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Economic Growth in Africa: Is trade openness the answer?

Introduction

Invigorating the wheels of economic growth in Africa and shifting the story of the continent from one of ‘coups, conflict and corruption’ to the ‘the world’s next economic powerhouse,’ is the interest of policymakers and economists with vested interest in Africa’s future. While, most scholars agree that institutional strength, fostering human capital and technological progress are essential to economic growth, the effect of trade openness on growth is often disputed. The African Continental Free Trade Area (AFCFTA), an agreement between 54 African countries to create a free trade zone, was ratified in May 2022. Based on the prerogative that openness to trade causes economic growth, the World Bank predicts that the agreement will lift 50 million people out of extreme poverty.

In the literature, Frankel and Romer (1999) argue that trade openness leads to higher economic growth while Acemoglu contests that once institutions were accounted for, the effect of trade on growth in Africa was insignificant. If a causal relationship truly exists between trade openness and development, then policies like the AFCFTA will have the impact that the World Bank project and bring the continent out of poverty. On the other hand, if Acemoglu is correct in that the causal link between trade and growth is merely due to confounding factors, then the efforts of policy makers will be better served in other areas.

This paper will explore how openness to trade impacts economic growth in sub-Saharan Africa. Through using machine learning methods like LASSO and principal component analysis

alongside traditional econometrics methods like OLS and fixed effects, I find that trade openness does not lead to higher economic growth in sub-Saharan Africa.

Data Sources

The dependent variables were GDP growth and GDP per capita growth for 46 countries in sub-Saharan Africa in the time period 1961-2021. My independent variable of interest was trade openness, and I used three trade openness indexes: the traditional exports plus imports normalized by GDP, and two indexes I constructed using principal component analysis. My final dataset was a panel dataset of sub-Saharan countries observed yearly. I used the World Bank open-source data for statistics on GDP growth, imports, exports as well as the control variables I used such as agricultural data, human capital accumulation, strength of legal rights, natural resources, and population density. Additionally, The World Trade Organization had data on tariffs that I used in constructing my trade openness index.

Figure 1 shows that exports and imports have had an upward trend with a notable spike in imports in 1980. Another interesting trend displayed in Figure 2, is that GDP and GDP per capita growth also seem to be increasing over time, the highest growth rates occurring in the early 2000s. In addition, Covid-19 is also represented by a recession in 2020, interestingly growth rates appear to be recovering within a year.

Methodology

Firstly, I was interested in exploring different ways to represent trade openness and using machine learning techniques to better represent complex concepts that cannot be measured directly. For instance, the conventional measure for trade openness is imports plus exports,

normalized by GDP. However, when this measure for trade openness was used in Japan there was variability between regions. As there is no difference in trade policies between regions in Japan and each region trades freely with the others, this shows that the measure does not necessarily quantify the effect of trade liberalization policies and instead gauges the economic remoteness and the distribution of production sectors within regions. If the goal is to discover the effect of inherent characteristics of a country like proximity to ports, viable trading partners, and suitability for manufacturing or agricultural sectors, then the conventional measure of trade is appropriate.

However, my research goal is focused on the policies that promote trade openness as well as the activity of trade itself. To achieve this goal, I use Principal Component Analysis (PCA) to create new measures of trade openness. Firstly, I take the first PCA of imports as a percent of GDP and exports as a percent of GDP. I also construct an indicator for trade openness by using PCA to find the common variance in variables like taxes on international trade, duty-free imports, and taxes on exports, as well as exports and imports. One problem that arises when using PCA is that the interpretability of the components is limited, especially in a causal setting. To gain insight on which variables the PCA is most representative of, I compute the correlation between the variables used in the PCA and the first principal component.

I use LASSO regression to reduce dimensionality and enhance the predictive power of my model. I also use GDP growth in the following year to avoid reverse causality. Using lagged regressors will mean that my dependent variable cannot affect my regressors, as long as the no anticipation assumption holds. I also employ time and country fixed effects, so I only make

comparisons between the same units within a given year to avoid omitted variable bias. Lastly, I ran an OLS regression with the variables and fixed effects that were selected by the LASSO regression. However, I find that my R-squared for my OLS regressions are generally low, meaning that my model does not account for most of the variation in my dependent variable. This could be due to the fact that LASSO was not necessary as there did not exist multicollinearity, but I suspect that it is due to the ample missing values and the imputation strategy.

As I use a K nearest neighbor (KNN) imputer which replaces missing values with the mean of a specified number of nearest neighbors, to compute PCA and LASSO. While this approach is better than my original simple imputer which replaced missing values with the mean of each variable, the KNN imputer may lead to overfitting as the predictions of values are determined by in-sample values.

Results

As shown by Table 1 and Table 2, the effect of trade openness index 1 on GDP and GDP per capita growth is slightly negative. However, as the p-value is greater than 0.05 the coefficients are not statistically significant from zero. Trade openness index 1 is constructed using PCA of tariffs, imports and exports and Table 9 shows that it is highly correlated with all the variables used in its construction except ‘maximum duty.’ Hence, this index is representative of both trade liberalization efforts as characterized by tariffs as well as trade activity.

