The Fiscal Response To Oil Shocks

by

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Abstract

In countries where oil revenue is a major source of government revenue, oil price changes are shocks to the public budget. This thesis looks at the large and sudden changes in oil prices over the last three decades as natural experiments for understanding the factors that determine expenditure, taxation and government saving levels. The first chapter develops a forecasting model of the real price of crude oil applying Hamilton's Markov regime switching model on a 127 year long series of the real price of oil. The model provides strong statistical evidence favoring the presence of changes in regime. As a forecasting tool, the model outperforms both linear reduced-form models which do not consider structural change and DOE price forecasts. Finally, it is shown how the model can be applied to the measurement of the wealth effect of oil price shocks.

The second chapter measures the expenditure and taxation response to oil shocks over the last 25 years. The key findings, based on an empirical analysis of a panel data set of 13 petroleum exporting countries, are: 1) the sum of non-oil tax cuts and spending increases does not exceed the annuity value of oil shocks, 2) most of the response occurs through increased government expenditure, indicating the presence of "fly-paper" effects, 3) there is no significant evidence of asymmetries in the response to negative and positive shocks, and 4) there are significant cross-country differences in the way governments respond to oil shocks. The third chapter is an empirical essay in political economics. Its purpose is to assess the effects of politics and institutions on fiscal policy, by looking at the response to oil shocks. The main finding of the third chapter is that the more autocratic a government is, the more moderate the expenditure response to an oil shock: democracies exhibit an over-spending tendency. A second finding is that "left-wing" governments tend spend more than "right-wing" ones after a windfall.

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To Virginia

Introduction

After decades of stability, during the past 25 years the price of oil has shifted back-and-forth from historical lows to unprecedented highs, taking along the fortunes of countries for which oil is a significant source of government revenue. While for importing countries the largely unexpected price increases of the 1970s led to recession and economic turmoil, for oil exporting nations the shocks meant new riches and opportunity –which in most cases did not come true. Then, when the shocks were reversed in the 1980s, oil exporting countries faced very large negative wealth shocks that severely darkened their prospects of economic growth and prosperity. Today, as the price of oil is down to its lowest level in the 1990s and importing nations enjoy the boost of cheap energy, exporters are forced once again to adjust their government budgets and revise downward growth expectations.

To petroleum exporting nations, oil price shocks affect their economies first and foremost through the fiscal channel, as a very large fraction (or all) of oil generated revenues accrue to the government. The way in which governments adjust their expenditure and revenue policies is, therefore, a key element in the transmission mechanism of these shocks into the rest of the economy. The main objective of this dissertation is to improve our understanding of the way in which the fiscal policy of nations that produce and export crude oil responds to changes in value of their petroleum assets. The three essays that follow address four main issues which are key to understanding how this mechanism operates: What has been the size (present value) of the shocks? How should governments respond to oil shocks? How have governments responded to oil shocks over the last 25 years? Do political institutions determine the fiscal response to oil shocks? By providing answers to these questions, this dissertation contributes to our understanding of links between oil price fluctuations and fiscal policy, and more broadly, to the response of fiscal policy to public wealth shocks in general.

Economists have many theories that try to explain fiscal policy and the size of government but only very limited ways to test them. Because government activity influences almost every economic variable that we observe, the empirical identification of the determinants of revenue and expenditure policies is an elusive goal. Oil shocks in exporter countries are good natural experiments that serve this purpose for several reasons. First, they are essentially exogenous for many countries that do not play a role in price determination. Second, the shocks are quite large: the value of the shocks in a year was as high as 1.2 times GDP for Venezuela, half GDP for Norway and Tunisia, and a third of GDP for Indonesia –just to name some examples. The budgetary impact of these shocks is considerably larger than that of the shocks to the public budget commonly studied in the public finance literature, like aid and grants to state and local governments. An important finding of those studies is the so-called "fly-paper" effect: when state and local governments receive a windfall, they tend to spend most of it themselves –as opposed to transferring it to society. The experiment in this thesis is a powerful tool to look after the fly-paper effect in the national governments level. Third, oil shocks have been both positive and negative. This fact allows tests on the possible asymmetries in government behavior. Finally, there is rich diversity in the characteristics of the countries suitable for this study. Oil exporting nations are different along many economic, political and institutional dimensions, and this variation can be a powerful tool for understanding the determinants of fiscal behavior.

The first essay (chapter 1) examines the long-run statistical properties of the price of crude oil. It develops a forecasting model of the real price of crude oil based on two principles. The first is reduced-form analysis. Instead of trying to explain and predict the behavior of the real price of crude oil in terms of the underlying supply and demand structures as done in structural modeling, a reduced-form time-series model looks only at the statistical properties of the history of the oil price over more than a century in order to draw conclusions about the underlying law of motion. The second modeling principle is allowing for structural change to take place over time. The motivation relies on the historical record of events in the international oil market, in particular those that have taken place starting in 1973. To many observers it appears that the workings of the international oil market were significantly altered in the decade of the 1970s, when market control shifted early in the decade from oil companies to producing nations, who eventually raised prices. The argument in chapter 1 is that these events introduce non-linearities (structural breaks) in the stochastic process of the oil price which should be a feature of any complete univariate description of the process. Both principles are achieved by applying Hamilton's Markov regime switching model to a long annual series of the real price of crude oil. The model provides strong statistical evidence favoring the presence of changes in regime, indicating that over the last 127 years the price of oil has switched back-and-forth between a "low-mean/low-variance/high-persistence" regime and a "high-mean/high-variance/low-persistence" regime. The model yields a rational expectations forecasting tool, which outperforms both linear reduced-form models that do not consider structural change, as well as the annual price forecast published by the U.S. Department of Energy (DOE). The model is then applied to the measurement of the wealth effect of oil price shocks, defined as the change in the present discounted value of oil revenues. The resulting estimates of the wealth effects of price shocks are smaller than those obtained in the previous literature, which typically assumes oil prices follow a random walk with drift –as opposed to the mean-reverting Markov-switching process featured here.

The essay in chapter 2 starts by asking: How should governments respond to oil windfalls? An intuitive answer to this normative question is that governments should distribute the annuity value of the shock between reduced non-oil taxes and increased government spending, in proportions consistent with the social preferences for private and government goods. The chapter presents a stylized neoclassical model of government spending and taxation that confirms this intuition, but which also shows that in the presence of distortionary taxation of non-oil income an oil shock reduces the relative price of any level of government spending. The resulting substitution effect predicts an increase of the share of government provided goods and services in the economy. After some simplifying assumptions the model is calibrated to obtain a benchmark against which the observed response can be compared.

Chapter 2 then looks at the actual fiscal response to oil shocks. The contemporaneous wealth value of the shocks – that is, the value of the shocks as perceived when they happened – is measured using price expectations generated with the Markov- switching model of chapter 1, as well as the annual DOE forecast. These two alternative measures of wealth change are used as explanatory variables in panel data regressions in which non-oil tax revenue and government expenditure are the dependent variables. Within this framework I can test for differences in the response across countries, for asymmetries in the response to positive and negative shocks, and for the interaction of the response with other economic and institutional variables. The key findings, based on annual data from 13 countries over the 1970-1995 period, are the following. First, the total magnitude of the fiscal response does not exceed the annuity value of oil shocks. Second, there is evidence of fly-paper effects as most of the response occurs through increased government expenditure. These two results are consistent with the findings of previous case studies on the effects of positive oil shocks in exporting economies. Third, I find no evidence of asymmetries in the response to negative and positive shocks. Finally, there are significant cross-country differences in the way governments respond to oil shocks.

Chapter 3 is an empirical essay in political economics. Traditionally positive economic analysis of public finance policy has mainly focused on the effects of alternative expenditure and revenue actions on the economy. Recently, however, economists have expanded the set of questions in order to investigate why governments choose particular policies. The field known as political economics, with its emphasis on the role that politics and institutions play in the definition of policies, is among the most active branches of economics. The purpose of the essay is to contribute to our understanding of the effects of politics and institutions on fiscal policy, by looking at the response of public expenditure, taxation and saving to oil shocks. Changes in the oil price offer a good context in which to explore the effects of institutions and politics on fiscal policy mainly because we can identify a relevant source of exogenous variation in the government's budget of an oil exporting country. Knowing that a public wealth shock occurred, it is then possible to compare the response of countries with different institutions. The institutional variables employed are indicators of several aspects of democracy, geographical centralization, the quality of institutions and the political orientation of the government in office. The main finding is that the more autocratic a government is, the more moderate the expenditure response to an oil shock: democracies appear to exhibit an over-spending bias. A closer examination indicates that the two aspects of democracy that induce spending are competition in the access to power and institutional constraints on the authority of the executive. A second finding is that "left-wing" governments tend spend more than "right-wing" ones after a windfall.

The findings of this dissertation imply that the actual fiscal response to oil shocks deviates from what would be predicted as optimal in a stylized neoclassical model, in the sense that an expenditure-bias is detected. Moreover, this tendency appears positively correlated with the presence of democratic institutions. This leads to the conclusion that, from a normative perspective, the relevant issues are not only about which policies are better, but about the workings of the institutions that will put them in practice. If democratic governments have indeed a tendency to over-spend, the case for budgetary procedures and rules designed to counteract this effect – like balanced-budget rules or a strong finance minister – becomes stronger.

The three essays presented here open a research agenda. A first extension would be to augment the sample to include more countries and other sources of exogenous wealth variation. The methodology followed here is readily applicable to a broader sets of natural experiments; by doing so it would be possible to test the robustness of the results shown here and to add power to the tests on the effects on institutions. A second extension can be to focus on more specific institutional features, such as budgetary rules and procedures. In order to advance in this direction it will be necessary to generate variables that describe such institutions in a comparable way. More broadly, there remains a whole set of questions surrounding the presence of oil revenue in the government's budget that are worth studying, such as the effects of alternative fiscal systems on the oil industry, the intergenerational distribution of oil shocks, or the role and effects of government hedging against oil shocks.

Chapter 1

The Long-run Forecast of Oil Prices: A Regime Switching Approach

Introduction

The price of crude oil has been one of the most important economic variables in the world economy throughout the 20th century, and is likely to remain so in the foreseeable future. This has led energy sector firms, economic analysts, governments, and speculators to be interested in better understanding and predicting its behavior. Although the full dynamics of the oil price are beyond the reach of our current analytic capabilities, the relevance of the topic is such that efforts to improve our knowledge do not cease. This chapter presents a reduced-form model that allows for structural breaks in the long-run stochastic process of the price of crude oil. The model provides strong statistical evidence favoring the presence of regime shifts, indicating that over the last 127 years the price of oil has switched back and forth between a "low-mean/low-variance/high-persistence" regime and a "high-mean/high-variance/low-persistence" regime. Moreover, the model yields medium and long-run oil price forecasts superior to those achieved by other, commonly used, models.

The econometric approach developed in this chapter is an application of the Markov-switching regime model developed by James Hamilton (1989, 1990). Instead of trying to explain and predict the behavior of the real price of crude oil in terms of the underlying supply and demand structures as done in structural modeling, the reduced-form time-series model below looks only at the statistical properties of the history of the oil price over more than a century in order to draw conclusions about the underlying law of motion. As Pindyck (1997) argues, a structural approach is unlikely to be useful for long-run forecasting; the results in this chapter reinforce this view by showing that the reduced-form forecasting model presented here significantly outperforms one of the leading structural models, constructed by the U.S. Department of Energy (DOE).

1.1 The case for structural breaks

Previous reduced-form analysis of the stochastic process of the oil price has generally been studied using a linear approach in which the price is normally assumed to follow some form of autoregressive specification and no breaks are considered. Under this framework, the main issue of interest has been whether a unit root is present or not in the process: is the oil price best modeled in the long-run as a random-walk or as mean-reverting? In order to answer this question numerous authors have made the assumption that spot prices of exhaustible resources follow a geometric Brownian motion with drift (see Lund (1993) for references). Although it is usually not made explicit, the justification for this assumption is largely theoretical and related to the Hotelling (1931) model, in which a unit of resource is very much treated as a financial asset[1]. The prevalence of the Brownian motion with drift in the finance literature has therefore led to their widespread adoption in the modeling of exhaustible resource prices. However, the assumption has been contested, both on empirical and on theoretical grounds. From an empirical point of view, unit roots tests are not conclusive. While Slade (1988), is not able to reject the unit root hypothesis for the oil price using data from 1906 to 1973, Dixit and Pindyck (1994) and Pindyck (1997) do reject it using a longer sample of annual data. Their conclusion is that the oil price is mean reverting, but the rate of mean reversion is very slow. Therefore, only tests on very long series have enough power to reject the null. From a theoretical point of view, Lund (1993) argues that the geometric Brownian motion with drift is hardly an equilibrium price process, if resource deposits have different extraction costs and each resource owner follows an optimal extraction strategy.

The main hypothesis of this article is that the stochastic process of the oil price can not be modeled correctly if structural breaks are not considered in the analysis. The motivation relies on the historical record of events in the international oil market, in

[1] The theory of exhaustible resources in the tradition of Hotelling's model is presented in Dasgupta and Heal (1979). Alternative views appears in Adelman (1993) and Stevens (1995).

particular those that took place starting in 1973. After decades of stability and relatively low prices, in 1973 the price of a barrel of crude oil sky-rocketed, leading to a period of higher prices and volatility which seriously affected the world economy. To observers it appeared that the workings of the market were significantly altered in the decade of the 1970s, when market control shifted early in the decade from oil companies to producing nations, who eventually raised prices and caused the so-called "oil-shocks"[2]. While the analysis of the structure of this very complex international oil market is beyond the scope of this chapter, the argument presented here is that these events introduce non-linearities (structural breaks) in the stochastic process of the oil price which should be a feature of any complete univariate description of the process.

The empirical literature that deals explicitly with structural breaks in the oil price process is quite scarce. One exception is Akarca and Andrianacos (1995), who conduct tests of structural change on a second order autoregressive model (AR(2)) using monthly data for the 1974-1994 period. They find evidence that the stochastic process changed after January 1986, resulting in a more volatile process in which shocks are less persistent. A second example – more closely related to the work reported below – is Green, et. al (1994), who apply an extended version of variance-change and outlier-search techniques to oil price annual data for the 1860-1989 period. These authors find that movements in the price of crude oil are not all of the same kind: while "normal" changes are well described by a stationary AR(1) model, some infrequent changes are larger than usual, but quite persistent. While both Akarca and Andrianacos and Green et. al. provide strong evidence in favor of the presence of structural breaks in the oil price process, they fail to model the process driving the breaks. By treating the breaks as exogenous events, the usefulness of both models is limited, as they are unable to estimate historic price expectations or provide forecasts that include the possibility of future breaks. In contrast, the econometric method applied here models the process of structural change in a simple yet powerful way: regime dynamics follow a first order Markov chain. This feature

[2] A comprehensive analysis of this events is offered in Adelman (1995).

enables the model to provide price forecasts which turn out to be better over the medium and long-run than those provided by a simple autoregression.

The rest of the chapter is organized as follows. Section 1.2 introduces the model Markov-switching model, shows the estimates and reports the results of several specification tests. Section 1.3 reports both within-sample and out-of -sample forecasts of the model, and compares them with forecasts from a linear model and from the U.S. Department of Energy. Section 1.4 shows how the model can be used to measure changes in oil wealth due to changes in oil prices, and section 1.5 concludes.

1.2 A Model of Markov Regime-switching

In this section a regime-switching model is applied to the estimation of the process followed by the real price of oil. According to this formulation, the stochastic process is represented as a non-linear combination of dynamics: the price is assumed to follow one of two alternative regimes, depending on the value of a discrete variable that indicates which regime (also known as *state*) is in place at each point in time. This "regime-indicator" variable follows itself a stochastic process. The particular model estimated below is given by[3]:

(1)
$$y_t - \mu_{S_t} = \phi_{S_t}(y_{t-1} - \mu_{S_{t-1}}) + \varepsilon_{S_t},$$
$$\varepsilon_{S_t} \sim N(0, \sigma^2_{S_t}),$$
$$S_t = 1,2.$$

[3] Several other formulations were tried, including a simple-switch (as opposed to Markov switching), and Markov-switching models either excluding the within regime autoregressive components or including time trends. All of these alternatives proved to be inferior in both specification tests and forcasting.

where y_t is the real price of crude oil, and S_t is the discrete unobservable variable that indicates the regime the process is in at time t. ϕ_{S_t} is an autoregressive term in regime S_t and μ_{S_t} is the mean under regime S_t. The number of states is arbitrarily set to two, with the purpose of testing if a relatively simple model is able to approximate the process. However, augmenting the number of states would increase the computational complexity of estimation by maximum likelihood and would significantly reduce the number of observations available to estimate coefficients within each state. The distribution of S_t defines the type of switching. A special case of Hamilton's (1989,1990) Markov regime-switching model (from here on "MS") arises if the distribution of S_t is given by

(2)
$$P[S_t = 1|S_{t-1} = 1] = p,$$
$$P[S_t = 2|S_{t-1} = 1] = 1 - p, \qquad \text{where } 0 \leq p \leq 1,$$
$$P[S_t = 2|S_{t-1} = 2] = q, \text{ and}$$
$$P[S_t = 1|S_{t-1} = 2] = 1 - q, \qquad \text{where } 0 \leq q \leq 1.$$

Therefore, the states follow a Markov chain, where the probabilities of being in one regime next year depend on the regime in place this year. Hamilton's Markov switching model is explained in Hamilton (1993, 1994) and has been applied successfully to many economic and financial time series, including interest rates [Hamilton (1988), Sola and Driffill (1994)], aggregate output [Hamilton (1989), Lam (1990), Goodwin (1993), Diebold and Rudebusch (1994)], exchange rates [Engel and Hamilton (1990), Engel (1994)], stock returns [Schwert (1989), Turner, Startz and Nelson (1989), Hamilton and Susmel (1993), van Norden and Schaller (1993), Kim and Kim (1996)], and mergers and acquisitions [Town (1992)].

1.2.1 Data

This chapter's focus is on the long-run behavior of the price of crude oil. For that purpose I use a 127 year long series of annual average producers' price of crude oil in the United States[4]. The data -deflated with the U.S. Producer Price Index for all commodities (1982=100)- is shown in figure 1. Table 1 presents descriptive statistics. This long series is used as a proxy for the world oil price during the period. However, this data is not free of problems, as barriers to trade were in place during some periods and a single price may be hard to define in some others[5]. While these problems are very real, here I make the assumption that the available data provides useful information for us to learn something about the stochastic process of the real oil price. Nevertheless, any interpretation of results should keep these problems in sight.

1.2.2 Model estimates

The model was estimated by maximum likelihood using the procedures written by van Norden and Vigfusson (1996)[6]. These models are highly non-linear, and several local maxima were found. The results reported in table 2 were obtained after maximizing the likelihood function employing several hundred starting values for the parameter vector; the model was estimated both for the full sample (1870-1996) and for a shorter sample (1937-1996). The estimates indicate that the stochastic process followed by the real price of crude oil is characterized by two clearly different regimes. In the first regime (when S_t=1), both the mean and the variance appear to be smaller than in regime 2 (when S_t=2), while the autoregressive coefficient is higher in regime 1. This suggests that the price of oil has switched back and forth between a "low-mean/low-variance/high-persistence" regime and a "high-mean/high-variance/high- persistence" regime. All but one of the

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[4] The data used for the estimates presented here was generously provided by Robert Pindyck. I also tried other international markers -provided by Morris Adelman- and results are quite similar.

[5] I am in debt to Morris Adelman for highlighting these and other data problems to me.

[6] Both models were also estimated using procedures written by James D. Hamilton, and identical or very similar results were obtained. Both sets of procedures are Gauss programs made publicly available by the authors over the Internet.

parameters are estimated quite precisely, as the standard errors in table 2 indicate; the exception is μ_2. Due to this fact, the Wald test for equal means -reported also in table 2, can not reject the null hypothesis; in contrast, the Wald test for equal means strongly rejects the null.

The MS model presented here assumes global stationarity. This assumption is in line with the evidence showing that once the structural breaks are taken into account, the presence of a unit root is strongly rejected in the remaining process[7]. Here I can test the presence of a unit root *within the regimes.* ϕ_1 is estimated at 0.88, and the t-statistic for the null $\phi_1 = 1$ is -6.0, signaling no evidence of a unit root within regime 1, although the reversion to the mean is slow. In state 2, the within-regime autoregressive coefficient is lower -estimated at 0.77-, which implies a more rapid mean reversion; however, this coefficient is estimated more imprecisely and the t-statistic for the unit root hypothesis within the regime is only -1.8. The reason why the standard errors on the estimates of both μ_2 and ϕ_2 are relatively larger and therefore the power of the tests is lower seems to be the fact that the model allocates relatively few observations into regime 2; this implies that only a relatively small fraction of the information in the sample is used for the purpose of estimating the parameters of regime 2.

The estimates of the transition probabilities p and q imply that regime 1 expected duration is 11.1 years, while regime 2 is only expected to last 4.5 years. Finally, the last row in the table shows a Wald test for the null $p = 1 - q$; the strong rejection reinforces implies that the state-switching dynamics can not be captured properly by a simple switch, therefore making a case for a more complex specification, such as the Markov transition probabilities employed here.

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[7] Green, et. al (1994). In an exercise not shown here, using the techniques developed by Perron (1989) and Perron and Vogelsang (1992a), I find that the inclusion of a single mean break into a linear AR(1) process with trend is enough to substantially weaken the evidence in favor of a unit root, even in relatively small samples.

Hamilton's method allows us to estimate the probability that the regime was in either regime for every period of time. Figure 2 shows the "filtered" probabilities of being in state 2 at time t, in which only the observations up to time t are used to make the inference:

$$(3) \qquad P[S_t = 2 | y_t, y_{t-1}, \ldots, y_1 ; \theta],$$

where θ is the vector of maximum likelihood parameter estimates. These estimated probabilities are quite useful for modeling rational expectations in this model[8]. Figure 3 shows "smoothed" probabilities[9], which use information in the whole sample:

$$(4) \qquad P[S_t = 2 | y_T, y_{T-1}, \ldots, y_1 ; \theta],$$

where T is the sample size. Figures 2.1 and 2.2 show the filtered and smoothed probabilities respectively obtained from the full sample[10], and table 6 presents the years in which the smoothed probability of being in regime 2 is larger than 0.5.

Using both filters, state 2 is estimated to prevail in only 24 out of 126 years. Table 3 shows the estimated years under regime 2 obtained using the smoothed probabilities. First, the 1870's decade is estimated to be under the high-mean/high-variance state (regime 2). Next, there are a series of bursts into regime 2 at the end of the 19th century, and at the beginning of the 1920's and 1930's. After that, a 51 year "period of calm" takes place. From the perspective of this model, this long period of stability is an anomaly, since regime 1's expected duration is only 11.1 years. It is interesting to note

[8] See Hamilton (1988).

[9] Smoothed probabilities were obtained by exploiting a result that appears in Kim (1994), incorporated into the procedures of van Norden and Vigfusson (1996).

[10] Filtered and smoothed probabilities obtained with the 1937-1996 sample (not shown) are very similar to those obtained with the full sample.

that during this lapse the international oil market was dominated by the so-called "Seven sisters"[11]. Then, after 1973, the process switches more frequently. The spikes in 1974 and 1979 coincide with the two oil shocks, although the estimated duration of this episodes is short; the period 1986-1990 -which includes the oil price drop of 1986 and the Gulf War- is estimated to be under the more volatile state. This particular result is consistent with Akarca and Andrianacos (1995), who find that after 1986 the process reverts more rapidly to the mean and is more volatile; also, Bessembinder, et. al (1995) -looking at futures contracts for the period 1983-1991- find evidence of mean reversion, while Lee, Ni and Ratti (1995) find larger volatility after 1986 using a GARCH(1,1) model. Finally, the 1990's are estimated as being in the low-mean/low-variance regime. In general, the dating provided by this model seems to emphasize the changes in volatility and does not look inconsistent with the history of the oil market.

