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**Oil Wealth and Economic  
Growth Revisited:  
A Bayesian Model Averaging Approach**

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# Oil Wealth and Economic Growth Revisited: A Bayesian Model Averaging Approach

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## Abstract

We investigate the effect of oil revenues on long-term economic growth within a Bayesian framework that accounts for model uncertainty. Our analysis is based on an updated cross country data set for long term growth in the period 1970-2014 including 91 countries and 54 potential growth determinants. Initially, we do not find any empirical evidence for the existence of the “natural resource curse” in our sample. On the contrary, we document a robust positive effect of oil rents on long-term economic growth. Then, we introduce interaction terms of oil rents with potential conditions under which oil dependency can lead to sub-standard growth. Our second set of results shows that the interaction of institutional quality and oil revenues has a robust positive effect on growth, while the constituent oil rent term is no longer robust. We conclude that institutional quality is necessary condition for oil revenues to have a growth-enhancing effect.

**Keywords:** Oil, Growth, Natural Resource Curse, Bayesian Model Averaging

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# 1 Introduction

A quick examination of the growth record of resource-rich countries in retrospect may suggest a negative effect of natural resources on long term economic growth (see e.g. Sachs and Warner 1995, Gylfason 2001, Sachs and Warner 2001). As Frankel (2010) points out “It is striking how often countries with oil or other natural resource wealth have failed to grow more rapidly than those without”. This observation is widely known as the “natural resource curse” (Auty 1993). Frankel considers six possible channels through which natural resource abundance may lead to a sub-standard economic performance, long-term trends in world commodity prices, volatility, crowding out of manufacturing, civil war, Dutch Disease and poor institutions. Mehlum et al. (2006) argue that institutions define conditions under which resources may have positive or negative effects on economic growth. They conclude that “institutions are decisive for the resource curse,” rather than being a channel as suggested by Sachs and Warner (1995).

The discussion indicates that there remains uncertainty about the effects of resources on growth and about conditions under which these can be positive or negative. In addition to this theoretical uncertainty there is uncertainty about the empirical specifications. Alexeev and Conrad (2009) argue that one of the main drivers of the positive evidence for a resource curse is the inclusion of initial GDP per capita in most regression analysis. Because, they claim, initial GDP accounts already for much of the resource related growth. The argument shows that the literature on the effects of resources on economic growth suffers from a fundamental problem in growth regressions: the uncertainty about which of the many potential growth determinants to include in the analysis, as the choice can importantly affect the outcome and lead to misleading (see. e.g. Sala-i Martin et al. 2004, Durlauf et al. 2008). Moreover, the uncertainty extends to potential conditions under which a resources curse prevails.

The present paper empirically investigates the support for positive or negative effects of oil and the potential conditions under which such effects may occur. We contribute to the literature in several dimensions. First, we analyze the effects of resources with a focus on oil and potential conditioning variables, such as institutions or the size of the manufacturing sector, by adding interaction terms of the latter with a measure of oil rents. Second we employ an updated data set for the period 1970-2014 (while traditional data sets end in the mid-1990s). This allows us not only to incorporate recent growth experiences but also to include some important oil producers from the Gulf region which previous data sets miss due to data availability. Third, we address the issue of model uncertainty by using a Bayesian

Model Averaging (BMA) framework.

BMA addresses the problem of model uncertainty, i.e., uncertainty concerning the factors that explain an outcome of interest, by considering all models. Classical regression analysis estimates one or a few candidate models, where a model consists of a specific (often arbitrary) choice of explanatory variables. The results then depend on the specific model that is estimated, in other words the results are conditional on the specific model. In contrast BMA considers all models and averages over the results. This is achieved in two steps. First, one computes conditional estimates for all possible models. Second, one calculates a weighted averages of the conditional estimates. The weights are chosen proportional to the model fit, so that models which better explain the data have a higher weight and therefore more impact on the results. BMA, thus, generates unconditional estimates in the sense that they do not depend on one particular model. In the context of natural resource curse, the existence of model uncertainty may be particularly important as discussed above.

