An analysis of the factors driving long-term economic growth

A Business Computing project by Exchange Students

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- Macroeconomic theories
- Our data
- Our models
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- Predictive power of our model
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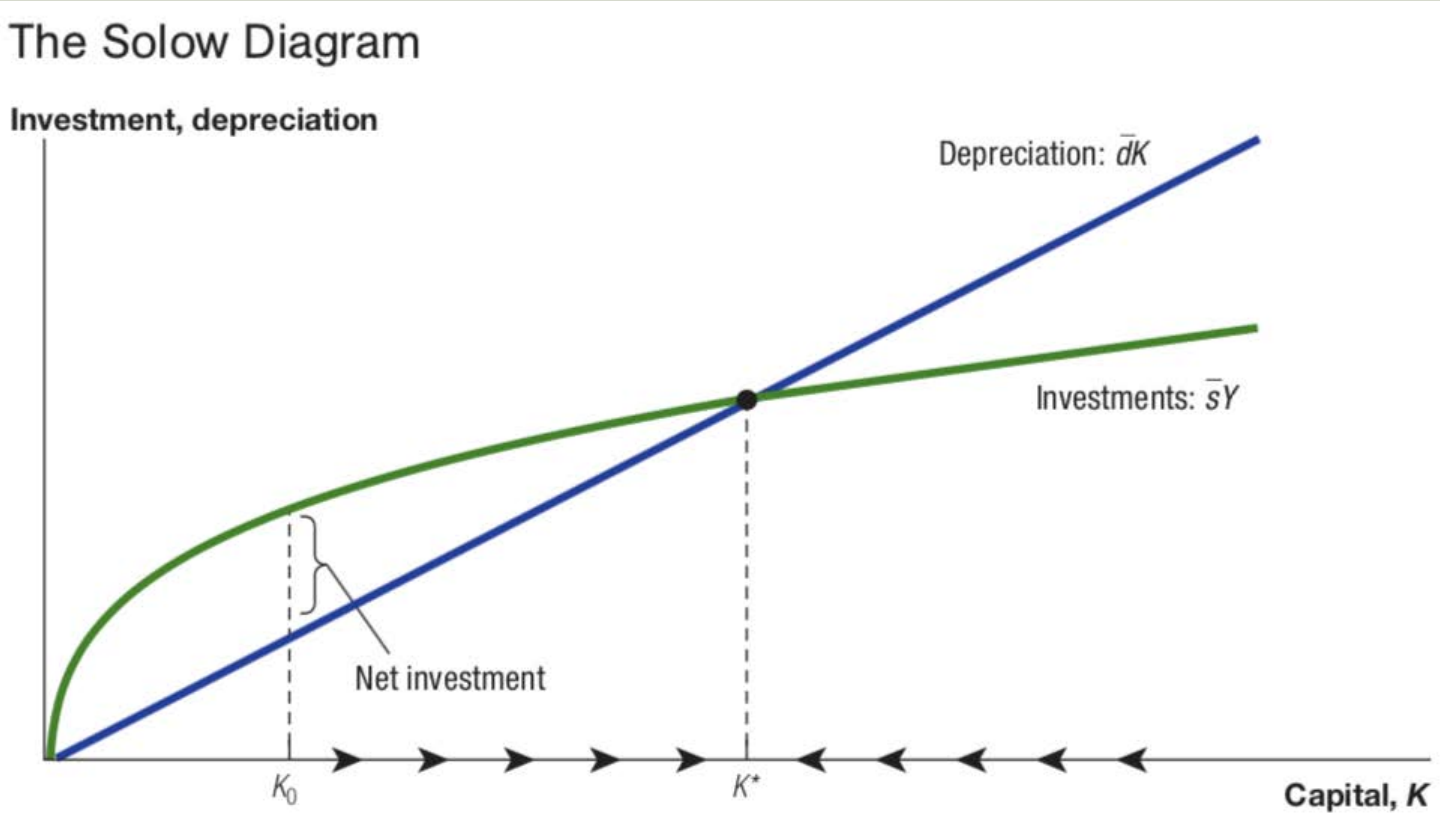
The problem