1.2.3 Specification diagnostics

The first question we should ask about this kind of model is if there is in fact statistical evidence of the existence of two regimes versus just one. This happens to be a non-standard testing set-up since under the null hypothesis of one regime

$$H_o: \mu_1 = \mu_2, \sigma_1 = \sigma_2, \text{ and } \phi_1 = \phi_2, \tag{5}$$

the statistics from Wald or likelihood ratio (LR) tests do not have standard distributions because the probability p is not identified. Score tests (Lagrange multiplier tests) based on the linear model are not available either, since the scores with respect to the mean or variance parameter of interest are identically zero if the probability of staying in regime 1 is either 0 or 1. In this non-standard context, two closely related tests have been suggested. First, Hansen (1992) proposes a bound test that is valid under these conditions.

[11] For an analysis of the oil market in those days see Adelman (1972,1993,1995). Sampson (1975) provides a history of the rise of the "Seven Sisters".

Hansen's test draws on empirical process theory to view the LR statistic as the sum of a limit function and an empirical process under the null. The test statistic is therefore chosen to be the supremum of the LR over the entire space of $(\mu_2,\sigma_2,\phi_2,p)$; since the empirical process is dependent on the "nuisance" parameters (here μ_1, σ_1 and ϕ_1) the LR must be standardized for interpretation. The test is computationally intensive since the likelihood function has to be maximized with respect of the nuisance parameters for every point in a large grid in the space of $(\mu_2,\sigma_2,\phi_2, p)$. An alternative approach appears in Garcia (1995) who treats the transition probabilities as nuisance parameters. Based on another result by Hansen (1992), the likelihood ratio test statistic for the null hypothesis of one state is then defined as the supremum over all admissible values of the transition probabilities. The asymptotic distribution has been tabulated by Garcia (1995) for a model like this. The likelihood ratio statistic and its corresponding p-value are reported in the first row of table 4, and indicate a clear rejection of the hypothesis of one state. Therefore, there is very strong evidence in favor of the switching specification, and therefore, the presence of structural change in the oil price series.

However strong the evidence may be in favor of the two-regimes formulation, a satisfactory model should also capture all salient features in the data. The rest of the rows in table 4 show tests statistics for the presence of three other effects that may not be fully captured by the model: higher-order Markov switching effects, higher order within-regime autoregressive components, and within-regime first order autoregressive conditional heteroskedasticity (ARCH(1)) effects. The tests are White (1987) dynamic score tests, which are based on previous results by Newey (1985) and Tauchen (1985). These tests examine the null hypothesis that the score statistics (the derivative of the conditional log-likelihood of the t-th observation) are serially uncorrelated, which should be the case if the model is correctly specified. Hamilton (1996) and van Norden and

Vigfusson (1996) show how White's tests can be applied to switching models[12]; here I apply a finite-sample correction suggested by Hamilton (1996). The test statistics in table 4 show that the MS specification employed here captures a great deal of the dynamics of the oil price, but also indicate there are some further complexities in the process which escape the model. When the model is estimated using the whole sample, there is no evidence of ARCH effects, and no evidence of AR(1) remaining in regime 1. However, the model is not capturing some remaining autoregressive components under regime 2, and higher order Markov effects may be present. This last result suggests that the dynamics of switching are in reality more complex than assumed here, and that a first order Markov chain is just an approximation. Despite this limitation, in the next section it is shown how the model provides significantly better medium and long-run forecasts than alternative linear models, which do not model structural change itself.

1.3 Forecasting

Although the two-state description that comes out of the model may be a valuable insight into the historical workings of the international oil market, the main purpose of such a model is to provide good forecasts. In this section it is shown that the reduced-form MS model outperforms in the medium and long-run reduced-form linear models, as well as a leading structural model.

In order to evaluate the forecasting capabilities of the model, a benchmark should be defined. For this purpose, after Box-Jenkins identification (results not shown here), two AR(1) models -with and without a linear time trend- were estimated (coefficients are shown in table 5). Since the time trend appears significant, the comparison shown below

[12] The asymptotic distribution of the tests is only valid at interior conditions, such as $0 < p < 1$. See Hamilton (1996), p.133. In this model, the validity of the asymptotic distributions used for the tests requires also that $\phi_i < 1$ for i=1,2.

is made against the AR(1) with trend model, although the outcome is similar when the no-trend AR(1) model is used as benchmark. The AR(1) model is also the alternative hypothesis in Dixit and Pindyck (1994) and Pindyck (1997), where the null hypothesis of a unit-root is clearly rejected in sufficiently long samples. Comparisons are made between both within-sample and out-of-sample forecasts, and are based on the root mean squared error (RMSE) criteria, which is a measure of how far from the actual values the forecasts turn out to be -the model with the smallest RMSE is considered a better forecasting tool. For any model, the m-periods ahead within-sample RMSE is given by:

$$(6) \qquad RMSE^{w}{}_{h} = \sqrt{\frac{1}{T-m}\sum_{t=1}^{T-m}\left[y_{t+m} - E(y_{t+m} \mid y_t, \ldots y_1; \hat{\theta}_T)\right]^2}$$

where the forecast (the expected value) employs the vector of parameter estimates $\hat{\theta}_T$ obtained from estimating the model over the full sample of size *T*. In the MS model, the parameters in the vector $\hat{\theta}_T$ are the means and the AR(1) coefficients of each state, plus the two transition probabilities; in the AR(1) with trend model, the parameters are the mean, the time trend coefficient and the AR(1) coefficient. Hamilton (1993) shows how the forecasts are obtained. Table 6 presents a comparison of the within-sample RMSE of the two models over 1 to 15 years ahead horizons. While the AR(1) with trend does a better job in forecasting the prices in the short-run (1 and 2 years), the MS model looks better in the medium and long-run (5 years and more). This is indicative that including the possibility of regime-switching pays-off by enhancing the predictive power of the model.

The comparison of within-sample forecasts is nothing else than an additional way to evaluate the specification of the model, since in practice the econometrician can not make use of future observations to estimate parameters. In contrast, the out-of-sample RMSE compares more accurately the forecasting ability of the models, since only current information is used to make the forecasts of future values. For this purpose, both the MS model and the AR(1) models were reestimated over the 1870-1980 sub-sample, and then the values for the period 1981-1996 were forecasted and compared. The out-of-sample RMSE for a given base year t (here 1980) is based on the average forecast error across different horizons:

$$(7) \qquad RMSE^{o}_{t} = \sqrt{\frac{1}{H}\sum_{h=1}^{H}\left[y_{t+h} - E(y_{t+h} | y_t, \ldots y_1; \hat{\theta}_t)\right]^2},$$

where H is the number of years in the sample not used for reestimation (here 1981-1996), and $\hat{\theta}_t$ is the vector of reestimated parameters. As before, the model with the smallest out-of-sample RMSE is considered the best forecasting tool. Given that all post-1980 information is excluded in forming the forecasts with both the MS and the AR(1) models, we can also compare their RMSE with that of other forecasts made back in 1980. Here I also present the 1981-1996 RMSE of the 1980 U.S. Department of Energy (DOE) crude oil price forecast[13]; back in 1980, the DOE predicted the real oil price would grow at an average annual rate of 1.9%.

Figure 4 shows the three forecasts made only with information available in 1980 (labeled "DOE", "MS model" and "AR(1)"), along with the actual price. There are several things to highlight from this chart. First, both reduced-form models (AR(1) and MS) do much better in the medium and long-run than the DOE forecast. The key factor here is the mean reversion built into the MS and AR(1) models, which contrasts with the steady growth assumption underlying the DOE as well as the majority of structural forecasts of the time (Lynch, 1994). As the prices collapsed in 1986 and then did not go back into the high early-eighties levels, the 2% annual increase DOE forecast yielded very inaccurate forecasts. Behind the relative success of the reduced-form forecasts is the long-lasting conflict between two ways of looking at the oil market: the one which favors the

[13] Lynch (1994) shows that by 1980 the DOE prediction was already a representative of the forecasting consensus.

immediate applicability of the Hotelling tradition and pushes the notion of increasing prices in a world dominated by imminent oil exhaustion, vs. the one which believes history will repeat itself with higher prices and new technologies enabling the discovery of new reserves and repeatedly postponing exhaustion. The events in the 1981-1996 period strongly favor the "historical" view; not surprisingly, the models built only from historical price data do a better forecasting job in this lapse. Their continuing success in the future depends very much on whether oil market history will continue to repeat itself.

Second, the MS model has the smallest RMSE, 16% lower than the AR(1), and 61% lower than the DOE prediction. This implies that the MS model, with its built-in non-linear switching, is likely to be a better forecasting tool than linear reduced-form models linear. Third, as in the within-sample comparison, the MS model forecasts are worse in the short run, but better after four years or more. The RMSE of the MS over the 1986-1996 period is 57% smaller than the RMSE of the AR(1) model over the same lapse. As the forecasting horizon grows longer, the MS model becomes a better crude oil price forecasting tool.

1.4 Application: measuring the wealth impact of oil shocks

The analysis of the forecasting capabilities of the MS model indicates that its relative strength is in the formation of long-run price expectations. This feature is particularly useful in the valuation of the wealth a government (or a private agent) holds in the form of oil rights -which clearly depends on the prices that are expected to prevail in the future. Since the MS model provides a tool for obtaining long-run price expectations, it can be used as an input in the task of measuring oil wealth. An alternative application would be to the valuation of oil companies stock. In this section I briefly show how the price expectations that come out of the MS model can be used to assess the wealth consequences of oil price shocks. The values shown below are considerably smaller than those obtained by Boskin et. al. (1985, 1987) where prices are expected to follow the Hotelling rule.

The value of wealth in the form of oil rights at any point in time is given by the expected net present value (NPV) of the flows coming out of the property. Leaving aside for simplicity any heterogeneity in costs and quality, "oil wealth" in year t (Wt) can be defined as:

(8) $$W_t \equiv \sum_{h=0}^{H} \frac{1}{1+r_t}\left[\lambda_{t+h} q_{t+h} E\left(y_{t+h} | \Omega_t\right)\right], \text{ s.t.}$$

(9) $$\sum_{h=0}^{H} q_{t+h} = R_t$$

where H is the number of production years, r_t is the discount rate, q_{t+h} is the number of barrels planned to be produced in year $t+h$, $\lambda_{t+h} \in [0,1]$ is the fraction of the price y_{t+h} that constitutes net revenue to the field owner, Ω_t is the information available in year t -which is the basis for the price forecasts-, and R_t is the number of economically recoverable barrels in reserve in year t. Expression (8) means that W_t is the NPV of the government's take in gross revenue, as expected in year t. If the owner of the field is the government, and the field is leased, the term λ_{t+h} summarizes the fraction of the price that is paid to the government in the form of royalties, taxes, bonuses, etc. in year $t+h$. Finally, expression (9) simply states that production is constrained by the amount of reserves. It should be noted that this measure refers to *contemporaneous* wealth, that is, as perceived in year t. The objective here is to measure the change in W_t that happens as a result of oil price changes.

The relationship between the paths of price, production, reserves and even the government's take is a complex one. As price variation occurs, production plans are modified, the assessment of economically recoverable reserves is adjusted, and the share of the government also changes -either through a non-linear tax structure or due to tax system adjustments. Obtaining a measure of all these effects would be necessary to construct an accurate figure of wealth change; if this is not feasible, some assumptions should be made. Here I make the unrealistic assumption that all variables are independent of the price path. Moreover, I also assume that annual production is always a constant share of remaining reserves. These two assumptions imply that the percentage change in oil wealth can be conveniently measured as the percentage change in the expected present value of a one barrel of oil annuity (Y_t), which is defined as:

$$(10) \qquad Y_t \equiv \sum_{h=0}^{\infty} \frac{1}{1+r_t} E(y_{t+h} | \Omega_t).$$

With the MS model is straight forward to calculate Y_t for any given discount rate (Hamilton, 1993). Table 7 shows the estimated percent change in Y_t for real discount rates of 1 and 3 percent for the period 1980-1996. These measures of oil wealth percentage change are significantly smaller than those appearing in Boskin, et. al. (1985, 1987), where it is assumed that the real price will rise at the rate of real interest (as in the Hotelling model); such an assumption implies that the change in the Y_t is simply equal to the change in price, which is shown in the last column of table 7. The reason why the MS estimates are smaller is the mean-reversion feature of the model, which projects deviations to gradually erode. In contrast, the Boskin, et. al. approach treats price movements as shifts in the base level from which thereafter price is expected to rise at the interest rate; therefore, *observed* price changes are assumed permanent. As Lynch (1994) shows, this assumption has been the rule in oil price forecasting during the last two decades; however, applying the MS model to this issue shows how this common assumption leads to a significant overstatement of the wealth impact of price shocks.

1.5 Conclusions

This chapter develops a forecasting model of the real price of crude oil based in two principles. The first one is reduced-form analysis, which implies making the estimation based solely on the history of oil prices; the second is allowing for structural change in the series. Both principles are achieved by applying Hamilton's Markov regime switching model on a 127 years long series of the real price of oil. This exercise yields a stylized description of oil price history and provides a potentially useful forecasting tool.

The model provides strong statistical evidence favoring the presence of changes in regime, indicating that the price of oil has switched back and forth between a two AR(1) regimes. Although this is a crude simplification of the process -as some of the specification tests reveal- it still provides valuable insights into the medium and long-run dynamics of the oil price, by suggesting that in "normal" times (more than 80% of the sample) the price moves around a relatively low mean, volatility is low and the persistence of disturbances is high; however, there are recurrent episodes (every 11 years in average) in which the price moves around a much higher mean, volatility is very high but persistence of disturbances is relatively low. These episodes last on average between 4 and 5 years.

As a forecasting tool, the model performs better than linear reduced-form models which do not consider structural change, and better than the DOE price forecast. The key to the forecasting success reported here is that oil price history so far repeats itself, enabling a model based on the statistical description of past behavior to provide good quality expectations. Should this model should be used to forecast prices out of the sample depends on whether we believe or not that the future of the oil price will be in some sense similar to its past. Although that is an issue which may never be settled, the use of the MS model in this chapter shows that even the notable events of the 1970's and

1980's are not so different from those that took place during the first century of oil exploitation.

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Table 1. Descriptive Statistics

Average	13.53
Median	12.12
Standard Deviation	6.61
Minimum	5.76
Maximum	43.50

Note: The units are U.S. dollars of 1982 per barrel of crude oil.

Table 2. Markov switching model estimates

Parameter	Maximum likelihood estimates (1871-1996)	Maximum likelihood estimates (1937-1996)
μ_1	10.78	11.61
	(2.83)	(2.89)
μ_2	18.15	25.85
	(11.61)	(16.17)
σ_1	1.24	0.55
	(0.19)	(0.07)
σ_2	5.70	5.83
	(0.92)	(1.11)
ϕ_1	0.88	0.91
	(0.02)	(0.02)
ϕ_2	0.77	0.76
	(0.13)	(0.17)
p	0.91	0.90
	(0.29)	(0.26)
Expected duration of state 1 (years)	11.1	10.0
q	0.76	0.69
	(0.33)	(0.40)
Expected duration of state 2 (years)	4.5	3.2
Log likelihood	-281.94	-103.03
Wald test for H_o: $\mu_1 = \mu_2$ ($\chi^2(1)$)	1.29	2.07
Wald test for H_o: $\sigma_1 = \sigma_2$ ($\chi^2(1)$)	28.07***	16.27***
Wald test for H_o: $p=1-q$ ($\chi^2(1)$)	4.34**	4.37**

Note: Sample is 1870-1996. Covariance matrix of the parameters obtained as the inverse of the computed hessian. *** and ** indicate significance at the 1% and 5% levels respectively.

Table 3. Estimated years for the high mean-high variance state according to the Markov switching model II

	Start	End
1	1871	1879
2	1895	1899
3	1920	1921
4	1931	1932
5	1974	1974
6	1979	1981
7	1986	1990

Note: This are the years for which the smoothed probability of being in state 2 is larger than 0.5, according to the Markov switching model with autoregressive component estimated on the full sample (1871-1996).

Table 4. Specification diagnostics of the Markov switching model

	1870-1996	1937-1996
LR test for the hypothesis		
of only one state	94.72	102.66
	(0.00)	(0.00)
<u>White tests</u> (F(1,T-1))		
The null hypothesis is:		
Higher order Markov	23.10	48.92
effects in regime 1	(0.00)	(0.00)
Higher order Markov	8.96	1.51
effects in regime 2	(0.00)	(0.22)
No AR(1) in regime 1	0.01	10.61
	(0.92)	(0.00)
No AR(2) in regime 1	8.4	16.91
	(0.00)	(0.00)
No ARCH(1) effects	2.70	21.11
in regime 1	(0.10)	(0.00)
No ARCH(1) effects	0.67	4.58
in regime 2	(0.66)	(0.04)

Note: P-values in parenthesis. T is the sample size. A finite-sample correction proposed by Hamilton (1996) was applied to White tests statistics; therefore, the critical values are obtained from the F distribution instead of the χ^2.

Table 5. Estimates from AR(1) models

	No time trend	With time trend
Mean	12.79	6.00
	(4.57)	(3.83)
Autoregressive coefficient	0.86	0.82
	(0.04)	(0.05)
Time trend	-	0.02
		(0.01)

Standard errors in parenthesis. Estimates were obtained using the full sample (1870-1996).

Table 6. Within-sample RMSE comparison

Horizon	MS model	AR(1) model*	% improvement over the AR(1) model
1	3.20	3.00	-6.9%
2	4.56	4.39	-3.8%
3	5.18	5.20	0.4%
4	5.34	5.65	5.6%
5	5.50	6.14	10.3%
6	5.68	6.54	13.1%
7	5.84	6.89	15.2%
8	5.96	7.20	17.2%
9	6.04	7.45	19.0%
10	6.12	7.68	20.4%
11	6.16	7.87	21.8%
12	6.16	8.03	23.3%
13	6.21	8.17	24.0%
14	6.25	8.30	24.6%
15	6.31	8.41	25.0%

*AR(1) model includes linear time trend.

Table 7. Estimates of contemporaneous changes in oil wealth due to oil price variation*

	MS model		Hotelling model
	$r_t = 1\%$	$r_t = 3\%$	(price variation)
1980	14.4%	17.2%	48%
1981	13.6%	15.7%	35%
1982	-2.4%	-2.5%	-11%
1983	-1.6%	-1.6%	-9%
1984	-1.2%	-1.4%	-4%
1985	-2.3%	-2.6%	-7%
1986	-22.5%	-26.3%	-46%
1987	5.1%	6.2%	20%
1988	-7.9%	-9.4%	-27%
1989	4.8%	5.9%	21%
1990	5.2%	6.2%	20%
1991	-0.9%	-1.0%	-12%
1992	0.9%	1.2%	-6%
1993	-2.2%	-2.7%	-11%
1994	-0.6%	-0.7%	-3%
1995	0.8%	1.0%	4%
1996	1.2%	1.4%	16%

*Assumes production plans, reserves and government's take are independent of the price path, and that production is planned as a constant fraction of reserves.

Figure 1

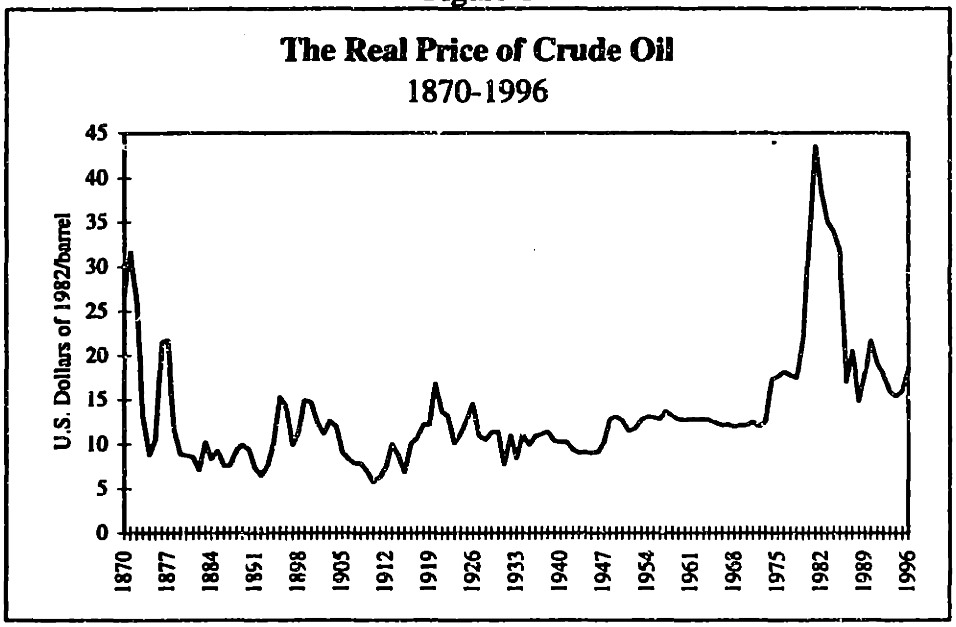

The Real Price of Crude Oil
1870-1996
U.S. Dollars of 1982/barrel
45
40
35
30
25
20
15
10
5
0
1870
1877
1884
1851
1898
1905
1912
1919
1926
1933
1940
1947
1954
1961
1968
1975
1982
1989
1996

Figure 2

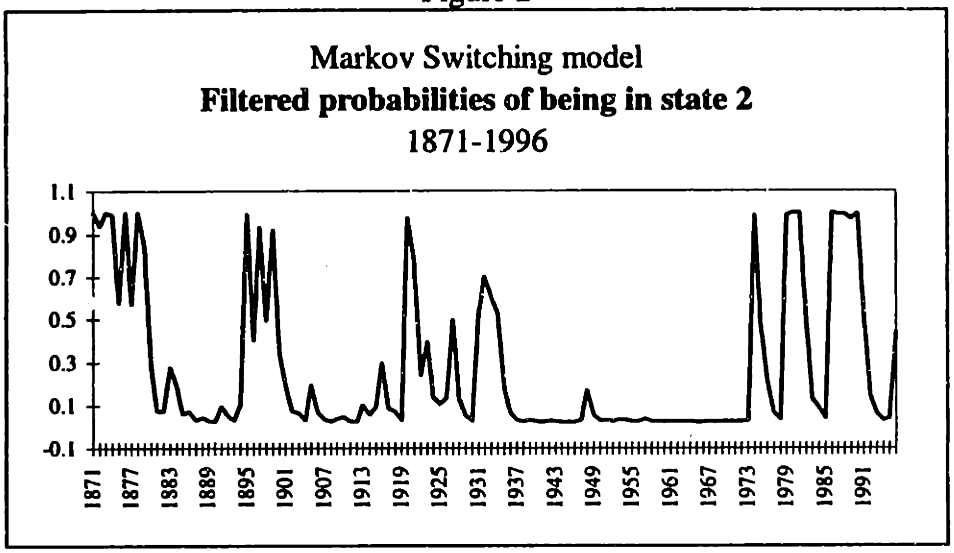


Figure 3

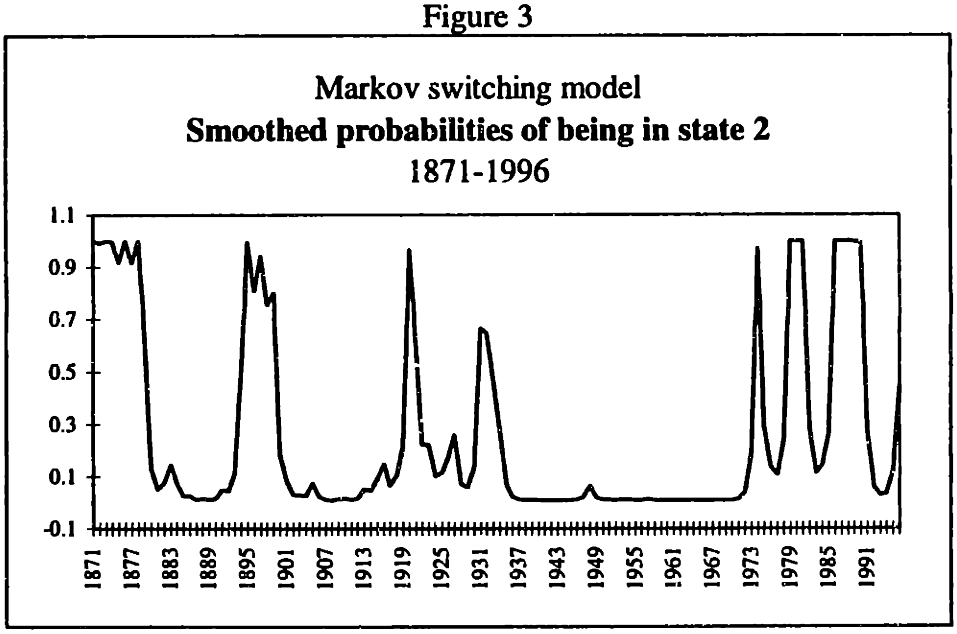
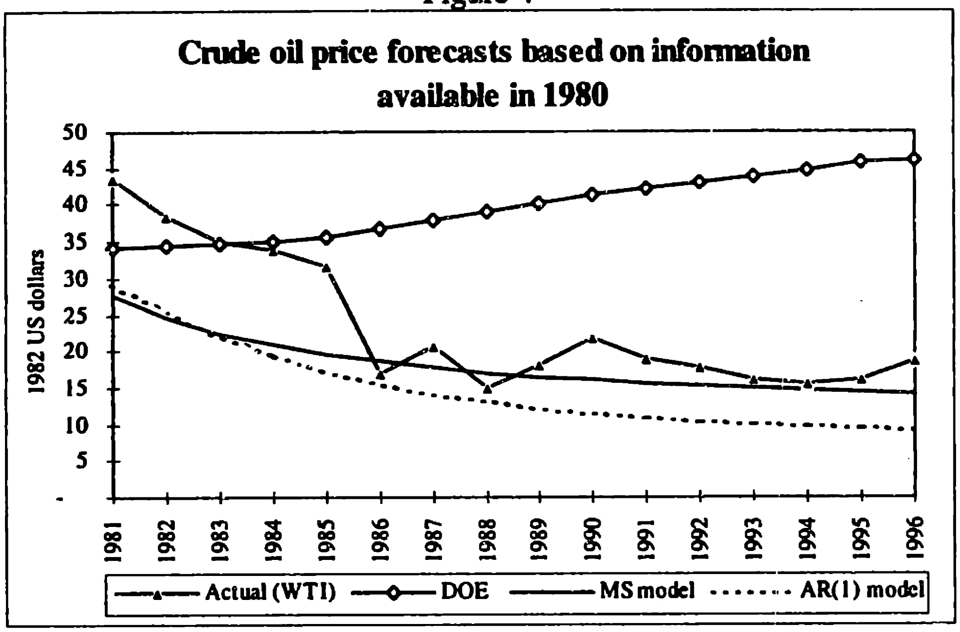


Figure 4



Crude oil price forecasts based on information available in 1980
1982 US dollars
50
45
40
35
30
25
20
15
10
5
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
Actual (WTI)
DOE
MS model
AR(1) model

Chapter 2

The Fiscal Response to Oil Shocks

Introduction

Economists have many theories that try to explain fiscal policy and the size of government but only very limited ways to test them. Because government activity influences almost every economic variable that we observe, the identification of the determinants of revenue and expenditure policies is an elusive goal. This chapter looks at the large and sudden changes in oil prices over the last three decades as a natural experiment for understanding the factors that determine tax and expenditure levels in countries where oil revenue is a major source of government revenue.

