The impact of Economics Freedom on Economics Growth

--- Empirical Studies Based on a Machine Learning Indicator

Author: Anqi Zhou

Date: May 27, 2020

Abstract

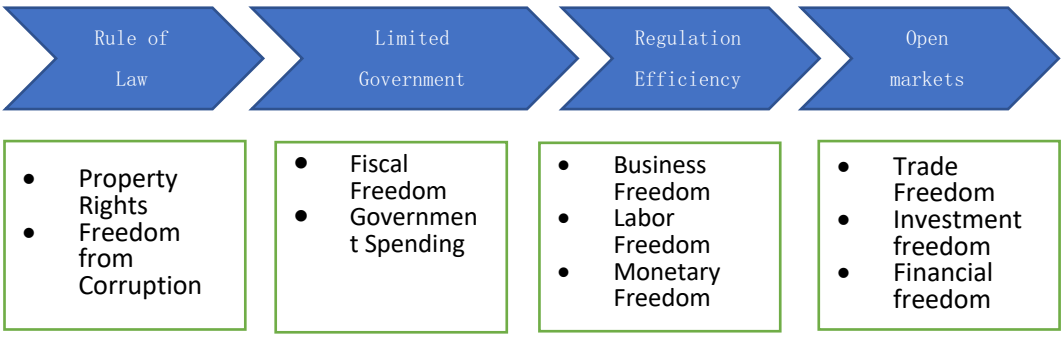
This paper empirically examines the importance of economic freedom by using a new constructed machine learning index that measure four basic areas - government influence, legal structure and property rights, open markets, and access to sound money. This paper compares 6 different machine learning models - SVR model with three different kernels, Random Forest, Decision Tree, and Neural Network. Finally, choose SVR model with linear kernel to construct the new economic freedom index. The empirical results show that economic freedom is a significant determinant of economic growth, even when education, health and openness are taken into account.

A. Methods

There are much literature indicating the relationship of economics freedom and economics growth, for example, Carlsson, F., & Lundström, S. (2002), Gwartney, et.al (1999), De Haan, J., & Sturm, J. E. (2000), etc. However, there is not a unified approach to measure economics, for instance, Heckelman, J. C. (2000) use Heritage economics freedom index[1]; Shi-zhuan, H. A. N. (2008) use EFW Index compiled by Fraser institute[2]; Gwartney, Lawson and Block(1996) have developed a measure of economic freedom independent of political freedom for their own research. In fact, the measurement of economics freedom has always been a controversial issue. Before the development of EFW Index and Heritage index, various methods are used to quantify the economics freedom degree before economics can actually analyze the relationship between economics freedom and economics growth. After the development of these two indices, the two indices have always been critically discussed. For instance, De Haan, J., Lundström, S., & Sturm, J. E. (2006) identified various shortcomings of empirical studies using EFW Index.

Here we begin with brief discussion about the two most popular indices. One is the Index of Economic Freedom Composition (Heritage Foundation). This index has four broad categories composed of total 10 factors.