- Analyze the factors driving long-term economic growth

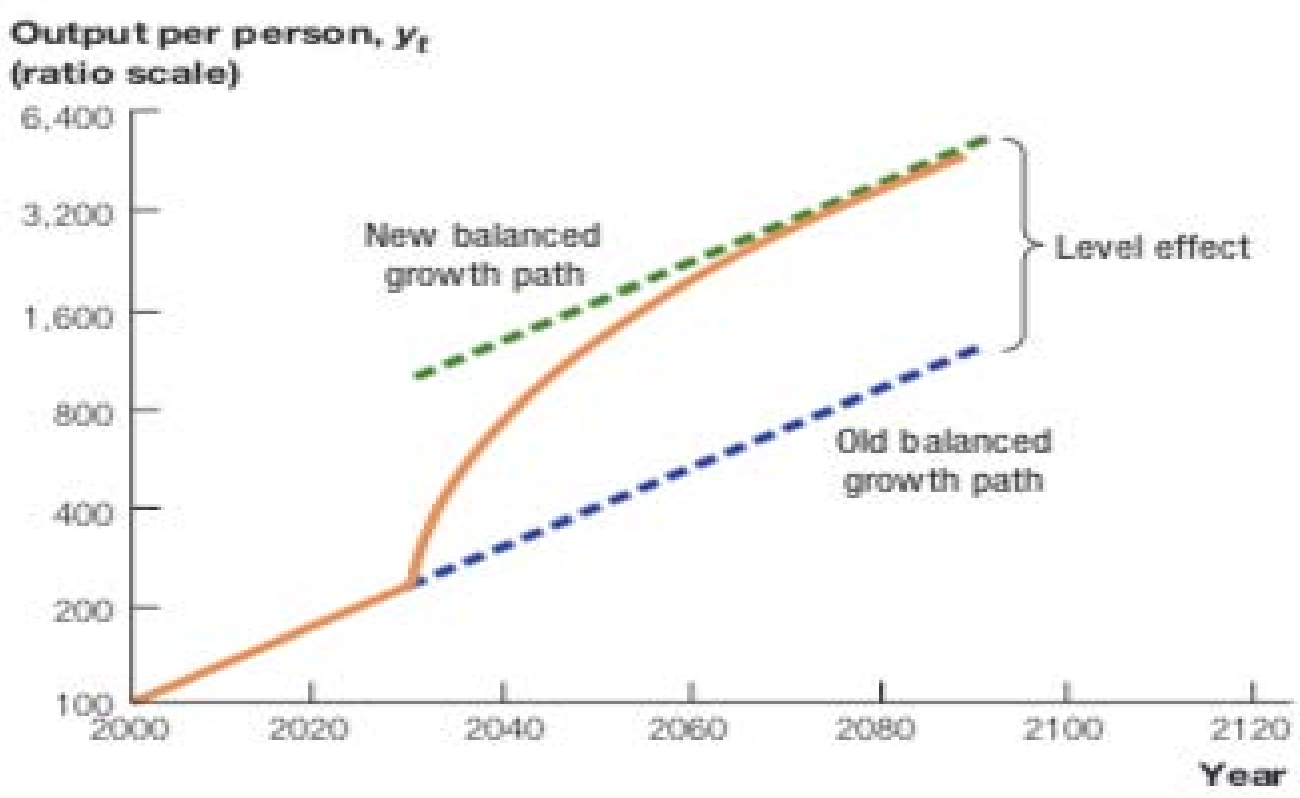
Macroeconomic theories

- Solow-model
  - Robert Solow – Winner of Nobel Price in Economics in 1987
- Comined Solow-Romer model



Solow-model

- Growth is a function of **capital accumulation**, **capital depreciation** and **productivity**
- Ends in '**steady-state**'
- Poor countries **converge** towards rich countries



Combined Solow-Romer model

- Productivity is a function of **existing knowledge** and **allocation of labor** between production and research within a nation
- Knowledge is a **non-rivalry** asset
    - Investing in research can yield **increasing marginal returns**