Oil shocks offer a good natural experiment to study fiscal behavior for several reasons. The value of the shocks in a year was as high as 1.2 times GDP for Venezuela, half GDP for Norway and Tunisia, and a third of GDP for Indonesia –just to name some examples. The budgetary impact of these shocks is considerably larger than that of the shocks to the public budget commonly studied in the public finance literature, like aid and grants to state and local governments [Wyckoff (1991) and Hines and Thaler (1995) survey and discuss this literature]. Second, oil shocks have been both positive and negative. This fact allows tests on the possible asymmetries in government behavior. And third, there is rich diversity in the characteristics of the countries suitable for this study. Oil exporting nations are different along many economic, political and cultural dimensions, and this variation can be a powerful tool for understanding the determinants of fiscal behavior. In addition to its appeal as a natural experiment, the fiscal response to oil shocks is by itself of great interest to oil exporting nations, as oil shocks operate first and foremost through the fiscal channel.

How should governments respond to oil windfalls? An intuitive answer to this normative question is that governments should distribute the annuity value of the shock between reduced non-oil taxes and increased government spending, in proportions consistent with the social preferences for private and government goods. I present a simple normative model of government spending and taxation that confirms this intuition, but which also shows that in the presence of distortionary taxation of non-oil income an oil shock reduces the relative price of any level of government spending. The resulting substitution effect predicts an increase of the share of government provided goods and services in the economy.

How do we expect governments to respond to oil shocks? Will they consume more than the annuity value of the shock? Will they cut taxes or increase expenditure? Will the response be symmetric to positive and negative shocks? Different theories of government yield different answers. From Barro's (1979) tax-smoothing model, to Brennan and Buchanan's (1980) Leviathan, and from Alesina and Drazen's (1991) war-of-attrition to Becker and Mulligan's (1997) model of inefficient taxes and the size of government, each theoretical point of view predicts a particular pattern of adjustment of taxes and expenditure in response to wealth shocks. This chapter provides an empirical answer to these questions.

My empirical approach starts by measuring the present discounted value of oil shocks, as perceived at the time of the price change. The critical inputs are the expectations about the oil price that we assume were held in the past. I use two alternative measures of expectations. In the first one I suppose the price was expected to behave as forecasted annually by the U.S. Department of Energy. In the second measure I model the long-run price of oil as a two-stage Markov-switching autoregressive process, as in Hamilton (1988, 1989). This approach provides rational expectations forecasts that allow structural breaks in the stochastic process. Once I have measures of wealth change, I use them as explanatory variables in panel data regressions in which non-oil tax revenue and government expenditure are the dependent variables. Within this framework I can test for differences in the response across countries, for asymmetries in the response to positive and negative shocks, and for the interaction of the response with other economic and institutional variables.

The key findings, based on annual data from 13 countries over the 1970-1995 period, are the following. First, the total magnitude of the fiscal response does not exceed the annuity value of oil shocks. Second, there is evidence of "fly-paper" effects [Hines and Thaler (1995)], as most of the response occurs through increased government expenditure. These two results are consistent with the findings of Gelb's (1988) case studies on the effects of positive oil shocks in exporting economies . Third, I find no evidence of asymmetries in the response to negative and positive shocks. Finally there are significant cross-country differences in the way governments respond to oil shocks.

The chapter is organized in five sections. In section one I discuss the normative and positive frameworks to think about the fiscal response to oil shocks. Section two describes the method of oil shocks valuation. Section three describes the data sample. Section four presents the empirical results, and section five offers conclusions and suggestions for further research.

2.1 Previous literature and theoretical framework

Petroleum is a fundamental part of public finances for many oil exporting nations around the globe. In these countries governments hold substantial claims on the oil wealth of their land, and either through taxation of private oil firms or through direct state ownership, oil related revenues constitute a very important fraction of total government revenues (see table 1.1). This fact suggests that oil wealth and oil revenues may play a very important role in the determination of the overall government fiscal behavior: for these nations, oil shocks are fiscal shocks. The objective of this chapter is to find out how the expenditure and taxation policy of oil exporting nations responded to the large oil shocks — positve and negative — that have occurred in the last 25 years. By investigating this response we aim to shed some light into the more general question of what determines fiscal policy.

Table 1.1 Oil revenue

Percentage of total government revenues in selected countries	
Iran (1993)	61.9
Ecuador (1994)	50.7
Venezuela (1992)	43.5
Mexico (1995)	39.0
Cameroon (1992)	13.6
Gabon (1991)	19.2
Trinidad Tobago (1994)	8.3
U.K. (1994)	5.2

Source: IMF. Government Finance Statistics Yearbook, 1995.

The interest in the fiscal effects of oil price movements in oil exporting nations is not new. In 1988 a group of researchers led by Alan H. Gelb of the World Bank published a volume of case studies about the economic impact of oil windfalls in six exporting countries (Algeria, Ecuador, Indonesia, Nigeria, Trinidad and Tobago, and Venezuela). The title of the book, "Oil Windfalls: Blessing or Curse?", is indicative of its main theme. Oil windfalls, concludes the study, were in general turned into a curse mainly due to inadequate government policy. The fiscal response to the positive oil shocks of the 1970s reported in Gelb (1986, 1988) can be summarized as follows:

1. Oil price hikes were mainly converted into increased fiscal revenues, in part due to a rapid upward adjustment of tax and royalty rates on the oil industry.

2. The primary destiny of the additional revenue was increased expenditure, mainly on large industrial projects with low productivity, and to a lesser degree on government consumption.

3. Governments did not transfer their windfalls to the private sector by sharply cutting non-oil taxes, although in some cases non-oil tax efforts slackened.

4. The composition of non-oil tax revenue changed. Taxes on international trade increased their share (as imports grew substantially) while taxes levied on domestic goods and services declined in importance.

5. Governments tried to insulate domestic consumers from the effects of higher oil prices by holding domestic oil prices at or near former levels.

Although Gelb's empirical approach is quite different from mine, the results I present below are in line with his main findings: although far from uniform, we also detect a significantly stronger response in government expenditure than in non-oil tax revenue. This pattern of results prompts various questions. First, how should governments respond to an oil shock? How much should they save and how much should they spend? Is it possible for an expenditure-biased outcome to be optimal? Second, what do we expect governments actual response to the windfalls to be? What do our theories of government fiscal behavior predict about the direction, magnitude and cross-country differences of the responses? This section is dedicated to these questions. After laying out the intertemporal budget identity of the government, I present a very simple normative model. The model shows the basic effects that play into a socially optimal fiscal response to oil shocks and provides a quantitative benchmark to evaluate our empirical results. Then I discuss some positive theories that try to explain actual government fiscal behavior.

2.1.1 The budget identity: how can governments respond to oil shocks

A government that receives a windfall in the form of increased value of its oil assets can basically respond by taking one or more of the following three fiscal actions: a) change its expenditure, b) transfer the windfall to the private sector and c) change its net asset position. For example, expenditure changes can be done on the government's provision of goods and services, or on public capital formation; transfers to the private sector can take the form of changes in tax revenue, subsidies and/or transfers; and finally, the net asset position may be altered by changing the level of government indebtedness or by acquiring/divesting real assets. These three broad categories are summarized in the following simplified version of the intertemporal government budget identity:

$$(1.1) \qquad \phi W = G - \tau Y - NPA$$

In this equation the letters *W*, *G* and *Y* represent the present discounted value (PDV) of oil income available to the economy as a whole (*W*), government expenditure (*G*) and non-oil income in the economy (*Y*). τ is a uniform and time-invariant tax rate imposed on non-oil income, so τY stands for the PDV of non-oil government revenue, (which in equation (1.1) is only composed of non-oil income tax revenue). Equivalently, ϕ is a tax rate imposed on petroleum income, so ϕW is the value of public oil wealth. Finally, NPA_t stands for net non-petroleum government assets[14]. Equation (1.1) can be translated into a dynamic (or cash-flow) budget constraint:

$$(1.2) \qquad \phi w_t = g_t - \tau y_t + rNPA_{t-1} + \Delta NPA_t$$

where w_t, g_t and y_t are respectively the current values of petroleum income, government expenditure and non-oil income, and *r* is the rate of return earned (or paid) on net non-oil government assets. Equation (1.2) states that current government oil income will be equal to the primary deficit (g_t - τy_t) plus the return earned (or paid) on net non-oil assets, plus the change in these assets.

[14] Equation (1.1) also assumes that the government will not violate its intertemporal budget constraint (i.e. no Ponzi games) and that prices remain constant.

2.1.2 A normative theory: how should governments respond to oil shocks

Budget identities (1.1) and (1.2) define, in a simplified fashion, the set of options available to a government that faces a change in the value of its petroleum assets. However, they provide no insight into what the particular policy mix should or will arise. In order to evaluate and predict the fiscal response to oil shocks we need a theory of government fiscal behavior. Although the main objective of this chapter is to empirically identify what this response has been in the last 25 years in several oil exporting nations, here I briefly discuss some theoretical ideas that try to explain government's fiscal behavior.

Start by asking a normative question: what should a government do with an oil-windfall? Even without the aid of a formal model we can broadly outline an intuitive answer. First, the government should only spend — either through increased outlays or reduced revenue collection — a fraction of the cash windfall equivalent to the annuity value of the shock; the rest of the cash windfall should be saved, increasing the net asset position of the public sector. Second, the fraction of the shock that is not saved should be spent on government expenditure and on reduced taxation in proportions that correspond, at least roughly, to the relative social preference for public and private goods. I now formalize these notions using a normative model, closely related to Barro's (1979) tax smoothing model.

Assume for simplicity that social preferences can be represented by the utility function of an infinitely lived representative agent, who derives utility from two goods, private consumption (c) and government expenditure (g):

$$(1.3) \qquad U = \sum_{t=0}^{\infty} \beta^{t} u(c_t, g_t),$$

where $0 < \beta < 1$ is a discount factor. The utility function u satisfies the usual concavity conditions, with $\delta u/\delta c_t > 0$, $\delta u/\delta g_t > 0$, and is assumed to be homogeneous of degree less than one and homothetic[15]. The endowment of this economy is given by streams of oil income (w) and non-oil income (y), assumed to be known with certainty. Following Barro, I assume there is an increasing cost of taxing non-oil income (y), which I attribute to administrative costs of collection and/or dead-weight loss. For every dollar taxed the collection cost is given by a function $f(\tau)$, where $f' > 0$ and $f'' > 0$ if $\tau > 0$ or zero otherwise. We know from Barro's tax smoothing result that the constancy of the tax rate (which I assume) will be part of the optimal policy.

I also assume that if there is any cost of taxing oil-income (w), it is considerably lower than the cost of non-oil income taxation. The reasons behind this assumption are, first, that most taxes on oil income are taxes on a Ricardian resource rent, and therefore less likely than ordinary taxes to distort behavior. Second, administrative costs are also likely to be lower given the scale of operations of the oil industry. The result of assuming this difference in the cost of taxation across types of income will be that in the optimal solution oil income will be more heavily taxed than non-oil income. To simplify the exposition, I assume that the cost of taxing oil income is zero (this will yield a corner solution).

Given these assumptions, the optimization problem is to maximize the intertemporal utility function (1.3) with respect to c_t and g_t for all t=0,1,..., subject to the following endowment restrictions:

(1.4a) $$C + G = W + (1 - f(\tau))Y,$$

(1.4b) $$G = \phi W + \tau Y,$$

[15] The homogeneity of degree less than one is introduced to obtain consumption smoothing of both goods. Equation (1.3) also implies no population growth.

with $0 \leq \tau \leq 1$, and $0 \leq \phi \leq 1$.

As before, capital letters denote PDV values (obtained by using the discount factor β). By stating the endowment restrictions in PDV values I am implicitly assuming an unlimited ability to borrow and lend, so that it is the PDVs of the endowments, and not their specific time paths, the ones that restrict the optimal paths of g_t and c_t.

The optimal solution will depend on the value of W relative to the value of G. If W is large enough, it should be able to completely finance G, avoiding any tax collection costs by setting the non-oil tax rate (τ) to zero. In what follows I assume that W is small enough as to guarantee an optimal τ that is strictly positive. Under these assumptions, the first order conditions are:

(1.5a) $$\phi = 1,$$

(1.5b) $$\tau = \frac{G-W}{Y},$$

(1.5c) $$\frac{u_g(c_t,g_t)}{u_c(c_j,g_j)} = 1 + f'(\tau) \qquad \text{for } t,j=0,1,2\ldots$$

(1.5d) $$\frac{u_c(c_t,g_t)}{u_c(c_j,g_j)} = 1 \qquad \text{for } t,j=0,1,2\ldots, \text{ and}$$

(1.5e) $$\frac{u_g(c_t,g_t)}{u_g(c_j,g_j)} = 1 \qquad \text{for } t,j=0,1,2\ldots,$$

The set of first order conditions (1.5) and the endowment restriction (1.4a) jointly determine the optimal levels of public consumption as well as oil and non-oil taxes. Condition (1.5a) indicates that (when W is small enough) we have a corner solution regarding the taxation of oil income. Since the taxation of oil income generates no cost, oil income should be completely devoted to the financing of government consumption in order to minimize the loss associated with collecting non-oil taxes. In consequence condition (1.5b) — which defines the tax rate on non-oil income — states that Y should be taxed only to the extent necessary to cover the gap between oil wealth and the present value of desired government spending. Equation (1.5c) is the familiar condition which states that the marginal rate of substitution between government and private goods should be equal to the marginal rate of transformation between these same goods, which in this case is one plus the marginal cost of collection of non-oil taxes. The fact that W appears in condition (1.5b) and therefore in condition (1.5c) makes clear that a change in oil wealth will not only induce an *income* effect, but also a *substitution* effect: a larger W means a lower implicit price of government goods relative to private consumption. Finally, conditions (1.5d) and (1.5e) yield consumption smoothing over time of both private and government goods.

Based on conditions (1.5) we can do comparative statics to get an answer to the normative question we made before: what should a government do with oil windfalls? In order to get a precise answer we would need to describe more specifically functions $u(c,g)$ and $f(\tau)$. We can get a simple quantitative approximation if we assume that the marginal collection cost $f'(\tau)$ is positive (so tax smoothing is preserved) but small, so that we can ignore it at this point (we return to it below). Since the utility function is homothetic, a negligible $f'(\tau)$ implies a negligible substitution effect. This means that any endowment will be allocated into private and government expenditure in fixed proportions, because the cost of government spending relative to private consumption will be nearly constant for any value of W; any changes in government and private consumption will be due to the income effect of the oil shock. We denote α as the fraction of total income devoted to government spending. Given that we already know that the tax rate on oil income (ϕ) is set to one, we focus on the tax rate on non-oil income (τ) and on the level of government consumption (which we know will be smoothed over time). Under these particular assumptions the problem is linear so comparative statics are given by:

(1.6a) $$\frac{\Delta g}{\Delta W} = \alpha(1-\beta)g^*, \text{ and}$$

(1.6b) $$\frac{\Delta \tau}{(\Delta W)/y^*} = (1-\alpha)(1-\beta)$$

where Δ is the first difference operator and y^* is permanent non-oil income. Conditions 1.6 indicate that an increment of one dollar in oil wealth (*W*) should lead to an increase of $\alpha(1\text{-}\beta)$ in government spending. Also, an increase of oil wealth the size of y^* should induce a reduction of $(1\text{-}\alpha)(1\text{-}\beta)$ in the tax rate. Table 1.1 shows these values for two discount rates (12% and 20%) and three values of α (0.2, 0.3 and 0.4)[16]. The figures in the table indicate that, under this rough benchmark, the optimal increase in the level of government spending is between 2 and 7 cents on the dollar of wealth increase, while the optimal reduction in non-oil tax collection is between 6 and 13 cents on the dollar[17] (these numbers correspond to the optimal response to changes in the value of oil wealth, not to changes in current oil income).

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[16] The average value of α in the sample of countries we use in the empirical analysis is 0.29.

[17] Because tax smoothing is optimal, the appropriate comparative statics are based on the tax rate, not on tax revenue. To interpret the results obtained for the tax rate as results about tax revenue we need to assume that current income is at its permanent level.

Table 1.2 Optimal fiscal response to a one dollar increase in the value of oil wealth*

Government expenditure			
Discount rate	α=0.4	α=0.3	α=0.2
12%	0.04	0.03	0.02
20%	0.07	0.05	0.03

Non-oil tax revenue			
Discount rate	α=0.4	α=0.3	α=0.2
12%	-0.06	-0.08	-0.09
20%	-0.10	-0.12	-0.13

* Assuming small non-oil tax collection costs.

The model implies, as mentioned before, that only the annuity value of a change in wealth will be consumed the year in which the shock occurs. Therefore, if the shock is not perceived as permanent, it follows from the dynamic budget constraint (1.2) that a portion of the current shock should translate into a change in net assets (NPA). The magnitude of the optimal non-spent fraction of the cash-flow shock will depend on the expected behavior of the price of oil after the shock, an issue that is critical for the empirical analysis and that we discuss in the next section.

The figures in table 1.2 were obtained assuming negligible collection cost of non-oil taxation, therefore ignoring the substitution effects that may be present as an oil shock occurs. While the impact of collection costs in developed countries may not be significant enough as to make the optimal fiscal response very different from what we just calculated, this can not be said about developing countries. In many developing economies, a large fraction of income originates in the informal economy and may be costly to tax. Moreover, the taxation technology in low income countries may yield high taxation costs. In such a context, the values of table 1.1 may underestimate the optimal expenditure response and overestimate the optimal non-oil tax revenue response. As we noted already, when the cost of taxing oil income is lower than the cost of taxing non-oil income, an oil shock is not a pure windfall, since the price of government spending relative to private consumption $(1+f'(\tau))$ changes, inducing a substitution effect. A positive (negative) oil shock, makes public consumption relatively less (more) expensive. It may even be optimal, in an economy in which the marginal cost of non-oil taxation is very high, to dedicate all of a positive oil shock to government spending. From an empirical perspective, the effect of different collection costs on the fiscal response can potentially be tested if we can get a measure of $(1+f'(\tau))$.

The model just shown is only intended to provide a basic framework to think about the problem, and there are at least two relevant issues not mentioned so far. First, the model rules out uncertainty and therefore the role of hedging against oil shocks as part of the optimal policy (the analysis we made is comparative statics in a certainty environment). Under uncertainty about the future values of oil income, however, a risk averse society can find some form of hedging to be optimal. If the government is able to completely hedge against oil price fluctuations, an oil shock should not originate an observable fiscal response. In the empirical analysis that follows we do find a fiscal response, which is then evidence against the presence of complete hedging. This lack of smoothing of consumption across states of nature may be explained by incomplete markets and high costs of carrying out a hedging strategy through the available instruments.

A second issue left out of the model is the possible covariance of the PDV of oil income (W) and the PDV of non-oil income (Y). If this covariance is not zero, the change in W is an incorrect measure of the wealth shock. The covariance between W and Y can be positive if the economy is not automatically on the production possibility frontier (PPF); then a positive shock can increase non-oil output, at least temporarily, through the effect of aggregate demand (fueled by the wealth effect). Conversely, a negative shock can bring the economy inside the PPF. If this mechanism is relevant then the true change in wealth is larger than the change in W, and the numbers in table 1.1 understate the optimal response of both government expenditure and tax revenue. However, an increment in the international oil price can also have a negative effect on non-oil output. Petroleum is an important input to production, so (without price controls) a rise in the oil price is a negative supply shock to the rest of the economy. Moreover, the negative impact of an oil shock in oil importing nations means that the demand for non-oil exports from those countries diminishes. Therefore, ex-ante, we can not predict the sign of the covariance between *W* and *Y*. A conjecture is that a negative covariance is more likely to exist in the economies in which the oil sector is relatively smaller. Mork, Olsen and Mysen (1994) show evidence supporting this view, as they find that the correlation between the change in GDP and the change in the oil price has been negative in Canada and the United Kingdom (where the oil sector accounts for approximately 3 percent of GDP) and positive in Norway (where the oil sector is about 12 percent of GDP).

2.1.3 Positive theories: what to expect from governments

The model just outlined provides a simple normative theory of how governments *should* behave. However, there is a wealth of theoretical and empirical literature that suggests that fiscal policy may not be determined in order to maximize social welfare. By examining the fiscal response to oil shocks we may be able to learn something about how governments behave in reality. Before doing so, I briefly discuss some positive theories of fiscal behavior that may explain the observed response of taxation and expenditure to windfalls.

2.1.3.1) *Benevolent government: the representative agent model as a positive theory.* A representative agent model of the kind shown above may be not only a normative theory, but also a positive description of how governments behave. Under this view, government is a benevolent agent that acts in the best interest of society. The prediction derived from this view is that government spending and taxes should respond to an oil shock approximately like the normative model of section 1.2 prescribes. Barro (1979, 1986, 1987), Sahasakul (1986) and Hercowitz (1986) have found at least partial evidence in support Barro's tax smoothing model as a positive theory of taxes and government debt. However, as Alesina and Perotti (1994) argue, the tax smoothing model is unable to explain the large build-up of public debt observed in several OECD nations after 1970, suggesting that there must be important elements of government fiscal behavior that escape this class of models.