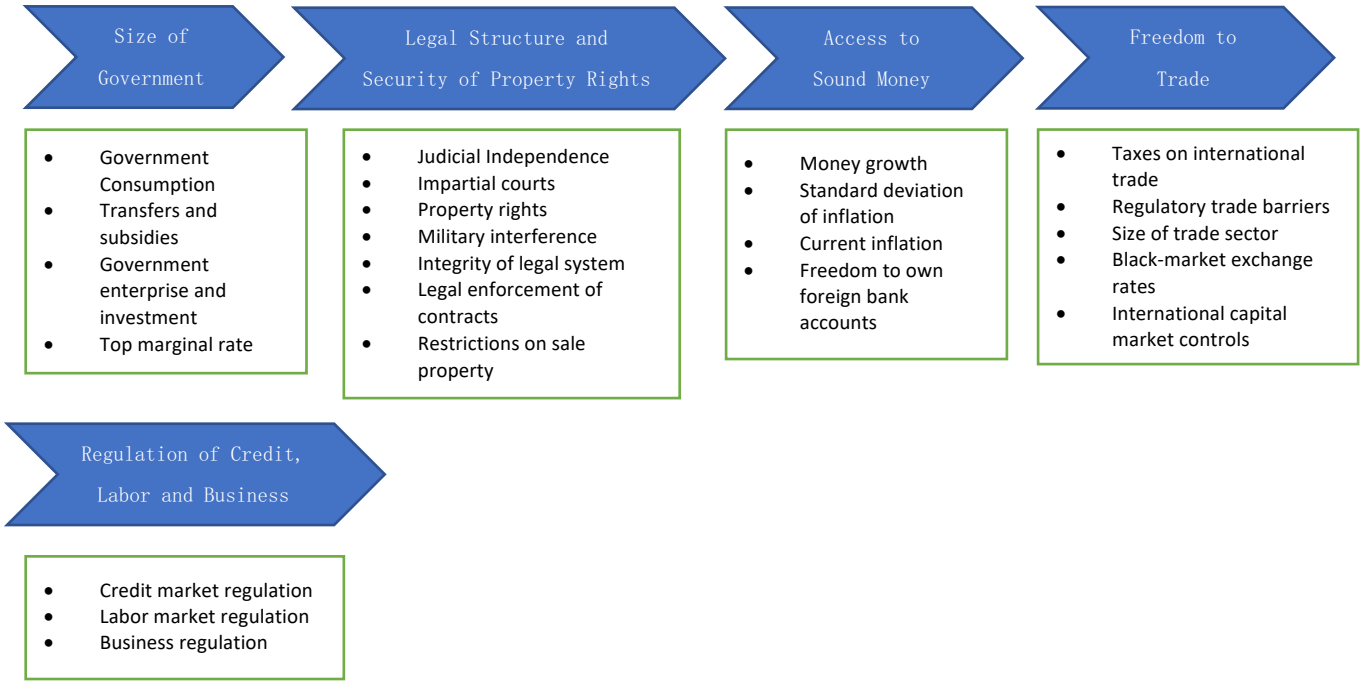
Figure 1 – Components of Index of Economic Freedom Composition (Heritage Foundation)



[1] The Index of Economic Freedom Composition (Heritage Foundation).
[2] Economic Freedom of the World (Fraser Institute)

The other one is Economic Freedom of the World (Fraser Institute). This index measures economics freedom through five broad areas of measurement which encompass 23 categories and include 42 variables.

Figure 2 – Components of Economic Freedom of the World (Fraser Institute)



Basically, there are two main concerns about these two indices, which are mainly about weights and subjectivity. First, the Heritage index average the factors "so that the overall score will not be biased toward any one component or policy direction" with equal weight. Also, the scores are not normalized, inherently weighting the various factors because of the large variation in means.

Second, these two indices all introduce the elements of subjectivity, particularly the factors regarding perceptions. The basic logic of these two indices is just that estimate each factor with various kinds of methods, and obtain a final number, then average the numbers of all factors with particular weights. It's no wonder that they would be criticked as subjective.

In this essay, I am going to use the machine learning knowledge that I've learned last quarter to develop a novel approach of economics freedom measurement to solve these two concerns. The idea is inspired by Gründler K, Krieger T.(2016), but I have made improvements based on their idea and also discussed more models that may be applied to this problem.

Gründler K, Krieger T.(2016) investigate the relationship of democracy degree and economic growth. They applied a report which reports the countries regarded as either “completely democratic” or “completely undemocratic”. If the country is always recognized by the public as “democratic”, they set its democracy index as 1, inferring it’s “completely democratic”, vice versa. Then they use such information to form a training dataset and perform the SVR method to construct a new democracy index, which is continuous between 0 and 1.

Instead of finding out the countries which recognized as completely economic free or unfree, I take advantage of the two existing indices. I divided the countries in each index report into 10 groups by quantiles. So, the first group refers to the countries of top 10% economic freedom degree, the second group refers to the countries of top 10%-20% economic freedom degree, and so on. Because there are 187 countries in the Heritage index report and 167 countries in the EFW index report, each group of Heritage index has 19 countries and each group of EFW index has 17 countries.[3] Then I extract the countries which are in the same rank groups of both indices, for example, the countries that are in both the top 10% group of Heritage index and the top 10% group of EFW index. In fact, among 147 countries common in both index report, there are only 52 countries whose ranking range are consistent, although many component concepts of the two indices are similar, which reflects the unreliability of the two indices to some degree.[4]

Because these countries’ ranking range is consistent in the two popular indices, they are considered as widely recognized by the public about their economics freedom degree. In this way, we can basically consider the economic freedom degree of these countries as common sense, which decreases the influence of subjectivity a lot. Then I set the freedom degree as 10 for the countries in both top 10% groups; set the degree as 9 for the countries in both top 10%-20% groups, and so on. Finally, we form a training dataset of 52 countries. It tends to provide more accurate results compared to the dataset in Gründler K, Krieger T.(2016), which has only two values, 0 and 1.