Furthermore, Table 3 and 4 demonstrate the effect of trade openness index 2 on GDP and GDP per capita growth. With a one unit increase in trade openness leading to a 0.1 increase in both GDP and GDP per capita growth, and as the p-value is less than 0.05 for both coefficients the effects are statistically significant. Similarly, a one unit increase in the conventional measure of trade openness (trade openness index 3) results in a 0.1 increase in GDP growth and a 0.14 increase in GDP per capita growth (shown in Table 5 and Table 6). As trade openness index 2 is the first principal component of exports and imports, the consistency in the effect of the two indexes further bolsters my premise that the conventional measure of trade openness measures the level of trade activity rather than trade policy. Additionally, as shown in Table 10 the first principal component of exports and imports captures 81 % of the variation while the first PC of the tariff variables, exports and imports encapsulates 53% of the variation. One the one hand, this could be due to the fact that there are more variables used trade index 1. It could also point to the fact that exports and imports do not vary in a similar manner to other tariff indicators. I test this hypothesis by calculating the explained variance with just the tariff variables, excluding export and imports, and 63% of the variation was captured in the first principal component. Overall, this shows that indeed the conventional measure of trade openness does not represent trade policy.

Conclusion

Overall, this paper explores the causal relationship between trade openness and economic growth in sub-Saharan Africa. By combining traditional econometric methods like OLS and fixed effects with the frontier of machine learning in principal component analysis and LASSO, it reconciles the causal identification techniques of econometrics with the dimension reduction ability of

machine learning. In particular, through representing trade openness with different PCA indexes, I interrogate conventional measures of trade openness and differentiate between the effect of trade policy and trade interactions on growth. I find that trade openness index 2 and 3 which represent mainly trade activity in terms of exports and imports have a positive effect on economic growth. While trade openness index 1 which represents both trade openness policy and export/import activity has no effect on economic growth. This supports my hypothesis that past studies of trade on economic growth in Africa, mischaracterize the effect of natural economic factors like remoteness and suitability to manufacturing as the effect of trade openness policies. While further study is needed to explore this dichotomy, I hypothesize that due to asymmetrical trade relations, African countries that liberalize trade do not benefit. In contrast, the positive effect of the conventional trade openness index could be relaying the effect of closeness to trading partners, suitability for production as the effect of policy. In an environment in which economic integration and trade openness are referenced as essential to the development of the continent, clearly defining what trade openness represents and what it does not is crucial. Even if one can interpret the constructed index as a measure of trade openness, proving a causal relationship provides another challenge. How do we know that there are no omitted variables which confound our results? My argument is that conditioned on my control variables, as well as the fixed country and time effects I compare the effect of trade within each country, in a given year hence a lack of a causal effect of trade openness on economic growth is suggested.

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OLS Regression Results

Dep. Variable:	GDP Growth	R-squared (uncentered):	0.398
Model:	OLS	Adj. R-squared (uncentered):	0.345
Method:	Least Squares	F-statistic:	7.535
Date:	Thu, 23 Mar 2023	Prob (F-statistic):	1.45e-32
Time:	12:35:31	Log-Likelihood:	-621.02
No. Observations:	533	AIC:	1328.
Df Residuals:	490	BIC:	1512.
Df Model:	43		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
Employment in agriculture (% of total employment) (modeled ILO estimate) [SL.AGR.EMPL.ZS]	0.0930	0.076	1.225	0.221	-0.056	0.242
Land area (sq. km) [AG.LND.TOTL.K2]	-0.2079	0.072	-2.898	0.004	-0.349	-0.067
Official exchange rate (LCU per US$, period average) [PA.NUS.FCRF]	0.2169	0.048	4.489	0.000	0.122	0.312
Manufacturing, value added (% of GDP) [NV.IND.MANF.ZS]	-0.1310	0.062	-2.128	0.034	-0.252	-0.010
Gross fixed capital formation (% of GDP) [NE.GDI.FTOT.ZS]	0.2089	0.057	3.693	0.000	0.098	0.320
Net ODA received per capita (current US$) [DT.ODA.ODAT.PC.ZS]	-0.1081	0.061	-1.768	0.078	-0.228	0.012
CPIA transparency, accountability, and corruption in the public sector rating (1=low to 6=high) [IQ.CPA.TRAN.XQ]	0.2469	0.076	3.242	0.001	0.097	0.397
Trade openness	-0.0653	0.065	-1.004	0.316	-0.193	0.063
Country Name_Benin	-0.0427	0.043	-0.994	0.321	-0.127	0.042
Country Name_Botswana	-0.0470	0.040	-1.171	0.242	-0.126	0.032
Country Name_Burkina Faso	0.0143	0.040	0.354	0.724	-0.065	0.094
Country Name_Burundi	-0.0383	0.044	-0.868	0.386	-0.125	0.048
Country Name_Cabo Verde	-0.1761	0.072	-2.452	0.015	-0.317	-0.035
Country Name_Central African Republic	-0.0837	0.042	-1.979	0.048	-0.167	-0.001
Country Name_Chad	-0.0239	0.039	-0.620	0.536	-0.100	0.052
Country Name_Comoros	-0.0147	0.039	-0.373	0.709	-0.092	0.062
Country Name_Equatorial Guinea	0.0962	0.037	2.597	0.010	0.023	0.169
Country Name_Eritrea	-0.0464	0.036	-1.290	0.197	-0.117	0.024
Country Name_Ethiopia	0.0967	0.039	2.456	0.014	0.019	0.174
Country Name_Gabon	-0.0392	0.042	-0.944	0.346	-0.121	0.042
Country Name_Ghana	0.0078	0.043	0.181	0.856	-0.077	0.092
Country Name_Guinea	0.0195	0.038	0.518	0.605	-0.055	0.094
Country Name_Lesotho	-0.1316	0.042	-3.145	0.002	-0.214	-0.049
Country Name_Madagascar	-0.0870	0.037	-2.326	0.020	-0.161	-0.014
Country Name_Mauritania	-0.0666	0.040	-1.662	0.097	-0.145	0.012
Country Name_Mauritius	0.0177	0.045	0.393	0.694	-0.071	0.106
Country Name_Mozambique	0.0506	0.038	1.315	0.189	-0.025	0.126
Country Name_Rwanda	0.0047	0.045	0.106	0.916	-0.083	0.092
Country Name_Sierra Leone	0.0366	0.040	0.922	0.357	-0.041	0.115
Country Name_Sudan	-0.0294	0.056	-0.524	0.600	-0.139	0.081
Country Name_Uganda	0.0547	0.039	1.396	0.163	-0.022	0.132
Country Name_Zimbabwe	-0.0270	0.054	-0.501	0.616	-0.133	0.079
Time_2005.0	0.0243	0.037	0.647	0.518	-0.049	0.098
Time_2006.0	0.0773	0.038	2.026	0.043	0.002	0.152
Time_2008.0	-0.1234	0.038	-3.267	0.001	-0.198	-0.049
Time_2009.0	0.1146	0.037	3.075	0.002	0.041	0.188
Time_2010.0	0.0672	0.037	1.795	0.073	-0.006	0.141
Time_2014.0	-0.0514	0.037	-1.379	0.168	-0.125	0.022
Time_2015.0	-0.0558	0.038	-1.486	0.138	-0.129	0.018