Capital accumulation and Productivity - our first challenge

- Capital accumulation = last year's capital +this years investment
  - Hard to measure
    - GDP
- Productivity
  - Similarly hard to measure
    - Education
- Exogenous shocks
  - Change investment and productivity

Dataset – our variables

- GDP **per capita** ’60,’96, and ’14
  - Growth rates from ’60-’96 and ’96-’14
- Education, **primary** ’60 and ’96, **higher** ’60
- Mining, Oil, Malaria, capitalism
- Data from 182 countries, but only 111 observations on growth.
  - Many less developed countries are left out

Descriptive statistics

	lgdppc_1960	lgdppc_1996	lgdppc_2014	education_p_1960	education_h_1960	mines_1960	oil_1960	malaria_1960	capitalism_1960
count	111.000000	180.000000	182.000000	113.000000	114.000000	123.000000	126.000000	108.000000	126.000000
mean	8.078464	8.839345	9.295894	0.707522	0.031754	0.057724	0.095238	0.358718	3.373016
std	0.990250	1.244994	1.174845	0.311372	0.046435	0.091730	0.294715	0.429967	1.511207
min	5.783145	5.144375	6.345705	0.050000	0.000000	0.000000	0.000000	0.000000	0.000000
25%	7.304172	7.946936	8.477570	0.460000	0.000000	0.000000	0.000000	0.000000	3.000000
50%	7.940775	8.883772	9.438845	0.830000	0.010000	0.020000	0.000000	0.046085	3.000000
75%	8.868837	9.764272	10.101928	1.000000	0.050000	0.080000	0.000000	0.867500	5.000000
max	10.260106	11.666056	12.003310	1.000000	0.320000	0.530000	1.000000	1.000000	5.000000

The effect of initial GDPpc

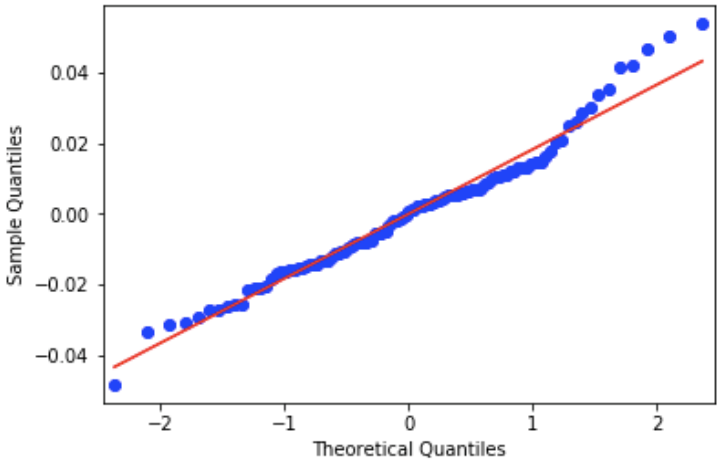
Dep. Variable:	Growth_1960_1996	**R-squared:**	0.022
Model:	OLS	**Adj. R-squared:**	0.013
Method:	Least Squares	**F-statistic:**	2.431
Date:	Tue, 12 Jun 2018	**Prob (F-statistic):**	0.122
Time:	13:37:12	**Log-Likelihood:**	286.92
No. Observations:	111	**AIC:**	-569.8
Df Residuals:	109	**BIC:**	-564.4
Df Model:	1		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	-0.0035	0.014	-0.243	0.808	-0.032	0.025
lgdppc_1960	0.0028	0.002	1.559	0.122	-0.001	0.006

Omnibus:	7.534	**Durbin-Watson:**	2.053
Prob(Omnibus):	0.023	**Jarque-Bera (JB):**	7.278
Skew:	0.517	**Prob(JB):**	0.0263

Robustness Analysis 1

- 5 assumptions of regression
  - 1. linear relationship
  - 2. Residuals are normally distributed
  - 3. No or little multicollinearity
  - 4. No autocorrelation
  - 5. Homoscedasticity



Including productivity

- GDP is now significant
- Primary education is significant
- GDP has now a **negative** effect on growth rate
- R-squared 41,7%