---

[3] Here I use the 2017 annual report for both indices.

4 See Table **错误!仅主文档。** – Groups of Countries Consistent with Their Ranks in Both Indices in Appendix.

To construct the new economic freedom index, I considered several models, including SVR model with different kernels, Random Forest, Decision Tree, and Neural Network. SVR model is the continuous version of SVM model, which can output the continuous index basically range from 0 to 10. The rest three model outputs the discrete index from 1 to 10 that indicates the economic freedom degree of countries. Thus, we solve the weights problem naturally by performing machine learning models.

As for the features to be included in the models, I basically combine all the key component concepts of these two indices to be most comprehensive but delete some repetitive factors. The features I considered can be divided into 4 categories, which are mainly government influence, legal structure and property rights, open markets, and access to sound money. The variables consist of the index of government integrity, size of government, government spending, tax burden, legal system & property rights, business freedom, monetary freedom, trade freedom, investment freedom, financial freedom, and sound money.

After applying these models to construct a proper economic freedom index, I investigate the impact of economics freedom on economics growth based on the panel data of 100 countries in 2000-2017. The main model is as below:

Equation 1 - main model

$$y_{i,t} = \beta_0 + \beta_1 Index_{i,t} + \beta_2 M_{i,t} + \beta_3 Z_{i,t} + \varepsilon_{i,t}$$

where the subscript refers to country i at year t; $y_{i,t}$ is the per capita GDP of country I at year t; $Index_{i,t}$ is our new constructed economic freedom index; $M_{i,t}$ is a vector of standard economic explanatory variables, which have shown to be robustly linked with GDP by previous empirical studies; $Z_{i,t}$ is a vector of possible additional economic explanatory variables, which may be related to GDP based on previous literature; and $\varepsilon_{i,t}$ is the error term. The variables in M vector includes the investment share of GDP, the average years of schooling to proxy human capital and education, the trade share to reflect openness, the government consumption. These variables are chosen based on the findings of previous literature, such as Levine and Renelt(1992), Ferder(1982) and Romer (1989). The variables in Z vector consists of the life expectancy at birth,

mortality rate of infants, population growth and inflation rate. The choice of these variables refers to the models in De Haan, J., & Sturm, J. E. (2000) and Gründler K, Krieger T(2016). Gründler K, Krieger T(2016) use life expectancy at birth and fertility rate to proxy health. Population growth is added because Baumol et al. (1989) suggested it may enhance growth. The inflation rate is added as it has been founded by Fischer (1993) and Barro (1995) that it's robustly correlated with economic growth.

In this way, most of exogenous variables linked with GDP has been included in the regression. Then I use fixed effects and MLE methods to estimate the main model, in order to eliminate the effects of countries' particular characteristics.

B. Data

i. Data for constructing index:

I consider 11 features to construct my economic freedom index for 100 countries from year 2000 to 2017. The data of government integrity, government spending, tax burden, business freedom, monetary freedom, trade freedom, investment freedom, and financial freedom variables from 2000 to 2017 come from Heritage Index dataset.[5] The data of sound money, size of government, and legal system & property rights variables from 2000 to 2017 come from EFW Index panel data report.[6]

ii. Data for main model:

As for the data of main model, the data of GDP per capita, investment share of GDP, government expenditure, trade share of GDP, life expectancy at birth, mortality rate, inflation rate, population growth all come from the World Bank dataset.[7] De Haan, J., & Sturm, J. E. (2000) used secondary school enrollment rate as the proxy of education. But the data of secondary school enrollment rate from World Bank has a lot of missing value. So, I choose the average years of schooling as the proxy of education. This variable is also used in Gründler K,

[5] Details refer to https://www.heritage.org/index/.
[6] Details refer to https://www.fraserinstitute.org/economic-freedom/dataset?geozone=world&page=dataset&min-year=2&max-year=0&filter=0.
[7] Details refer to https://data.worldbank.org.