2.1.3.2) *The Leviathan and the "voracity" effect.* An opposing view, put forth by Brennan and Buchanan (1980), argues that government's objective is to exploit its citizenry through the maximization of tax revenue. The government is not an agent acting on behalf of society, but a self interested entity. Under this paradigm, there is no reason why a "Leviathan" would reduce tax rates in the presence of a windfall. This view predicts that the fiscal response to oil shocks will be through increased spending or asset net accumulation, without tax cuts or other transfers to society. The Leviathan hypothesis has been the subject of intense debate and it does not always find support in the empirical literature [Oates, 1985]. A more complex version of this view of government has been developed by Tornell and Lane (1996). In their model, fiscal power is divided among a few rent-seeking groups. They show how a dynamic problem of the commons may arise -- the "voracity" effect -- leading to a negative net change in social wealth after a positive windfall. A testable implication of this model is that governments will consume more than the annuity value of a positive oil shock.

2.1.3.1) *Political and budget institutions matter.* The benevolent and the Leviathan views of government are extreme positions. Perhaps a more realistic view is that fiscal policy is the outcome of a complex political process. Under this view, agents representing different segments of society interact to determine tax end expenditure levels. Since policy making takes place under a set of specific institutions and rules, these institutions and rules may determine the fiscal outcome. Alesina and Perotti (1994, 1996) and Poterba (1997) offer surveys of the growing theoretical and empirical literature that focuses on the role of political and fiscal institutions. The evidence emerging from these studies is that rules and institutions do play a role in determining fiscal policy. Here I mention four hypothesis with testable implications affecting the fiscal response to a windfall.

a) *Political competition and the size of government.* Based on Becker (1983), Becker and Mulligan (1997) model the formation of fiscal policy as a process of political competition between taxpayers and the beneficiaries of subsidies. Their model implies that a more efficient taxation leads to bigger government, and that a windfall should increase the size of government in the presence of inefficient taxes. They argue that the observed enlargement of government (relative to GDP) in oil producing countries after the oil shocks of the 1970s is evidence in favor of their theory.

b) *Political cycles.* Political calendars can affect the timing of fiscal policy, particularly in countries with alternating governing parties. Rogoff (1990) predicts expansionary policies to occur the years before elections and Alesina (1987) predicts expansionary policies after the elections; Bizer and Durlauf (1990) show how political cycles have influenced the timing of taxes in the U.S. Differences in the fiscal response to oil shocks along the electoral cycle would support this line of thought.

c) *Decentralization.* A policy making process in which the benefits of government expenditures are more concentrated than their costs may induce a bias toward government expenditure, as argued by Weingast, Shepsle and Johnsen (1981). If this is the case, we expect to find that the greater the degree of decentralization in the making of the budget, the more biased toward expenditure the response to an oil shock will be.

d) *Fragmented governments.* Divided governments are be deficit prone. Roubini and Sachs (1989) have found that, after 1975, coalition governments tend to accumulate higher debt. A theory that may explain this finding is the war of attrition model of Alesina and Drazen (1991), in which two political rival groups delay a fiscal stabilization in an attempt to bear the smallest fraction of the adjustment cost. An implication of this theory is that fragmented government may show an asymmetric response to positive and negative oil shocks, as the adjustment to a negative wealth shock would be sluggish

d) *Budget rules*. The rules and regulations according to which budgets are drafted, approved and implemented have been found to influence fiscal behavior. Focusing on American States, Poterba (1994), Alt and Lowry (1994), Bayoumi and Eichengreen (1995) and Bohn and Inman (1995) provide support to the view that, at least in the short run, the stringency of budget rules affects the response to shocks. Von Hagen (1992), Von Hagen and Harden (1994) and Alesina et. al. (1996) reach similar conclusions in cross-country comparisons (although in an international context it is quite possible that the correlation found is due to omitted political, social or preference variables) If budget rules matter, we may expect to find different fiscal responses to oil shocks across countries with different fiscal rules.

2.1.3.4) *Behavioral phenomena and the flypaper effect*. Numerous empirical studies have investigated the effect on spending of various types of grants to states and local governments, and found that spending grows by much more than the normative theory predicts. This fact is known as the "flypaper effect", since the money that the government receives "stays where it hits". Hines and Thaler (1995) offer a short survey of this literature and suggest an explanation: agents in the economy don't treat funds as fungible. That is, taxpayers don't frame the policy choice as expenditure vs. tax cuts, but as a decision on what to do with the extra money within the government. Hines and Thaler argue that if the explanation of the flypaper effect is behavioral, it should also be found in the private sector. The findings of Blanchard, Lopez-de-Silanes and Shleifer

(1994) offer evidence in favor of this view, as they show how managers of firms that receive large windfalls keep the money inside the firm[18]. If a behavioral mechanism is at work in the fiscal response to oil shocks, we would expect to see the windfall allocated largely within the public sector.

2.2 Measuring the value of oil shocks

In the aftermath of the oil shocks of the 1970s economists showed considerable interest in measuring the value of oil rights held by governments. Perhaps the best known articles in the resource accounting literature are those published in the mid-1980s by a team led by Michael Boskin on the value of the federal government's mineral rights in the United States [Boskin et. al. (1985, 1986), Boskin and Robinson (1987)]. Other important studies are those of Landefeld and Hines (1982) and Soladay (1980). These papers present several wealth valuation methodologies, all of which are based in the PDV of the stream of net revenues the government receives from its oil assets (denoted W in the previous section). In any given year, the amount of oil revenue a government gets is a function of the quantity of barrels sold, the price of the barrel, and the "government's take" –the fraction of the barrel price the government receives. Therefore, we can identify two basic sources of potentially exogenous variation in oil wealth: changes in known reserves and changes in current and expected future oil prices (it should be noted that changes in the extraction path and in the government's take can not be taken as exogenous, as both are likely to be set or influenced by government policy). In this section I describe my approach to measuring exogenous changes in the PDV of government oil revenue. First, I explain how data limitations prevent the measurement of random changes in reserves. Then I discuss the expected behavior of oil prices and present alternative valuations of oil price shocks.

[18] This interpretation is due to Hines and Thaler (1995). Blanchard, Lopez-de-Silanes and Shleifer (1994) do not make the point in favor of a behavioral view of the world. They interpret their findings as evidence supporting the agency model of managerial behavior.

2.2.1 Discovery shocks

If the objective is to identify and measure sources of truly exogenous variation in oil wealth, nothing would fit better than oil wealth changes brought by random discoveries. Unfortunately, there is no reliable registry of such truly random discoveries, (also known as *wildcats*). The international oil industry, dominated by sovereign governments, is widely recognized as secretive, which makes empirical research difficult [Stevens (1995)]. The only measure of crude oil reserves held by a country are those published at the end of every year by *The Oil and Gas Journal* (OGJ), and correspond to "proved reserves", defined as the volume of crude oil that could be recovered from oil fields in the future under existing economic and operating conditions. Proved reserves are essentially those confirmed and ready for extraction. However, reserves are classified as proved only toward the end of an exploration process that occurs in stages. It takes money and time in order for a potential or probable field to be classified into proved reserves. Therefore, annual variations in OGJ reserve data are more related to investment decisions than to random discoveries. The true random discovery (if there is such thing) can not be known, while changes reported in the OGJ data are very likely to be affected by government policy.

In addition, the quality of OGJ reserves data is questionable. Table 2.1 shows the percentage of years over the period 1965-1996 with implicit "negative discoveries" for a group of oil producing nations. A negative discovery is implied when the sum of the change in reserves and crude oil extraction in a given year is negative. The high percentages in the table are an indication of bad quality in the reserves data. While the OGJ figures may provide a reasonable approximation to the *level* of proved reserves, they can be misleading for measuring *changes* in proved reserves. We can only speculate on the explanations behind the "disappearing reserves" phenomena illustrated in table 2.1. One reason is that reserve figures are kept unchanged during long spells, probably due to a slow and incomplete updating by producer countries; since production is positive, the implicit discovery is automatically negative in a year in which reserves are not reported to change. A second contributing factor is the occurrence of negative revisions, due to initial overstatements of the size of new fields. In summary, the potential endogeneity and lack of reliability of the existing reserves data prevents the measurement of truly exogenous "discovery shocks".

Table 2.1
Percentage of years showing implicit "negative discoveries" in OGJ* proved crude oil reserves data

Tunisia	35%	Peru	23%	Argentina	12%
Mexico	31%	Syria	23%	Gabon	12%
Norway	31%	Trinidad & Tobago	23%	Nigeria	12%
Bolivia	27%	Angola	19%	Cameroon	8%
Colombia	27%	Canada	19%	Oman	8%
United Kingdom	27%	Egypt	19%	Papua New Guinea	4%
Congo	23%	Indonesia	19%	Venezuela	4%
Ecuador	23%	Malaysia	15%		

**The Oil and Gas Journal*, various year-end issues. "Discovery" is the sum of the change in reserves and crude oil extraction in a given year.

2.2.2 Price shocks

In the task of wealth valuation no assumption is more important than the expected price path. Changes in current and expected future prices can yield large variations in wealth values. However, defining the expected path of future crude oil prices is not trivial. The stochastic process of the oil price has been a topic of intense debate over the past 25 years. While our understanding of the matter has improved, no consensus has been achieved. At this point it is important to keep in mind that the focus is on the *contemporaneous* valuation of oil wealth, that is, as perceived at the time when revenue and expenditure decisions were made based on these valuations. I am looking for past values of oil wealth as perceived in the past, not in the present.

2.2.2.1) *The stochastic process of the price of crude oil.* There is a voluminous literature, produced both by economists and by the oil industry, on the nature of the process the price of crude oil follows. As noted by Lund (1993), a very widespread practice is to assume that the crude oil price, as well as other non-renewable resources prices, follow a Brownian motion with drift. Although it is not always explicit, the justification for this assumption is largely theoretical and related to the Hotelling (1931) model, which predicts that, under competitive equilibrium, the margin of price over marginal cost of a unit of a resource in limited supply should rise over time at the discount rate; if suppliers have some degree of monopoly power, it is the difference between marginal revenue and marginal cost which should rise at the discount rate [Dasgupta and Heal (1979)]. In this framework, all of the observed price changes are considered to be permanent shifts of the base from which the price is expected to increase. Therefore, the Hotelling modeling tradition predicts the oil price should follow a random walk with trend, or its continuos-time equivalent, a geometric Brownian motion with drift. As noted by Lynch (1994), the Hotelling modeling tradition has been the theoretical foundation for the majority of oil price forecasts published since the late 1970s. However, the Hotelling modeling tradition has been contested, both on theoretical and empirical grounds.

From a theoretical perspective, the presence of a significant potential for exploration and reserve additions can make unclear the shape of the trajectory of the price of a resource. As shown by Pindyck (1978), exploration and reserves additions can result in a U-shaped time pattern instead of the always ascending path predicted in the Hotelling modeling tradition. Adelman (1993) shows that reserve additions have played a major role in the determination of the price of crude oil, in particular in preventing oil price to rise steadily after the oil price crash of 1986. Moreover, Lund (1993) argues that the geometric Brownian motion with drift is hardly an equilibrium price process, if resource deposits have different extraction costs -- which seems plausible -- and each resource owner follows an optimal extraction strategy.

From an empirical point of view, unit roots tests are far from conclusive. While Slade (1988), is not able to reject the unit root hypothesis for the oil price using data from

1906 to 1973, Dixit and Pindyck (1994) and Pindyck (1997) do reject it using a longer sample of annual data; their conclusion is that the oil price is mean reverting, but the rate of mean reversion is very slow. Furthermore, there is both anecdotal and econometric evidence about the presence of non-linearities in the process. Green, et. al (1994) find that movements in the price of crude oil are not all of the same kind: while "normal" changes are well described by a stationary AR(1) model, some infrequent changes are larger than usual, but quite persistent. In a similar fashion, chapter 1 of this thesis – applying the method developed by Hamilton (1988, 1989) to a 127 years sample – presents strong statistical evidence in favor of a non-linear Markov-regime switching in the oil price stochastic process.

The description of the oil price process in chapter 1 is particularly useful for the purpose of oil wealth valuation, since the Hamilton framework provides a method to calculate rational expectations price forecasts made with information available at any base year t=1,...,T. According to this model, the price of crude oil is expected to follow a switching process between two alternative linear first order autoregression regimes. The regime is itself determined by a discrete variable, which follows a first-order two-state Markov process. This implies that the expectation at year t about the price in year $t+h$ is given by:

(2.1) $$E[p_{t+h} - \mu_{S_{t+h}} | \Omega_t] = E[\phi_{S_{t+h}} (y_{t+h-1} - \mu_{S_{t+h-1}}) | \Omega_t],$$

where p_{t+h} is the real price of a barrel of crude oil, S_{t+h} =1,2 is the discrete indicator of the regime the process is in at year $t+h$. $\mu_{S_{t+h}}$ and $\phi_{S_{t+h}}$ are the estimated mean and autoregressive coefficients under regime S_{t+h}. The process of the regime variable is assumed to follow a first-order Markov chain of the form:

(2.2) $$P[S_{t+h} = 1 | S_{t+h-1} = 1] = m,$$
$$P[S_{t+h} = 2 | S_{t+h-1} = 1] = 1 - m, \text{ where } 0 \leq m \leq 1,$$

$P[S_{t+h} = 2 | S_{t+h-1} = 2] = n$, and

$P[S_{t+h} = 1 | S_{t+h-1} = 2] = 1 - n$, where $0 \leq n \leq 1$.

The Hamilton algorithm also yields estimates of the probabilities that in any given year the process is under either regime,

$$(2.3) \qquad P[S_t = i | p_t, p_{t-1}, \ldots, p_1; \theta], \; i=1,2, \; \forall t \in [1,T],$$

where θ is the vector of maximum likelihood parameter estimates of μ_1, μ_2, ϕ_1, ϕ_2, m, and n. With probabilities (2.3), equations (2.1) and (2.2) can be iterated forward starting from each value of p_t $\forall t \in [1,T]$ in order to calculate every price rational expectation series $E(p_{t+h}|\Omega_t)$ $\forall h \in [0,\infty)$. These price expectations can then used to measure the contemporaneous PDV of oil revenue.

2.2.2.2) *Three measures of price shocks.* Given the discrepancies in the literature surrounding the stochastic process of the oil price and the difficulties in measuring reserves, I use three measures of oil price shocks. The first measure is based on the PDV of oil revenue with price expectations given by the U.S. Department of Energy annual forecasts; the second measure is also based on the PDV of oil revenue, but with price expectations given by the two-state Markov-switching first-order autoregression described above; and finally, a third measure is based on the cash flow derived from current oil production.

A. *DOE forecasts.* Most forecasts made during the last two decades have followed the Hotelling (1931) tradition by assuming that oil prices would increase at a constant rate[19]. The first measure of contemporaneous wealth change used here assumes oil prices were expected to follow the U.S. Department of Energy (DOE) annual forecasts, which after 1978 followed the Hotelling tradition [Lynch (1995)]. The fact that many of these forecasts turned out to be dramatically wrong is not necessarily a problem for our purpose, since we are looking for price path contemporaneous *expectations*. The DOE shock measure is given by:

(2.4) $$\Delta W_t^{DOE} = \phi\, R_t\,(v_t^{DOE} - v_{t-1}^{DOE}),$$

where ϕ is the government's marginal take on oil gross revenue, R_t is the amount of reserves known at the beginning of the year, and v_t^{DOE} is the expected PDV of gross oil revenue derived from a barrel of oil in reserve when expectations are given by the DOE forecast:

(2.5) $$v_t^{DOE} \equiv \sum_{h=0}^{\infty} \frac{E^{DOE}(p_{t+h} | \Omega_t)}{(1+r)^h} (1-q) q^h .$$

r denotes the discount rate and (1-q) is a fixed percentage of reserves extracted every year.

B. Markov-switching expectations. The second measure of wealth change is based on estimates of the two-state Markov-switching first-order autoregression obtained in chapter 1. Price expectations are assumed to be formed according to (2.1)-(2.3). As noted already, the Markov-switching model provides rational expectation forecasts, in the sense that in every year t agents are assumed to know the model's true parameters but to only observe the price series up to year t. Since we know ex-post that the model estimated in chapter 1 yields a better statistical representation of actual price behavior than the Hotelling tradition models, using the Markov switching estimates is closer to assuming that agents knew the ex-post price process when assessing wealth changes. The Markov switching shock measure is given by:

[19]The valuation of U.S. federal mineral rights by Boskin et. al. (1985) was made under the assumption that prices would grow at a constant rate, as in the Hotelling (1931) model.

(2.6) $$\Delta W_t^{MS} = \phi\, R_t\,(v_t^{MS} - v_{t-1}^{MS}),$$

where v_t^{MS} is the expected PDV of gross oil revenue derived from a barrel of oil in reserve when price expectations are given by (2.1)-(2.3) :

(2.6) $$v_t^{MS} \equiv \sum_{h=0}^{\infty} \frac{E^{MS}(p_{t+h} | \Omega_t)}{(1+r)^h}(1-q)q^h .$$

C. Cash flow shocks. The third measure of government's wealth change is based in the cash flow from current production:

(2.7) $$\Delta W_t^{CF} = \phi\; z_{t-1}(p_t - p_{t-1}),$$

where z_t is the observed crude oil production in year t. This measure implicitly assumes all price changes were perceived as strictly temporal, with no effects after year t. Although this assumption is unrealistic, there are three arguments in favor of the inclusion of such a measure. First, a cash-flow shock may be the relevant variable that affects government revenue and expenditure, if the government faces liquidity constraints. Liquidity constraints probably play a more important role in less developed countries, who are likely to have a more restricted access to international capital markets. Second, this measure provides a reasonable lower bound for the wealth shock. Third, this measure is not affected by the size of reserves (R_t), which we can only measure using the OGJ data.

In order to compute these three shock measures I need specific values of the government's marginal take (ϕ), and -- for ΔW_t^{DOE} and ΔW_t^{MS} -- the extraction rate (q) and the discount rate (r). I assume a government's marginal take equal to one. This assumption is based on abundant evidence describing how petroleum fiscal systems impose very high marginal tax rates, mainly in the form of windfall taxes or through the reform of the tax system as a response to the oil price variations as governments attempt to capture any positive difference between oil prices and costs [Adelman (1993), Gelb (1988), Johnston (1996), Kemp (1987)]. Assuming $\phi = 1$ makes sense as long as the price of oil stays above its long-run marginal cost, which has been the relevant scenario after 1973. The extraction rate is set equal to 4 percent, the average in the sample, and I use a real rate of discount of 12 percent, which is close to the average rate used by private oil producers to discount industry projects [Adelman (1993)][20].

Table 2.2 illustrates the quantitative differences between the three oil price processes assumed. The first column is just the change in the price of oil, in 1996 dollars. The next three columns are the change in the PDV of one barrel of crude oil in reserve, according the three alternative measures just described. As expected, using DOE forecasts we obtain larger measures of wealth change than with the switching model. The difference is due to the mean reversion assumed in the switching process, in contrast with the Hotelling assumption underlying the DOE forecasts.

[20] Adelman (1993) argues that the risk faced borne by governments holding oil assets is higher than the risk private companies face, due to most governments inability to diversify their portfolio (inability to divest oil assets), high leveraged positions and political instability; according to his calculation, the appropriate discount rates for oil producing governments is of 20 percent or higher.

Table 2.2 Change in the PDV of one barrel of crude oil in reserve*

US Dollars of 1996

		Change in value**		
	Price change	DOE	Switching model	Cash flow
1974	6.19	2.68	1.33	0.25
1980	13.33	8.15	2.17	0.53
1981	14.26	3.35	2.32	0.57
1986	-18.58	-3.03	-3.61	-0.74
1990	4.65	0.59	0.55	0.19

*WTI. Prices are assumed to remain above long-run marginal cost. **Assumes 4% of reserves extracted each year and a 12% discount rate.

Table 2.3 shows the minimum, maximum, and average positive and average negative shocks, according of each of the three wealth measures, for each of the 13 countries in the sample (country selection is explained in section 4). The figures show the ratio of change in oil wealth to trend GDP[21]. Since oil prices are denominated in U.S. dollars and the rest of the variables (including GDP) are expressed in national currencies, some conversion rate must be used. There is a risk that by using the spot exchange rate we may introduce endogeneity, as the exchange rate is a variable influenced by government policy. Therefore I converted currencies using a purchasing power parity equilibrium rate obtained from GDP deflators. The numbers in table 2.3 indicate that oil shocks have been quite large. The average positive shock, excluding Oman (that has faced particularly large shocks), has been 13 percent of trend GDP according to the DOE forecasts measure, and 4 percent according to the Markov switching model measure; average negative shocks have been 11 and 3 percent respectively. However, the real magnitude of oil shocks is evident when we look at extreme realizations for each country. Except for Canada, Colombia and the U.K., the absolute value of the shocks has reached 80 percent of trend GDP or more (using the DOE measure) or 20 percent of trend GDP or more (using the Markov switching measure). Even cash flow shocks have been large, as 10 out of 13 countries have faced changes in oil cash-flows of 8 percent of trend GDP or larger.

[21] For each country, trend GDP is obtained by assuming a uniform growth rate equal to the average growth rate over the sample period, using the average of the first three years as initial value.

Table 2.3 Wealth shocks measures
Change in oil wealth as a fraction of trend GDP

	Average positive	Average negative	Largest positive	Largest negative
		DOE Forecast		
Canada	0.02	-0.01	0.13	-0.09
Colombia	0.03	-0.02	0.19	-0.10
Ecuador	0.21	-0.11	2.04	-0.69
Egypt	0.10	-0.07	0.59	-0.36
Indonesia	0.18	-0.11	1.24	-0.67
Malaysia	0.10	-0.08	0.81	-0.48
Mexico	0.15	-0.21	1.36	-1.39
Norway	0.10	-0.13	0.82	-0.77
Oman	2.20	-1.51	11.57	-8.98
Trinidad & Tobago	0.30	-0.17	1.86	-0.95
Tunisia	0.21	-0.14	2.01	-0.82
United Kingdom	0.02	-0.02	0.23	-0.14
Venezuela	0.36	-0.49	2.57	-2.53
Mean*	0.13	-0.11		
		Switching Model		
Canada	0.01	0.00	0.03	-0.04
Colombia	0.01	-0.01	0.06	-0.09
Ecuador	0.07	-0.03	0.93	-0.41
Egypt	0.03	-0.02	0.20	-0.22
Indonesia	0.05	-0.03	0.30	-0.31
Malaysia	0.03	-0.02	0.21	-0.24
Mexico	0.05	-0.06	0.48	-0.70
Norway	0.03	-0.04	0.20	-0.51
Oman	0.61	-0.44	5.27	-5.07
Trinidad & Tobago	0.09	-0.05	0.85	-0.49
Tunisia	0.06	-0.04	0.49	-0.47
United Kingdom	0.01	-0.01	0.06	-0.07
Venezuela	0.12	-0.14	0.66	-1.27
Mean*	0.04	-0.03		
		Cash-flow shocks		
Canada	0.00	0.00	0.03	-0.02
Colombia	0.01	0.00	0.03	-0.03
Ecuador	0.03	-0.01	0.17	-0.16
Egypt	0.02	-0.01	0.11	-0.11
Indonesia	0.03	-0.01	0.20	-0.11
Malaysia	0.01	-0.01	0.08	-0.08
Mexico	0.01	-0.01	0.08	-0.09
Norway	0.01	-0.01	0.07	-0.09
Oman	0.26	-0.14	1.31	-1.45
Trinidad & Tobago	0.08	-0.04	0.51	-0.37
Tunisia	0.01	-0.01	0.09	-0.07
United Kingdom	0.00	0.00	0.02	-0.03
Venezuela	0.06	-0.02	0.33	-0.19
Mean*	0.02	-0.01		

* Excluding Oman. Sample period is 1970-199[illegible]

2.3 Country selection and public finance data

In this section I describe the selection criteria of the 13 countries included in the sample and present the public finance variables used in the empirical analysis.

2.3.1 Country selection

According to the Energy Information Administration (EIA) of the U.S. Department of Energy, 105 countries produced some form of hydrocarbons in 1994. In principle, all these countries are candidates to be considered for this study. However, there are several restrictions that limit the sample to 13 countries. The selection of countries was based on there criteria: net exporter status, plausibility of the exogeneity of price shocks assumption, and data availability.

