, 2001). Ramey and Ramey (1995) provide evidence that volatility

Table 1.3: Comparative assessment of mineral taxes

Tax	*Neutrality*	*Investor risk*		*Government risk*			*Implementation*		
	Efficiency	Stability	Project risk	Loss	Flexibility	Delay	Design	Administration	Tax credit
Royalties	-3	-1	-1	+2	-1	+3	-1	+1	-3
Progressive profits taxes	+1	+3	+1	0	+2	+1	+2	-2	0
Resource rent taxes	+2	+3	+2	-2	+3	-1	+3	-3	-2
Production sharing	-1	+1	0	0	+2	+2	+2	-2	-3
Fixed fee	-3	-3	-2	+3	-2	+3	-2	+2	-3
Corporate income taxes	-1	+1	0	0	+1	+2	+1	-1	+3

reduces growth rate. Oil revenue is usually associated with the "Dutch disease" and the "Resource curse". Volatility of oil revenue and its unpredictability also causes problems for fiscal policy (the budget often has a significant surplus or deficit). The "Dutch disease" is a negative relationship between an increase in resource revenues and the manufacturing sector (Corden and Neary, 1982). An increase in resource revenues causes the manufacturing sector to decline due to the appreciation of domestic currency. The resource boom brings in extra revenue, causing an increase in demand (mostly of non-tradable goods such as services), which, in turn, causes an increase in domestic prices, and thus real appreciation of domestic currency. Appreciation of domestic currency makes domestic goods less competitive. Why is the "Dutch disease" a problem? Oil is an exhaustible resource; therefore in the long run, resource revenue will decline and the country will need another source of revenue other than oil. However, if the country had "Dutch disease", manufacturing sector is not competitive. So, why does a country fail to develop a manufacturing sector after it runs out of oil? Competitive manufacturing industries do not return as easily as they leave due to technological growth. Unlike the oil sector, which has low technological growth, the manufacturing sector requires higher technological growth to be competitive with other countries (Van Wijnbergen, 1984). It is believed that the threat of Dutch disease can be reduced by the reduction of the real appreciation of domestic currency. Oil revenue can be sterilized by taking oil revenue away from domestic spending, saving it abroad and spending it slowly. This is one of the reasons why oil-producing countries establish oil revenue funds. During oil booms extra revenue spent in a country causes real appreciation of domestic currency, so taking away oil revenue during booms should prevent real appreciation. An increase of savings in the economy can reduce spending during oil booms and thus prevent appreciation of domestic currency[1]. This also reduces the need for loans to cover budget deficits during low oil prices.

1.2 Oil revenue funds

Oil revenue funds have different names: sovereign wealth funds (oil-based), petroleum revenue funds, hydrocarbon revenue funds, stabilization funds, mineral revenue funds, exhaustible resource funds and natural resource funds.

Oil revenue funds are those sovereign wealth funds (SWFs) that are accumulated from oil related revenues. SWFs are government-owned investment funds operating in private financial markets and funded by foreign exchange assets (the SWF Institute, Date unknown). Oil revenue funds are funded by taxes paid by oil producers, fiscal surpluses, privatization of oil related property and investment profits of fund. They differ from public investment funds (pension funds) because they are accumulated not from public income, but from oil related revenue. Oil revenue funds also differ from foreign currency reserve assets held by monetary authorities. Countries are more likely to create oil revenue funds during oil shocks (oil price booms or discovery of significant oil reserves). The establishment of oil revenue funds involves different issues, namely: objectives, accumulation rules, withdrawal rules, investments and others. Here we examine each of them in turn.

The main objectives of funds are saving for future generations due to oil exhaustibility (usually known as "saving funds") and stabilization of the budget due to oil revenue volatility and unpredictability (usually known as "stabilization funds"). Other objectives might include diversification of oil exports, earning of greater returns than on foreign exchange reserves, assistance to monetary authorities, dissipation of unwanted liquidity, funding for social and economical development, sustainable long term capital growth for target countries and political strategy (SWF Institute, Date unknown).

Stabilization funds guarantee a minimum expenditure level. They are built during boom times and used during recessions. While these funds do not guarantee savings for future generations, they may leave a strong economy for future generations (Bacon and Tordo, 2006). Saving funds protect future consumption and provide intergenerational equity. Each country sets accumulation and withdrawal rules according to its objectives.

The aim of saving funds is to save oil revenue for future generations, while the aim of stabilization funds is to keep some oil revenue to cover a budget deficit when oil prices are low. The greater the variation of oil revenue relative to government expenditure, the greater the fund should be. Accumulation rules determine the size of funds. There are two types of accumulation rules: revenue-based (a fixed portion of oil revenue that accumulates the fund) and expenditure-based (a fixed portion of the budget surplus that accumulates the fund or a reference oil price). The accumulation rule, based on a reference oil

[1] The real exchange rate changes in both fixed and flexible exchange rate regimes (Corden and Neary, 1982).

price, is almost the same as that based on a portion of the budget surplus. It means that any revenue above the budgeted revenue based on a budgeted (reference) price is saved in a fund. The revenue-based accumulation rule is the most appropriate for saving funds because it guarantees savings for future generations. For stabilization funds, the most appropriate is the expenditure-based accumulation rule, which allows for saving only during booms.

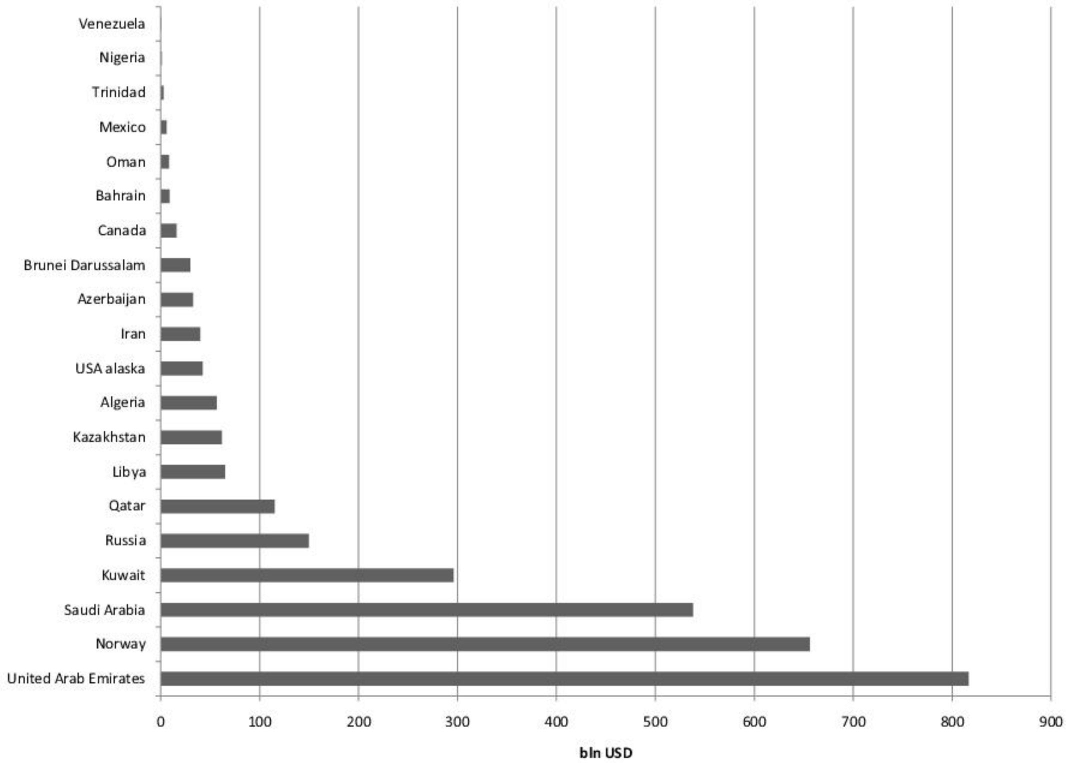
Withdrawal rules are important to prevent overspending by the government (Humphrey and Sandbu, 2007). A withdrawal rule is a constraint on how much of the fund's resources can be spent. Withdrawal rules of stabilization funds are constrained by the budget deficit. Usually when a budget has a deficit or the oil price is below the reference oil price, transfers out of the fund are allowed in order to cover the budget deficit. Some countries set a maximum amount that can be withdrawn from the fund. Withdrawal rules for saving funds are usually limited to real returns on the investment or no withdrawals are allowed. When a budget has a deficit, no more than the real return on the investment can be withdrawn from the fund.

Funds can invest in domestic or foreign assets. This choice depends on the objectives of the funds. Funds invest in foreign assets if the country aims to reduce the volatility of the exchange rate due to oil revenue volatility, also called sterilization of oil revenue. Funds invest in local assets if the country aims to stimulate the economy.

One more objective of funds is the transparency of oil revenue. The Linaburg-Maduell transparency index (Linaburg and Maduell, 2009) rates funds according to their transparency. According to this index, funds earn one point for matching each of the following parameters:

- fund provides the history, including the reason for its creation, origins of wealth, and government ownership structure;
- fund provides up-to-date independently audited annual reports;
- fund provides ownership percentage of company holdings, and geographic locations of holdings;
- fund provides total portfolio market value, returns, and management compensation;
- fund provides guidelines in reference to ethical standards, investment policies, and enforcer of guidelines;
- fund provides clear strategies and objectives;
- fund clearly identifies subsidiaries and contact information;
- fund identifies external managers;
- fund manages its own web site;
- fund provides main office location address and contact information such as telephone and fax.

Figure 1.3: Size of oil revenue funds



Source: SWF Institute, available from swfinstitute.org.

The size of oil revenue funds is measured in billion US dollars of assets (see Figure 1.3).

2 Literature review

2.1 The effectiveness of oil revenue funds

Existing empirical literature on the effectiveness of oil revenue funds provide contradictory results. It can be divided in two sections: the effect of funds on stabilization of real exchange rate and the effect of funds on the stabilization of government expenditure. The first test allows for the determination of how funds can smooth government expenditure, cutting the link between expenditure and oil revenue (or oil price). The second test allows for the determination of how funds can help avoid appreciation of domestic currency due to oil prices increase, cutting the link between exchange rate and oil revenue (oil prices). Existing literature about the effect of funds in oil-producing countries is mostly concentrated on the existence of funds and their sizes, but not on the funds' specific characteristics.

The research literature has two foci, namely: the effect of funds on exchange rates and the effect of funds on government expenditures.

Shabsigh and Ilahi (2007) and Hart (2010) test the existence of oil revenue funds on real effective exchange rates. Both of them use several resource-rich countries with and without funds. Shabsigh and Ilahi (2007) use annual data over the period 1980-2003 from 15 countries, while Hart (2010) uses a more frequent time series (quarterly data) over the period 1996-2008 from a smaller number of countries (six countries). Shabsigh and Ilahi (2007) do not find the effect of funds on stabilization of real effective exchange rates, while Hart (2010) provides evidence that oil revenue funds can stabilize exchange rates.

Shabsigh and Ilahi (2007) estimate the effect of existence of funds on volatility of real effective exchange rate, including other independent variables such as real GDP growth rate, financial depth, share of oil exports in total exports, oil price growth rate and dummy variables controlling for shocks (1973, 1974, 1979, 1986, 1998 and 2000). The empirical results of Shabsigh and Ilahi (2007) suffer from data limitations. In two countries (Kuwait and Oman), funds were established before the sample size started, so it is impossible to test the effect of funds of those two countries. Funds in three countries (Mexico, Trinidad and Venezuela) were established by the end of the sample size, so it is difficult to test the effect after funds were established in those three countries.

The results of Hart (2010) are limited by the small number of countries with funds; only three countries with a fund (Mexico, Norway and Chile) are used. Apart from testing just the existence of funds, the author also includes the size of funds. The results of the empirical regression show that funds can stabilize exchange rate movements due to the terms of trade.

An alternative focus is the effect of the establishment of funds on the stabilization of government expenditure. Davis et al. (2001), Crain and Devlin (2003) and Ossowski et al. (2008) test the existence of funds on the stabilization of government expenditure. None of them provide evidence on the funds' effectiveness using panel data regressions. Davis et al. (2001) find that in some countries funds are effective in stabilizing government expenditure, while in others they are not. The authors suggest that country specific effects and funds' characteristics are important. Crain and Devlin (2003), apart from the existence of funds, also include the size of funds as an explanatory variable. Due to the nature of government expenditure data, all authors used annual data.

Davis et al. (2001) estimate the effect of funds on the real government expenditure per capita by including other independent data such as real non-renewable resource export earnings per capita and its interaction term with a dummy variable indicating the existence of funds. The first differences of variables are used to correct data for nonstationarity. They use data from four countries with funds (Chile, Kuwait, Norway, Oman) over the period 1963-1999. Authors test the statistical significance of interaction terms. The results for each of the countries show no effect of the funds on government spending.

Crain and Devlin (2003) estimate the effect of funds on the volatility of government expenditure[2] by

[2] Volatility of government expenditure was computed as a standard deviation in the regression residuals from the following regression:

$e_it = ß_0 + ß_1 GDP_{it} + ß_2 ln(Population)_{it} + ß_3 Density_{it} + ß_4 Age_{it} + ß_5 Trade_{it} + ß_6 OilX_{it} + ß_7 MetalX_it + ß_{12} Year_{it} + u_i + e_{it}$, where e is a government expenditure.

including other independent variables such as per capita GDP, log of population, population density, a ratio of the number of dependents to working age population, foreign trade as a percentage of GDP, oil export as a percentage of GDP and its interaction term with fund existence, ore and metal exports as a percentage of GDP and its interaction term with fund existence, and the size of fund as a percentage of GDP. They estimate panel data from 71 countries over the period from 1970 to 2000 using fixed effects model.

An empirical regression of panel data shows a limited impact of funds on government spending. The results of country-by-country regressions[3] show that funds reduce fiscal volatility in some countries (Norway, Oman and Chile). The authors suggest that the effect of funds differs across countries because accumulation and withdrawal rules and the overall fiscal policy framework are critical elements for managing volatility of government expenditure. They also found that the size of funds matters.

Ossowski et al. (2008) also do not provide empirical evidence of funds' effectiveness, suggesting that the quality of funds matters and that under an appropriate institutional framework, well-designed oil revenue funds may help to stabilize government expenditure.

There are other authors who have studied the effectiveness of funds such as Arrau and Claessens (1992), Murphy et al. (2010), Varangis et al. (1995). They also state the importance of rules that oil revenue funds follow.