Krieger T(2016). The data of years of schooling is taken from the dataset of Our World in Data compiled by University of Oxford.[8]

Because there are a lot of missing value, I deleted some countries to be considered. For countries which lacked data no more than three years, I filled the null value with most recent year values. After I construct the index, there are 107 countries left in the economic free index table. During the second data cleaning process, I deleted another 7 countries due to the lack of data for exogenous variables of the main model. Finally, I collected the complete data of 100 countries in 18 years to estimate the main model.[9]

Table 1 - Summary Statistics

	GDP per capita	economic freedom index	Investment share	trade share	government consumption	life expectancy at birth	mortality rate	years of schooling	population growth	inflation rate
count	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800
mean	15141.99	5.250382	23.73837	84.76955	8.89E+10	70.03874	27.4285	8.3149	1.413715	5.584358
std	20162.23	3.330837	7.360406	54.70444	2.77E+11	10.4703	28.1028	3.264539	1.559699	8.393967
min	113.5674	−6.35971	1.09681	19.79813	57387668	39.441	1.5	1.1	−9.08064	−25.9584
25%	1123.138	2.976958	19.58674	53.16341	1.46E+09	62.443	4.9	6.1	0.455856	1.482216
50%	4792.078	5.231427	22.77783	71.33072	6.39E+09	73.6285	15	8.7	1.23281	3.503722
75%	23640.54	7.665727	27.02375	100.3164	4.7E+10	78.44634	43.75	11.1	2.424802	7.50453
max	118823.6	13.34248	61.46902	437.3267	2.76E+12	84.09976	142.4	14.1	15.17708	112.6936

C. Results

i. Model Comparison and New Index:

I performed different classification model, in order to select the most fit model. Table 2 compares the MSE associated with test data of each model.

Table 2-MSE comparison

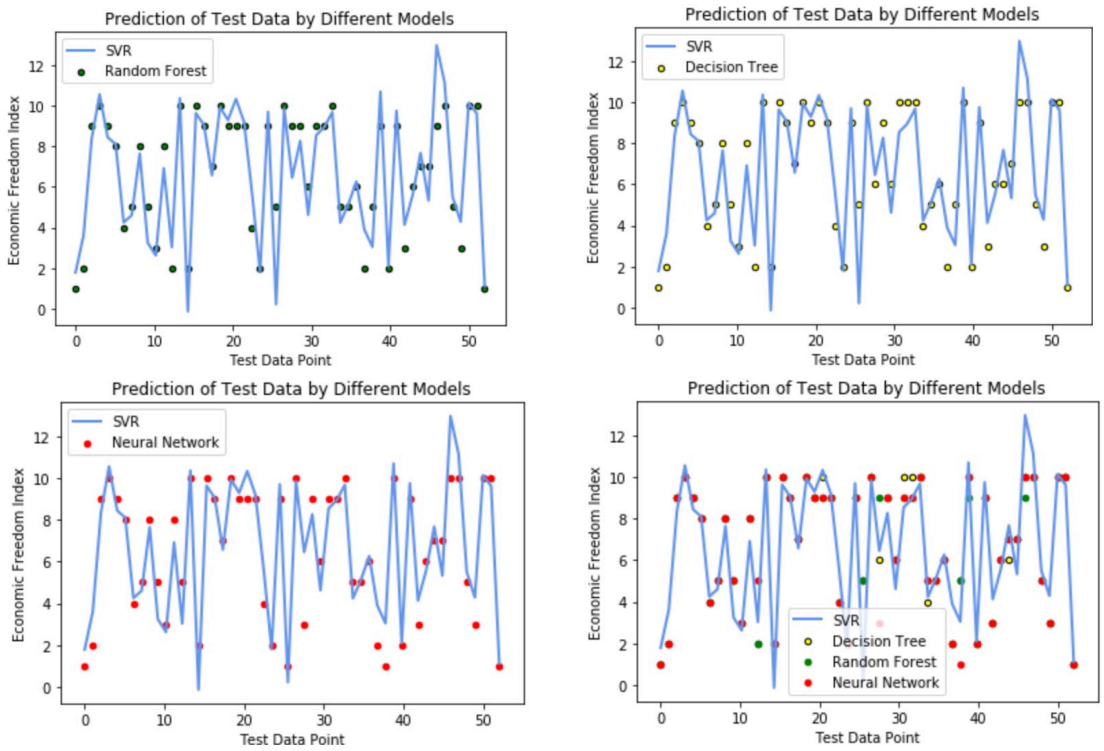
Models		MSE
SVR	RBF kernel	2.9923008
	linear kernel	0.9754689
	polynomial kernel	1.16029322
Random Forest		1.07692308
Decision Tree		1.15384615
Neural Network		1.30769231