In our paper, we analyze the effects of resources on economic growth concentrating on oil revenues. We use two different measures for oil: a dummy variable for oil producing countries as used by Sala-i Martin et al. (2004) (henceforth SDM) and a measure of oil rents as percent of GDP. We also add the widely used measure for primary resource exports as share of GDP. Moreover, we analyze if the sign of the effect of oil rents depends on specific conditions, such as institutions, revolutions, and the size of the manufacturing sector by including interaction terms of these factors and oil rents. Our data is an update of the widely used data set employed in SDM which contains a large number of potential growth determinants. We update the growth data to the period 1970-2014 using GDP data from the Penn World Tables. This allows us to add some of the important oil producers in the Gulf region. We adapt the set of potential growth determinants with respect to our focus and add, among others, a measure of oil rents and the manufacturing share. Unfortunately we are forced to drop a few variables due to availability for the Gulf region. However our final data includes a large set of 54 potential growth determinants (not including interaction terms) covering a total of 91 countries.

The main finding of the present paper is that oil rents have a robust positive effect on economic growth conditional on good institutions. In a first set of results we ignore interaction terms and find that oil rents is one of the variables with the highest posterior probability and has a positive effect on growth. This result contradicts the existence of a “Natural Resource Curse” and is consistent with the recent literature that emphasize that “curse” may be a red-herring (Brunnschweiler 2008; Alexeev

and Conrad 2009).

When we add interaction terms to investigate the conditions under which a positive growth effect occurs, the interaction term of oil revenues with political rights, which is a control for institutional quality, is the only one that is robust (has a high posterior probability). Moreover, the constitutive oil rents term is no longer robust. The result sheds new light on the findings on the conditional effects of oil on growth. While Mehlum et al. (2006) find that the resource curse is caused by bad institutions our results go one step further. We do not find evidence supporting the existing of a resource curse but instead that oil rents have a positive effect on growth if institutional quality is high. This underlines the importance of institutions for natural resources to have a growth-enhancing effect.

The remainder of the paper is organized as follows: Section 2 briefly reviews the channels through which natural resources may retard economic growth. Sections 3 and 4 present data and empirical methodology, respectively. Our results are discussed in detail in Section 5. Finally, Section 6 concludes.

## 2 Conditions and Channels of the Natural Resource Effects

Our analysis of the effect of natural resources on economic growth focuses on the conditions that determine if the effects may be positive or negative and on channels through which these may work. The method we employ is to interact a measure of resource wealth with each of the conditions or channels. While there is a difference between conditions and channels both can be tested in our empirical framework. Conditions are prerequisites, such as good institutions, and the use of interaction terms provides a direct test for conditions. Channels on the other hand are intermediate outcomes that lead from resources to growth. For example, the so called Dutch Disease is a process in which a strong resource sector reduces growth potential by crowding out other sectors. This implies that if crowding out can be avoided the negative growth effects would not occur. We can thus reformulate the argument as a condition, which states that if other sectors are strong than oil may not have negative effects, and which can be tested using an interaction term. This section discusses the conditions and channels that have been suggested by the literature summarized in three categories: institutions, political instability, and Dutch Disease.<sup>1</sup>

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<sup>1</sup>Note that Frankel (2010) suggests oil price related channels as an additional category encompassing long term drops in resource/commodity prices, as well as their volatility. Controlling for oil price trends and volatility in a cross-country setting is of little value as they are the same for all

## 2.1 Institutions

Sachs and Warner (1995) and Sala-i Martin and Subramanian (2013) argue that oil wealth has indirect negative effects on growth through institutions. More specifically, oil rents negatively affect the quality of institutions in a country, and institutions negatively affect growth rates. On the contrary, Alexeev and Conrad (2009) argue, negative relationship between natural resources and institutions exists because of the use per capita GDP as one of the control variables:

*Given the positive relationship between oil and GDP and between institutional quality and GDP, the inclusion of GDP as a control variable in the institutional quality regression drives the coefficient on the measure of oil wealth down. This happens apparently because oil wealth, like any kind of wealth, raises GDP, but does not seem to improve institutions, at least not in the medium term. Therefore, in terms of GDP, oil producers belong to the club of nations with relatively good institutions, but in terms of institutions they remain with the otherwise similar but relatively poor non-oil producing countries.*

In contrast Mehlum et al. (2006) argue that good institutions may be a prerequisite for positive growth effects of resource wealth, rather than a channel. There results indicate that previous studies prematurely dismissed the role of institutions by focusing only on the rent seeking arguments. In this paper we follow the argument of Mehlum et al. (2006) and test the preposition using interaction terms of oil rents and institutional quality.