3.1.1) *Net exporter status.* Only countries showing a positive oil international trade balance are considered. The rationale for leaving out net importers of oil is that for those countries an increase in the price of oil may not be a windfall, as the terms of trade they face are negatively affected; therefore the net effect on the intertemporal budget constraint of the government is ambiguous. According to EIA data, in 1993 only 35 oil producing countries qualify as net exporters. It should be noted that some important oil producers, like the U.S., are not included (the U.S. has not been an oil net exporter since the 1930s). Most nations which meet the status are non-OECD countries.

3.1.2) *Exogeneity of price shocks with respect to the fiscal process.* The key identifying assumption in the empirical analysis that follows is the exogeneity of oil price shocks with respect to fiscal policy. The exogeneity assumption would be violated if a country is not a price taker in the international oil market *and* its oil market strategy is dependent on the country's taxation and expenditure policy. The exogeneity condition is less stringent than price-taking by itself because, even if the country has market power in the international oil industry, its pricing behavior may still be independent of its own fiscal policy. If, for example, there is a strategy that maximizes the PDV of net revenues, it may be followed regardless of the profile of non-oil taxes and expenditure. Nevertheless, I excluded from the sample those countries more likely to have played a major role in the formation of international oil prices.

The existence of a cartel of oil exporting nations in and around OPEC is widely recognized, although there is much debate on the extent of its past and present influence. Currently 11 nations belong to OPEC, and two others have recently dropped out (Ecuador in 1992 and Gabon in 1995). However, market power is not distributed evenly within the organization. On one side, there is a group of countries like Indonesia, Nigeria, Ecuador and Gabon who have formally participated in OPEC but who may have no real ability to affect prices on their own, due to their relatively small share of international reserves and production. On the other side, Saudi Arabia – the owner of nearly 25% percent of proved reserves in the world -- plays a prominent role in price determination as the cartel leader. I left out of the sample Saudi Arabia, plus Kuwait, Iraq and Iran, in order to avoid a possible endogeneity bias. This reduced the potential sample to 31 countries.

3.1.3) *Data availability*. The final cut to get a sample of 13 nations is availability of data on public sector finances from candidate countries. In order to perform the analysis, it is necessary to obtain annual series on oil and non-oil related government revenue and expenditure. The primary source for international data on government finance is the IMF's Government Finance Statistics Yearbook (GFS), which provides only limited information about oil related government finance. Only for five countries (Ecuador, Mexico, Norway, Oman, and Venezuela) GFS provides long enough series on oil related government revenue, while oil related government expenditure can not be determined from GFS data alone for any country. The years of coverage of GFS are heterogeneous, with all country series starting in or after 1970.

There may be several reasons why the GFS does not report data on oil related government revenue and expenditure. First, oil revenue and expenditure may not be reported in the source country publications. This would occur if, for example, oil related revenues were labeled under a broader revenue source, like the corporate income tax or the property tax. Second, in the case of a government owned oil industry, information may be lost by a "netting" practice in the GFS: the receipts and operating expenditures of departmental enterprises (industrial or commercial units within government) are first netted against each other, and then operating surpluses are included in the figures for government revenue and operating deficits are labeled as government expenditure. This practice may "hide" part of the revenue and expenditure of state-owned oil companies. Third, the GFS data refers only to "central government" (defined as all units representing the territorial jurisdiction of the central authority throughout a country), and a publicly owned oil industry may not belong in that classification. The availability of public finance data led a 13 countries sample, listed in table 3.1. The nations included in the sample are different along many dimensions; table 3.1 gives some general institutional and economic information about the sample countries.

Table 3.1 Country characteristics

	Form of government	GDP/capita 1995 US$	Total government expenditure over GDP (sample average)	Consumption tax revenue as a share of total tax revenue (sample average)	Oil industry organization	Value of oil production over GDP (1975)	Value of oil production over GDP (1990)	Oil production over proved reserves (average 80-95)
Canada	Confederation with parliamentary democracy	24,400	0.22	0.03	Petro-Canada (prominent role in 1975-84) and private firms	0.03	0.02	0.09
Colombia	Republic	5,300	0.13	0.17	Ecopetrol	0.03	0.08	0.08
Ecuador	Republic	4,100	0.14	0.47	Petroecuador; OPEC member (until 1992)	0.15	0.17	0.07
Egypt	Republic	2,760	0.43	0.31	EGPC, under Production sharing contracts (PSCs)	0.10	0.11	0.07
Indonesia	Republic	3,500	0.20	0.11	Pertamina, under Production sharing contracts (PSCs); OPEC member	0.25	0.12	0.06
Malaysia	Constitutional monarchy	9,800	0.28	0.30	Petronas, under Production sharing contracts (PSCs)	0.08	0.11	0.05
Mexico	Republic	7,700	0.20	0.25	Pemex (government monopoly)	0.05	0.09	0.02
Norway	Constitutional monarchy	24,500	0.38	0.07	Statoil (participates in all ventures)	0.06	0.21	0.04
Oman	Monarchy	10,800	0.48	0.21	PDO	2.06	1.99	0.05
Trinidad & Tobago	Parliamentary democracy	8,000	0.36	0.19	Private	0.50	0.39	0.10
Tunisia	Republic	5,750	0.33	0.51	Production sharing contracts (PSCs)	0.09	0.06	0.02
United Kingdom	Constitutional monarchy	19,500	0.37	0.21	Private	0.02	0.03	0.09
Venezuela	Republic	9,300	0.23	0.26	Pdvsa; OPEC member	0.32	0.31	0.02

2.3.2 Expenditure and non-oil tax variables

I use two alternative measures of government spending and two estimates of non-oil tax rates. The first measure of spending is total government expenditure (as reported in the GFS), less interest payments and social security transfers; this variable is available only for 8 countries (142 observations). This measure, however, can be misleading in countries in which the oil industry is part of the public sector. If a change in the price of oil affects investment in the oil industry, this may show up as a change in total government spending. Therefore I also use government consumption (from national accounts), which excludes all (oil and non-oil) capital formation; this measure is available for 13 countries (259 observations). The true value of non-oil government spending is most likely bounded by these two measures.

As mentioned before, GFS provides information on oil related government revenue only for five countries. We can, however, use the average tax rate on private consumption as an approximation for the average tax rate on non-oil income. I calculate the average tax rate on private consumption as the ratio of consumption tax revenue (from GFS) to private consumption (from national accounts). This measure is available for 13 countries (259 observations). I also use the ratio of non-oil tax revenue to trend GDP for the group of countries that have information on non-oil tax revenue in GFS (5 countries, 119 observations). However, the usefulness of this measure is limited because deviations of GDP from trend are correlated with oil price movements. If the denominator stays constant as the price of oil increases, we are likely to detect a positive response of taxes to oil shocks, not because fiscal policy changes, but due to an enlargement of the tax base[22]. Table 3.2 shows the average values of the four public finance variables over the sample period.

[22] This problem will be avoided by using a measure of non-oil GDP in the denominator instead of trend GDP.

Table 3.2 Public finance variables
Country averages over the available sample period

	Gov expenditure/GDP		Average tax rate	
	Total*	Gov. consumption	Consumption tax	Non-oil tax**
Canada	0.13	0.20	0.06	na
Colombia	na	0.10	0.04	na
Ecuador	na	0.12	0.04	0.10
Egypt	0.42	0.17	0.06	na
Indonesia	na	0.10	0.05	na
Malaysia	0.23	0.16	0.09	na
Mexico	0.13	0.10	0.10	0.12
Norway	0.25	0.20	0.33	0.40
Oman	na	0.29	0.01	0.35
Trinidad & Tobago	na	0.16	0.05	na
Tunisia	0.32	0.18	0.11	na
United Kingdom	0.24	0.21	0.16	na
Venezuela	0.22	0.12	0.02	0.08

* Total expenditure less interest payments and social security transfers. Calculated using trend GDP.
"na" indicates long enough series not available.

2.4 Results

The empirical results that describe the fiscal response to oil shocks were obtained from panel data and country-by-country regressions where either the first difference of the estimated tax rate or the first difference of government expenditure are the dependent variables, and with one of the estimates of oil wealth change among the explicative variables. The basic form of these regressions is:

$$(4.1) \qquad \frac{\Delta g_t}{y_t^*} = \gamma^g \frac{\Delta W_t}{y_t^*} + \psi^g X_t + \varepsilon_t^g \text{, and}$$

$$(4.2) \qquad \Delta \tau_t = \gamma^\tau \frac{\Delta W_t}{y_t^*} + \psi^\tau X_t + \varepsilon_t^\tau ,$$

where Δg_t is the first difference of government expenditure and $\Delta\tau_t$ is the first difference of the tax rate, obtained as explained in section 3.2. For all specifications I show results using the DOE forecasts wealth shock measure (ΔW_t^{DOE}), the Markov switching measure (ΔW_t^{MS}) and the cash-flow measure (ΔW_t^{CF}). Both the shock and government expenditure are normalized by trend GDP (y_t^*) in order to make the coefficients γ^g and γ^t comparable with the comparative statics coefficients (1.6) of the normative model and the benchmark of table 1.2. X_t is a set of controls including lags of the wealth shocks, first lags of both tax and expenditure variables first differences, the first lag of the first difference of private consumption, a constant, a time trend, and country fixed effects (in some specifications). ε_t^g and ε_t^τ are stochastic disturbances.

Results are shown in tables 4.1 through 4.8. Tables 4.1-4.4 show pooled estimates and tables 4.5-4.8 show country-by-country results. The key findings shown in these tables can be summarized as: 1) the net change of non-oil tax cuts and spending increases does not exceed the annuity value of oil shocks, 2) most of the response occurs through increased government expenditure, indicating the presence of "fly-paper" effects, 3) there is no statistical evidence of asymmetries in the response to negative and positive shocks, and 4) there are significant cross-country differences in the way governments respond to oil shocks. I comment first on the panel data estimates and then on the country-by-country regression.

2.4.1 Panel data estimates

Table 4.1 shows the aggregate response of total government expenditure (less interest payments and social security transfers) in eight countries to the three alternative measures of oil wealth shocks described above. For each shock measure the table shows results with and without country fixed effects, and also estimates allowing the response to positive and negative shocks to be different. All the coefficients of the shock variables in the symmetric specification are positive and significant, and quite robust to the inclusion of country fixed effects[23]. I showed in table 2.1 that an optimal response of expenditure, when the discount rate is 12 percent and government expenditure is around 30 percent of GDP, would yield a coefficient of approximately 0.03. The coefficients obtained assuming the oil price was expected to evolve as predicted by the U.S. Department of Energy are below that mark, implying there is no evidence of governments spending more than they should. If we look at the coefficients obtained assuming Markov switching expectations, the point estimates are higher than prescribed by the normative model, but still lower than the annuity value of the shock (approximately 0.10). These esitmates are consistent with an argument made by Gelb (1988), where he pointed out that if oil prices were expected to behave as in the Hotelling model, the case studies show no evidence of increased spending exceeding the permanent value of the shock. The fact that governments did not spend by themselves the whole value of the wealth shock goes against the Leviathan view of government [Brennan and Buchanan (1980) and the presence of the "voracity" effect [Lane and Tornell's (1996)].

The coefficients obtained using the cash flow value of the shock are also quite small, implying that less than a fifth of the increase (or decrease) in the value oil production was channeled into government expenditure. Where did the rest of the money go? According to the dynamic budget identity (1.2), the other two possible destinies are transfers to the private sector or a positive change in net assets. Since the response of non-oil taxes was negligible (as shown below), the change in the value of current production had to be reflected in a changed net asset position or in other form of transfers that do not show up in the data, like domestic sales of oil at controlled prices[24].

Table 4.1 also shows the statistics for tests on differences in the response to wealth changes across countries, and for asymmetric response. The symmetry null hypothesis can not be rejected --although the response to negative shocks is insignificant, while the response to positive shocks is significant. In contrast, the homogeneous cross-

[23] Other specifications tried were GLS with cross-country heteroskedasticity and within-country autocorrelation, and random effects. Results are quite similar.

country response null hypothesis is rejected under the symmetric specification with the DOE and cash-flow measures, and with all measures when asymmetry is allowed[25]. The significance of cross-country differences suggest that joint estimates do not tell the whole story.

The measure of expenditure used in table 4.1 has two problems. First, it may include oil related expenditure in some countries where the oil industry is government owned. Second, because capital formation is included, we are not really capturing an increase in the permanent level of government consumption. I therefore show results using government consumption in table 4.2. The change of variable also allows the inclusion of five additional countries. As before, coefficients under the symmetry specification are positive, significant and robust to the inclusion of fixed effects. As expected, coefficients are smaller. We reject the symmetry hypothesis only with the Markov switching measure of wealth change. Again, only the response to positive shocks is significant. The homogeneous cross-country response hypothesis is rejected using the Markov switching and cash flow measures.

Table 4.3 and 4.4 look at the response of non-oil taxation to oil shocks. The dependent variable in table 4.3 is the estimated average consumption tax rate. The shock coefficients have the expected negative sign, but are small and not statistically significant. In table 4.4 the dependent variable is the estimated average tax rate on non-oil income. The coefficients are now positive but still non-significant. The lack of a response in the tax side is in principle evidence against the tax smoothing [Barro (1979)] positive view of government. In summary, panel data estimates show that the fiscal response to oil shocks was to increase government spending, but within the limits of the annuity value of the wealth shock. This expenditure bias is in line with the findings of the "fly-paper" effect literature [Hines and Thaler (1995)]: extra money given to governments "sticks where it

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[24] The coefficients can also be small due to measurement error of the cash-flow variable.

[25] The F-statistics for cross-country homogeneity were obtained from Chow tests. Since in the presence of heteroskedasticity the Chow test may lead to incorrect rejections, I also perfomed the tests using a weighted least squares estimator, obtaining the same rejections.

hits". Although the expenditure response is only significant for positive shocks, I find no statistically significant evidence of asymmetries.

2.4.2 Country-by-country regressions

The panel data estimates indicate that the way in which nations respond to shocks is not homogeneous. Tables 4.5-4.8 show the estimated shock coefficients obtained in country-by-country regressions. The set of controls was the same as in the panel regresions. Given the limited size of each country sample (25 annual observations or less), non-significant controls were excluded from the regressions reported here. The pattern revealed by these results is very interesting. According to the significance of their response we can classify countries in four groups, shown in table 4.9. In the first group (Indonesia, Malaysia and Trinidad and Tobago) I found a statistically significant response of both expenditure and non-oil taxation. Indonesia stands out as the only country for which the response of non-oil taxation is larger than the response of expenditure; in fact the estimates for Indonesia (0.05 and -0.09) are very much in line with the prescribed coefficients of table 1.2. Indonesia looks like a "Barrovian" country. Malaysia, on the other hand, shows a very strong expenditure response, far in excess of the estimated annuity value of the PDV shock and even greater than the cash-flow value of the shock.

The second and largest group (Canada, Ecuador, Oman, Tunisia, UK, Venezuela) conforms to the pattern found in the panel regressions: significant response of expenditure but no response of non-oil taxation. Canada and the U.K. show very large expenditure coefficients, which suggest over-spending. There is however, an alternative explanation. As noted by Mork, Olsen and Mysen (1994), both Canada and the U.K. show negative correlations of GDP growth and oil price changes. Therefore, I might be picking up a counter-cyclical adjustment of fiscal policy, rather than the response to changes in government wealth. The other four countries show expenditure coefficients within the range of the annuity value of the shock.

The third group (Colombia and Mexico) shows the opposite pattern, no expenditure response but a significant response of non-oil taxation. Finding Mexico in this group is puzzling, as it is frequently cited as an example of a country where the oil shocks led to public expenditure booms. If we look at table 4.5 we see that the response of expenditure in Mexico is only significant for negative shocks; the cash-flow measure coefficient indicates that the reduction of total expenditure after negative shocks was almost equivalent to the current value of the shock. Finally, I found no significant response in either margin in Egypt and Norway. There are three possible explanations. First, the bulk of response could have occured through transfers not recorded in the figures reported by the GFS. This is likely to be the case of Norway. Second, there might be some kind of hedging of the shocks. Third, the quality of GFS data is questionable.

Table 4.9 Cross-country pattern of the fiscal response

		Expenditure Response	
		Significant	Non-significant
Non-oil taxation response**	Significant	Indonesia* Malaysia Trinidad & Tobago*	Colombia Mexico
	Non-significant	Canada Ecuador* Oman* Tunisia United Kingdom Venezuela	Egypt Norway

Based in the Markov switching shock measures. *Response of government consumption. ** Estimated consumption tax rate.

In summary, I interpret these pattern of variation as evidence that any "extreme" view of government, either as a benevolent agent that maximizes social welfare or as a self interested Leviathan, are unable to explain the pattern of observed fiscal behavior triggered by oil shocks. The immediate next research step is to explain the observed differences in the way governments respond to shocks.

2.5 Conclusions

The topic of this chapter is the role of oil revenue and wealth in oil producing countries' fiscal policies. Given the size of public oil wealth in many nations, analyzing how governments respond to variations in oil wealth is a powerful tool to understand fiscal behavior in general. The concrete objective of the chapter was to identify the response to oil shocks of both non-oil tax revenue and government expenditure in oil producing countries. I first addressed the issue from a theoretical perspective by laying out a simple normative model, useful to show the main effects that play into the optimal response to wealth shocks. The model highlights the presence of both income and substitution effects brought by changes in oil wealth, the latter due to increasing marginal costs of non-oil tax collection. With the aid of some simplifications, I calculated a numerical normative benchmark. Then I discussed some of the predictions of alternative positive theories of government. The second issue I addressed was the measurement of oil wealth and oil wealth changes. I showed why the changes in reserves can not be used as a source of exogenous variation, and then developed three alternative measures of price shocks, based on three different assumptions about price path expectations. The regression results in section 4 show that overall, governments respond to shocks mainly through increased expenditure, with little or no change of taxes. I interpret this as evidence of fly-paper effects. There are, however, important exceptions. Indonesia responded close to what the normative model prescribed, and Colombia did the adjustment mostly through reduced taxation. Also, I find no evidence of countries spending more than the annuity value of the shocks and no evidence of asymmetries between positive and negative shocks.

Perhaps the most provocative finding in this chapter is the rich variation in the way governments respond to shocks. Explaining these differences is the next research step, which might lead to a better understanding of the determinants of fiscal policy. In particular, studying the effects of alternative fiscal rules and institutions on the way governments respond to wealth shocks is a promising way to learn more about the effectiveness of such institutions. A second extension of this chapter is to augment the sample to include more countries and other sources of wealth variation. More broadly, there remains a whole set of questions surrounding the presence of oil revenue in the government's budget that are worth studying, such as the effects of alternative fiscal systems on the oil industry, the intergenerational distribution of oil shocks, or the role and effects of government hedging against oil shocks.

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Table 4.1 The response of public expenditure

Public expenditure measured as total spending less interest payments an social security outlays

8 countries, 134 observations

	DOE forecast measure		Markov-switching measure		Cash flow measure	
	No fixed effects	Fixed effects	No fixed effects	Fixed effects	No fixed effects	Fixed effects
Symmetric response						
Wealth shock	0.014	0.013	0.062	0.065	0.138	0.183
	(0.005)	(0.006)	(0.020)	(0.022)	(0.044)	(0.063)
Lagged change in expenditure	0.125	-0.064	0.110	-0.099	0.123	-0.103
	(0.146)	(0.143)	(0.144)	(0.141)	(0.149)	(0.142)
Lagged change in revenue	0.048	-0.019	0.110	0.039	0.116	0.063
	(0.140)	(0.114)	(0.167)	(0.155)	(0.137)	(0.105)
Lagged change in private consumption	0.093	0.111	0.139	0.172	0.099	0.184
	(0.163)	(0.157)	(0.176)	(0.166)	(0.166)	(0.151)
Time trend	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
F-statistic for cross-country differences	2.36**	1.45*	1.42	1.13	2.12**	1.51*
Asymmetric response						
Positive Wealth shock	0.024	0.019	0.071	0.080	0.140	0.200
	(0.012)	(0.012)	(0.019)	(0.025)	(0.047)	(0.071)
Negative Wealth shock	0.004	0.004	0.065	0.065	0.114	0.120
	(0.009)	(0.009)	(0.051)	(0.046)	(0.159)	(0.128)
Lagged change in expenditure	0.111	-0.107	0.101	-0.105	0.124	-0.103
	(0.147)	(0.148)	(0.141)	(0.141)	(0.151)	(0.142)
Lagged change in revenue	0.050	-0.015	0.168	0.112	0.118	0.078
	(0.132)	(0.108)	(0.139)	(0.118)	(0.138)	(0.101)
Lagged change in private consumption	0.103	0.132	0.140	0.184	0.096	0.195
	(0.170)	(0.161)	(0.191)	(0.175)	(0.167)	(0.154)
Time trend	-0.001	-0.002	-0.001	-0.001	-0.001	-0.001
	(0.000)	(0.001)	(0.000)	(0.004)	(0.000)	(0.000)
F-statistic for cross-country differences	2.68**	1.64**	3.12**	2.03**	3.67**	2.37**
F-statistic for asymmetric response	1.18	0.79	0.01	0.09	0.02	0.30

Robust standard errors in parenthesis. * and ** indicate significance at the 10 and 5 percent levels repectively

Table 4.2 The response of public expenditure

Public expenditure measured as government consumption

13 Countries, 246 observations

	DOE forecast measure		Markov-switching measure		Cash flow measure	
	No fixed effects	Fixed effects	No fixed effects	Fixed effects	No fixed effects	Fixed effects
Symmetric response						
Wealth shock	0.002	0.003	0.014	0.015	0.044	0.049
	(0.001)	(0.001)	(0.004)	(0.004)	(0.013)	(0.012)
Lagged change in expenditure	0.066	-0.014	0.050	-0.040	0.036	-0.045
	(0.099)	(0.093)	(0.105)	(0.099)	(0.094)	(0.083)
Lagged change in revenue	0.063	0.052	0.081	0.071	0.098	0.091
	(0.094)	(0.068)	(0.095)	(0.070)	(0.092)	(0.067)
Lagged change in private consumption	0.020	0.004	0.035	0.023	0.043	0.041
	(0.060)	(0.061)	(0.062)	(0.061)	(0.065)	(0.063)
Time trend	-0.001	-0.001	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
F-statistic for cross-country differences	1.19	0.82	1.87**	1.41*	1.70**	1.35*
Asymmetric response						
Positive Wealth shock	0.004	0.005	0.020	0.022	0.044	0.053
	(0.002)	(0.002)	(0.006)	(0.006)	(0.015)	(0.014)
Negative Wealth shock	0.001	0.001	0.008	0.009	0.042	0.044
	(0.003)	(0.003)	(0.004)	(0.004)	(0.027)	(0.027)
Lagged change in expenditure	0.069	-0.010	0.058	-0.032	0.043	0.045
	(0.100)	(0.095)	(0.111)	(0.098)	(0.095)	(0.082)
Lagged change in revenue	0.065	0.051	0.093	0.082	0.098	0.093
	(0.094)	(0.071)	(0.092)	(0.069)	(0.092)	(0.067)
Lagged change in private consumption	0.026	0.010	0.025	0.021	0.043	0.042
	(0.062)	(0.067)	(0.066)	(0.070)	(0.070)	(0.076)
Time trend	-0.001	-0.001	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
F-statistic for cross-country differences	1.01	0.77	2.06**	1.51**	1.99**	1.42**
F-statistic for asymmetric response	0.55	0.89	3.40*	5.07**	0.01	0.12

Robust standard errors in parenthesis. * and ** indicate significance at the 10 and 5 percent levels repectively