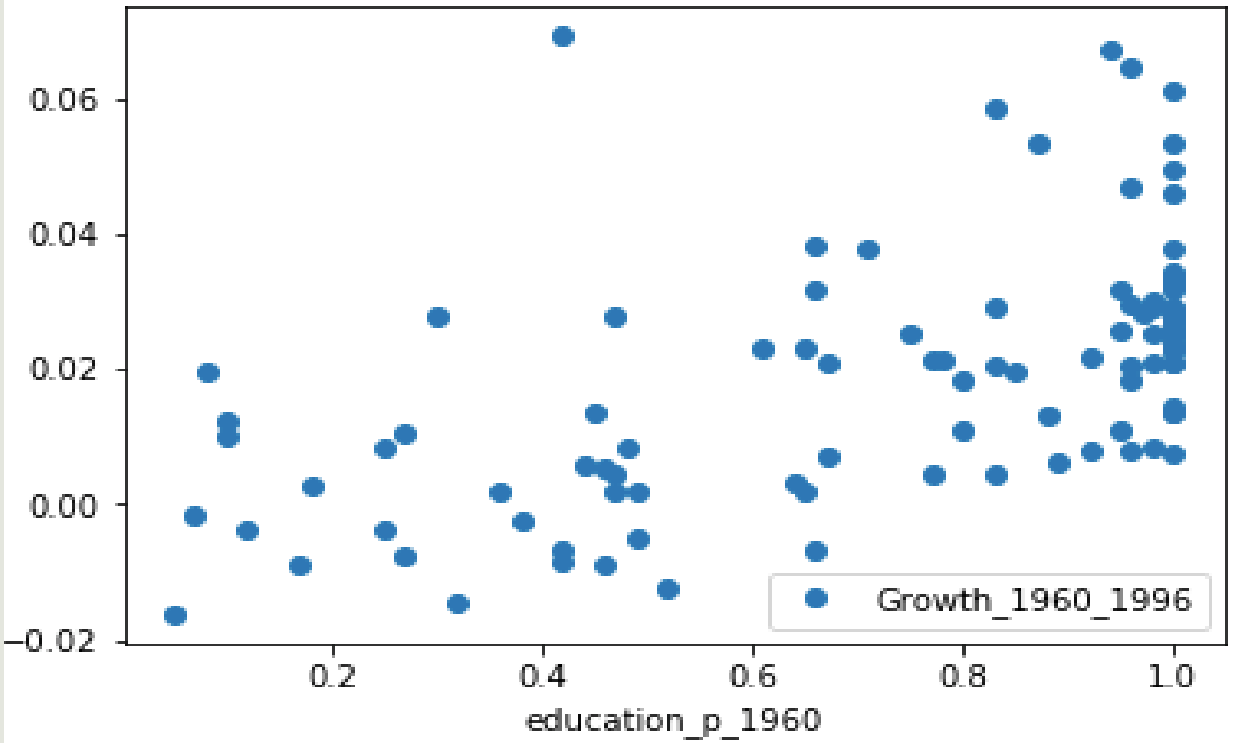
Dep. Variable:	Growth_1960_1996	**R-squared:**	0.417
Model:	OLS	**Adj. R-squared:**	0.399
Method:	Least Squares	**F-statistic:**	22.88
Date:	Sun, 10 Jun 2018	**Prob (F-statistic):**	2.93e-11
Time:	22:08:53	**Log-Likelihood:**	285.21
No. Observations:	100	**AIC:**	-562.4
Df Residuals:	96	**BIC:**	-552.0
Df Model:	3		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	0.0514	0.015	3.453	0.001	0.022	0.081
lgdppc_1960	-0.0086	0.002	-4.042	0.000	-0.013	-0.004
education_p_1960	0.0502	0.007	7.670	0.000	0.037	0.063
education_h_1960	0.0410	0.039	1.041	0.301	-0.037	0.119

Omnibus:	13.155	**Durbin-Watson:**	2.131
Prob(Omnibus):	0.001	**Jarque-Bera (JB):**	15.404
Skew:	0.726	**Prob(JB):**	0.000452
Kurtosis:	4.260	**Cond. No.**	234.