## 2.2 Political Instability

Frankel (2010) lists civil war as one of the channels by which resource rents may affect economic outcomes. The abundance of resources may increase fighting over the rents leading to the link between resources and conflict elicited by the literature (e.g., Fearon and Laitin 2003, Humphreys 2005). On the other hand, Mathiesen (2014) argues that oil dependent countries, on average, experience a lower number of anti-government demonstrations than countries that are not dependent on oil rents. This result is consistent with Smith (2004) who contends that oil wealth is positively related with increased regime durability, even after controlling for repression. However, Mathiesen (2014) shows that, when the price of oil is low and the

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countries, and would better be done in a panel study where volatility changes over time and price trends can differ over time. We thus leave the examination of this channel to future research.

resource rents are correspondingly low, countries that are dependent on oil experience a higher number of anti-government demonstrations.

As the seminal paper of Alesina et al. (1996) show that political instability significantly retards economic growth, it is rather important to control for the aforementioned channel. We do so by adding an interaction term between oil rents and the number of revolutions and coups experienced by a country to our benchmark selection of variables.

### 2.3 Dutch Disease

Kremers (1986) was the first study which drew attention to the side effects natural gas discoveries by the Netherlands in the late 1950s. Since then, those side effects, including a large real appreciation of the domestic currency, an increase in government spending an increase in the price of non-traded goods (goods and services such as housing that are not internationally traded), relative to traded goods, and a current account deficit, all referred to as “Dutch Disease”. As Frankel (2010) points out, there are two problems associated with the previously stated side-effects. First, the process may be reversed when the world price of the export commodity goes back down. Second, and more importantly, the crowding out of non-commodity exports is undesirable, perhaps because the manufacturing sector has greater externalities for long-run growth (Matsuyama 1992). In order to control for the latter effect, we have add an interaction of oil rents with the share of manufacturing in GDP.

## 3 Data

For our empirical analysis we build a cross country data set including 54 potential growth determinants for 91 countries. We add 4 interaction terms to study the conditions, discussed in section 2, under which oil rents can lead to economic growth.

Our focus is on long term growth measured as average annual growth in the period 1970-2014. Using data past the 2000s is a novel feature compared to similar cross country studies using BMA which mostly use data for the period from 1960 to the mid nineties. Our starting point is the data set of SDM, which is one of the prominent data sets in the literature and includes a large number of potential growth determinants.

GDP data for some of the oil rich countries only becomes available from 1970, as is the case for example for the countries of the Gulf region. As a consequence these countries are not included in the most commonly used data sets for cross country growth regressions (e.g., Sala-i Martin 1997 Fernández et al. 2001 and SDM). We



focus on growth after 1970 precisely because we believe adding these countries will give a more complete inside into the average growth effects of oil. At the same time we believe it is important that the data also reflects the growth experience in the almost to decades since 1996/97. Thus in a first step we update GDP data from the Penn World Tables (PWT). This allows us to include for example the countries of the Gulf Cooperation Council (except Qatar) and generate a growth measure for the period 1970-2014.

In SDM many explanatory variables are measure in the initial period because either growth theory suggests so or to minimize problems of endogeneity. Accordingly we update the initial values in a second step for our sample period. In some cases updates are not available and we use the 1960 from SDM data as proxy. This is the case for example for the fraction of population within various religions, but as these are very persistent the 1960 data should give a good approximation.

In a third step we add various variables that account for our focus on oil and the conditions discussed above. In particular these are oil rents as percent of GDP, and the share of manufacturing in GDP from the World Bank. In a final step we then selects variables which are available for many OPEC and GCC countries.<sup>2</sup> This leave us with a data set of 54 variables and 4 interaction terms. Of the 54 variables three cover resource related factors: a dummy for oil producing countries, primary exports, and oil rents.

Table 3 displays a list of variables and some summary statistics. Columns 1-2 show the mean and standard deviation (SD) for the entire sample of 91 countries. Further we split according to whether countries are classified as mayor oil producers (columns 3-5) and whether countries have zero or non-zero oil rents (columns 6-8). For the split samples we report the mean within each group and the p-value of a t-test for difference between the means. While groups differ along some dimensions, it is striking that there is no significant difference in average growth between countries who are major oil producer and who are not, and neither between countries with some or with zero oil rents.