[8] Details refer to https://ourworldindata.org/grapher/mean-years-of-schooling-1.

[9] I perform the data collection process by Excel, because the operation of data collecting only consists of the most basic Excel functions, such as copy, replicate, and vlookup().

The SVR model with linear kernel results in the least MSE, following by Random Forest, Decision Tree, and Neural Network. This indicates SVR model fits the data best. And from Figure 3, we can see the predictions of SVR model (linear) about test sample are very similar to the predictions of Random Forest, which has the second least MSE.

Figure 2- Predictions of Different Models



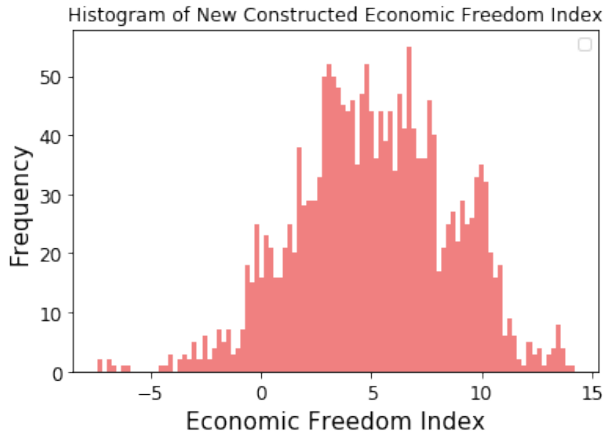
As for the parameter tuning, I apply SearchCV package to tune the parameter of Decision Tree and Neural Network model. The parameter values have very limited influence on accuracy. Gründler K, Krieger T(2016) advised to set c = 1 and gamma = 0.05 in the SVR model to make index mainly fall in the range between 0 and 1. In fact, when I set the parameter as (1, 0.05), there is still a few points falling a little higher than 10 or a little lower than 0, and the MSE remains the same. So, I still use the automatically setting parameter values for SVR model (linear).

The SVR model with linear kernel has the least MSE, and the continuity of its output index allow us to estimate the impact of lag of economic freedom index more accurately, since the lag of economic freedom level has a large probability of being the same as concurrent

economic freedom level in the discrete output. Therefore, I selected SVR model with linear kernel to construct the new index.

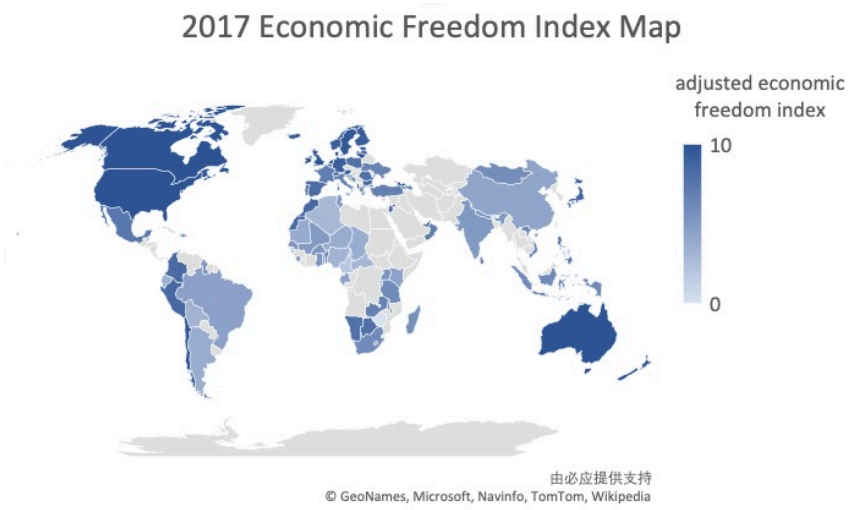
Figure 2 shows that the index values of most countries fall in the range between 0 and 10, although a small proportion are outliers.