Table 4.3 The response of non-oil taxation

Average tax rate on private consumption

13 countries, 234 observations

	DOE forecast measure		Markov-switching measure		Cash flow measure	
	No fixed effects	Fixed effects	No fixed effects	Fixed effects	No fixed effects	Fixed effects
Symmetric response						
Wealth shock	-0.001	-0.001	-0.003	-0.002	-0.005	-0.004
	(0.001)	(0.001)	(0.002)	(0.002)	(0.004)	(0.004)
Lagged change in expenditure	-0.022	-0.025	-0.012	-0.014	-0.027	-0.031
	(0.045)	(0.036)	(0.050)	(0.038)	(0.048)	(0.039)
Lagged change in revenue	-0.051	-0.076	-0.052	-0.078	-0.054	0.079
	(0.058)	(0.065)	(0.058)	(0.066)	(0.058)	(0.066)
Lagged change in private consumption	0.013	0.012	0.008	0.008	0.016	0.016
	(0.022)	(0.023)	(0.025)	(0.025)	(0.023)	(0.023)
Time trend	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
F-statistic for cross-country differences	1.54*	0.99	1.44*	0.94	1.05	0.75
Asymmetric response						
Positive Wealth shock	-0.002	-0.002	-0.003	-0.003	-0.004	-0.004
	(0.002)	(0.002)	(0.002)	(0.002)	(0.004)	(0.004)
Negative Wealth shock	0.000	0.000	-0.004	-0.004	-0.008	-0.075
	(0.001)	(0.001)	(0.003)	(0.002)	(0.008)	(0.077)
Lagged change in expenditure	-0.019	-0.027	0.011	0.003	-0.021	-0.029
	(0.042)	(0.036)	(0.054)	(0.040)	(0.048)	(0.038)
Lagged change in revenue	-0.055	-0.078	-0.052	-0.075	-0.054	-0.079
	(0.059)	(0.066)	(0.060)	(0.067)	(0.059)	(0.066)
Lagged change in private consumption	0.010	0.007	0.002	0.000	0.015	0.013
	(0.027)	(0.028)	(0.026)	(0.027)	(0.023)	(0.024)
Time trend	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
F-statistic for cross-country differences	2.53**	1.98**	0.91	0.73	0.73	0.65
F-statistic for asymmetric response	0.65	0.65	0.44	0.15	0.31	0.16

Robust standard errors in parenthesis. * and ** indicate significance at the 10 and 5 percent levels repectively

Table 4.4 The response of non-oil taxation

Average tax rate on non-oil revenue

5 countries, 114 observations

	DOE forecast measure		Markov-switching measure		Cash flow measure	
	No fixed effects	Fixed effects	No fixed effects	Fixed effects	No fixed effects	Fixed effects
Symmetric response						
Wealth shock	0.004	0.004	0.018	0.018	0.031	0.030
	(0.005)	(0.005)	(0.008)	(0.008)	(0.033)	(0.032)
Lagged change in expenditure	0.125	0.227	0.070	0.134	0.165	0.243
	(0.254)	(0.268)	(0.184)	(0.199)	(0.241)	(0.263)
Lagged change in revenue	-0.098	-0.136	0.173	0.150	0.109	0.077
	(0.109)	(0.116)	(0.102)	(0.100)	(0.109)	(0.116)
Lagged change in private consumption	0.145	0.180	0.083	0.107	0.077	0.110
	(0.124)	(0.127)	(0.114)	(0.126)	(0.123)	(0.128)
Time trend	0.000	-0.001	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
F-statistic for cross-country differences	0.59	0.34	1.79*	1.23	0.86	0.58
Asymmetric response						
Positive Wealth shock	0.005	0.004	0.018	0.020	0.016	0.008
	(0.009)	(0.009)	(0.013)	(0.013)	(0.044)	(0.050)
Negative Wealth shock	0.003	0.003	0.023	0.022	0.068	0.067
	(0.007)	(0.008)	(0.008)	(0.009)	(0.032)	(0.034)
Lagged change in expenditure	0.125	0.200	-0.003	0.013	0.200	0.275
	(0.236)	(0.263)	(0.191)	(0.202)	(0.234)	(0.278)
Lagged change in revenue	-0.098	-0.124	0.158	0.136	0.061	0.020
	(0.109)	(0.114)	(0.113)	(0.112)	(0.116)	(0.144)
Lagged change in private consumption	0.148	0.185	0.091	0.134	0.100	0.109
	(0.129)	(0.138)	(0.126)	(0.132)	(0.128)	(0.121)
Time trend	0.000	-0.001	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
F-statistic for cross-country differences	0.52	0.36	1.15	0.93	0.70	0.50
F-statistic for asymmetric response	0.01	0.01	0.08	0.02	0.66	0.69

Robust standard errors in parenthesis. * and ** indicate significance at the 10 and 5 percent levels repectively

Table 4.5 The response of public expenditure

Public expenditure measured as total spending less interest payments an social security outlays

	Canada	Egypt	Malaysia	Mexico	Norway	Tunisia	United Kingdom	Venezuela
NPV Shock measure (DOE price forecast)								
Symmetric	0.106	0.051	0.125	-0.001	0.017	0.018	0.148	0.016
	(0.039)	(0.072)	(0.030)	(0.015)	(0.008)	(0.012)	(0.062)	(0.009)
Asymmetric			*	*				
Positive	0.070	0.203	-0.115	0.030	0.025	-0.008	0.190	0.032
	(0.077)	(0.126)	(0.074)	(0.012)	(0.022)	(0.024)	(0.110)	(0.018)
Negative	0.145	-0.148	0.265	-0.020	0.011	0.043	0.137	0.000
	(0.087)	(0.169)	(0.164)	(0.019)	(0.014)	(0.028)	(0.135)	(0.018)
NPV Shock measure (MS price forecast)								
Symmetric	0.310	0.300	0.449	0.037	0.025	0.071	0.418	0.064
	(0.145)	(0.219)	(0.070)	(0.047)	(0.021)	(0.036)	(0.184)	(0.031)
Asymmetric				*				
Positive	0.271	0.227	0.458	0.043	0.018	0.028	0.279	0.121
	(0.170)	(0.289)	(0.079)	(0.039)	(0.050)	(0.046)	(0.243)	(0.047)
Negative	0.423	0.865	0.867	0.167	0.043	0.178	0.717	0.014
	(0.208)	(0.413)	(0.866)	(0.048)	(0.044)	(0.078)	(0.378)	(0.044)
Cash-flow Shock measure								
Symmetric	0.441	0.484	1.160	0.314	0.065	0.420	0.786	0.185
	(0.152)	(0.701)	(0.446)	(0.287)	(0.097)	(0.180)	(0.478)	(0.069)
Asymmetric				*				
Positive	0.314	0.337	1.167	0.274	-0.021	0.255	0.365	0.273
	(0.191)	(0.405)	(0.219)	(0.209)	(0.141)	(0.216)	(0.621)	(0.094)
Negative	0.817	1.140	1.252	0.968	0.140	0.969	0.971	0.094
	(0.350)	(0.639)	(1.911)	(0.290)	(0.179)	(0.434)	(0.877)	(0.179)

Standard errors in parenthesis. * and ** indicate the asymmetry is significant and the 10 and 5 percent confidence levels

Table 4.6 The response of public expenditure

Public expenditure measured as government consumption

	Canada	Colombia	Ecuador	Egypt	Indonesia	Malaysia	Mexico	Norway	Oman	Trinidad & Tobago	Tunisia	United Kingdom	Venezuela
NPV Shock measure (DOE price forecast)													
Symmetric	0.139	-0.017	0.016	0.004	0.016	0.043	0.000	0.011	0.006	0.017	-0.001	0.116	0.004
	(0.053)	(0.031)	(0.006)	(0.016)	(0.007)	(0.011)	(0.006)	(0.006)	(0.003)	(0.014)	(0.012)	(0.041)	(0.002)
Asymmetric													
Positive	0.149	0.043	0.006	0.005	0.022	0.056	0.009	0.017	0.008	0.017	-0.005	0.156	0.006
	(0.091)	(0.056)	(0.015)	(0.027)	(0.012)	(0.020)	(0.007)	(0.011)	(0.006)	(0.029)	(0.026)	(0.076)	(0.005)
Negative	0.078	-0.540	-0.005	-0.027	0.016	0.027	-0.005	0.007	0.002	-0.012	0.010	0.056	0.002
	(0.098)	(0.060)	(0.015)	(0.029)	(0.016)	(0.025)	(0.008)	(0.011)	(0.006)	(0.033)	(0.030)	(0.094)	(0.005)
NPV Shock measure (MS price forecast)													
Symmetric	0.538	0.012	0.046	0.017	0.055	0.125	-0.010	0.014	0.021	0.077	0.014	0.312	0.013
	(0.146)	(0.082)	(0.016)	(0.045)	(0.021)	(0.031)	(0.017)	(0.018)	(0.007)	(0.037)	(0.038)	(0.127)	(0.007)
Asymmetric													
Positive	0.546	0.006	0.035	-0.009	0.044	0.126	0.019	0.044	0.031	0.064	-0.009	0.337	0.024
	(0.178)	(0.120)	(0.026)	(0.061)	(0.025)	(0.041)	(0.018)	(0.030)	(0.009)	(0.054)	(0.050)	(0.162)	(0.011)
Negative	0.597	0.004	0.006	0.061	0.087	0.123	-0.007	0.036	0.007	0.075	0.064	0.363	0.014
	(0.250)	(0.140)	(0.032)	(0.080)	(0.043)	(0.064)	(0.023)	(0.034)	(0.011)	(0.077)	(0.086)	(0.255)	(0.013)
Cash-flow Shock measure													
Symmetric	0.800	-0.012	0.063	0.062	0.103	0.336	-0.009	0.085	0.056	0.105	0.057	0.531	0.049
	(0.188)	(0.161)	(0.056)	(0.079)	(0.037)	(0.090)	(0.105)	(0.076)	(0.023)	(0.036)	(0.197)	(0.330)	(0.020)
Asymmetric										**			
Positive	0.729	0.052	0.089	0.020	0.093	0.334	0.107	0.079	0.068	0.062	-0.023	0.576	0.044
	(0.224)	(0.220)	(0.069)	(0.098)	(0.042)	(0.117)	(0.107)	(0.106)	(0.031)	(0.033)	(0.241)	(0.450)	(0.026)
Negative	0.949	-0.132	0.008	0.218	0.209	0.330	-0.071	0.104	0.023	0.283	0.360	0.334	0.066
	(0.442)	(0.357)	(0.120)	(0.156)	(0.110)	(0.196)	(0.152)	(0.150)	(0.050)	(0.073)	(0.493)	(0.645)	(0.060)

Standard errors in parenthesis. * and ** indicate the asymmetry is significant and the 10 and 5 percent confidence levels

Table 4.7 The response of non-oil taxation

Average tax rate on private consumption

	Canada	Colombia	Ecuador	Egypt	Indonesia	Malaysia	Mexico	Norway	Oman	Trinidad & Tobago	Tunisia	United Kingdom	Venezuela
NPV Shock measure (DOE price forecast)													
Symmetric	-0.001	-0.123	-0.005	0.011	-0.031	-0.021	-0.056	-0.006	0.001	-0.017	0.011	-0.126	0.000
	(0.046)	(0.040)	(0.004)	(0.016)	(0.014)	(0.010)	(0.020)	(0.014)	(0.001)	(0.009)	(0.005)	(0.067)	(0.001)
Asymmetric		*											
Positive	-0.058	-0.060	-0.010	0.002	-0.021	-0.016	-0.051	0.038	0.001	-0.017	0.012	-0.130	0.000
	(0.073)	(0.067)	(0.011)	(0.032)	(0.021)	(0.016)	(0.031)	(0.024)	(0.001)	(0.018)	(0.010)	(0.116)	(0.003)
Negative	0.015	-0.253	-0.001	0.023	-0.015	-0.016	-0.046	-0.045	0.000	-0.015	0.007	-0.184	-0.001
	(0.080)	(0.073)	(0.010)	(0.035)	(0.270)	(0.021)	(0.035)	(0.025)	(0.001)	(0.022)	(0.011)	(0.142)	(0.003)
NPV Shock measure (MS price forecast)													
Symmetric	0.093	-0.258	-0.015	0.023	-0.091	-0.066	-0.169	-0.047	0.003	-0.055	0.019	-0.266	-0.006
	(0.149)	(0.111)	(0.010)	(0.046)	(0.042)	(0.030)	(0.053)	(0.038)	(0.001)	(0.026)	(0.015)	(0.209)	(0.004)
Asymmetric													
Positive	0.183	-0.217	-0.023	-0.001	-0.090	-0.078	-0.112	0.015	0.004	-0.057	0.028	-0.111	-0.009
	(0.205)	(0.165)	(0.016)	(0.074)	(0.054)	(0.035)	(0.080)	(0.070)	(0.002)	(0.038)	(0.020)	(0.272)	(0.006)
Negative	-0.043	-0.249	-0.027	0.035	-0.088	-0.071	-0.221	-0.106	0.002	-0.047	0.001	-0.486	-0.010
	(0.283)	(0.187)	(0.020)	(0.079)	(0.091)	(0.055)	(0.099)	(0.080)	(0.002)	(0.060)	(0.035)	(0.425)	(0.007)
Cash-flow Shock measure													
Symmetric	0.175	-0.510	-0.038	0.012	-0.181	-0.182	-1.055	0.143	0.005	-0.053	0.111	-0.444	-0.010
	(0.203)	(0.230)	(0.030)	(0.078)	(0.075)	(0.084)	(0.346)	(0.177)	(0.004)	(0.024)	(0.079)	(0.524)	(0.012)
Asymmetric													
Positive	0.221	-0.266	-0.014	-0.014	-0.151	-0.190	-0.759	0.007	0.004	-0.055	0.134	0.139	-0.005
	(0.259)	(0.290)	(0.038)	(0.100)	(0.091)	(0.105)	(0.468)	(0.240)	(0.007)	(0.031)	(0.098)	(0.631)	(0.015)
Negative	0.038	-0.759	-0.081	-0.007	-0.263	-0.216	-1.407	-0.341	0.005	-0.044	0.031	-0.650	-0.035
	(0.496)	(0.440)	(0.065)	(0.157)	(0.236)	(0.176)	(0.653)	(0.344)	(0.011)	(0.070)	(0.199)	(0.896)	(0.035)

Standard errors in parenthesis.
* and ** indicate the asymmetry is significant and the 10 and 5 percent confidence levels

Table 4.8 The response of non-oil taxation

Average tax rate on non-oil revenue

	Ecuador	Mexico	Norway	Oman	Venezuela
NPV Shock measure (DOE price forecast)					
Symmetric	-0.009	0.004	-0.035	0.005	0.000
	(0.004)	(0.005)	(0.033)	(0.004)	(0.004)
Asymmetric					
Positive	-0.004	0.003	-0.003	0.002	0.004
	(0.011)	(0.008)	(0.057)	(0.008)	(0.006)
Negative	-0.009	0.002	-0.076	0.006	-0.007
	(0.011)	(0.010)	(0.058)	(0.009)	(0.007)
NPV Shock measure (MS price forecast)					
Symmetric	-0.022	0.004	-0.118	0.022	0.008
	-(0.010)	-(0.014)	-(0.085)	-(0.009)	-(0.009)
Asymmetric					
Positive	-0.008	0.003	-0.145	0.019	-0.017
	(0.018)	(0.020)	(0.149)	(0.012)	(0.012)
Negative	-0.037	-0.013	-0.313	0.026	0.010
	(0.022)	(0.025)	(0.168)	(0.014)	(0.014)
Cash-flow Shock measure					
Symmetric	-0.054	0.022	-0.529	0.043	0.010
	(0.033)	(0.089)	(0.216)	(0.030)	(0.028)
Asymmetric					
Positive	-0.025	0.039	-0.221	0.024	0.029
	(0.039)	(0.116)	(0.251)	(0.041)	(0.031)
Negative	-0.143	-0.070	-1.267	0.084	0.024
	(0.068)	(0.164)	(0.355)	(0.066)	(0.073)

Standard errors in parenthesis.
* and ** indicate the asymmetry is significant and the 10 and 5 percent confidence levels

Chapter 3

Oil shocks, Institutions and Fiscal Policy

Introduction

Traditionally positive economic analysis of public finance policy has mainly focused on the effects of alternative expenditure and revenue actions on the economy. Recently, however, economists have expanded the set of questions in order to investigate why governments choose particular policies. The field known as "political economy", with its emphasis on the role that politics and institutions play in the definition of policies, is among the most active branches of economics [see for example Poterba (1997) or Persson and Tabellini (1997)]. The purpose of this chapter is to contribute to our understanding of the effects of politics and institutions on fiscal policy, by looking at the response of public expenditure and taxation to oil shocks.

The large oil shocks of the last 25 years offer a good context in which to explore the effects of institutions and politics on fiscal policy mainly because we can identify a relevant source of exogenous variation in the government's budget of an oil exporting country. Knowing that a public wealth shock occurred, it is then possible to compare the response of countries with different institutions. In chapter 2 I have shown that oil shocks have induced a significant response of public expenditure with little or no movement of non-oil tax revenue. Moreover, I have also found significant cross-country differences in the way that governments respond to oil shocks, which suggest that institutional heterogeneity may play a role.

Alesina and Perotti (1994, 1996) and Poterba (1997) offer surveys of the growing theoretical and empirical literature that focuses on the role of institutions on budget outcomes. The evidence emerging from these studies is that budget rules and institutions do play a role in determining fiscal policy. Focusing on American States, Poterba (1994), Alt and Lowry (1994) and Bohn and Inman (1995) provide support to the view that, at least in the short run, the stringency of budget rules affects the response to unexpected fiscal shocks. Von Hagen (1992), von Hagen and Harden (1994) – focusing on the OECD

-- and Alesina et. al. (1996) – focusing on Latin America -- reach similar conclusions in cross-country comparisons. These cross-country studies highlight the importance of centralization of budget-making authority and transparency of the process as a key to fiscal stability.

Given the limited availability of data describing budget rules and institutions in many oil exporting nations, in this chapter I focus on broader aspects of institutions[26]. The institutional variables used in this chapter are indicators of several aspects of democracy, geographical centralization, the quality of institutions and the political orientation of the government in office. The main finding is that the more autocratic a government is, the more moderate the expenditure response to an oil shock: democracies exhibit an over-spending tendency. A closer examination indicates that the two aspects of democracy that induce spending are competition in the access to power and institutional constraints on the authority of the executive. A second finding is that "left-wing" governments tend spend more than "right-wing" ones after a windfall.

The chapter is organized as follows. The first section briefly outlines three reasons why the institutional variables used in this chapter may affect the fiscal response to wealth shocks: political opportunism, dispersion of power and heterogeneity of political preferences. The second section describes the institutional variables and discusses their predicted effect on the fiscal response to shocks. The third section explains describes the sample, the non-institutional variables and the specification approach. The fourth section presents results and a fifth one concludes.

[26] The lack of information on specific budget rules and procedures exists because the majority of oil exporting countries are outside the regions that have been the focus of previous papers (the European Communities in von Hagen (1992), Latin America in Alesina et. al. (1996)) for which descriptive variables are available.

3.1 Potential roles for institutions and politics

For an oil producing and exporting country, an oil shock is mainly a wealth shock to public resources. As with any other kind of windfall, from a normative perspective we expect the government to spend (or cut, if the shock is negative) only the annuity value of the change in wealth. Current consumption of the windfall can occur through an increase in public spending, or by a transfer to the private sector in the form of tax reduction. The optimal distribution between increased expenditure and tax reduction will depend on social preferences an on the relative cost of public and private goods; as a first approximation, the share of the windfall devoted to public goods should be similar to the share of government provided goods in the economy[27].

The evidence I present in Chapter 2 suggests, however, that governments do not behave in such a way. While there is no evidence that the overall fiscal response exceeds the annuity value of the shock, it seems clear that most of the windfall is devoted to government expenditure. Nonetheless, some countries[28] appear closer to the normative benchmark than others. Can institutions or politics explain the differences? In this section I outline three channels through which an interaction of institutions and shocks may operate. The purpose of this discussion is to provide a framework to interpret the empirical results While the following potential explanations are not the only possibilities, they are perhaps the most frequently mentioned in the political economy literature of fiscal policy.

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[27] In Chapter 2 I develop this intuition formally and discuss several reasons why an optimal distribution of the windfall may deviate from the rough benchmark suggested here.

[28] Malaysia and specially Indonesia.

3.1.1 Political opportunism.

Political opportunism arises when an incumbent government defines its policy with the objective of increasing its chance to remain in power . Persson and Tabellini (1997) and Alesina and Roubini (1997) offer surveys of the theoretical and empirical literature on political opportunism –which may explain the presence of political business cycles and aggregate demand manipulation before elections. Political opportunism may take place if three conditions are met. First, politicians should value holding office per-se. Second, there must be competition in the access to power: if the incumbent perceives its hold on power unlikely to be challenged, there can not be much benefit from policies that deviate from social optimality. In a country with no elections -- or in one in which elections are gimmicky – there is little need for window-dressing. Third, the electorate should be either backward-looking, or rational but imperfectly informed. If voters are rational and can perfectly observe the competence of the incumbent government and its actions, policy can not be effective to affect electoral outcomes. There is substantial evidence on the presence of "retrospective voting" (citizens show a tendency to re-elect governments that have brought high growth rates), suggesting that agents are not fully rational or not fully informed or both [Fair (1978), Fiorina (1981), Lewis-Beck (1988)]. In Nordhaus (1975) and the rest of the earlier literature on political business cycles obtained retrospective voting by modeling backward-looking agents; Buchanan and Wagner (1977) suggest that opportunistic politicians take advantage of voters that do not understand the intertemporal budget constraint of the government. The more recent literature --Rogoff and Siebert (1988), Rogoff (1990) for example -- explains retrospective voting based upon rational agents that have imperfect information[29].

The existing evidence on political opportunism has been obtained by looking at the behavior of policy (and economic performance) around the electoral calendar. In this

[29] In these models opportunistic behvior has an impact on voters behavior because it is part of a separating equilibrium in an adverse selection setup. A "competent" government can effectively signal its higher quality by being willing to deal with the costs of opportunistic policies.

chapter I take an alternative route, based upon the fiscal response to wealth shocks. I assume that the first and third conditions are met (governments like power and citizens can be impressed) and then test if the fiscal response to a public wealth shock is affected by how competitive access to power is. If there is effective political competition, incumbents may have the incentive to impress the public by having an excessive expenditure response after an oil windfall. A testable implication is that in regimes with more political competition we should observe larger expenditure responses to oil shocks.

3.1.2 Dispersion of power

Decision-making power within the government is often dispersed among several political actors. This lack of power centralization may give rise to suboptimal fiscal policies, in the sense that a Pareto-superior is achievable if agents coordinate themselves. This suboptimality may be due to both static and dynamic effects. In a static context, when each decision maker fully internalizes the benefits of public spending but only a fraction of the cost, the result can be over-spending -as argued by Weingast, Shepsle and Johnsen (1981). This is a "common pool" problem, analog to that occurring in natural resources exploitation. Levhari and Mirman (1980). If the common pool problem arises, we expect to find that the greater the degree of power dispersion, the more biased toward expenditure the response to an oil shock will be. In a dynamic context, myopic behavior may emerge: each political actor wants to spend sooner rather than later in order to avoid resources being appropriated by others in the future. As before, this effect implies that a windfall will be more rapidly spent. The dynamic common pool problem was first applied to fiscal policy by Tabellini (1987) in a dynamic game of monetary and fiscal policy coordination, and more recently by Tornell and Lane (1996) and Velasco (1996). The existing evidence reinforces the perception that dispersion of power leads to over-spending and deficits. Roubini and Sachs (1989) and Alesina and Perotti (1993) have shown that coalition governments in OECD countries accumulate more debt. Poterba (1994) shows that U.S. states in which the executive and legislative branches are held by different political parties are less effective in reacting to negative fiscal shocks.

In essence, a "common pool" problem arises due to a budget-making process in which decision-makers are given authority over part of the budget, but none is fully responsible of the aggregate outcome. Therefore, the rules and institutions that govern the making of the budget are likely to have an effect on the outcome. There is empirical work that suggests that this is the case. Alesina and Perotti (1994, 1996) and Poterba (1997) offer surveys of the growing theoretical and empirical literature that focuses on the role of political and fiscal institutions. The evidence emerging from these studies is that rules and institutions that make the budgeting process more centralized – by giving strong authority to the executive or the finance minister – lead to smaller primary deficits. In this chapter I look at the effect on the fiscal response to oil shocks of alternative constraints on executive authority.

3.1.3. Heterogeneous political preferences

It is hard to argue against the claim that political groups do not share homogeneous preferences about what the proper economic role of is widely acknowledged. The economics literature has exploited the heterogeneity in preferences to build theoretical models that address some observed facts about fiscal policy [Alesina and Tabellini (1990), Persson and Svensson (1989) are examples of models in which an intertemporal game is played between groups with different political preferences]. A frequent characterization [as in Persson and Svensson (1989)] is that of two groups disputing power: one, "the right", dislikes big government, while the other, "the left", promotes public sector involvement in economic activity. If such characterization is valid, we expect the fiscal response to wealth shocks to depend on which group is holding offfice. A left-wing government will take advantage of a positive shock to increase the size of government, while a right-wing one might rather distribute the windfall in the form of reduced taxes. In section four I will use an indicator of political orientation to test this claim.