Table 1: Variables and Summary Statistics

	All sample		Oil Producers			Oil Rents		
	Mean	SD	No Oil	Oil	difference	No Oil	Oil	difference
	(1)	(2)	(3)	(4)	p-value	(6)	(7)	p-value
Average Growth 1970-2014	0.024	0.016	0.024	0.023	0.789	0.022	0.026	0.255
East Asia Dummy	0.077	0.268	0.075	0.091	0.855	0.050	0.098	0.399

<sup>2</sup>Our sample includes all GCC countries except Qatar, which is dropped due to limited data availability.

Table 1 continued

	All sample		Oil Producers			Oil Rents		
	Mean	SD	No Oil	Oil	difference	No Oil	Oil	difference
	(1)	(2)	(3)	(4)	p-value (5)	(6)	(7)	p-value (8)
Primary Education	0.791	0.266	0.803	0.704	0.248	0.717	0.849	0.018
Investment Price	0.210	0.154	0.217	0.160	0.251	0.206	0.213	0.820
Log GDP per capita 1970	8.380	1.173	8.227	9.493	0.001	7.819	8.819	0.000
Tropical Area	0.544	0.472	0.545	0.535	0.949	0.699	0.422	0.005
Life Expectancy	57.14	11.15	57.75	52.65	0.156	53.62	59.89	0.007
Confucian Fraction	0.008	0.065	0.010	0.000	0.650	0.019	0.000	0.176
Africa Dummy	0.297	0.459	0.313	0.182	0.379	0.525	0.118	0.000
Latin America Dummy	0.220	0.416	0.238	0.091	0.276	0.225	0.216	0.916
Mining (fraction GDP)	0.063	0.094	0.042	0.214	0.000	0.044	0.078	0.086
Spanish Colony Dummy	0.176	0.383	0.188	0.091	0.436	0.175	0.176	0.986
Muslim Fraction	0.205	0.351	0.140	0.682	0.000	0.128	0.266	0.061
Buddhist Fraction	0.038	0.160	0.044	0.001	0.412	0.034	0.042	0.820
Population Density	103	360	115	19.61	0.415	157	61.21	0.212
Foreing Language Speakers	0.347	0.412	0.326	0.499	0.192	0.282	0.397	0.188
Trade (fraction GDP)	0.374	0.344	0.344	0.589	0.026	0.383	0.367	0.820
Political Rights	3.870	1.997	3.700	5.110	0.027	4.326	3.513	0.053
Government Consumption	0.182	0.098	0.184	0.166	0.566	0.199	0.168	0.138
Higher Education Enrolment	0.069	0.081	0.075	0.024	0.052	0.038	0.093	0.001
Population in Tropics	0.288	0.365	0.295	0.242	0.654	0.392	0.207	0.016
Primary Exports	0.739	0.273	0.709	0.955	0.005	0.759	0.724	0.549
Protestant Fraction	0.136	0.285	0.154	0.004	0.101	0.094	0.169	0.214
Hindu Fraction	0.033	0.134	0.037	0.002	0.414	0.041	0.027	0.614
Latitude	24.03	16.41	24.61	19.79	0.364	19.65	27.46	0.023
Catholic Fraction	0.324	0.410	0.355	0.101	0.054	0.295	0.347	0.549
Fertility	1.580	0.429	1.543	1.850	0.025	1.679	1.503	0.052
European Dummy	0.220	0.416	0.250	0.000	0.062	0.125	0.294	0.054
Colony Dummy	0.736	0.443	0.738	0.727	0.943	0.825	0.667	0.091
Civil Liberties	0.507	0.324	0.531	0.333	0.057	0.442	0.559	0.087
Revolutions and Coups	0.194	0.232	0.187	0.245	0.445	0.165	0.217	0.297
British Colony Dummy	0.330	0.473	0.325	0.364	0.801	0.400	0.275	0.211
Population above Age 65	0.051	0.035	0.054	0.030	0.032	0.042	0.059	0.021
Total Population	23950	64000	24271	21609	0.898	6065	37977	0.017
Terms of Trade Growth	0.007	0.045	-0.006	0.105	0.000	-0.008	0.020	0.003
Education Spending (frac. GDP)	0.039	0.015	0.040	0.031	0.062	0.037	0.040	0.376
Landlocked Dummy	0.187	0.392	0.213	0.000	0.092	0.375	0.039	0.000
Religious Intensity	0.783	0.202	0.772	0.858	0.188	0.769	0.793	0.574
Total GDP (Economy Size)	24.17	1.876	24.10	24.66	0.352	22.96	25.11	0.000
Socialist Experience Dummy	0.077	0.268	0.075	0.091	0.855	0.075	0.078	0.952
Fraction English Speakers	0.081	0.249	0.092	0.000	0.252	0.053	0.103	0.342
Average Inflation 1970-2014	29.05	85.27	31.30	12.65	0.499	27.24	30.46	0.859
Oil Producer Dummy	0.121	0.328	0.000	1.000	.	0.000	0.216	0.001
Population Growth 1970-2014	0.020	0.012	0.018	0.035	0.000	0.021	0.019	0.518
Timing of Independence	1.033	0.971	0.963	1.545	0.062	1.250	0.863	0.059
Inflation squared (1970-2014)	8034	47084	9110	210	0.560	10875	5807	0.613
Land Area	865250	1787915	846779	999579	0.792	296178	1311580	0.006
Capitalism	3.440	1.343	3.513	2.909	0.164	3.475	3.412	0.825
Orthodox Fraction	0.018	0.097	0.020	0.001	0.537	0.010	0.024	0.514
GCC Dummy	0.055	0.229	0.000	0.455	0.000	0.000	0.098	0.042
Mena Dummy	0.132	0.340	0.063	0.636	0.000	0.025	0.216	0.007
Investment fraction of GDP	0.212	0.120	0.205	0.260	0.159	0.188	0.231	0.094