Figure 3 - Histogram of New Constructed Economic Freedom Index



I normalize the new constructed economic freedom index of 107 countries in year 2017 and visualize the data in Figure 5.

Figure 4 - 2017 Economic Freedom Index Map[10]



ii. Results of Main Model:

Table 3 - Estimation Results

Dependent Variable: GDP per capita							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)

[10] Made by Power Map module in Excel.

economic freedom	658.47***	648.24***	597.55***	528.29***	276.27*	453.86***	469.17***
	(4.17)	(4.10)	(3.90)	(3.48)	(1.89)	(3.23)	(3.38)
L.economic freedom	730.22***	730.04***	608.07***	524.69***	141.32	265.78*	256.23*
	(4.80)	(4.81)	(4.14)	(3.60)	(1.00)	(1.95)	(1.90)
investment share		57.24**	47.05*	24.95	0.031	68.78**	54.59**
		(1.96)	(1.67)	(0.89)	(0.00)	(2.63)	(2.11)
government consumption			1.98e-09***	2.02e-08***	1.54e-08***	1.50e-08***	1.52e-08***
			(11.06)	(11.42)	(9.07)	(9.24)	(9.49)
trade share				68.56***	42.29***	33.12***	35.22***
				(7.15)	(4.59)	(3.73)	(4.02)
years of schooling					3771.35***	3843.55***	3902.01***
					(14.48)	(12.77)	(13.08)
life expectancy at birth						768.122***	739.77***
						(7.16)	(6.98)
mortality rate						401.69***	390.19***
						(11.45)	(11.25)
inflation rate							922.83***
							(6.28)
population growth							30.20*
							(1.72)

* significant at 90% level.
** significant at 95% level.
*** significant at 99% level.

The empirical result shows that economic freedom is related to GDP with a significant positive coefficient in every model. This indicates economic freedom level exerts a strong and robust influence on economic growth. Before adding years of schooling into the regression, the lag of economic freedom has almost the same large impact on GDP with the concurrent economic freedom and also robust. The education indicator, years of schooling, increases the explanatory power of the model and generally reduce the significance of other variables. Both the impact level and the significance of the lag of economic freedom decrease after years of schooling has been taken into account. But in equation (6) and (7), it still exerts a significant and strong impact on GDP, although the impact is less than concurrent economic freedom level.

After the impact of years of schooling, life expectancy at birth and mortality rate has been taken into account, the investment share has been proved to be robustly positive related to economic growth. The government consumption exerted a significant but relatively small impact on GDP per capita in every model. The proxy of openness, education and health - trade share, years of schooling and life expectancy at birth all exert a robust and strong impact on economic growth, which is consistent with findings of previous literature. A negative sign for mortality rate is expected, however, the actual result indicates the mortality rate of infants is positively linked with

GDP. Furthermore, the inflation rate and population growth has always been positively related to GDP.

Therefore, we can conclude economic freedom is a significant determinant of economic growth, even when education, health and openness are taken into account.

D. Reference

- Carlsson, F., & Lundström, S. (2002). Economic freedom and growth: Decomposing the effects. *Public choice*, *112*(3-4), 335-344.
- Gwartney, J. D., Lawson, R. A., & Holcombe, R. G. (1999). Economic freedom and the environment for economic growth. *Journal of Institutional and Theoretical Economics (JITE)/Zeitschrift für die gesamte Staatswissenschaft*, 643-663.
- De Haan, J., & Sturm, J. E. (2000). On the relationship between economic freedom and economic growth. *European Journal of Political Economy*, *16*(2), 215-241.
- Heckelman, J. C. (2000). Economic freedom and economic growth: A short-run causal investigation. *Journal of Applied Economics*, *3*(1), 71-91.
- Shi-zhuan, H. A. N. (2008). Measurement and Prediction on the Degree of Freedom of China's Economic——Based on the View of EFW Idex Compiled by Fraser Institute of Canada [J]. In Statistics & Information Forum (Vol. 9).
- Gwartney, J. D., Lawson, R., & Block, W. (1996). Economic freedom of the world, 1975-1995. The Fraser Institute.
- De Haan, J., Lundström, S., & Sturm, J. E. (2006). Market-oriented institutions and policies and economic growth: A critical survey. Journal of Economic Surveys, 20(2), 157-191.
- Gründler, K., & Krieger, T. (2016). Democracy and growth: Evidence from a machine learning indicator. European Journal of Political Economy, 45, 85-107.
- Levine, R., & Renelt, D. (1992). A sensitivity analysis of cross-country growth regressions. The American economic review, 942-963.
- Feder, G. (1983). On exports and economic growth. Journal of development economics, 12(1-2), 59-73
- Romer, P. M. (1989). Human capital and growth: theory and evidence (No. w3173). National Bureau of Economic Research.
- Baumol, W. J., Blackman, S. A. B., & Edward N.. Wolff. (1989). Productivity and American leadership: the long view. MIT press.

