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Essays on Stock Market Integration and on the Curse of Natural Resources

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Dissertation

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Table of Contents:

1 Introduction

This thesis contains three essays, each of which calls into question generally accepted empirical results through the use of more appropriate data or econometric techniques. In doing so, I shed novel light on already well established results.

In the first essay I address the issue of stock market integration from a new perspective. The hypothesis of stock market integration assumes that information originating from one market should be important to other markets as well. The idea that with the relaxation of various types of economic barriers and with the developments in information technologies, stock markets should become integrated as opposed to fragmented has motivated broad empirical research on the transmission of information across equity markets. Studies that focus primarily on stock market integration investigate statistical relationships between the indices from different markets, typically using cointegration or Granger causality analysis with daily closing time data.

I substantially extend the existing research by performing cointegration and Granger causality tests with data of different frequencies. I use a unique dataset covering two years of high frequency data on the indices from the markets in the U.S., London, Frankfurt, Paris, Warsaw, Prague, and Budapest. This allows me to vary the data frequency from five minutes to one day. My aim is to uncover the time structure of the reaction of prices on one market to the information revealed in prices on other markets. Particularly I am interested in the speed at which the information is transmitted between the markets. My results show a rich and interesting pattern of mutual reactions of the investigated stock market indices. The results suggest that the markets react very quickly to the information revealed in the prices on other markets. The decisive reaction occurs within 1 hour, while the first reaction is detected often after only 5 minutes. This is also in line with the findings of the research that investigates the effect of macroeconomic releases from different countries on stock markets' returns, volatility, and trading volumes and concludes that markets react to macroeconomic releases very quickly, faster than within one hour. In the light of these results the use of daily closing time data in the studies of stock market integration was clearly misleading.

The other two essays focus on the curse of natural resources, a well known result obtained in cross-country growth regressions and various case studies. The curse of natural resources claims that countries with natural resources intensive economies grow more slowly than resource-free countries. It is a very robust result confirmed in numerous studies and based on broad empirical evidence with data from the last four decades.

In the second essay I introduce in detail the issue of the curse of natural resources as it is presented in the existing literature. Moreover, I focus on its proclaimed robustness and often stressed possibility to mitigate the curse with prudent economic policies and mature institutions. I study the robustness of the curse of natural resources with respect to variables measuring the quality of democracy and regime stability. I also use smoothed least trimmed squares, a robust estimation procedure to estimate the resource curse regressions. Overall my results confirm the reported robustness of the curse of natural resources. However, I find limited evidence suggesting that the intensity of the curse depends on the level of civil liberties. The power of the curse seems to decrease steadily with the level of civil liberties once a minimal level is achieved. Similarly as other authors, I employ variables that measure natural resource dependence or intensity rather than abundance or wealth in order to estimate the effect of natural resources on economic growth. The relationship between pure natural resource abundance and economic growth is investigated in the third essay.

In the third essay I challenge the prevailing interpretation of the resource curse result. I construct variables expressing per capita natural resource wealth and focus on the differences in results obtained with the measures of natural resource dependence and abundance. My results do not provide any statistical evidence that natural resources themselves are associated with or even cause slow economic growth. This finding thoroughly questions the prevailing interpretation of the resource curse regressions.

2 Stock Market Integration and the Speed of Information Transmission

Abstract:

Using a unique dataset covering two years of high frequency data on the indices from markets in the U.S., London, Frankfurt, Paris, Warsaw, Prague, and Budapest, I perform Cointegration and Granger causality tests with data of different frequencies (from 5 minutes to 1 day). The aim is to describe the time structure in which markets react to the information revealed in prices on other markets. The results suggest that the speed of information transmission is very fast. In all cases the strongest reaction occurs within 1 hour. Therefore, the use of daily data may be misleading when analyzing the issues of stock market integration and information transmission among markets.

2.1 Introduction

Increasing globalization of the world economy should obviously have an impact on the behavior of national stock markets. The relaxation of all types of economic barriers and developments in information technologies are, among others, expected to induce stronger stock market integration as opposed to stock market fragmentation. With integrated stock markets, information originating from one market should be important to other markets. This assumption has motivated an intensive area of empirical research on the transmission of information across equity markets.

Using a rough criterion, this research can be divided into two areas. The first area studies stock market integration and focuses on statistical relationships between the indices from different markets, typically using cointegration or Granger causality analysis, e.g., Huang and Fok (2001), Seabra (2001), Dickinson (2000), Bracker et al. (1999), Chelley-Steeley et al. (1998), Richards (1996), Chou et al. (1994). The second area focuses on the effect of macroeconomic releases from different countries on different markets. It studies the impact of the releases on market returns, volatility, and trading volumes. Papers from this area include, for example, Andersen et al. (2003), Connolly and Wang (2003), Wongswan (2003), and Ehrmann and Fratzscher (2002).

In this paper I address the same problem of stock market integration as the first area of research does, but employ high frequency data characteristic for the second research area. So far, cointegration and Granger causality tests between stock market indices were performed with daily or even lower data frequencies.[1] The reason for this might be that historical high frequency data on indices from most stock markets are not easily available. Studies of the reaction of stock markets to macroeconomic releases employ typically high frequency index data only from the markets in the U.S. and London, using FTSE 100 futures as a proxy for the spot index. Nevertheless, these studies suggest that the markets react to macroeconomic releases very quickly, faster than within one hour. Therefore, there are good reasons to believe that also the reaction of

[1] The term frequency is actually used incorrectly in this area of research. When I say daily frequency of the data, I mean, in fact, a daily period. With higher frequencies, like hourly or 30 minutes frequencies, I mean data collected hourly or at 30 minute intervals.

stock markets to the information revealed in prices on other stock markets should be very fast. The use of daily data in cointegration and Granger causality tests could then be misleading.[2]

If the reaction of prices on a market A to the information revealed in prices on a market B occurs faster than within one day, then we should not detect cointegration or Granger causality with daily data. With the use of daily data, the markets would appear informationally efficient. Informational efficiency means in this case that today's expectation of tomorrow's return on market A, conditional on the available information, equals today's return on market A. However, cointegration and Granger causality would imply that we could improve the expectation of tomorrow's return on market A using the information about today's return on market B. On the other hand, we should detect cointegration and Granger causality among indices from two markets when using data of a frequency close to the speed of information transmission between the two markets. When further increasing the data frequency, cointegration and Granger causality should disappear once the data are collected at intervals much lower than is the time needed for information transmission between the two markets. With such high frequency data, the markets would appear as completely independent.

The arguments presented above suggest that data frequency should play an important role for cointegration and Granger causality tests among indices from different stock markets. Therefore, I perform cointegration and Granger causality tests with data of different frequencies. I use a unique dataset covering two years of high frequency data on the indices from the markets in the U.S., London, Frankfurt, Paris, Warsaw, Prague, and Budapest. This allows me to vary the data frequency from five minutes to one day. My aim is to uncover the time structure of the reaction of prices on one market to the information revealed in prices on other markets. Particularly I am interested in the speed at which the information is transmitted between the markets.[3]

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[2] In general, even if markets react relatively quickly to any specific information, analysis based on daily data can make sense, because information is coming throughout the day and the change in daily closing price can be viewed as its aggregation. However, Granger causality and cointegration analysis with daily data should not be used to decide about the presence or absence of stock market integration.

[3] Egert and Kočenda (2005) employ an identical dataset but investigate only the highest five minute frequency data using a wide range of econometric techniques.

I am aware that I cannot directly address the nature of the information transmission. My tests cannot distinguish if the information revealed in the prices on one market is transmitted directly to the prices on another market or if the two markets react to some other relevant information about economic fundamentals (like macroeconomic releases could be) in a similar manner but at slightly different speeds. In other words, I do not address the question of contagion between markets versus reaction to economic fundamentals.

2.2 Data

The data employed in this paper were provided free of charge by Bloomberg, Prague. I use five minute interval data on the following stock market indices: S&P 500 and Dow Jones Industrial Average (U.S.), FTSE 100 (London), DAX 30 (Frankfurt), CAC 40 (Paris), WIG 20 (Warsaw), PX 50 (Prague), and BUX (Budapest). It is not possible to obtain historical five minute interval data on all these indices. The data are stored in the Bloomberg database only for the previous few months. Therefore, the data were downloaded 24 times during 24 months so that a time span starting on June 2, 2003, at 13:30 and ending on June 6, 2005, at 23:55 West and Central European Daylight Time was covered.[4]

Table 1: Daily time periods of available data on individual indices.

	Time period	
Index	**From**	**To**
S&P 500	15:30	22:10
DJIA	15:30	22:00
FTSE 100	9:00	17:25
DAX 30	9:00	20:10, from Nov. 2003 only to 17:40
CAC 40	9:05	17:25
WIG 20	10:05	15:55
PX 50	9:30	15:55
BUX	9:00	16:25

Notes: Time is given in West and Central European Daylight Time.

[4] West and Central European Daylight Time is equal to GMT+1:00 but observes a daylight saving time period, during which it is equal to GMT+2:00.

Table 1 shows the time periods for which the data are mostly available each trading day for each individual index. Table 2 shows basic summary statistics on the natural logarithms of the indices and on the associated logarithmic five minute returns (five minute logarithmic differences).

Table 2: Statistics on logarithms of indices and five minute logarithmic returns.

	Logarithms of indices					**Logarithmic 5 minute returns**				
Index	**Obs.**	**Mean**	**Std.Dev.**	**Min.**	**Max.**	**Obs.**	**Mean**	**Std.Dev.**	**Min.**	**Max.**
S&P 500	40007	7.01	0.063	6.87	7.11	39499	3.40E-6	7.22E-4	-0.010	0.008
DJIA	39133	9.22	0.050	9.09	9.30	38590	3.15E-6	7.47E-4	-0.012	0.011
FTSE 100	50484	8.42	0.060	8.28	8.53	49874	-2.94E-6	5.37E-4	-0.014	0.007
DAX 30	55868	8.26	0.093	8.01	8.42	55363	3.60E-6	9.17E-4	-0.023	0.016
CAC 40	50959	8.20	0.078	8.01	8.34	50441	2.17E-6	7.33E-4	-0.008	0.010
WIG 20	35053	7.44	0.123	7.08	7.66	34546	7.80E-7	1.29E-3	-0.012	0.019
PX 50	38296	6.70	0.244	6.27	7.15	37451	1.56E-5	7.41E-4	-0.020	0.019
BUX	44295	9.36	0.243	8.95	9.84	43798	5.91E-6	1.06E-3	-0.014	0.011

2.3 Methodology

To test for Granger causality and cointegration, I use the standard methodology proposed by Granger (1969, 1986) and Engle and Granger (1987) as described, for example, in Enders (1995). All tests are performed on natural logarithms of the indices' time series using simple OLS estimation procedures.[5]

2.3.1 Granger Causality and Cointegration Tests

In order to test for Granger causality among stock market indices x_t and y_t, I estimate the equation

$$\Delta \ln y_t = c + \sum_{i=1}^{K} \alpha_i \Delta \ln y_{t-i} + \sum_{i=1}^{K} \beta_i \Delta \ln x_{t-i} + \varepsilon_t \qquad (1)$$

and perform an F test for joint insignificance of the coefficients β_i, $i=1\ldots K$. The null hypothesis claims that x_t does not Granger cause y_t. For each pair of stock market indices, I can perform two Granger causality tests so that I can decide whether x_t Granger causes y_t, or y_t Granger causes x_t, or both, or none.

When testing for cointegration of a pair of stock market indices x_t and y_t, I have to first determine if the logarithms of both indices are integrated of the order 1, denoted as *I(1)*.[6] It means that the levels of the series' logarithms must be non-stationary (contain a unit root) and the differences must already be stationary. To test for stationarity, I employ the standard augmented Dickey-Fuller test (ADF test). For levels I estimate equation (2) and for differences equation (3):

$$\ln y_t = c + \beta t + \delta \ln y_{t-1} + \sum_{i=1}^{K} \alpha_i \Delta \ln y_{t-i} + \varepsilon_t , \tag{2}$$

$$\Delta \ln y_t = c + \delta \Delta \ln y_{t-1} + \sum_{i=1}^{K} \alpha_i \Delta^2 \ln y_{t-i} + \varepsilon_t . \tag{3}$$

I allow the levels to contain a constant term and a linear time trend, whereas for the differences I include only a constant term in the estimated equation. Under the null hypothesis of the presence of a unit root (non-stationarity), the test statistic defined as the t-ratio of $(\delta\text{-}1)$ equals zero. To test this hypothesis, I compare the test statistic to the finite sample critical values tabulated by Cheung and Lai (1995).

If the logarithms of both series x_t and y_t are found to be *I(1)*, then I proceed to the test of cointegration. I estimate a simple linear relationship between the two time series defined by equations (4) or (5):

$$\ln y_t = c + \alpha \ln x_t + \varepsilon_t , \tag{4}$$

$$\ln x_t = c + \alpha \ln y_t + \varepsilon_t . \tag{5}$$

Then I apply the ADF test to the estimated residuals e_t from each of the two equations (4) or (5). It means that I estimate the equation

$$e_t = \delta e_{t-1} + \sum_{i=1}^{K} \alpha_i \Delta e_{t-i} + \varepsilon_t . \tag{6}$$

In this case I do not even allow for a constant in equation (6) because e_t is a series of regressions' residuals. Further, I proceed as with the ADF test applied on levels and

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[5] The results do not change significantly when OLS with a correction for heteroscedasticity is employed.

[6] It should be mentioned that a simple random walk like stochastic time series models of a stock price (and thus also of a stock market index) imply that the logarithms of the stock price contain a unit root and its differences (logarithmic returns) are stationary. This result is also predominantly confirmed in many previous studies.

differences of the logarithms of stock market indices, but employ the finite sample critical values tabulated by MacKinnon (1991). If the time series of the residuals e_t is tested as stationary, then I claim that the stock market indices x_t and y_t are cointegrated.

Cointegration between the indices x_t and y_t indicates the presence of a long run equilibrium relationship represented by the equation (4) or (5). If one index deviates from this relationship in a period *t*, then it tends to return back to it in the following periods. As a result none of the indices should depart too far from this equilibrium. This idea is mathematically expressed with an error correction model that can be estimated using the following equations:

$$\Delta \ln y_t = c_1 + \delta_1 e_{t-1} + \sum_{i=1}^{K} \alpha_{1i} \Delta \ln y_{t-i} + \sum_{i=1}^{K} \beta_{1i} \Delta \ln x_{t-i} + \varepsilon_t, \qquad (7)$$

$$\Delta \ln x_t = c_2 + \delta_2 e_{t-1} + \sum_{i=1}^{K} \alpha_{2i} \Delta \ln y_{t-i} + \sum_{i=1}^{K} \beta_{2i} \Delta \ln x_{t-i} + \varepsilon_t, \qquad (8)$$

where e_t are the estimated residuals from equations (4) or (5). If the indices x_t and y_t are found cointegrated, then at least one of the coefficients δ_1 and δ_2 should appear significant in the estimated equations (7) and (8) and its sign should be such that the deviation from the long run equilibrium in period t-1 (e_{t-1} is used as a proxy for this deviation) will be corrected in the following period *t*.

In the tests described above, sums of lagged differences are included in the estimated equations (1), (2), (3), (6), (7), and (8). The lagged differences control for potential serial autocorrelation in residuals. To select the highest lag *K*, I use a modification of the non-parametric method presented by Campbell and Perron (1991), and Ng and Perron (1995). The number of lags *K* is initially set at the maximum value eight and the statistical significance of the coefficient on the highest lag is checked using a simple t-test. If it is insignificant at the 10 per cent level, the number of lags is reduced by one and the procedure is repeated until statistical significance of the coefficient by the highest lag is achieved. If lagged differences for two variables are included (as in equations (1), (7), and (8), then I include the same number of lagged differences for both of them. Therefore, *K* is set when at least one of the coefficients on the highest lag is significant at the 10 per cent level of significance.

2.3.2 Tests with Different Data Frequencies

The major goal of this paper is to compare the results of Granger causality and cointegration tests for different data frequencies. Namely, I perform the tests with the stock market index data of the following frequencies: 5 minutes, 10 minutes, 20 minutes, 30 minutes, 40 minutes, 50 minutes, 1 hour, and 1 day. To assure comparability of the results with different data frequencies, I proceed in the following way. For each pair of the tested indices I choose one time and select the available daily observations only for this particular time. The chosen times are 21:50 for a pair of U.S. indices, 15:40 for a pair of European indices, and 17:15 for a pair consisting of one U.S. and one European index. All the times are expressed in West and Central European Daylight Time. With such 'daily' time series, I use different lags for the tests with different frequencies. For example, when performing Granger causality tests on 5 minute interval data I employ 5 minute lags in equation (1), with 10 minute interval data I employ 10 minute lags, etc. With daily frequency data, I do not control for any potential Monday effects and take Friday as the preceding day. The times 21:50, 15:40, and 17:15 are chosen so that enough lags on all frequencies are available for both indices in the pair. Simultaneously, I avoid the closing times of any of the markets to prevent some potential special properties of the closing time index values from influencing the results. Nevertheless, the maximum number of lags allowed in the estimated equations is lower than eight as the frequencies approach one hour (see Table 3 below in Results).

Depending on each individual pair of indices, the number of observations employed in the tests ranges between 408 and 498 for frequencies up to 1 hour, with a typical value around 470. For the tests with daily frequency the number of observations ranges between 313 and 483.

2.4 Results

The results of all Granger causality tests, cointegration tests, and error correction model estimations are given in Tables A.1 to A.3 in Appendix A. I performed Granger causality and cointegration tests with different frequencies of the following twelve pairs of stock market indices: S&P 500 and DJIA, S&P 500 and FTSE 100, S&P 500 and DAX 30, FTSE 100 and DAX 30, FTSE 100 and CAC 40, DAX 30 and CAC 40, DAX 30 and WIG 20, DAX 30 and PX 50, DAX 30 and BUX, WIG 20 and PX 50, WIG 20 and BUX, and PX 50 and BUX.

DJIA and S&P 500 are two indices covering stock markets in the same country. Therefore, Granger causality or cointegration relationships should occur only at very high frequencies, because the transmission of information should be very fast. Unfortunately, the two indices do not measure the performance of two non-intersecting sets of stocks. In fact, the DJIA can be viewed as a 'subset' of the S&P 500. All 30 DJIA index components are among the 500 stocks, whose prices are used to compute the value of the S&P 500 index (this held at least throughout the time span investigated in this paper). For example, in August 2004, the weight of the 30 DJIA index components in the S&P 500 index was around 35%. This weight can slightly change over time due to the S&P500 index weighting scheme. While the DJIA is calculated on a price-weighted basis, the S&P 500 components are weighted proportionally to the market capitalization of the corresponding companies. Therefore, it is not possible to compute that part of the S&P 500 index measuring the remaining 470 stocks not included in the DJIA, unless we know the exact market capitalization of all the S&P 500 components at any point in time. The 'overlap' of the two indices could cause a slight bias in the results of this paper. The bias should lead towards not detecting any Granger causality, because any time series will never Granger cause itself. In the case of cointegration, the bias should lead towards finding a cointegration relationship because any time series is trivially cointegrated with itself, as the residuals from the regressions (4) or (5) equal zero. However, any of the two biases should not be too serious, because about two thirds of the S&P 500 index is calculated using prices of the 470 stocks not included in the DJIA. Nevertheless, it should be mentioned that any of the 470 companies whose stocks are not included in the DJIA index has a much lower market capitalization than any of the 30 companies whose stocks are included in both indices. Thus, when using DJIA and S&P 500 indices in Granger causality and cointegration analysis in this paper, we in fact investigate the transmission of information revealed in prices of large (represented by the DJIA) and relatively small U.S. companies (represented by S&P 500).

The second and third pair investigate the relationships between the U.S. S&P 500 index and the two major European indices of the markets in London (FTSE 100) and Frankfurt (DAX 30). The next three pairs include three European indices: FTSE 100, DAX 30, and CAC 40 of the stock market in Paris. The next three pairs study the relationships between DAX 30 and three indices from relatively small and still emerging Eastern European markets in Warsaw (WIG 20), Prague (PX 50), and Budapest (BUX). The last three pairs include the three emerging markets indices WIG 20, PX 50, and BUX.

Table 3: Maximum number of lags available in Granger causality and cointegration tests for each pair of indices and different data frequencies.

Indices	**Frequency**							
pair	**5 min**	**10 min**	**20 min**	**30 min**	**40 min**	**50 min**	**1 hour**	**1 day**
DJIA and S&P	8	8	8	8	8	6	5	8
S&P and FTSE	8	8	4	2	1	1	0	8
S&P and DAX	8	8	4	2	1	1	0	8
FTSE and DAX	8	8	8	8	8	6	5	8
FTSE and CAC	8	8	8	8	8	6	5	8
DAX and CAC	8	8	8	8	8	6	5	8
DAX and WIG	8	8	8	8	7	5	4	8
DAX and PX	8	8	8	8	8	6	5	8
DAX and BUX	8	8	8	8	8	6	5	8
WIG and PX	8	8	8	8	7	5	4	8
WIG and BUX	8	8	8	8	7	5	4	8
PX and BUX	8	8	8	8	8	6	5	8

If possible, I allow for a maximum of 8 lags of the logarithmic differences in all the performed tests. However, the number of available lags is lower for data frequencies close to 1 hour. The maximum number of available lags in Granger causality and cointegration tests for different frequencies with each pair of indices is given in Table 3. The problem of a low number of available lags becomes the most serious in the case of the following two pairs: S&P 500 with FTSE 100 and S&P 500 with DAX 30. Here, the number of available lags drops to 2 for 30 minute frequencies and to 1 for 40 and 50 minute frequencies. With hourly data the tests cannot be performed at all because zero lags are available. Therefore, the results of the tests for these two indices' pairs cannot be viewed as fully comparable to the results with the other pairs.

I should be also careful when comparing the test results from daily data to the results from data of other frequencies. With daily data the number of available observations is lower than with other frequencies. Moreover, I do not control for any possible Monday effects and regard Fridays as directly preceding Mondays.[7]

2.4.1 Granger Causality

The results of Granger causality tests are given in Table A.1 in Appendix A. They show a rich structure of Granger causality relationships. Table 4 summarizes these results for each pair of indices and each data frequency.

First, let us consider Granger causality between the two U.S. stock market indices: S&P 500 and DJIA. This pair can serve as a benchmark because the two indices are from markets in the same country. In line with this fact I detect the strongest result only with the highest 5 minute frequency where the DJIA index Granger causes the S&P 500 index at the 1 per cent significance level and vice versa, S&P 500 Granger causes DJIA but only at the 10 per cent level of significance. It means that the two indices either react very quickly to each other, or react to information relevant for the U.S. stock markets almost equally fast and in a similar manner. Moreover, the direction of Granger causality goes from the DJIA index to the S&P 500 index. It suggests that the prices of stocks of relatively small U.S. companies (represented by the S&P 500 index) react very quickly to the price changes of stocks of large U.S. companies (represented by the DJIA index). Additionally, my results also suggest that S&P 500 Granger causes DJIA with 30 minute and 40 minute frequency data but only at the 10 per cent significance level.

[7] If Monday dummies are included in the regressions with daily data, the results of the tests do not change, even though the dummies are significant in most cases.

This result is, therefore, relatively unimportant compared to the result obtained with 5 minute frequency data.

Table 4: Results of Granger causality tests with different data frequencies.

	Frequency							
GC →	**5 min**	**10 min**	**20 min**	**30 min**	**40 min**	**50 min**	**1 hour**	**1 day**
S&P→DJIA	10%			10%	10%			
DJIA→S&P	1%							
S&P→FTSE	1%	10%						
FTSE→S&P								
S&P→DAX	5%			5%	10%			
DAX→S&P		5%						
FTSE→DAX			5%	1%	10%		10%	
DAX→FTSE	1%		1%			1%	10%	
FTSE→CAC				1%	5%		10%	
CAC→FTSE	5%		5%	5%		5%	5%	5%
DAX→CAC		10%		5%	1%	1%	5%	10%
CAC→DAX		5%		5%		5%	5%	10%
DAX→WIG	1%	5%		5%	1%	1%	1%	
WIG→DAX	5%				10%			10%
DAX→PX					5%	5%	1%	
PX→DAX								
DAX→BUX	1%				10%	1%	5%	
BUX→DAX					10%			
WIG→PX				5%	10%		5%	
PX→WIG	10%			1%	10%		1%	5%
WIG→BUX	10%						10%	
BUX→WIG		5%				5%	5%	
PX→BUX					10%			5%
BUX→PX		10%	1%	1%	1%	1%	1%	10%

Notes: The symbols stand for Granger causality at the 10%, 5%, and 1% significance level. With hourly frequency and the pairs of the S&P 500 index with the FTSE 100 and DAX 30 indices, not enough lags are available to perform Granger causality tests.

Second, I consider Granger causality between the S&P 500 index and the two major European indices FTSE 100 and DAX 30. Here, we see a slightly different pattern than with the two U.S. indices above. S&P 500 Granger causes FTSE 100 at the 1 per cent significance level with 5 minute frequency data and at the 10 per cent significance level also with 10 minute frequency data. With the DAX 30 index the pattern of Granger causality results is a bit richer. S&P 500 Granger causes DAX 30 at the 5 per cent significance level with 5 and 30 minute frequency data and additionally with 40 minute frequency data at the 10 per cent significance level. The opposite Granger causality relationship is detected only once. The DAX 30 index Granger causes S&P 500 with 10 minute frequency data at the 5 per cent significance level. Therefore, I conclude that the two major European stock markets react to the information from the stock markets in the U.S. approximately within 30 to 40 minutes after this information is reflected in the S&P 500 index. However, the first and strongest reaction occurs very quickly, approximately within the first 10 minutes. The evidence for an opposite reaction of the S&P 500 index to the information revealed in the European indices is weak.

Third, I analyze Granger causality results among the three European stock market indices, FTSE 100, DAX 30, and CAC 40. In this group a very rich Granger causality pattern is detected with frequencies ranging from 5 minute to 1 day. Numerous Granger causality relationships in both directions and among all the three pairs of indices are found with data frequencies between 20 minute and 1 hour. With the highest 5 minute data frequency only two Granger causality relationships are present: DAX 30 Granger causes FTSE 100 at the 1 per cent significance level and CAC 40 Granger causes FTSE 100 at the 5 per cent significance level. With daily data frequency Granger causality relationships are detected only at the 5 and 10 per cent levels of significance. The CAC 40 index Granger causes the FTSE 100 index at the 5 per cent level of significance and both directions of Granger causality are found between the DAX 30 and CAC 40 indices but only at the 10 per cent significance level. I conclude that the three European markets react to the information revealed on these markets approximately within 1 hour, with the strongest reaction occurring after 20 minutes. The fastest is the reaction of the FTSE 100 index whose first reaction to the DAX 30 and CAC 40 indices seems to occur within 5 minutes.

Fourth, I look at the results of Granger causality between the Frankfurt index DAX 30 and the three indices from the relatively small Eastern European stock markets in Warsaw (WIG 20), Prague (PX 50), and Budapest (BUX). I find evidence that the DAX 30 index Granger causes all the three Eastern European stock market indices. There is little evidence of an opposite relationship. With 5 minute frequency data, the DAX 30 index Granger causes the WIG 20 and BUX indices at the 1 per cent significance level. With this data frequency an opposite Granger causality relationship is also detected between the DAX 30 and WIG 20 indices but only at the 5 per cent level of significance. Additionally the DAX 30 index Granger causes the WIG 20 index with 10 minutes and 30 minutes data frequency at the 5 per cent significance level. With 40 minute, 50 minute, and 1 hour data frequencies, the DAX 30 index Granger causes all the three Eastern European stock market indices at different levels of significance with the strongest result for the WIG 20 index, where Granger causality is detected at the 1 per cent significance level with all the three data frequencies. Opposite Granger causality relationship is quite rare. WIG 20 and BUX Granger cause DAX 30 with 40 minute data frequency but only at the 10 per cent significance level and the WIG 20 index Granger causes the DAX 30 index also with daily data frequency but again only at the 10 per cent level of significance. As already mentioned the WIG 20 index also Granger causes the DAX 30 index with the highest 5 minute data frequency at the 5 percent level of significance, while the opposite Granger causality relationship is detected at the 1 per cent significance level. I conclude that the three small markets react to the information revealed on the market in Frankfurt and not vice versa. The stock market in Prague seems to react more slowly than the markets in Warsaw and Budapest. However, in all three cases the information is predominantly transmitted after 40 minutes to 1 hour. Thus, the speed of the reaction of these markets is slightly slower but comparable to that between the major European markets. This finding partly contradicts the results of various studies that investigate informational efficiency and various types of information transmission with the emerging Eastern European markets, e.g., Hanousek and Filer (2000) or Podpiera (2000 and 2001). These studies find typically little evidence for informational efficiency of these markets and are in this sense particularly skeptical about the stock market in Prague.

Finally, I consider Granger causality among the indices from the three markets in Warsaw, Prague, and Budapest (WIG 20, PX 50, and BUX).[8] With the pair WIG 20 and PX 50 I detect Granger causality with 5, 30, 40 minute, 1 hour, and 1 day data frequencies. However, the result with the 5 minute data frequency is weak. The PX 50 index Granger causes the WIG 20 index with 5 minute data frequency only at the 10

[8] An overview on the general developments and the specific features of Warsaw, Prague, and Budapest stock markets is available for example in Egert and Kočenda (2005).

percent significance level. With 30 minute and 1 hour data frequencies, the PX 50 index Granger causes the WIG 20 index at the 1 per cent significance level, while the opposite Granger causality relationship is detected at the 5 per cent level of significance. With 40 minute data frequency both directions of Granger causality appear but only at the 10 per cent significance level. Additionally PX 50 is found to Granger cause WIG 20 with daily data at the 5 per cent significance level. Thus, the Granger causality pattern between the WIG 20 and PX 50 indices is somewhat chaotic. Much more interesting are the results with the pair WIG 20 and BUX and particularly with the pair PX 50 and BUX. The BUX index is found to predominantly Granger cause the WIG 20 and PX 50 indices and not vice versa. This result is notably strong with the pair of indices PX 50 and BUX. With all the data frequencies ranging from 20 minute to 1 hour, the BUX index Granger causes the PX 50 index at the 1 per cent level of significance. Additionally, the same result is found with 10 minute and daily data frequencies, but only at the 10 per cent significance level. The opposite Granger causality relationship is detected only with 40 minute and daily data frequencies and only at the 10 and 5 percent levels of significance, respectively. With the pair of indices WIG 20 and BUX the dominance of the BUX index is not so obvious. However, also here the BUX index Granger causes the WIG 20 index with 10 minute, 50 minute, and 1 hour data frequencies at the 5 per cent significance level, while the WIG 20 index Granger causes the BUX index only with 5 minute and 1 hour data frequencies and only at the 10 per cent level of significance. Therefore, I conclude that among the three Eastern European stock markets the market in Budapest is a clear leader. The markets in Warsaw and Prague react to it within 1 hour. Particularly strong is the reaction of the stock market in Prague.[9]

[9] Admittedly, this conclusion is rather daring. It might be the case that the market in Prague reacts to the same information as the market in Budapest but with a delay, particularly as a slower reaction to changes in the DAX index was detected with the Prague market.

2.4.2 Order of Integration

The results of the order of integration tests are presented in Table A.2 in Appendix A. Note that for different pairs of indices I use different observations. Therefore, the results for one index could differ depending on the other index included in the pair. In line with the previous empirical research and with the theoretical stochastic models of stock prices, most of the indices are found to be *I(1)* at any frequency and using any significance level in the tests. However, with some indices and some data frequencies (particularly with daily data frequency), I find systematic deviations from this rule. Namely, the FTSE 100, DAX 30, CAC 40, and WIG 20 indices are in some cases found to be stationary already in levels, i.e. *I(0)*. The individual cases are listed below.