Table 1 continued

	All sample		Oil Producers			Oil Rents		
	Mean	SD	No Oil	Oil	difference	No Oil	Oil	difference
	(1)	(2)	(3)	(4)	p-value (5)	(6)	(7)	p-value (8)
Oil Rents	7.054	14.36	2.584	39.56	0.000	0.000	12.59	0.000
Manufacturing share in GDP	14.67	6.219	15.10	11.52	0.073	14.12	15.10	0.461
Oil rents X Manufacturing share	78.72	159	32.97	411	0.000	0.000	140	0.000
Oil rents X Political Rights	34.46	79.18	10.62	208	0.000	0.000	61.49	0.000
Oil rents X Civil Rights	2.541	5.468	1.131	12.79	0.000	0.000	4.534	0.000
Oil rents X Revolutions and Coups	1.696	4.572	0.647	9.326	0.000	0.000	3.026	0.001

## 4 Methodology

To address the question if and under which conditions oil resources affect economic growth we apply BMA. As we have argued one fundamental problem in this context is model uncertainty about under which conditions oil has positive or negative effects. Moreover, theoretical and empirical uncertainty about which potential determinants to include in the analysis is a general issue in growth regressions. BMA allows to overcome this problem and explicitly addresses model uncertainty. This section introduces the basic concept of BMA.

We start with a simple empirical growth model where the growth rate of country  $i = 1, \dots, N$  is given by:

$$g_i = \theta'_j x_i^j + \epsilon_i, \quad (1)$$

where  $g_i$  is the average annual growth rate of GDP per capita over the period 1970 to 2014 and  $\epsilon_i$  is an error term. A model is defined by a selection  $j = 1, \dots, J$  from the set of possible growth determinants  $x$ . A model is characterized by a specific set of growth determinants  $x^j$  and the corresponding parameter vector  $\theta_j$ . Given  $K$  possible regressors there is set of  $J = 2^K$  models  $M_j$ , each a particular linear combination of growth determinants.

Using BMA we calculate the unconditional (with respect to a specific model) posterior distribution of the parameter vector  $\theta$  given data  $D$ . The posterior distribution  $p(\theta|D)$  is given by the weighted average of the conditional distributions of model specific parameters with weights proportional to the model fit (cf. Leamer 1978). In the cross country context the conditional, i.e., model specific, parameter estimates are simply OLS estimates of each model.