- FICSHER, S. (1993). The role of macroeconomic factors in economic growth. Journal of Monetary Economics, 32, 484-512.
- Barro, R. J. (1995). Inflation and economic growth (No. w5326). National bureau of economic research.

E. Appendix

Table 4 – Groups of Countries Consistent with Their Ranks in Both Indices

CountryID	Country Name	Heritage Rank	Heritage Index	Fraser rank	Fraser Index
Top 10%					
7	Australia	5	81.0	9.0	8.1
29	Canada	7	78.5	8.0	8.1
33	Chile	10	76.5	13.0	7.9
45	Denmark	18	75.1	13.0	7.9
54	Estonia	6	79.1	13.0	7.9
61	Georgia	13	76.0	12.0	7.9
78	Ireland	9	76.7	6.0	8.1
98	Lithuania	16	75.8	16.0	7.9
99	Luxembourg	14	75.9	17.0	7.9
120	New Zealand	3	83.7	3.0	8.5
147	Singapore	2	88.6	2.0	8.7
158	Switzerland	4	81.5	4.0	8.4
174	United Kingdom	12	76.4	7.0	8.1
175	United States	17	75.1	5.0	8.2
Top 10% - 20%					
6	Armenia	33	70.3	27.0	7.7
8	Austria	30	72.3	26.0	7.7
57	Finland	24	74.0	21.0	7.8
62	Germany	26	73.8	20.0	7.8
73	Iceland	22	74.4	23.0	7.7
88	Korea, South	23	74.3	33.0	7.6
92	Latvia	20	74.8	24.0	7.7
124	Norway	25	74.0	32.0	7.6
Top 20% - 30%					
11	Bahrain	44	68.5	50.0	7.4
15	Belgium	49	67.8	40.0	7.5
23	Bulgaria	47	67.9	37.0	7.5
83	Jordan	53	66.7	43.0	7.4
130	Peru	43	68.9	42.0	7.5
Top 30% - 40%					
51	El Salvador	66	64.1	63.0	7.2
131	Philippines	58	65.6	53.0	7.3
Top 40% - 50%					
90	Kyrgyz Republic	89	61.1	77.0	6.9

114	Montenegro	83	62.0	83.0	6.8
129	Paraguay	80	62.4	72.0	7.0
Top 50%-60%					
14	Belarus	104	58.6	99.0	6.6
18	Bhutan	107	58.4	87.0	6.8
112	Moldova	110	58.0	97.0	6.7
162	Tanzania	105	58.6	87.0	6.8
Top 60% - 70%					
13	Barbados	130	54.5	112.0	6.5
63	Ghana	118	56.2	103.0	6.6
118	Nepal	125	55.1	110.0	6.5
Top 70% - 80%					
22	Brazil	140	52.9	120.0	6.2
26	Burundi	139	53.2	124.0	6.2
103	Malawi	149	52.2	131.0	6.1
126	Pakistan	141	52.8	136.0	5.9
165	Togo	138	53.2	121.0	6.2
Top 80% - 90%					
5	Argentina	156	50.4	146.0	5.7
32	Chad	162	49.0	150.0	5.4
66	Guinea	169	47.6	139.0	5.9
76	Iran	155	50.5	143.0	5.7
116	Mozambique	158	49.9	149.0	5.6
122	Niger	154	50.8	142.0	5.8
Top 90% - 100%					
3	Algeria	172	46.5	159.0	4.8
179	Venezuela	179	27.0	162.0	2.6