Tables and Figures

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Table 1: Trade openness index 1 (First principal component of tariffs, exports and imports) and GDP growth

				Time_2016.0	-0.0590	0.037	-1.586	0.113	-0.132	0.014
				Time_2018.0	-0.0389	0.038	-1.038	0.300	-0.113	0.035
				Time_2019.0	-0.3775	0.038	-10.059	0.000	-0.451	-0.304
				Time_2020.0	0.0227	0.038	0.604	0.546	-0.051	0.096
Omnibus:	342.206	Durbin-Watson:	1.821							
Prob(Omnibus):	0.000	Jarque-Bera (JB):	11073.348							
Skew:	-2.271	Prob(JB):	0.00							
Kurtosis:	24.863	Cond. No.	6.35							

Notes:
[1] R^2 is computed without centering (uncentered) since the model does not contain a constant.
[2] Standard Errors assume that the covariance matrix of the errors is correctly specified.

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OLS Regression Results

Dep. Variable:	GDP per capita growth	R-squared (uncentered):	0.383
Model:	OLS	Adj. R-squared (uncentered):	0.300
Method:	Least Squares	F-statistic:	4.622
Date:	Thu, 23 Mar 2023	Prob (F-statistic):	1.46e-22
Time:	12:37:02	Log-Likelihood:	-627.80
No. Observations:	533	AIC:	1382.
Df Residuals:	470	BIC:	1651.
Df Model:	63		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
Employment in agriculture (% of total employment) (modeled ILO estimate) [SL.AGR.EMPL.ZS]	0.1263	0.092	1.368	0.172	-0.055	0.308
Land area (sq. km) [AG.LND.TOTL.K2]	-0.2334	0.137	-1.703	0.089	-0.503	0.036
Population density (people per sq. km of land area) [EN.POP.DNST]	0.0803	0.121	0.663	0.508	-0.158	0.318
Official exchange rate (LCU per US$, period average) [PA.NUS.FCRF]	0.1359	0.039	3.514	0.000	0.060	0.212
Total natural resources rents (% of GDP) [NY.GDP.TOTL.RT.ZS]	0.0184	0.080	0.231	0.817	-0.138	0.175
Natural gas rents (% of GDP) [NY.GDP.NGAS.RT.ZS]	-0.0967	0.108	-0.894	0.372	-0.309	0.116
Manufacturing, value added (% of GDP) [NV.IND.MANF.ZS]	-0.3138	0.091	-3.441	0.001	-0.493	-0.135
Gross fixed capital formation (current US$) [NE.GDI.FTOT.CD]	-0.2582	0.140	-1.846	0.066	-0.533	0.017
Gross fixed capital formation (% of GDP) [NE.GDI.FTOT.ZS]	0.2630	0.082	3.223	0.001	0.103	0.423
Net ODA received per capita (current US$) [DT.ODA.ODAT.PC.ZS]	-0.0580	0.074	-0.789	0.430	-0.203	0.086
Net ODA received (% of imports of goods, services and primary income) [DT.ODA.ODAT.MP.ZS]	-0.1050	0.074	-1.423	0.156	-0.250	0.040
CPIA property rights and rule-based governance rating (1=low to 6=high) [IQ.CPA.PROP.XQ]	-0.0099	0.100	-0.099	0.921	-0.207	0.187
CPIA transparency, accountability, and corruption in the public sector rating (1=low to 6=high) [IQ.CPA.TRAN.XQ]	0.2210	0.111	1.996	0.047	0.003	0.439
Trade openness	-0.0827	0.121	-0.686	0.493	-0.320	0.154
Country Name_Benin	-0.0117	0.052	-0.224	0.823	-0.114	0.091