We can write the posterior mean of a parameter vector  $\theta$  as the expectation of

the weighted sum of model specific parameter estimates:

$$E(\theta|D) = \sum_{j=1}^{2^K} P(M_j|D) \hat{\theta}_j \quad (2)$$

where  $\hat{\theta}_j$  is the estimated parameter vector for model  $j$ , and  $P(M_j|D)$  is the posterior probability of model  $M_j$  which is used as a model weight. Similarly, the posterior variance is the sum of model-weighted conditional variances and a term measuring the uncertainty over the estimated posterior means:

$$Var(\theta|D) = \sum_{j=1}^{2^K} P(M_j|D) \left( Var(\theta_j|M_j, D) + (\hat{\theta}_j - E(\theta|D))^2 \right), \quad (3)$$

The posterior model probabilities or weights  $P(M_j|D)$  are proportional to the marginal likelihood of the model  $M_j$ , denoted  $L(D|M_j)$ , and a prior model probability  $P(M_j)$  which summarizes any prior beliefs or knowledge the researcher might have about a particular model. Formally,  $P(M_j|D) \propto P(M_j)L(D|M_j)$ . The marginal likelihood of model  $M_j$  is in turn calculated by integrating over the model specific parameters:  $L(D|M_j) = \int L(D|\theta_j, M_j)P(\theta_j|M_j)d\theta_j$ , where  $P(\theta_j|M_j)$  is a parameter prior summarizing any prior beliefs the researcher might have about a particular parameter. The model weights  $P(M_j|D)$  are normalized by the sum of weights over all models and can therefore be interpreted as probabilities.

In order to specify priors, we follow Ley and Steel (2009) and chose priors that have been shown to have little influence on the posterior results, so that results are driven by the data and not by potentially subjective prior beliefs. For the parameter prior this is a version of the  $g$ -prior proposed by Zellner 1986 with conditional distribution of the slope coefficients given by  $p(\theta_j|M_j) \propto \mathcal{N}(0, \sigma^2 g(X_j'X_j)^{-1})$  and  $g = \min \{1/N, 1/k^2\}$ , where  $N$  is the total number of countries. The model prior we use is the hierarchical binomial beta prior found to be preferable by Ley and Steel (2009). Finally, we have to specify a prior model size, that is, the prior belief about the number of variables in the true (or best model). The suggestion of parsimonious model prior size  $m = 7$  by SDM has become standard practice and we also follow their suggestion.

The large number of potential growth determinants considered in this paper makes it unfeasible to calculate all possible models in a reasonable time. To solve this problem BMA makes use of MCMC samplers that sample from the model space. We employ the Metropolis-Hastings algorithm which is widely used, and commonly available in BMA software packages. Our results are generated using 10 Million burn

ins and 50 Million iterations.

## 5 Results

This section discusses the results estimated using BMA as described above. We present two sets of results. The first set of results ignored interaction terms while the second set includes them.<sup>3</sup> For each set of results we tabulate three statistics. The first is the posterior inclusion probability (PiP) which summarizes the likelihood of all models in which a specific variable is included. The PiP indicates the robustness of a this particular variable. It indicates if a variable is likely to be in the true (best) model and is the key statistic in BMA. The variable is robust if the PiP is larger than its prior inclusion probability. Given the prior on the model size 7 this is  $7/K$ , where  $K$  is the number of variables considered.<sup>4</sup> Second, we report the posterior mean parameter, which is the weighted average of the estimated parameters given by equation 2. The posterior mean provides an unconditional measure for the effect of the variable. And finally we include the ratio of the posterior mean to the posterior standard error as a measure of precision of our estimates. This ratio is roughly comparable to a t-statistic in the frequentist approach. Following the literature we conclude that an estimate is precise if the ratio is larger than 1 (or 2. 2 corresponds roughly to a significance level of 5% in the frequentest approach and thus can serve as a benchmark).

Table 5 columns 1-3 report the results for the specification without interaction terms. Column 1 displays PiPs, column 2 the posterior means and column 3 the ratio of mean to standard error. We find that overall 9 robust growth determinants including the measure for oil rents.

The effect of oil rents is very robust (high PiP) and precisely estimated. The effect is positive which means that we do not find evidence of a resource curse but, quite the opposite, we find evidence of a positive effects of rents generated from oil income on economic growth. In contrast we do not find any robust effect, positive or negative, of a simply dummy variable for oil producing countries or the fraction of primary exports. The positive effect of oil stands in contrast with large parts of the literature presenting evidence in favor of a resource curse. However, it is in line with Alexeev and Conrad (2009) who argue that the negative effect is a result of controlling for initial GDP which may already have absorbed a major part of the

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<sup>3</sup>We follow the approach of Masanjala and Papageorgiou (2008) and treat interaction terms in the same way as the constitutive terms. With a prior that assumes a zero mean for each variable this seems to be a consistent approach.