The FTSE 100 index appears to be *I(0)* with 40 minute and daily data frequencies at the 10 per cent significance level when used in a pair with other European indices (daily observations at 15:40). With daily frequency data, the FTSE 100 is also found to be *I(0)* even at the 5 per cent significance level when used in a pair with the U.S. S&P 500 index (daily observations at 17:15). The DAX 30 index with daily data frequency is found to be *I(0)* at the 5 per cent significance level when used in any pair with other indices. The CAC 40 index is tested as *I(0)* with daily data frequency at the 10 per cent significance level when used in a pair with other European indices. Finally, the WIG 20 index is found to be *I(0)* with daily data frequency at the 5 per cent significance level when used in a pair with the DAX 30 index and the other Easter European indices. Here, I do not have any explanation for these surprising results other than the limitations of the used econometric techniques rather than some fundamental pattern.

2.4.3 Cointegration

The results of cointegration tests for different pairs of indices and different data frequencies are given in Table A.2 and the results of the estimation of error correction models are presented in Table A.3 in Appendix A. Cointegration of two time series represents a strong relationship. It implies the existence of a long run equilibrium, towards which the two time series tend to converge. It also implies that the two time series must share a common stochastic trend. Moreover, cointegration tests are based on the ADF test, which is known to have a low power. This means that even if the two time series are cointegrated in reality, the ADF test is quite likely to not detect this relationship. Therefore, it is not surprising that cointegration is detected only rarely in the data. Additionally, to test for cointegration the two time series must be *I(1)*. Thus, the above mentioned indices' time series that were tested as *I(0)* can not be considered as cointegrated with any other index, even if the residuals from the cointegrating equation (4) or (5) were found stationary. Regarding this limitation, I detect cointegration only with two pairs of stock market indices, the FTSE 100 and CAC 40 and the PX 50 and BUX. With these two pairs (particularly with the pair PX 50 and BUX), the pattern of detected Granger causality relationships was also very rich.

For the pair FTSE 100 and CAC 40, cointegration is detected with 30 minute, 50 minute, and 1 hour data frequencies. The error correction models suggest that the CAC 40 index reacts in all cases to the deviations from long run equilibrium. For the pair PX 50 and BUX cointegration is detected with data frequencies ranging from 30 minutes to 1 hour. In all these cases the error correction models show reaction of both indices to the deviations from long run equilibrium. However, the detected reaction of the PX 50 index is stronger confirming the dominance of the BUX index already revealed in the Granger causality tests.

The rare appearance of cointegration relationships contrasts with the findings of other studies that often suggested the presence of cointegration with closing times daily data of various pairs of stock market indices.[10] However, the use of closing time daily data in cointegration tests is quite misleading. Such data are not simultaneous as the closing times of different markets typically differ.

[10] E.g., Huang and Fok (2001), Seabra (2001), Dickinson (2000), Bracker et al. (1999), Chelley-Steeley et al. (1998), Richards (1996), or Chou et al. (1994)

2.5 Conclusion

Using a dataset covering two years of high frequency data, I investigate the issue of stock market integration from a novel perspective. I perform cointegration and Granger causality tests with data of different frequencies. My aim is to describe the time structure in which markets react to the information revealed in prices on other markets. Particularly, I want to detect the speed of information transmission between the different markets. I employ the indices from the U.S. stock markets (S&P 500 and Dow Jones Industrial Average), London (FTSE 100), Frankfurt (DAX 30), Paris (CAC 40), Warsaw (WIG 20), Prague (PX 50), and Budapest (BUX). The tests are performed for twelve different pairs of indices using data of 5, 10, 20, 30, 40, 50 minute, 1 hour, and daily frequencies.

Presented results suggest that the markets react very quickly to the information revealed in the prices on other markets. In all cases the strongest reaction occurs within 1 hour with the first reaction detected often after only 5 minutes. The U.S. markets seem to be an important source of information for the markets in London and Frankfurt; they react to it approximately within 30 to 40 minutes, with the strongest reaction occurring within the first 10 minutes. The three major European markets in London, Frankfurt, and Paris react to the information revealed on these markets within 1 hour, while the strongest reaction is detected after 20 minutes. The fastest is the reaction of the FTSE 100 index. The three small Eastern European markets in Warsaw, Prague, and Budapest react to the information revealed on the market in Frankfurt predominantly after 40 minutes to 1 hour. The slowest seems to be the reaction of the stock market in Prague. The stock market in Budapest appears to be a clear leader among the three Eastern European markets. The markets in Warsaw and Prague react to it within 1 hour, while the reaction of the stock market in Prague is particularly strong.

I am aware that when interpreting the results, I have neglected the differences in institutional arrangements of each of the stock markets. On the other hand, the aim of each stock market is to have a fast, efficient, and transparent trading system that helps to quickly reveal undistorted stock prices. Thus, when investigating information transmission, slight differences in institutional arrangements on the different markets should not matter too much.[11]

[11] To get a detailed description of the trading systems on each of the markets and for each of the stocks included in the investigated indices would be almost impossible. Some of the indices might contain stocks that are traded using different systems on the same market. Moreover, the U.S. indices S&P 500 and DJIA contain stocks that are traded on different markets.

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2.6 Appendix A

Table A.1: Results of Granger causality tests.

Data frequency	lnx_t GC lny_t				lny_t GC lnx_t			
	Obs.	***K***	R^2	**P-value**	**Obs.**	***K***	R^2	**P-value**
x_t = S&P 500; y_t = DJIA								
5 minute	488	3	0.028	*0.090*	487	3	0.040	*0.005*
10 minute	488	8	0.055	*0.517*	487	8	0.058	*0.468*
20 minute	487	6	0.036	*0.361*	486	6	0.036	*0.267*
30 minute	488	7	0.057	*0.085*	486	6	0.055	*0.587*
40 minute	488	4	0.040	*0.088*	487	4	0.042	*0.375*
50 minute	486	3	0.021	*0.302*	485	3	0.023	*0.276*
1 hour	488	4	0.020	*0.309*	486	4	0.022	*0.649*
1 day	428	2	0.008	*0.263*	427	2	0.010	*0.208*
x_t = S&P 500; y_t = FTSE 100								
5 minute	474	1	0.031	*0.001*	473	6	0.029	*0.519*
10 minute	473	3	0.016	*0.097*	470	8	0.029	*0.303*
20 minute	474	1	0.005	*0.114*	474	1	0.001	*0.663*
30 minute	471	2	0.019	*0.522*	471	1	0.014	*0.988*
40 minute	470	1	0.000	*0.763*	471	1	0.009	*0.721*
50 minute	470	1	0.001	*0.628*	475	1	0.008	*0.831*
1 hour								
1 day	430	1	0.009	*0.549*	432	1	0.013	*0.739*
x_t = S&P 500; y_t = DAX 30								
5 minute	480	1	0.023	*0.013*	480	1	0.009	*0.406*
10 minute	476	8	0.038	*0.567*	476	8	0.043	*0.034*
20 minute	480	1	0.004	*0.216*	480	1	0.001	*0.855*
30 minute	477	1	0.014	*0.035*	477	1	0.013	*0.840*
40 minute	476	1	0.006	*0.099*	481	1	0.009	*0.521*
50 minute	476	1	0.001	*0.598*	481	1	0.006	*0.977*
1 hour								
1 day	332	8	0.048	*0.451*	323	8	0.070	*0.173*
x_t = FTSE 100; y_t = DAX 30								
5 minute	488	4	0.040	*0.489*	488	5	0.064	*0.007*
10 minute	488	7	0.059	*0.266*	488	2	0.037	*0.116*
20 minute	485	7	0.068	*0.044*	485	7	0.073	*0.002*
30 minute	487	8	0.079	*0.002*	487	8	0.061	*0.107*
40 minute	486	6	0.052	*0.057*	486	6	0.035	*0.598*
50 minute	487	1	0.005	*0.154*	486	3	0.028	*0.004*
1 hour	487	4	0.045	*0.094*	487	4	0.033	*0.100*
1 day	404	6	0.029	*0.485*	397	6	0.038	*0.106*
x_t = FTSE 100; y_t = CAC 40								
5 minute	490	4	0.051	*0.233*	490	5	0.057	*0.028*
10 minute	489	8	0.059	*0.162*	490	4	0.049	*0.235*
20 minute	488	7	0.054	*0.203*	488	7	0.062	*0.030*
30 minute	485	8	0.067	*0.006*	485	8	0.076	*0.011*
40 minute	485	6	0.049	*0.016*	485	6	0.047	*0.128*
50 minute	488	3	0.010	*0.397*	485	6	0.049	*0.010*
1 hour	486	4	0.034	*0.079*	486	4	0.037	*0.040*
1 day	455	2	0.021	*0.139*	447	2	0.029	*0.030*

Table A.1: Continued.

Data frequency	lnx_t GC lny_t				lny_t GC lnx_t			
	Obs.	***K***	**R^2**	**P-value**	**Obs.**	***K***	**R^2**	**P-value**
x_t = DAX 30; y_t = CAC 40								
5 minute	497	8	0.076	*0.151*	497	7	0.051	*0.326*
10 minute	498	6	0.055	*0.060*	498	6	0.061	*0.048*
20 minute	493	7	0.055	*0.122*	496	4	0.047	*0.122*
30 minute	492	8	0.055	*0.045*	492	8	0.069	*0.013*
40 minute	497	1	0.029	*0.006*	491	7	0.054	*0.157*
50 minute	494	4	0.036	*0.004*	494	4	0.030	*0.018*
1 hour	494	3	0.034	*0.039*	493	4	0.053	*0.023*
1 day	465	4	0.013	*0.076*	440	8	0.048	*0.052*
x_t = DAX 30; y_t = WIG 20								
5 minute	483	7	0.120	*0.003*	483	6	0.068	*0.019*
10 minute	482	6	0.045	*0.013*	482	5	0.042	*0.631*
20 minute	478	6	0.038	*0.595*	482	2	0.030	*0.617*
30 minute	481	2	0.024	*0.014*	480	8	0.046	*0.545*
40 minute	481	2	0.038	*0.002*	479	7	0.061	*0.085*
50 minute	481	1	0.034	*0.000*	485	5	0.020	*0.694*
1 hour	481	1	0.029	*0.001*	485	4	0.033	*0.974*
1 day	395	4	0.034	*0.128*	391	5	0.039	*0.055*
x_t = DAX 30; y_t = PX 50								
5 minute	465	7	0.061	*0.501*	465	8	0.052	*0.804*
10 minute	464	8	0.064	*0.532*	469	7	0.047	*0.931*
20 minute	469	6	0.068	*0.593*	478	2	0.031	*0.616*
30 minute	463	8	0.054	*0.180*	467	8	0.039	*0.884*
40 minute	454	8	0.059	*0.034*	458	7	0.051	*0.689*
50 minute	471	4	0.036	*0.042*	417	6	0.027	*0.657*
1 hour	464	5	0.070	*0.004*	472	4	0.044	*0.299*
1 day	347	8	0.047	*0.530*	369	7	0.023	*0.485*
x_t = DAX 30; y_t = BUX								
5 minute	481	1	0.015	*0.008*	481	4	0.046	*0.362*
10 minute	481	7	0.028	*0.465*	481	5	0.045	*0.389*
20 minute	481	1	0.026	*0.368*	486	2	0.026	*0.646*
30 minute	481	1	0.019	*0.148*	484	8	0.042	*0.680*
40 minute	478	8	0.039	*0.096*	486	1	0.025	*0.077*
50 minute	471	7	0.083	*0.001*	476	7	0.044	*0.105*
1 hour	479	4	0.044	*0.020*	484	4	0.045	*0.250*
1 day	344	8	0.054	*0.198*	456	1	0.004	*0.609*
x_t = WIG 20; y_t = PX 50								
5 minute	458	7	0.059	*0.649*	458	8	0.074	*0.073*
10 minute	455	8	0.064	*0.525*	461	7	0.031	*0.441*
20 minute	460	6	0.071	*0.371*	466	5	0.031	*0.293*
30 minute	454	8	0.064	*0.047*	467	3	0.036	*0.007*
40 minute	448	7	0.049	*0.097*	472	2	0.025	*0.065*
50 minute	456	5	0.029	*0.251*	468	4	0.019	*0.229*
1 hour	457	4	0.046	*0.040*	470	3	0.036	*0.009*
1 day	318	7	0.068	*0.117*	315	7	0.058	*0.029*

Table A.1: Continued.

Data frequency	lnx_t GC lny_t				lny_t GC lnx_t			
	Obs.	***K***	**R^2**	**P-value**	**Obs.**	***K***	**R^2**	**P-value**
x_t = WIG 20; y_t = BUX								
5 minute	474	7	0.042	*0.052*	474	7	0.090	*0.713*
10 minute	474	2	0.013	*0.432*	474	3	0.027	*0.025*
20 minute	470	8	0.044	*0.428*	471	5	0.021	*0.887*
30 minute	470	8	0.050	*0.481*	473	1	0.006	*0.214*
40 minute	470	6	0.026	*0.220*	472	2	0.015	*0.514*
50 minute	471	5	0.050	*0.127*	473	1	0.014	*0.014*
1 hour	470	4	0.043	*0.053*	472	1	0.015	*0.034*
1 day	431	1	0.001	*0.522*	428	1	0.005	*0.480*
x_t = PX 50; y_t = BUX								
5 minute	475	1	0.002	*0.316*	460	7	0.059	*0.906*
10 minute	469	2	0.016	*0.179*	459	8	0.081	*0.061*
20 minute	474	1	0.025	*0.579*	461	8	0.171	*0.000*
30 minute	464	7	0.036	*0.756*	456	8	0.114	*0.000*
40 minute	452	7	0.033	*0.075*	449	8	0.082	*0.002*
50 minute	458	5	0.025	*0.891*	408	6	0.085	*0.000*
1 hour	460	4	0.018	*0.881*	457	5	0.092	*0.000*
1 day	313	7	0.063	*0.045*	313	7	0.089	*0.052*

Notes: Obs. stand for the number of observations and *K* for the number of lagged differences used in the Granger causality tests. The R^2 stands for that of the unrestricted equations. The reported P-values indicate the F-tests' significance levels at which the null hypothesis of no Granger causality can be rejected.

Table A.2: Results of cointegration and the order of integration tests.

	ADF tests on residuals from						ADF tests on levels and differences			
Data	$\ln y_t = c + \alpha \ln x_t + \varepsilon_t$			$\ln x_t = c + \alpha \ln y_t + \varepsilon_t$			$\ln x_t$	$\Delta \ln x_t$	$\ln y_t$	$\Delta \ln y_t$
Frequency	**Obs.**	***K***	**P-value**	**Obs.**	***K***	**P-value**	**P-value**	**P-value**	**P-value**	**P-value**
				x_t = S&P 500; y_t = DJIA						
5 minute	487	7	*0.802*	487	7	*0.941*	0.982	0.000	0.841	0.000
10 minute	487	4	*0.824*	487	4	*0.945*	0.977	0.000	0.858	0.000
20 minute	486	6	*0.961*	486	6	*0.993*	0.985	0.000	0.970	0.000
30 minute	487	4	*0.865*	487	4	*0.971*	0.958	0.000	0.864	0.000
40 minute	487	5	*0.836*	487	5	*0.974*	0.938	0.000	0.725	0.000
50 minute	485	3	*0.978*	485	3	*0.993*	0.995	0.000	0.986	0.000
1 hour	487	0	*0.998*	487	0	*0.999*	0.995	0.000	0.993	0.000
1 day	467	0	*0.784*	467	0	*0.954*	0.256	0.000	0.361	0.000
				x_t = S&P 500; y_t = FTSE 100						
5 minute	474	3	*0.999*	474	3	*0.996*	0.994	0.000	0.999	0.000
10 minute	470	6	*0.980*	473	3	*0.991*	0.998	0.000	0.999	0.000
20 minute	475	0	*0.896*	475	0	*0.883*	0.976	0.000	0.999	0.000
30 minute	475	0	*0.803*	475	0	*0.787*	0.755	0.000	0.951	0.000
40 minute	474	0	*0.906*	474	0	*0.693*	0.702	0.000	0.888	0.028
50 minute	471	0	*0.965*	471	0	*0.858*	0.564	0.000	0.823	0.000
1 hour										
1 day	317	6	*0.993*	317	6	*0.979*	0.419	0.000	0.037	0.000
				x_t = S&P 500; y_t = DAX 30						
5 minute	480	4	*0.990*	480	4	*0.973*	0.994	0.000	0.998	0.000
10 minute	476	7	*0.944*	476	7	*0.939*	0.998	0.000	0.997	0.000
20 minute	476	3	*0.954*	481	0	*0.872*	0.976	0.000	1.000	0.000
30 minute	477	1	*0.857*	481	0	*0.743*	0.755	0.000	0.992	0.000
40 minute	480	0	*0.897*	480	0	*0.684*	0.702	0.000	0.977	0.000
50 minute	477	0	*0.371*	476	1	*0.285*	0.564	0.000	0.959	0.003
1 hour										
1 day	384	4	*0.056*	384	4	*0.181*	0.419	0.000	0.044	0.000
				x_t = FTSE 100; y_t = DAX 30						
5 minute	488	7	*0.997*	488	7	*0.898*	0.997	0.000	1.000	0.000
10 minute	488	1	*0.989*	488	2	*0.827*	0.642	0.000	1.000	0.000
20 minute	487	4	*0.937*	487	4	*0.659*	0.220	0.000	0.990	0.000
30 minute	488	1	*0.915*	488	1	*0.515*	0.217	0.000	0.977	0.000
40 minute	488	1	*0.642*	488	1	*0.363*	0.096	0.000	0.977	0.000
50 minute	487	1	*0.410*	487	1	*0.156*	0.225	0.000	0.996	0.000
1 hour	488	0	*0.427*	488	0	*0.281*	0.906	0.000	0.998	0.000
1 day	460	1	*0.014*	460	1	*0.127*	0.087	0.000	0.043	0.000
				x_t = FTSE 100; y_t = CAC 40						
5 minute	490	5	*0.970*	490	5	*0.778*	0.997	0.000	1.000	0.000
10 minute	490	2	*0.872*	490	5	*0.415*	0.642	0.000	1.000	0.000
20 minute	489	4	*0.910*	489	4	*0.364*	0.220	0.000	0.998	0.000
30 minute	489	3	*0.587*	489	3	*0.075*	0.217	0.000	0.972	0.000
40 minute	489	2	*0.030*	489	2	*0.005*	0.096	0.000	0.941	0.000
50 minute	489	1	*0.006*	489	1	*0.001*	0.225	0.000	0.981	0.000
1 hour	484	5	*0.009*	484	5	*0.003*	0.906	0.000	0.992	0.000
1 day	475	0	*0.069*	475	0	*0.139*	0.087	0.000	0.060	0.000

Table A.2: Continued.

Data frequency	ADF tests on residuals from						ADF tests on levels and differences			
	$\ln y_t = c + \alpha \ln x_t + \varepsilon_t$			$\ln x_t = c + \alpha \ln y_t + \varepsilon_t$			$\ln x_t$	$\Delta \ln x_t$	$\ln y_t$	$\Delta \ln y_t$
	Obs.	***K***	**P-value**	**Obs.**	***K***	**P-value**	**P-value**	**P-value**	**P-value**	**P-value**
x_t = DAX 30; y_t = CAC 40										
5 minute	498	5	*1.000*	498	5	*1.000*	1.000	0.000	1.000	0.000
10 minute	497	8	*1.000*	497	8	*1.000*	1.000	0.000	1.000	0.000
20 minute	493	8	*0.995*	493	8	*0.987*	0.990	0.000	0.998	0.000
30 minute	498	0	*1.000*	494	7	*0.999*	0.977	0.000	0.972	0.000
40 minute	497	1	*1.000*	491	7	*0.999*	0.977	0.000	0.941	0.000
50 minute	496	1	*1.000*	498	0	*0.999*	0.996	0.000	0.981	0.000
1 hour	498	0	*0.998*	494	3	*0.997*	0.998	0.000	0.992	0.000
1 day	483	1	*0.254*	483	1	*0.084*	0.043	0.000	0.060	0.000
x_t = DAX 30; y_t = WIG 20										
5 minute	483	2	*0.999*	483	3	*1.000*	1.000	0.000	0.999	0.000
10 minute	482	6	*1.000*	482	6	*1.000*	1.000	0.000	0.998	0.000
20 minute	481	3	*0.653*	481	3	*0.842*	0.990	0.000	0.605	0.000
30 minute	481	2	*0.893*	481	2	*0.875*	0.977	0.000	0.866	0.000
40 minute	482	1	*0.852*	479	7	*0.941*	0.977	0.000	0.347	0.000
50 minute	481	1	*0.885*	481	1	*0.908*	0.996	0.000	0.483	0.000
1 hour	480	3	*0.840*	480	3	*0.891*	0.998	0.000	0.402	0.000
1 day	365	6	*0.239*	365	6	*0.346*	0.043	0.000	0.033	0.000
x_t = DAX 30; y_t = PX 50										
5 minute	462	8	*0.999*	462	8	*1.000*	1.000	0.000	0.999	0.000
10 minute	466	7	*0.999*	466	7	*1.000*	1.000	0.000	0.997	0.000
20 minute	472	4	*0.997*	472	4	*0.999*	0.990	0.000	0.974	0.002
30 minute	463	8	*0.985*	463	8	*0.986*	0.977	0.000	0.855	0.000
40 minute	455	7	*0.960*	455	7	*0.846*	0.977	0.000	0.864	0.000
50 minute	412	6	*0.988*	412	6	*0.872*	0.996	0.000	0.740	0.000
1 hour	464	5	*0.999*	479	0	*0.998*	0.998	0.000	0.580	0.000
1 day	463	0	*0.175*	463	0	*0.019*	0.043	0.000	0.577	0.000
x_t = DAX 30; y_t = BUX										
5 minute	481	5	*0.998*	481	5	*1.000*	1.000	0.000	0.561	0.000
10 minute	481	7	*0.989*	481	7	*0.999*	1.000	0.000	0.932	0.000
20 minute	481	3	*0.822*	481	3	*0.969*	0.990	0.000	0.935	0.000
30 minute	479	8	*0.791*	478	8	*0.936*	0.977	0.000	0.520	0.000
40 minute	481	1	*0.945*	478	7	*0.965*	0.977	0.000	0.932	0.000
50 minute	480	1	*0.961*	478	5	*0.978*	0.996	0.000	0.767	0.000
1 hour	479	4	*0.972*	479	4	*0.985*	0.998	0.000	0.859	0.000
1 day	463	0	*0.427*	463	0	*0.046*	0.043	0.000	0.692	0.000
x_t = WIG 20; y_t = PX 50										
5 minute	458	7	*0.998*	458	7	*0.997*	0.999	0.000	0.999	0.000
10 minute	460	6	*0.992*	460	6	*0.995*	0.998	0.000	0.997	0.000
20 minute	472	0	*0.668*	463	5	*0.577*	0.605	0.000	0.974	0.002
30 minute	470	0	*0.834*	470	0	*0.901*	0.866	0.000	0.855	0.000
40 minute	472	0	*0.468*	472	0	*0.446*	0.347	0.000	0.864	0.000
50 minute	475	0	*0.399*	475	0	*0.474*	0.483	0.000	0.740	0.000
1 hour	471	0	*0.512*	471	0	*0.510*	0.402	0.000	0.580	0.000
1 day	449	0	*0.118*	449	0	*0.011*	0.033	0.000	0.577	0.000

Table A.2: Continued.

Data frequency	ADF tests on residuals from						ADF tests on levels and differences			
	$\ln y_t = c + \alpha \ln x_t + \varepsilon_t$			$\ln x_t = c + \alpha \ln y_t + \varepsilon_t$			$\ln x_t$	$\Delta \ln x_t$	$\ln y_t$	$\Delta \ln y_t$
	Obs.	***K***	**P-value**	**Obs.**	***K***	**P-value**	**P-value**	**P-value**	**P-value**	**P-value**
				***x_t* = WIG 20; *y_t* = BUX**						
5 minute	474	7	*0.994*	474	7	*0.996*	0.999	0.000	0.561	0.000
10 minute	474	0	*0.986*	474	0	*0.993*	0.998	0.000	0.932	0.000
20 minute	471	5	*0.246*	471	5	*0.316*	0.605	0.000	0.935	0.000
30 minute	471	5	*0.604*	471	5	*0.865*	0.866	0.000	0.520	0.000
40 minute	472	2	*0.216*	472	2	*0.335*	0.347	0.000	0.932	0.000
50 minute	474	0	*0.339*	474	0	*0.515*	0.483	0.000	0.767	0.000
1 hour	473	0	*0.562*	473	0	*0.619*	0.402	0.000	0.859	0.000
1 day	447	0	*0.142*	447	0	*0.007*	0.033	0.000	0.692	0.000
				***x_t* = PX 50; *y_t* = BUX**						
5 minute	461	6	*0.987*	461	6	*0.989*	0.999	0.000	0.561	0.000
10 minute	474	0	*0.904*	474	0	*0.897*	0.997	0.000	0.932	0.000
20 minute	465	6	*0.321*	465	6	*0.319*	0.974	0.002	0.935	0.000
30 minute	456	8	*0.099*	456	8	*0.098*	0.855	0.000	0.520	0.000
40 minute	462	6	*0.023*	462	6	*0.025*	0.864	0.000	0.932	0.000
50 minute	457	5	*0.003*	457	5	*0.003*	0.740	0.000	0.767	0.000
1 hour	459	4	*0.002*	459	4	*0.001*	0.580	0.000	0.859	0.000
1 day	325	6	*0.347*	325	6	*0.333*	0.577	0.000	0.692	0.000

Notes: Obs. stand for the number of observations and *K* for the number of lagged differences used in the ADF tests. The reported P-values indicate the ADF tests' significance levels at which the null hypothesis of non-stationarity can be rejected. Finite sample critical values are from Cheung and Lai (1995) for the ADF tests with the levels and differences of indices' logarithms and from MacKinnon (1991) for the ADF tests with the residuals. P-values other than 0.01, 0.05, and 0.10 are computed using a logistic interpolation. Such P-values are fine for testing at the common significance levels of 10%, 5%, and 1%, but rather speculative outside this range.

Table A.3: Results of the estimation of error correction models.

Data frequency	Estimated equation											
	$\Delta \ln y_t = c_1 + \delta_1 e_{t-1} + \sum_{i=1}^{K} \alpha_{1i} \Delta \ln y_{t-i} + \sum_{i=1}^{K} \beta_{1i} \Delta \ln x_{t-i} + \varepsilon_t$						$\Delta \ln x_t = c_1 + \delta_1 e_{t-1} + \sum_{i=1}^{K} \alpha_{1i} \Delta \ln x_{t-i} + \sum_{i=1}^{K} \beta_{1i} \Delta \ln y_{t-i} + \varepsilon_t$					
	Residuals e_t from the equation						**Residuals e_t from the equation**					
	$\ln y_t = c + \alpha \ln x_t + \varepsilon_t$			$\ln x_t = c + \alpha \ln y_t + \varepsilon_t$			$\ln y_t = c + \alpha \ln x_t + \varepsilon_t$			$\ln x_t = c + \alpha \ln y_t + \varepsilon_t$		
	Obs.	***K***	**P-value**	**Obs.**	***K***	**P-value**	**Obs.**	***K***	**P-value**	**Obs.**	***K***	**P-value**
x_t = S&P 500; y_t = DJIA												
5 minute	488	3	*0.144*	488	3	*0.360*	487	3	*0.257*	487	3	*0.529*
10 minute	488	8	*0.219*	488	8	*0.516*	487	8	*0.339*	487	8	*0.685*
20 minute	487	6	*0.317*	487	6	*0.442*	486	6	*0.395*	486	6	*0.469*
30 minute	488	7	*0.159*	488	7	*0.307*	486	6	*0.242*	486	6	*0.396*
40 minute	488	4	*0.291*	488	4	*0.602*	487	4	*0.426*	487	4	*0.730*
50 minute	486	3	*0.888*	486	3	*0.629*	485	3	*0.623*	485	3	*0.449*
1 hour	488	4	*0.570*	488	4	*0.349*	486	4	*0.445*	486	4	*0.286*
1 day	428	2	*0.094*	428	2	*0.238*	427	2	*0.242*	427	2	*0.407*
x_t = S&P 500; y_t = FTSE 100												
5 minute	474	1	*0.957*	474	1	*0.846*	473	6	*0.778*	473	6	*0.862*
10 minute	473	3	*0.554*	473	3	*0.351*	470	8	*0.938*	470	8	*0.598*
20 minute	475	0	*0.333*	475	0	*0.588*	475	0	*0.051*	475	0	*0.146*
30 minute	471	2	*0.413*	471	2	*0.348*	475	0	*0.062*	475	0	*0.066*
40 minute	474	0	*0.535*	474	0	*0.477*	475	0	*0.115*	475	0	*0.054*
50 minute	471	0	*0.176*	471	0	*0.249*	476	0	*0.083*	476	0	*0.078*
1 hour												
1 day	433	1	*0.853*	433	1	*0.935*	458	0	*0.491*	458	0	*0.220*
x_t = S&P 500; y_t = DAX 30												
5 minute	480	1	*0.401*	480	1	*0.437*	481	0	*0.539*	481	0	*0.736*
10 minute	476	8	*0.160*	476	8	*0.061*	476	8	*0.414*	476	8	*0.240*
20 minute	481	0	*0.255*	481	0	*0.467*	481	0	*0.066*	481	0	*0.120*
30 minute	477	1	*0.956*	477	1	*0.813*	481	0	*0.457*	481	0	*0.431*
40 minute	480	0	*0.507*	480	0	*0.542*	485	0	*0.163*	485	0	*0.106*
50 minute	477	0	*0.917*	477	0	*0.806*	482	0	*0.186*	482	0	*0.174*
1 hour												
1 day	332	8	*0.336*	332	8	*0.572*	323	8	*0.940*	323	8	*0.809*
x_t = FTSE 100; y_t = DAX 30												
5 minute	488	4	*0.003*	488	4	*0.034*	488	8	*0.000*	488	8	*0.001*
10 minute	488	7	*0.005*	488	7	*0.039*	488	4	*0.000*	488	4	*0.001*
20 minute	485	7	*0.259*	485	7	*0.479*	485	7	*0.017*	485	7	*0.029*
30 minute	487	8	*0.238*	487	8	*0.349*	487	8	*0.011*	487	8	*0.008*
40 minute	486	6	*0.176*	486	6	*0.214*	486	6	*0.001*	486	6	*0.002*
50 minute	486	5	*0.067*	486	5	*0.083*	486	5	*0.000*	486	5	*0.000*
1 hour	487	4	*0.322*	487	4	*0.329*	487	4	*0.001*	487	4	*0.003*
1 day	404	6	*0.174*	404	6	*0.350*	397	6	*0.598*	397	6	*0.454*
x_t = FTSE 100; y_t = CAC 40												
5 minute	490	4	*0.117*	490	4	*0.328*	490	5	*0.021*	490	5	*0.024*
10 minute	489	8	*0.073*	489	8	*0.346*	490	4	*0.004*	490	4	*0.007*
20 minute	488	7	*0.106*	488	7	*0.319*	488	7	*0.005*	488	7	*0.007*
30 minute	485	8	*0.225*	485	8	*0.480*	485	8	*0.007*	485	8	*0.005*
40 minute	485	6	*0.510*	485	6	*0.759*	485	6	*0.001*	485	6	*0.001*
50 minute	488	3	*0.798*	488	3	*0.962*	485	6	*0.001*	485	6	*0.001*
1 hour	486	4	*0.628*	486	4	*0.493*	486	4	*0.015*	486	4	*0.020*
1 day	381	8	*0.254*	381	8	*0.328*	447	2	*0.862*	447	2	*0.862*

Table A.3: Continued.