2.2 Effect of oil prices on exchange rates

Amano and Van Norden (2003) suggest that oil prices may have an important influence on exchange rates and that oil prices might be sufficient to explain long-term movements in real exchange rates. Whether oil revenue funds can delink exchange rates from oil revenues or not is subject to the condition that exchange rates and oil revenues are correlated in oil-exporting countries. There are many studies that tested the effect of oil and other commodity prices (or oil revenues) on exchange rates such as Chen and Chen (2007), Cashin et al. (2004), Korhonen and Juurikkala (2007), Chen and Rogoff (2003) and Habib and Kalamova (2007). The authors claim that in resource-exporting countries, the resource price (or resource revenue) is the major source of exchange rates' fluctuations. That is why in their models, the only explanatory variable is the resource price[4]. Chen and Chen (2007) and Korhonen and Juurikkala (2007) provide empirical evidence that exchange rates and oil revenues (or oil prices) are positively correlated. The rest of the authors find a correlation in some countries, but not in all countries. Habib and Kalamova (2007) suggest that this may be due to other policy responses, for example, the accumulation of net foreign assets and their sterilization, and specific institutional characteristics. This suggestion supports our hypothesis

[3] Newey-West time series regression was used.

[4] Korhonen and Juurikkala (2007) include GDP as an explanatory variable. Chen and Rogoff (2003) include time trend as an explanatory variable in regression.

that rules followed by funds are important in correlation between exchange rates and oil revenues.[5]

The results on the unit root test of real exchange rates are contradictory. Chen and Chen (2007) and Cashin et al. (2004), using monthly data from G7 countries and 58 commodity-exporting countries respectively, find that real exchange rates are nonstationary data. While Habib and Kalamova (2007) find that real exchange rates are nonstationary only in some countries, Korhonen and Juulikkala (2007) find that real exchange rates are mostly nonstationary data. Chen and Rogoff (2003) do not clarify stationarity, referring to the weak statistical power of the test when the time series are short[6]. There is no controversy in the literature about nontationarity of oil prices.

The results of cointegration between real exchange rates and oil (commodity) prices are also contradictory. Chen and Chen (2007) find cointegration; for this reason they apply Fully Modified Ordinary Least Squares (FMOLS; Phillips and Hansen, 1990), Dynamic Ordinary Least Squares (DOLS; Stock and Watson, 1993) and Pooled Mean Group (PMG; Pesaran et al. 1999). Korhonen and Juulikkala (2007) are not sure about cointegration, so they use both pooled Ordinary Least Squares (OLS) with fixed effects model (as if there is no cointegration) and PMG model (like if there is a cointegration). Cashin et al. (2004), Habib and Kalamova (2007) find cointegration in one-third of the countries, and thus, use Error Correction model (ECM; Engle and Granger, 1987) only for series from those countries (using country-by-country regression).

Although many authors provide empirical evidence that real oil prices explain the major fluctuations in real exchange rates in oil-exporting countries, the results of a unit root test of real exchange rates are contradictory and thus authors use different estimation models. According to Maddala and Wu (1999), results of unit root tests depend on the countries and periods, so we cannot use results of previous literature and need to obtain our own results on stationarity.

3 Theoretical framework

The following theoretical model is based on Rickne (2010). It shows the effect oil revenue funds on exchange rate. In order to show the effect of oil revenue funds it is necessary to consider intertemporal budget constraints. However in this model a simplified one period budget constraint is considered.

Case 1: An oil revenue fund with a revenue-based accumulation rule (fixed share of oil revenue)[7].

Consider a small open economy producing tradable, non-tradable goods and crude oil. Non-tradable goods can be consumed by the government and domestic consumers. Tradable goods can be consumed by domestic and foreign consumers. The government receives a share of oil revenue via taxation of oil

[5] Real effective exchange rates not freely available, which is why some authors used bilateral real exchange rate admitting that it is better to use real effective exchange rate.

[6] Chen and Rogoff (2003) use quarterly data from three countries Australia, Canada and New Zeland over the period 1973-2001.

[7] This is the case of Azerbaijan, Canada, Iran, Norway and Oman.

producers (e.g. royalties or production sharing agreements). Exogenous prices of goods are assumed.

3.1 Production function

Outputs are given by constant returns to scale production functions of tradable (Y_T) and non-tradable (Y_N) goods:

$$Y_T = A_T L_T^{\alpha} \tag{3.1}$$

and

$$Y_N = A_N L_N^{\alpha}, \tag{3.2}$$

where L_T and L_N is a domestic labour supply used in production of tradable and non-tradable goods, A is productivity shifters and $\alpha \in (0, 1)$. Total domestic labour supply is fixed at:

$$L = L_N + L_T. \tag{3.3}$$

Profit maximizing firm continues to employ units of labour until wage equates marginal revenue product of labour:

$$w = PA\alpha L^{\alpha-1}, \tag{3.4}$$

where P is price index.

Using equations (3.1) and (3.2) the relative supply of tradable and non-tradable goods as follows:

$$\frac{Y_N}{Y_T} = \left[\frac{A_N}{A_T}\right]^{\frac{1}{1-\alpha}} \left[\frac{P_N}{P_T}\right]^{\frac{\alpha}{1-\alpha}}, \tag{3.5}$$

where P_T and P_N are price indexes of tradable and non-tradable goods.

3.2 Government

Government revenue consists of taxes from tradable goods ($\tau P_T Y_T$) and oil revenue ($\lambda P^{oil} Y^{oil}$). Oil revenue consists of taxes on oil, such as royalties or production sharing agreements paid by oil producers based on the value of oil production[8]. A fixed share of oil revenue $(1 - \lambda)$ can be accumulated in oil revenue funds and invested abroad, so $\lambda \in [0, 1]$ is the share of oil revenue available for a government to spend. The government's budget constraint:

$$P_N G = \tau P_T Y_T + \lambda P^{oil} Y^{oil}, \tag{3.6}$$

[8] Government can receive taxes from oil producers in physical form and then sell oil, Y^{oil}, later for price, P^{oil}, or in money form, $P^{oil}Y^{oil}$,. In both cases the oil revenue of Government equals $P^{oil}Y^{oil}$.

3.3 Consumers

Consumers maximize the Cobb-Douglas utility function:

$$U = C_N^{\gamma} C_T^{1-\gamma}, \tag{3.7}$$

where C_T and C_N are consumptions of tradable and non-tradable goods, γ is a fraction of the total consumer expenditure spent on non-tradables, thus:

$$P_N C_N = \gamma(P_N C_N + P_T C_T) \tag{3.8}$$

subject to budget constraint:

$$P_N Y_N + (1-\tau) P_T Y_T = P_N C_N + P_T C_T, \tag{3.9}$$

where consumers' income consists of wages and profits.

3.4 Domestic economy

The equilibrium condition for non-tradable goods:

$$Y_N = C_N + G. \tag{3.10}$$

Solving the government's and consumers' budget constraint, substituting for C_N and dividing by $P_T Y_T$, we get relative supply of tradable and non-tradable goods as follows:

$$\frac{Y_N}{Y_T} = \frac{1}{1-\gamma}\left[\gamma(1-\tau) + \tau + \lambda\left(\frac{P^{oil}Y^{oil}}{P_T Y_T}\right)\right]\frac{P_T}{P_N}. \tag{3.11}$$

3.5 Foreign economy

We assume that the aggregate price level is a geometric average with the weights of the prices of tradables (γ) and non-tradables ($1-\gamma$), then a domestic price index as in the following equation:

$$P = P_N^{\gamma} P_T^{1-\gamma} = P_T\left(\frac{P_N}{P_T}\right)^{\gamma} \tag{3.12}$$

and foreign price index as in the following equation:

$$P^* = P_T^*\left(\frac{P_N^*}{P_T^*}\right)^{\gamma}, \tag{3.13}$$

where P_T^* and P_N^* are price indexes for tradable and non-tradable goods abroad.

Thus, the real exchange rate is:

$$Q = \frac{EP}{P^*} = \frac{EP_T}{P_T^*}\left[\frac{P_N/P_T}{P_N^*/P_T^*}\right]^{\gamma}, \tag{3.14}$$

where E is exchange rate.

Assume the law of one price for tradable goods:

$$P_T^* = EP_T. \tag{3.15}$$

Substituting equations of relative supply of tradable and non-tradable goods (3.11) in the real exchange rate equation (3.14), we get:

$$Q = \left[\frac{A_T/A_N}{A_T^*/A_N^*}\right]^{\gamma}\left[\frac{\gamma(1-\tau)+\tau+\lambda\frac{P^{oil}Y^{oil}}{P_TY_T}}{\gamma^*(1-\gamma^*)+\tau^*}\right]^{\gamma(1-\alpha)}. \tag{3.16}$$

The first term of the above equation is the Balassa-Samuelson effect (Balassa, 1964). The term $\lambda\frac{P^{oil}Y^{oil}}{P_TY_T}$ shows that the magnitude of the effect of the oil price (or oil revenue) on the exchange rate depends on λ. The country can reduce appreciation of domestic currency due to oil prices by setting $0 \le \lambda < 1$. The smaller λ is, the smaller the effect of oil prices on exchange rate.

Case 2: An oil revenue fund with the expenditure-based accumulation rule (based on reference oil price).

Assume the government sets a reference oil price at $\bar{P}$. If the actual oil price is above that reference oil price, that revenue accumulates the oil revenue fund and government expenditure equals to: $\bar{P}Y^{oil}$. If the actual oil price is less than the reference oil price, then the government can spend the entire oil revenue and get the difference between the actual oil price and the reference oil price multiplied by an amount of oil produced from the fund: $P^{oil}Y^{oil} + (\bar{P} - P_0)Y^{oil}$. Suppose the probability that actual oil price is greater than the reference oil price equals a, then probability that actual oil price below the reference oil price equals $(1-a)$. Then government's budget constraint can be written as follows:

$$P_NG = \tau P_NY_N + a\bar{P}Y^{oil} + (1-a)\left[P^{oil}Y^{oil} + (\bar{P} - P^{oil})Y^{oil}\right], \tag{3.17}$$

which is identical to: $P_NG = \tau P_NY_N + \bar{P}Y^{oil}$.

Putting all equations together, similarly to Case 1, but using budget constraint as in equation (3.17) instead of equation (3.9), we get the real exchange rate equation:

$$Q = \left[\frac{A_T/A_N}{A_T^*/A_N^*}\right]^{\gamma}\left[\frac{\gamma(1-\tau)+\tau+\frac{\bar{P}Y^{oil}}{P_TY_T}}{\gamma^*(1-\gamma^*)+\tau^*}\right]^{\gamma(1-\alpha)}. \tag{3.18}$$

If the government sets a fixed reference oil price that does not depend on time or oil prices, then the exchange rate is independent from nominal oil price. The only source of change of the exchange rate could be the change in the productivity differential and oil extraction. If the reference oil price is changed over time depending on the actual oil price movements[9], then such fund is less effective in stabilizing the real exchange rate.

What happens if funds invest domestically and not abroad? If a fund's assets are invested domestically, then $\lambda = 1$, because $1 - \lambda$ is the share of oil revenue invested in foreign assets. This means that the effect of such fund on the exchange rate is the same as without a fund at all; thus, there is no effect of such fund on exchange rates. Investment in foreign assets is also called sterilization of foreign currency. So we can call $1 - \lambda$ not just the share of revenue that accumulates the fund, but also the share of oil revenue that is invested in foreign assets.

Based on the theoretical model, the following hypotheses can be derived:

1. exchange rates are correlated with the share of oil revenue in the total value of export;
2. the share of oil revenue that is accumulated in the fund and invested abroad reduces the effect of the share of oil revenue in the total value of the export on the exchange rate;
3. in countries where funds' accumulation rules are based on reference oil prices, the variation of exchange rate is mostly due to changes of reference oil prices and changes in oil production (but not due to changes in oil prices);
4. only funds that invest abroad (sterilize foreign currency) can stabilize the exchange rate.

These hypotheses are tested in the following empirical model.

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[9] Some countries change reference oil price often (Nigeria, Algeria) or set reference oil price as a moving average (Trinidad, Mexico).

4 Empirical model

4.1 The model

In oil-dependent countries, where a large portion of trade is oil, the share of oil revenue in the total value of exports might be the primary cause of real exchange rate movements. This means that in some countries the share of oil revenue in the total value of exports might be enough to explain real exchange rate movements. The aim of this paper is to test whether funds can stabilize real exchange rates and to answer the question of why some funds are more effective than others. In oil-exporting countries, the share of oil revenue in the total value of exports is highly correlated with real exchange rates. We test whether funds can weaken this correlation. And if so, what characteristics make some funds more effective than others. Using results of the theoretical model we can write[10]:

$$Q_{it} = \alpha + \sum_{j=0}^{k} \gamma_j S_{it} F_{it,j} + u_i + \epsilon_{it} \tag{4.1}$$

and

$$S = \left[\frac{P^{oil} Y^{oil}}{P_T Y_T} \right], \tag{4.2}$$

where Q is a log of real effective exchange rate (REER), weighted foreign currency per domestic currency deflated with CPI; S is a ratio of the value of oil produced in total export (oil share); P^{oil} is world oil price measured in US dollars per barrel; Y^{oil} is an oil production in millions barrels; $P_T Y_T$ is a value of total export in million US dollars; F are characteristics of oil revenue funds with dummy variables: fund existence, stabilization/saving fund, foreign/domestic investment, revenue/expenditure based accumulation rule, and string variables: reference oil prices (US dollars per barrel) and a share of oil revenue that accumulates the fund.

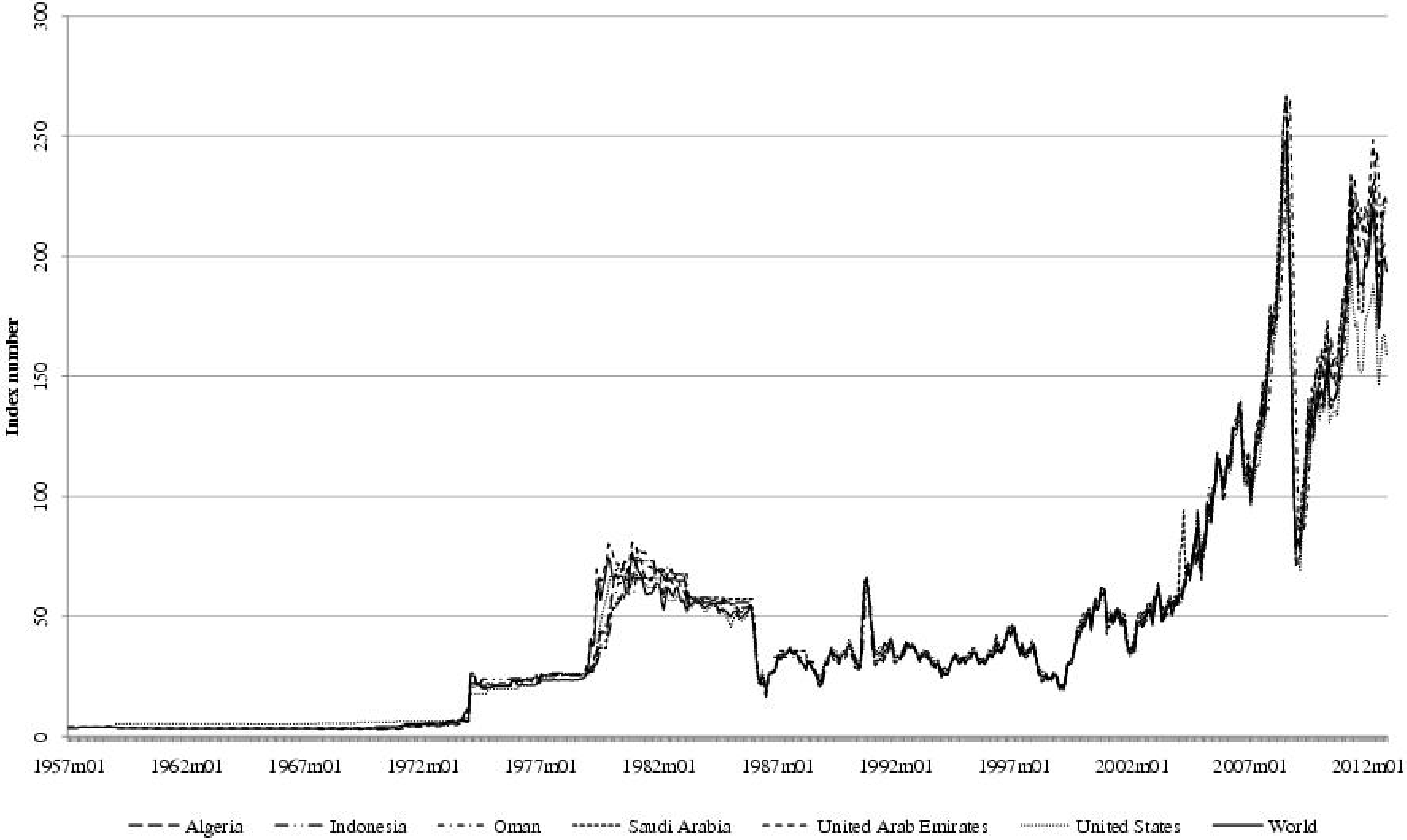
4.2 Data

Instead of using oil prices of each exporting country, world oil prices were used because oil prices of all exporting countries are highly correlated (correlation equals 0.99) (Figure4.1).