Country Name_Botswana	-0.0160	0.062	-0.256	0.798	-0.139	0.107
Country Name_Burkina Faso	0.0612	0.050	1.227	0.220	-0.037	0.159
Country Name_Burundi	-0.0499	0.067	-0.749	0.454	-0.181	0.081
Country Name_Cabo Verde	-0.1554	0.089	-1.749	0.081	-0.330	0.019
Country Name_Cameroon	0.0505	0.044	1.150	0.251	-0.036	0.137
Country Name_Chad	-0.0601	0.046	-1.315	0.189	-0.150	0.030
Country Name_Comoros	-0.0584	0.054	-1.084	0.279	-0.164	0.047
Country Name_Equatorial Guinea	0.0382	0.051	0.747	0.455	-0.062	0.139
Country Name_Eritrea	-0.0360	0.038	-0.938	0.349	-0.111	0.039
Country Name_Eswatini	0.2304	0.093	2.478	0.014	0.048	0.413
Country Name_Ethiopia	0.1307	0.054	2.434	0.015	0.025	0.236
Country Name_Gabon	-0.0596	0.058	-1.034	0.302	-0.173	0.054
Country Name_Ghana	0.0572	0.051	1.112	0.267	-0.044	0.158
Country Name_Guinea	0.0358	0.044	0.805	0.421	-0.052	0.123
Country Name_Guinea-Bissau	0.0301	0.048	0.624	0.533	-0.065	0.125
Country Name_Kenya	0.0669	0.046	1.457	0.146	-0.023	0.157
Country Name_Lesotho	-0.0282	0.071	-0.398	0.691	-0.167	0.111
Country Name_Liberia	-0.0011	0.045	-0.025	0.980	-0.089	0.087
Country Name_Madagascar	-0.0750	0.043	-1.735	0.083	-0.160	0.010
Country Name_Mauritania	-0.0736	0.051	-1.455	0.146	-0.173	0.026
Country Name_Mozambique	0.1564	0.104	1.504	0.133	-0.048	0.361
Country Name_Namibia	0.0510	0.059	0.862	0.389	-0.065	0.167
Country Name_Niger	0.0026	0.053	0.049	0.961	-0.101	0.107
Country Name_Nigeria	0.2114	0.106	2.000	0.046	0.004	0.419
Country Name_Senegal	0.0418	0.056	0.748	0.455	-0.068	0.152
Country Name_Seychelles	-0.0193	0.079	-0.243	0.808	-0.175	0.137
Country Name_Sierra Leone	0.0406	0.044	0.914	0.361	-0.047	0.128
Country Name_South Africa	0.3174	0.102	3.127	0.002	0.118	0.517
Country Name_Sudan	0.0505	0.081	0.623	0.533	-0.109	0.210
Country Name_Tanzania	0.0341	0.052	0.655	0.513	-0.068	0.137
Country Name_Uganda	0.0796	0.049	1.623	0.105	-0.017	0.176
Country Name_Zambia	-0.0173	0.047	-0.368	0.713	-0.110	0.075
Country Name_Zimbabwe	0.1425	0.052	2.755	0.006	0.041	0.244
Time_2006.0	0.0635	0.056	1.144	0.253	-0.046	0.173
Time_2007.0	-0.0309	0.055	-0.565	0.572	-0.138	0.076
Time_2008.0	-0.1597	0.057	-2.816	0.005	-0.271	-0.048
Time_2009.0	0.0880	0.056	1.578	0.115	-0.022	0.197
Time_2010.0	0.0634	0.056	1.122	0.262	-0.048	0.174
Time_2011.0	0.0016	0.056	0.029	0.977	-0.109	0.112
Time_2012.0	-0.0511	0.058	-0.887	0.375	-0.164	0.062
Time_2013.0	-0.0175	0.057	-0.306	0.760	-0.130	0.095
Time_2014.0	-0.0739	0.057	-1.295	0.196	-0.186	0.038
Time_2015.0	-0.0837	0.057	-1.460	0.145	-0.196	0.029
Time_2016.0	-0.0806	0.054	-1.486	0.138	-0.187	0.026
Time_2017.0	-0.0415	0.057	-0.728	0.467	-0.153	0.070
Time_2018.0	-0.0540	0.058	-0.932	0.352	-0.168	0.060
Time_2019.0	-0.4027	0.059	-6.878	0.000	-0.518	-0.288
Time_2020.0	0.0027	0.058	0.047	0.963	-0.112	0.117