	Estimated equation											
	$\Delta \ln y_t = c_1 + \delta_1 e_{t-1} + \sum_{i=1}^{K} \alpha_{1i} \Delta \ln y_{t-i} + \sum_{i=1}^{K} \beta_{1i} \Delta \ln x_{t-i} + \varepsilon_t$						$\Delta \ln x_t = c_1 + \delta_1 e_{t-1} + \sum_{i=1}^{K} \alpha_{1i} \Delta \ln x_{t-i} + \sum_{i=1}^{K} \beta_{1i} \Delta \ln y_{t-i} + \varepsilon_t$					
	Residuals e_t from the equation						**Residuals e_t from the equation**					
Data	$\ln y_t = c + \alpha \ln x_t + \varepsilon_t$			$\ln x_t = c + \alpha \ln y_t + \varepsilon_t$			$\ln y_t = c + \alpha \ln x_t + \varepsilon_t$			$\ln x_t = c + \alpha \ln y_t + \varepsilon_t$		
frequency	**Obs.**	***K***	**P-value**	**Obs.**	***K***	**P-value**	**Obs.**	***K***	**P-value**	**Obs.**	***K***	**P-value**
x_t = DAX 30; y_t = CAC 40												
5 minute	497	8	0.248	497	8	0.083	497	7	0.151	497	7	0.046
10 minute	498	6	0.536	498	6	0.206	498	6	0.205	498	6	0.080
20 minute	493	7	0.214	493	7	0.441	496	4	0.387	496	4	0.554
30 minute	492	8	0.310	492	8	0.526	492	8	0.766	492	8	0.906
40 minute	497	1	0.756	497	1	0.979	491	7	0.896	491	7	0.825
50 minute	494	4	0.496	494	4	0.319	494	4	0.297	494	4	0.217
1 hour	494	3	0.595	494	3	0.450	493	4	0.464	493	4	0.413
1 day	465	4	0.933	465	4	0.849	440	8	0.910	440	8	0.635
x_t = DAX 30; y_t = WIG 20												
5 minute	483	7	0.255	483	7	0.298	483	6	0.882	483	6	0.188
10 minute	482	6	0.509	482	6	0.640	482	5	0.488	482	5	0.116
20 minute	478	6	0.085	478	6	0.067	482	2	0.597	482	2	0.997
30 minute	481	2	0.202	481	2	0.083	480	8	0.857	480	8	0.867
40 minute	481	2	0.106	481	2	0.093	479	7	0.826	479	7	0.681
50 minute	481	1	0.090	481	1	0.055	485	5	0.750	485	5	0.594
1 hour	481	1	0.074	481	1	0.059	485	4	0.866	485	4	0.745
1 day	395	4	0.047	395	4	0.257	391	5	0.759	391	5	0.267
x_t = DAX 30; y_t = PX 50												
5 minute	465	7	0.569	465	7	0.617	465	8	0.578	465	8	0.137
10 minute	464	8	0.874	464	8	0.631	469	7	0.704	469	7	0.246
20 minute	469	6	0.051	469	6	0.102	478	2	0.544	478	2	0.954
30 minute	463	8	0.131	463	8	0.125	467	8	0.238	467	8	0.358
40 minute	454	8	0.237	454	8	0.254	458	7	0.123	458	7	0.059
50 minute	471	4	0.295	471	4	0.304	417	6	0.298	417	6	0.056
1 hour	464	5	0.254	464	5	0.221	472	4	0.990	472	4	0.703
1 day	347	8	0.086	347	8	0.120	474	0	0.038	474	0	0.002
x_t = DAX 30; y_t = BUX												
5 minute	481	1	0.137	481	1	0.011	481	4	0.282	481	8	0.020
10 minute	481	7	0.013	481	7	0.000	481	5	0.446	481	5	0.066
20 minute	481	3	0.010	481	3	0.001	486	2	0.666	485	4	0.764
30 minute	480	6	0.048	480	6	0.013	484	8	0.528	484	8	0.927
40 minute	481	1	0.108	481	1	0.040	486	1	0.800	486	1	0.839
50 minute	478	5	0.057	478	5	0.014	476	7	0.737	476	7	0.969
1 hour	479	4	0.042	479	4	0.010	484	4	0.721	484	4	0.586
1 day	344	8	0.748	344	8	0.870	473	0	0.028	473	0	0.004
x_t = WIG 20; y_t = PX 50												
5 minute	458	7	0.295	458	7	0.751	458	8	0.748	458	8	0.723
10 minute	455	8	0.495	455	8	0.909	461	7	0.634	461	7	0.940
20 minute	460	6	0.166	460	6	0.360	466	5	0.017	466	5	0.033
30 minute	454	8	0.733	454	8	0.905	467	3	0.135	467	3	0.291
40 minute	448	7	0.388	448	7	0.650	472	2	0.015	472	2	0.026
50 minute	456	5	0.798	456	5	0.993	477	2	0.015	477	2	0.044
1 hour	457	4	0.952	457	4	0.849	474	1	0.014	474	1	0.030
1 day	318	7	0.029	318	7	0.009	315	7	0.069	315	7	0.004

Table A.3: Continued.

Data frequency	Estimated equation											
	$\Delta \ln y_t = c_1 + \delta_1 e_{t-1} + \sum_{i=1}^{K} \alpha_{1i} \Delta \ln y_{t-i} + \sum_{i=1}^{K} \beta_{1i} \Delta \ln x_{t-i} + \varepsilon_t$						$\Delta \ln x_t = c_1 + \delta_1 e_{t-1} + \sum_{i=1}^{K} \alpha_{1i} \Delta \ln x_{t-i} + \sum_{i=1}^{K} \beta_{1i} \Delta \ln y_{t-i} + \varepsilon_t$					
	Residuals e_t from the equation						**Residuals e_t from the equation**					
	$\ln y_t = c + \alpha \ln x_t + \varepsilon_t$			$\ln x_t = c + \alpha \ln y_t + \varepsilon_t$			$\ln y_t = c + \alpha \ln x_t + \varepsilon_t$			$\ln x_t = c + \alpha \ln y_t + \varepsilon_t$		
	Obs.	***K***	**P-value**	**Obs.**	***K***	**P-value**	**Obs.**	***K***	**P-value**	**Obs.**	***K***	**P-value**
x_t =WIG 20; y_t = BUX												
5 minute	474	7	*0.837*	474	7	*0.375*	474	7	*0.995*	474	7	*0.749*
10 minute	474	2	*0.123*	474	2	*0.033*	474	3	*0.927*	474	3	*0.743*
20 minute	470	8	*0.007*	470	8	*0.001*	470	6	*0.078*	470	6	*0.118*
30 minute	470	8	*0.077*	470	8	*0.039*	474	0	*0.169*	474	0	*0.396*
40 minute	470	6	*0.163*	470	6	*0.074*	472	2	*0.028*	472	2	*0.053*
50 minute	471	5	*0.072*	471	5	*0.024*	473	1	*0.072*	473	1	*0.138*
1 hour	470	4	*0.081*	470	4	*0.028*	472	1	*0.158*	472	1	*0.192*
1 day	458	0	*0.468*	458	0	*0.310*	455	0	*0.025*	455	0	*0.001*
x_t = PX 50; y_t = BUX												
5 minute	477	0	*0.347*	477	0	*0.249*	460	7	*0.998*	460	7	*0.752*
10 minute	469	2	*0.269*	469	2	*0.217*	459	8	*0.805*	459	8	*0.704*
20 minute	474	1	*0.124*	474	1	*0.101*	461	8	*0.041*	461	8	*0.067*
30 minute	473	1	*0.107*	473	1	*0.093*	456	8	*0.007*	456	8	*0.011*
40 minute	452	7	*0.056*	452	7	*0.049*	450	7	*0.001*	450	7	*0.002*
50 minute	458	5	*0.005*	458	5	*0.003*	466	4	*0.001*	466	4	*0.001*
1 hour	460	4	*0.003*	460	4	*0.002*	457	5	*0.001*	457	5	*0.001*
1 day	313	7	*0.409*	313	7	*0.478*	313	7	*0.372*	331	6	*0.126*

Notes: Obs. stand for the number of observations and *K* for the number of lagged differences used in the error correction models. The reported P-values are those for the estimated coefficient δ.

3 The Curse of Natural Resources and the Role of Democracy

Abstract:

The curse of natural resources is a robust result based on broad empirical evidence with data from the last four decades. It claims that countries with natural resource intensive economies tend to grow slower than resource-free countries. Political, institutional, and economic environments play an important role in the explanations of the curse. Therefore, there are good reasons to believe that the quality of democracy and regime stability could interact with the curse. I test the robustness of the curse of natural resources with respect to various measures of the quality of democracy and regime stability. I also employ smoothed least trimmed squares, a robust estimation procedure, to estimate the curse. Overall, the curse of natural resources is found to be robust when I control for the quality of democracy and regime stability in growth regressions that estimate it. It also survives the application of the smoothed least trimmed squares procedure. The evidence presented indicates that the intensity of the curse depends on the level of civil liberties. Once a minimal level of democracy is achieved, the intensity of the curse seems to decrease with further increases in the level of civil liberties.

3.1 Introduction

"Why do some economies grow faster than others?" No doubt this is one of the fundamental questions of economics. Together with theoretical efforts to explain cross-country growth differences, this question has motivated wide-ranging empirical research. Particularly, since the influential work of Barro (1991), estimation of cross-country growth regression has experienced a boom. As a result we have a long list of growth determinants that appear as significant explanatory variables in various growth regressions.

In this empirical paper I focus on one of the growth determinants that I believe deserves special attention: the dependence on natural resources. Numerous studies such as those of Auty (1997 and 2001), Gylfason (2001a and 2001b), Gylfason and Zoega (2002) and Sachs and Warner (1995, 1999, and 2001) have shown that countries with natural resources intensive economies grow more slowly than resource-free countries. This rather counterintuitive observation, based mainly on data starting in the 1960s, is commonly called the curse of natural resources. Natural resource dependence with its negative effect on growth was even classified by Sala-i-Martin (1997) and Doppelhofer et al. (2000) as one of the most robust variables in empirical studies of economic growth determinants. At the same time, most of the authors agree that the curse of natural resources is, if not directly mediated, then at least magnified by poor economic policies.

This paper was motivated by the reported robustness of the natural resource curse and the proclaimed possibility to mitigate it with prudent economic policies. I will study the robustness of the curse of natural resources from a perspective that is, to my knowledge, novel. In cross-country growth regressions that estimate the curse, I will control for variables measuring the quality of democracy and regime stability. Further, I will investigate if the magnitude of the curse varies in different groups of countries sorted with respect to these democracy and stability measures. Finally, I will use smoothed least trimmed squares, a robust estimation procedure proposed by Cizek and Visek (2000) and Cizek (2001), to estimate the resource curse regressions. In my analysis I will employ two different data samples covering the average growth over the periods 1965-1998 with 85 countries and 1980-2000 with 117 countries and using different measures of natural resource dependence. With the use of democracy and stability measures, I assume that countries with different levels of democracy and stability could have different chances to implement economic policies that can mitigate the dangers of slow growth induced by natural resources. Previous research has used different measures of natural resource dependence and controlled for numerous variables in the growth regressions in order to test the robustness of the result. However, as far as I know, measures of the quality of democracy and regime stability were rarely used in this context. Also the hypothesis that the curse could have different magnitude among countries with democratic and authoritarian regimes has not been empirically tested. In general, the quality of macro data used in growth regressions is very questionable. Such data are very likely to be highly contaminated with errors. In spite of this, I am not aware of research that would employ robust procedures to systematically estimate the curse.

I am aware of the many problems associated with cross-country growth regressions. As shown for example by Hanousek et al. (2004), the results of these regressions are sensitive to the choice of data from which growth rates are calculated. Also, with the lack of generally accepted growth theory, the growth regressions typically suffer from unclear causality links and related troubles with possible endogeneity of explanatory variables. In spite of all these problems, I believe that the curse of natural resources with its robustness and potential relation to the quality of economic policies deserves further empirical attention. After all, the issue of cross-country growth differences is so complex and probably even exceeds the scope of economics so that we can hardly expect any general economic theory to fully explain it. This is also the reason why the search for growth determinants through the estimation of cross-country growth regressions can still provide a useful insight.

3.2 Natural Resources, Democracy, and Growth

3.2.1 The Curse of Natural Resources – Empirical Evidence

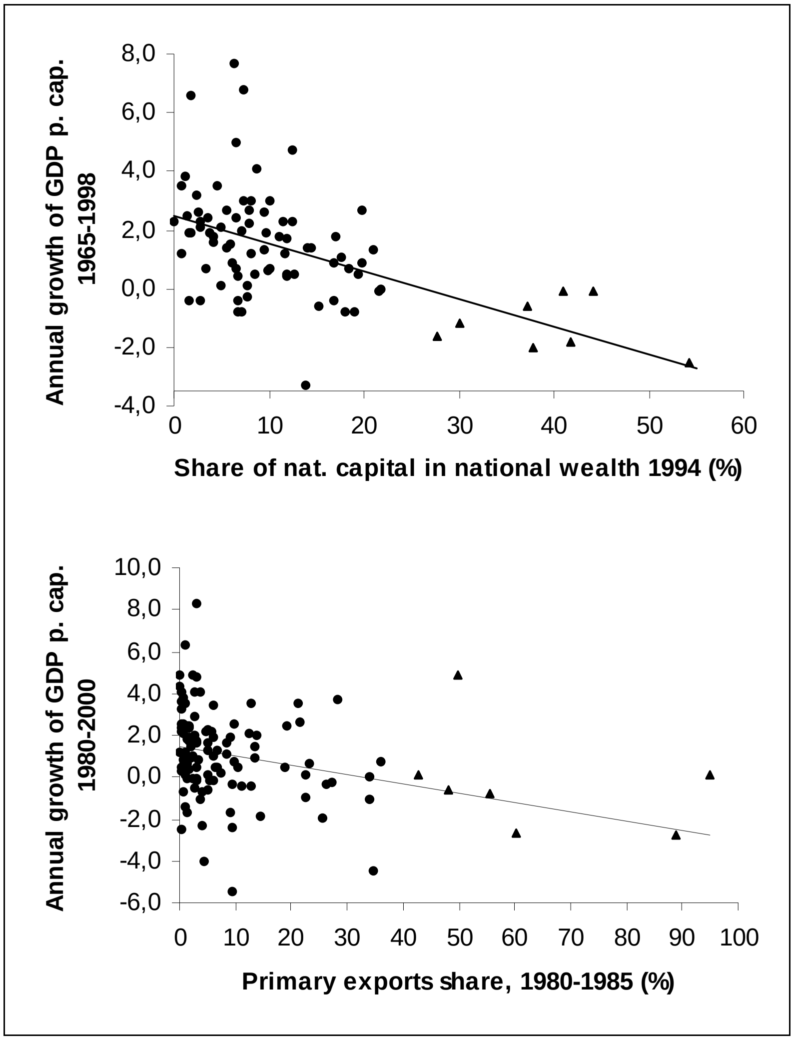

Figure 1: Economic growth and natural resource dependence in the samples 1965-1998 and 1980-2000.

Note: Triangles represent the most resource-dependent countries, which are the Central African Republic, Chad, Guinea-Bissau, Madagascar, Mali, Niger, Sierra Leone, and Zambia in the sample 1965-1998 and Bahrain, Brunei, the Republic of Congo, Gabon, Kuwait, Liberia, Saudi Arabia, and Singapore in the sample 1980-2000.

Source: Gylfason (2001a,b) or Gylfason and Zoega (2002) for the sample 1965-1998 and World Bank (2003) for the sample 1980-2000.

Figure 1 shows the relationship between economic growth and natural resource dependence. It plots the average per capita GDP growth over the period 1965-1998 for 85 countries as a function of the 1994 share of natural capital in total capital (see Gylfason, 2001a,b and Gylfason and Zoega, 2002) and the average growth of per capita GDP over the period 1980-2000 for 117 countries as a function of the average share of exports of primary products in GNP over the years 1980-1985 (source: World Bank, 2003). The slopes of the regression lines are -0.09 in the sample 1965-1998 and -0.04 in the sample 1980-2000. It indicates a surprisingly strong negative relationship between growth and natural resources. If the measure of natural resource dependence is increased by one standard deviation, then the average per capita growth decreases by almost 1.0 per cent in the first sample and by almost 0.7 per cent in the second sample. This is a serious issue with the average growth being 1.36 per cent and 0.96 per cent in the two samples respectively. If extremely resource dependent countries are excluded, the curse becomes even stronger.[12]

Is the negative relationship presented in Figure 1 just a spurious one or is the dependence on natural resources indeed a cause for slow economic growth? Further empirical evidence suggests that the second is most probably true. It was shown in many studies that the curse of natural resources survives control for most relevant variables. For example, in their 1995 paper Sachs and Warner control for initial per capita income, trade policy variables, investment rates, inequality measures, various monetary variables, quality and intensity of schooling, for index measuring bureaucratic efficiency, and in their 2001 paper also for previous growth rate and an index approximating the rule of law in each country. They also use various measures of resource dependence and experiment with different data samples, when replicating previous influential empirical studies on economic growth. With all this empirical exercise, the coefficient for the variable measuring natural resource dependence remains significant and negative in their growth regressions. This finding is confirmed also by other studies. Sala-i-Martin (1997) and Doppelhofer et al. (2000) ran their "millions" of

[12] As will be discussed later, this might be due to a non-linearity present in the statistical relationship between growth and natural resource dependence.

growth regressions while controlling for various subsets of 32 potential growth determinants and concluded that the dependence on natural resources belongs among the most robust of them. Thus, so far there is overwhelming evidence that the curse of natural resources is a robust finding that cannot be easily explained by other variables.

The only opposing view I traced in the literature is presented by Davis (1995). He argues that the natural resource curse is mainly a result of "the unhappy economic experience of certain minerals based economies in the 1970s and early 1980s." At the same time he claims that in his sample of 79 countries there is no evidence for a systematic curse over the period 1970-1991. However, in his analysis he works only with averages of selected development indicators measured from 1970 to 1991 in two sub-samples of what he classifies as mineral and never-mineral economies. He avoids any regression analysis and uses a methodology that radically differs from the approach of the other mentioned papers. Therefore, it is hard to judge to what extent he really questions their results. Nevertheless, the objection that the curse is valid only for the last three or four decades makes sense. Most of the mentioned papers work with data sets starting in the 1960s or 1970s. Also, a widespread belief exists that many countries rich in the present time once ignited their growth with the aid of natural resources. Due to the lack of reliable data it is hard to test this hypothesis empirically, but even if it were true, it would not degrade the empirical evidence for the curse in recent-day economies. Moreover, Sachs and Warner (1999) present evidence that in seven Latin American countries, natural resource booms did not serve as catalysts for future long-term growth. With showing this, they claim that in today's world the resource booms can not help to overcome the fixed costs of industrialization as the so called big-push reasoning would suggest.

In spite of the reported robustness of the curse, the causality question remains open. Is the dependence on natural resources really an exogenous cause for slow economic growth or, vice versa, is it a result of slow growth? I believe that the answer to this question is not so clear and both causal links appear in the empirical results. If cross-country investment and growth differences were caused by some unobserved exogenous variable constant over time and if countries were initially endowed randomly with natural resources, then after some period slow-growing countries would appear resource dependent. This possible bias is also discussed in Sachs and Warner (1995). To exclude it, they control for previous growth rates in their regressions and find the resource curse still significant. Nevertheless, it is probably not sufficient to conclude that the dependence on natural resources measured relatively to any variables related to economic activity is a purely exogenous cause for slow growth.

3.2.2 Possible Explanations of the Curse

Sachs and Warner (2001) write: "Just as we lack a universally accepted theory of economic growth in general, we lack a universally accepted theory of the curse of natural resources." Indeed, rather than a general theory, the existing literature offers a list of possible explanations for the curse. Here, I will mention only the most prevalent ones. As again Sachs and Warner (2001) point out, most of the explanations are based on crowding-out logic. In this logic natural resources crowd out an activity that has a positive effect on growth and consequently natural resources have a negative effect on growth.[13] First, natural resource abundance can lead to what is called rather morbidly the "Dutch disease." The name comes from the difficulties the Netherlands experienced with the shrinking manufacturing sector in the 1970s, after the boom in natural gas production. The crowded-out growth-inducing activity is represented by the tradable manufacturing sector here. A boom in a natural resource sector can lead to its reduction. The manufacturing sector can become uncompetitive for several reasons. The export of massive primary products can drive up the real exchange rate of the national currency; shocks to the primary production or to world prices of the exported primary commodity can increase exchange rate volatility; or the boom in the primary sector can attract labor from other industries or increase the overall wage rate in the economy. So far, there is nothing wrong about such structural adjustment of the economy. However, if manufacturing has a positive innovation and technology spillover effect on the whole economy, then its reduction can indeed lead to a slowdown of growth. Moreover, once the resource boom ends, the "devastated" manufacturing sector can have serious problems to recover and adapt the in-between missed technological innovations.

Second, natural resources can crowd out human capital. Gylfason (2001) shows that natural resource dependence is associated with lower public expenditures on education, expected years of schooling and secondary school enrollment rate. He claims that people and governments in countries with resource intensive economies can have lower incentives to invest in human capital being blinded by their natural wealth.

Third, natural resources can crowd out social and institutional capital. Governments of resource rich countries can feel secure enough with their natural resource rents to neglect the need of growth-oriented economic policies. More seriously, large and concentrated natural resource rents can lead to rent-seeking behavior. Governments can be tempted to back up favored groups with protection or privileged access to the natural resources. This behavior can seed corruption and intransparency in political and economic institutions. In an extreme case, it can lead to fights of various interest groups for the resource rents, sometimes resulting even in civil wars, like in many African countries. In this context, Auty (2001) concludes, "most resource abundant countries engender a political state that is factional or predatory and whose government distorts the economy in the pursuit of rents...."

3.2.3 Focus of this Paper

When looking at the possible explanations for the curse of natural resources, it is apparent that most of them combine natural resources with bad government policies or at least with the lack of good ones. McMahon (1997) writes, "The curse is not a result of fate or bad luck, but rather is induced by poor economic policies in general or an erroneous or inadequate policy response to a shock to the resource sector." Similarly, Gylfason (2001) stresses: "It needs to be emphasized that it is not the existence of natural resources as such that seems to be the problem, but rather the failure of public authorities to avert the dangers that accompany the gifts of nature."

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[13] Of course, the already mentioned question of causality is again relevant here, and I am aware that some

This relationship of the resource curse to the political and institutional environment and to the choice of appropriate policies together with its remarkable empirical robustness are the two major motifs for this paper. I will investigate the robustness of the curse with respect to several variables that measure the quality of democracy and regime stability.[14] To do so, I will simply control for these variables when estimating the curse regressions. Even if the curse remains present, it can still be the case that its power at least varies with the quality of democracy and regime stability. To test this hypothesis, I will estimate the basic curse regressions for different groups of countries sorted with respect to the democracy and stability measures. Obviously, with such tests I assume that countries with different levels of democracy and stability could have different chances to employ the correct policies needed to "avert the dangers that accompany the gifts of nature."

A finding that the empirical evidence for the curse is significantly stronger among authoritarian countries than among democratic countries would be clearly an optimistic result. It would support the idea that democracy is good for growth, at least in the context of the course of natural resources. So far the attempts to identify the positive effect of democracy on growth have given only mixed results. The relationship between democracy and economic performance in general was studied, for example, by Helliwell (1992) and Barro (1997, 1999). Both authors find a positive and significant effect of economic performance on the quality of democracy. However, the evidence for the opposite causality is mixed. Helliwell (1992) does not detect any direct effect of democracy on subsequent growth and indicates only an indirect positive effect through the positive effect of democracy on education and investment. Barro (1997) claims that the effect of democracy on growth is non-linear with an effect that is initially positive but turns negative once a moderate level of democracy is achieved.

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of these explanations can be speculative.

[14] Surprisingly, measures of the quality of democracy and regime stability were used in a very limited way in the empirical research on the curse. To my knowledge, only Sachs and Warner (2001) controlled for the index measuring the rule of law in their regressions. Sala-i-Martin (1997) and Doppelhofer et al. (2000) included the rule of law index to their set of 32 potential growth determinants as well. They also included the indices of political rights and civil liberties later used in this paper. However, they did not focus on the natural resource curse particularly, but rather searched for robust growth determinants in general.

Finally, I will use the smoothed least trimmed squares (SLTS) method to test the robustness of the curse. SLTS is a robust estimation procedure proposed by Cizek and Visek (2000) and Cizek (2001). I find the application of robust estimation methods to be particularly suitable for growth regressions, where the data are expectably very noisy and prone to suffer from various kinds of contamination. In spite of this, I am not aware of any previous research that would apply the latest robust procedures to estimate the curse of natural resources.

3.3 Smoothed Least Trimmed Squares

The SLTS estimation procedure extends robust estimation methods applicable to models with discrete and categorical explanatory variables, e.g., Hubert and Rousseeuw (1997). It is based on the least trimmed squares estimator proposed by Rousseeuw (1985), but with less drastic trimming. Instead of excluding the observations beyond the trimming point completely, it assigns decreasing weights to observations ordered with respect to their squared residuals when minimizing the sum of squares of these residuals. Formally the SLTS estimator of the coefficient β in a linear regression model $y_i = x_i^T\beta + \varepsilon_i$, $i = 1,...,n$, is defined as

$$\hat{\beta}^{(SLTS,\omega)} = \arg\min_{\beta} \sum_{i=1}^{n} \omega_i r_{[i]}(\beta),$$

where $r_{[i]}(\beta)$, $i = 1,...,n$, is the ordered sample of squared residuals $r_i(\beta) = (y_i - x_i^T\beta)^2$ for all possible β coefficients; and $\omega = (\omega_1,\omega_2,...,\omega_n)$ is the vector of weights with $\omega_1 \geq \omega_2 \geq ... \geq \omega_n \geq 0$. The decreasing weights are for each observation computed with the function

$$\omega_i = \frac{1}{1+e^{w((i-t)/n)}}.$$

The weight parameter w and the trimming parameter t determine the shape of the weighting function that decreases in i. The higher is the weight parameter w, the faster the weights decline to values close to zero for $i > t$. The weight and trimming parameters w and t have to satisfy the conditions $w \geq 0$ and $t \in \langle n/2, n \rangle$. They are chosen during the estimation procedure according to an algorithm that optimizes the trade off between the robustness and noisiness of the SLTS estimator. For more details on the estimation algorithm and for properties of the SLTS estimator, see for example Cizek (2001).

The advantage of SLTS over least trimmed squares is that it uses (even though down-weighs) the information from the whole sample. Thus, it cannot happen that some observations would be completely excluded, which might be a serious problem in regression models containing discrete and categorical explanatory variables. Also the choice of the weight parameter *w* and the trimming parameter *t* gives more degrees of freedom in the search for "optimal robustness" of a SLTS estimator. Moreover, in the context of cross-country growth regressions, we can further investigate what the causes might be for a particular country being assigned a low weight in a particular regression.

3.4 Data

Data used in this paper and definitions of all variables are given in Appendix A. I use two different data samples. Tables 1 to 4 provide basic statistics and mutual correlations of the variables in both samples. The first sample covers 85 countries and the period 1965-1998.[15] The second sample includes 117 countries and measures average economic indicators over the period 1980-2000.[16]

In the sample 1965-1998, I use the same variables as Gylfason in his 2001 papers. Natural resource dependence is measured with the share of natural capital in total capital in 1994 (*natural capital*) as estimated by the World Bank (1997). Total capital comprises estimates of physical, human, and natural capital. Unfortunately, 1994 is the only year for which this estimate is available. Other economic indicators include per capita GDP growth (*economic growth*), the ratio of gross domestic investment to GDP

[15] The core variables of the sample 1965-1998 were kindly provided by Thorvaldur Gylfason, who previously used them in his research; see Gylfason (2001a,b) and Gylfason and Zoega (2002). The data are also available in Gylfason and Zoega (2002). The main original source of the data is the World Development Indicators 2000 CD. Only the estimates of *natural capital* are taken from World Bank (1997).

[16] The core variables of the sample 1980-2000 were computed using the World Development Indicators 2003 data set provided by the World Bank (2003).

(investment ratio), and gross secondary school enrollment rate (*enrollment rate*), all averaged over the period 1965-1998. The logarithm of initial per capita income (*log initial income*) is computed from the purchasing power parity adjusted per capita GNP in 1998 by dividing it with the appropriate growth factor for the period 1965-1998 and taking the natural logarithm.

Table 1: Statistics on variables used in the sample 1965-1998.

Variable	Mean	Median	Max.	Min.	Standard deviation	Obs.
Economic growth	1.36	1.30	7.70	-3.30	1.92	85
Enrollment rate	43.8	36.8	101.9	3.30	30.2	85
Log initial income	7.85	7.67	9.81	5.85	1.06	85
Investment ratio	20.2	20.6	31.7	7.36	5.27	85
Natural capital	11.8	8.21	54.2	0.00	10.8	85
Autocracy	0.31	0.28	0.83	0.00	0.28	85
Democracy	0.47	0.39	1.00	0.00	0.38	85
Civil liberties	0.56	0.52	1.00	0.08	0.28	85
Political rights	0.57	0.54	1.00	0.03	0.32	85
Regime instability	0.07	0.05	0.31	0.00	0.08	85

Table 2: Correlations of variables used in the sample 1965-1998.

Variable	*Economic growth*	*Enrollment rate*	*Log initial income*	*Natural capital*	*Investment ratio*
Economic growth	1.00				
Enrollment rate	0.39	1.00			
Log initial income	-0.02	0.82	1.00		
Natural capital	-0.53	-0.57	-0.45	1.00	
Investment ratio	0.61	0.48	0.21	-0.41	1.00
Autocracy	-0.32	-0.66	-0.65	0.41	-0.28
Democracy	0.31	0.76	0.73	-0.43	0.33
Civil liberties	0.29	0.81	0.81	-0.47	0.35
Political rights	0.35	0.78	0.76	-0.48	0.37
Regime instability	-0.26	-0.42	-0.31	0.18	-0.38

	Autocracy	*Democracy*	*Civil liberties*	*Political rights*	*Regime instability*
Economic growth					
Enrollment rate					
Log initial income					
Natural capital					
Investment ratio					
Autocracy	1.00				
Democracy	-0.94	1.00			
Civil liberties	-0.88	0.92	1.00		
Political rights	-0.92	0.95	0.97	1.00	
Regime instability	0.33	-0.45	-0.45	-0.44	1.00

Table 3: Statistics on variables used in the sample 1980-2000.

Variable	Mean	Median	Max.	Min.	Standard deviation	Obs.
Economic growth	0.96	0.92	8.32	-7.05	2.27	117
Log initial income	7.61	7.46	10.6	5.00	1.54	117
Primary exports	10.9	4.15	95.1	0.08	16.8	117
Autocracy	0.30	0.23	1.00	0.00	0.29	104
Democracy	0.48	0.45	1.00	0.00	0.38	104
Civil liberties	0.56	0.55	1.00	0.02	0.28	117
Political rights	0.58	0.58	1.00	0.06	0.32	117
Regime instability	0.07	0.03	0.40	0.00	0.09	104

Table 4: Correlations of variables used in the sample 1980-2000.

Variable	*Economic growth*	*Log initial income*	*Primary exports*	*Autocracy*
Economic growth	1.00			
Log initial income	0.16	1.00		
Primary exports	-0.33	0.19	1.00	
Autocracy	-0.39	-0.43	0.46	1.00
Democracy	0.37	0.63	-0.35	-0.92
Civil liberties	0.41	0.65	-0.33	-0.86
Political rights	0.46	0.60	-0.38	-0.91
Regime instability	-0.52	-0.47	-0.01	0.31
	Democracy	*Civil liberties*	*Political rights*	*Regime instability*
Economic growth				
Log initial income				
Primary exports				
Autocracy				
Democracy	1.00			
Civil liberties	0.93	1.00		
Political rights	0.96	0.97	1.00	
Regime instability	-0.43	-0.46	-0.47	1.00

In the sample 1980-2000, natural resource dependence is measured differently. I use the average ratio of primary products exports to GDP over the years 1980-1985 (*primary exports*), where primary products exports comprise ores and metals, fuel, and agricultural raw materials exports. Further, I employ only two basic economic indicators in this sample, average per capita GDP growth over the period 1980-2000 (*economic growth*) and natural logarithm of per capita GDP in 1980 (*log initial income*).