The data sources are presented in Table 4.1. Data about oil revenue funds is provided in Appendix A. The summary statistics are provided in Table 4.2. The summary statistics of data before and after funds were established are presented in Table 4.3. Table 4.4 provides correlation between REER and oil share.

[10] The productivity differential variables (real GDP per capita) were not included because the model built for monthly data.

Figure 4.1: Prices of different oil origins



Data source: International Monetary Fund (2012): International Financial Statistics (Edition: December 2012), ESDS International, University of Manchester.

Table 4.1: Data sources

Name	Source
Nominal oil prices, US dollars/barrel	International Monetary Fund (IMF), International Financial Statistics (IFS), Average Crude Price (World)
Consumer price index (CPI)	International Monetary Fund (IMF), International Financial Statistics (IFS)
Nominal exchange rates, domestic currency per Special drawing rights(SDR)	International Monetary Fund (IMF), International Financial Statistics (IFS)
Exports, Imports	International Monetary Fund (IMF), Direction of trade statistics (DOTS)
Oil production	International Energy Agency (IEA), Oil information, World oil statistics, Oil products exports
Total export	International Monetary Fund (IMF), Direction of trade statistics (DOTS)

Table 4.2: Summary statistics

Variable	Observations	Mean	Std. Dev.	Minimum	Maximum
Log of REER	15,076	-1.40	8.79	-53.09	8.51
Oil share	12,193	0.61	0.89	0	23.46
Fund exists	15,076	0.28	0.45	0	1
Stabilisation fund exists	15,076	0.17	0.38	0	1
Accumulation rule exists	15,076	0.13	0.33	0	1
Investment in foreign assets	15,076	0.21	0.40	0	1
Reference oil price	15,076	1.70	6.70	0	50
Percentage of accumulation	15,076	5.08	19.47	0	100

Table 4.3: Summary statistics before and after funds were established

Statistics	No fund	Never had fund	Countries that ever had fund	
			Before fund	After fund
Log of REER				
Obsservations	10825	6074	4751	4251
Mean	-2.04	-2.09	-1.98	0.23
Std. Deviation	10.1	12.83	4.69	3.3
Minimum	-53.1	-53.1	-12.66	-7.26
Maximum	8.52	8.52	5.87	5.45
Oil share				
Obsservations	9447	5613	3834	2746
Mean	0.54	0.39	0.77	0.86
Std. Deviation	0.72	0.65	0.76	1.31
Minimum	0	0	0	0.05
Maximum	9.64	8.91	9.64	23.47

Table 4.4: Correlation between REER and oil share

Characteristics	Correlation
Never had fund	-0.06
Ever had fund	-0.18
Before fund	-0.22
After fund:	
if funds invest domestically	0.38
if funds invest abroad	-0.15
if saving fund	-0.51
if stabilisation fund	-0.06
if accumulation rule expenditure-based	-0.14
if accumulation rule revenue-based	-0.56

4.3 Unit root and cointegration tests

Since the sample includes a cross-sectional time series over a long time period, it is necessary to perform unit root tests. Karlsson and Lothgren (2000) suggested careful analysis of both country-by–country and panel unit root test results to fully access the stationarity properties of the panel. Thus, in this paper individual and panel unit root tests and cointegration tests were performed.

4.3.1 Country-by-country unit root tests

Several unit root tests were applied. The first test is the Dickey-Fuller (DF) test (Dickey and Fuller, 1979). This test can include drift and a time trend:

$$\triangle y_t = \mu + \gamma^* y_{t-1} + \epsilon_t \tag{4.3}$$

and

$$\triangle y_t = \mu + \beta t + \gamma^* y_{t-1} + \epsilon_t, \tag{4.4}$$

where the null hypothesis is $H0 : \gamma^* = 0$ (y_t is nonstationary) is tested against the alternative hypothesis $H1 : \gamma^* < 0$ (y_t is stationary, $AR(1)$.

In most cases, both tests with and without the time trend provide the same result on stationarity. If both tests provided different results, we used graphs to determine the visual presence of a time trend. If the series tends to increase or decrease over time, results from the DF test with drift and time trend were used, otherwise we used the DF test with drift, since the model without the drift is rarely used (Davidson and MacKinnon, 1993).

In the presence of serial correlation, the DF test is not valid. Thus, it is important to test for autocorrelation. The Durbin-Watson (DW) test for first-order autocorrelation (Durbin and Watson,

1950) was the most commonly used test for serial correlation until the 1990s. Nowadays, the Breusch-Godfrey Lagrange Multiplier (LM) test (Breusch and Godfrey, 1981) is more popular because it can be applied in a wider set of circumstances and can test for higher-order serial correlation (Wooldridge, 2009). The null and alternative hypotheses for the Breusch-Godfrey LM test are $H0$: no serial correlation in e_t and $H1 : e_t$ is $AR(p)$ or $MA(p)$.

$$e_t = x_t'\gamma + \rho_1 e_{t-1} + \ldots + \rho_p e_{t-p} + u_t, \tag{4.5}$$

where e_t are residuals from equations (4.3) and (4.4). The test statistic is simply TR^2 and, under $H0$, we have as $T \to \infty$,

$$LM = TR^2 \sim X_p^2. \tag{4.6}$$

In most countries there is an evidence of autocorrelation in series; thus, it is necessary to use the Augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1979) instead of the DF test to test the series of such countries. The ADF test, using an appropriate amount of lags, removes serial correlation from the residuals. Therefore it is crucial to determine an appropriate amount of lags, p. If p is too small, then the remaining serial correlation in the errors bias the test. If p is too large, then the power of the test is lower. In order to determine the optimal amount of lags, we used the Schwarz's Bayesian information criterion (SBIC) by (Schwatrz, 1978), the Akaike's information criterion (AIC) by Akaike (1974), and the Hannan and Quinn information criterion (HQIC) by Hannan and Quinn (1979). Using obtained results, we again test for serial correlation using the Breusch-Godfrey Lagrange Multiplier (LM) test in the same models as above, but including the suggested amount of lagged dependent variables (where residuals are from equations (4.7) and (4.8). In most cases, results showed no serial correlation, thus the amount of lags obtained using information criteria can be used in ADF test. In a few cases, when results showed the presence of serial correlation or when information criterions suggested different lag lengths, another approach was used to determine the appropriate amount of lags suggested by Ng and Perron (1995). We started by adding a number of lags and sequentially dropping the last lag if it is not significant at ten percent. If the last lag is significant at ten percent, then p is found. At every step, we checked for possible serial correlation of the errors using the Breusch-Godfrey LM test as above.

ADF test can include drift and time trend:

$$\triangle y_t = \mu + \gamma^* y_{t-1} + \sum_{i=1}^{p-1} \gamma_i \triangle y_{t-i} + \epsilon_t \tag{4.7}$$

and

$$\triangle y_t = \mu + \beta t + \gamma^* y_{t-1} + \sum_{i=1}^{p-1} \gamma_i \triangle y_{t-i} + \epsilon_t. \tag{4.8}$$

The test of the hypothesis in ADF test is the same as in DF test. The results of DF/ADF unit root tests of the real effective exchange rate are presented in the Appendix B. The results of DF/ADF unit root tests of the oil share are presented in the Appendix C.

Another unit root test, which allows the presence of autocorrelation, is the Phillips-Perron (PP) test proposed by Phillips and Perron (1988). This test corrects for serial correlation and heteroskedasticity in the errors by modifying the Dickey-Fuller test statistics. PP test statistics correct for serial correlation by using the Newey–West (1987) heteroskedasticity and autocorrelation-consistent covariance matrix estimator. The PP test is asymptotically equivalent to the ADF test.

The PP test can include drift and time trend:

$$\triangle y_t = \mu + \beta' D_t + \rho y_{t-1} + \epsilon_t \tag{4.9}$$

and

$$\triangle y_t = \mu + \alpha t + \beta' D_t + \rho y_{t-1} + \epsilon_t, \tag{4.10}$$

where the null hypothesis $H_0 : \rho = 0$ (y_t has unit root) is tested against the alternative hypothesis $H_1 : \rho \neq 0$ (y_t is stationarity). The results of PP unit root test of the real effective exchange rate are presented in Appendix D. The results of PP unit root test of the oil share are presented in Appendix E.

Another unit root test is the Dickey-Fuller Generalized Least Squares (DF-GLS) test proposed by Elliott et al. (1996; ERS[11]). It is similar to the ADF test, but transformation using the GLS regression before the test is required. Baum and Sperling (2001) show that the ERS test is superior to the ADF test and it is preferred in most cases to the first generation unit root tests of the DF/ADF and the PP because the ERS test has the best overall performance in terms of small sample-size and power. For this test, an optimal amount of lags was obtained using the sequential t-test by Ng-Perron criterion (Ng and Perron, 1995), the modified Akaike information criterion (MAIC) by Bhansali and Downham (1977) and the Schwartz criterion (SC) by Schwartz (1978) with or without time trend. Presence of the time trend was determined, as before, using graphs. The results of the DF-GLS unit root test of real effective exchange rate are presented in the Appendix F. The results of the DF-GLS unit root test of oil share are presented in Appendix G.

[11] The ERS test was performed using STATA command dfgls (ers). This command is developed by Baum and Sperling (2001).

Table 4.5: Panel unit root tests

1st generation: cross sectional independence			2nd generation: cross-sectional dependence		
H0: unit root		H0: no unit root	H0: unit root		H1: no unit root
H1: all panels are stationary	H1: some panels are stationary	H1: some panels contain unit roots	H1: all panels are stationary	H1: some panels are stationary	H1: some panels contain unit roots
LLC Breitung HT LL	IPS Fisher-type	Hadri LM	MP BN Choi O'Connel Breitung robust	Pesaran Chang	Hadri LM robust

4.3.2 Panel unit root tests

Panel unit root tests are believed to be more powerful than individual unit root tests. Recently unit root tests for multiple time series were developed such as LL (Levin and Lin, 1992, 1993), LLC (Levin et al. 2002), IPS (Im et al. 2003), Fisher-type (Maddala and Wu, 1999; Choi, 2001), Hadri LM (Hadri , 2000) and Breitung (Breitung, 2001). These tests do not allow for cross-sectional dependence; they also called the first generation panel unit root tests. The second generation of panel unit root tests allow for cross-sectional dependence such as CADF (Pesaran, 2006), Breitung robust (Breitung and Das, 2005), Hadri robust (Hadri and Kurozumu, 2008), MP (Moon and Perron, 2004), BN (Bai and Ng, 2002, 2004), Choi (Choi, 2006), O'Connell (O'Connell, 1998) and Chang (Chang, 2002, 2004). Panel unit root tests have different null hypotheses and alternative hypotheses. Panel unit root tests and their hypotheses are summarized in Table 4.5.

In the presence of cross-sectional dependence, the first generation panel unit root tests are not valid. Thus, it is important to test whether panels are cross-sectionally dependent. The following two tests to identify cross-sectional dependence were used. Pesaran (2004) provides a test for error cross-section dependence (Pesaran's CD test) for panel data with short number of periods (T) and large number of panels (N)[12]. The Breusch-Pagan Lagrange Multiplier (LM) test (Breusch and Pagan, 1979) is a test for cross-sectional correlation in a fixed effects model[13] for long panel data ($T > N$). The results of both tests on cross-sectional dependence strongly indicate the presence of common factors affecting cross-sectional units (Table 4.6). All first generation panel unit root tests exhibit size distortion and low power under cross-sectional dependence; however, the Fisher-type test performs better than LL and IPS tests in the presence of cross-sectional dependence according to Maddala and Wu (1999).

Table 4.6: The results of tests on cross-sectional dependence

Null: no cross-sectional dependence	Statistics
Breusch-Pagan LM test	14971***
Pesaran's CD test	107.97***

* Significant at 10 percent level.
** Significant at 5 percent level.
*** Significant at 1 percent leve.

Unit root tests allowing for cross-section dependence are the second generation of unit root tests and were developed relatively recently. That is why some of them are not available in statistical software. We used only those tests that are available in statistical software STATA.

Pesaran (2006) provides a cross-sectionally augmented DF (CADF)[14] test. The CADF tests for the unit root in heterogeneous panels with cross-section dependence and serial correlation using the t-test. An amount of lags was chosen same as the highest lag length from individual unit root tests ($p = 4$). Cross-sectional dependence in DF/ADF regressions is augmented with cross-section average lags and first differences of the individual series. An average of the CADF test for country-by-country was used:

$$\triangle y_{it} = \alpha_i + \rho_i y_{it-1} + c_i \bar{y}_{t-1} + \sum_{j=0}^{p} d_{ij} \triangle \bar{y}_{t-j} + \sum_{j=0}^{p} \beta_{ij} \triangle \bar{y}_{t-j} + \mu_{it}. \tag{4.11}$$

The CADF tests the null hypothesis $H0 : \rho_i = 1$ for all i (unit root) against the alternative hypothesis $H1 :$ some series are stationary (individual unit root process).