Table 2: Trade openness index 1 and GDP per capita growth

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OLS Regression Results

Dep. Variable:	GDP Growth	R-squared (uncentered):	0.118
Model:	OLS	Adj. R-squared (uncentered):	0.097
Method:	Least Squares	F-statistic:	5.412
Date:	Thu, 23 Mar 2023	Prob (F-statistic):	3.78e-30
Time:	12:45:12	Log-Likelihood:	-2854.2
No. Observations:	2105	AIC:	5810.
Df Residuals:	2054	BIC:	6099.
Df Model:	51		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
Agricultural land (% of land area) [AG.LND.AGRI.ZS]	0.0274	0.024	1.129	0.259	-0.020	0.075
Official exchange rate (LCU per US$, period average) [PA.NUS.FCRF]	0.0397	0.021	1.871	0.061	-0.002	0.081
Natural gas rents (% of GDP) [NY.GDP.NGAS.RT.ZS]	-0.0904	0.035	-2.592	0.010	-0.159	-0.022
Manufacturing, value added (% of GDP) [NV.IND.MANF.ZS]	-0.0084	0.023	-0.365	0.715	-0.054	0.037
Gross fixed capital formation (current US$) [NE.GDI.FTOT.CD]	-0.0188	0.025	-0.763	0.445	-0.067	0.029
Gross fixed capital formation (% of GDP) [NE.GDI.FTOT.ZS]	0.0355	0.025	1.445	0.149	-0.013	0.084
Net ODA received (% of imports of goods, services and primary income) [DT.ODA.ODAT.MP.ZS]	0.0478	0.025	1.902	0.057	-0.001	0.097
Trade openness	0.1020	0.025	4.105	0.000	0.053	0.151
Country Name_Botswana	0.0941	0.022	4.347	0.000	0.052	0.137
Country Name_Burkina Faso	0.0386	0.021	1.805	0.071	-0.003	0.081
Country Name_Cabo Verde	0.0507	0.022	2.275	0.023	0.007	0.094
Country Name_Central African Republic	-0.0477	0.023	-2.101	0.036	-0.092	-0.003
Country Name_Equatorial Guinea	-0.0012	0.033	-0.037	0.971	-0.065	0.063
Country Name_Ethiopia	0.0663	0.021	3.148	0.002	0.025	0.108
Country Name_Kenya	0.0388	0.021	1.844	0.065	-0.002	0.080
Country Name_Madagascar	-0.0449	0.021	-2.089	0.037	-0.087	-0.003
Country Name_Mauritania	-0.0208	0.022	-0.942	0.346	-0.064	0.022
Country Name_Mozambique	0.0901	0.025	3.600	0.000	0.041	0.139
Country Name_Namibia	-0.0213	0.021	-1.004	0.316	-0.063	0.020
Country Name_Rwanda	0.0438	0.022	2.021	0.043	0.001	0.086
Country Name_Sierra Leone	-0.0308	0.022	-1.431	0.153	-0.073	0.011
Country Name_South Sudan	-0.0969	0.021	-4.623	0.000	-0.138	-0.056
Country Name_Tanzania	0.0374	0.021	1.767	0.077	-0.004	0.079
Country Name_Uganda	0.0526	0.021	2.469	0.014	0.011	0.094
Country Name_Zimbabwe	-0.0356	0.022	-1.643	0.101	-0.078	0.007
Time_1968.0	0.0302	0.021	1.442	0.150	-0.011	0.071
Time_1969.0	0.0642	0.021	3.068	0.002	0.023	0.105
Time_1970.0	0.0304	0.021	1.449	0.147	-0.011	0.071
Time_1972.0	-0.0033	0.021	-0.156	0.876	-0.044	0.038
Time_1973.0	0.0544	0.021	2.598	0.009	0.013	0.095
Time_1975.0	0.0430	0.021	2.064	0.039	0.002	0.084
Time_1979.0	-0.0414	0.021	-1.981	0.048	-0.082	-0.000
Time_1981.0	-0.0318	0.021	-1.520	0.129	-0.073	0.009
Time_1982.0	-0.0658	0.021	-3.150	0.002	-0.107	-0.025
Time_1983.0	-0.0332	0.021	-1.590	0.112	-0.074	0.008
Time_1984.0	0.0184	0.021	0.879	0.379	-0.023	0.059
Time_1986.0	-0.0340	0.021	-1.605	0.109	-0.076	0.008
Time_1989.0	-0.0316	0.021	-1.505	0.132	-0.073	0.010
Time_1991.0	-0.0634	0.021	-3.022	0.003	-0.105	-0.022
Time_1992.0	-0.0652	0.021	-3.110	0.002	-0.106	-0.024
Time_1993.0	-0.0506	0.021	-2.415	0.016	-0.092	-0.010
Time_1994.0	0.0055	0.021	0.263	0.792	-0.036	0.047
Time_1996.0	0.0188	0.021	0.897	0.370	-0.022	0.060
Time_1998.0	-0.0252	0.021	-1.203	0.229	-0.066	0.016
Time_2004.0	0.0178	0.021	0.848	0.397	-0.023	0.059
Time_2005.0	0.0295	0.021	1.408	0.159	-0.012	0.071
Time_2006.0	0.0227	0.021	1.084	0.278	-0.018	0.064
Time_2008.0	-0.0359	0.021	-1.698	0.090	-0.077	0.006
Time_2009.0	0.0450	0.021	2.148	0.032	0.004	0.086
Time_2010.0	0.0156	0.021	0.745	0.456	-0.025	0.057
Time_2019.0	-0.1424	0.021	-6.803	0.000	-0.183	-0.101

Omnibus:	480.864	Durbin-Watson:	1.703
Prob(Omnibus):	0.000	Jarque-Bera (JB):	9118.409
Skew:	-0.571	Prob(JB):	0.00
Kurtosis:	13.132	Cond. No.	3.28

Notes:
[1] R^2 is computed without centering (uncentered) since the model does not contain a constant.
[2] Standard Errors assume that the covariance matrix of the errors is correctly specified.

Table 3: Trade openness index 2 (First principal component of exports and imports) and GDP growth