Robustness Analysis 2

- Residuals are slightly non-normal
- Breusch-Pagan test indicate heteroscedasticity
- Multicollinearity?
- Distribution of education is skewed



Including luck and failure

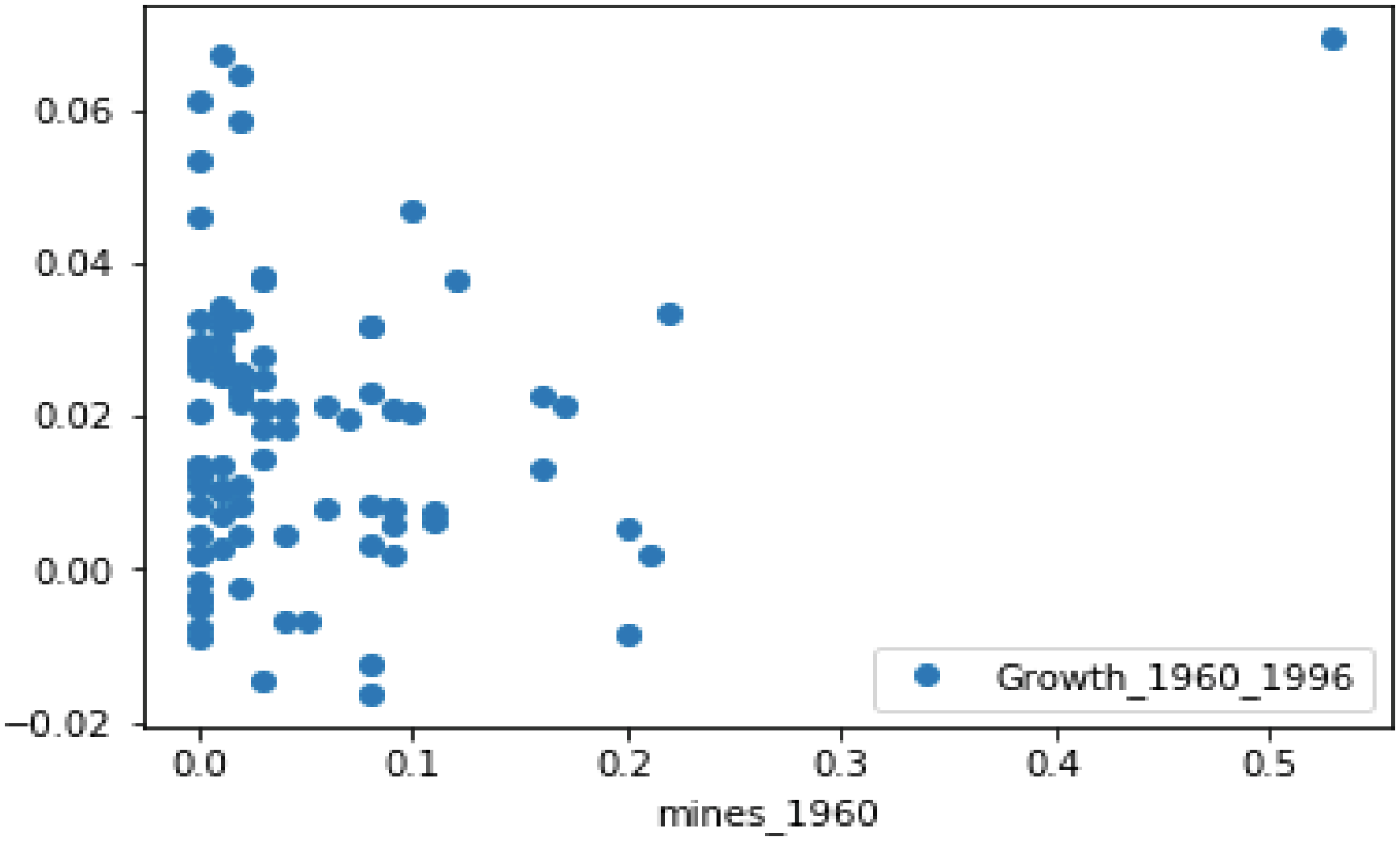
- All significant

Dep. Variable:	Growth_1960_1996	**R-squared:**	0.492
Model:	OLS	**Adj. R-squared:**	0.469
Method:	Least Squares	**F-statistic:**	21.56
Date:	Mon, 11 Jun 2018	**Prob (F-statistic):**	1.84e-12
Time:	00:40:56	**Log-Likelihood:**	276.10
No. Observations:	94	**AIC:**	-542.2
Df Residuals:	89	**BIC:**	-529.5
Df Model:	4		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	0.0725	0.015	4.891	0.000	0.043	0.102
lgdppc_1960	-0.0097	0.002	-5.090	0.000	-0.014	-0.006
education_p_1960	0.0408	0.007	6.145	0.000	0.028	0.054
mines_1960	0.0493	0.019	2.586	0.011	0.011	0.087
malaria_1960	-0.0182	0.004	-4.075	0.000	-0.027	-0.009