The Breitung robust test proposed by Breitung and Das (2005) is an extension of Breitung test. The Breitung robust test is based on robust panel corrected standard errors to allow for cross-sectional dependence. These standard errors are asymptotically normally distributed under weak cross-sectional dependence and large sample size (Herwartz and Siedenburg, 2007). This test requires a strongly balanced panel, and for this reason, the panel data was converted to balanced. This transformation reduced sample size, thus reducing the power of the test. The null hypothesis is that there is a unit root and the alternative hypothesis is that all panels are stationary (common unit root process).

The Hadri LM robust test proposed by Hadri and Kurozumi (2008) is an extension of Hadri LM test. The cross-sectional dependence is corrected in this test using the same method as the one proposed by Pesaran (2007). The null hypothesis of this test is different from other panel unit root tests. The null hypothesis is that there is no unit root in any panels and the alternative hypothesis is that there is a unit root in some panels (individual unit root process). Table 4.7 presents the results of the panel unit root tests of REER and oil share with and without a time trend.

Since we found the presence of cross-sectional dependence among panels, the second generation panel unit tests are more appropriate as they allow for cross-sectional dependence among panels. Panel unit root tests have different alternative hypothesis, which is why it is important to pay attention not only to the null hypothesis but also to the alternative hypothesis. The null hypothesis that all panels are nonstationary is not rejected in favour of the alternative hypothesis that all panels are stationary, but is strongly rejected in favour of the alternative hypothesis that some panels are stationary. The hypothesis that all panels are stationary is strongly rejected in favour of the alternative that some panels are nonstationary. Similar results are provided by the first generation unit root tests that do not allow for cross-sectional dependence.

[14] The CADF test was performed using STATA command pescadf. This command is developed by Lewandowski (2007).

Table 4.7: The results of panel unit root tests

Method	Log of REER		Oil share	
	Individual effects	Individual effects and individual linear trends	Individual effects	Individual effects and individual linear trends
1st generation tests (no cross-sectional dependence)				
Null: Unit root (common unit root process)				
LLC, t-stat	-6.010***	-1.752**	4.845	3.491
Breitung, t-stat	4.697	1.455	-7.092***	-5.180***
HT, rho-stat	0.995**	0.918***	0.921***	0.847***
Null: Unit root (individual unit root process)				
IPS, W-stat	-0.132	-2.722***	-7.762***	-7.417***
ADF-Fisher, Chi2	95***	118***	194***	184***
PP-Fisher, Chi2	293***	431***	575***	669***
Null: No unit root (individual unit root process)				
Hadri LM, Z-stat	497***	374***	201***	82***
2nd generation tests (cross-sectional dependence)				
Null: Unit root (common unit root process)				
Breitung robust, t-stat	1.263	-0.24	-2.603***	0.059
Null: Unit root (individual unit root process)				
CADF, t-bar [15]	-2.587***	-3.124***	-2.486***	-2.681**
Null: No unit root (individual unit root process)				
Hadri LM robust, Z-stat	404***	251***	170***	85***

* Significant at 10 percent level.

** Significant at 5 percent level.

*** Significant at 1 percent level.

We suggest that probably not in all countries REER and oil share have unit roots. That is why it is important to test for a unit root country-by-country; unfortunately individual unit root tests DF/ADF, PP and DF-GLS provide contradictory results in most cases. Only in Kuwait, Oman, Azerbaijan and Netherlands is the stationarity of oil share supported by all unit root tests (Table 4.8).

[15] Critical values of CADF test are -2.080 at 10 percent, -2.160 at 5 percent, -2.300 at 1 percent level of significance; Critical values of CADF test with a time trend are -2.590 at 10 percent, -2.650 at 5 percent, -2.770 at 1 percent level of significance.

Table 4.8: Stationary oil share

Country	Log of REER			Oil share		
	DF-GLS	DF/ADF	PP	DF-GLS	DF/ADF	PP
Kuwait	I(1)	I(0)	I(0)	I(0)	I(0)	I(0)
Oman	I(1)	I(0)	I(0)	I(0)	I(0)	I(0)
Azerbaijan	I(1)	I(0)	I(0)	I(0)	I(0)	I(0)
Netherlands	I(1)	I(1)	I(1)	I(0)	I(0)	I(0)

I(0) - series is stationary
I(1) - series is nonstationary

While all unit root tests agree on the stationarity of the oil share in these four countries, they provide different results on the stationarity of the REER. Since it is believed that the DF-GLS test is superior to the DF/ADF test, we assume that the REERs in these four countries (Kuwait, Oman, Azerbaijan and Netherlands) are nonstationary. Panel unit root tests are more powerful than individual unit root tests, but it is not possible to use them to test for the presence of unit root in the REER from just four countries. Unfortunately, the panel unit root tests are designed for a large number of panels (whereas T can be small or large), thus, we did not use panel unit root tests to check whether indeed REERs are nonstationary from those four countries.

The nonstationarity of oil share could be explained by nonstationary oil prices, for which nonstationarity is well-documented. The first differences of the REER and the oil share are stationary in all countries. Thus series which are nonstationary are nonstationary at the first order, $I(1)$.

4.3.3 Country-by-country cointegration test

The REER from all countries can be nonstationary, and the oil share from most countries can be nonstationary. Cointegration is only possible if both series are nonstationary. Thus, there is a need to test for cointegration between the REER and the oil share from all countries except from Kuwait, Oman, Azerbaijan and Netherlands (the oil share is clearly stationary from those four countries).

Johansen's cointegration test (Johansen, 1991) provides the cointegration rank. There is no cointegration if the rank equals zero. We applied the trace test where the null hypothesis is $H0 : r = 0$ and the alternative hypothesis is $H1 : r > 0$. The critical value of the trace test without time trend equals 15.41 at five percent level of significance. We also applied the trace test where the null hypothesis is $H0 : r \leq 1$ and alternative hypothesis is $H1 : r = 2$. The critical value of the trace test without time trend equals 3.76 at five percent level of significance.

Vector autoregression (VAR) model has the following equation:

$$y_t = Bx_t + \sum_{i=1}^{p+1} \phi_i y_{t-i} + \epsilon_t. \tag{4.12}$$

Vector error correction model (VECM) has the following equation:

Table 4.9: The results of Johansen's cointegration test

Country	Log of REER			Oil share			Cointegration test
	DF-GLS	DF/ADF	PP	DF-GLS	DF/ADF	PP	max rank
Saudi Arabia	I(1)	I(0)	I(0)	I(1)	I(0)	I(0)	1
UAE	I(1)	I(0)	I(1)	I(1) or I(0)	I(0)	I(0)	1
Kazakhstan	I(1)	I(0)	I(0)	I(1)	I(1)	I(0)	1
Qatar	I(1) or I(0)	I(0)	I(0)	I(0)	I(1)	I(0)	1
Libya	I(1)	I(1)	I(0)	I(1) or I(0)	I(0)	I(0)	1
Angola	I(1)	I(1)	I(1)	I(1)	I(0)	I(0)	1
Argentina	I(1)	I(1)	I(1)	I(1)	I(0)	I(0)	1
Colombia	I(1)	I(1)	I(0)	I(1) or I(0)	I(0)	I(0)	1
Egypt	I(1)	I(1)	I(1)	I(1)	I(0)	I(0)	1
Iraq	I(1) or I(0)	I(1)	I(0)	I(1)	I(1)	I(0)	1
Canada	I(1)	I(1)	I(1)	I(1)	I(0)	I(0)	0
USA	I(1)	I(1)	I(1)	I(1) or I(0)	I(1)	I(1)	0
Norway	I(1)	I(1)	I(1)	I(1)	I(1)	I(0)	0
Venezuela	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	0
Algeria	I(1)	I(1)	I(1)	I(0)	I(1)	I(0)	0
Trinidad	I(1)	I(1)	I(1)	I(1) or I(0)	I(1)	I(0)	0
Mexico	I(1)	I(1)	I(1)	I(1)	I(1)	I(0)	0
Nigeria	I(1)	I(1)	I(1)	I(1)	I(1)	I(0)	0
India	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	0
UK	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	0
Ecuador	I(1)	I(1)	I(1)	I(1)	I(1)	I(0)	0
Iran	I(1)	I(1)	I(1)	I(1)	I(1)	I(0)	2
Russia	I(1)	I(1)	I(1)	I(1)	I(0)	I(0)	2
Bahrain	I(1)	I(0)	I(0)	I(1)	I(0)	I(0)	2

I(0) - series is stationary
I(1) - series is nonstationary

$$\triangle y_t = Bx_t + \prod y_{t-1} + \sum_{i=1}^{p} \Gamma_i \triangle y_{t-i} + \epsilon_t. \tag{4.13}$$

If $\prod = 0$ there is no cointegration; If $\prod = 1$ there is one cointegrating vector[16] ; If $\prod = 2$ there is a full rank.

The results of Johansen's cointegration test (Table 4.9) show that REER and oil share are cointegrated (rank=1) in 10 countries, not cointegrated (rank=0) in 11 countries and have full rank (rank=2) in three countries. These mixed results on cointegration in countries are consistent with Amano and Van Norden (2003), Chaudhuri and Daniel (1998) and Chen and Chen (2007)[17].

Full rank leads to contradictions among the assumptions of the model. Johansen's cointegration test

[16] Since we test cointegration between two variables there only one possible cointegrating relationship.

[17] Amano and Van Norden (2003) and Chen and Chen (2007) use the Johansen's cointegration test, whereas Chaudhuri and Daniel (1998) use the Engle-Grager cointegration test.

Table 4.10: The results of Westerlund panel cointegration test

Statistics	P-value		Robust p-value	
(H0: no cointegration)	Constant	Constant and trend	Constant	Constant and trend
Individual cointegration process				
Group mean test, Gt	0.054	0.456	0.015	0.383
Group mean test, Gt	0.783	0.128	0.670	0.523
Common cointegration process				
Panel test, Pt	0.074	1.000	0.245	1.000
Panel test, Pa	0.780	1.000	0.665	1.000

requires all variables to be nonstationary and there can only be $M-1$ cointegrating relationships between M variables. If $\prod$ has full rank, there are M stationary linear combinations of the series, which is only possible if both the REER and the oil share are stationary (Davidson and MacKinnon, 1993). Although DF-GLS showed that REER and oil share are nonstationary in these countries, we assumed that both the REER and the oil share are stationary when $\prod$ has full rank.

4.3.4 Panel cointegration test

An error correction-based cointegration test in heterogeneous panel models (Westerlund test) proposed by Westerlund (2007) is based on time series error correction by countries[18]. The Westerlund test allows for cross-sectional dependence and is suitable for unbalanced panel data:

$$\triangle y_{it} = \delta\prime_i d_t + \alpha_i y_{it-1} + \lambda\prime_i x_{it} + \sum_{j=1}^{p_i} y_{ij} \triangle x_{it-j} + e_{it}. \tag{4.14}$$

The G_a and the G_t statistics test the null hypothesis $H0 : a_i = 0$ for all countries (no cointegration in all countries) against the alternative hypothesis $H1 : a_i < 0$ for at least one country (cointegration at least in one country). The P_a and the P_t statistics test the null hypothesis $H0 : a_i = 0$ for all countries (no cointegration in the whole panel) against the alternative hypothesis $H1 : a_i < 0$ for all countries (cointegration in the whole panel data). A number of lags and leads were determined using the optimal amount of lags chosen with Akaike information criterion p_i for each separate time series, within the given limits: $(1, 4)$ lags and $(0, 3)$ leads.

These test statistics are robust in the presence of common factors in the time series. As the results about cross-sectional dependence strongly indicate the presence of common factors affecting cross-sectional units, it is important to obtain robust P-values. This could be done using the bootstrap approach proposed by Westerlund (2007). A constant and a time trend were included in the Westerlund test.

The results of the panel cointegration test with a constant (Table 4.10) show that there is a cointe-

[18] The Westerlund test was performed using STATA command xtwest. This command is developed by Persyn and Westerlund (2008).

grating relationship in at least one country (we can reject the null hypothesis of no cointegration at five percent level of significance in favour of an alternative hypothesis that there is a cointegrating relationship in at least one country). These results support the results of country-by-country Johansen's cointegration test that there is a cointegrating relationship between the REER and the oil share in some countries.

4.4 Country-by-country estimation

With the obtained results on stationarity and the cointegration of variables it is possible to test country-by-country whether oil revenue funds are effective in the reduction of correlation between the REER and the oil share, and which rules make such funds effective.

4.4.1 Cointegrated time series

To estimate cointegrated series Johansen's approach (1988, 1991, 1995) maximum likelihood in an error correction model (MLECM) was used. MLECM is a type of vector autoregression in which some of the variables are cointegrated. Gonzalo (1994) shows that when series are cointegrated, MLECM has better properties than alternative estimators such as OLS by Engle and Granger (1987), nonlinear least squares by Stock (1987), canonical correlations by Bossaerts (1988), instrumental variables (IV) by Hansen and Phillips (1990) and spectral regression by Phillips (1991). MLECM is presented in the following equations:

$$\triangle Y_t = \alpha + \zeta_0 Y_{t-1} + \sum_{j=1}^{p-1} \zeta_j \triangle Y_{t-j} + \epsilon_t \tag{4.15}$$

and

$$\zeta_0 = -BA\prime, \tag{4.16}$$

where Y_t is a vector of observations on the levels of a set of variables each of which is assumed to be nonstationary (the REER, the oil share, interactions of the oil share with the funds' characteristics), p is an optimal lag length for the MLECM that is chosen using information criteria (same as in the cointegration test).

If ϵ_t $i.i.d.N(0,\Omega)$, then the log-likelihood function is given by the equation:

$$L(\Omega, \varsigma_1, \ldots \varsigma_{p-1}, \alpha, \varsigma_0 = -\frac{nT}{2} ln 2\pi - \frac{T}{2} ln\Omega - \frac{1}{2}\sum_{t=1}^{T}(\triangle Y_t - \alpha - \zeta_0 Y_{t-1} - \sum_{j=1}^{p-1}\zeta_j \triangle Y_{t-j})\prime \times \Omega^{-1}$$
$$(\triangle Y_t - \alpha - \zeta_0 Y_{t-1} - \sum_{j=1}^{p-1}\zeta_j \triangle Y_{t-j}). \tag{4.17}$$

The MLECM approach can be summarized in three steps: 1) calculate auxiliary regressions; 2) calculate canonical correlations; 3) calculate maximum likelihood estimates of parameters.