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OLS Regression Results

Dep. Variable:	GDP per capita Growth	R-squared (uncentered):	0.131
Model:	OLS	Adj. R-squared (uncentered):	0.102
Method:	Least Squares	F-statistic:	4.459
Date:	Thu, 23 Mar 2023	Prob (F-statistic):	4.45e-29
Time:	12:45:22	Log-Likelihood:	-2838.8
No. Observations:	2105	AIC:	5816.
Df Residuals:	2036	BIC:	6205.
Df Model:	69		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
Population density (people per sq. km of land area) [EN.POP.DNST]	0.0428	0.026	1.618	0.106	-0.009	0.095
Official exchange rate (LCU per US$, period average) [PA.NUS.FCRF]	0.0440	0.021	2.077	0.038	0.002	0.085
Natural gas rents (% of GDP) [NY.GDP.NGAS.RT.ZS]	-0.0959	0.034	-2.825	0.005	-0.162	-0.029
Gross fixed capital formation (current US$) [NE.GDI.FTOT.CD]	0.0002	0.026	0.008	0.993	-0.050	0.050
Gross fixed capital formation (% of GDP) [NE.GDI.FTOT.ZS]	0.0072	0.026	0.280	0.780	-0.043	0.058
Net ODA received per capita (current US$) [DT.ODA.ODAT.PC.ZS]	0.0334	0.029	1.160	0.246	-0.023	0.090
Net ODA received (% of imports of goods, services and primary income) [DT.ODA.ODAT.MP.ZS]	0.0266	0.025	1.055	0.291	-0.023	0.076
Trade openness	0.1063	0.030	3.521	0.000	0.047	0.166
Country Name_Benin	0.0112	0.021	0.533	0.594	-0.030	0.053
Country Name_Botswana	0.0928	0.022	4.211	0.000	0.050	0.136
Country Name_Burkina Faso	0.0404	0.021	1.904	0.057	-0.001	0.082
Country Name_Cabo Verde	0.0496	0.026	1.896	0.058	-0.002	0.101
Country Name_Central African Republic	-0.0385	0.021	-1.801	0.072	-0.080	0.003
Country Name_Chad	-0.0095	0.021	-0.445	0.657	-0.051	0.032
Country Name_Comoros	-0.0155	0.023	-0.686	0.493	-0.060	0.029
Country Name_Congo, Rep.	-0.0287	0.022	-1.279	0.201	-0.073	0.015
Country Name_Equatorial Guinea	-0.0210	0.031	-0.673	0.501	-0.082	0.040
Country Name_Eswatini	0.0195	0.023	0.845	0.398	-0.026	0.065
Country Name_Ethiopia	0.0645	0.021	3.057	0.002	0.023	0.106
Country Name_Guinea	0.0218	0.021	1.036	0.300	-0.019	0.063
Country Name_Madagascar	-0.0394	0.021	-1.847	0.065	-0.081	0.002
Country Name_Mali	0.0223	0.021	1.051	0.294	-0.019	0.064
Country Name_Mauritania	-0.0208	0.023	-0.914	0.361	-0.065	0.024
Country Name_Mozambique	0.0827	0.025	3.339	0.001	0.034	0.131
Country Name_Namibia	-0.0164	0.022	-0.754	0.451	-0.059	0.026
Country Name_Niger	-0.0279	0.021	-1.308	0.191	-0.070	0.014
Country Name_Rwanda	0.0395	0.023	1.687	0.092	-0.006	0.086
Country Name_South Sudan	-0.1050	0.021	-5.001	0.000	-0.146	-0.064
Country Name_Tanzania	0.0363	0.021	1.701	0.089	-0.006	0.078
Country Name_Uganda	0.0446	0.021	2.088	0.037	0.003	0.086
Country Name_Zimbabwe	-0.0256	0.022	-1.191	0.234	-0.068	0.017
Time_1963.0	0.0286	0.021	1.348	0.178	-0.013	0.070
Time_1967.0	0.0185	0.021	0.876	0.381	-0.023	0.060
Time_1968.0	0.0322	0.021	1.531	0.126	-0.009	0.074
Time_1969.0	0.0667	0.021	3.163	0.002	0.025	0.108
Time_1970.0	0.0284	0.021	1.349	0.177	-0.013	0.070
Time_1972.0	-0.0045	0.021	-0.212	0.832	-0.046	0.037
Time_1973.0	0.0472	0.021	2.238	0.025	0.006	0.088
Time_1974.0	0.0085	0.021	0.405	0.685	-0.033	0.050
Time_1975.0	0.0368	0.021	1.754	0.080	-0.004	0.078
Time_1978.0	-0.0207	0.021	-0.985	0.325	-0.062	0.020
Time_1979.0	-0.0519	0.021	-2.474	0.013	-0.093	-0.011
Time_1981.0	-0.0368	0.021	-1.744	0.081	-0.078	0.005
Time_1982.0	-0.0724	0.021	-3.444	0.001	-0.114	-0.031
Time_1983.0	-0.0370	0.021	-1.758	0.079	-0.078	0.004
Time_1984.0	0.0142	0.021	0.673	0.501	-0.027	0.055
Time_1985.0	-0.0240	0.021	-1.138	0.255	-0.065	0.017
Time_1986.0	-0.0413	0.021	-1.940	0.053	-0.083	0.000
Time_1987.0	0.0081	0.021	0.385	0.700	-0.033	0.049
Time_1989.0	-0.0391	0.021	-1.850	0.064	-0.081	0.002
Time_1990.0	-0.0346	0.021	-1.637	0.102	-0.076	0.007
Time_1991.0	-0.0702	0.021	-3.322	0.001	-0.112	-0.029
Time_1992.0	-0.0677	0.021	-3.206	0.001	-0.109	-0.026
Time_1993.0	-0.0484	0.021	-2.292	0.022	-0.090	-0.007
Time_1994.0	0.0139	0.021	0.658	0.511	-0.028	0.055
Time_1996.0	0.0133	0.021	0.631	0.528	-0.028	0.055
Time_1997.0	-0.0174	0.021	-0.825	0.410	-0.059	0.024
Time_1998.0	-0.0262	0.021	-1.243	0.214	-0.067	0.015
Time_1999.0	-0.0312	0.021	-1.481	0.139	-0.073	0.010
Time_2004.0	0.0140	0.021	0.663	0.507	-0.027	0.055
Time_2005.0	0.0235	0.021	1.114	0.265	-0.018	0.065
Time_2006.0	0.0179	0.021	0.851	0.395	-0.023	0.059
Time_2008.0	-0.0443	0.021	-2.076	0.038	-0.086	-0.002
Time_2009.0	0.0355	0.021	1.678	0.094	-0.006	0.077
Time_2010.0	0.0167	0.021	0.785	0.433	-0.025	0.058
Time_2013.0	0.0131	0.021	0.617	0.537	-0.028	0.055
Time_2014.0	-0.0293	0.021	-1.382	0.167	-0.071	0.012
Time_2016.0	-0.0218	0.021	-1.034	0.301	-0.063	0.020
Time_2019.0	-0.1464	0.021	-6.943	0.000	-0.188	-0.105