Variables measuring the quality of democracy are taken from two distinct sources. The indices of *democracy* and *autocracy* are from the Polity IV 2001 data set.[17] They correspond to the variables DEMOC and AUTOC from the original data set. These sort countries into eleven groups each year. The value 0 of *autocracy* and *democracy* indices corresponds to the lowest level of democracy and autocracy respectively. The value 10 indicates the highest level of democracy for the *democracy* index and the toughest autocratic regime in the case of the *autocracy* index. In this paper the indices are divided by 10, which transform them to the range between 0 and 1. In the samples 1965-1998 and 1980-2000, *democracy* and *autocracy* indices stand for averages of the individual yearly values over the respective time periods.[18]

The indices of *civil liberties* and *political rights* come from the Freedom House country ratings.[19] Freedom House ranks countries in each year into seven categories according to these indices. The value 1 corresponds to the highest and the value 7 to the lowest level of political rights or civil liberties. For the purposes of this paper both indices are converted to the scale from 0 to 1, where 0 corresponds to the lowest and 1 to the highest level of rights. The Freedom House indices are available only from the year 1973. Therefore, in the sample 1965-1998, I take the average over the period 1973-1998. In the second sample I can take the average over the whole relevant period 1980-2000.

To get an idea of how countries are rated with the different measures of democracy consider the following examples. The "best" countries in the sample 1980-2000 are Australia, Austria, Canada, Denmark, Netherlands, New Zealand, Norway, Sweden, Switzerland and United states. They receive the maximum average value 1 for *democracy*, *civil liberties*, and *political rights* indices and the minimum average value 0 for the *autocracy* index. France and Germany receive the maximum value 1 for *democracy* and *political rights* indices and the minimum value 0 for the *autocracy* index but only the values 0.83 and 0.84 for the index of *civil liberties*. Algeria receives 0.04 for the *democracy* index, 0.64 for the *autocracy* index, 0.22 for the *civil liberties* index, and 0.18 for the *political rights* index. Finally, Saudi Arabia "boasts" the following

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[17] A detailed methodology used to assign these indices is described in Polity IV Project (2001) and Marshall and Jaggers (2002).

[18] In the sample 1980-2000, these indices are available only for 104 countries out of the total 117.

[19] For a detailed description of the methodology used to assign each index, see Freedom House (2002). Freedom House indices are quite popular in economic research and were previously used for example by Helliwell (1992), Barro (1999), and Easterly (2001).

values: 0 *democracy* index, 1 *autocracy* index, 0.06 *civil liberties* index, and 0.08 *political rights* index. Not surprisingly, Tables 2 and 4 show high correlations among the four measures of the quality of democracy in both samples. When measured with these correlations, the two indices that differ the most are *autocracy* and *civil liberties* indices. Their correlation coefficient is -0.88 in the sample 1965-1998 and -0.86 in the sample 1980-2000.

The index of *regime instability* is a variable quite distinct from the democracy indicators described above, and it is not strongly correlated with them. The correlation coefficients in absolute value ranges only between 0.31 and 0.48. I computed the *regime instability* index from the variable DURABLE available in the Polity IV 2001 data set. The variable DURABLE gives for each country and each year the duration of the current regime in power. If a regime change occurs, then its value drops to zero and from that point it starts to count the duration of the new regime. The index of *regime instability* is the maximum likelihood estimator of regime change probability in each country for the corresponding periods 1965-1998 and 1980-2000 in the two samples. It is estimated in the framework of duration analysis. For details see Appendix A. The distribution of the instability index is very asymmetrical, because 27 countries out of 85 in the sample 1965-1998 and 43 countries out of 104 in the sample 1980-2000 have the estimated probability of regime change equal to 0. The highest probabilities of regime change were estimated for Thailand, Chad, Ghana, Philippines, Burundi, Pakistan, and El Salvador in the sample 1965-1980 and for the Congo Democratic Republic, Haiti, Liberia, Chad, Mexico, Sierra Leone, and Ghana in the sample 1980-2000. All these countries have the estimated probability of regime change higher than 0.2 in the respective samples, with the highest value 0.31 for Thailand in the first and 0.40 for the Congo Democratic Republic in the second sample.

The major difference between the samples 1965-1998 and 1980-2000 lies in the different measures of natural resource dependence. Table 5 shows selected correlations of corresponding economic variables between the two samples, when reduced to 82 countries contained in both of them. Correlation between the variables that measure economic growth is 0.88. The variables measuring logarithms of initial income in 1965 and 1980 are correlated even stronger, with a coefficient 0.93. The correlation among the democracy and stability measures between the two samples is not reported in Table 5 but is comparably high. However, the correlation coefficient between *natural capital* and *primary exports* is only 0.18. It will be shown later that even if I reduce both samples to 82 overlapping countries and estimate basic resource curse regressions of *economic growth* on a *constant*, *log initial income*, and *natural capital* or *primary exports*, the results differ radically for the two data samples. Table 5 clearly suggests that it is due to the different measures of natural resource dependence.

Table 5: Correlations of selected variables between the samples 1965-1998 and 1980-2000.

Sample 1980-2000 82 observations	Sample 1965-1998 *Economic growth*	*Log initial income*	*Natural capital*
Economic growth	0.88		
Log initial income		0.93	
Primary exports			0.18

Note: Only 82 overlapping country observations can be used in both samples.

Finally, let me consider the two measures of resource dependence with respect to their possible endogeneity. The 1994 share of natural capital in total capital has the advantage of using an estimate of the total value of a country's resource endowment, which is exogenous and independent of any economic activity. However, the resource endowment is related relative to total capital, which already depends on the investment history of each country. Past investment is typically positively correlated with current growth. Therefore, the share of natural capital in total capital can be negatively correlated with current growth without any direct causal effect from the pure resource abundance. Moreover, the only year for which this measure is available is 1994, which is close to the end of the sample period 1965-1998. Thus, the 1994 share of natural capital in total capital also depends on investment during the sample period, again typically positively correlated with economic growth during this period. The second problem can be partially eliminated by showing that the curse remains present even after controlling for average investment relative to GDP in the period 1965-1998. The average ratio of primary products exports to GDP over the years 1980-1985 is probably an even more problematic measure. It has only the advantage of being measured in the beginning of the sample period 1980-2000. On the other hand, the use of primary exports relative to GDP is a clear disadvantage because both primary exports and GDP are related to endogenous economic activity. As a result the ratio will again depend on the history of investment into different sectors of the economy. Moreover, the average ratio of primary products exports to GDP can be expected to be noisier than the 1994 share of natural capital in total capital. The average is taken only over five years. During these years primary exports could have encountered various types of fluctuations unrelated to the actual resource wealth or even to the real resource dependence of the country. Thus, I would conclude that the 1994 share of natural capital in total capital is probably a better variable to be used to estimate the effect of natural resources on economic growth. Nevertheless, both measures clearly indicate endogenous resource dependence rather than exogenous resource abundance.

3.5 Empirical Results

3.5.1 Robustness of the Curse

First, I investigate if the curse of natural resources remains present in growth regressions, when controlling for democracy indices and for the index of *regime instability* and when using the robust SLTS estimation procedure.

Table 6 reports the OLS estimates of the curse in the sample 1965-1998. For comparison purposes I reestimate two regressions already presented in Gylfason (2001). First, I regress the average per capita economic growth over the period 1965-1998 on the 1994 share of natural capital in total capital, logarithm of initial income, average gross domestic investment ratio over the relevant period, and the average secondary school enrollment rate over the same period. Second, I estimate the same regression just with the *enrollment rate* excluded. Additionally, I also include the basic regression of *economic growth* on *natural capital* and *log initial incom*e and the simplest regression of *economic growth* on *natural capital* only. The coefficient estimates in the first two equations are very close to those reported in Gylfason (2001).[20] The coefficient for *natural capital* is significant and negative in all the four estimated equations. It remains almost unchanged, when four different measures of the quality of democracy and the index of *regime instability* are included. These results are in line with the reported empirical robustness of the curse of natural resources. The four different indices of the quality of democracy appear significant in most of the estimated equations, with the expected sign supporting the idea that democracy and growth are correlated. Of course, without any possibility to decide what is the causality direction of the relationship in this case. The index of *regime instability* has the expected negative sign in all equations. However, it is significant only in the regression that includes just *natural capital* and *log initial income*, which is quite surprising.

Table 7 contains the results of the robust SLTS estimation of the same four equations with the same sample 1965-1998. Again the coefficient for *natural capital* remains negative and significant. However, in three out of the four equations it decreases slightly in absolute value (the difference is not statistically significant). The coefficient estimates by *investment ratio* and *enrollment rate* remain completely unchanged compared to OLS. The estimated coefficient for *log initial income* remains negative but decreases significantly in absolute value compared to OLS and even becomes insignificant in two out of the three equations where it is included. Thus, unlike the curse of natural resources, the convergence result is not found to be robust here. In fact, also Gylfason (2001) mentions that there is no sign of absolute convergence in his sample as the logarithm of initial income is uncorrelated with growth (the correlation coefficient is only -0.02; see Table 2). Similar changes in the value of estimated coefficients between OLS and SLTS were found also when SLTS were applied to estimate the equations with the four indices of democracy and the *regime instability* index included. Therefore, I do not report these results here. Important is that also in this case the coefficient for *natural capital* remains significant and negative.

[20] A small difference is present due to the fact that Gylfason estimated the equations in a seemingly unrelated regressions system.

Table 6: OLS estimates of the natural resource curse with the sample 1965-1998. Dependent variable is *economic growth*.

OLS method; Obs. 85						
Constant	*Natural capital*	*Log initial income*	*Investment ratio*	*Enrollment rate*	*X*	R^2
10.1(5.79)	-0.07(4.60)	-1.54(7.05)	0.10(3.43)	0.05(5.36)		0.67
[a]3.51(2.45)	-0.08(5.30)	-0.60(3.97)	0.18(5.92)			0.55
7.29(4.77)	-0.12(6.74)	-0.58(3.20)				0.36
2.47(9.29)	-0.09(5.63)					0.28
X = Autocracy						
12.5(7.01)	-0.06(4.66)	-1.73(8.13)	0.10(3.57)	0.04(4.89)	-1.98(3.43)	0.71
7.59(4.55)	-0.08(5.26)	-0.99(5.83)	0.16(5.84)		-2.56(3.99)	0.63
11.8(6.61)	-0.11(6.52)	-1.05(5.20)			-3.07(4.07)	0.47
2.62(8.87)	-0.09(4.66)				[c]-0.82(1.16)	0.29
X = Democracy						
11.5(6.69)	-0.07(4.85)	-1.74(8.03)	0.10(3.42)	0.04(4.40)	1.56(3.15)	0.71
7.14(4.59)	-0.08(5.49)	-1.14(6.11)	0.14(5.37)		2.24(4.28)	0.63
11.2(7.13)	-0.11(6.68)	-1.27(5.95)			2.88(4.88)	0.50
2.12(4.88)	-0.09(4.64)				[c]0.54(1.03)	0.29
X = Civil liberties						
11.9(6.92)	-0.06(4.85)	-1.88(8.27)	0.09(3.33)	0.04(4.33)	2.72(3.46)	0.71
7.78(4.91)	-0.08(5.45)	-1.34(6.38)	0.14(5.18)		3.79(4.60)	0.65
11.9(7.56)	-0.10(6.58)	-1.54(6.49)			4.91(5.38)	0.53
2.16(3.73)	-0.09(4.68)				[c]0.44(0.60)	0.28
X = Political rights						
11.8(7.06)	-0.06(4.67)	-1.85(8.52)	0.09(3.20)	0.04(4.60)	2.38(3.86)	0.72
7.26(4.82)	-0.08(5.22)	-1.23(6.46)	0.14(5.12)		3.11(4.69)	0.65
11.2(7.51)	-0.10(6.25)	-1.40(6.51)			4.04(5.52)	0.53
X = Regime instability						
10.4 (5.76)	-0.07(4.63)	-1.55(7.04)	0.10(3.18)	0.05(5.09)	[c]-1.52(0.81)	0.67
4.69(2.90)	-0.09(5.47)	-0.68(4.28)	0.16(5.07)		[c]-3.20(1.52)	0.56
9.08(5.79)	-0.12(6.96)	-0.74(4.13)			-6.91(3.07)	0.42
2.69(9.21)	-0.09(5.26)				[b]-4.06(1.73)	0.30

Notes: Absolute values of t-statistics are in parenthesis. All the estimated coefficients are significant at the 1% significance level. Exceptions: [a] significant at 5%; [b] significant at 10%; [c] insignificant at 10%.

Table 7: SLTS estimates of the natural resource curse with the sample 1965-1998. Dependent variable is *economic growth*.

SLTS method; Obs. 85						
Constant	*Natural capital*	*Log initial income*	*Investment ratio*	*Enrollment rate*	Trimming	Weight
7.79(5.50)	-0.04(3.88)	-1.28(24.0)	0.10(4.37)	0.05(6.19)	44	10.5
[c]-0.31(0.22)	-0.06(4.55)	[c]-0.16(1.19)	0.18(7.21)		52	10.5
[c]1.69(0.70)	-0.09(3.49)	[c]0.07(0.25)			43	50.0
2.35(5.92)	-0.10(3.24)				43	50.0

Notes: Absolute values of t-statistics are in parenthesis. All the estimated coefficients are significant at the 1% significance level. Exceptions: [a] significant at 5%; [b] significant at 10%; [c] insignificant at 10%.

In Table 8, I present the result of OLS and SLTS estimates in the sample 1980-2000. I focus only on the basic regression of the average per capita economic growth over the period 1980-2000 on the average ratio of primary products exports to GDP over the years 1980-1985 and on the logarithm of initial income. I also include the simplest regression of *economic growth* on *primary exports*. The coefficient for *primary exports* is again significant and negative in the two estimated equations. Its absolute value is lower than in the case of the sample 1965-1998. However, this does not mean that the power of the curse would be lower here. First, we use a different measure of resource dependence in the two samples. The sample variance of the natural capital share in the sample 1965-1998 is lower than the sample variance of primary exports ratio in the sample 1980-2000. Second, the sample average of *economic growth* is higher in the first sample than in the second. Thus, in both samples an increase of the respective measure of resource dependence by one standard deviation leads to a similar decrease in *economic growth* relative to its sample mean. Similarly as in the sample 1965-1998, the coefficient for *primary exports* survives the application of SLTS. It remains significant and negative; only it decreases significantly in absolute value in the equation that contains the *log initial income*. Similarly as in the sample 1965-1998, there is little evidence for convergence here. The coefficient for *log initial income* is either insignificant in the regressions or if significant, then even slightly positive, rather than negative (the simple correlation coefficient between *log initial income* and *economic growth* is 0.16). Also in line with results in the sample 1965-1998, the coefficients for the indices measuring the quality of democracy and *regime instability* have the expected signs and are significant in all the estimated equations.

Nevertheless, the remaining results here are radically different from those in the sample 1965-1998. The coefficient for *primary exports* loses significance when I control for the four different measures of democracy quality in the regressions. It either becomes completely insignificant or at least moves from 1 per cent to 10 or 5 per cent significance levels. It survives only the control for *regime instability*. Therefore, unlike the sample 1965-1998, the conclusion here is that the curse of natural resources is not robust when controlling for the quality of democracy in the basic curse regressions.

However, I would not assign a particularly high importance to this result. First, the overall significance of the regressions here is much lower than of those with the sample 1965-1998. Second, as I have already suggested in the previous section, the average ratio of primary products exports to GDP over the years 1980-1985 is probably a worse measure of natural resource dependence than the 1994 share of natural capital in total capital. Moreover, if SLTS are applied to the equations that control also for the democracy measures and the *regime instability* index (the results are not reported in the table), then the coefficient for *primary exports* regains its significance in most cases. This could be limited evidence for the noisiness and contamination of the primary exports ratio used as a measure of natural resource dependence.

Table 8: OLS and SLTS estimates of the natural resource curse with the sample 1980-2000. Dependent variable is *economic growth*.

OLS method					
Constant	*Primary exports*	*Log initial income*	*X*	Obs.	R^2
[c]-1.08(1.10)	-0.05(4.31)	0.35(2.69)		117	0.16
1.48(6.25)	-0.04(3.76)			117	0.11
X = Autocracy					
[c]0.79(0.60)	[c]-0.02(1.23)	[c]0.12(0.77)	-2.22(2.30)	104	0.17
1.77(6.02)	[c]-0.01(1.00)		-2.64(3.37)	104	0.16
X = Democracy					
[c]-0.06(0.05)	[c]-0.02(1.39)	[c]0.04(0.20)	1.75(2.06)	104	0.16
[c]0.15(0.38)	[c]0.02(1.51)		1.87(3.29)	104	0.16
X = Civil liberties					
[c]0.01(0.01)	[b]-0.03(1.91)	[c]-0.05(0.26)	2.99(2.67)	117	0.21
[c]-0.23(0.46)	[a]-0.03(2.50)		2.76(3.85)	117	0.21
X = Political rights					
[c]0.21(0.20)	[c]-0.02(1.36)	[c]-0.11(0.60)	3.18(3.36)	117	0.24
[c]-0.33(0.71)	[a]-0.02(2.08)		2.76(4.35)	117	0.24
X = Regime instability					
[a]2.28(2.12)	-0.04(3.14)	[c]-0.02 (0.16)	-13.0(5.60)	104	0.33
2.11(8.10)	-0.04(3.23)		-12.8(6.32)	104	0.33
SLTS method			Obs.	Trimming	Weight
-2.38(4.21)	-0.02(2.87)	0.43(5.69)	117	59	13.1
1.44(5.78)	-0.05(4.79)		117	59	8.39

Notes: Absolute values of t-statistics are in parenthesis. All the estimated coefficients are significant at the 1% significance level. Exceptions: [a] significant at 5%; [b] significant at 10%; [c] insignificant at 10%.

Table 9: OLS and SLTS estimates of the natural resource curse with the samples 1965-1998 and 1980-2000 for 82 overlapping country observations.
Dependent variable is *economic growth*.

OLS method; Obs. 82	*Constant*	*Natural capital (Primary exports)*	*Log initial income*	*X*	R^2
Sample 1965-1998	6.18(4.06)	-0.11(6.49)	[a]-0.45(2.53)		0.35
	2.37(9.43)	-0.09(5.80)			0.30
Sample 1980-2000	[c]-0.82(0.79)	[c]-0.03(0.98)	[a]0.28(2.08)		0.06
	1.26(4.39)	[c]-0.03(0.97)			0.01
X = Autocracy					
Sample 1965-1998	10.3(5.45)	-0.10(6.36)	-0.89(4.18)	-2.61(3.35)	0.43
	2.49(8.80)	-0.08(4.93)		[c]-0.63(0.92)	0.30
Sample 1980-2000	[c]1.24(0.78)	[c]-0.02(0.66)	[c]0.06(0.33)	[b]-2.07(1.72)	0.10
	1.75(5.30)	[c]-0.02(0.62)		-2.34(2.71)	0.10
X = Civil liberties					
Sample 1965-1998	10.7(6.31)	-0.10(6.42)	-1.34(5.28)	4.30(4.51)	0.48
	2.09(3.82)	-0.09(4.87)		[c]0.39(0.57)	0.30
Sample 1980-2000	[c]0.54(0.41)	[c]-0.02(0.68)	[c]-0.12(0.46)	[b]2.76(1.69)	0.10
	[c]-0.00(0.01)	[c]-0.02(0.76)		2.11(2.67)	0.09
X = Regime instability					
Sample 1965-1998	7.54(4.87)	-0.11(6.67)	-0.58(3.25)	-6.16(2.72)	0.41
	2.58(9.45)	-0.09(5.52)		[b]-4.25(1.84)	0.32
Sample 1980-2000	[c]1.65(1.43)	[c]-0.03(1.28)	[c]0.04(0.26)	-11.4(3.86)	0.21
	1.94(6.50)	[c]-0.03(1.29)		-11.7(4.49)	0.21
SLTS method; Obs. 82				Trimming	Weight
Sample 1965-1998	[c]1.34(0.54)	-0.09(3.24)	[c]0.11(0.38)	42	50.0
	2.39(5.44)	-0.10(2.94)		42	50.0
Sample 1980-2000	-3.04(5.61)	[c]-0.00(0.26)	0.49(6.84)	42	20.5
	1.17(3.61)	[c]-0.03(1.17)		62	13.1

Notes: Absolute values of t-statistics are in parenthesis. All the estimated coefficients are significant at the 1% significance level. Exceptions: [a] significant at 5%; [b] significant at 10%; [c] insignificant at 10%.

As shown in Table 9 the differences between the results with the samples 1965-1998 and 1980-2000 can be fully attributed to the different measures of natural resource dependence. There is little evidence that the differences could be due to the different sizes of both samples. Table 9 shows OLS and SLTS results of the basic curse regressions in both samples when reduced to 82 overlapping country observations (included in both samples). The results with the reduced sample 1965-1998 remain almost unchanged from those when all 85 observations are used (compare to Tables 6 and 7) and the curse of natural resources remains significant in all the estimated equations. However, it is insignificant in all equations with the reduced sample 1980-2000. As I have shown in Table 5, both *economic growth* and *log initial income* are highly correlated between the two samples (correlation coefficients are 0.88 and 0.93) but the correlation coefficient between the natural capital share and primary exports ratio is only 0.18. Thus, the only cause for such dramatic differences between the estimates in the two samples can lie only in the different measures of natural resource dependence.

Finally, let us consider if there is some regularity in the way the SLTS procedure assigns the weights to different observations. Note that in most cases the choice of the trimming parameter is very close to its lower bound n/2. It means that in most cases a maximum trimming is needed in order to achieve the required robustness of the SLTS estimator. This can support the idea that the data are highly noisy and contaminated. Such conclusion is really not surprising in the context of growth regressions. In Table 10, I report basic statistics of variables employed in the sample 1965-1998 for two groups of countries – those that were assigned low weights and those that were assigned high weights with the SLTS procedure. The first group comprises only those countries that were assigned weights below the trimming point when estimating both basic regressions, of *economic growth* on *natural capital* and *log initial income* and of *economic growth* on *natural capital* only. Obviously, the opposite rule was used to select the countries into the second group. Table 11 shows the same information for the sample 1980-2000.

In the sample 1965-1998, the only variable that significantly differs between the two groups is *investment ratio*. The highest weighted countries seem to have a significantly lower ratio of investment to GDP than least weighted countries (at 5% level of significance). It might have the following, rather speculative, explanation. The dependence on natural resources is measured as the 1994 ratio of natural capital to total capital. It is measured relatively close to the end of the studied period. Investment over the studied period increases the total capital, and therefore contaminates the measure of resource dependence with endogeneity. This contamination would be higher by countries that invested more over the studied period, which could be the reason why they were assigned lower weights with the robust SLTS procedure. Consider also the possible resulting bias present in the results with the sample 1965-1998. When using the

1994 natural capital share, countries that invested more over the period 1965-1998 would seem to be less dependent on natural resources than they actually were at the beginning of the investigated period. At the same time, investment is positively correlated with growth in general and also in this sample. Thus, countries that invested more and grew more rapidly over the period 1965-1998 would appear less resource dependent than they should. This would clearly magnify the power of the curse. This might also be the reason why the estimated coefficients for *natural capital* decreased in most equations when using SLTS, which assigned low weights to the high investing countries' observations.

Table 10: Statistics on variables used in the sample 1965-1998 divided into two sub-samples that were assigned low and high weights with the SLTS procedure respectively.

Sample 1965-1998 Variable	Mean	Median	Max.	Min.	Standard deviation	z-statistic for difference in means
42 Observations with low weights in the SLTS procedure						
Economic growth	1.65	1.25	7.70	-3.30	2.42	[c]1.37
Enrollment rate	40.3	34.0	93.8	6.42	23.8	[c]-1.07
Log initial income	7.68	7.62	9.81	5.85	0.94	[c]-1.50
Investment ratio	21.4	21.2	30.8	7.36	5.71	[a]1.96
Natural capital	10.7	7.73	44.2	0.76	9.47	[c]-0.96
Autocracy	0.34	0.32	0.83	0.00	0.27	[c]0.95
Democracy	0.42	0.36	1.00	0.00	0.35	[c]-1.31
Civil liberties	0.51	0.46	1.00	0.08	0.24	[c]-1.58
Political rights	0.52	0.48	1.00	0.08	0.29	[c]-1.45
Regime instability	0.07	0.04	0.31	0.00	0.08	[c]0.31
43 Observations with high weights in the SLTS procedure						
Economic growth	1.08	1.40	2.60	-2.50	1.23	
Enrollment rate	47.2	40.2	101.9	3.30	35.4	
Log initial income	8.02	8.06	9.76	6.03	1.14	
Investment ratio	19.1	19.8	31.7	7.47	4.60	
Natural capital	12.9	9.94	54.2	0.00	11.9	
Autocracy	0.28	0.23	0.81	0.00	0.28	
Democracy	0.53	0.58	1.00	0.00	0.40	
Civil liberties	0.61	0.58	1.00	0.12	0.31	
Political rights	0.62	0.65	1.00	0.03	0.34	
Regime instability	0.07	0.06	0.29	0.00	0.07	

Notes: The division of the sample 1965-1998 into the two subsamples is based on weights assigned with the SLTS procedure when regressing *economic growth* on a *constant*, *log initial income*, and *natural capital* and *economic growth* on a *constant* and *natural capital* only. The group of observations with low weights contains only those observations that were assigned low weights when estimating both equations. The group of observations with high weights contains only those observations that were assigned high weights when estimating both equations. Low weights are those below the trimming point weight.
The z-statistics show a significant difference of means in the two sub-samples at the 1% significance level. Exceptions: [a] significant at 5%; [b] significant at 10%; [c] insignificant at 10%.

Table 11: Statistics on variables used in the sample 1980-2000 divided into two sub-samples that were assigned low and high weights with the SLTS procedure respectively.

Sample 1980-2000 Variable	Mean	Median	Max.	Min.	Standard deviation	z-statistic for difference in means
44 Observations with low weights in the SLTS procedure						
Economic growth	1.19	2.57	8.32	-7.05	3.47	[c]0.26
Log initial income	7.32	7.44	10.5	5.12	1.28	-3.27
Primary exports	10.4	3.93	60.3	0.08	14.4	[c]0.38
Autocracy	0.39	0.40	1.00	0.00	0.30	3.65
Democracy	0.35	0.24	1.00	0.00	0.34	-4.19
Civil liberties	0.49	0.44	0.98	0.06	0.26	-3.33
Political rights	0.51	0.50	1.00	0.08	0.30	-3.09
Regime instability	0.08	0.06	0.40	0.00	0.10	[b]2.07
45 Observations with high weights in the SLTS procedure						
Economic growth	1.05	1.01	2.38	-1.07	0.80	
Log initial income	8.25	8.34	10.3	5.75	1.41	
Primary exports	9.34	5.14	42.6	0.11	11.1	
Autocracy	0.17	0.00	0.89	0.00	0.25	
Democracy	0.67	0.87	1.00	0.00	0.38	
Civil liberties	0.68	0.71	1.00	0.02	0.27	
Political rights	0.71	0.77	1.00	0.06	0.30	
Regime instability	0.04	0.00	0.23	0.00	0.07	

Notes: The division of the sample 1980-2000 into the two subsamples is based on weights assigned with the SLTS procedure when regressing *economic growth* on a *constant*, *log initial income*, and *primary exports* and *economic growth* on a *constant* and *primary exports* only. The group of observations with low weights contains only those observations that were assigned low weights when estimating both equations. The group of observations with high weights contains only those observations that were assigned high weights when estimating both equations. Low weights are those below the trimming point weight.

The z-statistics show a significant difference of means in the two sub-samples at the 1% significance level. Exceptions: [a] significant at 5%; [b] significant at 10%; [c] insignificant at 10%.

In the sample 1980-2000, the higher weighted countries have significantly higher levels of *log initial income* and quality of democracy when measured with all the four different indices (at the 1% significance level). They also seem to be more stable (at the 5% significance level). A speculative reason for this can be that the macroeconomic indicators provided by these countries are more reliable and less noisy than those provided by unstable and authoritarian regimes.

3.5.2 The Curse in Different Groups of Countries

Here I attempt to test the hypothesis that the power of the curse of natural resources differs between democratic and authoritarian and between stable and unstable countries. I employ only the sample 1965-1998, because here the evidence for the curse is much more robust. I sort the countries into different groups according to selected measures of the quality of democracy and with respect to the index of *regime instability*. Within these groups I estimate the basic curse regressions of *economic growth* on *natural capital* and *log initial income*. To save space, I use only two out of the four democracy measures, the *autocracy* index and the *civil liberties* index.[21] With respect to the correlation between the four democracy measures, these two differ the most (see Table 2). I will also include the results for the index of *regime instability*.

Figure 2 plots the estimated coefficients for *natural capital* in different groups of countries as a function of the average value of the appropriate index in each group. In the case of the *civil liberties* and *autocracy* indices, countries were sorted with respect to the quartiles of these variables. In case of *regime instability*, due to the unsymmetrical distribution of this index it is not possible to sort the countries into four quartiles. Instead, the countries are sorted into three groups only. The first group includes countries with *regime instability* (probability of regime change) equal to zero. The remaining countries with *regime instability* greater than zero were sorted around their median value.

The plots in Figure 2 suggest that the resource curse coefficient as a function of the *autocracy* index is almost constant, but shows signs of a U-shape in the case of *civil liberties* and *regime instability* indices. Chow tests are significant in all three cases. However, they test for a structural change in all the regression coefficients, which include those of the *constant*, *natural capital*, and *log initial income*. The coefficient of my interest is only that of *natural capital*. Its differences are significant only in the case of the index of *civil liberties*. Here, this coefficient is significantly different (at 5 per cent) between the first and second quartile and between the second and fourth quartile.

[21] The results with the indices of democracy and political rights would be very close to those with the index of civil liberties.

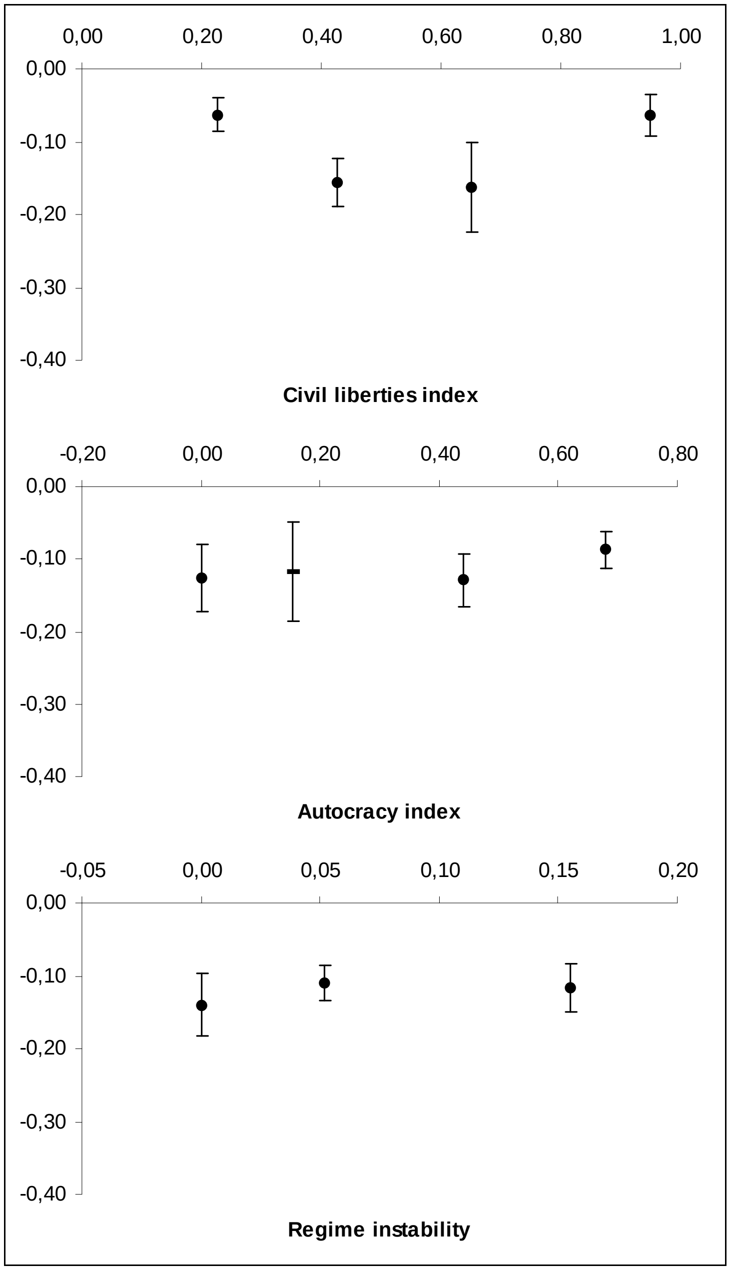

Figure 2: The resource curse estimated coefficient as a function of democracy and stability measures. Sample 1965-1998.