4.4.2 Not cointegrated series

For countries where both the REER and the oil share are nonstationary, but not cointegrated, it is necessary to include their first differences to correct for nonstationarity (VAR):

$$\triangle Q_t = \alpha + \sum_{j=1}^{p-1} \beta_i \triangle Q_{t-j} + \sum_{j=1}^{p-1} \sum_{k=0}^{K} \gamma_{j,k} \triangle S_{t-j} F_{t-j,k} + \epsilon_t. \tag{4.18}$$

For countries where REER is nonstationary and oil share is stationary, it is necessary to use the first differences of the REER to correct for nonstationarity (VAR):

$$\triangle Q_t = \alpha + \sum_{j=1}^{p-1} \beta_i \triangle Q_{t-j} + \sum_{j=1}^{p-1} \sum_{k=0}^{K} \gamma_{j,k} S_{t-j} F_{t-j,k} + \epsilon_t. \tag{4.19}$$

For countries where both the REER and the oil share are stationary (VAR) it is not necessary to use first differences of the REER and the oil share:

$$Q_t = \alpha + \sum_{j=1}^{p-1} \beta_i Q_{t-j} + \sum_{j=1}^{p-1} \sum_{k=0}^{K} \gamma_{j,k} S_{t-j} F_{t-j,k} + \epsilon_t. \tag{4.20}$$

In order to find out which countries' exchange rate movements can be explained by the share of oil production, we tested the null hypothesis $H0 : \gamma_{j,k} = 0$ against the alternative hypothesis $H1 : \gamma_{j,k} \neq 0$, where $k = 0$. In order to find which countries' funds are effective, we can test the null hypothesis $H0 : \gamma_{j,k} < 0$ against the alternative hypothesis $H1 : \gamma_{j,k} \geq 0$, where $k \neq 0$. The description of variables is presented in Table 4.11.

A number of lags were chosen using the same information criteria as for the individual cointegration test. The results of the country-by-country estimation are extremely limited because countries establish a fund only once, and once the fund is established, the type of investment, the type of accumulation rule, the reference oil price and the share of oil revenue that accumulates the fund are not often changed.

4.5 Estimation of panel data

For panel estimation, four lags ($p = 4$) were used, which is the highest optimal lag length used in the country-by-country cointegration test[20].

Thus panels are estimated by the following groups:

1. cointegrated panels;

2. nonstationary, but not cointegrated panels;

[20] The author thanks Professor Joao M. C. Santos Silva for this advice.

Table 4.11: Variables

Notation	Unit	Interpretation
Q	log	Real effective exchange rate in logs
S	ratio	The share of value of oil produced in total export
Interaction terms with oil share		
Fund	dummy variable 1 if fund exist	Existence of fund
Investment	dummy variable 1 if fund invests in foreign assets, 0 if in domestic assets	Existence of fund which invests in foreign assets
Accumulation Rule	dummy variable 1 if revenue-based, 0 if expenditure-based	Existence of fund with expenditure-based accumulation rule of fund
Reference oil price	US dollars per barrel/nominal oil price	Reference oil price[19]
Percentage	%	Share of oil revenue which accumulates fund

3. REER is nonstationary and oil share is stationary;

4. stationary panels.

In each group there are countries with and without a fund, so these models are able to test the effect of the existence of funds on exchange rates, but there is a low power of the tests on the significance of rules of funds (Table 4.12).

[19] Reference oil price is a budgeted price that is used in estimation of government revenue and expenditure. If oil prices fall below the reference oil price a country might have budget deficit; if oil prices rise above reference oil price a country might have surplus.

Table 4.12: Panel data sorted by stationarity and cointegration

Country	Fund	Investment	Accumulation rule	Reference oil price, USD/barrel	Percent of oil revenue
Cointegrated panels					
Saudi Arabia	1958	foreign	NA		
United Arab Emirates	1976	foreign	expenditure-based	NA	
Kazakhstan	Aug-00	foreign	expenditure-based	19	
Qatar	2005	foreign	expenditure-based	40	
Libya	2006	foreign	NA	NA	
Argentina	*No Fund*				
Colombia	*No Fund*				
Iraq	*No Fund*				
Egypt	*No Fund*				
Not cointegrated panels					
Canada	1976	foreign	revenue-based		30 (1976-1983), 15 (1984-1987)
USA	1976	foreign	revenue-based		25 (1976-1979), 50 (1980-2010)
Norway	1990	foreign	revenue-based		100
Venezuela	1998	foreign	expenditure-based	17 (1998), 9 (1999-2010)	
Algeria	2000	foreign	expenditure-based	19 (2000), 22 (2006-2008), 37 (2009-2010)	
Trinidad	2000	foreign	expenditure-based	11-year MA	

continued...

. . . Table 1.15 continued

Country	Fund	Investment	Accumulation rule	Reference oil price, USD/barrel	Percent of oil revenue
Mexico	2000	NA	expenditure-based	1.5 (2000-2005), weight of 3/4 to oil futures prices and a weight of 1/4 to the average oil price of last 10 years (2006-2010)	
Nigeria	2004	domestic	expenditure-based	25 (2004), 30 (2005), 35 (2006-2010)	
India	*No Fund*				
UK	*No Fund*				
Ecuador	*No Fund*				
Log of REER is nonstationary, but oil share is stationary					
Kuwait	1960	foreign	expenditure-based (1960-1975), revenue-based (1976-2010)	NA (1973-2005), 36 (2006), 43 (2007), 50 (2008-2010)	10 (1976-2010)
Oman	1980	foreign	revenue-based (1980-1988), expenditure-based (1989-2010)	15 (1989-2008), 45 (2009-2010)	15 (1980-1985), 5 (1986-1988)
Azerbaijan	Dec-99	foreign	revenue-based		100
Netherlands	*No Fund*				
Both log of REER and oil share are stationary					

continued. . .

... Table 1.15 continued

Country	Fund	Investment	Accumulation rule	Reference oil price, USD/barrel	Percent of oil revenue
Iran	1999	foreign	revenue-based		100
Bahrain	Jun-06	domestic	NA		
Russia	2004	foreign	expenditure-based	20 (2004-2005), 27 (2006-2010)	

NA - not available.

4.5.1 Estimation of cointegrated panels

There are several estimation models available for cointegrated panels that can be divided into single equations and system estimators. Single equations include: Fully Modified OLS (FMOLS) by Pedroni (2001) and Phillips and Moon (1999,); Pooled Mean Group (PMG)[21] by Pesaran et al. (1999); Dynamic Ordinary Least Squares (DOLS)[22] by Kao and Chiang (2000). System estimators include: panel vector autoregression (PVAR) by Binder et al. (2005), panel Vector Error Correction Model (VECM) by Larsson and Lyhagen (1999), Groen and Kleibergen (2003) and Breitung (2005).

Pesaran's method allows for a common cointegrating vector and heterogeneous short-run dynamics. Long-run relationships in dynamic heterogeneous panels are estimated using the following equation:

$$\triangle y_{it} = \phi(y_{it-1} - \phi_i' X_{it}) + \sum_{j=1}^{p-1} \lambda^*{}_{ij} \triangle y_{it-1} + \sum_{j=0}^{q-1} \delta'{}_{ij} \triangle X_{it-j} + \mu_i + \epsilon_{it}, \tag{4.21}$$

where ϕ is the error correction speed of the adjustment parameter to be estimated, ϕ' is a $(k \times 1)$ vector of parameters, p is a number of lags, X_{it} is a $(1 \times k)$ vector of covariates, q is a number of parameters to be estimated and ϵ_{it} is an error term. The assumed distribution of the error term depends on the estimated model.

Estimators from single estimations have several disadvantages compared to system estimators. Binder et al. (2005) have developed a panel vector autoregressive (PVAR) model for panels with fixed T and large N. The PVAR model obtains the generalized method of moments (GMM) estimators[23]. The following is a PVAR model using GMM estimation:

[21] PMG was performed using STATA command *xtpmg*. This command is developed by Blackburne and Frank (2009).

[22] DOLS was performed using STATA command *xtdolshm*. This command is developed by Amadou (2011).

[23] PVAR estimation was performed using STATA command pvar. This command is developed by Love (Love and Zicchino, 2006).

$$z_t = \Gamma_0 + \Gamma_1 z_{t-1} + e_t, \tag{4.22}$$

where z_t is a variable vectors: the log of the REER, the oil share, the interaction terms of the oil share with fund characteristics. The number of lags is chosen using the highest lag length from individual cointegration tests ($p = 4$).

Cointegrated panels of 10 countries (Saudi Arabia, United Arab Emirates, Kazakhstan, Qatar, Libya, Angola, Argentina, Colombia, Egypt and Iraq) can only test effects of the existence of funds and reference oil prices because there are no countries with different accumulation rules and different types of investments.

4.5.2 Estimation of not cointegrated panels

If panels are nonstationary, but not cointegrated, the first differences model was used:

$$\triangle Q_t = \alpha + \sum_{j=1}^{p-1} \beta_i \triangle Q_{it-j} + \sum_{j=1}^{p-1}\sum_{k=0}^{K} \gamma_j \triangle S_{it-j} F_{it-j,k} + \epsilon_{it}. \tag{4.23}$$

Using data of not cointegrated panels of 11 countries (Canada, USA, Norway, Venezuela, Algeria, Trinidad, Mexico, Nigeria, India, UK, and Ecuador) the effects of the existence of funds, investment, accumulation rule, reference oil price, and percentage of revenue can be tested. Since, in most countries, the series are both nonstationary and not cointegrated, we can also use equation (4.23) to regress using data from all 27 countries because the results of regressions by groups depending on stationarity and cointegration are limited by the small number of countries.

If only the REER is nonstationary, the model with the first differences of nonstationary series was used:

$$\triangle Q_t = \alpha + \sum_{j=1}^{p-1} \beta_i \triangle Q_{it-j} + \sum_{j=1}^{p-1}\sum_{k=0}^{K} \gamma_j S_{it-j} F_{it-j,k} + \epsilon_{it}. \tag{4.24}$$

Only the existence of funds and the effect of reference oil prices was tested when using data from four countries (Kuwait, Oman, Azerbaijan, Netherlands).

If both the REER and the oil share are stationary, the fixed effect model can be used:

$$Q_{it} = \alpha + \sum_{j=1}^{p-1} \beta_i Q_{it-j} + \sum_{j=1}^{p-1}\sum_{k=0}^{K} \gamma_j S_{it-j} F_{it-j,k} + \epsilon_{it}. \tag{4.25}$$

Using data from three countries (Iran, Bahrain and Russia) only the effects of the existence of funds can be tested.

4.6 Empirical results and limitations

In the current paper we try to answer the questions, "Are oil revenue funds effective?" and "What makes them effective?". To answer these questions the following estimations were performed:

- country-by-country;
- panel estimation by groups (according to stationarity and cointegration);
- all panels (27 countries).

Results of the country-by-country estimation with cointegrated series (Appendix H), not cointegrated series (Appendix I), nontationary REER (Appendix J), stationary series (Appendix K) and panels by groups estimation with cointegrated panels (Appendix L and M), not cointegrated panels (Appendix N), panels with nonstationary REER (Appendix O), stationary panels (Appendix P) are highly limited as the number of countries is very small, whereas the estimation of all 27 countries is more powerful in its prediction of the effects of funds.

Estimation of panel data using 27 countries (Appendix Q) requires an assumption that the REER and the oil share are nonstationary and not cointegrated. The empirical results of 27 oil-producing countries (19 with funds and 8 without funds) over the period from January 1957 to November 2010 show that oil revenue funds are effective in the stabilization of exchange rates. Thus, oil revenue funds can help avoid appreciation of domestic currency, which is the first chain of Dutch disease. The effect of funds on exchange rates is large enough to offset the appreciation of domestic currency due to oil.

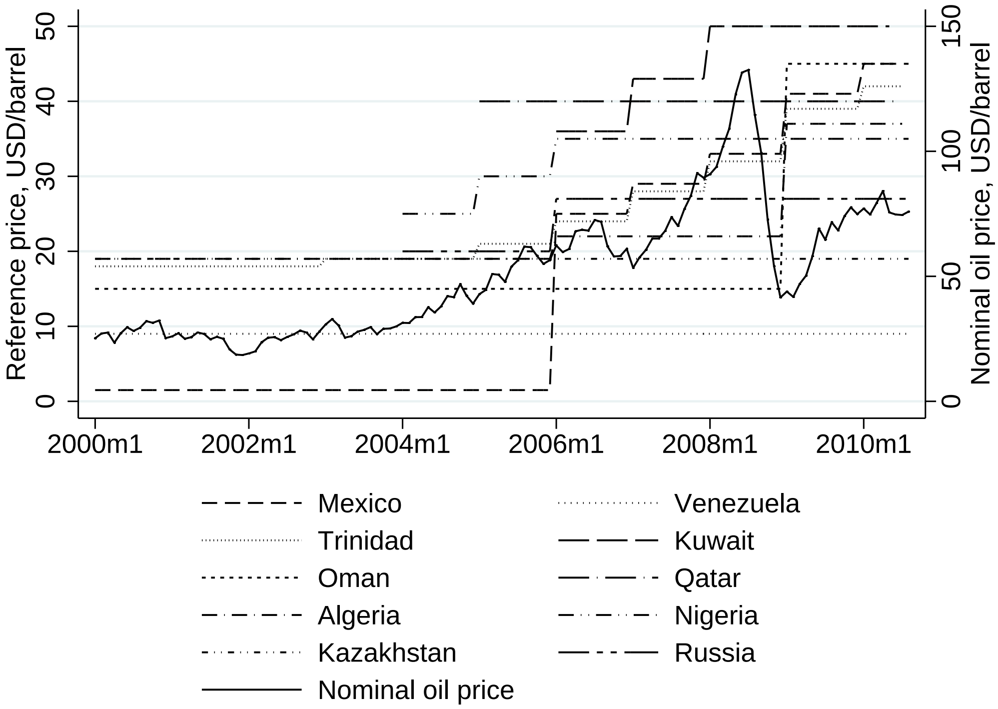
After controlling for the rules that funds follow, such as investment (foreign/domestic), the accumulation rule (revenue/expenditure based), reference oil price and percentage of oil revenue that accumulates the fund, we found that just the existence of the fund does not guarantee its effectiveness. The results show that the following rules of funds make them effective (at a ten percent level of significance and with a one-month lag):

- revenue-based accumulation rules;
- the percentage of oil revenue that accumulates fund.

The above variables have a statistically negative effect on the correlation between the REER and the oil share. This means that:

1. funds that follow revenue-based accumulation rules (a certain portion of oil revenue accumulates the fund) are more effective than funds that follow expenditure-based accumulation rules (a revenue above budget expenditure accumulates fund);
2. funds with a higher percentage of oil revenue accumulating this fund are more effective.

Figure 4.2: Reference oil prices and nominal oil prices



Data sources: International Monetary Fund (2011): International Financial Statistics (Edition: December 2011), ESDS International, University of Manchester; and the SWF Institute, available at www.swfinstitute.org.

It is believed that revenue-based accumulation rules are more suitable for the saving needs of funds, while expenditure-based accumulation rules are more suitable for the needs of stabilization funds. However, our results suggest that revenue-based rules are more effective in stabilization of exchange rates. Countries that set a revenue-based accumulation rule rarely change the percentage of accumulation (Table 4.13), whereas countries that set an expenditure-based accumulation rule have more incentives to adjust the reference oil price (or government expenditure) as nominal oil prices increase (Figure 4.2).

The effectiveness of the percentage of oil revenue that accumulates the fund is well explained in the theoretical model. The higher the percent of accumulation, the larger the portion of oil revenue that is taken away from government expenditure and sterilized (assuming that funds invest abroad) and thus the smaller the effect of oil revenue on exchange rates.