Table 4: Trade openness index 2 and GDP per capita growth

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OLS Regression Results

Dep. Variable:	GDP Growth	R-squared (uncentered):	0.134
Model:	OLS	Adj. R-squared (uncentered):	0.124
Method:	Least Squares	F-statistic:	13.34
Date:	Thu, 23 Mar 2023	Prob (F-statistic):	3.42e-55
Time:	13:31:58	Log-Likelihood:	-3166.6
No. Observations:	2351	AIC:	6387.
Df Residuals:	2324	BIC:	6543.
Df Model:	27		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
Total natural resources rents (% of GDP) [NY.GDP.TOTL.RT.ZS]	0.0624	0.023	2.771	0.006	0.018	0.107
Natural gas rents (% of GDP) [NY.GDP.NGAS.RT.ZS]	-0.1695	0.024	-7.203	0.000	-0.216	-0.123
Gross fixed capital formation (% of GDP) [NE.GDI.FTOT.ZS]	0.0315	0.022	1.451	0.147	-0.011	0.074
Trade openness (share of exports and imports in GDP)	0.1010	0.022	4.540	0.000	0.057	0.145
Country Name_x_Botswana	0.0702	0.020	3.560	0.000	0.032	0.109
Country Name_x_Central African Republic	-0.0452	0.019	-2.321	0.020	-0.083	-0.007
Country Name_x_Congo, Dem. Rep.	-0.0533	0.020	-2.717	0.007	-0.092	-0.015
Country Name_x_Congo, Rep.	-0.0462	0.021	-2.158	0.031	-0.088	-0.004
Country Name_x_Equatorial Guinea	0.2244	0.023	9.816	0.000	0.180	0.269
Country Name_x_Ethiopia	0.0462	0.020	2.355	0.019	0.008	0.085
Country Name_x_Mozambique	0.0846	0.021	4.036	0.000	0.044	0.126
Country Name_x_South Sudan	-0.0817	0.020	-4.154	0.000	-0.120	-0.043
Country Name_x_Uganda	0.0427	0.019	2.193	0.028	0.005	0.081
Time_1969.0	0.0558	0.019	2.880	0.004	0.018	0.094
Time_1973.0	0.0417	0.019	2.151	0.032	0.004	0.080
Time_1975.0	0.0367	0.019	1.897	0.058	-0.001	0.075
Time_1981.0	-0.0425	0.019	-2.187	0.029	-0.081	-0.004
Time_1982.0	-0.0652	0.019	-3.363	0.001	-0.103	-0.027
Time_1989.0	-0.0382	0.019	-1.972	0.049	-0.076	-0.000
Time_1991.0	-0.0565	0.019	-2.916	0.004	-0.095	-0.019
Time_1992.0	-0.0603	0.019	-3.113	0.002	-0.098	-0.022
Time_1993.0	-0.0493	0.019	-2.544	0.011	-0.087	-0.011
Time_1995.0	0.0417	0.019	2.150	0.032	0.004	0.080
Time_1996.0	0.0705	0.019	3.635	0.000	0.032	0.109
Time_2003.0	0.0355	0.019	1.831	0.067	-0.003	0.073
Time_2009.0	0.0426	0.019	2.196	0.028	0.005	0.081
Time_2019.0	-0.1086	0.019	-5.597	0.000	-0.147	-0.071

Omnibus:	1840.556	Durbin-Watson:	1.579
Prob(Omnibus):	0.000	Jarque-Bera (JB):	387059.627
Skew:	2.771	Prob(JB):	0.00
Kurtosis:	65.614	Cond. No.	2.27

Table 5: Trade openness index 3 (conventional share of exports and imports in GDP) and GDP growth