<sup>4</sup>As  $K$  differs in the two specifications the prior inclusion probably also differs.

growth effects. In contrast to their study we do not decide a priori if to include or exclude initial GDP but allow the data to decide using BMA. We show that simply addressing model uncertainty leads to a similar result as in Alexeev and Conrad (2009), namely a positive growth effect of oil.

Table 2: Oil and Growth Revisited - Results from BMA

	Baseline Results			with Interaction Terms		
	PiP (1)	Post. Mean (2)	Mean/SD (3)	PiP (4)	Post. Mean (5)	Mean/SD (6)
Oil Rents	0.99	0.00054	3.66	0.10	0.00005	3.66
Oil Producer Dummy	0.00	0.00003	0.03	0.00	0.00001	0.03
Primary Exports	0.00	0.00000	0.01	0.00	0.00002	0.01
Oil rents X Political Rights				0.90	0.00009	
Oil rents X Revol. and Coups				0.00	0.00000	
Oil rents X Civil Rights				0.00	0.00000	
Oil rents X Manufacturing				0.00	0.00000	
Log GDP per capita 1970	1.00	-0.01862	9.64	1.00	-0.01878	9.64
Life Expectancy	1.00	0.00125	6.31	1.00	0.00132	6.31
Trade (fraction GDP)	0.93	0.01447	2.66	0.97	0.01555	2.66
Population in Tropics	0.83	-0.01242	1.88	0.78	-0.01108	1.88
Total GDP (Economy Size)	0.54	0.00144	1.00	0.61	0.00166	1.00
Mining (fraction GDP)	0.45	0.02189	0.85	0.41	0.01905	0.85
Confucian Fraction	0.40	0.01891	0.76	0.40	0.01892	0.76
Manufacturing share in GDP	0.13	0.00008	0.36	0.11	0.00006	0.36
Timing of Independence	0.06	-0.00018	0.23	0.04	-0.00010	0.23
Investment fraction of GDP	0.05	0.00178	0.22	0.02	0.00046	0.22
Africa Dummy	0.04	-0.00042	0.19	0.05	-0.00048	0.19
East Asia Dummy	0.03	0.00029	0.15	0.02	0.00020	0.15
Tropical Area	0.03	-0.00019	0.15	0.01	-0.00007	0.15
Total Population	0.03	0.00000	0.15	0.02	0.00000	0.15
Colony Dummy	0.02	-0.00012	0.13	0.01	-0.00003	0.13
Latitude	0.02	0.00000	0.13	0.01	0.00000	0.13
Fertility	0.01	-0.00011	0.10	0.01	-0.00004	0.10
Foreing Language Speakers	0.01	0.00005	0.10	0.01	0.00005	0.10
Socialst Experience Dummy	0.01	-0.00008	0.10	0.02	-0.00015	0.10
Land Area	0.01	0.00000	0.09	0.01	0.00000	0.09
Population Density	0.01	0.00000	0.09	0.01	0.00000	0.09
Political Rights	0.01	-0.00002	0.09	0.05	-0.00012	0.09