Table 4.13: Revenue-based rules

Country	Percent of oil revenue
Azerbaijan	100
Canada	30 (1976- 1983), 15 (1984-1987)
Iran	100
Kuwait	10 (1976-2010)
Norway	100
Oman	15 (1980), 5 (1986-1988)
USA	25 (1976-1979), 50 (1980-2010)

The following funds' rules show a negative, but statistically not significant effect on effectiveness of funds:

- reference oil prices;
- foreign/domestic investment.

Although empirical estimations did not show the significance of the above rules on funds' effectiveness, the theoretical model shows their importance. A reference oil price is a budgeted oil price. A part of the oil revenue above that price accumulates the fund and a part of the oil revenue up to that price covers government expenditure. When the nominal oil price is below the reference oil price, the fund's assets are transferred to cover the budget deficit. The empirical estimation did not support the hypothesis that reference oil prices can stabilize exchange rates. This could be due to the fact that countries that set reference oil prices change them as nominal oil prices change, whereas the theoretical model assumes a fixed reference oil price (does not depend on nominal oil price). Also, a positive correlation between nominal oil prices and reference oil prices makes it difficult to estimate the effect of reference oil prices when they are correlated with nominal oil prices in some countries (Figure 4.2).

Investment in foreign assets means the sterilization of foreign currency (taking oil revenue away from spending in the country and saving it abroad). That is why the theoretical model predicts the importance of investment in foreign assets on the funds' effectiveness; however, empirical results showed that the effect of a fund that invests abroad are negative, but statistically not significant. The low significance level could be due to a very small sample size of funds which invest domestically (only three countries, namely: Bahrain, Nigeria and Mexico, of 27 countries, do not invest abroad). To get robust estimation of the effect of investment abroad/domestically we need to include more countries with funds that invest only domestically in our sample data. Another limitation of the results is that we used a dummy variable (whether funds invest abroad or not), whereas it would be ideal to use the share of oil revenue that was invested abroad because some funds invest a part of the oil revenue abroad and another part domestically (for example Iran invests 50/50). Unfortunately the share of oil revenue that is invested domestically or abroad for most of countries was not available.

The results of country-by-country estimations did not show the effectiveness of funds or their rules. Also, these empirical results in most cases did not support assumption that, in oil-producing countries, oil share must be the major determinant of exchange rates (oil share is statistically insignificant). The results of some estimations of panels by groups (depending on stationarity and cointegration) show statistically significant effectiveness of funds in stabilizing real effective exchange rates (in not cointegrated panels and panels with nonstationary real effective exchange rates). The results of the pooled mean group estimation of cointegrated panels showed a statistically significant effect of the reference oil price on the effectiveness of oil revenue funds. The results of estimations of panels by groups did not show a statistically significant effect of other oil revenue fund rules. These results are limited by the small number of countries used in the estimation (the largest is 11 countries). Usually countries do not change accumulation rules often (Table 4.13), which is why the number of countries in a sample must be large enough to obtain robust results.

In this paper, rules that funds follow in oil-producing countries are categorized very generally, because each fund is unique and rules from country to country vary a lot. In theoretical and empirical models withdrawal rules were not included, which is important in preventing overspending by government, and thus affecting exchange rates. The data on withdrawal rules for most countries was not available. Another omitted variable from the theoretical model are taxes on oil. For most countries data of tax rates are negotiable depending on the project, and this data is not available for most countries.

Results are limited by data availability because information about funds was not available for some countries. Since countries do not change the rules of funds often, an estimation of a larger number of oil-producing countries with and without a fund would be beneficial.

5 Conclusion

The most common problem of oil-producing countries is that they suffer from the “Resource curse”: resource-rich countries usually grow at lower rates than resource-poor countries (Sachs and Warner, 2000; Sala-i-Martin and Subramanian, 2003). One of the explanations for the “Resource curse” is that oil-producing countries suffer from volatile and unpredictable oil revenue movements (this volatility is mostly due to oil prices and extraction rate movements). Another explanation is that the quality of institutions and governance matters (Mehlum et al., 2006; Collier and Goderis, 2007). So, what can oil-producing countries suffering from volatile oil revenue with poor institutions do? The most popular solution recently has become the establishment of oil revenue funds. However, the efficiency of oil revenue funds is still under debate. An efficient fund must be able to delink exchange rate/government expenditure and oil revenue. The existing literature on the efficiency of oil revenue funds provides contradictory results.

Crain and Devlin (2003) suggest that the difference in accumulation and withdrawal rules could be a possible explanation. Rules of funds were studied mostly in a qualitative analysis of a country case study. Empirically only the existence of funds was tested.

In this paper we try to answer questions "Are oil revenue funds effective?", and, if so, "What makes them effective?" The current paper presents simple theoretical and empirical models to show the effectiveness of funds in the reduction of the correlation between the oil share and the real effective exchange rate, and which rules of funds are important.

A simple theoretical model is based on the well known Balassa-Samuelson model. This model explains how oil share in total exports affects exchange rates, how funds affect this relationship, and how rules of funds, such as investment abroad, percentage of the oil revenue that accumulates the fund and reference oil price, are important. Based on the findings of the theoretical model, we developed an empirical model.

Using monthly data from 27 oil-producing countries with funds and without funds over the period January 1957 - November 2010, we tested the effectiveness of funds and the importance of their rules.

Since we have cross-sectional data with a long T, it is necessary to test for the presence of a unit root. Panel unit root tests of the REER and the oil share could not reject the hypothesis that all panels have a unit root in favour of the fact that all panels are stationary, but rejected the same hypothesis in favour that at least one panel is stationary. Also, the hypothesis that all panels are stationary was rejected. We suggest that the REER and the oil share not from all countries have unit roots. Individual unit root tests (DF/ADF, PP and DF-GLS) provide contradictory results, but support the hypothesis that in some countries the REER and the oil share are stationary and in others are nonstationary. In four countries, oil shares are clearly stationary (according to all unit root tests) while the REER is not clear as unit root tests provide contradictory results. We assume that the REER is nonstationary using the results of the DF-GLS test, which is believed to be superior to the DF/ADF test. Thus we assume that in four countries, namely: Kuwait, Oman, Azerbaijan and Netherlands, the oil share is stationary and the REER is nonstationary.

In the rest of countries we assume that the REER and the oil share are nonstationary. Johansen's cointegration test showed cointegration (rank=1) in 10 countries, no cointegration (rank=0) in 11 countries, and full rank (rank=2) in 3 countries. Full rank is a violation of the assumption that both variables are nonstationary; thus, we assume that in these three countries, namely: Iran, Bahrain and Russia, variables are stationary (Davidson and MacKinnon, 1993).

Using these results on stationarity and cointegration we can regress country-by-country, panels by groups and all panels. To estimate country-by-country, Johansen's ML ECM was used if series are cointegrated and FD was used if series are not cointegrated but nonstationary. To estimate panels by groups (cointegrated, not cointegrated, both variables are stationary and only the REER is nonstationary), PVAR and PMG were used if panels are cointegrated, FD was used if panels are nonstationary to correct for nostationarity. To estimate all panels, FD model was used since most of panels are nonstationary but not cointegrated.

The results of the country-by-country estimation and panels by groups do not provide results on the effectiveness of funds and their rules. These estimations are limited to a small number of countries. The results of the estimation all 27 countries show that a fund can offset the effect of the oil share in total exports on exchange rates. If we control for the fund's rules, then the existence of a fund does not have a significant effect, while the following rules do have a significant effect on the stabilization of exchange rates:

- revenue-based accumulation rules;
- the percentage of oil revenue that accumulates funds.

We conclude that:

- just the existence of an oil revenue fund alone does not guarantee a reduction in the correlation between exchange rates and oil revenue;
- funds that follow revenue-based accumulation rules are more effective than funds that follow expenditure-based accumulation rules;
- funds with a higher percentage of oil revenue that accumulates funds are more effective.

The results did not show significance of other variables such as investment in foreign assets and reference oil prices due to data limitation. One can include other important variables such as withdrawal rules of funds and taxes on oil. These variables were not included in the current paper due to data limitations.

A Funds and their rules by country

Table A.1: Funds and their rules by country

Country	Fund	Investment	Accumulation rule	Reference oil price	Percent of oil revenue
Algeria	2000	foreign	expenditure-based	19 (2000), 22 (2006), 37 (2009)	
Azerbaijan	Dec-99	foreign	revenue-based		100.00%
Bahrain	Jun-06	domestic	NA		
Canada	1976	foreign	revenue-based		30% (1976-1983), 15% (1984-1987)
Iran	1999	foreign	revenue-based		100.00%
Kazakhstan	Aug-00	foreign	expenditure-based	19	
Kuwait	1960	foreign	expenditure-based (1960-1975), revenue- based (1976-2010)	NA (1973-2005), 36 (2006), 43 (2007), 50 (2008)	10% (1976-2010)
Libya	2006	foreign	NA		
Nigeria	2004	domestic	expenditure-based	25 (2004), 30 (2005), 35 (2006)	
Norway	1990	foreign	revenue-based		100.00%
Oman	1980	foreign	revenue-based (1980-1988), expenditure-based (1989-2010)	15 (1989), 45 (2009)	15% (1980), 5% (1986-1988)
Qatar	2005	foreign	expenditure-based	40	

continued. . .

. . . Table A.1 continued

Country	Fund	Investment	Accumulation rule	Reference oil price	Percent of oil revenue
Russia	2004	Foreign	expenditure-based	20 (2004-2005), 27 (2006)	
SA	1958	Foreign	NA		
Trinidad	2000	Foreign	expenditure-based	11-year MA	
UAE	1976	Foreign	expenditure-based		
Venezuela	1998	Foreign	expenditure-based	17 (1998), 9 (1999)	
Mexico	2000	Domestic	expenditure-based	1.5 (2000-2005), weight of 3/4 to oil futures prices and a weight of 1/4 to the average oil price of last 10 years (2006-2010)	
USA	1976	Foreign	revenue-based		25% (1976-1979), 50% (1980-2010)

NA - not available.

B DF/ADF unit root test of REER

Table B.1: DF/ADF unit root test of REER

Country	Trend	Breusch-Godfrey LM test without lags			Optimal lags with constant			Optimal lags no constant			Breusch-Godfrey LM test with p lags				DF/ADF with p lags		
		trend	no trend	auto-correlation	AIC	HQIC	SBIC	AIC	HQIC	SBIC	p lags	trend	no trend	auto-correlation	drift	drift and trend	stationarity
Saudi Arabia	yes	18.374***	28.391***	yes	3	3	3	3	3	3	3	0.064	0.0654	no	-1.839**	-3.708**	stationary
Kuwait	yes	13.576***	21.049***	yes	3	3	3	3	3	3	3	0.604	0.573	no	-3.780***	-4.780***	stationary
Canada	no	0.030	0.072	no	1	1	1	1	1	1	0	0.030	0.072	no	-1.506	-0.617	nonstationary
UAE	no	30.235***	31.133***	yes	3	3	3	3	3	3	3	0.774	0.811	no	-2.931**	-2.429	stationary
USA	yes	10.465***	9.669***	yes	2	2	2	2	2	2	2	0.224	0.379	no	-1.941	-2.286	nonstationary
Oman	no	15.207***	17.609***	yes	4	4	4	4	4	4	4	0.136	0.319	no	-3.358**	-4.868***	stationary
Norway	no	0.687	1.011	no	1	1	1	1	1	1	0	0.687	1.011	no	-1.173	-1.276	nonstationary
Venezuela	yes	19.591***	17.228***	yes	4	3	3	4	3	3	3	1.046	2.066	no	2.527	-1.863	nonstationary
Iran	yes	14.771***	18.055***	yes	4	4	4	4	4	4	5	0.224	0.378	no	-1.082	-2.752	nonstationary
Algeria	yes	29.104***	31.141***	yes	3	3	3	3	3	3	3	0.342	0.449	no	-0.207	-2.149	nonstationary
Azerbaijan	no	23.418***	23.240***	yes	2	2	2	2	2	2	2	2.727*	3.688*	no	-3.833***	-3.809**	stationary
Kazakhstan	yes	23.883***	12.128***	yes	4	2	2	4	2	2	5	0.775	1.905	no	-2.119	-5.007***	stationary

continued...

... Table B.1 continued

Country	Trend	Breusch-Godfrey LM test without lags			Optimal lags with constant			Optimal lags no constant			Breusch-Godfrey LM test with p lags				DF/ADF with p lags		
		trend	no trend	auto-correlation	AIC	HQIC	SBIC	AIC	HQIC	SBIC	p lags	trend	no trend	auto-correlation	drift	drift and trend	stationarity
Trinidad	yes	150.641***	159.847***	yes	4	4	4	4	4	4	5	1.506	1.469	no	0.152	-2.832	nonstationary
Mexico	yes	10.724***	10.690***	yes	3	3	2	4	3	3	5	0.842	0.826	no	0.126	-1.480	nonstationary
Nigeria	yes	4.274**	61.333***	yes	3	3	3	3	3	3	3	0.938	0.634	no	0.718	-1.858	nonstationary
Russia	yes	2.381	2.292	no	2	1	1	4	4	2	0	2.381	2.292	no	-3.933***	-2.028	nonstationary
Bahrain	no	26.377***	36.386***	yes	3	3	3	4	3	3	3	0.252	0.580	no	-3.142**	-3.908**	stationary
Qatar	yes	19.513***	45.375***	yes	3	3	3	4	3	3	4	1.736	4.084	no	-2.355	-5.042***	stationary
Libya	yes	2.425	7.256***	yes	3	3	3	3	3	3	3	0.044	0.772	no	-2.282	-3.036	nonstationary
Angola	yes	4.048**	3.852**	yes	2	2	1	2	1	1	2	0.295	0.568	no	-4.401***	-1.845	nonstationary
Argentina	yes	2.917*	2.869*	no	4	4	4	4	4	4	0	2.917*	2.869*	no	-0.185	-0.605	nonstationary
Colombia	yes	65.682***	76.986***	yes	3	3	3	3	3	3	3	1.404	1.487	no	-1.096	-2.272	nonstationary
Egypt	yes	131.051***	135.143***	yes	4	4	4	4	4	4	4	3.349*	0.121	no	0.525	-1.358	nonstationary
India	yes	92.403***	93.365***	yes	3	3	3	3	3	3	3	0.105	0.085	no	1.088	-1.310	nonstationary
Iraq	no	25.360***	28.739***	yes	3	3	3	3	3	3	3	0.074	0.141	no	-2.175	-2.804	nonstationary
UK	yes	29.270***	28.454***	yes	2	2	2	2	2	2	2	0.086	0.1456	no	-0.913	-1.884	nonstationary

continued...