Omnibus:	1.593	**Durbin-Watson:**	2.097
Prob(Omnibus):	0.451	**Jarque-Bera (JB):**	1.508
Skew:	0.304	**Prob(JB):**	0.471
Kurtosis:	2.874	**Cond. No.**	117.

Botswana


0.06
0.04
0.02
0.00
−0.02
0.0
0.1
0.2
0.3
0.4
0.5
mines_1960
Growth_1960_1996

Excluding Botswana

Dep. Variable:	Growth_1960_1996	**R-squared:**	0.517
Model:	OLS	**Adj. R-squared:**	0.495
Method:	Least Squares	**F-statistic:**	23.57
Date:	Mon, 11 Jun 2018	**Prob (F-statistic):**	2.88e-13
Time:	01:33:06	**Log-Likelihood:**	279.11
No. Observations:	93	**AIC:**	-548.2
Df Residuals:	88	**BIC:**	-535.6
Df Model:	4		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	0.0650	0.014	4.621	0.000	0.037	0.093
lgdppc_1960	-0.0087	0.002	-4.777	0.000	-0.012	-0.005
education_p_1960	0.0412	0.006	6.618	0.000	0.029	0.054
mines_1960	-0.0127	0.025	-0.513	0.610	-0.062	0.036
malaria_1960	-0.0157	0.004	-3.705	0.000	-0.024	-0.007