Table 2 continued

	Baseline Results			with Interaction Terms		
	PiP	Post. Mean	Mean/SD	PiP	Post. Mean	Mean/SD
	(1)	(2)	(3)	(4)	(5)	(6)
Religious Intensity	0.01	-0.00006	0.07	0.02	-0.00019	0.07
Protestant Fraction	0.01	-0.00004	0.07	0.01	-0.00003	0.07
Latin America Dummy	0.01	-0.00003	0.06	0.00	0.00000	0.06
Buddhist Fraction	0.01	0.00006	0.07	0.00	0.00003	0.07
Investment Price	0.01	0.00005	0.06	0.00	0.00003	0.06
Muslim Fraction	0.01	0.00004	0.06	0.01	0.00002	0.06
Population Growth	0.01	-0.00103	0.05	0.01	-0.00085	0.05
Landlocked Dummy	0.01	-0.00002	0.05	0.00	-0.00001	0.05
Fraction English Speakers	0.01	-0.00002	0.05	0.00	-0.00001	0.05
European Dummy	0.01	0.00002	0.05	0.00	0.00000	0.05
Catholic Fraction	0.01	0.00001	0.05	0.01	0.00002	0.05
Hindu Fraction	0.00	0.00003	0.04	0.01	0.00005	0.04
Capitalism	0.00	0.00000	0.05	0.00	0.00000	0.05
GCC Dummy	0.00	0.00003	0.04	0.00	0.00000	0.04
Population above Age 65	0.00	0.00014	0.03	0.00	-0.00001	0.03
Average Inflation	0.00	0.00000	0.04	0.00	0.00000	0.04
Spanish Colony Dummy	0.00	0.00000	0.00	0.00	0.00001	0.00
Terms of Trade Growth	0.00	-0.00010	0.04	0.00	-0.00006	0.04
Revolutions and Coups	0.00	0.00001	0.04	0.00	0.00001	0.04
British Colony Dummy	0.00	0.00001	0.03	0.00	0.00001	0.03
Higher Education Enrolment	0.00	0.00001	0.01	0.00	0.00000	0.01
Tropical Climate	0.00	0.00001	0.02	0.00	0.00001	0.02
Mena Dummy	0.00	-0.00001	0.02	0.00	-0.00001	0.02
Civil Liberties	0.00	0.00001	0.02	0.00	0.00001	0.02
Government Consumption	0.00	0.00002	0.02	0.00	0.00001	0.02
Primary Education	0.00	-0.00001	0.02	0.00	0.00000	0.02
Inflation squared	0.00	0.00000	0.01	0.00	0.00000	0.01
Orthodox Fraction	0.00	0.00000	0.00	0.00	0.00000	0.00
Education Spending	0.00	0.00001	0.00	0.00	-0.00002	0.00

In order to investigate the result further we analyze the conditions (or channels) that have been theorized to be causing the resource curse using interaction terms. The results are displayed in columns 4-6 of table 5 where we add interaction terms for oil rents with two measures for institutional quality, coups and revolutions and

the share of manufacturing in GDP.

We find a robust positive effect of the interaction of oil rents with political rights. None of the other interaction effects is robust. Interestingly the constituting effect of oil rents is also no longer robust. This finding suggests that the robust positive effect found without interactions is driven by countries with high oil rents and good political institutions. A related result is presented in Mehlum et al. (2006) showing that the resource curse is only present in countries with bad institutions.<sup>5</sup> The present paper, using an updated data set and addressing model uncertainty, add a new dimension to the results presented in Mehlum et al. (2006). The results indicate no evidence for a resource curse, but instead no robust effects for oil itself and a positive effect of oil rents conditional on institutions.

Out of the set of other variables we find 7 to be robust determinants of long term growth. Five of these are also precisely estimated: initial GDP per capita, life expectancy, trade as percent of GDP, share of population in the tropics, and the size of the economy. Mining as a fraction of GDP and the fraction of population with Confucian religion are robust but not precisely estimated. These findings are the same in both specification. In addition the size of the manufacturing sector is marginally robust in the specification without interaction terms, but never precisely estimated.

To summarize we find that oil rents have robust positive effect on economic growth if political institutions are good. Moreover, we find no evidence for a resource curse. Thus by using BMA we can control for many potential other growth determinants and add the literature that analyzes under which conditions resource rents can have positive growth effects.

## 6 Conclusion

Our major contribution is to address model uncertainty in the context of the empirical link between oil dependency and economic growth. We use an updated cross country data set for growth in the period 1970-2014 encompassing 91 countries, including major oil producers in the Gulf region, and 55 potential growth determinants. Employing BMA directly addresses model uncertainty and thus offers a statistically rigorous approach towards identifying variable importance.

We conclude that there is no evidence for the existence of natural resource curse, i.e., the harmful effect of oil revenues. On the contrary, we find that oil revenues

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<sup>5</sup>The study differs from ours in that Mehlum et al. (2006) use an older data set (1965-1990) and a very limited number of control variables.



can be growth-enhancing, but with the pre-condition of good institutions. Future avenues for research may include investigating this issue in a panel data setting. This would allow to explore effects of oil price levels and volatility, which are constant for all countries but change over time.

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