. . . Table B.1 continued

Country	Trend	Breusch-Godfrey LM test without lags			Optimal lags with constant			Optimal lags no constant			Breusch-Godfrey LM test with p lags				DF/ADF with p lags		
		trend	no trend	auto-correlation	AIC	HQIC	SBIC	AIC	HQIC	SBIC	p lags	trend	no trend	auto-correlation	drift	drift and trend	stationarity
Netherlands	yes	0.076	0.020	no	3	1	1	3	1	1	0	0.076	0.020	no	-2.742*	-0.157	nonstationary
Ecuador	yes	16.738***	18.496***	yes	3	3	3	3	3	3	3	0.313	0.207	no	-1.445	-2.101	nonstationary

* Significant at 10 percent level.

** Significant at 5 percent level.

*** Significant at 1 percent level.

AIC - Akaike information criterion.

HQIC - Hannan and Quinn information criterion.

SBIC - Schwarz's Bayesian information criterion.

C DF/ADF unit root test of oil share

Table C.1: DF/ADF unit root test of oil share

Country	Trend	Breusch-Godfrey LM test without lags			Optimal lags with constant			Optimal lags no constant			Breusch-Godfrey LM test with p lags				DF/ADF with p lags		
		trend	no trend	serial correlation	AIC	HQIC	SBIC	AIC	HQIC	SBIC	p lags	trend	no trend	serial correlation	drift	drift and trend	stationarity
Saudi Arabia	no	0.987	1.058	no							0	0.987	1.058	no	-5.527***	-5.513***	stationary
Kuwait	no	7.481***	8.541***	yes	2	2	2	4	2	2	2	0.002	0.045	no	-4.245***	-4.707***	stationary
Canada	no	0.360	0.418	no							0	0.360	0.418	no	-3.347**	-3.522**	stationary
UAE	no	11.237***	15.563***	yes	3	3	2	3	3	3	3	0.004	0.122	no	-3.187**	-4.282**	stationary
USA	no	9.775**	10.309**	yes	3	3	3	3	3	3	3	0.010	0.004	no	-2.200	-2.534	nonstationary
Oman	yes	21.804***	24.943***	yes	2	2	2	2	2	2	2	0.897	0.457	no	-3.446***	-4.285***	stationary
Norway	no	59.168***	74.038***	yes	3	3	3	3	3	3	3	1.678	0.484	no	-1.606	-4.294**	nonstationary
Venezuela	no	2.578	3.191*	no							0	2.578	3.191*	no	0.063	-0.717	nonstationary
Iran	no	35.184***	42.382***	yes	3	3	3	3	3	3	3	0.103	0.327	no	-2.779*	-3.170*	nonstationary
Algeria	yes	2.596	2.616	no							0	2.596	2.616	no	-2.943**	-2.952	nonstationary
Azerbaijan	no	6.673***	6.674***	yes	3	2	2	4	4	3	2	2.031	2.023	no	-5.486***	-5.481***	stationary
Kazakhstan	no	23.956***	33.105***	yes	4	3	3	4	4	3	3	1.466	2.505	no	-2.626*	-3.342*	nonstationary

continued...

. . . Table C.1 continued

Country	Trend	Breusch-Godfrey LM test without lags			Optimal lags with constant			Optimal lags no constant			Breusch-Godfrey LM test with p lags				DF/ADF with p lags		
		trend	no trend	serial correlation	AIC	HQIC	SBIC	AIC	HQIC	SBIC	p lags	trend	no trend	serial correlation	drift	drift and trend	stationarity
Trinidad	yes	95.266***	95.251***	yes	4	4	4	4	4	4	4	0.407	0.416	no	-3.077**	-3.082	nonstationary
Mexico	no	40.224***	40.200***	yes	4	3	3	4	3	3	3	2.115	2.071	no	-2.513	-2.628	nonstationary
Nigeria	no	41.715***	48.806***	yes	4	4	4	4	4	4	4	1.965	2.555	no	-2.344	-2.602	nonstationary
Russia	no	13.478***	12.625***	yes	3	3	3	3	3	3	3	0.927	0.495	no	-3.971***	-3.990***	stationary
Bahrain	no	31.038***	44.917***	yes	4	3	3	4	4	3	3	1.104	2.522	no	-2.945**	-4.339**	stationary
Qatar	no	12.332***	12.620***	yes	4	4	4	4	4	4	4	0.169	0.175	no	-2.444	-2.503	nonstationary
Libya	no	20.144***	19.554***	yes	3	3	3	4	4	3	3	1.687	1.839	no	-5.086***	-5.134***	stationary
Angola	no	3.677*	0.477	no							0	3.677*	0.477	no	-5.213***	-7.745***	stationary
Argentina	no	0.641	0.560	no							0	0.641	0.560	no	-4.276***	-4.367***	stationary
Colombia	no	36.194***	50.911***	yes	3	3	3	4	3	3	3	0.089	0.775	no	-4.522***	-5.988***	stationary
Egypt	no	94.085***	99.777***	yes	4	4	4	4	4	4	5	0.014	0.003	no	-3.499***	-3.591**	stationary
India	no	23.535***	23.560***	yes	4	3	3	3	3	3	3	2.316	2.336	no	-2.474	-2.396	nonstationary
Iraq	no	21.349***	23.490***	yes	4	4	4	4	4	4	5	1.025	0.926	no	-1.753	-1.851	nonstationary
UK	no	0.624	0.646	no							0	0.624	0.646	no	-2.088	-2.100	nonstationary

continued. . .

. . . Table C.1 continued

Country	Trend	Breusch-Godfrey LM test without lags			Optimal lags with constant			Optimal lags no constant			Breusch-Godfrey LM test with p lags				DF/ADF with p lags		
		trend	no trend	serial correlation	AIC	HQIC	SBIC	AIC	HQIC	SBIC	p lags	trend	no trend	serial correlation	drift	drift and trend	stationarity
Netherlands	no	5.342**	5.400**	yes	4	3	3	4	4	3	4	1.453	1.463	no	-2.748*	-2.732	stationary
Ecuador	no	56.148***	60.541***	yes	4	4	4	4	4	4	6	0.323	0.387	no	-2.320	-2.521	nonstationary

* Significant at 10 percent level.

** Significant at 5 percent level.

*** Significant at 1 percent leve.

AIC - Akaike information criterion.

HQIC - Hannan and Quinn information criterion.

SBIC - Schwarz's Bayesian information criterion.

D PP unit root test of REER

Table D.1: PP unit root test of REER

Country	Trend	Drift	Drift and trend	Stationarity
Saudi Arabia	yes	-4.068***	-7.076***	stationary
Kuwait	yes	-5.626***	-7.533***	stationary
Canada	no	-1.581	-0.798	nonstationary
United Arab Emirates	no	-2.892*	-2.539	nonstationary
USA	yes	-1.913	-2.427	nonstationary
Oman	no	-5.033***	-6.168***	stationary
Norway	no	-1.127	-1.198	nonstationary
Venezuela	yes	2.317	-1.773	nonstationary
Iran	yes	-1.834	-3.855**	nonstationary
Algeria	yes	-0.300	-2.343	nonstationary
Azerbaijan	no	-9.595***	-9.520***	stationary
Kazakhstan	yes	-7.381***	-10.602***	stationary
Trinidad	yes	-0.663	-4.122***	nonstationary
Mexico	yes	0.263	-1.484	nonstationary
Nigeria	yes	0.586	-1.925	nonstationary
Russia	yes	-3.426**	-2.034	nonstationary
Bahrain	no	-6.342***	-8.569***	stationary
Qatar	yes	-5.259***	-10.888***	stationary
Libya	yes	-2.413	-4.555***	stationary
Angola	yes	-3.997***	-1.397	nonstationary
Argentina	yes	-0.227	-0.772	nonstationary
Colombia	yes	-1.049	-3.628**	stationary
Egypt	yes	-0.033	-2.128	nonstationary
India	yes	0.877	-1.456	nonstationary
Iraq	no	-3.200**	-4.574***	stationary
UK	yes	-0.899	-1.880	nonstationary

continued...

. . . Table D.1 continued

Country	Trend	Drift	Drift and trend	Stationarity
Netherlands	yes	-2.700*	-0.172	nonstationary
Ecuador	yes	-1.870	-2.830	nonstationary

* Significant at 10 percent level.

** Significant at 5 percent level.

*** Significant at 1 percent leve.

E PP unit root test of oil share

Table E.1: PP unit root test of oil share

Country	Trend	Drift	Drift and trend	Stationarity
Saudi Arabia	no	-5.412***	-5.410***	stationary
Kuwait	no	-4.843***	-5.423***	stationary
Canada	no	-3.054**	-3.236*	stationary
United Arab Emirates	no	-4.710***	-6.421***	stationary
USA	no	-2.459	-2.828	nonstationary
Oman	no	-4.261***	-5.403***	stationary
Norway	yes	-1.677	-5.650***	stationary
Venezuela	no	0.278	-0.607	nonstationary
Iran	no	-4.659***	-6.269***	stationary
Algeria	no	-3.016**	-3.028	stationary
Azerbaijan	yes	-10.332***	-10.313***	stationary
Kazakhstan	no	-6.228***	-8.283***	stationary
Trinidad	no	-7.213***	-7.208***	stationary
Mexico	yes	-3.068**	-3.159*	stationary
Nigeria	no	-2.982**	-4.510***	stationary
Russia	no	-4.534***	-4.418***	stationary
Bahrain	no	-5.629***	-8.690***	stationary
Qatar	no	-4.786***	-4.873***	stationary
Libya	no	-5.543***	-5.615***	stationary
Angola	no	-4.302***	-7.185***	stationary
Argentina	no	-3.788***	-3.877**	stationary
Colombia	no	-8.395***	-11.364***	stationary
Egypt	no	10.650***	-11.521***	stationary
India	no	-2.616*	-2.550	nonstationary
Iraq	no	-3.028**	-3.693**	stationary
UK	no	-2.048	-2.059	nonstationary

continued...

. . . Table E.1 continued

Country	Trend	Drift	Drift and trend	Stationarity
Netherlands	no	-3.447***	-3.461**	stationary
Ecuador	no	-5.653***	-6.610***	stationary

* Significant at 10 percent level.

** Significant at 5 percent level.

*** Significant at 1 percent leve.

NA - not available.

F DF-GLS ERS unit root test of REER

Table F.1: DF-GLS ERS unit root test of REER

Country	Trend	Ng-Perron criterion lags	DF-GLS with Ng-Perron lags	SC lags	DF-GLS with SC lags	MAIC lags	DF-GLS with MAIC lags	p lags (from ADF test)	DF-GLS with p lags	Stationarity
Saudi Arabia	yes	9	-1.550	2	-2.525	9	-1.550	3	-2.464	I(1)
Kuwait	yes	13	-0.915	6	-0.768	13	-0.915	3	-1.526	I(1)
Canada	no	19	-0.708	1	-0.669	13	-0.666	1	-0.669	I(1)
UAE	no	17	0.518	4	0.236	12	0.516	3	0.065	I(1)
USA	yes	1	-1.484	1	-1.484	1	-1.484	2	-1.448	I(1)
Oman	no	4	-1.535	1	-1.668*	4	-1.535	4	-1.535	I(1)
Norway	no	14	-0.641	1	-0.782	1	-0.782	1	-0.782	I(1)
Venezuela	yes	18	-0.235	1	0.162	18	-0.235	3	0.189	I(1)
Iran	yes	15	-1.192	4	-1.802	4	-1.802	5	-1.741	I(1)
Algeria	yes	13	-1.141	2	-1.147	2	-1.147	3	-1.107	I(1)
Azerbaijan	no	10	0.258	1	-0.257	10	0.258	2	-0.177	I(1)
Kazakhstan	yes	12	-2.853*	1	-2.466	1	-2.466	5	-2.659*	I(1)
Trinidad	yes	8	-0.539	3	-1.009	8	-0.539	5	-0.822	I(1)

continued...

...Table F.1 continued

Country	Trend	Ng-Perron criterion lags	DF-GLS with Ng-Perron lags	SC lags	DF-GLS with SC lags	MAIC lags	DF-GLS with MAIC lags	p lags (from ADF test)	DF-GLS with p lags	Stationarity
Mexico	yes	17	-1.087	1	-0.581	11	-1.076	5	-0.742	I(1)
Nigeria	yes	15	-0.828	2	-0.703	15	-0.828	3	-0.696	I(1)
Russia	yes	12	-1.223	4	-1.050	13	-1.044	5	-1.130	I(1)
Bahrain	no	14	-1.228	2	-2.493	6	-1.814	3	-2.304	I(1)
Qatar	yes	13	-2.815*	1	-6.686***	11	-2.436	4	-4.932***	I(1) or I(0)
Libya	yes	10	-0.769	2	-1.777	2	-1.777	3	-1.701	I(1)
Angola	yes	13	-0.278	2	0.459	13	-0.278	2	0.459	I(1)
Argentina	yes	15	-1.377	8	-1.075	15	-1.377	5	-0.752	I(1)
Colombia	yes	18	-1.239	2	-2.293	18	-1.239	3	-2.293	I(1)
Egypt	yes	4	-0.871	3	-0.966	4	-0.871	4	-0.871	I(1)
India	yes	19	-0.464	2	-0.485	19	-0.464	3	-0.476	I(1)
Iraq	no	9	-1.781*	2	-2.061**	7	-1.688*	3	-2.009**	I(1) or I(0)
UK	yes	15	-1.514	1	-1.233	13	-1.609	2	-1.209	I(1)
Netherlands	yes	19	-0.069	2	0.030	19	-0.069	3	0.096	I(1)
Ecuador	yes	5	-2.290	2	-2.048	2	-2.048	3	-2.096	I(1)

continued...

. . . Table F.1 continued

Country	Trend	Ng-Perron criterion lags	DF-GLS with Ng-Perron lags	SC lags	DF-GLS with SC lags	MAIC lags	DF-GLS with MAIC lags	p lags (from ADF test)	DF-GLS with p lags	Stationarity

* Significant at 10 percent level.

** Significant at 5 percent level.

*** Significant at 1 percent level.

Critical values of DF-GLS ERS test are: -2.580 at 1 percent level of significance; -1.950 at 5 percent; and -1.620 at 10 percent.

The test statistic must be significantly negative to reject the null hypothesis of nonstationarity.

G DF-GLS ERS unit root test of oil share

Table G.1: DF-GLS ERS unit root test of oil share

Country	Trend	Ng-Perron criterion lags	DF-GLS with Ng-Perron lags	SC lags	DF-GLS with SC lags	MAIC lags	DF-GLS with MAIC lags	Stationarity
Saudi Arabia	no	11	-0.978	2	-1.275	3	-1.168	nonstationary
Kuwait	no	9	-3.142***	1	-3.084***	3	-2.720***	stationary
Canada	no	16	-0.821	1	-1.642	16	-0.821	nonstationary
United Arab Emirates	no	11	-1.782*	1	-3.530***	11	-1.782*	not sure
USA	no	16	-1.133	2	-1.964**	16	-1.133	not sure
Oman	no	16	-1.706*	1	-3.517***	6	-2.341**	stationary
Norway	yes	17	0.332	1	-0.609	17	0.090	nonstationary
Venezuela	no	17	2.152	13	2.283	17	2.152	nonstationary
Iran	no	16	-1.031	2	-1.908	6	-1.420	nonstationary
Algeria	no	11	-2.903***	1	-2.547**	1	-2.547**	stationary
Azerbaijan	yes	14	-2.507**	2	-5.323***	12	-2.175**	stationary
Kazakhstan	no	12	0.162	2	-0.891	13	0.007	nonstationary
Trinidad	no	16	-1.219	5	-1.951**	16	-1.219	not sure

continued...