Notes: On the horizontal axis I plot the estimated coefficient of *natural capital* in the regression of *economic growth* on a *constant*, *natural capital*, and *log initial income*. Coefficients insignificant at the 10% significance level are plotted with a dash. The error bars indicate estimated standard errors. The groups contain 21, 23, 20, and 21 country observations, when sorting with respect to the index of *civil liberties*, 25, 18, 21, and 21 country observations, when sorting with respect to the *autocracy* index, and 27, 29, and 29 country observations, when sorting with respect to *regime instability*.

This gives some support for the claim that the curse of natural resources is not very dramatic in the group of countries with the highest level of *civil liberties*; then it becomes more severe as the index of *civil libertie*s decreases but it again weakens among the group of countries with the lowest level of *civil liberties*.

The U-shape of the resource curse coefficient plotted as a function of *civil liberties* and *regime instability* indices in Figure 2 leads me to consider possible non-linearities in the curse regressions. Table 12 reports the results of the basic curse regression of *economic growth* on *natural capital* and *log initial income*, when controlling for possible non-linear effects. Namely, I include *natural capital* squared, *autocracy* index squared, *democracy* index squared and *regime instability* index squared. Further, I control for the interaction between *natural capital* and the indices of the quality of democracy and *regime instability* by including a variable defined as natural capital times the respective index. Of course, I also control for the linear effects in the regressions. The results give little support for non-linearity in the *civil liberties* and *autocracy* indices. Only in the case of *regime instability* is some non-linear effect present as the coefficient for its squares is significant even at the 1 per cent level of significance. The interaction non-linear terms appear insignificant. They become partially significant (at the 10 per cent level) only when the linear effect of the quality of democracy is excluded in the case of *autocracy* and *civil liberties* indices. However, the results indicate non-linearity in *natural capital* as its squares are significant in all regressions at least at the 10 per cent level and when controlling for *regime instability* and the index of *civil liberties* even at the 5 per cent level of significance. Besides this, there is little evidence for any missed non-linearity in the relationship between growth, natural capital dependence, and democracy.

As I have already pointed out when commenting on the introductory Figure 1, the non-linearity in the resource curse in the sample 1965-1998 could be due to the eight most resource dependent countries. These are Central African Rep., Chad, Guinea-Bissau, Madagascar, Mali, Niger, Sierra Leone, and Zambia. For all these countries their 1994 share of natural capital in total capital is greater than 28% with Niger slightly exceeding 54%. Table 13 reports the same result as Table 12 but with the eight most resource dependent countries excluded. After this adjustment the non-linearity in *natural capital* clearly disappears. The only other important effect is that the coefficient for the interaction term between *natural capital* and *autocracy*, *civil liberties*, and *regime instability* indices becomes significant when not controlling for the linear effect of these indices.

Table 12: OLS estimates of non-linear effects with the sample 1965-1998.
Dependent variable is *economic growth*.

OLS method; Obs. 85						
Constant	*Natural capital*	*Log initial income*	*X*	*Y*	*Y =*	R^2
7.29(4.77)	-0.12(6.74)	-0.56(3.20)				0.36
8.69(5.14)	-0.21(4.02)	-0.68(3.66)		[b]0.002(1.83)	*Nat. cap.²*	0.38
X = Autocracy						
13.4(7.05)	-0.20(4.27)	-1.17(5.69)	-3.11(4.22)	[b]0.002(2.13)	*Nat. cap.²*	0.49
12.2(6.81)	-0.11(6.47)	-1.07(5.34)	-6.08(2.90)	[c]4.27(1.54)	*X²*	0.48
12.7(6.76)	-0.16(3.98)	-1.11(5.42)	-4.24(3.87)	[c]0.11(1.47)	*Nat. cap.**X*	0.49
8.03(5.15)	[b]-0.06(1.86)	-0.69(3.67)		[b]-0.10(1.84)	*Nat. cap.**X*	0.38
X = Civil liberties						
13.7(8.14)	-0.21(4.70)	-1.69(7.12)	5.05(5.70)	[a]0.002(2.52)	*Nat. cap.²*	0.56
13.0(7.34)	-0.11(6.74)	-1.57(6.62)	[c]1.49(0.54)	[c]2.90(1.31)	*X²*	0.54
12.0(7.69)	[a]-0.06(2.29)	-1.61(6.75)	6.05(5.31)	[c]-0.11(1.64)	*Nat. cap.**X*	0.54
8.26(5.14)	-0.15(5.88)	-0.72(3.67)		[b]0.11(1.74)	*Nat. cap.**X*	0.38
X = Regime instability						
10.6(6.21)	-0.21(4.32)	-0.86(4.65)	-7.08(3.21)	[a]0.002(2.05)	*Nat. cap.²*	0.45
9.75(6.40)	-0.11(6.77)	-0.79(4.55)	-22.1(3.78)	61.8(2.80)	*X²*	0.48
9.57(5.96)	-0.14(5.41)	-0.77(4.28)	-10.7 (3.01)	[c]0.28(1.29)	*Nat. cap.**X*	0.44
7.55(4.93)	-0.10(4.30)	-0.61(3.39)		[c]-0.21(1.40)	*Nat. cap.**X*	0.37

Notes: Absolute values of t-statistics are in parenthesis. All the estimated coefficients are significant at the 1% significance level. Exception: [a] significant at 5%; [b] significant at 10%; [c] insignificant at 10%.

Finally, there is another problem related to the eight most resource dependent countries. In Figure 3, I plot the index of *civil liberties* against the natural capital share in the sample 1965-1998.[22] It shows a relatively homogeneous distribution of *natural capital* for different levels of the index (at least when I imagine the countries to be sorted according to its four quartiles) except all the eight most resource dependent countries have a very low level of *civil liberties*. Therefore, when I sort the countries

[22] To save space only the index of *civil liberties* is chosen as an example; the distribution would be very similar if the indices of *political rights*, *democracy*, or *autocracy* were selected.

according to the quartiles of this index, all these extremely resource dependent countries fall in the first quartile. The non-linearity in *natural capital* can then bias down the coefficient estimate for *natural capita*l in this quartile. Therefore, I exclude the eight extremely resource dependent countries from the sample and reestimate the basic curse regressions for the different groups of countries sorted with respect to the indices of *civil liberties*, *autocrac*y, and *regime instability*.

Figure 4 is plotted similarly as Figure 3, plotting the estimated coefficients for *natural capital* in the different groups of countries as a function of the average value of the appropriate democracy or instability index in each group. The countries are sorted in the same way as in the previous case; only the eight extremely resource dependent countries are ex-ante excluded from the sample.

Table 13: OLS estimates of non-linear effects for the sample 1965-1998 with the eight most resource-dependent countries excluded.
Dependent variable is *economic growth*.

OLS method; Obs. 77						
Constant	*Natural capital*	*Log initial income*	*X*	*Y*	*Y =*	R^2
8.29(4.84)	-0.16(4.57)	-0.66(3.40)				0.24
8.57(4.64)	[b]-0.21(1.74)	-0.67(3.40)		[c]0.002(0.43)	*Nat. cap.*^{2}	0.24
X = Autocracy						
13.4(6.51)	[a]-0.23(2.06)	-1.17(5.39)	-3.14(4.05)	[c]0.003(0.70)	*Nat. cap.*^{2}	0.38
13.5(6.91)	-0.16(4.91)	-1.18(5.55)	-6.32(2.93)	[c]4.56(1.59)	X^2	0.40
13.1(6.59)	-0.16(3.68)	-1.15(5.34)	-3.50(2.77)	[c]0.04(0.39)	*Nat. cap.*$\ast X$	0.38
10.3(5.76)	[a]-0.10(2.52)	-0.91(4.42)		-0.18(2.80)	*Nat. cap.*$\ast X$	0.31
X = Civil liberties						
13.8(7.61)	[b]-0.19(1.91)	-1.72(6.88)	5.22(5.60)	[c]0.002(0.39)	*Nat. cap.*^{2}	0.47
14.4(7.60)	-0.16(5.37)	-1.74(6.98)	[c]2.4(0.85)	[c]2.34(1.03)	X^2	0.48
13.7(7.59)	-0.17(2.74)	-1.72(6.87)	5.09(4.05)	[c]0.01(0.16)	*Nat. cap.*$\ast X$	0.47
12.2(6.29)	-0.31(5.79)	-1.14(5.04)		0.27(3.52)	*Nat. cap.*$\ast X$	0.35
X = Regime instability						
10.6(5.74)	[c]-0.17(1.51)	-0.87(4.46)	-7.96(3.27)	[c]0.000(0.01)	*Nat. cap.*^{2}	0.34
11.1(6.51)	-0.17(5.14)	-0.90(4.83)	-22.0(3.58)	[a]59.6(2.47)	X^2	0.39
10.6(5.99)	-0.17(4.25)	-0.87(4.48)	[b]-7.88(1.80)	[c]-0.01(0.02)	*Nat. cap.*$\ast X$	0.34
9.71(5.63)	-0.13(3.81)	-0.82(4.20)		-0.64(2.73)	*Nat. cap.*$\ast X$	0.31

Notes: Absolute values of t-statistics are in parenthesis. All the estimated coefficients are significant at the 1% significance level. Exceptions: [a] significant at 5%; [b] significant at 10%; [c] insignificant at 10%.

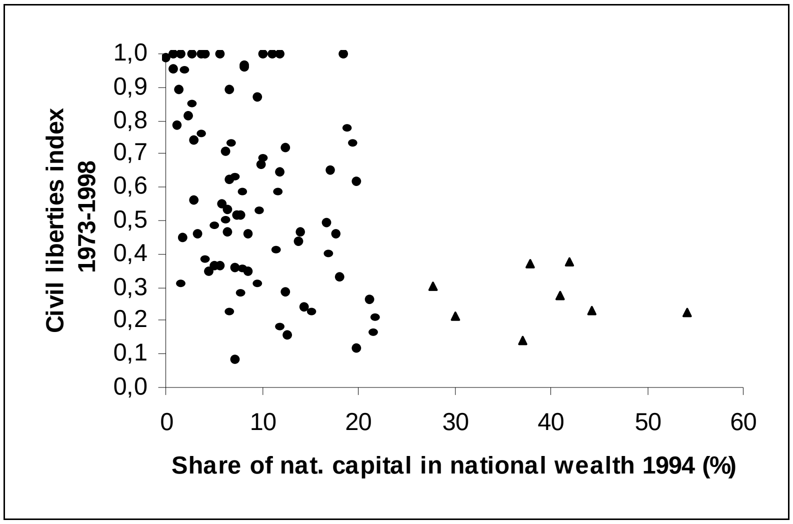

Figure 3: Natural resource dependence and the index of *civil liberties* in the sample 1965-1998.

Note: Triangles represent the most resource-dependent countries, which are the Central African Republic, Chad, Guinea-Bissau, Madagascar, Mali, Niger, Sierra Leone, and Zambia

Figure 4 suggests again U-shapes of the plotted functions, however, this time in the case of *civil liberties* and *autocracy* indices. The resource curse coefficient as a function of *regime instability* increases slightly in absolute value as *regime instability* increases. However, the increase is not statistically significant. The estimated coefficients are in general more noisy than those reported in Figure 2. It is not surprising, as fewer observations are used. Nevertheless, the Chow tests remain significant in all three cases. The differences in the plotted coefficient for *natural capital* are again significant only in the case of the index of *civil liberties*. This time there are significant differences in this coefficient between the first and second quartile (at 10 per cent), between the third and fourth quartile (at 10 per cent), and between the second and fourth quartile (at 5 per cent). Interestingly, the power of the course seems to decrease steadily from the second to the fourth quartile. It is an optimistic result that suggests that once a minimal level of *civil liberties* is achieved, the curse of natural resources becomes weaker as the level of *civil liberties* increases.

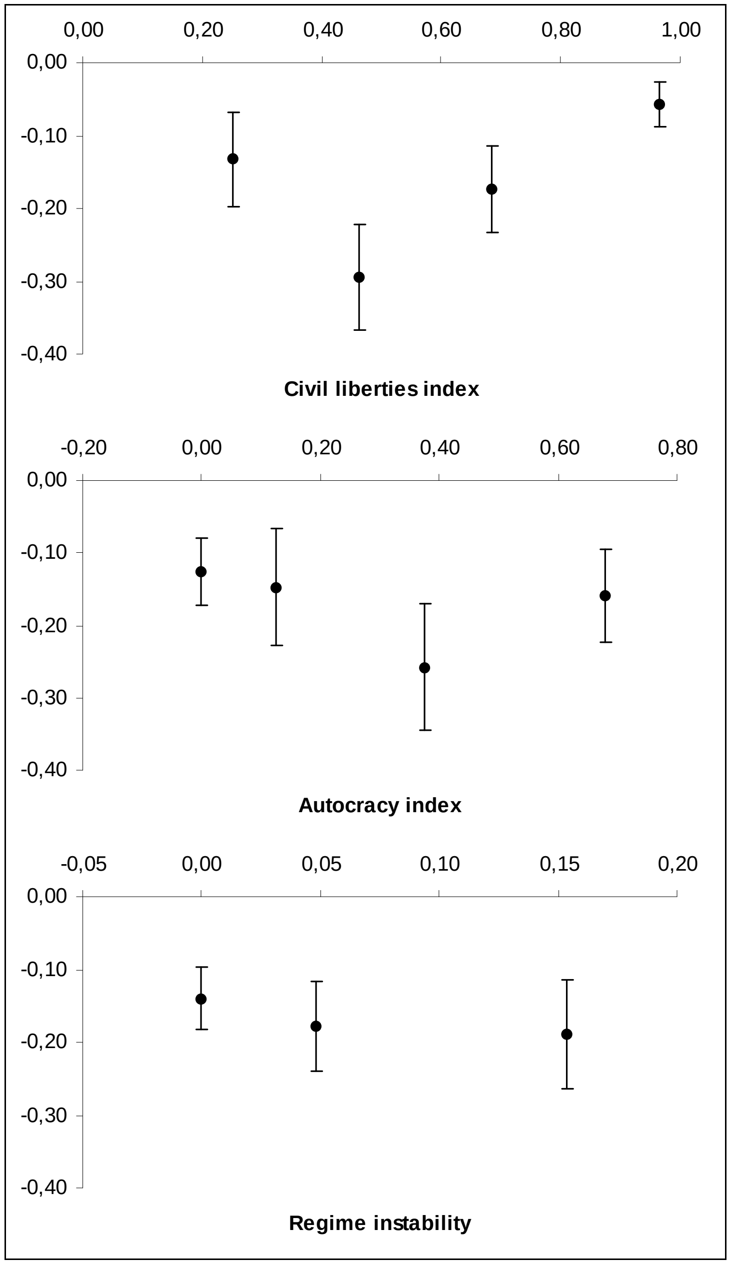

Figure 4: The resource curse estimated coefficient as a function of democracy and stability measures. Sample 1965-1998 with the eight most resource-dependent countries excluded.

Notes: On the horizontal axis I plot the estimated coefficient of *natural capital* in the regression of *economic growth* on a *constant*, *natural capital*, and *log initial income*. Coefficients insignificant at the 10% significance level are plotted with a dash. The error bars indicate estimated standard errors. The groups contain 19, 20, 19, and 19 country observations, when sorting with respect to the index of *civil liberties*, 25, 14, 19, and 19 country observations, when sorting with respect to the *autocracy* index, and 27, 25, and 25 country observations, when sorting with respect to *regime instability*.

3.6 Conclusion

In two different data samples I employ various measures of the quality of democracy and a measure of regime instability and test the robustness of the curse of natural resources with respect to these variables. I also assume that democratic versus authoritarian and stable versus unstable countries could have different chances to employ the policies needed to mitigate the curse. I test this hypothesis by estimating the curse regressions in different groups of countries that differ in the indices of the quality of democracy and in the index of regime instability. Finally, I use smoothed least trimmed squares (SLTS) to test the robustness of the curse of natural resources.

The curse of natural resources is found to be robust when estimated with the SLTS procedure. The curse remains present also when I control for the democracy and instability measures in the first data sample, but it becomes insignificant in the second sample. However, this difference can be caused by the unreliability of the natural resource dependence measure used in the second sample. Additionally, I find limited evidence suggesting that the intensity of the curse depends on the level of civil liberties. The power of the curse seems to decrease steadily with the level of civil liberties once a minimal level is achieved.

To conclude, it must be noted that the evidence for the curse of natural resources in cross-country growth regressions is obtained when the effect of natural resources is estimated with the use of measures that approximate natural resource dependence or intensity rather than abundance. A question remains, what would be the effect of exogenous natural resource wealth on economic growth? This issue certainly deserves special attention in future research.

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3.7 Appendix A – Data and Definitions

Sample 1965-1998

Country	*Economic growth*	*Enrollment rate*	*Log initial income*	*Investment ratio*	*Natural capital*	*Autocracy*	*Democracy*	*Civil liberties*	*Political rights*	*Regime Instability*
Argentina	0.400	56.103	9.238	22.810	6.697	0.376	0.409	0.622	0.641	0.095
Australia	1.700	85.758	9.433	23.727	11.889	0.000	1.000	1.000	1.000	0.000
Austria	2.600	92.031	9.202	23.788	2.642	0.000	1.000	1.000	1.000	0.000
Bangladesh	1.400	17.714	6.790	20.000	14.060	0.348	0.244	0.468	0.519	0.222
Belgium	2.300	96.871	9.320	19.545	0.003	0.000	1.000	0.987	1.000	0.000
Benin	0.100	12.000	6.720	15.176	7.678	0.506	0.152	0.282	0.231	0.147
Botswana	7.700	25.688	6.217	26.853	6.302	0.000	0.870	0.705	0.853	0.030
Brazil	2.200	33.097	8.055	20.690	7.894	0.424	0.385	0.583	0.654	0.088
Burkina Faso	0.900	3.448	6.468	21.000	16.911	0.542	0.036	0.397	0.276	0.134
Burundi	0.900	3.300	6.034	11.500	19.858	0.669	0.003	0.115	0.032	0.265
Cameroon	1.300	17.467	6.814	21.458	21.077	0.712	0.021	0.263	0.141	0.026
Canada	1.800	86.900	9.446	21.545	11.069	0.000	1.000	1.000	1.000	0.000
Central African Rep.	-1.200	9.556	7.400	10.409	30.160	0.571	0.106	0.212	0.167	0.084
Chad	-0.600	4.923	6.936	7.471	37.133	0.685	0.012	0.141	0.096	0.288
Chile	1.900	54.806	8.428	19.000	9.782	0.303	0.382	0.526	0.391	0.074
China	6.800	44.500	5.852	30.619	7.229	0.741	0.000	0.083	0.077	0.000
Colombia	2.000	39.516	8.023	18.971	7.183	0.000	0.774	0.628	0.776	0.000
Congo Rep.	1.400	50.065	6.282	31.720	14.466	0.639	0.091	0.244	0.173	0.087
Costa Rica	1.200	40.242	8.274	20.618	8.205	0.000	1.000	0.968	1.000	0.000
Cote D'Ivoire	-0.800	16.424	7.568	17.324	18.009	0.832	0.000	0.333	0.186	0.000
Denmark	1.900	101.419	9.459	22.939	3.753	0.000	1.000	1.000	1.000	0.000
Dominican Rep.	2.300	35.333	7.625	20.794	12.407	0.145	0.430	0.718	0.776	0.118
Ecuador	1.800	43.448	7.419	19.235	17.011	0.150	0.582	0.654	0.628	0.105
Egypt	3.500	52.455	6.919	20.765	4.550	0.553	0.026	0.346	0.288	0.000
El Salvador	-0.400	24.419	8.428	15.500	2.846	0.166	0.445	0.564	0.641	0.206
Finland	2.400	101.938	9.152	23.970	6.602	0.000	1.000	0.891	0.904	0.000
France	2.100	86.031	9.277	21.758	2.735	0.012	0.815	0.846	1.000	0.013
Gambia	0.400	13.097	7.132	19.500	11.844	0.088	0.656	0.647	0.660	0.059
Ghana	-0.800	31.333	7.724	11.875	7.221	0.500	0.117	0.359	0.250	0.281
Greece	2.400	80.125	8.764	25.394	3.657	0.167	0.703	0.756	0.859	0.064
Guatemala	0.700	16.379	7.923	14.324	3.309	0.252	0.291	0.462	0.538	0.123
Guinea-Bissau	-0.100	6.417	6.384	29.150	44.204	0.592	0.083	0.229	0.243	0.120
Haiti	-0.800	13.300	7.494	10.875	6.683	0.716	0.131	0.224	0.141	0.170
Honduras	0.600	22.083	7.560	19.765	9.940	0.091	0.353	0.667	0.571	0.070
India	2.700	33.969	6.751	18.559	19.788	0.000	0.835	0.615	0.782	0.000
Indonesia	4.700	31.469	6.270	25.500	12.378	0.685	0.000	0.288	0.250	0.000
Ireland	3.000	89.875	8.822	21.030	8.117	0.000	1.000	0.962	1.000	0.000
Italy	2.500	72.313	9.107	21.606	1.320	0.000	1.000	0.891	0.974	0.000
Jamaica	-0.400	58.296	8.247	24.853	6.776	0.000	0.982	0.731	0.865	0.000
Japan	3.500	92.387	8.933	30.818	0.758	0.000	1.000	0.955	0.936	0.000

Jordan	-0.400	47.970	8.001	29.391	1.589	0.791	0.050	0.308	0.301	0.023
Kenya	1.300	17.097	6.445	17.382	9.439	0.591	0.053	0.308	0.250	0.054
Korea	6.600	71.625	7.385	29.353	1.750	0.364	0.321	0.449	0.558	0.085
Madagaskar	-1.800	14.833	7.207	10.500	41.871	0.391	0.233	0.378	0.423	0.080
Malawi	0.500	5.871	6.147	17.385	11.782	0.765	0.103	0.179	0.212	0.059
Malaysia	4.100	47.939	7.623	28.412	8.618	0.094	0.535	0.462	0.590	0.042
Mali	-0.100	7.121	6.545	17.500	41.041	0.552	0.142	0.276	0.212	0.055
Mauritania	-0.100	9.226	7.346	20.357	21.570	0.676	0.000	0.160	0.090	0.000
Mauritius	3.800	44.813	7.786	21.824	1.245	0.000	0.955	0.788	0.853	0.032
Mexico	1.500	43.032	8.425	19.588	5.885	0.376	0.138	0.551	0.545	0.155
Morocco	1.800	25.875	7.478	20.441	4.075	0.812	0.000	0.385	0.429	0.029
Mosambique	0.500	5.000	6.442	12.737	12.681	0.588	0.125	0.159	0.196	0.083
Namibia	0.700	51.667	8.341	19.053	10.071	0.000	0.600	0.685	0.796	0.111
Nepal	1.100	21.500	6.713	17.500	17.698	0.529	0.185	0.462	0.519	0.053
Netherlands	1.900	99.375	9.392	21.848	1.524	0.000	1.000	1.000	1.000	0.000
New Zeland	0.700	86.515	9.455	22.242	18.473	0.000	1.000	1.000	1.000	0.000
Nicaragua	-3.300	33.515	8.655	19.971	13.878	0.434	0.213	0.436	0.397	0.128
Niger	-2.500	4.094	7.427	11.421	54.241	0.606	0.097	0.231	0.122	0.084
Norway	3.000	93.813	9.198	26.697	10.016	0.000	1.000	1.000	1.000	0.000
Pakistan	2.700	15.630	6.531	16.265	5.552	0.253	0.433	0.365	0.410	0.227
Panama	0.700	54.903	8.272	19.579	6.473	0.415	0.294	0.468	0.359	0.038
Papua New Guinea	0.500	10.903	7.534	23.382	19.324	0.000	1.000	0.732	0.826	0.042
Paraguay	2.300	26.469	7.619	20.765	11.539	0.579	0.168	0.410	0.410	0.050
Peru	-0.300	52.750	8.437	20.971	7.784	0.281	0.388	0.519	0.500	0.150
Philippines	0.900	61.667	7.927	21.647	6.174	0.376	0.400	0.500	0.538	0.243
Portugal	3.200	59.000	*8.547*	27.000	2.313	0.253	0.700	0.814	0.859	0.066
Rwanda	0.000	4.519	6.477	12.647	21.708	0.661	0.024	0.205	0.103	0.085
Senegal	-0.400	12.333	7.300	12.441	16.785	0.450	0.124	0.494	0.462	0.027
Sierra Leone	-1.600	13.154	6.630	7.357	28.009	0.566	0.081	0.301	0.237	0.162
South Africa	0.100	62.231	8.991	22.206	5.043	0.247	0.731	0.365	0.468	0.069
Spain	2.300	84.000	8.927	23.000	2.857	0.226	0.665	0.744	0.840	0.097
Sri Lanca	3.000	57.032	7.012	22.103	7.421	0.047	0.662	0.519	0.692	0.000
Sweden	1.400	90.906	9.437	19.939	5.608	0.000	1.000	1.000	0.994	0.000
Switzerland	1.200	85.387	9.805	25.182	0.868	0.000	1.000	1.000	1.000	0.000
Thailand	5.000	29.182	7.007	28.706	6.486	0.203	0.394	0.532	0.545	0.306
Togo	-0.600	19.813	7.408	17.316	15.184	0.619	0.019	0.224	0.083	0.084
Trinidad and Tobago	2.600	62.333	8.036	21.265	9.487	0.000	0.850	0.872	0.936	0.000
Tunisia	2.700	34.121	7.671	26.147	7.908	0.721	0.018	0.353	0.224	0.024
Turkey	2.100	36.750	8.108	18.613	5.019	0.103	0.738	0.481	0.660	0.109
United Kingdom	1.900	87.656	9.298	17.970	1.859	0.000	1.000	0.949	1.000	0.000
United States	1.600	90.600	9.759	18.273	4.112	0.000	1.000	1.000	1.000	0.000
Uruguay	1.200	66.742	8.659	14.441	11.645	0.278	0.575	0.583	0.609	0.099
Venezuela	-0.800	32.871	8.914	21.941	18.929	0.012	0.859	0.776	0.910	0.041
Zambia	-2.000	17.133	7.186	17.828	37.770	0.574	0.185	0.372	0.391	0.088
Zimbabwe	0.500	25.697	7.655	17.029	8.483	0.393	0.332	0.346	0.346	0.043

Definitions:

- *Economic growth*: The average growth of per capita GDP over the period 1965-1998; unit: percent; source: World Bank (2000).
- *Enrollment rate*: The average secondary school enrollment rate (gross) over the period 1965-1998; unit: percent; source: World Bank (2000).
- *Log initial income*: Natural logarithm of 1965 per capita GNP computed from the 1998 purchasing power parity adjusted per capita GNP by dividing with $(1+\text{Economic Growth}/100)^{33}$ and by taking natural logarithm; unit: index; source: World Bank (2000).
- *Investment ratio*: The average gross domestic investment as percentage of GDP over the period 1965-1998; unit: percent; source: World Bank (2000).
- *Natural capital*: Share of natural capital in total capital (natural, human, and physical capital) in 1994; unit: percent; source: World Bank (1997).
- *Autocracy*: Average of the Polity IV variable AUTOC over the period 1965-1998 (for each country only the years with available data were used) rescaled to the range between 0 and 1; 1 indicates the highest and 0 the lowest level of autocracy; unit: index; source Polity IV Project (2001).
- *Democracy*: Average of the Polity IV variable DEMOC over the period 1965-1998 (for each country only the years with available data were used) rescaled to the range between 0 and 1; 1 indicates the highest and 0 the lowest level of democracy; unit: index; source Polity IV Project (2001).
- *Civil liberties*: Average of the Freedom House index of civil liberties over the period 1973-1998 (for each country only the years with available data were used) rescaled to the range between 0 and 1; 1 indicates the highest and 0 the lowest level of civil liberties; unit: index; source Freedom House (2002).
- *Political rights*: Average of the Freedom House index of political rights over the period 1973-1998 (for each country only the years with available data were used) rescaled to the range between 0 and 1; 1 indicates the highest and 0 the lowest level of political rights; unit: index; source Freedom House (2002).
- *Regime instability*: maximum likelihood estimator of regime change probability over the period 1965-1998 computed with the use of the Polity IV variable DURABLE that gives for each year and each country the duration of actual regime in power; maximizes the likelihood function $(1-x)^t * x^n$, where t denotes the total duration of all regimes that were in power over the period 1965-1998 and n denotes the number of regime changes over this period; unit: index; source Polity IV Project (2001).