3.2 Institutional data

Institutions are hard to measure. For starters, they are qualitative. Any quantification of a institutional or political particular feature is highly subjective and even arbitrary. Moreover, institutions are multi-dimensional. The thing we call democracy is a composite of many attributes –like open and fair elections, freedom of speech, liberty to participate, a set of checks and balances, etc. Any attempt to measure such a thing involves adding up measures of each dimension, and the weights we use to sum them are again subjective and arbitrary. In consequence, in order to interpret the results of any research based upon numeric descriptors of institutions, the variables used should be carefully examined and understood. For this purpose here I describe the institutional variables employed in the chapter, which refer to four categories: autocracy/democracy, geographical centralization, the quality of institutions and the political orientation of the government in office.

a) *Autocracy/Democracy*. The first group of variables were obtained from the Polity III database (P3). Carried out under the auspices of the Data Development for International Research (DDIR) project, Polity III was designed to develop longitudinal indicators of political structures and regime change. The Polity Project has evolved since the 1970s and has become a widely used source of cross-national, longitudinal data on the authority characteristics of nations. It is most widely used for its assessments of the degree of democracy and autocracy in the political structures of modern countries. P3 is the third version of the database, which now covers 177 countries and the time period 1800-1994[30]. In this chapter I use the democracy and autocracy aggregate indices, as well as their individual components. The definitions of variables is based on Gurr (1997).

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[30] The institutional variables utilized in this paper were made available by the Inter-university Consortium for Political and Social Research. The data for POLITY III: Regime Change and Political Authority, 1800-1994. were originally collected and prepared by Jaggers and Gurr (1996). Neither the collector of the original data nor the Consortium bears any responsibility for the analyses or interpretations presented here. The data is publicly available at www.colorado.edu/IBS/GAD/spacetime/data/Polity.html.

Autocracies are defined in P3 as those regimes that restrict or suppress competitive political participation. Their chief executives are chosen in a regularized process of selection within the political elite, and once in office they exercise power with few institutional constraints. The autocracy variable is an aggregate index of several other more specific indices, which are: i) the competitiveness and openess of executive recruitment, ii) the constraints on the chief executive, and iii) the competitiveness and regulation of political participation. Each individual variable will be taken into account only if its values are within a certain range considered to be autocratic. The index is on a 0-10 scale; the higher the score, the more autocratic a regime is considered. Democracy, on the other hand, is defined by the presence of institutions and procedures through which citizens can express effective preferences about alternative policies and leaders, the existence of institutionalized constraints on the exercise of power by the executive and the guarantee of civil liberties to all citizens in their daily lives and in acts of political participation. As with the autocracy variable, democracy is an aggregate index of measured also in a 0-10 scale (a high value indicates a highly democratic regime). The difference between the autocracy and democracy variables is the criteria used to include or not the values of the components and the weights attached to each of them. Therefore, the variables are not simple the inverse of each other. However, the correlation between them is high and therefore I will not use them simultaneously in any regression. The individual components of the autocracy and democracy variables that I use in this chapter are the following.

i) *Competitiveness of executive recruitment.* Competitiveness refers to the extent that outsiders (individuals and groups) have equal opportunities to access power. For example, selection of chief executives through elections matching two or more viable parties or candidates is regarded as competitive. The index is coded in a 1-3 scale. A value of 1 is assigned if chief executives are determined by hereditary succession, designation, or by a combination of both, as in countries whose chief minister is chosen by king or court. Examples are rigged, unopposed elections; repeated replacement of presidents before their terms end; recurrent military selection of civilian executives; selection within an institutionalized single party; recurrent incumbent selection of successors; repeated election boycotts by the major opposition parties, etc. Competitiveness is coded 2 in the cases of dual executives in which one is chosen by hereditary succession, the other by competitive election, or in transition circumstances. Finally, a value of 3 is given if chief executives are typically chosen in or through competitive elections matching two or more major parties or candidates (elections may be popular or by an elected assembly). As mentioned before, competitive access to power is a necessary condition for political opportunism to take place. In consequence, the significance of the interaction of this variable with an oil shock can be interpreted as an indirect test on the relevance of opportunism in the determination of fiscal policy.

ii) *Institutional (de jure) constraints on the executive.* Also referred to as "monocratism" (one-man rule) this 1-5 index focuses on the structural character distinguishing between pure individual and collective executives. The first category refers to "Pure Individual Executive", where the executive is a single individual, not dependent either formally or informally for his position or authority on a cabinet, council or junta. An executive who is a "front man" for a strong man" behind the scenes is also coded here. Monarchs are almost always "pure individual executives", presidents and dictators usually are as well. Category 2 is an intermediate. Category 3 refers to "Qualified Individual Executive", where the executive is formally a cabinet, supreme council, or junta, but one member is first among equals" and holds substantially more effective authority than the other members. Most parliamentary, junta, and Communist regimes are of this sort. Category 5 (after a second intermediate) refers to "Collective Executive". In the sample I use, all values are 1 to 3. This variable is included as a test for the dispersion of power hypothesis, focusing on the dispersion within the executive authority.

iii) *Operational (de facto) constraints on the executive.* This variable refers to the extent of institutionalized constraints on the decision-making powers of chief executives, whether individuals or collectivities. Such limitations may be imposed by any "accountability groups". In Western democracies these are usually legislatures. Other kinds of accountability, groups are the ruling party in a one-party state; councils of nobles or powerful advisors in monarchies; the military in coup-prone polities; and in many states a strong, independent judiciary. The concern is therefore with the checks and balances bet the various parts of the decision-making process. A seven-category scale is used. This variable is included with the purpose of testing the dispersion of power hypothesis, but focusing on the dispersion between the executive authority and some other instance of power.

iv) *Competitiveness of Participation.* The competitiveness of participation refers to the extent to which alternative preferences for policy and leadership can be in the political arena. Political participation is measured on a five-category scale: suppressed, restricted, factional, transitional, and competitive. This variable gives a measure on the constraints that groups and individuals outside of power may impose on policy, that is, a third dimension of dispersion of power.

b) *Geographic Centralization.* The degree in which power is dispersed geographically may also affect the fiscal response to wealth shocks, in particular if representatives of local constituencies enjoy the benefits of spending programs financed with national-level revenues. Persson and Tabellini (1993) have shown that different federalist arrangements have important implications for fiscal stabilization. Therefore, I include a variable – also obtained from P3 -- that describes the degree of federalism. The index has three categories. The first is centralized or unitary state, where no more than moderate decision-making authority is vested in local or regional governments (many nominally "federal" systems in fact centralized in this sense). After an intermediate category, the third one refers to decentralized or federal states, where local and/or regional governments have substantial decision-making authority. Switzerland, Canada, and the United States are contemporary examples of effectively-decentralized governments.

c) *Quality of institutions.* Often formal laws and institutions are quite separate from actual practice. In general, democracy is associated with a better "quality of-institutions". In order to incorporate this dimension, I use an average of the ICRG indicators of the quality of institutions. The ICRG database was assembled by IRIS (University of Maryland) from hard copies of the "International Country Risk Guide" a monthly publication of Political Risk Services. The database includes five longitudinal measures: i) government repudiation of contracts, ii) risk of expropriation, iii) corruption, iv) law and order tradition ("rule of law") and v) bureaucratic quality. The variable "ICRG" used in the regressions is a simple average of these variables (after 0-1 normalization); a high value indicates good quality of institutions. The data covers the years 1982-1995.

d) *Political Orientation.* The final variable is an index of the political orientation of the government, along the right-left spectrum. Its purpose is to test for the heterogeneous political preferences hypothesis. The indicator used here was assembled upon the descriptions presented in the comparative politics compendium by Derbyshire and Derbyshire (1996). This is a 1-3 variable that classifies governments as being on the political right (1), center- left (2) or left (3).

Table 1.1 shows the means and standard deviations of the nine institutional variables for each country in the sample (the selection of countries is explained in the next section). The first thing to notice is that or most variables show no variation in the majority of countries, as bottom row indicates. The variables with less within country variation are centralization, institutional constraints on the executive and competition in the access to power. Only the ICRG variable shows within-country variation in all countries, but the degree of variation is small, as shown by standard deviations. Even the political orientation variable remains constant in eight out of fourteen countries. Seven countries (China, Egypt, Indonesia, Malaysia, Mexico, Norway and the U.K. show variation only in one or two variables other than ICRG. This lack of within-country variation is a relevant consideration in the specification of the empirical model –including fixed country effects will likely diminish the explanatory power of the institutional variables.

A second point is that there is significant cross-country variation. In the majority of the variables we observe the two extreme possible scores. This variation is a good sign that we may be able to learn something about the effects of institutions on countries facing similar shocks. A final thing to highlight from table 1.1 is the that no patterns of variation across variables and countries are obvious. While autocracy and democracy exhibit a pattern of inverse correlation, this is less clear among the rest of the variables. As an example compare China and Mexico, both countries with a very low score on democracy. China has relatively high scores on institutional and operational constraints on the executive, but the lowest possible mark on political participation. In contrast, Mexico shows the lowest score on institutional constraints on the executive (therefore can be labeled as "monocratic") but its scores on operational contraints and participation are in the middle of the scale. Moreover, there is no pattern relating lack of democracy and political orientation. While Argelia, China, Egypt and Tunisia are left-wing autocracies, Indonesia – a zero-democracy nation as well—is a right-wing regime.

The pattern of co-variation between institutional variables is further examined in table 1.2, which presents correlations in the sample. As expected, autocracy and democracy are highly correlated among themselves, and with their components. For this reason, autocracy and democracy should not be in the same regression specificaction, and should be excluded if the components are in; otherwise, multicllinearity is likely to arise. The democracy components are also correlated, but in an uneven way: while competitiveness and operational constraints are highly correlated, there is no correlation between institutional constraints and political participation. Finally, neither centralization nor political orientation show high correlations with other variables.

3.3 Sample selection and empirical specification

The empirical analysis reported in this chapter was performed on annual data of fourteen oil producing countries in a 26 year period (1970-1995). The fourteen countries in the sample are shown in figure 1. Three criteria were applied on its selection[31]. First, they had to be exporters of a non-trivial amount of its oil production (20 percent or more). This meant excluding large oil producers –like Canada and the U.S.—that are not important exporters and reducing the number of observations for some others to avoid the years in which the coutry did not met the status (examples are Mexico, Norway and the U.K. in the early 1970s). The second criteria was to exclude nations suspected to have the ability to consistently affect the international price of crude oil by themselves. The purpose of this requirement is to avoid those countries for which an oil shock may not be truly exogenous. The main concern here was Saudi Arabia, but also Irak, Iran and Kuwait were excluded. Finally, data availability problems on public finance figures also limited the number of nations.

The basic model specification is a regression in which the dependent variable is the first difference of a fiscal policy variable, and the regressors include both a measure of the oil shock and the interaction of the shock with one or more of the institutional

[31] Country selection closely follows Chapter 2, where a more detailed discussion can be found.

variables. By adding the interaction term we can test the null hypothesis of no significant differences in the fiscal response between governments with different institutions by looking at the significance of the interaction coefficient. Formally, the regressions are of the form:

$$(1) \qquad \Delta F_{it} = \beta \Delta W_{it} + \gamma_1 X_{1,it} + \ldots + \gamma_m X_{m,it} + \theta_1 \Delta W_{it} I_{1,it} + \ldots + \theta_k \Delta W_{it} I_{k,it}$$

where ΔF_{it} is the change of the fiscal policy variable in question in country i at year t, ΔW_{it} is the oil shock, X_{it} is a m-vector of control variables and I_{it} is a k-vector of institutional variables (which were all normalized into a 0-1 scale). The null hypothesis of interest is that the coefficients on the interactions between the oil shock and the institutional variables (parameters $\theta_1, \ldots \theta_k$,) are zero; the alternative hypothesis, therefore, is that institutional and political variables do affect fiscal policy.

The variables as defined as follows:

a) *Fiscal variables*. Three dependent fiscal variables are studied, with the purpose of looking at the expenditure side, the revenue side, and the overall outcome. These varaibles are:

i) government consumption (over trend GDP),

ii) the average consumption tax rate, measured as the ratio of consumption tax revenue to private consumption, and

iii) consolidated central government saving, defined as current revenue minus current expenditure (over trend GDP).

It should be noted that although variables *i* and *ii* refer each to a different side of the budget identity, by subtracting them we do not get the budget deficit. This is because government consumption is only a fraction of total government consumption, and consumption taxes are only a fraction of total government revenue. The selection of these two indicators of fiscal policy was determined by data availability[32]. Nonetheless, if there is any effect of institutions on government consumption and on consumption tax revenue, it is likely to show up in the overall fiscal balance as well. For this reason I have included as a third dependent variable the consolidated central government saving, obtained from (unpublished) World Bank data Loayza, López, Schmidt-Hebbel and Servén (1998).

b) *Oil shock*. The oil shock is measured as:

(2) $$\Delta W_{it} = [\, q_{it-1}(p_t - p_{t-1}) \,] / y^*_{it},$$

where q_{it-1} refers to lagged crude oil production in country i, p_t is the price of crude oil, expressed in local currency and y^*_{it} is trend GDP[33]. This measure of the value of the shock refers only to the current "cash-flow" value of the shock, therefore ignoring the impact of a change in current price on the value of the stream of oil revenue after year t. Clearly, a full assessment of the wealth value of a price shock should be made upon oil reserves data and expected price paths. Except for the case in which the prices are expected to fully revert to their previous level in the immediate next year (no persistence at all), the cash-flow measure of the shock is likely to under estimate the wealth effect of an oil price change. In chapters 1 and 2 I built several present discounted value (PDV) measures of the oil shocks and used them to assess the fiscal response of countries. Here I report only the cash-flow measure due to three reasons. First, the focus here is not on the ***absolute*** size of the oil shock coefficient, but on the significance of the interaction of the shock and the institutional variables, as well as on the size of the interaction effects ***relative*** to the size of the shock coefficient. Second, the cash flow measure needs no assumptions about oil price expectations, a controversial topic [see Chapter 1]. Finally,

[32] The source of private consumption, government consumption and GDP information is national accounts data (through the IMF's International Finance Statistics); consumption tax revenue was obtained from the Government Finance Statistics Yearbook (GFS).

[33] Currency conversion was made through a purchasing power parity exchange rate, assuming PPP equilibrium in the year 1970

the results using PDV measures (which I do not report here) are basically the same, except for the size of the estimates; this is confirmed by the findings in Chapter 2, where the use of alternative assumptions about the expected stochastic process of the price of oil makes little difference on the observed pattern of the fiscal response to oil shocks. Table 2 shows the average extreme and average values of the cash-flow shocks for each country.

c) *Control variables.* If oil shocks are truly exogenous, they are likely to be orthogonal to the rest of the variables affecting expenditure and taxation policies. If this is the case, controlling for other factors affecting fiscal policy should not have an effect on the coefficients. In fact, the estimates of the shock and interaction coefficients are quite robust to alternative sets of controls. Nonetheless, I report the estimates obtained with the following set of controls:

i) Lagged change in the dependent variable.
ii) Lagged change in output gap, defined as the ratio of actual GDP to trend-GDP.
iii) A dummy variable for wars and major natural catastrophes.
iv) A dummy variable for election years.
v) A constant (not reported).
iv) Fixed country-effects, in some specifications (the country coefficients are not reported).

3.4 Results

Tables 3 through 8 present the coefficient estimates of particular specifications of model (1). The first two tables (3 and 4) show regressions where the expenditure variable (government consumption) is the dependent variable. Then, tables 5 and 6 show the estimated coefficients of regressions where the dependent variable is from the revenue side – the consumption tax rate. Finally, tables 7 and 8 show the estimates of specifications where government saving is on the left-hand side. I first discuss the results of the expenditure regressions. Table 3 shows OLS estimates of regressions including shock interactions with the institutional and political variables. The standard errors reported are robust to heteroskedasticity. Column I shows the benchmark estimates, obtained without institutional interactions. The shock coefficient is positive, significant and quantitatively very similar to the obtained in Chapter 2[34]. It implies that five cents on the oil shock dollar are spent on increased government consumption. Lagged change in the output gap and catastrophes are also significant and positive.

Columns II to VII in table 3 focus on autocracy, democracy and their components individually. It should be noted that all coefficients have the expected sign. However, only the coefficients on the interactions with autocracy (II) and with competitive access to power (IV) have small enough standard errors as to reject the null hypothesis of no effect of institutions on expenditure policy. These results imply that the more autocratic a government is, the smaller the expenditure response is to an oil shock. According to the point estimate in column II, a fully autocractic government (a 10 in the scale) increases expenditure in only a third of what a non-autocrat (0 in the scale) does. Column VIII shows the coefficients of the four components of democracy obtained jointly. These coefficients, which differ change in a significant way from those in the previous columns, are very likely affected by severe multicollinearity. Although the institutional variables are not all highly correlated, once they are interacted with the shock the correlation among them rises, increasing the likelihood of colinearity among the regressors.

Column IX to XI show estimates of the interactions of the shock with centralization, "quality-of-institutions" (ICRG) and political orientation. The coefficient of ICRG and political orientation have the correct sign, whereas centralization is

[34] Results are not identical due to slight changes in the sample and differences in the controls used.

negative. Only political orientation is significant. The point-estimate of the political orientation interaction coefficient in column IX suggests that left-wing governments increase expenditure after an oil shock more that five times of what right-wing governments do. Column XII presents a specification that includes both autocracy and political orientation. Both interactions are nearly significant; the coefficient on autocracy is very similar, and the coefficient on political orientation is larger. Finally, columns XIII and XIV show two specificaction with several institutional variables estimated jointly. As in column VIII, the large differences in the magnitude of the coefficients, as well as the considerably larger standard errors, indicate these regressions are plagued by multicollinearity.

In summary, the results reported in table 3 indicate that the null hypothesis of no effects of institutions on fiscal policy is clearly rejected. In particular, autocracy and political orientation appear to be the most important factors. It is interesting to note at this point that in country-by-country regressions in Chapter 2 I found that the nation whose response more closely follows the normative model is Indonesia. Looking at table 1 we can see that Indonesia has been governed by a long-lasting highly autocractic right-wing regime. About the components of autocracy/democracy, column IV shows that in countries where access to power is competitive public consumption increases nearly two thirds more than countries in which executive recruitment is not competitive. Political opportunism and a dynamic common pool problem are both candidate explanations.

Table 4 shows the same specifications as table 3, except for the inclusion of fixed country effects. Given the lack of within country variation of the institutional variables, this approach is likely to obscure the effects of institutions. In general, this is confirmed by larger standard errors. Nonetheless, the autocracy and political orientation interactions still have small standard errors, therefore strengthening the results form the OLS regressions. In similar fashion, the interactions with competitive access and institutional constraints are significant.

In tables 5 and 6 the dependent variables shifts from the expenditure side of the budget to the revenue side using the average consumption tax rate as the left-hand side variable. It should be noted that the sample has been reduced from the previous tables due lack of data. Algeria, China and Nigeria do not appear anymore, and the available years for other countries are fewer. In Chapter 2 I found that the fiscal response to oil shocks is heavily biased toward expenditure, implying little or no response at all from the non-oil tax side. Column I in table 5 confirms this result: while the shock coefficient has the expected sign, it is small and non-significant. Column II, however, shows that the interaction of autocracy is negative and significant. The implication is that autocracies do cut taxes in the aftermath of oil windfalls. Unfortunately, this result disappears when other variables are included, or when fixed country effects are considered, as in table 6. The rest of the results in tables 5 and 6 show that the individual components of autocracy and democracy have little or no explanatory power.

Combined, the results in tables 3 through 6 suggest that the institutional variables considered here are useful to explain cross-country differences in the magnitude of the expenditure response, but not to explain the expenditure bias –that is, the lack of response in the tax revenue margin. In general it appears that autocratic regimes show more moderate spending expansions after oil windfalls, suggesting that both political opportunism and dispersion of power may play a role in the making of fiscal policy in democratic nations. Moreover, the governing ideology also appears to influence the strength of the expenditure response. While the dependent variables in tables 3-4 (government consumption) and tables 5-6 (consumption taxes) are far from being the only elements in the budget identity, still the pattern revealed so far should be reflected in the budget balance. In order to explore this issue tables 7 and 8 present the estimates of regressions where the dependent variable is government saving.

Tables 7 and 8 show that most of the institutional interactions have the expected sign, but most of them have relatively large standard errors. As expected, the more autocratic a government is, the larger the response of government saving after a windfall (column II), whereas competitive access to power (IV) and institutional constraints on the executive (V) appear to reduce government saving. The coefficient on political orientation (XI) is positive, suggesting that left-wing governments tend to save less after a shock; however, the standard error on the coefficient is not small enough to reject the null hypothesis. The rest of the columns in table 7 refer to specifications where more than one interaction is included. Column XII shows that the effect of autocracy remains constant once we control for political orientation; the rest of the specifications suffer from the multicollinearity problem discussed above.

3.5 Conclusions

The findings of this chapter suggest that democratic governments have a tendency to over-spend. Although the results shown above do suggest that the lack of political competition and the concentration of power that prevail in autocracies may contribute to a less myopic and more responsible policy, a generalization can not be made. In first place, the evidence presented here is based upon a relatively small sample: only 14 countries over 25 years. Much more evidence is needed. Second, the fiscal policy dependent variables I used may draw a partial picture given its limited scope. Unfortunately, limited availability of data forbids the use of wider measures of fiscal expenditure and taxation policies. Finally, the institutional descriptors I employed are probably too wide to focus on the specific mechanisms at work. Developing variables that describe in detail the rules and institutions that govern the making and implementation of the public budget[35] is a necessary condition to understand the determinants of fiscal policy.

The main conclusion of this chapter is that institutions and politics matter. If this factor is not included in the analysis of fiscal policy, economists work in a vacuum. From a normative perspective, the relevant issues are not only about which policies are better, but about the workings of the institutions that will put them in practice. If democratic governments have indeed a tendency to over-spend, the case for budgetary procedures and rules designed to counteract this effect – like balanced-budget rules or a strong finance minister – becomes stronger.

[35] von Hagen (1992) for the European Communities and Alesina (et. al.) for Latin America are two pioneering steps in this direction.