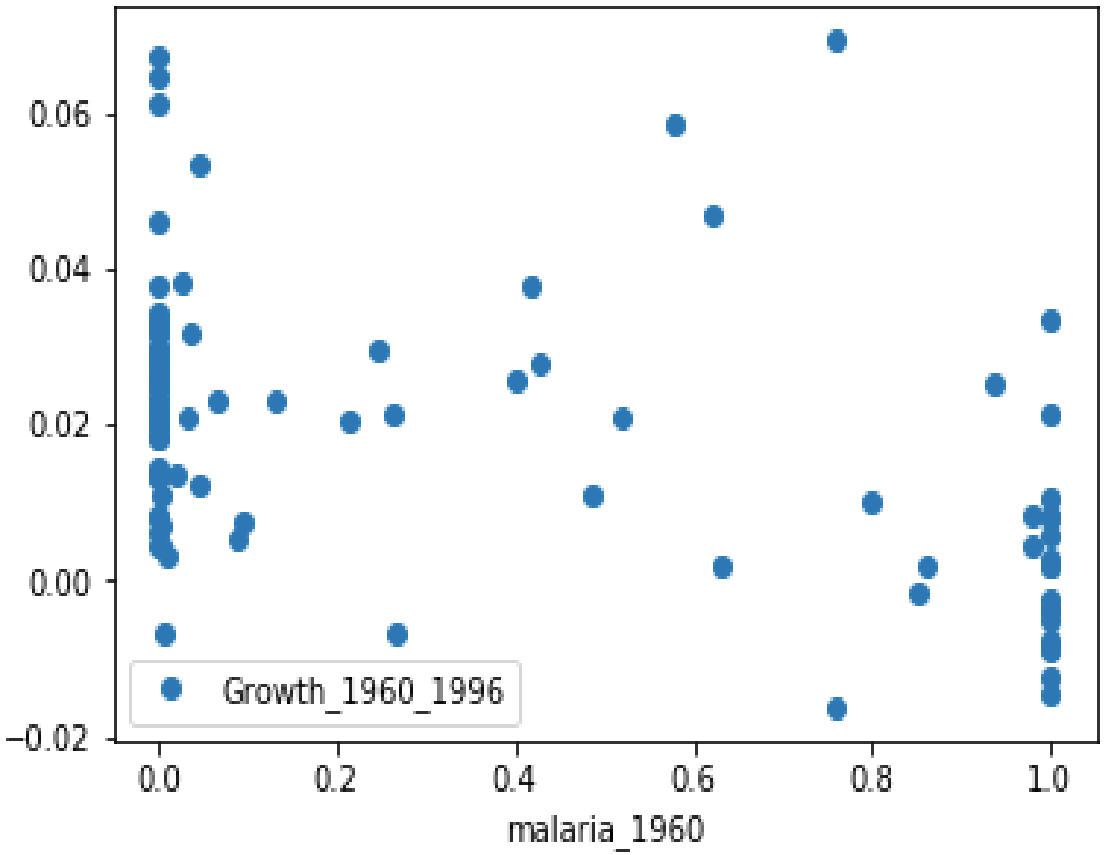
Omnibus:	2.118	**Durbin-Watson:**	2.169
Prob(Omnibus):	0.347	**Jarque-Bera (JB):**	1.932
Skew:	0.351	**Prob(JB):**	0.381
Kurtosis:	2.932	**Cond. No.**	161.

The insignificance of the oil dummy

- Higher GDP than their counterparts
  - Effect caught by GDP?
- ”Dutch disease”
  - Change in demand of public goods, inflation and subsequent restructuring of the economy
    - Fluctuations
- Potential of laying the foundation of long-term growth
  - Example: Norway
- **No findings**

Malaria

- What is it about malaria?
- A symptom of an underlying issue in a nation?
- When does Malaria have a negative effect?



Dummy_malaria_1960

- Malaria has a negative influence growth
- Differentiate between states that handle malaria better and worse
- Catch underlying effect

Dep. Variable:	Growth_1960_1996	**R-squared:**	0.508
Model:	OLS	**Adj. R-squared:**	0.493
Method:	Least Squares	**F-statistic:**	33.03
Date:	Thu, 14 Jun 2018	**Prob (F-statistic):**	9.36e-15
Time:	23:39:16	**Log-Likelihood:**	293.69
No. Observations:	100	**AIC:**	-579.4
Df Residuals:	96	**BIC:**	-569.0
Df Model:	3		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	0.0652	0.013	5.054	0.000	0.040	0.091
education_p_1960	0.0436	0.006	7.065	0.000	0.031	0.056
dummy_malaria_1960	-0.0159	0.004	-4.363	0.000	-0.023	-0.009
lgdppc_1960	-0.0091	0.002	-5.093	0.000	-0.013	-0.006

Omnibus:	6.472	**Durbin-Watson:**	2.183
Prob(Omnibus):	0.039	**Jarque-Bera (JB):**	5.935
Skew:	0.508	**Prob(JB):**	0.0514
Kurtosis:	3.628	**Cond. No.**	83.8

Robustness analysis 3

- Normality is ok accounted for the sample size (100)
- Problems with heteroskedasticity
- Reduce the precision of the model

Predictive power of our model

- Gathered new data on malaria in 1990
  - Issues with comparison
- Used coefficients of previous regressions
- Compared the predicted growth rate with actual growth rate with a Wilcoxon Signed Rank test
- Conclusion: Difference between the pair does not follow a distribution around 0.
  - = They are different.

Conclusion

- Initial GDP per capita is **not** able to explain growth rate
- Primary education is able to explain growth rate
- Malaria explain those that suffer from other issues
- **Nothing** has been proven – links are discovered

Q&A