Sample 1980-2000

Country	*Economic growth*	*Log initial income*	*Primary exports*	*Political rights*	*Civil liberties*	*Democracy*	*Autocracy*	*Regime instability*
Algeria	-0.226	7.427	27.283	0.183	0.222	0.043	0.643	0.113
Antigua and Barbuda	4.099	8.308	3.725	0.684	0.684			
Argentina	0.081	8.960	1.127	0.714	0.675	0.638	0.119	0.027
Australia	1.935	9.683	5.912	1.000	1.000	1.000	0.000	0.000
Austria	1.983	10.009	2.584	1.000	1.000	1.000	0.000	0.000
Bahrain	0.139	9.288	95.073	0.206	0.294	0.000	0.962	0.000
Bangladesh	2.558	5.417	0.811	0.595	0.468	0.286	0.290	0.083
Barbados	1.169	8.818	0.112	1.000	0.984			
Belgium	1.900	9.966	8.936	1.000	0.968	1.000	0.000	0.000
Belize	2.166	7.619	4.618	0.991	0.947			
Benin	0.670	5.893	1.332	0.365	0.381	0.300	0.350	0.077
Bolivia	-0.317	6.924	26.192	0.770	0.627	0.800	0.067	0.095
Brazil	0.417	8.356	1.827	0.722	0.643	0.643	0.129	0.026
Brunei	-2.801	10.290	89.036	0.103	0.286			
Burkina Faso	1.486	5.197	2.147	0.230	0.373	0.000	0.581	0.048
Cameroon	-0.351	6.585	9.528	0.127	0.206	0.043	0.667	0.019
Canada	1.658	9.713	8.303	1.000	1.000	1.000	0.000	0.000
Central African Rep.	-1.036	6.033	3.604	0.270	0.310	0.229	0.424	0.114
Chad	1.069	5.171	8.448	0.103	0.183	0.033	0.487	0.381
Chile	3.502	7.888	12.646	0.500	0.595	0.471	0.257	0.076
China	8.321	5.116	3.004	0.079	0.103	0.000	0.700	0.000
Colombia	1.013	7.532	1.367	0.738	0.579	0.790	0.000	0.000
Comoros	-0.686	6.214	0.745	0.373	0.413	0.210	0.380	0.180
Congo Dem. Rep.	-5.431	5.634	9.570	0.087	0.127	0.000	0.883	0.404
Congo Rep.	0.152	6.643	42.605	0.159	0.286	0.150	0.585	0.116
Costa Rica	1.195	8.038	0.929	1.000	0.944	1.000	0.000	0.000
Cote D'Ivoire	-1.719	6.952	9.020	0.190	0.373	0.025	0.745	0.072
Cyprus	4.067	8.757	2.638	0.968	0.897	1.000	0.000	0.000
Denmark	1.730	10.215	2.893	1.000	1.000	1.000	0.000	0.000
Dominica	3.624	7.429	0.425	0.873	0.921			
Dominican Rep.	2.207	7.191	0.325	0.841	0.683	0.638	0.000	0.045
Ecuador	-0.409	7.344	12.664	0.825	0.730	0.862	0.000	0.048
Egypt	2.577	6.595	9.861	0.294	0.317	0.043	0.471	0.020
El Salvador	0.491	7.375	3.131	0.627	0.548	0.659	0.000	0.238
Fiji	0.799	7.746	0.640	0.571	0.683	0.620	0.095	0.118
Finland	2.223	9.933	5.862	0.937	0.921	1.000	0.000	0.000
France	1.715	9.972	1.748	1.000	0.833	0.871	0.000	0.000
Gabon	-0.810	8.547	55.481	0.270	0.341	0.000	0.650	0.065
Gambia	-0.080	5.931	1.307	0.540	0.556	0.490	0.190	0.025
Germany	1.694	10.059	1.951	1.000	0.841	1.000	0.000	0.000
Ghana	0.239	5.976	7.469	0.349	0.405	0.132	0.400	0.238
Greece	1.043	9.278	2.216	0.952	0.778	0.943	0.000	0.000

Grenada	4.081	7.445	0.460	0.738	0.706			
Guatemala	-0.112	7.376	2.462	0.524	0.405	0.400	0.200	0.121
Guinea-Bissau	0.903	5.166	2.072	0.302	0.254	0.137	0.526	0.179
Guyana	0.669	6.707	23.232	0.532	0.571	0.257	0.400	0.095
Haiti	-2.479	6.409	0.398	0.175	0.254	0.239	0.506	0.345
Honduras	-0.158	6.598	3.048	0.730	0.667	0.589	0.000	0.143
Hungary	1.239	8.343	4.965	0.587	0.603	0.560	0.300	0.106
India	3.571	5.429	0.849	0.770	0.619	0.829	0.000	0.000
Indonesia	3.570	6.221	21.080	0.230	0.294	0.076	0.633	0.024
Iran	0.922	7.230	13.377	0.222	0.159	0.084	0.495	0.190
Ireland	4.853	9.296	2.288	1.000	0.984	1.000	0.000	0.000
Israel	1.953	9.358	1.531	0.889	0.786	0.910	0.000	0.000
Italy	1.805	9.588	1.476	0.992	0.889	1.000	0.000	0.000
Jamaica	0.477	7.578	6.501	0.833	0.730	0.962	0.000	0.000
Japan	2.321	10.250	0.280	0.976	0.929	1.000	0.000	0.000
Jordan	-0.569	7.504	5.201	0.365	0.365	0.100	0.648	0.015
Kenya	-0.134	5.821	5.539	0.214	0.278	0.038	0.576	0.031
Korea	6.271	8.271	1.086	0.651	0.556	0.470	0.240	0.073
Kuwait	-0.609	9.661	48.308	0.310	0.389	0.000	0.810	0.115
Liberia	-7.054	6.716	47.382	0.206	0.246	0.086	0.543	0.339
Madagascar	-1.661	5.839	1.197	0.500	0.373	0.370	0.330	0.083
Malawi	0.249	5.078	0.364	0.325	0.230	0.233	0.595	0.071
Malaysia	3.750	7.739	28.392	0.524	0.405	0.471	0.100	0.000
Mali	-0.187	5.722	5.977	0.325	0.381	0.295	0.385	0.066
Malta	4.047	8.447	0.469	0.937	0.833			
Mauritania	0.096	6.185	22.437	0.063	0.175	0.000	0.652	0.000
Mauritius	4.366	7.465	0.080	0.897	0.794	0.990	0.000	0.000
Mexico	0.744	8.096	9.779	0.579	0.532	0.276	0.210	0.229
Morocco	1.040	7.016	5.955	0.429	0.381	0.000	0.743	0.000
Mozambique	0.887	5.076	1.096	0.270	0.214	0.200	0.481	0.038
Nepal	2.495	4.997	0.354	0.651	0.508	0.367	0.224	0.052
Netherlands	1.972	9.958	13.813	1.000	1.000	1.000	0.000	0.000
New Zeland	1.273	9.542	6.630	1.000	1.000	1.000	0.000	0.000
Nicaragua	-2.340	6.507	4.142	0.444	0.452	0.420	0.135	0.190
Niger	-2.424	5.788	9.581	0.151	0.262	0.200	0.475	0.161
Nigeria	-1.066	5.750	33.864	0.310	0.413	0.200	0.455	0.143
Norway	2.405	10.069	19.034	1.000	1.000	1.000	0.000	0.000
Oman	2.639	8.163	21.590	0.167	0.175	0.000	0.952	0.000
Pakistan	2.446	5.762	1.810	0.381	0.365	0.410	0.281	0.131
Panama	0.965	7.904	1.211	0.508	0.579	0.490	0.267	0.023
Papua New Guinea	0.428	6.773	18.860	0.833	0.706	1.000	0.000	0.000
Paraguay	-0.497	7.538	2.733	0.437	0.484	0.338	0.357	0.061
Peru	-0.459	7.851	10.962	0.603	0.556	0.545	0.095	0.190
Philippines	-0.092	7.067	3.026	0.627	0.579	0.560	0.210	0.201
Portugal	2.874	8.899	2.588	0.976	0.905	0.990	0.000	0.000
Rwanda	-1.400	5.772	0.994	0.119	0.175	0.000	0.655	0.115

Samoa	0.482	7.133	0.304	0.675	0.754			
Saudi Arabia	-2.652	9.355	60.264	0.079	0.056	0.000	1.000	0.000
Senegal	0.495	6.313	6.890	0.540	0.516	0.229	0.290	0.045
Seychelles	1.486	8.493	13.609	0.333	0.341			
Sierra Leone	-4.017	5.850	4.283	0.278	0.294	0.029	0.659	0.223
Singapore	4.867	9.306	49.831	0.437	0.357	0.200	0.400	0.000
South Africa	-0.693	8.438	4.146	0.508	0.421	0.774	0.179	0.103
Spain	2.381	9.293	1.554	0.976	0.849	0.990	0.000	0.000
Sri Lanka	3.480	6.120	6.153	0.643	0.468	0.600	0.086	0.000
St. Kitts and Nevis	4.840	7.846	0.126	0.980	0.912			
St. Lucia	3.271	7.638	0.306	0.960	0.817			
St. Vincent and the Grenadines	3.776	7.187	0.617	0.889	0.889			
Sudan	1.619	5.426	2.915	0.167	0.135	0.120	0.610	0.116
Suriname	0.001	6.892	33.941	0.429	0.508			
Sweden	1.640	10.027	4.928	1.000	1.000	1.000	0.000	0.000
Switzerland	0.806	10.593	1.238	1.000	1.000	1.000	0.000	0.000
Syrian Arab Rep.	0.493	6.578	10.403	0.111	0.024	0.000	0.890	0.000
Thailand	4.750	7.018	3.176	0.667	0.563	0.562	0.062	0.092
Togo	-1.825	6.145	14.329	0.127	0.238	0.042	0.532	0.114
Trinidad and Tobago	0.719	8.437	35.913	0.976	0.889	0.900	0.000	0.000
Tunisia	2.066	7.403	12.362	0.238	0.357	0.038	0.567	0.014
Turkey	2.407	7.579	1.418	0.595	0.421	0.724	0.138	0.095
United Arab Emirates	-4.453	10.541	34.761	0.238	0.333	0.000	0.800	0.000
United Kingdom	2.272	9.560	5.139	1.000	0.921	1.000	0.000	0.000
United States	2.103	9.952	0.827	1.000	1.000	1.000	0.000	0.000
Uruguay	0.800	8.557	3.279	0.746	0.706	0.743	0.167	0.024
Venezuela	-0.945	8.292	22.696	0.889	0.738	0.848	0.000	0.000
Zambia	-1.953	6.370	25.496	0.405	0.389	0.214	0.519	0.078
Zimbabwe	0.080	6.414	5.192	0.389	0.349	0.143	0.448	0.051

Definitions:

- *Economic growth*: The average growth of per capita GDP over the period 1980-2000; unit: percent; source: World Bank (2003).
- *Primary exports*: The average ratio of primary products exports to GDP over the years 1980-1985 (Primary products exports comprise ores and metals, fuel, and agricultural raw materials exports.); unit: percent; source: World Bank (2003).
- *Log initial income*: Natural logarithm of 1980 per capita GDP in constant 1995 U.S. dollars; unit: index; source: World Bank (2003).
- *Autocracy*: Average of the Polity IV variable AUTOC over the period 1980-2000 (for each country only the years with available data were used) rescaled to the range between 0 and 1; 1 indicates the highest and 0 the lowest level of autocracy; unit: index; source Polity IV Project (2001).
- *Democracy*: Average of the Polity IV variable DEMOC over the period 1980-2000 (for each country only the years with available data were used) rescaled to the range between 0 and 1; 1 indicates the highest and 0 the lowest level of democracy; unit: index; source Polity IV Project (2001).
- *Civil liberties*: Average of the Freedom House index of civil liberties over the period 1980-2000 (for each country only the years with available data were used) rescaled to the range between 0 and 1; 1 indicates the highest and 0 the lowest level of civil liberties; unit: index; source Freedom House (2002).
- *Political rights*: Average of the Freedom House index of political rights over the period 1980-2000 (for each country only the years with available data were used) rescaled to the range between 0 and 1; 1 indicates the highest and 0 the lowest level of political rights; unit: index; source Freedom House (2002).
- *Regime instability*: maximum likelihood estimator of regime change probability over the period 1980-2000 computed with the use of the Polity IV variable DURABLE that gives for each year and each country the duration of actual regime in power; maximizes the likelihood function $(1-x)^t * x^n$, where t denotes the total duration of all regimes that were in power over the period 1980-2000 and n denotes the number of regime changes over this period; unit: index; source Polity IV Project (2001).

4 Natural Resources: Are They Really a Curse?

Abstract:

The curse of natural resources detected in numerous cross-country growth regressions is questioned. Although natural resource dependence is associated with slow economic growth, there is no evidence that natural resource abundance per se is negatively related to growth. Thus, the supposed link between resource dependence and growth arises not from the numerator of the dependence measures (i.e. resources themselves) but rather, because of the inherent relationship between slow growth and a small non-resource sector caused by other undetermined characteristics of the economy.

4.1 Introduction

Economists have long believed that natural resources (NR) constitute a fundamental requirement for economic development, but recently, it has become conventional wisdom that NR are also a curse to development. Two diverse departure points provide empirical evidence: one relies on case studies (e.g., Gelb, 1998); the other uses cross-country growth regressions (e.g., Sachs and Warner, 1995b, 1997, and 2001, or Gylfason, 2001a, 2001b, and Gylfason and Zoega, 2002). I question the causality nature of the curse relationship arguing that the link between high NR dependence and slow economic growth results from increases in measured dependence caused by a small non-resource sector in slow growing economies.

Figure 1 shows the relationship between economic growth and NR dependence as it is presented in the literature. It plots the average per capita GDP growth over the period 1965-1998 for 85 countries as a function of the 1994 share of natural capital in total capital (as used by Gylfason, 2001a,b and Gylfason and Zoega, 2002) and the average growth of per capita GDP over the period 1970-1990 for 86 countries as a function of the share of exports of primary products in GNP in 1970 (as used by Sachs and Warner, 1997 and also Sachs and Warner, 1995a and 2001). In both cases a surprisingly strong negative relationship between growth and NR dependence is apparent. If the measure of NR dependence is increased by one standard deviation, the average per capita growth decreases by 1.0 per cent in the first sample and by almost 0.85 per cent in the second sample. This is a serious issue, with growth averaging 1.36 per cent and 1.21 per cent, respectively in the two samples.

The existing literature offers several possible explanations for the curse rather than a general theory.[23] Sachs and Warner (2001) point out that most of the explanations are based on a logic where NR crowd out a growth-inducing activity such as the tradable

[23] The issue of cross-country growth differences is so complex that we can hardly expect any general economic theory to fully explain it. This is also the reason why cross-country growth regressions can provide useful insights, in spite of the problems, e.g. sensitivity to sample coverage, time period, specification, and the data sources used to compute right-hand side variables and growth rates. Also, without a generally accepted growth theory, the growth regressions typically suffer from unclear causality links and related troubles with possible endogeneity of explanatory variables. Finally, the data are often very noisy and unreliable.

manufacturing sector and physical capital ("Dutch disease"), human capital, or institutional capital. Most plausible explanations also stress the role of institutions. In order to inhibit economic growth, NR must be combined with bad government policies or at least with the lack of good ones.

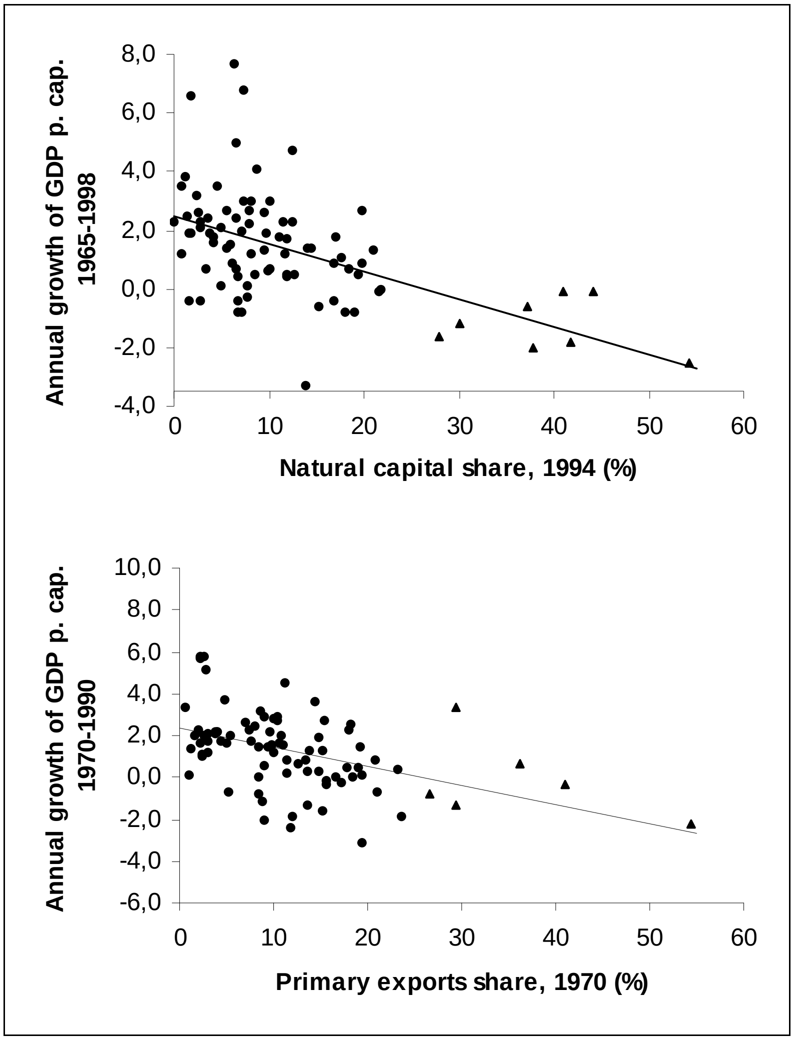

Figure 1: Economic growth and NR dependence in the Natural Capital Sample and Primary Exports Sample.

Note: Triangles represent the most NR dependent countries, which are the Central African Republic, Chad, Guinea-Bissau, Madagascar, Mali, Niger, Sierra Leone, and Zambia in the Natural Capital Sample and the Ivory Coast, Gambia, Mauritania, Mauritius, Uganda, and Zambia in the Primary Exports Sample. Source: Gylfason (2001a,b) or Gylfason and Zoega (2002) for the Natural Capital Sample and Sachs and Warner (1997) for the Primary Exports Sample.

When estimating resource curse cross-country growth regressions, most authors use variables that measure NR dependence or intensity rather than abundance or wealth. By replicating the regressions with the data samples used originally by Sachs and Warner and by Gylfason and Gylfason with Zoega, I confirm the robustness of the negative association between growth and NR dependence. However, I challenge the prevailing interpretation of this result. When I substitute per capita NR wealth, the results change substantially. In order to address the oft-stressed role of institutions, I also control for four different indices of the quality of democracy.

The results presented here do not provide any evidence that NR themselves are associated with slow economic growth. Apparently, the resource curse regressions capture a different statistical relationship between the structure of the economy and economic growth: the relatively small size of the non-resource sector leads to a high measure of NR dependence, and is associated with slow economic growth.

Therefore, a question of causality and particularly of a subtle “developmental bias” mentioned by Sachs and Warner (1995b, 1997, and 2001) becomes relevant. Is the small size of the non-resource sector measured by NR dependence a cause of slow growth, or is it only a result of slow growth? In other words, permanently slow-growing countries would, after a while, appear as NR dependent countries compared to permanently fast-growing countries. NR dependence measured at any time within the period studied would then be statistically associated with subsequent slow economic growth.

4.2 Data

Data used in this paper, detailed definitions of all variables, and basic statistics and correlations are in Appendix A. The first data sample, which I will henceforth refer to as the Natural Capital Sample, includes 85 countries and contains average economic indicators and indicators of the quality of democracy over the period 1965-1998.[24] The

[24] The core variables of the Natural Capital sample were kindly provided by Thorvaldur Gylfason, who previously used them in his research; see Gylfason (2001a,b) and Gylfason and Zoega (2002). The data are also available in Gylfason and Zoega (2002). The main original source of the data is the World

second sample, henceforth the Primary Exports Sample, covers 86 countries and the period 1970-1990.[25]

The core variables of the Natural Capital Sample include the average annual growth of real per capita GDP over the period 1965-1998 (*economic growth*), the indicator of NR dependence measured by the share of natural capital in total capital (natural, human, and physical capital) in 1994 (*natural capital share*), natural logarithm of 1965 per capita GNP (*log initial income*), the average gross domestic investment as percentage of GDP over the period 1965-1998 (*investment ratio*), and the average secondary school enrollment rate computed over the same period (*enrollment rate*).

The core variables of the Primary Exports Sample include the average annual growth of real GDP divided by the economically active population over the period 1970-1990 (*economic growth*), the indicator of NR dependence measured by the share of exports of primary products in GNP in 1970 (*primary exports share*), natural logarithm of real GDP divided by the economically active population in 1970 (*log initial income*), the fraction of years during the period 1970-1990 in which the country is rated as an open economy as defined in Sachs and Warner (1995b) (*openness*), and the natural logarithm of the ratio of real gross domestic investment to real GDP, averaged over the period 1970-1989 (*log investment ratio*).

Additionally, I construct the measures of NR abundance in both samples. These are defined as the per capita exports of primary products in 1970 (*primary exports per capita*) in the Primary Exports Sample and as per capita value of natural capital in 1994 (*natural capital per capita*) in the Natural Capital Sample. These variables are described in the following section.

Development Indicators 2000 CD. Only the estimates of natural capital are taken from World Bank (1997).

[25] The core variables of the Primary Exports Sample are taken from the dataset used in Sachs and Warner (1997). The data are available at http://www.cid.harvard.edu/. Sachs and Warner also used them with minor modifications in their subsequent papers (1995a and 2001). The main original source of the data are Penn World Tables, mark 5.6. Only *primary exports share* and *log initial income* are computed with the use of the World Bank World Data 1995 CD. With some variables and for some particular country observations, Sachs and Warner use additional data sources and eventually also different years of measurement than those given in the basic definitions. For a detailed description and definitions of all variables see Appendix A of this paper and the description of variables in Sachs and Warner (1997).

Both samples are further extended by measures of the quality of democracy (*autocracy, democracy, civil liberties,* and *political rights*) taken from two distinct sources. The indices of *autocracy* and *democracy* are from the Polity IV 2001 data set.[26] These indices correspond to the variables AUTOC and DEMOC in the original data set. They sort countries into eleven groups for each year. The 0 value corresponds to the lowest level of autocracy and democracy, respectively. The value 10 indicates the toughest autocratic regime for the *autocracy* index, and the highest level of democracy for the *democracy* index. In this paper the indices are divided by 10, which transform them into a range between 0 and 1. In both samples, *democracy* and *autocracy* indices stand for averages of the individual yearly values over the respective time periods. Some yearly observations are missing for a few countries, in which case only the available observations are used.

The indices of *civil liberties* and *political rights* come from the Freedom House country ratings.[27] Every year Freedom House ranks countries into seven categories with "one" corresponding to the highest and "seven" to the lowest level of civil liberties or political rights. For the purposes of this paper, both indices are converted to a scale from 0 to 1, where 0 corresponds to the lowest and 1 to the highest level. Since the Freedom House indices are only available starting in 1973, for the Natural Capital Sample, which runs from 1965 to 1998, I take for each country the average of available observations from 1973 to 1998. In the Primary Exports Sample, which runs from 1970 to 1990, I use the average of available observations over the period 1973-1990.

Not surprisingly, the four measures of the quality of democracy are highly correlated in both samples. The two indices that differ the most are *autocrac*y and *civil liberties*, but their correlation coefficient is still very high (-0.88 in the Natural Capital Sample and -0.90 in the Primary Exports Sample.)

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[26] A detailed methodology used to assign these indices is described in Polity IV Project (2001) and Marshall and Jaggers (2002).

Table 1: Correlations of selected variables between the Natural Capital Sample and Primary Exports Sample.

74 observations	Sample 1965-1998			
Sample 1970-1990	*Economic growth*	*Nat. capital share*	*Nat. Capital p. cap.*	*Log initial income*
Economic growth	0.88			
Primary exports share		0.38	-0.01	
Primary exports p. cap.		-0.19	0.59	
Log initial income				0.93

Note: Only 74 overlapping country observations can be used in both samples.

With both samples, I employ the same set of countries as Gylfason, and Sachs and Warner, except for excluding Hong Kong from the Primary Exports Sample, because measures of the quality of democracy are not available. This exclusion changes the results only negligibly. In addition, *primary exports per capita* are missing from Primary Exports Sample for Germany, Iran, and Taiwan. When comparing the results of different regressions in the Primary Exports Sample or across the two samples, various country observations can be missing. Therefore, I always refer also to results using only identical country observations. This issue is important given that numerous cross-country growth regressions have been found to be sensitive to sample coverage (e.g., Levine and Renelt, 1992). Surprisingly, many researchers who study the curse of natural resources neglect this issue and compare regressions' results that employ samples of notably different coverage (e.g. Sachs and Warner, 1997).

In addition to the sample coverage, results of cross-country growth regressions can be sensitive to time period, specification, and the data source used to compute both right-hand-side variables and growth rates (see, for example, Hanousek et al., 2004). Thus, many potentially important differences exist between the two samples employed here. Nevertheless, the major difference between the Natural Capital and Primary Exports Samples seems to rest in the use of different measures of NR dependence and abundance. Table 1 shows correlations of selected corresponding economic variables between the two samples when reduced to 74 overlapping countries. The lowest are the correlations between *natural capital per capita* and *primary exports per capita*, which is

[27] For a detailed description of the methodology used to assign each index, see Freedom House (2002). Freedom House indices are quite popular in empirical economic research and were previously used, for

only 0.59, and between *natural capital share* and *primary exports share*, which is only 0.38. In spite of this, the nature of all major results presented below is almost the same, independent of which sample is used.

4.3 Measures of NR Dependence and Abundance

When studying the resource curse most authors[28] use the share of primary product exports or mineral production in either GNP or total exports in order to measure the effect of NR. Typically, this variable is computed for the initial year of the period over which growth rates are computed. To my knowledge, Gylfason (2001a,b) and Gylfason and Zoega (2002) are the only researchers who use the share of natural capital in total capital. This measure is taken from a World Bank (1997) study that attempts to estimate the value of natural capital for 92 countries. The value of natural capital comprises the value of pastureland, cropland, timber resources, non-timber forest resources, protected areas, and subsoil assets. Since 1994 is the only year for which this estimate is available, it is impossible to employ the share of natural capital in total capital in the sample's initial year, 1965.

Both measures, indicate NR dependence rather than abundance, because they are expressed as ratios of NR abundance to the total performance of the economy. To investigate if natural resources are really associated with slow growth, I focus on truely exogenous NR abundance, in each of the two samples. The resulting pairs of variables estimating NR dependence versus abundance are *natural capital share* versus *natural capital per capita* in the Natural Capital Sample and *primary exports share* versus *primary exports per capita* in the Primary Exports Sample.

Natural capital per capita is taken directly from World Bank (1997) and includes the per capita value of pastureland, cropland, timber resources, non-timber forest resources, and subsoil assets in 1994. The estimated value of protected areas is excluded, because protected areas in part represent an achievement of developed industrial countries and,

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example, by Helliwell (1992), Barro (1999), or Easterly (2001).

[28] E.g., Sachs and Warner, 1995b, 1997, and 2001, Mehlum et al. (2002), or Papyrakis and Gerlagh (2004).

as such, do not approximate exogenous natural wealth properly.[29] To make the coefficient estimates directly comparable to earlier work, *natural capital per capita* is further multiplied by an appropriate constant so that the sample maximum of *natural capital per capita* equals the sample maximum of *natural capital share*.

Primary exports per capita are computed by multiplying primary exports share by the 1970 per capita GNP measured in constant 1995 U.S dollars as reported by the World Bank (2000).[30] *Primary exports per capita* are also multiplied by a constant such that the maxima of *primary exports per capita* and *primary exports share* are equal.

4.4 Empirical Results

4.4.1 NR Dependence and Economic Growth

First, I replicate earlier work by using NR dependence in cross-country growth regressions. I also investigate whether the estimates of resource effects remain negative and significant when controlling for the four democracy indicators.

Table 2 reports the OLS estimates of the curse in the Natural Capital Sample. For comparison purposes, I reestimate two regressions presented in Gylfason (2001), regressing *economic growth* on *natural capital share*, *log initial income*, *investment ratio*, and *enrollment rate*, and the same regression excluding the *enrollment rate*. Additionally, I also include regression of *economic growth* on *natural capital share* and *log initial income* and the simplest regression of *economic growth* on *natural capital share* alone. The coefficient estimates in the first two equations are very close to those reported in Gylfason (2001).[31] The coefficient for *natural capital share* is significant and negative in all four estimated equations. It remains almost unchanged when four different measures of the quality of democracy are included. These results are in line

[29] The results presented in this paper do not change when the value of protected areas is included. The results also remain nearly the same if only the per capita value of subsoil assets is taken into account.
[30] In some cases Sachs and Warner use years other than 1970 to compute the variable named *primary exports share* here. I follow these exceptions and use the same years for GNP per capita when transforming *primary exports share* to *primary exports per capita*.
[31] A negligible difference is present due to the fact that Gylfason estimated the equations in a seemingly unrelated regressions system.

with the reported robustness of the curse of natural resources. The four different indices of the quality of democracy appear significant in most of the estimated equations, with the expected sign supporting the idea that democracy and growth are correlated. Of course, it is not possible to decide the direction of causality of the relationship in this case.

Table 2: OLS estimates of the natural resource curse for the Natural Capital Sample using the share of natural capital in total capital the measure of NR dependence. Dependent variable is *economic growth*.

OLS method; Obs. 85						
Constant	*Natural capital share*	*Log initial income*	*Investment ratio*	*Enrollment rate*	*X*	R^2
10.1(5.79)	-0.07(4.60)	-1.54(7.05)	0.10(3.43)	0.05(5.36)		0.67
[a]3.51(2.45)	-0.08(5.30)	-0.60(3.97)	0.18(5.92)			0.55
7.29(4.77)	-0.12(6.74)	-0.58(3.20)				0.36
2.47(9.29)	-0.09(5.63)					0.28
X = Autocracy						
12.5(7.01)	-0.06(4.66)	-1.73(8.13)	0.10(3.57)	0.04(4.89)	-1.98(3.43)	0.71
7.59(4.55)	-0.08(5.26)	-0.99(5.83)	0.16(5.84)		-2.56(3.99)	0.63
11.8(6.61)	-0.11(6.52)	-1.05(5.20)			-3.07(4.07)	0.47
2.62(8.87)	-0.09(4.66)				[c]-0.82(1.16)	0.29
X = Democracy						
11.5(6.69)	-0.07(4.85)	-1.74(8.03)	0.10(3.42)	0.04(4.40)	1.56(3.15)	0.71
7.14(4.59)	-0.08(5.49)	-1.14(6.11)	0.14(5.37)		2.24(4.28)	0.63
11.2(7.13)	-0.11(6.68)	-1.27(5.95)			2.88(4.88)	0.50
2.12(4.88)	-0.09(4.64)				[c]0.54(1.03)	0.29
X = Civil liberties						
11.9(6.92)	-0.06(4.85)	-1.88(8.27)	0.09(3.33)	0.04(4.33)	2.72(3.46)	0.71
7.78(4.91)	-0.08(5.45)	-1.34(6.38)	0.14(5.18)		3.79(4.60)	0.65
11.9(7.56)	-0.10(6.58)	-1.54(6.49)			4.91(5.38)	0.53
2.16(3.73)	-0.09(4.68)				[c]0.44(0.60)	0.28
X = Political rights						
11.8(7.06)	-0.06(4.67)	-1.85(8.52)	0.09(3.20)	0.04(4.60)	2.38(3.86)	0.72
7.26(4.82)	-0.08(5.22)	-1.23(6.46)	0.14(5.12)		3.11(4.69)	0.65
11.2(7.51)	-0.10(6.25)	-1.40(6.51)			4.04(5.52)	0.53
1.93(3.54)	-0.08(4.39)				[c]0.72(1.13)	0.29

Notes: Absolute values of t-statistics are in parenthesis. All the estimated coefficients are significant at the 1% significance level. Exceptions: [a] significant at 5%; [b] significant at 10%; [c] insignificant at 10%.

Table 3: OLS estimates of the natural resource curse for the Primary Exports Sample using the share of exports of primary products in GNP as the measure of NR dependence. Dependent variable is *economic growth*.

Constant	*Primary exports share*	*Log initial income*	*Openness*	*Log investment ratio*	*X*	R^2
OLS method; Obs. 86						
8.94(7.05)	-0.07(5.55)	-1.34(7.89)	2.34(6.90)	1.26(5.79)		0.68
8.78(5.85)	-0.07(4.48)	-0.95(5.16)	2.99(7.89)			0.55
[b]3.35(1.91)	-0.09(4.63)	[c]-0.13(0.64)				0.21
2.24(8.01)	-0.09(4.67)					0.21
X = Autocracy						
8.93(5.51)	-0.07(5.51)	-1.33(6.78)	2.34(6.67)	1.26(5.75)	[c]0.005(0.01)	0.68
8.43(4.41)	-0.07(4.44)	-0.92(4.24)	3.01(7.70)		[c]0.17(0.29)	0.55
5.31(2.17)	-0.09(4.62)	[c]-0.33(1.24)			[c]-0.84(1.15)	0.22
2.31(7.22)	-0.09(4.45)				[c]-0.25(0.45)	0.21
X = Democracy						
9.03(5.74)	-0.07(5.48)	-1.35(6.40)	2.33(6.53)	1.25(5.75)	[c]0.04(0.10)	0.68
9.06(4.87)	-0.07(4.45)	-0.99(4.15)	2.95(7.36)		[c]0.14(0.26)	0.55
6.76(2.88)	-0.09(4.85)	[a]-0.60(2.03)			[a]1.35(2.12)	0.25
2.04(5.65)	-0.08(4.41)				[c]0.38(0.89)	0.21
X = Civil liberties						
9.17(5.97)	-0.07(5.51)	-1.37(6.21)	2.31(6.39)	1.26(5.77)	[c]0.18(0.27)	0.68
8.74(4.82)	-0.07(4.43)	-0.94(3.82)	2.99(7.41)		[c]-0.03(0.03)	0.55
6.36(2.77)	-0.09(4.77)	[b]-0.61(1.94)			[b]1.84(1.98)	0.25
1.97(4.22)	-0.08(4.39)				[c]0.44(0.73)	0.21
X = Political rights						
9.63(6.15)	-0.07(5.57)	-1.44(6.55)	2.27(6.45)	1.25(5.75)	[c]0.44(0.76)	0.68
9.61(5.20)	-0.07(4.51)	-1.08(4.32)	2.90(7.33)		[c]0.53(0.77)	0.55
6.99(3.00)	-0.09(4.77)	[a]-0.69(2.21)			[a]1.93(2.31)	0.26
1.93(4.34)	-0.08(4.33)				[c]0.48(0.91)	0.21

Notes: Absolute values of t-statistics are in parenthesis. All the estimated coefficients are significant at the 1% significance level. Exceptions: [a] significant at 5%; [b] significant at 10%; [c] insignificant at 10%.