. . . Table G.1 continued

Country	Trend	Ng-Perron criterion lags	DF-GLS with Ng-Perron lags	SC lags	DF-GLS with SC lags	MAIC lags	DF-GLS with MAIC lags	Stationarity
Mexico	yes	16	-1.129	2	-1.930	16	-1.129	nonstationary
Nigeria	no	14	-0.589	3	-0.803	7	-0.589	nonstationary
Russia	no	12	-0.229	12	-0.229	12	-0.229	nonstationary
Bahrain	no	16	-0.853	2	-1.817	7	-1.427	nonstationary
Qatar	no	3	-2.233**	3	-2.233**	3	-2.233**	stationary
Libya	no	13	-1.619	2	-3.134***	13	-1.619	not sure
Angola	no	19	-0.340	6	0.217	19	-0.340	nonstationary
Argentina	no	12	-1	12	-1	12	-1	nonstationary
Colombia	no	17	-1.363	5	-2.389**	5	-2.389**	not sure
Egypt	no	16	-1.427	12	-1.664*	16	-1.427	nonstationary
India	no	19	-1.252	2	-1.504	16	-1.070	nonstationary
Iraq	no	4	-0.550	3	-0.717	4	-0.550	nonstationary
UK	no	14	-1.334	3	-1.247	3	-1.247	nonstationary
Netherlands	no	15	-1.810*	2	-1.795*	12	-1.657*	stationary
Ecuador	no	7	-1.615	5	-1.935*	7	-1.615	nonstationary

continued. . .

. . . Table G.1 continued

Country	Trend	Ng-Perron criterion lags	DF-GLS with Ng-Perron lags	SC lags	DF-GLS with SC lags	MAIC lags	DF-GLS with MAIC lags	Stationarity

* Significant at 10 percent level.

** Significant at 5 percent level.

*** Significant at 1 percent level.

Critical values of DF-GLS ERS test are: -2.580 at 1 percent level of significance; -1.950 at 5 percent and; -1.620 at 10 percent.

The test statistic must be significantly negative to reject null hypothesis of nonstationarity.

H Results of estimation with cointegrated series

Table H.1: Results of estimation with cointegrated series

REER in logs (first difference)	Lag	Libya	Iraq	Angola	Colombia	Saudi Arabia	Egypt	Argentina	UAE	Kazakhstan	Qatar
REER in logs (first difference)	1	0.016	-0.019	-0.115*	-0.441***	-0.397***	-0.593***	0.015	-0.315***	-0.392***	-0.394***
	2				-0.249***	-0.174***	-0.310***	0.135***	-0.157***		-0.118**
	3						-0.220***	0.078*			
Oil share (first difference)	1	-0.099	0.021	-0.334**	0.127	-0.008	0.035**	0.041	0.188	-0.444*	-0.093
	2				0.040	-0.008	0.023*	-0.152	0.111		-0.028
	3						0.011	-0.139			
Fund exists (interaction terms with first dfifference of oil share)	1								0.092	0.358*	0.024
	2								-0.026		-0.022
Error correction term	1	-0.014	-0.000	-0.015***	-0.002	-0.027**	-0.000	-0.000***	-0.016	-0.003	-0.211***
Constant		-0.003	-0.006	0.006	0.024***	0.006	0.021**	0.005	-0.017	0.009	0.012
Sample size		190	262	210	617	557	639	616	284	169	315
R-squared		0.016	0.003	0.18	0.193	0.159	0.284	0.134	0.128	0.228	0.278
F-statistic		3	1	45***	146***	104***	251***	94***	40***	48***	118***

continued...

… Table H.1 continued

REER in logs (first difference)	Lag	Libya	Iraq	Angola	Colombia	Saudi Arabia	Egypt	Argentina	UAE	Kazakhstan	Qatar

* Significant at 10 percent level.

** Significant at 5 percent level.

*** Significant at 1 percent level.

I Results of estimation with not cointegrated series

Table I.1: Results of estimation with not cointegrated series

REER in logs (first difference)	Lag	UK	India	Ecuador	Norway	Venezuela	Algeria	Trinidad	Mexico	Nigeria	Canada	USA
REER in logs (first difference)	1	0.214***	-0.464***	-0.342***	0.037	-0.163***	-0.448***	-0.653***	-0.120***	-0.368***	0.003	0.142***
	2		-0.221***	-0.248***		-0.093**	-0.485***	-0.292***	0.091**	-0.145***		
	3							-0.162***				
Oil share (first difference)	1	0.079	0.058	0.168	0.000	0.006	-0.001	0.101*	-0.002	-0.022	-0.034	0.052**
	2		-0.029	0.185		-0.047	-0.031	0.085	-0.052	0.070		
	3							-0.006				
Interaction terms with oil share (first dfifference)												
Fund exists	1				-0.011	-0.001	-0.103	0.074	-0.249	-0.320	-0.034	0.037
	2					0.039	0.029	0.380	-0.156	-0.219		
	3							0.025				
Reference oil price	1					0.004	0.173	-0.091	-0.145	0.162		
	2					0.014	-0.187	-0.879	0.030	-0.193		
	3							0.939**				
Percentage	1										0.0002	-0.001
Constant		0.000	0.012**	0.017	0.000	0.023***	-0.016	0.008	0.023***	0.027**	0.000	-0.001**

continued...

... Table I.1 continued

REER in logs (first difference)	Lag	UK	India	Ecuador	Norway	Venezuela	Algeria	Trinidad	Mexico	Nigeria	Canada	USA
Sample size		632	641	384	632	593	96	564	617	555	642	632
R-squared		0.046	0.186	0.131	0.001	0.033	0.280	0.332	0.029	0.124	0.006	0.021
F-statistic		31***	147***	58***	1	20***	38***	281***	18**	79***	3.874	14***

* Significant at 10 percent level.

** Significant at 5 percent level.

*** Significant at 1 percent level.

J Results of estimation with nonstationary REER

Table J.1: Results of estimation with nonstationary REER

REER in logs (first difference)	Lag	Netherlands	Azerbaijan	Oman	Kuwait
REER in logs (first difference)	1	0.004	-0.438***	-0.538***	-0.446***
	2	0.100**			-0.232***
	3				-0.111*
Oil share	1	-1.425*	-0.022	0.188	-0.134
	2	1.290*			0.289
	3				-0.084
Interaction terms with oil share					
Fund exists	1		-0.024		
Accumulation rule	1				0.061
	2				0.035
	3				-0.088
Reference oil price	1			-0.080	
Constant		-0.001	0.131	-0.110	-0.100
Sample size		631	149	121	281
R-squared		0.016	0.225	0.270	0.172
F-statistic		10**	43***	44***	58***

* Significant at 10 percent level.

** Significant at 5 percent level.

*** Significant at 1 percent level.

K Results of estimation with stationary series

Table K.1: Results of estimation with stationary series

REER in logs (first difference)	Lag	Iran	Bahrain	Russia
REER in logs (first difference)	1	0.774***	0.448***	0.995***
	2		0.297***	
Oil share	1	-0.013	0.453*	-0.524***
	2		0.163	
Interaction terms with oil share				
Fund exists	1		-1.064	0.179*
	2		0.975	
Reference oil price	1			-0.252
Constant		0.051	-0.790***	0.352***
Sample size		193	330	198
R-squared		0.606	0.623	0.164
F-statistic		297***	545***	38***

* Significant at 10 percent level.

** Significant at 5 percent level.

*** Significant at 1 percent level.

L Results of PVAR esimation of cointegrated panels

Table L.1: Results of PVAR esimation of cointegrated panels

REER in logs (first difference)	Lag			
REER in logs (first difference)	1	0.772***	0.771***	0.778***
	2	0.238***	0.238***	0.239***
	3	-0.010	-0.010	-0.018
Oil share (first difference)	1	0.014	0.019	0.020
	2	-0.017	-0.020	-0.020
	3	0.003	0.000	0.000
Interaction terms with oil share (first difference)				
Fund exists	1		-0.028	-0.027
	2		0.030	0.039
	3		0.000	-0.008
Reference oil price	1			0.013
	2			-0.013
	3			0.003
Number of countries		9	9	9
Sample size		3790	3790	3790

* Significant at 10 percent level.

** Significant at 5 percent level.

*** Significant at 1 percent level.

M Results of PMG esimation of cointegrated panels

Table M.1: Results of PMG esimation of cointegrated panels

REER in logs (first difference)			
Long-run			
Oil share (first difference)	0.179***	0.073	0.133
Interaction terms with oil share (first difference)			
Fund exits		0.097	1.737**
Reference oil price			-0.041**
Short-run			
Error correction term	-0.058*	-0.058*	-0.062
Oil share (first difference)	0.053	0.103	0.069
Interaction terms with oil share (first difference)			
Fund exits		-0.063	
Reference oil price			-0.002
Constant	-0.056	-0.049	-0.046
Number of countries	10	10	9
Sample size	3828	3828	3054
Log likelihood	-15.1	-11.9	-137

* Significant at 10 percent level.

** Significant at 5 percent level.

*** Significant at 1 percent level.

N Results of estimation not cointegrated panels

Table N.1: Results of estimation not cointegrated panels

REER in logs (first difference)	Lag					
REER in logs (first difference)	1	-0.346***	-0.346***	-0.347***	-0.346***	-0.350***
	2	-0.143***	-0.143***	-0.143***	0.143***	-0.145***
	3	0.002	0.002	0.002	0.002	0.008
Oil share (first difference)	1	0.012	0.041*	0.041*	0.041*	0.051**
	2	0.006	0.038	0.038	0.038	0.041*
	3	-0.001	-0.008	-0.008	-0.008	-0.001
Interaction terms with oil share (first dfifference)						
Fund exists	1		-0.033	-0.308	-0.033	-0.057**
	2		-0.039	-0.128	-0.039	-0.047*
	3		0.014	0.175	0.015	0.006
Investment	1			0.275		
	2			0.089		
	3			-0.161		
Accumulation rule	1				-0.020	
	2				-0.018	
	3				-0.040	
Percentage	1					0.000
	2					0.000
	3					-0.000
Reference oil price	1					0.085
	2					-0.056
	3					-0.003
Constant		0.012***	0.012***	0.012***	0.012***	0.010***
Number of countries		11	11	11	11	11
Sample size		6302	6302	6302	6302	6302
R-squared within		0.110	0.113	0.114	0.113	0.113
R-squared between		0.990	0.993	0.993	0.993	0.993

continued...

. . . Table N.1 continued

REER in logs (first difference)					
R-squared overall	0.110	0.110	0.111	0.110	0.110
Wald chi-squared	779***	782***	770***	782***	782***

* Significant at 10 percent level.

** Significant at 5 percent level.

*** Significant at 1 percent level.

O Results of estimation panels with stationary oil share and non-stationary REER

Table O.1: Results of estimation panels with stationary oil share and nonstationary REER

REER in logs (first difference)	Lag				
REER in logs (first difference)	1	-0.476***	-0.463***	-0.463***	-0.481***
	2	-0.214***	-0.252***	-0.252***	-0.280***
	3	-0.124***	-0.131***	-0.132***	-0.170***
Oil share	1	-0.080***	-0.302***	-0.302***	-0.303***
	2	0.065***	0.282***	0.282***	0.275***
	3	0.033*	0.140***	0.140***	0.154***
Interaction terms with oil share					
Fund exists	1		0.269***	0.158	0.312
	2		-0.268***	-0.159	-0.716
	3		-0.118***	-0.133	0.334
Accumulation rule	1			0.111	
	2			-0.108	
	3			0.014	
Percentage	1				-0.000
	2				0.004
	3				-0.004
Reference oil price	1				-0.032
	2				0.851
	3				-0.905
Constant		-0.010	-0.006	-0.005	-0.006
Number of countries		4			3
Sample size		1174	1174	1174	891
R-squared within		0.22	0.27	0.27	0.37
R-squared between		0.14	0.94	0.96	0.95
R-squared overall		0.22	0.27	0.27	0.37

continued...

. . . Table O.1 continued

REER in logs (first difference)				
Wald chi-squared	342***	437***	437***	519***

* Significant at 10 percent level.

** Significant at 5 percent level.

*** Significant at 1 percent level.

P Results of estimation stationary panels

Table P.1: Results of estimation stationary panels

REER in logs	Lag		
REER in logs	1	0.658***	0.656***
	2	0.146***	0.144***
	3	0.181***	0.177***
Oil share	1	0.037	0.039
	2	0.001	0.002
	3	-0.04	-0.038
Fund exists (interaction term with oil share)	1		-0.065
	2		0.122
	3		0.051
Constant		0.006	-0.012
Number of countries		3	3
Sample size		717	717
R-squared within		0.90	0.90
R-squared between		0.99	0.99
R-squared overall		0.96	0.96
Wald chi-squared		17205***	17205***

* Significant at 10 percent level.

** Significant at 5 percent level.

*** Significant at 1 percent level.

Q Results of estimation all panels

Table Q.1: Results of estimation all panels

REER in logs (first difference)	Lag					
REER in logs (first difference)	1	-0.309***	-0.310***	0.310***	-0.307***	-0.294***
	2	-0.071***	-0.071***	-0.071***	-0.068***	-0.052***
	3	0.008	0.008	0.008	0.008	0.017*
Oil share (first difference)	1	-0.011*	-0.002**	-0.002	-0.002	-0.003
	2	0.006	0.021**	0.022**	0.022**	0.021**
	3	0.010	0.014***	0.015*	0.014	0.014*
Interaction terms with oil share (first dfifference)						
Fund exists	1		-0.013**	0.049	0.005	0.017
	2		-0.028*	0.079	-0.023	-0.027
	3		-0.003**	-0.014	-0.008	-0.019
Investment	1			-0.062		
	2			-0.107		
	3			0.011		
Accumulation rule	1				-0.011*	
	2				0.013	
Percentage	1					-0.0004*
	2					-0.000
	3					0.000
Reference oil price	1					-0.001
	2					0.000
	3					0.000
Constant		0.017***	0.017**	0.017***	0.018***	0.018***
Number of countries		28	28	28	27	26
Sample size		11980	11973	11846	11406	10909
R-squared within		0.090	0.099	0.099	0.098	0.093
R-squared between		0.990	0.996	0.995	0.996	0.986
R-squared overall		0.080	0.089	0.089	0.089	0.083

continued...

. . . Table Q.1 continued

REER in logs (first difference)					
Wald chi-squared	1175***	1180***	1168***	1114***	993***

* Significant at 10 percent level.

** Significant at 5 percent level.

*** Significant at 1 percent level.

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