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Figure 1. Countries in the sample

Algeria
China
Colombia
Ecuador
Egypt
Indonesia
Malaysia
Mexico
Nigeria
Norway
Trinidad & Tobago
Tunisia
United Kingdom
Venezuela

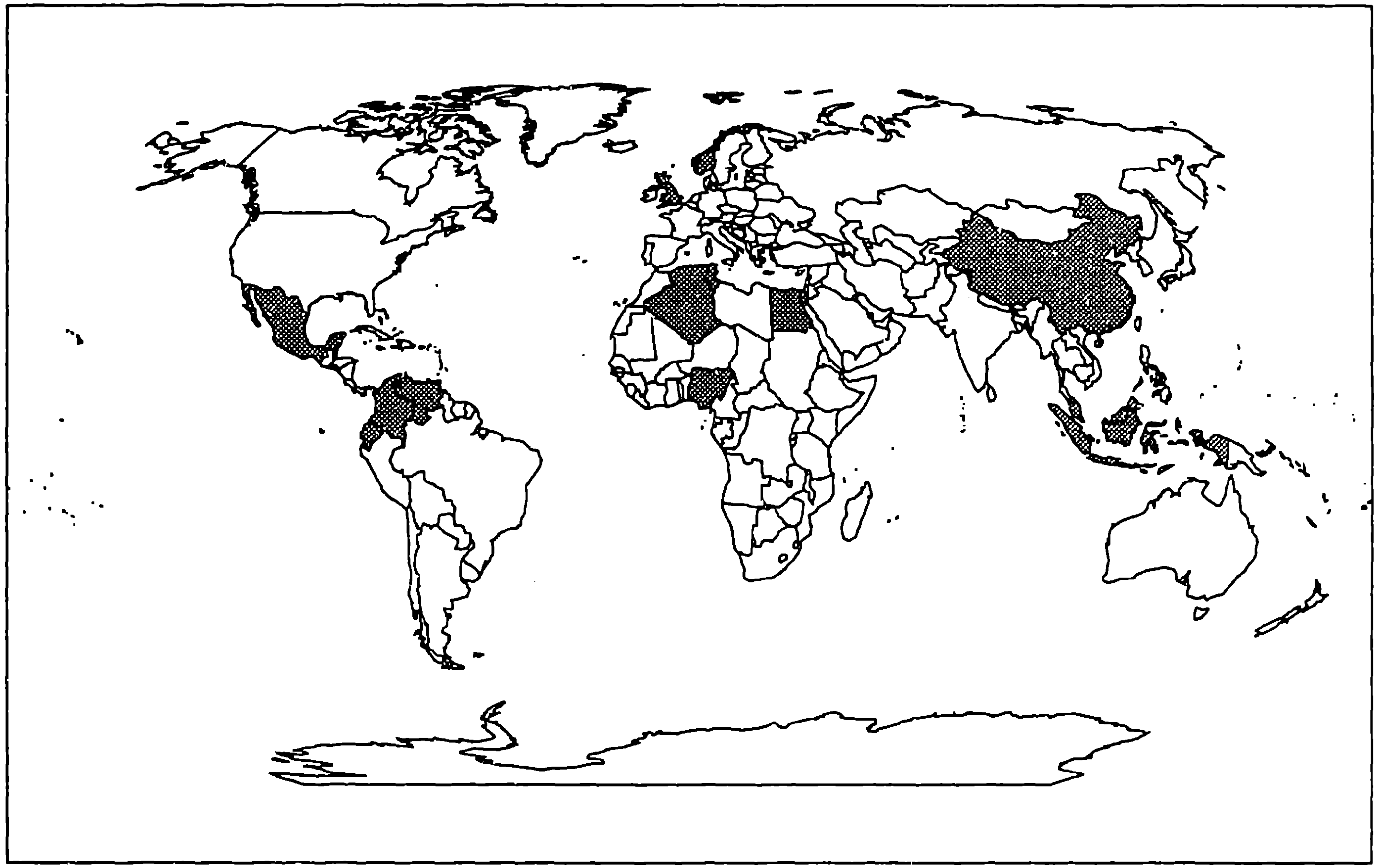

Table 1.1 Descriptive statistics of institutional variables

Variable		Autoc.	Democ.	Comp	Ins. Con.	Op. Con.	Part.	Cent.	ICRG	Pol. Or.
Scale		0-10	0-10	1-3	1-5	1-7	1-5	1-3	1-6	1-3
Argelia	Mean	7.9	0.3	1.0	1.8	1.1	1.2	1.0	2.6	3.0
	Std. Dev.	(2.3)	(1.0)	(0.5)	(0.7)	(0.3)	(0.7)	(0.0)	(0.4)	(0.0)
	Obs.	26	26	26	26	26	26	26	14	26
China	Mean	7.0	0.0	1.0	3.0	3.0	1.0	1.0		3.0
	Std. Dev.	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)		(0.0)
	Obs.	14	14	14	14	14	14	14	0	14
Colombia	Mean	0.0	8.1	2.8	1.4	6.3	4.0	1.0	2.7	1.8
	Std. Dev.	(0.0)	(0.7)	(0.4)	(0.5)	(0.5)	(0.0)	(0.0)	(0.1)	(0.4)
	Obs.	18	18	18	18	18	18	18	10	18
Ecuador	Mean	1.5	6.2	2.1	1.0	5.1	3.4	1.0	3.4	1.8
	Std. Dev.	(2.3)	(4.1)	(1.4)	(0.0)	(2.7)	(0.9)	(0.0)	(0.1)	(0.7)
	Obs.	24	24	24	24	24	24	24	14	24
Egypt	Mean	5.2	0.0	1.0	1.0	3.0	2.0	1.0	2.5	3.0
	Std. Dev.	(0.4)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.8)	(0.0)
	Obs.	19	19	19	19	19	19	19	14	19
Indonesia	Mean	7.0	0.0	1.0	1.0	2.0	2.0	1.0	1.7	1.0
	Std. Dev.	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(1.0)	(0.0)
	Obs.	26	26	26	26	26	26	26	14	26
Malaysia	Mean	0.4	8.0	3.0	3.0	7.0	3.0	3.0	4.0	2.0
	Std. Dev.	(0.5)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.6)	(0.0)
	Obs.	20	20	20	20	20	20	20	14	20
Mexico	Mean	4.0	1.0	1.0	1.0	3.0	3.0	3.0	3.0	1.3
	Std. Dev.	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.2)	(0.5)
	Obs.	18	18	18	18	18	18	18	14	18
Nigeria	Mean	5.6	1.7	0.6	2.6	2.3	1.6	2.1	1.9	2.0
	Std. Dev.	(2.4)	(3.2)	(1.2)	(0.8)	(2.4)	(0.8)	(0.6)	(0.6)	(0.0)
	Obs.	26	26	26	26	26	26	26	14	26
Norway	Mean	0.0	10.0	3.0	3.0	7.0	5.0	1.0	5.8	1.8
	Std. Dev.	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.2)	(0.4)
	Obs.	20	20	20	20	20	20	20	14	20
Trinidad & Tobago	Mean	0.0	8.2	3.0	3.0	7.0	3.2	2.0	3.2	2.2
	Std. Dev.	(0.0)	(0.4)	(0.0)	(0.0)	(0.0)	(0.4)	(0.9)	(0.2)	(0.4)
	Obs.	26	26	26	26	26	26	26	14	26
Tunisia	Mean	7.3	0.1	1.0	1.0	1.7	1.7	1.0	2.9	3.0
	Std. Dev.	(1.9)	(0.3)	(0.0)	(0.0)	(1.0)	(0.6)	(0.0)	(0.3)	(0.0)
	Obs.	26	26	26	26	26	26	26	14	26
United Kingdom	Mean	0.0	10.0	3.0	3.0	7.0	5.0	1.0	5.5	1.0
	Std. Dev.	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.3)	(0.0)
	Obs.	14	14	14	14	14	14	14	14	14
Venezuela	Mean	0.0	8.8	3.0	1.0	6.0	4.8	3.0	3.2	1.6
	Std. Dev.	(0.0)	(0.4)	(0.0)	(0.0)	(0.2)	(0.4)	(0.0)	(0.3)	(0.5)
	Obs.	26	26	26	26	26	26	26	14	26
Countries without variation		8	7	10	11	8	8	12	1	8

Table 1.2 Correlations between institutional variables

	Autoc.	Democ.	Comp	Ins. Con.	Op. Con.	Part.	Cent.	ICRG	Pol. Or.
Autoc.	1.00								
Democ.	-0.94 (0.00)	1.00							
Comp	-0.90 (0.00)	0.96 (0.00)	1.00						
Ins. Con.	-0.23 (0.00)	0.30 (0.00)	0.20 (0.00)	1.00					
Op. Con.	-0.95 (0.00)	0.96 (0.00)	0.95 (0.00)	0.30 (0.00)	1.00				
Part.	-0.90 (0.00)	0.89 (0.00)	0.83 (0.00)	0.06 (0.33)	0.83 (0.00)	1.00			
Cent.	-0.36 (0.00)	0.29 (0.00)	0.28 (0.00)	0.04 (0.50)	0.30 (0.00)	0.27 (0.00)	1.00		
ICRG	-0.61 (0.00)	0.66 (0.00)	0.59 (0.00)	0.51 (0.00)	0.62 (0.00)	0.70 (0.00)	-0.06 (0.41)	1.00	
Pol. Or.	0.40 (0.00)	-0.37 (0.00)	-0.29 (0.00)	0.04 (0.53)	-0.33 (0.00)	-0.51 (0.00)	-0.24 (0.00)	-0.24 (0.00)	1.00

Significance levels in parenthesis

Table 2. Size of the oil shocks

"Cash-flow" shock as percentage of trend GDP

	Average positive	Average negative	Largest positive	Largest negative
Argelia	6.0%	-2.5%	38.7%	-25.6%
China	0.1%	-0.1%	0.7%	-0.5%
Colombia	0.6%	-0.2%	2.5%	-1.7%
Ecuador	3.0%	-1.5%	17.0%	-16.0%
Egypt	2.0%	-1.5%	10.9%	-11.4%
Indonesia	3.2%	-1.1%	20.0%	-11.0%
Malaysia	1.4%	-1.0%	8.0%	-8.0%
Mexico	1.3%	-1.2%	8.2%	-9.0%
Nigeria	4.5%	-1.5%	29.7%	-15.6%
Norway	1.3%	-1.2%	7.3%	-8.5%
Trinidad & Tobago	8.4%	-3.8%	50.7%	-36.7%
Tunisia	1.5%	-0.7%	9.4%	-6.9%
United Kingdom	0.2%	-0.5%	0.7%	-3.1%
Venezuela	5.8%	-2.0%	33.0%	-19.1%
Mean*	2.1%	-1.0%		

Table 3. The response of government consumption to oil price shocks

Oil shocks defined as "cash-flow" shocks

OLS regressions

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV
Oil shock	0.046 (0.017)	0.055 (0.024)	0.033 (0.015)	0.036 (0.021)	-0.021 (0.033)	0.031 (0.020)	0.033 (0.025)	-0.038 (0.045)	0.055 (0.030)	0.029 (0.090)	0.011 (0.038)	-0.008 (0.037)	-0.146 (0.051)	0.184 (0.225)
Lagged change in expenditure	0.119 (0.091)	0.119 (0.089)	0.119 (0.090)	0.121 (0.091)	0.130 (0.087)	0.122 (0.090)	0.120 (0.092)	0.122 (0.087)	0.112 (0.092)	0.110 (0.098)	0.118 (0.091)	0.117 (0.090)	0.117 (0.088)	0.124 (0.096)
Lagged change in output gap	0.058 (0.027)	0.060 (0.026)	0.061 (0.027)	0.061 (0.026)	0.046 (0.027)	0.061 (0.026)	0.058 (0.027)	0.045 (0.023)	0.060 (0.027)	0.011 (0.034)	0.057 (0.027)	0.059 (0.027)	0.043 (0.023)	0.021 (0.032)
War/catastrophe	0.007 (0.002)	0.008 (0.002)	0.008 (0.002)	0.007 (0.002)	0.007 (0.002)	0.007 (0.002)	0.007 (0.027)	0.008 (0.002)	0.007 (0.002)	0.009 (0.004)	0.007 (0.002)	0.008 (0.003)	0.008 (0.002)	0.010 (0.004)
Elections	0.002 (0.003)	0.001 (0.003)	0.001 (0.003)	0.002 (0.003)	0.001 (0.003)	0.002 (0.003)	0.002 (0.003)	0.001 (0.003)	0.002 (0.003)	0.004 (0.004)	0.002 (0.003)	0.001 (0.003)	0.002 (0.003)	0.005 (0.004)
Autocracy*Oil shock		-0.035 (0.016)										-0.036 (0.023)		-0.352 (0.127)
Democracy*Oil shock			0.022 (0.019)											
Competitive access*Oil shock				0.021 (0.010)				0.162 (0.123)					0.255 (0.129)	
Inst. Const.on Executive*Oil shock					0.169 (0.109)			0.266 (0.083)					0.227 (0.087)	
Oper. Const.on Executive*Oil shock						0.022 (0.038)		-0.503 (0.522)					-0.671 (0.550)	
Political participation*Oil shock							0.023 (0.036)	0.238 (0.072)					0.321 (0.086)	
Centralization*Oil shock									-0.014 (0.042)					-0.065 (0.172)
ICRG*Oil shock										0.211 (0.191)				-0.268 (0.209)
Political orientation*Oil shock											0.051 (0.029)	0.115 (0.061)	0.321 (0.137)	0.626 (0.311)
Number of countries	14	14	14	14	14	14	14	14	13	13	14	14	14	14
Mumber of observations	270	270	270	270	270	270	270	270	251	170	270	270	270	170
R-squared	0.15	0.16	0.16	0.16	0.20	0.17	0.16	0.26	0.15	0.19	0.15	0.18	0.27	0.25

Robust standard errors in parenthesis

Table 4. The response of government consumption to oil price shocks

Oil shocks defined as "cash-flow" shocks

Fixed country effects regressions

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV
Oil shock	0.048	0.062	0.029	0.030	-0.034	0.024	0.020	-0.085	0.047	0.115	0.065	0.044	-0.083	0.142
	(0.016)	(0.023)	(0.015)	(0.028)	(0.034)	(0.020)	(0.024)	(0.043)	(0.030)	(0.088)	(0.034)	(0.035)	(0.048)	(0.201)
Lagged change in expenditure	-0.001	-0.003	-0.002	0.001	0.010	-0.002	-0.002	-0.006	-0.006	-0.043	-0.002	-0.001	-0.004	-0.023
	(0.077)	(0.075)	(0.076)	(0.076)	(0.073)	(0.077)	(0.078)	(0.074)	(0.078)	(0.086)	(0.077)	(0.076)	(0.074)	(0.090)
Lagged change in output gap	0.071	0.073	0.075	0.075	0.058	0.076	0.072	0.059	0.074	0.050	0.072	0.073	0.058	0.063
	(0.024)	(0.024)	(0.024)	(0.024)	(0.023)	(0.024)	(0.024)	(0.021)	(0.024)	(0.034)	(0.024)	(0.024)	(0.021)	(0.035)
War/catastrophe	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.009	0.008	0.007	0.008	0.009	0.009	0.008
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)	(0.003)
Elections	0.002	0.001	0.002	0.002		0.002	0.002	0.001	0.002	0.004	0.002	0.001	0.001	0.006
	(0.003)	(0.003)	(0.003)	(0.003)		(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.003)	(0.003)	(0.003)	(0.004)
Autocracy*Oil shock		-0.051										-0.060		-0.244
		(0.032)										(0.045)		(0.167)
Democracy*Oil shock			0.033											
			(0.023)											
Competitive access*Oil shock				0.070				0.106					0.106	
				(0.039)				(0.117)					(0.117)	
Inst. Const.on Executive*Oil shock					0.207			0.330					0.330	
					(0.106)			(0.078)					(0.087)	
Oper. Const.on Executive*Oil shock						0.033		-0.959					-0.957	
						(0.039)		(0.462)					(0.493)	
Political participation*Oil shock							0.049	0.301					0.299	
							(0.036)	(0.077)					(0.095)	
Centralization*Oil shock									0.001					-0.052
									(0.048)					(0.175)
ICRG*Oil shock										0.028				-0.241
										(0.191)				(0.188)
Political orientation*Oil shock											0.073	0.091	-0.002	0.586
											(0.049)	(0.073)	(0.133)	(0.291)
Number of countries	14	14	14	14	14	14	14	14	13	13	14	14	14	14
Mumber of observations	270	270	270	270	270	270	270	270	261	170	270	270	270	170
R-squared	0.26	0.28	0.27	0.27	0.32	0.28	0.26	0.38	0.26	0.31	0.26	0.28	0.38	0.36

Robust standard errors in parenthesis

Table 5. The response of consumption taxes to oil price shocks

Oil shocks defined as "cash-flow" shocks

OLS regressions

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV
Oil shock	-0.013	-0.009	-0.041	-0.047	-0.031	-0.062	0.004	0.004	0.005	-0.079	-0.036	-0.030	-0.004	0.044
	(0.009)	(0.008)	(0.032)	(0.056)	(0.023)	(0.044)	(0.030)	(0.055)	(0.024)	(0.107)	(0.029)	(0.027)	(0.066)	(0.298)
Lagged change in average tax rate	-0.080	-0.082	-0.085	0.085	0.092	-0.085	0.091	0.090	-0.076	-0.034	-0.083	-0.085	0.092	0.088
	(0.064)	(0.066)	(0.068)	(0.094)	(0.094)	(0.068)	(0.092)	(0.100)	(0.063)	(0.078)	(0.065)	(0.068)	(0.105)	(0.105)
Lagged change in output gap	-0.033	-0.033	-0.032	-0.005	-0.010	-0.033	-0.008	-0.005	-0.033	-0.031	-0.034	-0.035	-0.006	-0.001
	(0.022)	(0.022)	(0.022)	(0.023)	(0.025)	(0.022)	(0.025)	(0.024)	(0.024)	(0.029)	(0.025)	(0.025)	(0.025)	(0.031)
War/catastrophe	-0.003	-0.001	-0.001	-0.001	-0.001	0.000	-0.004	-0.001	-0.001	-0.003	-0.001	0.000	-0.001	-0.003
	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.033)	(0.002)	(0.002)	(0.002)	(0.003)
Elections	-0.002	-0.003	-0.003	-0.001	-0.001	-0.003	-0.001	-0.001	-0.002	-0.004	-0.002	-0.002	-0.001	-0.002
	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.003)	(0.003)	(0.002)	(0.003)	(0.002)	(0.002)	(0.003)	(0.004)
Autocracy*Oil shock		-0.042										-0.038		-0.182
		(0.025)										(0.029)		(0.198)
Democracy*Oil shock			0.037											
			(0.037)											
Competitive access*Oil shock				0.117				0.751					0.818	
				(0.169)				(1.201)					(1.363)	
Inst. Const.on Executive*Oil shock					0.049			-0.058					-0.064	
					(0.049)			(0.098)					(0.107)	
Oper. Const.on Executive*Oil shock						0.056		-0.124					-0.145	
						(0.046)		(0.306)					(0.353)	
Political participation*Oil shock							-0.007	-0.158					-0..61	
							(0.043)	(0.153)					(0.162)	
Centralization*Oil shock									-0.025					0.012
									(0.033)					(0.254)
ICRG*Oil shock										0.093				-0.484
										(0.189)				(0.479)
Political orientation*Oil shock											0.076	0.068	0.044	0.502
											(0.088)	(0.084)	(0.163)	(0.342)
Number of countries	11	11	11	11	11	11	11	11	11	11	11	11	11	11
Mumber of observations	162	162	162	162	162	162	162	162	162	107	162	162	162	107
R-squared	0.06	0.05	0.05	0.02	0.03	0.05	0.02	0.05	0.04	0.05	0.04	0.05	0.05	0.07

Robust standard errors in parenthesis

Table 6. The response of consumption taxes to oil price shocks

Oil shocks defined as "cash-flow" shocks

Fixed country effects regressions

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV
Oil shock	-0.014	-0.011	-0.044	-0.050	-0.031	-0.059	-0.008	-0.005	0.001	0.012	-0.049	-0.044	-0.024	0.139
	(0.008)	(0.008)	(0.033)	(0.057)	(0.022)	(0.043)	(0.035)	(0.068)	(0.033)	(0.110)	(0.027)	(0.024)	(0.072)	(0.302)
Lagged change in average tax rate	-0.095	-0.096	-0.100	0.067	0.075	-0.098	0.072	0.076	-0.092	-0.022	-0.101	-0.100	0.077	0.074
	(0.068)	(0.070)	(0.072)	(0.095)	(0.095)	(0.072)	(0.093)	(0.100)	(0.066)	(0.074)	(0.070)	(0.072)	(0.104)	(0.086)
Lagged change in output gap	-0.033	-0.035	-0.033	-0.006	-0.010	-0.035	-0.008	-0.005	-0.034	-0.031	-0.037	-0.038	-0.006	-0.005
	(0.022)	(0.022)	(0.021)	(0.022)	(0.025)	(0.022)	(0.025)	(0.024)	(0.025)	(0.029)	(0.024)	(0.024)	(0.024)	(0.033)
War/catastrophe	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.004	-0.003	-0.003	-0.013	-0.003	-0.003	-0.003	-0.011
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.009)	(0.002)	(0.002)	(0.002)	(0.008)
Elections	-0.002	-0.003	-0.003	-0.001	-0.001	-0.003	-0.001	-0.002	-0.002	-0.004	-0.002	-0.002	-0.002	-0.002
	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.002)	(0.003)	(0.003)	(0.002)	(0.003)	(0.002)	(0.002)	(0.003)	(0.004)
Autocracy*Oil shock		-0.037										-0.031		-0.201
		(0.026)										(0.026)		(0.233)
Democracy*Oil shock			0.040											
			(0.039)											
Competitive access*Oil shock				0.118				0.912					1.020	
				(0.175)				(1.632)					(1.719)	
Inst. Const.on Executive*Oil shock					0.042			-0.019					-0.032	
					(0.050)			(0.135)					(0.142)	
Oper. Const.on Executive*Oil shock						0.052		0.204					-0.241	
						(0.046)		(0.400)					(0.427)	
Political participation*Oil shock							-0.007	-0.139					-0.140	
							(0.043)	(0.245)					(0.248)	
Centralization*Oil shock									-0.021					0.061
									(0.044)					(0.241)
ICRG*Oil shock										-0.072				-0.694
										(0.196)				(0.504)
Political orientation*Oil shock											0.112	0.106	0.093	0.479
											(0.083)	(0.077)	(0.148)	(0.316)
Number of countries	11	11	11	11	11	11	11	11	11	11	11	11	11	11
Mumber of observations	162	162	162	162	162	162	162	162	162	107	162	162	162	107
R-squared	0.06	0.08	0.08	0.02	0.03	0.05	0.02	0.05	0.07	0.12	0.07	0.08	0.08	0.07

Robust standard errors in parenthesis

Table 7. The response of government saving

Oil shocks defined as "cash-flow" shocks

OLS regressions

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV
Oil shock	0.099 (0.052)	0.095 (0.058)	0.110 (0.087)	0.107 (0.110)	0.112 (0.118)	0.138 (0.105)	0.080 (0.169)	0.070 (0.207)	0.100 (0.156)	-0.114 (0.229)	0.082 (0.120)	0.074 (0.135)	0.006 (0.262)	-0.256 (0.486)
Lagged change in gov. saving	0.058 (0.104)	0.065 (0.106)	0.061 (0.106)	0.065 (0.106)	0.055 (0.107)	0.064 (0.106)	0.055 (0.104)	0.057 (0.111)	0.058 (0.104)	0.040 (0.131)	0.057 (0.105)	0.063 (0.107)	0.054 (0.111)	0.058 (0.133)
Lagged change in output gap	-0.093 (0.050)	-0.101 (0.055)	-0.098 (0.057)	-0.098 (0.057)	-0.090 (0.049)	-0.100 (0.055)	-0.089 (0.055)	-0.084 (0.059)	-0.094 (0.053)	-0.052 (0.071)	-0.094 (0.052)	-0.102 (0.058)	-0.086 (0.060)	-0.074 (0.077)
War/catastrophe	-0.004 (0.004)	-0.005 (0.005)	-0.004 (0.005)	-0.004 (0.004)	-0.003 (0.004)	-0.004 (0.005)	-0.003 (0.004)	-0.004 (0.004)	-0.004 (0.004)	-0.006 (0.006)	-0.003 (0.004)	-0.004 (0.005)	-0.004 (0.004)	-0.007 (0.006)
Elections	-0.005 (0.006)	-0.005 (0.006)	-0.005 (0.006)	-0.005 (0.006)	-0.005 (0.006)	-0.005 (0.006)	-0.005 (0.006)	-0.005 (0.006)	-0.005 (0.006)	-0.002 (0.007)	-0.005 (0.006)	-0.005 (0.006)	-0.005 (0.006)	-0.005 (0.008)
Autocracy*Oil shock		0.045 (0.026)										0.047 (0.028)		0.403 (0.450)
Democracy*Oil shock			-0.014 (0.018)											
Competitive access*Oil shock				-0.025 (0.016)				2.751 (2.471)					3.102 (2.442)	
Inst. Const.on Executive*Oil shock					-0.029 (0.019)			0.303 (0.430)					0.267 (0.447)	
Oper. Const.on Executive*Oil shock						-0.045 (0.130)		-1.087 (0.916)					-1.214 (0.930)	
Political participation*Oil shock							0.028 (0.239)	0.015 (0.385)					0.014 (0.391)	
Centralization*Oil shock									-0.002 (0.223)					0.495 (0.326)
ICRG*Oil shock										0.389 (0.427)				0.881 (0.621)
Political orientation*Oil shock											0.029 (0.020)	0.036 (0.032)	0.138 (0.304)	-0.664 (0.242)
Number of countries	13	13	13	13	13	13	13	13	13	12	13	13	13	12
Mumber of observations	225	225	225	225	225	225	225	225	225	144	225	225	225	144
R-squared	0.27	0.28	0.27	0.28	0.28	0.28	0.27	0.31	0.27	0.24	0.27	0.29	0.33	0.31

Robust standard errors in parenthesis