In Table 3, I present the results of the OLS estimates for the Primary Exports Sample, replicating the three basic regressions in Sachs and Warner (1995a and 1997). I also include the simplest regression of *economic growth* on *primary exports share*. The coefficient estimates in the first three equations are very close to those reported in Sachs and Warner (1995a and 1997).[32] The robustness of the resource curse result is again confirmed. The coefficient for *primary exports share* is significant and negative in all four estimated equations and it survives, with only minor changes, the inclusion of the four different measures of the quality of democracy. The coefficient estimates for the

[32] A negligible difference is present due to the fact that, unlike Sachs and Warner, I exclude Hong Kong from the sample.

indices of the quality of democracy have the expected signs, supporting the idea that democracy is associated with economic growth. However, unlike the results in the Natural Capital Sample, the *autocracy* index is insignificant in all four equations, while the indices of *democracy*, *civil liberties*, and *political rights* are significant only at the 5 per cent or 10 per cent level and only in the regression of *economic growth* on *primary exports share* and *log initial income*. These differences can be partly explained by the inclusion of a measure of openness in the Primary Exports Sample. *Openness* can be also interpreted as a measure of the institutional environment.

4.4.2 NR Abundance and Economic Growth

To see the effect of pure NR wealth on growth, I estimate regressions identical to those in the previous section, but replace *natural capital share* in the Natural Capital Sample with *natural capital per capita*, and *primary exports share* in the Primary Exports Sample with *primary exports per capita*. That is, measures of NR dependence are replaced by measures of NR abundance. Simple correlations suggest that we can expect radically different results. *Natural capital per capita* with *natural capital share* and *primary exports per capita* with *primary exports share* are almost uncorrelated. (The correlation coefficients are only 0.12 and 0.03 respectively.) Also, in contrast to the strong negative correlation of *natural capital share* and *primary exports share* with *economic growth*, very low positive correlations are detected between *economic growth* and *natural capital per capita* or *primary exports per capita*. (Both correlation coefficients are only 0.05.)

Regression results using the Natural Capital Sample are reported in Table 4, results for the Primary Exports Sample in Table 5.[33] The coefficient for *natural capital per capita* and *primary exports per capita* is close to zero and insignificant in all the estimated equations. To further confirm this result, I reduce both samples to the 74 overlapping country-observations and estimate the four basic equations in each sample by using different measures of NR dependence and abundance. The results presented in

Tables 6 and 7 are clear. While *natural capital share* and *primary exports share* are significantly negatively related to growth in all equations, *natural capital per capita* and *primary exports per capita* are insignificant, with coefficient values close to zero in all equations in both samples.

Table 4: OLS estimates of the natural resource curse for the Natural Capital Sample using *natural capital per capita* as the measure of NR abundance. Dependent variable is *economic growth*.

OLS method; Obs. 85						
Constant	*Natural capital p. cap.*	*Log initial income*	*Investment ratio*	*Enrollment rate*	*X*	R^2
8.10(4.19)	[c]-0.00(0.06)	-1.50(5.97)	0.13(3.89)	0.06(5.98)		0.58
[c]-1.10(0.78)	[c]0.01(0.25)	[c]-0.30(1.64)	0.23(7.24)			0.40
[c]1.99(1.17)	[c]0.02(0.62)	[c]-0.10(0.43)				0.00
1.27(4.39)	[c]0.01(0.47)					0.00
X = Autocracy						
10.67(5.40)	[c]-0.01(0.35)	-1.69(6.93)	0.12(4.01)	0.05(5.45)	-2.17(3.33)	0.63
[a]3.90(2.17)	[c]-0.00(0.11)	-0.75(3.73)	0.21(7.01)		-2.96(3.99)	0.50
8.20(3.86)	[c]0.00(0.21)	-0.72(2.86)			-3.92(4.25)	0.19
2.24(5.32)	[c]-0.02(0.70)				-2.39(3.05)	0.10
X = Democracy						
9.35(4.90)	[c]-0.01(0.38)	-1.69(6.73)	0.12(3.88)	0.05(5.03)	1.58(2.78)	0.62
[b]3.00(1.83)	[c]-0.00(0.24)	-0.87(3.99)	0.20(6.54)		2.48(4.03)	0.50
7.22(3.90)	[c]-0.00(0.01)	-0.96(3.58)			3.55(4.85)	0.23
[a]0.68(2.06)	[c]-0.02(0.88)				1.81(3.09)	0.11
X = Civil liberties						
9.78(5.13)	[c]-0.01(0.61)	-1.83(7.04)	0.12(3.80)	0.05(4.95)	2.87(3.17)	0.63
[a]3.80(2.27)	[c]-0.01(0.54)	-1.10(4.52)	0.19(6.30)		4.32(4.42)	0.51
8.22(4.44)	[c]-0.01(0.38)	-1.31(4.44)			6.19(5.48)	0.28
[c]0.21(0.47)	[c]-0.02(0.98)				2.43(2.94)	0.10
X = Political rights						
9.97(5.37)	[c]-0.01(0.42)	-1.83(7.35)	0.11(3.63)	0.05(5.13)	2.62(3.77)	0.65
[a]3.67(2.30)	[c]-0.00(0.23)	-1.03(4.63)	0.19(6.12)		3.63(4.74)	0.53
7.89(4.54)	[c]-0.00(0.03)	-1.21(4.53)			5.17(5.94)	0.31
[c]0.20(0.49)	[c]-0.02(1.05)				2.41(3.49)	0.13

Notes: Absolute values of t-statistics are in parenthesis. All the estimated coefficients are significant at the 1% significance level. Exceptions: [a] significant at 5%; [b] significant at 10%; [c] insignificant at 10%.

[33] The sample 1970-1990 is reduced to 83 observations because the data on Primary exports per capita are missing for Germany, Iran, and Taiwan.

Table 5: OLS estimates of the natural resource curse for the Primary Exports Sample using exports of primary products per capita as the measure of NR abundance. Dependent variable is *economic growth*.

OLS method; Obs. 83						
Constant	*Primary exports p. cap.*	*Log initial income*	*Openness*	*Log investment ratio*	*X*	R^2
5.27(3.16)	[c]-0.02(1.18)	-0.97(4.27)	2.53(6.33)	1.20(4.82)		0.55
5.27(2.80)	[c]-0.02(1.00)	[a]-0.62(2.53)	3.13(7.31)			0.41
[c]-0.59(0.27)	[c]-0.00(0.16)	[c]0.22(0.79)				0.01
1.13(5.00)	[c]0.01(0.48)					0.00
X = Autocracy						
[a]5.15(2.52)	[c]-0.02(1.16)	-0.96(3.76)	2.54(6.18)	1.20(4.78)	[c]0.06(0.10)	0.55
[a]4.96(2.15)	[c]-0.02(0.96)	[a]-0.59(2.13)	3.15(7.16)		[c]0.16(0.24)	0.41
[c]1.23(0.43)	[c]-0.01(0.25)	[c]0.03(0.10)			[c]-0.82(0.98)	0.02
1.53(3.90)	[c]-0.00(0.23)				[c]-0.86(1.26)	0.02
X = Democracy						
5.07(2.65)	[c]-0.02(1.11)	-0.94(3.61)	2.55(6.15)	1.20(4.79)	[c]-0.12(0.21)	0.55
[a]5.40(2.49)	[c]-0.02(0.99)	[a]-0.63(2.21)	3.12(6.94)		[c]0.07(0.12)	0.41
[c]2.07(0.77)	[c]-0.01(0.54)	[c]-0.16(0.46)			[b]1.28(1.71)	0.05
0.84(3.12)	[c]-0.02(0.76)				[b]1.06(1.84)	0.04
X = Civil liberties						
5.14(2.71)	[c]-0.02(1.12)	-0.95(3.44)	2.54(6.08)	1.20(4.78)	[c]-0.12(0.15)	0.55
[a]5.03(2.34)	[c]-0.02(0.92)	[b]-0.57(1.92)	3.17(7.04)		[c]-0.22(0.25)	0.41
[c]1.58(0.60)	[c]-0.01(0.48)	[c]-0.14(0.38)			[c]1.58(1.44)	0.04
[c]0.58(1.42)	[c]-0.01(0.63)				[c]1.30(1.60)	0.03
X = Political rights						
5.81(2.97)	[c]-0.02(1.23)	-1.06(3.80)	2.48(6.02)	1.19(4.76)	[c]0.38(0.54)	0.55
6.09(2.76)	[c]-0.02(1.07)	[a]-0.75(2.45)	3.05(6.87)		[c]0.57(0.72)	0.41
[c]2.72(1.00)	[c]-0.01(0.44)	[c]-0.30(0.81)			[a]1.94(2.01)	0.06
[c]0.54(1.50)	[c]-0.02(0.81)				[a]1.40(2.01)	0.05

Notes: Absolute values of t-statistics are in parenthesis. All the estimated coefficients are significant at the 1% significance level. Exceptions: [a] significant at 5%; [b] significant at 10%; [c] insignificant at 10%.

In short, while NR dependence, measured either by *natural capital share* or *primary exports share*, is clearly associated with slower economic growth, no relationship exists between economic growth and NR abundance per se, whether measured by *natural capital per capita* or by *primary exports per capita*. The insignificant coefficient for *natural capital per capita* becomes positive and significant at the 1 per cent level if both *natural capital share* and *natural capital per capita* are included in all the estimated equations in the Natural Capital Sample (A result already noted by Gylfason and Zoega, 2002). At the same time, the estimated coefficients for other variables remain almost untouched by this specification change and their values remain very close to those reported in Table 2, except for the coefficient for *natural capital share*, which increases even more in absolute value.[34] Thus, for a given level of NR dependence, an increase in NR abundance is associated with an increase in economic growth. Surprisingly, this result was not detected in the Primary Exports Sample. If both *primary exports share* and *primary exports per capita* are included in all the estimated equations, the estimated coefficients for all variables remain almost the same as those reported in Table 3 and the coefficient for *primary exports per capita* is still insignificant and close to zero.

Table 6: OLS estimates of the natural resource curse for the Natural Capital Sample using several measures of NR dependence/abundance.
Dependent variable is *economic growth*.

OLS method; Obs. 74					
Constant	*X*	*Log initial income*	*Investment ratio*	*Enrollment rate*	R^2
X = Natural capital share					
9.96(5.37)	-0.07(4.17)	-1.47(6.66)	[a]0.08(2.47)	0.05(5.34)	0.65
[b]3.11(1.97)	-0.09(4.27)	-0.53(3.37)	0.17(4.87)		0.51
6.92(4.39)	-0.13(6.10)	-0.52(2.85)			0.34
2.50(9.01)	-0.10(5.14)				0.27
X = Natural capital per capita					
7.12(3.66)	[c]0.00(0.00)	-1.35(5.40)	0.12(3.46)	0.05(5.38)	0.57
[c]-1.10(0.77)	[c]0.01(0.49)	[c]-0.29(1.61)	0.23(6.56)		0.38
[c]1.77(1.03)	[c]0.01(0.57)	[c]-0.06(0.27)			0.00
1.31(4.63)	[c]0.01(0.51)				0.00
X = Primary exports share					
6.75(3.71)	-0.05(2.97)	-1.19(5.00)	0.13(3.82)	0.04(4.29)	0.62
[c]0.63(0.50)	-0.07(4.33)	[a]-0.33(2.30)	0.21(6.50)		0.51
[a]3.55(2.38)	-0.09(4.44)	[c]-0.14(0.76)			0.22
2.44(8.14)	-0.09(4.39)				0.21
X = Primary exports per capita					
6.67(3.45)	[c]-0.02(1.37)	-1.28(5.18)	0.12(3.28)	0.06(5.63)	0.58
[c]-0.97(0.59)	[c]0.01(0.39)	[c]-0.31(1.45)	0.23(6.55)		0.38
[c]2.14(1.07)	[c]0.01(0.61)	[c]-0.11(0.40)			0.01
1.34(5.30)	[c]0.01(0.47)				0.00

Notes: Only those country observations are used for which all the three measures of natural-resource abundance are available. As a result, 74 out of the total 86 observations are employed. Absolute values of t-statistics are in parenthesis. All the estimated coefficients are significant at the 1% significance level. Exceptions: [a] significant at 5%; [b] significant at 10%; [c] insignificant at 10%.

[34] To save space the results are not reported here.

Table 7: OLS estimates of the natural resource curse for the Primary Exports Sample using several measures of NR dependence/abundance.
Dependent variable is *economic growth*.

OLS method; Obs. 74					
Constant	*X*	*Log initial income*	*Openness*	*Log investment ratio*	R^2
X = Primary exports share					
8.77(6.88)	-0.06(5.09)	-1.29(7.62)	2.36(6.60)	1.13(5.10)	0.68
8.88(5.98)	-0.06(3.94)	-0.98(5.33)	2.99(7.64)		0.56
[b]3.06(1.78)	-0.08(4.07)	[c]-0.12(0.62)			0.19
2.01(7.17)	-0.08(4.06)				0.19
X = Primary exports per capita					
6.71(3.99)	[c]-0.01(0.73)	-1.11(4.93)	2.77(6.75)	1.02(3.97)	0.56
7.12(3.86)	[c]-0.01(0.47)	-0.86(3.62)	3.30(7.74)		0.46
[c]0.75(0.33)	[c]0.01(0.25)	[c]0.04(0.14)			0.00
1.06(4.54)	[c]0.01(0.46)				0.00
X = Natural capital share					
9.25(6.14)	-0.05(3.04)	-1.27(6.78)	2.52(6.44)	0.77(3.04)	0.61
10.0(6.36)	-0.07(3.95)	-1.11(5.84)	2.83(7.05)		0.56
5.59(2.98)	-0.10(4.80)	[b]-0.41(1.93)			0.25
2.00(7.51)	-0.08(4.33)				0.21
X = Natural capital per capita					
7.83(4.79)	[c]0.01(0.68)	-1.26(5.68)	2.79(6.73)	0.99(3.84)	0.56
8.37(4.70)	[c]0.02(1.01)	-1.04(4.44)	3.34(7.84)		0.47
[c]0.31(0.16)	[c]-0.00(0.10)	[c]0.10(0.40)			0.00
1.10(4.19)	[c]0.00(0.13)				0.00

Notes: Only those country observations are used for which all the three measures of natural-resource abundance are available. As a result, 74 out of the total 86 observations are employed. Absolute values of t-statistics are in parenthesis. All the estimated coefficients are significant at the 1% significance level. Exceptions: [a] significant at 5%; [b] significant at 10%; [c] insignificant at 10%.

To summarize, I have so far shown that in the cross-country growth regressions, natural resources themselves do not prove to be a threat to economic growth. Only NR dependence is associated with slow growth. Additionally, the correlation between the measures of NR abundance and dependence is very low in both data samples. It is the structure of the economy, namely the relatively small size of the non-resource sector, that results in increased NR dependence and is associated with slow economic growth. Therefore, it seems that cross-country growth regressions were previously misinterpreted when used as evidence for the curse of natural resources. Instead, NR dependence, indeed, serves as a proxy for a more fundamental structural problem that causes slow economic growth.

4.4.3 The Link between NR Effects and Institutional Development

Many authors, including Auty, Gelb, Gylfason, and Sachs and Warner, stress the role of policies and institutions in the curse of natural resources. Robinson, et al. (2002) and Mehlum, et al. (2002) develop models combining political incentives with NR endowments to generate the curse result. Mehlum even shows statistical evidence of the interaction between institutions and NR dependence in cross-country growth regressions. As seen above, when we include various democracy indicators to measure the effect of the institutional environment, the negative relationship between NR dependence and economic growth remains unchanged. To further address the supposed interaction between institutions and NR dependence, I sort the countries in each sample into quartiles using the democracy indicators, and estimate the basic regressions of *economic growth* on the *log initial income* and the appropriate measure of NR dependence.

In Figure 2, I plot the index of *civil liberties* against *natural capital share* in the Natural Capital Sample, and against *primary exports shar*e in the Primary Exports Sample.[35] It shows a relatively homogeneous distribution of natural capital dependence in both samples for different levels of *civil liberties*, with one exception. All eight of the most NR dependent countries in the Natural Capital Sample and four out of the six most NR dependent countries in the Primary Exports Sample have a very low level of civil liberties. Therefore, when I sort the countries according to quartiles, almost all the extremely NR dependent countries fall in the first quartile. This might bias down the coefficient estimate for NR dependence in this quartile, particularly if non-linearity in the relationship between economic growth and NR dependence is present. Indeed, when regressing *economic growth* on *log initial income*, *natural capital share*, and *natural capital share* squared in the Natural Capital Sample, the coefficient for *natural capital share* squared is significant at the 10 per cent level. Once the eight extremely NR dependent countries are excluded from the sample, the coefficient becomes insignificant. With the Primary Exports Sample, the coefficient for *primary exports*

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[35] To save space only the index of civil liberties is chosen as an example; the distribution would be very similar if the indices of political rights, democracy, or autocracy were selected.

share squared is insignificant. Once the six extremely NR dependent countries are excluded, however, the t-statistic drops from 1.38 to 0.18. This result indicates the presence of a non-linearity that disappears when the most NR dependent countries are excluded. In further analysis, therefore, I also employ reduced samples with the eight (for the Natural Capital Sample) and six (for the Primary Exports Sample) extremely NR dependent countries excluded.

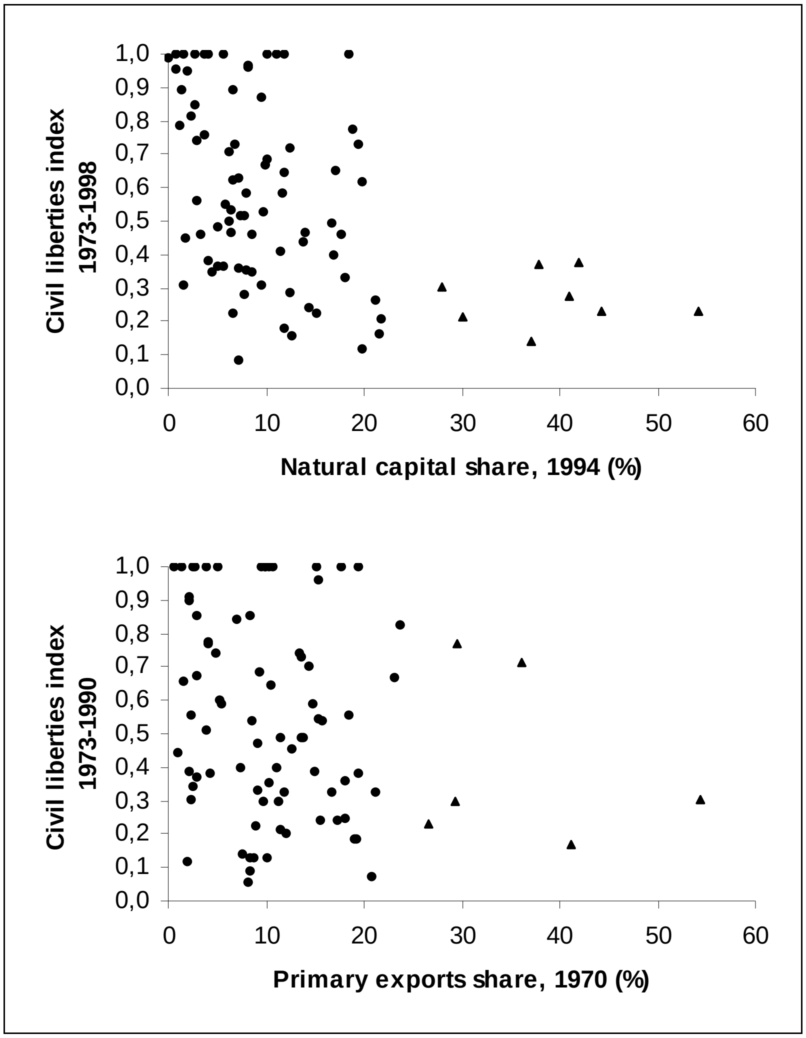

Figure 2: NR dependence and the index of civil liberties in the Natural Capital Sample and Primary Exports Sample.

Note: Triangles represent the most NR dependent countries, which are the Central African Republic, Chad, Guinea-Bissau, Madagascar, Mali, Niger, Sierra Leone, and Zambia in the Natural Capital Sample and the Ivory Coast, Gambia, Mauritania, Mauritius, Uganda, and Zambia in the Primary Exports Sample.

Figures 3 and 4 plot the estimated coefficients for *natural capital share* (Natural Capital Sample) and *primary exports share* (Primary Exports Sample) in groups of countries sorted with respect to the *civil liberties* and *autocracy* indices.[36] The estimated coefficients are plotted as a function of the average value of the appropriate index in each group.

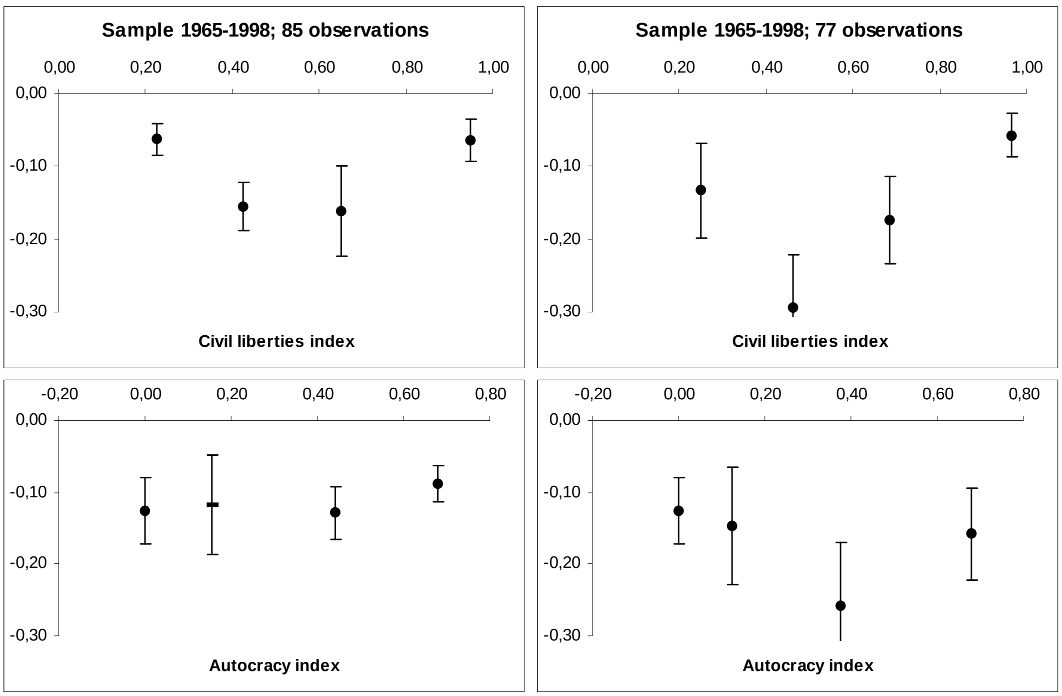

Figure 3: The resource curse estimated coefficient as a function of democracy measures in the Natural Capital Sample. The graphs on the left show results for the full sample; on the right, results for a reduced sample with the eight most NR dependent countries excluded.

Notes: On the horizontal axis I plot the estimated coefficient of *natural capital share* in the regression of *economic growth* on a *constant*, *natural capital share*, and *log initial income*. The error bars stand for estimated standard errors. Coefficients that are insignificant at the 10 per cent level are plotted with a dash. The four groups contain 21 (19), 23 (20), 20 (19), and 21 (19) country observations, when sorting with respect to the index of *civil liberties* and 25 (25), 18 (14), 21 (19), and 21 (19) country observations, when sorting with respect to the *autocracy index*. The figures in parentheses give the number of country observations when the reduced sample excluding the eight most NR dependent countries is employed.

[36] The results with the indices of democracy and political rights would be very close to those with the

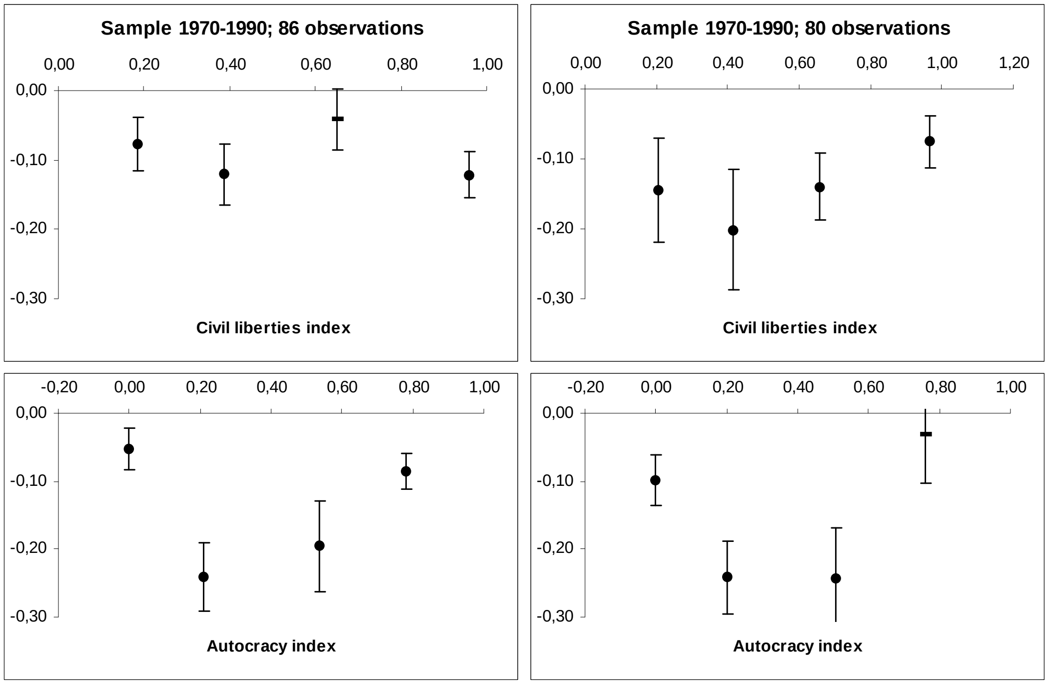

Figure 4: The resource curse estimated coefficient as a function of democracy measures in the Primary Exports Sample. The graphs on the left show results for the full sample; on the right, results for a reduced sample with the six most NR dependent countries excluded.

Notes: On the horizontal axis I plot the estimated coefficient of *primary exports share* in the regression of *economic growth* on a *constant*, *primary exports share*, and *log initial income*. The error bars stand for estimated standard errors. Coefficients that are insignificant at the 10 per cent level are plotted with a dash. The four groups contain 21 (22), 22 (18), 22 (20), and 21 (20) country observations, when sorting with respect to the index of *civil liberties* and 28 (26), 15 (14), 23 (20), and 20 (20) country observations, when sorting with respect to the *autocracy index*. The figures in parentheses give the number of country observations when the reduced sample excluding the six most NR dependent countries is employed.

The largest differences in the value of estimated coefficients for NR dependence are detected for countries sorted by quartiles on the index of *civil liberties* for the Natural Capital Sample and into the quartiles of the *autocracy* index for the Primary Exports Sample. These are also the only cases where some of the differences in the values of estimated coefficients are statistically significant. With the Natural Capital Sample, statistically significant differences are detected between the first and second and between the second and fourth quartile at the 5 per cent level. When the eight most NR

index of civil liberties.

dependent countries are excluded, statistically significant differences at the 10 per cent level are present between the first and second quartile and between the third and fourth quartile, and at the 1 per cent level between the second and third quartile. With the Primary Exports Sample, statistically significant differences are detected between the first and second quartile and between the second and fourth quartile at the 1 percent level, and between the first and third quartile at the 10 per cent level. When the six most NR dependent countries are excluded, statistically significant differences are present between the first and second, second and fourth, and third and fourth quartile at the 5 per cent level, and between the first and third quartile at the 10 per cent.

Figures 3 and 4 show a prevailing U-shape of the coefficient for NR dependence as a function of the *civil liberties* index with the Natural Capital Sample, and of the *autocracy index* with the Primary Exports Sample. The U-shape becomes more pronounced once the most NR dependent countries are excluded from both samples. The functions' U-shape suggests that further possible non-linearity in the resource curse regressions should be tested. To explore this issue, I tested for possible non-linear effects in the basic resource curse regressions of *economic growth* on *log initial income*, and the appropriate measure of NR dependence. Specifically, I included the indices of *civil liberties* and *autocracy* squared and the interaction term of the appropriate measure of NR dependence with the indices of *civil liberties* and *autocracy*, defined as NR dependence times the respective index. I also controlled for the linear effects of both indices in the regressions. The results provided limited support for non-linearity. With the Natural Capital, the interaction terms are significant at the 10 per cent level and with the eight most NR dependent countries excluded, even at the 1 per cent level, although only if the linear effects of the indices of *civil liberties* and *autocracy* are not considered. The significance of the interaction terms is in line with the observed functions' U-shapes. With the Primary Exports Sample, only the *autocracy index* squared is significant at the 1 per cent level with the full, and significant at the 5 per cent level with the six most NR dependent countries excluded. Admittedly, this result is somehow confusing, and it is not clear how it is related to the observed U-shapes of the functions in Figure 4.

Gylfason (2001) states, "It needs to be emphasized that it is not the existence of natural resources as such that seems to be the problem, but rather the failure of public authorities to avert the dangers that accompany the gifts of nature." Indeed, the prevailing interpretation suggests that healthy institutions and wise economic policies can mitigate the dangers of NR wealth. In this paper, however, I present evidence that it is not natural resources per se, but neglect of the non-resource sector that is the real cause for slow growth. Poor institutions seem to be the underlying cause of both slow growth and the resulting high degree of NR dependence.

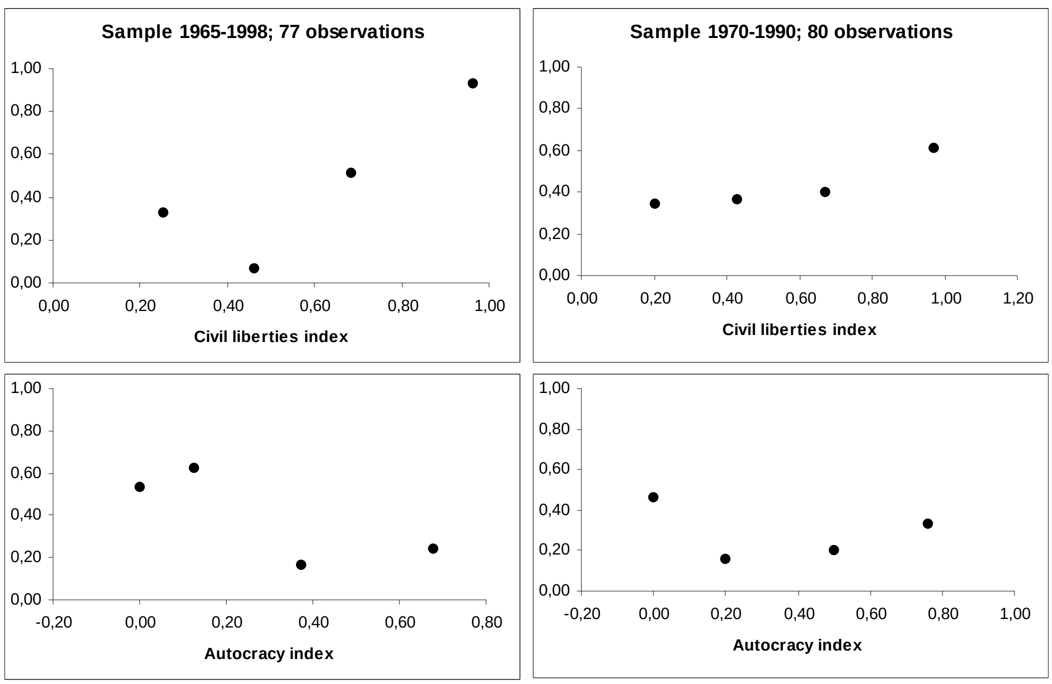

Figure 5: Correlation between *natural capital share* and *natural capital per capita* in the Natural Capital Sample and between *primary exports share* and *primary exports per capita* in the Primary Exports Sample plotted as a function of democracy measures. The graphs show results for reduced samples of 77 and 80 observations, where the eight most NR dependent countries are excluded from the Natural Capital Sample and the six most NR dependent countries are excluded from the Primary Exports Sample.

In Figure 5, I plot the correlation between NR dependence and abundance measures for the two samples as a function of *civil liberties* and *autocracy* indices. Reduced samples with the most NR dependent countries excluded are used, and the correlation coefficient is computed for the same country groups as the coefficient for NR dependence in Figures 3 and 4. Let us focus on the cases where statistically significant differences were detected between the values of the estimated coefficients. Remember that these are the cases where the countries are sorted with respect to the *civil liberties* index in the Natural Capital Sample and with respect to the *autocracy* index in the Primary Exports Sample. Indeed, the differences in the correlation coefficients are also the greatest here. Moreover, the correlation between the measures of NR dependence and abundance is low where the estimated coefficient for NR dependence was large, and vice-versa. In the remaining cases, the differences in the correlation coefficients are not that distinct. Nevertheless, the overall pattern remains: for groups of countries with a stronger resource curse result, the correlation between the measures of NR dependence and abundance tends to be lower and vice-versa.

The results in Figure 5 suggest that the capacity of NR dependence to measure the neglect of the non-resource sector can differ in different subsets of countries and that it is not NR dependence, but neglect of the non-resource sector that is the real cause of slow growth. If the correlation between NR abundance and dependence is high for a given subset of countries, then NR dependence is largely driven by real resource wealth and cannot serve as a good measure of non-resource sector neglect. Therefore, the curse of natural resources estimated in this subset of countries is not very strong. Conversely, the resource curse result is much stronger in those subsets of countries where the correlation between NR dependence and abundance is low. In such cases NR dependence does not vary with real NR wealth and serves as a good measure of non-resource sector neglect.

The argument presented above can also partly explain the prevailing U-shape of the coefficient for NR dependence plotted as a function of the *civil liberties* and *autocracy* indices in Figures 3 and 4. It is quite likely that the variation in economic institutions and policies and consequently in the neglect of the non-resource sector are much higher among countries that are moving toward democracy than among fully democratic or authoritarian countries. In other words, the imaginary mapping from the level of democracy to the quality of economic institutions and policies has the shape of a sigmoid. Additionally, if NR wealth is distributed more or less randomly and homogeneously, then variation in the neglect of the non-resource sector relative to variation in the NR wealth would be much higher in the second and third quartiles than in the first and fourth quartiles, when the countries are sorted with respect to the civil liberties and autocracy indices. Thus, the capacity of NR dependence to measure non-resource sector neglect should be much higher in the second and third quartiles, which would result in the observed U-shape of the resource curse coefficient plotted as a function of civil liberties and autocracy indices.

4.5 Conclusion

The results of cross-country growth regressions presented here provide no statistical evidence that natural resources themselves are associated with slow economic growth. Previous cross-country growth regressions re-estimated were misinterpreted when used as evidence for the curse of natural resources. These regressions clearly capture a different statistical relationship between the structure of the economy and economic growth. Countries with small non-resource sectors exhibit both a high degree of NR dependence and slow growth. Misinterpreting the previous results has led researchers and policy makers to focus overly on the resource sector. In fact, the link between measured resource dependence and growth is an artifact arising from factors that cause slow growth and underdeveloped economies in general. Our focus should be these factors that appear to be independent of resource abundance, but may be linked to institutional quality.

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4.6 Appendix A – Data and Definitions

Natural Capital Sample

Country	*Economic growth*	*Natural capital share*	*Natural capital p. cap.*	*Log initial income*	*Investment ratio*	*Enrollment rate*	*Autocracy*	*Democracy*	*Civil liberties*	*Political rights*
Argentina	0.400	6.697	12.855	9.238	22.810	56.103	0.376	0.409	0.622	0.641
Australia	1.700	11.889	44.419	9.433	23.727	85.758	0.000	1.000	1.000	1.000
Austria	2.600	2.642	7.898	9.202	23.788	92.031	0.000	1.000	1.000	1.000
Bangladesh	1.400	14.060	4.087	6.790	20.000	17.714	0.348	0.244	0.468	0.519
Belgium	2.300	0.003	2.241	9.320	19.545	96.871	0.000	1.000	0.987	1.000
Benin	0.100	7.678	2.386	6.720	15.176	12.000	0.506	0.152	0.282	0.231
Botswana	7.700	6.302	6.764	6.217	26.853	25.688	0.000	0.870	0.705	0.853
Brazil	2.200	7.894	9.058	8.055	20.690	33.097	0.424	0.385	0.583	0.654
Burkina Faso	0.900	16.911	3.046	6.468	21.000	3.448	0.542	0.036	0.397	0.276
Burundi	0.900	19.858	2.545	6.034	11.500	3.300	0.669	0.003	0.115	0.032
Cameroon	1.300	21.077	8.609	6.814	21.458	17.467	0.712	0.021	0.263	0.141
Canada	1.800	11.069	39.237	9.446	21.545	86.900	0.000	1.000	1.000	1.000
Central African Republic	-1.200	30.160	7.344	7.400	10.409	9.556	0.571	0.106	0.212	0.167
Chad	-0.600	37.133	7.159	6.936	7.471	4.923	0.685	0.012	0.141	0.096
Chile	1.900	9.782	17.575	8.428	19.000	54.806	0.303	0.382	0.526	0.391
China	6.800	7.229	3.507	5.852	30.619	44.500	0.741	0.000	0.083	0.077
Colombia	2.000	7.183	7.687	8.023	18.971	39.516	0.000	0.774	0.628	0.776
Congo	1.400	14.466	5.828	6.282	31.720	50.065	0.639	0.091	0.244	0.173
Costa Rica	1.200	8.205	9.822	8.274	20.618	40.242	0.000	1.000	0.968	1.000
Ivory Coast	-0.800	18.009	4.984	7.568	17.324	16.424	0.832	0.000	0.333	0.186
Denmark	1.900	3.753	12.051	9.459	22.939	101.419	0.000	1.000	1.000	1.000
Dominican Republic	2.300	12.407	10.679	7.625	20.794	35.333	0.145	0.430	0.718	0.776
Ecuador	1.800	17.011	11.497	7.419	19.235	43.448	0.150	0.582	0.654	0.628
Egypt	3.500	4.550	3.019	6.919	20.765	52.455	0.553	0.026	0.346	0.288
El Salvador	-0.400	2.846	1.516	8.428	15.500	24.419	0.166	0.445	0.564	0.641
Finland	2.400	6.602	17.812	9.152	23.970	101.938	0.000	1.000	0.891	0.904
France	2.100	2.735	9.783	9.277	21.758	86.031	0.012	0.815	0.846	1.000
Gambia	0.400	11.844	2.729	7.132	19.500	13.097	0.088	0.656	0.647	0.660
Ghana	-0.800	7.221	2.518	7.724	11.875	31.333	0.500	0.117	0.359	0.250
Greece	2.400	3.657	6.790	8.764	25.394	80.125	0.167	0.703	0.756	0.859
Guatemala	0.700	3.309	2.070	7.923	14.324	16.379	0.252	0.291	0.462	0.538
Guinea-Bissau	-0.100	44.204	10.508	6.384	29.150	6.417	0.592	0.083	0.229	0.243
Haiti	-0.800	6.683	1.108	7.494	10.875	13.300	0.716	0.131	0.224	0.141
Honduras	0.600	9.940	4.153	7.560	19.765	22.083	0.091	0.353	0.667	0.571
India	2.700	19.788	5.010	6.751	18.559	33.969	0.000	0.835	0.615	0.782
Indonesia	4.700	12.378	9.730	6.270	25.500	31.469	0.685	0.000	0.288	0.250
Ireland	3.000	8.117	23.284	8.822	21.030	89.875	0.000	1.000	0.962	1.000
Italy	2.500	1.320	4.179	9.107	21.606	72.313	0.000	1.000	0.891	0.974
Jamaica	-0.400	6.776	4.061	8.247	24.853	58.296	0.000	0.982	0.731	0.865
Japan	3.500	0.758	2.386	8.933	30.818	92.387	0.000	1.000	0.955	0.936

Jordan	-0.400	1.589	1.213	8.001	29.391	47.970	0.791	0.050	0.308	0.301
Kenya	1.300	9.439	2.123	6.445	17.382	17.097	0.591	0.053	0.308	0.250
Korea	6.600	1.750	3.362	7.385	29.353	71.625	0.364	0.321	0.449	0.558
Madagascar	-1.800	41.871	8.557	7.207	10.500	14.833	0.391	0.233	0.378	0.423
Malawi	0.500	11.782	1.108	6.147	17.385	5.871	0.765	0.103	0.179	0.212
Malaysia	4.100	8.618	14.477	7.623	28.412	47.939	0.094	0.535	0.462	0.590
Mali	-0.100	41.041	6.289	6.545	17.500	7.121	0.552	0.142	0.276	0.212
Mauritania	-0.100	21.570	6.658	7.346	20.357	9.226	0.676	0.000	0.160	0.090
Mauritius	3.800	1.245	1.622	7.786	21.824	44.813	0.000	0.955	0.788	0.853
Mexico	1.500	5.885	8.596	8.425	19.588	43.032	0.376	0.138	0.551	0.545
Morocco	1.800	4.075	2.901	7.478	20.441	25.875	0.812	0.000	0.385	0.429
Mozambique	0.500	12.681	1.490	6.442	12.737	5.000	0.588	0.125	0.159	0.196
Namibia	0.700	10.071	8.965	8.341	19.053	51.667	0.000	0.600	0.685	0.796
Nepal	1.100	17.698	3.547	6.713	17.500	21.500	0.529	0.185	0.462	0.519
Netherlands	1.900	1.524	5.155	9.392	21.848	99.375	0.000	1.000	1.000	1.000
New Zealand	0.700	18.473	54.241	9.455	22.242	86.515	0.000	1.000	1.000	1.000
Nicaragua	-3.300	13.878	4.746	8.655	19.971	33.515	0.434	0.213	0.436	0.397
Niger	-2.500	54.241	15.874	7.427	11.421	4.094	0.606	0.097	0.231	0.122
Norway	3.000	10.016	33.106	9.198	26.697	93.813	0.000	1.000	1.000	1.000
Pakistan	2.700	5.552	2.347	6.531	16.265	15.630	0.253	0.433	0.365	0.410
Panama	0.700	6.473	7.212	8.272	19.579	54.903	0.415	0.294	0.468	0.359
Papua New Guinea	0.500	19.324	9.849	7.534	23.382	10.903	0.000	1.000	0.732	0.826
Paraguay	2.300	11.539	9.084	7.619	20.765	26.469	0.579	0.168	0.410	0.410
Peru	-0.300	7.784	6.039	8.437	20.971	52.750	0.281	0.388	0.519	0.500
Philippines	0.900	6.174	3.560	7.927	21.647	61.667	0.376	0.400	0.500	0.538
Portugal	3.200	2.313	5.076	8.547	27.000	59.000	0.253	0.700	0.814	0.859
Rwanda	0.000	21.708	1.371	6.477	12.647	4.519	0.661	0.024	0.205	0.103
Senegal	-0.400	16.785	6.711	7.300	12.441	12.333	0.450	0.124	0.494	0.462
Sierra Leone	-1.600	28.009	4.008	6.630	7.357	13.154	0.566	0.081	0.301	0.237
South Africa	0.100	5.043	5.432	8.991	22.206	62.231	0.247	0.731	0.365	0.468
Spain	2.300	2.857	7.054	8.927	23.000	84.000	0.226	0.665	0.744	0.840
Sri Lanka	3.000	7.421	4.259	7.012	22.103	57.032	0.047	0.662	0.519	0.692
Sweden	1.400	5.608	16.204	9.437	19.939	90.906	0.000	1.000	1.000	0.994
Switzerland	1.200	0.868	3.204	9.805	25.182	85.387	0.000	1.000	1.000	1.000
Thailand	5.000	6.486	8.728	7.007	28.706	29.182	0.203	0.394	0.532	0.545
Togo	-0.600	15.184	3.296	7.408	17.316	19.813	0.619	0.019	0.224	0.083
Trinidad and Tobago	2.600	9.487	15.835	8.036	21.265	62.333	0.000	0.850	0.872	0.936
Tunisia	2.700	7.908	8.385	7.671	26.147	34.121	0.721	0.018	0.353	0.224
Turkey	2.100	5.019	5.142	8.108	18.613	36.750	0.103	0.738	0.481	0.660
United Kingdom	1.900	1.859	5.577	9.298	17.970	87.656	0.000	1.000	0.949	1.000
United States	1.600	4.112	19.909	9.759	18.273	90.600	0.000	1.000	1.000	1.000
Uruguay	1.200	11.645	19.513	8.659	14.441	66.742	0.278	0.575	0.583	0.609
Venezuela	-0.800	18.929	25.776	8.914	21.941	32.871	0.012	0.859	0.776	0.910
Zambia	-2.000	37.770	7.199	7.186	17.828	17.133	0.574	0.185	0.372	0.391
Zimbabwe	0.500	8.483	2.953	7.655	17.029	25.697	0.393	0.332	0.346	0.346

Definitions:

- *Economic growth*: The average annual growth of real per capita GDP over the period 1965-1998; unit: percent; source: World Bank (2000).
  Note: Data are available in Gylfason and Zoega (2002).
- *Natural capital share*: The share of natural capital in total capital (natural, human, and physical capital) in 1994; the value of natural capital comprises the value of pastureland, cropland, timber resources, non-timber forest resources, protected areas, and subsoil assets; unit: percent; source: World Bank (1997).
  Note: Data are available in Gylfason and Zoega (2002).
- *Natural capital per capita*: The per capita value of pastureland, cropland, timber resources, non-timber forest resources, and subsoil assets in 1994 multiplied by an appropriate constant so that the sample maximum of *Natural capital per capita* equals the sample maximum of *Natural capital share*; unit: 1994 U.S. dollars (times 758.5); source: World Bank (1997).
- *Log initial income*: Natural logarithm of 1965 per capita GNP computed from the 1998 purchasing power parity adjusted per capita GNP by dividing with $(1+\textit{Economic growth}/100)^{33}$ and by taking the natural logarithm; unit: index; source: World Bank (2000).
  Note: Data are available in Gylfason and Zoega (2002).
- *Investment ratio*: The average gross domestic investment as a percentage of GDP over the period 1965-1998; unit: percent; source: World Bank (2000).
  Note: Data are available in Gylfason and Zoega (2002).
- *Enrollment rate*: The average secondary school enrollment rate (gross) over the period 1965-1998; unit: percent; source: World Bank (2000).
  Note: Data are available in Gylfason and Zoega (2002).
- *Autocracy*: Average of the Polity IV variable AUTOC over the period 1965-1998 (for each country only the years with available data were used) rescaled to the range 0 to 1; 1 indicates the highest and 0 the lowest level of autocracy; unit: index; source Polity IV Project (2001).
- *Democracy*: Average of the Polity IV variable DEMOC over the period 1965-1998 (for each country only the years with available data were used) rescaled to the range 0 to 1; 1 indicates the highest and 0 the lowest level of democracy; unit: index; source Polity IV Project (2001).
- *Civil liberties*: Average of the Freedom House index of civil liberties over the period 1973-1998 (for each country only the years with available data were used) rescaled to the range 0 to 1; 1 indicates the highest and 0 the lowest level of civil liberties; unit: index; source Freedom House (2002).
- *Political rights*: Average of the Freedom House index of political rights over the period 1973-1998 (for each country only the years with available data were used) rescaled to the range 0 to 1; 1 indicates the highest and 0 the lowest level of political rights; unit: index; source Freedom House (2002).

Table A.1: Statistics on variables used in the Natural Capital Sample.

Variable	Mean	Median	Max.	Min.	Standard deviation	Obs.
Economic growth	1.36	1.30	7.70	-3.30	1.92	85
Nat. capital share	11.8	8.21	54.2	0.00	10.8	85
Nat. capital p. cap.	8.82	6.29	54.2	1.11	9.35	85
Log initial income	7.85	7.67	9.81	5.85	1.06	85
Invest. ratio	20.2	20.6	31.7	7.36	5.27	85
Enrollment rate	43.8	36.8	101.9	3.30	30.2	85
Autocracy	0.31	0.28	0.83	0.00	0.28	85
Democracy	0.47	0.39	1.00	0.00	0.38	85
Civil liberties	0.56	0.52	1.00	0.08	0.28	85
Political rights	0.57	0.54	1.00	0.03	0.32	85

Table A.2: Correlations of variables used in the Natural Capital Sample.

Variable	*Economic growth*	*Nat. capital share*	*Nat. capital p. cap.*	*Log initial income*	*Invest. ratio*
Economic growth	1.00				
Nat. capital share	-0.53	1.00			
Nat. capital p. cap.	0.05	0.12	1.00		
Log initial income	-0.02	-0.45	0.47	1.00	
Invest. ratio	0.61	-0.41	0.16	0.21	1.00
Enrollment rate	0.39	-0.57	0.43	0.82	0.48
Autocracy	-0.32	0.41	-0.32	-0.65	-0.28
Democracy	0.31	-0.43	0.43	0.73	0.33
Civil liberties	0.29	-0.47	0.48	0.81	0.35
Political rights	0.35	-0.48	0.43	0.76	0.37

Variable	*Enrollment rate*	*Autocracy*	*Democracy*	*Civil liberties*	*Political rights*
Economic growth					
Nat. capital share					
Nat. capital p. cap.					
Log initial income					
Invest. ratio					
Enrollment rate	1.00				
Autocracy	-0.66	1.00			
Democracy	0.76	-0.94	1.00		
Civil liberties	0.81	-0.88	0.92	1.00	
Political rights	0.78	-0.92	0.95	0.97	1.00

Primary Exports Sample

Country	Economic growth	Primary exports share	Primary exports p. cap.	Log initial income	Openness	Log investment ratio	Autocracy	Democracy	Civil liberties	Political rights
Algeria	1.478	19.237	5.205	8.255	0.000	3.301	0.843	0.010	0.185	0.167
Argentina	-0.688	5.262	7.619	9.088	0.000	2.826	0.419	0.381	0.602	0.537
Australia	1.152	9.983	28.232	9.748	1.000	3.312	0.000	1.000	1.000	1.000
Austria	2.161	3.891	13.199	9.411	1.000	3.254	0.000	1.000	1.000	1.000
Bangladesh	0.141	0.978	0.043	7.827	0.000	1.139	0.495	0.095	0.444	0.417
Belgium	2.016	10.775	37.385	9.489	1.000	3.103	0.000	1.000	1.000	1.000
Benin	-0.802	8.385	0.649	7.677	0.038	1.493	0.660	0.010	0.093	0.000
Bolivia	-0.006	18.452	3.294	8.037	0.731	2.730	0.362	0.371	0.556	0.500
Brazil	1.992	5.487	3.013	8.408	0.000	2.981	0.471	0.319	0.593	0.593
Burkina Faso	1.722	4.348	0.181	6.544	0.000	2.251	0.535	0.060	0.380	0.269
Burundi	2.796	10.079	0.346	6.425	0.000	1.817	0.700	0.000	0.130	0.019
Cameroon	2.556	18.146	1.911	7.286	0.000	2.360	0.786	0.000	0.250	0.157
Canada	2.189	9.588	25.410	9.702	1.000	3.189	0.000	1.000	1.000	1.000
Central African Republic	-1.112	8.826	0.864	7.198	0.000	1.670	0.700	0.000	0.130	0.028
Chile	0.263	14.879	7.640	8.773	0.577	2.901	0.490	0.171	0.389	0.194
China	2.252	1.950	0.070	7.126	0.000	3.019	0.729	0.000	0.120	0.111
Colombia	1.433	9.417	2.815	8.329	0.192	2.751	0.000	0.781	0.685	0.824
Congo	1.737	7.630	0.880	8.026	0.000	2.224	0.757	0.000	0.139	0.074
Costa Rica	0.131	19.346	7.798	8.652	0.154	2.848	0.000	1.000	1.000	1.000
Ivory Coast	-1.289	29.321	5.626	8.072	0.000	2.308	0.890	0.000	0.296	0.194
Cyprus	3.604	14.406	11.320	8.761	1.000	3.283	0.000	0.943	0.704	0.833
Denmark	1.585	9.858	45.426	9.616	1.000	3.196	0.000	1.000	1.000	1.000
Dominican Republic	0.851	13.459	2.506	8.036	0.000	2.877	0.152	0.410	0.741	0.815
Ecuador	1.639	10.561	1.980	8.164	0.731	3.132	0.205	0.533	0.648	0.546
Egypt	2.226	7.320	0.707	7.669	0.000	1.635	0.576	0.005	0.398	0.315
El Salvador	-0.125	15.674	5.443	8.180	0.038	2.103	0.206	0.363	0.537	0.620
Finland	2.661	7.018	22.095	9.412	1.000	3.521	0.000	1.000	0.843	0.861
France	1.775	2.998	10.633	9.599	1.000	3.285	0.000	0.824	0.852	1.000
Gambia	0.614	36.125	2.510	7.174	0.192	1.800	0.000	0.757	0.713	0.759
Germany	1.678	2.181		9.602	1.000	3.247	0.000	1.000	0.898	1.000
Ghana	-0.727	21.091	2.167	7.623	0.192	1.620	0.574	0.116	0.324	0.185
Greece	2.139	4.087	5.907	8.795	1.000	3.201	0.140	0.690	0.769	0.796
Guatemala	0.234	11.399	2.885	8.283	0.077	2.218	0.345	0.180	0.491	0.519
Honduras	0.363	23.196	2.828	7.809	0.000	2.595	0.100	0.316	0.667	0.491
India	1.987	1.648	0.077	7.268	0.000	2.653	0.000	0.814	0.657	0.833
Indonesia	4.557	11.239	0.721	7.176	0.769	3.071	0.700	0.000	0.296	0.333
Iran	-1.908	11.946		9.155	0.000	3.022	0.800	0.000	0.204	0.259
Ireland	2.728	15.430	24.487	9.071	0.962	3.256	0.000	1.000	0.963	1.000
Israel	2.219	3.985	7.249	9.207	0.192	3.199	0.000	0.900	0.778	0.833
Italy	2.186	2.081	4.851	9.370	1.000	3.254	0.000	1.000	0.907	0.963
Jamaica	-1.350	13.681	5.200	8.626	0.385	2.937	0.000	1.000	0.731	0.880
Japan	3.314	0.640	2.753	9.269	1.000	3.537	0.000	1.000	1.000	0.926

Jordan	2.934	8.976	3.536	7.933	1.000	2.821	0.910	0.010	0.222	0.213
Kenya	2.241	18.082	0.846	7.111	0.115	2.676	0.686	0.000	0.361	0.278
Korea	5.706	2.242	1.049	8.031	0.846	3.295	0.540	0.145	0.306	0.435
Madagascar	-2.372	11.874	0.987	7.665	0.000	0.333	0.543	0.033	0.324	0.296
Malawi	0.872	20.730	0.606	6.760	0.000	2.424	0.900	0.000	0.074	0.102
Mali	1.418	8.383	0.444	6.677	0.077	1.772	0.700	0.000	0.130	0.019
Mauritania	-0.319	41.095	4.353	7.383	0.000	2.838	0.700	0.000	0.167	0.102
Mauritius	3.388	29.484	7.662	8.405	1.000	2.340	0.000	0.943	0.769	0.806
Mexico	1.063	2.413	1.494	8.990	0.154	2.839	0.438	0.081	0.556	0.556
Morocco	1.589	11.000	2.008	7.930	0.231	2.417	0.833	0.000	0.398	0.472
Netherlands	1.246	15.127	54.311	9.596	1.000	3.149	0.000	1.000	1.000	1.000
New Zealand	0.513	17.748	47.359	9.662	0.154	3.169	0.000	1.000	1.000	1.000
Nicaragua	-3.094	19.390	3.281	8.473	0.000	2.501	0.521	0.063	0.380	0.315
Nigeria	1.296	13.821	0.699	7.323	0.154	2.712	0.700	0.000	0.491	0.352
Norway	2.924	10.317	34.541	9.459	1.000	3.481	0.000	1.000	1.000	1.000
Pakistan	1.153	2.937	0.168	7.619	0.000	2.259	0.378	0.311	0.370	0.343
Paraguay	1.580	9.705	2.178	7.930	0.038	2.742	0.733	0.029	0.296	0.343
Peru	-1.628	15.285	8.032	8.558	0.115	2.861	0.295	0.411	0.546	0.537
Philippines	0.681	12.598	2.250	7.903	0.077	2.803	0.590	0.200	0.454	0.454
Portugal	3.751	4.781	5.072	8.581	1.000	3.135	0.189	0.758	0.741	0.796
Rwanda	0.864	11.368	0.625	7.158	0.000	1.548	0.686	0.014	0.213	0.111
Senegal	0.248	13.522	1.792	7.667	0.000	1.630	0.448	0.124	0.491	0.444
Sierra Leone	-2.089	9.056	0.592	7.865	0.000	0.311	0.643	0.014	0.333	0.296
Singapore	5.770	2.619	3.504	8.559	1.000	3.584	0.400	0.200	0.343	0.417
South Africa	-0.231	17.200	14.615	8.683	0.000	2.920	0.295	0.700	0.241	0.389
Spain	2.115	2.988	5.215	9.150	1.000	3.221	0.194	0.700	0.676	0.769
Sri Lanka	1.924	14.804	1.086	7.734	0.231	2.391	0.038	0.676	0.593	0.759
Sudan	-0.322	15.529	0.759	7.342	0.000	1.876	0.605	0.126	0.241	0.269
Sweden	1.661	5.037	20.583	9.707	1.000	3.108	0.000	1.000	1.000	0.991
Switzerland	0.993	2.467	19.450	9.894	1.000	3.363	0.000	1.000	1.000	1.000
Syria	2.405	8.076	1.056	8.499	0.038	2.729	0.900	0.000	0.056	0.194
Taiwan	5.771	2.226		8.246	1.000	3.196	0.648	0.038	0.389	0.306
Thailand	3.145	8.559	1.406	8.008	1.000	2.865	0.200	0.284	0.537	0.509
Togo	0.473	19.072	1.551	7.057	0.000	2.910	0.700	0.000	0.185	0.056
Trinidad and Tobago	-0.006	8.306	3.549	9.450	0.000	2.573	0.000	0.833	0.852	0.907
Tunisia	2.759	10.302	2.134	7.967	0.038	2.677	0.790	0.000	0.352	0.231
Turkey	2.086	3.798	1.367	8.305	0.038	3.115	0.138	0.671	0.509	0.694
Uganda	-0.802	26.551	1.317	7.157	0.077	0.924	0.542	0.105	0.231	0.204
United Kingdom	1.985	2.632	6.757	9.517	1.000	2.897	0.000	1.000	1.000	1.000
United States	1.342	1.263	4.954	9.949	1.000	3.128	0.000	1.000	1.000	1.000
Uruguay	0.594	9.100	7.604	8.782	0.000	2.663	0.468	0.337	0.472	0.463
Venezuela	-1.847	23.696	21.249	9.620	0.038	3.098	0.000	0.900	0.824	0.963
Zambia	-2.184	54.311	7.267	7.683	0.000	2.771	0.843	0.029	0.306	0.315
Zimbabwe	0.016	16.607	2.301	7.717	0.000	2.699	0.310	0.465	0.324	0.361

Definitions:

- *Economic growth*: The average annual growth of real GDP divided by the economically active population over the period 1970-1990; unit: percent; source: Penn World Tables, mark 5.6.
  Note: Data are available at http://www.cid.harvard.edu/. A more detailed description of the data and some exceptions from the basic definition can be found in Sachs and Warner (1997), where this variable is called GEA7090.
- *Primary exports share*: The share of exports of primary products in GNP in 1970; primary products exports are exports of fuels and non-fuel primary products; both numerator and denominator are measured in nominal U.S. dollars; local currency GNP is converted to dollars using a smoothed exchange rate; unit: percent; source: World Bank (1995).
  Note: Data are available at http://www.cid.harvard.edu/. A more detailed description of the data and some exceptions from the basic definition can be found in Sachs and Warner (1997), where this variable is called SXP.
- *Primary exports per capita*: Exports of primary products per capita in 1970; computed by multiplying *Primary exports share* with GNP per capita in 1970 measured in constant 1995 U.S. dollars and by multiplying the result with an appropriate constant so that the sample maximum of *Primary exports per capita* equals the sample maximum of *Primary exports share*; unit: 1995 U.S. dollars (times 46.4); source: World Bank (2000) for the 1970 GNP per capita.
  Note: In some cases a different year than 1970 is chosen for the GNP per capita. The exceptions are in accord with the exceptions from the basic definition of *Primary exports share* as described in Sachs and Warner (1997).
- *Log initial income*: Natural logarithm of real GDP divided by the economically active population in 1970; unit: index; source: Penn World Tables, mark 5.6 for the real GDP and World Bank (1995) for the economically active population.
  Note: Data are available at http://www.cid.harvard.edu/. A more detailed description of the data and some exceptions from the basic definition can be found in Sachs and Warner (1997), where this variable is called LGDPEA70.
- *Openness*: The fraction of years during the period 1970-1990 in which the country is rated as an open economy; unit: index; source: Sachs and Warner (1995b).
  Note: Data are available at http://www.cid.harvard.edu/. In Sachs and Warner (1997), this variable is called SOPEN.
- *Log Investment ratio*: Natural logarithm of the ratio of real gross domestic investment (public plus private) to real GDP, averaged over the period 1970-1989; unit: index; source: Penn World Tables, mark 5.6.
  Note: Data are available at http://www.cid.harvard.edu/. In Sachs and Warner (1997), this variable is called LINV7089.
- *Autocracy*: Average of the Polity IV variable AUTOC over the period 1970-1990 (for each country only the years with available data were used) rescaled to the range 0 to 1; 1 indicates the highest and 0 the lowest level of autocracy; unit: index; source Polity IV Project (2001).
- *Democracy*: Average of the Polity IV variable DEMOC over the period 1970-1990 (for each country only the years with available data were used) rescaled to the range 0 to 1; 1 indicates the highest and 0 the lowest level of democracy; unit: index; source Polity IV Project (2001).

- *Civil liberties*: Average of the Freedom House index of civil liberties over the period 1973-1990 (for each country only the years with available data were used) rescaled to the range 0 to 1; 1 indicates the highest and 0 the lowest level of civil liberties; unit: index; source Freedom House (2002).
- *Political rights*: Average of the Freedom House index of political rights over the period 1973-1990 (for each country only the years with available data were used) rescaled to the range 0 to 1; 1 indicates the highest and 0 the lowest level of political rights; unit: index; source Freedom House (2002).

Table A.3: Statistics on variables used in the Primary Exports Sample.

Variable	Mean	Median	Max.	Min.	Standard deviation	Obs.
Economic growth	1.21	1.43	5.77	-3.09	1.77	86
Primary exports share	11.9	10.2	54.3	0.64	9.23	86
Primary exports p. cap.	7.54	2.88	54.3	0.04	11.3	83
Log initial income	8.32	8.25	9.95	6.43	0.91	86
Openness	0.38	0.12	1.00	0.00	0.44	86
Log invest. ratio	2.66	2.84	3.58	0.31	0.68	86
Autocracy	0.36	0.37	0.91	0.00	0.32	86
Democracy	0.43	0.32	1.00	0.00	0.41	86
Civil liberties	0.54	0.50	1.00	0.06	0.30	86
Political rights	0.55	0.50	1.00	0.00	0.33	86

Table A.4: Correlations of variables used in the Primary Exports Sample.

Variable	*Economic growth*	*Prim. exports share*	*Prim. exports p. cap.*	*Log initial income*	*Openness*
Economic growth	1.00				
Primary exports share	-0.45	1.00			
Primary exports p. cap.	0.05	0.03	1.00		
Log initial income	0.08	-0.30	0.66	1.00	
Openness	0.57	-0.33	0.47	0.61	1.00
Log invest. ratio	0.48	-0.20	0.42	0.60	0.57
Autocracy	-0.14	0.21	-0.51	-0.68	-0.54
Democracy	0.17	-0.19	0.62	0.76	0.62
Civil liberties	0.17	-0.22	0.63	0.79	0.63
Political rights	0.19	-0.23	0.60	0.80	0.62

	Log invest. ratio	*Autocracy*	*Democracy*	*Civil liberties*	*Political rights*
Economic growth					
Prim. exports share					
Prim. exports p. cap.					
Log initial income					
Openness					
Log invest. ratio	1.00				
Autocracy	-0.42	1.00			
Democracy	0.53	-0.94	1.00		
Civil liberties	0.51	-0.90	0.92	1.00	
Political rights	0.54	-0.92	0.94	0.97	1.00