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OLS Regression Results

Dep. Variable:	GDP per capita Growth	R-squared (uncentered):	0.148
Model:	OLS	Adj. R-squared (uncentered):	0.130
Method:	Least Squares	F-statistic:	8.186
Date:	Thu, 23 Mar 2023	Prob (F-statistic):	1.71e-51
Time:	13:32:13	Log-Likelihood:	-3147.1
No. Observations:	2351	AIC:	6392.
Df Residuals:	2302	BIC:	6675.
Df Model:	49		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
Agricultural land (% of land area) [AG.LND.AGRI.ZS]	0.0394	0.025	1.559	0.119	-0.010	0.089
Population density (people per sq. km of land area) [EN.POP.DNST]	0.0248	0.023	1.069	0.285	-0.021	0.070
Official exchange rate (LCU per US$, period average) [PA.NUS.FCRF]	0.0442	0.019	2.268	0.023	0.006	0.082
Total natural resources rents (% of GDP) [NY.GDP.TOTL.RT.ZS]	0.0455	0.025	1.808	0.071	-0.004	0.095
Natural gas rents (% of GDP) [NY.GDP.NGAS.RT.ZS]	-0.1735	0.024	-7.254	0.000	-0.220	-0.127
Gross fixed capital formation (% of GDP) [NE.GDI.FTOT.ZS]	0.0365	0.022	1.632	0.103	-0.007	0.080
Net ODA received per capita (current US$) [DT.ODA.ODAT.PC.ZS]	0.0206	0.026	0.798	0.425	-0.030	0.071
Trade openness (share of exports and imports in GDP)	0.1429	0.024	5.896	0.000	0.095	0.190
Country Name_x_Botswana	0.0642	0.020	3.187	0.001	0.025	0.104
Country Name_x_Burkina Faso	0.0399	0.020	2.029	0.043	0.001	0.078
Country Name_x_Cabo Verde	0.0267	0.024	1.125	0.261	-0.020	0.073
Country Name_x_Central African Republic	-0.0151	0.021	-0.727	0.467	-0.056	0.026
Country Name_x_Congo, Dem. Rep.	-0.0466	0.021	-2.234	0.026	-0.088	-0.006
Country Name_x_Congo, Rep.	-0.0512	0.022	-2.333	0.020	-0.094	-0.008
Country Name_x_Equatorial Guinea	0.2045	0.024	8.471	0.000	0.157	0.252
Country Name_x_Ethiopia	0.0490	0.020	2.487	0.013	0.010	0.088
Country Name_x_Gambia, The	-0.0201	0.020	-1.022	0.307	-0.059	0.018
Country Name_x_Kenya	0.0277	0.020	1.412	0.158	-0.011	0.066
Country Name_x_Liberia	-0.0433	0.020	-2.157	0.031	-0.083	-0.004
Country Name_x_Madagascar	-0.0347	0.020	-1.744	0.081	-0.074	0.004
Country Name_x_Mozambique	0.0889	0.021	4.212	0.000	0.047	0.130
Country Name_x_Rwanda	0.0373	0.021	1.763	0.078	-0.004	0.079
Country Name_x_South Sudan	-0.0908	0.020	-4.592	0.000	-0.130	-0.052
Country Name_x_Tanzania	0.0361	0.020	1.840	0.066	-0.002	0.075
Country Name_x_Uganda	0.0337	0.020	1.708	0.088	-0.005	0.072
Country Name_x_Zambia	-0.0397	0.020	-1.990	0.047	-0.079	-0.001
Time_1968.0	0.0361	0.019	1.859	0.063	-0.002	0.074
Time_1969.0	0.0605	0.019	3.117	0.002	0.022	0.099
Time_1973.0	0.0410	0.019	2.113	0.035	0.003	0.079
Time_1975.0	0.0339	0.019	1.749	0.080	-0.004	0.072
Time_1979.0	-0.0403	0.019	-2.082	0.037	-0.078	-0.002
Time_1981.0	-0.0470	0.019	-2.420	0.016	-0.085	-0.009
Time_1982.0	-0.0716	0.019	-3.691	0.000	-0.110	-0.034
Time_1983.0	-0.0393	0.019	-2.024	0.043	-0.077	-0.001
Time_1989.0	-0.0420	0.019	-2.164	0.031	-0.080	-0.004
Time_1990.0	-0.0400	0.019	-2.054	0.040	-0.078	-0.002
Time_1991.0	-0.0605	0.019	-3.111	0.002	-0.099	-0.022
Time_1992.0	-0.0603	0.019	-3.104	0.002	-0.098	-0.022
Time_1993.0	-0.0455	0.019	-2.344	0.019	-0.084	-0.007
Time_1994.0	0.0252	0.019	1.297	0.195	-0.013	0.063
Time_1995.0	0.0361	0.019	1.858	0.063	-0.002	0.074
Time_1996.0	0.0688	0.019	3.543	0.000	0.031	0.107
Time_2000.0	0.0168	0.019	0.869	0.385	-0.021	0.055
Time_2002.0	-0.0201	0.019	-1.039	0.299	-0.058	0.018
Time_2003.0	0.0381	0.019	1.965	0.050	7.49e-05	0.076
Time_2004.0	0.0186	0.019	0.961	0.337	-0.019	0.057
Time_2005.0	0.0218	0.019	1.121	0.263	-0.016	0.060
Time_2009.0	0.0365	0.019	1.873	0.061	-0.002	0.075
Time_2019.0	-0.1101	0.019	-5.653	0.000	-0.148	-0.072

Omnibus:	1977.098	Durbin-Watson:	1.667
Prob(Omnibus):	0.000	Jarque-Bera (JB):	407803.111
Skew:	3.152	Prob(JB):	0.00
Kurtosis:	67.213	Cond. No.	2.88

Table 6: Trade openness index 3 and GDP per capita growth

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Table 7: Summary of dependent variables

	GDP growth (%)	GDP per capita growth (%)
Count	2461	2461
Mean	3.864508	1.210051
Std	6.964170	6.743760

Table 8: Summary of independent variables of interest

	Imports % of GDP	Exports % of GDP
Count	2213	2213
Std	19.249454	27.144759
Mean	36.080747	17.664572

explained variance [0.53913072]

Table 9: This table has the variable used for the construction of trade openness index 1 and their correlation with the constructed index

Variable Name	Correlation with trade openness index
Simple Average Duty	-0.81700426
Maximum Duty	0.3096884
Duty free	0.886164
Imports Duty free	0.75167799
Exports	0.74235359
Imports	0.74878542

Table 10: This table has the two constructed indexes and the variation in the underlying variables captured by the indexes

Index	Explained variation
Trade openness index 1 (first PCA of tariffs, exports and imports)	0.53913072
Trade openness index 2 (first PCA of exports and imports)	0.81351763
First PCA of tariffs (without exports and imports)	0.61871109

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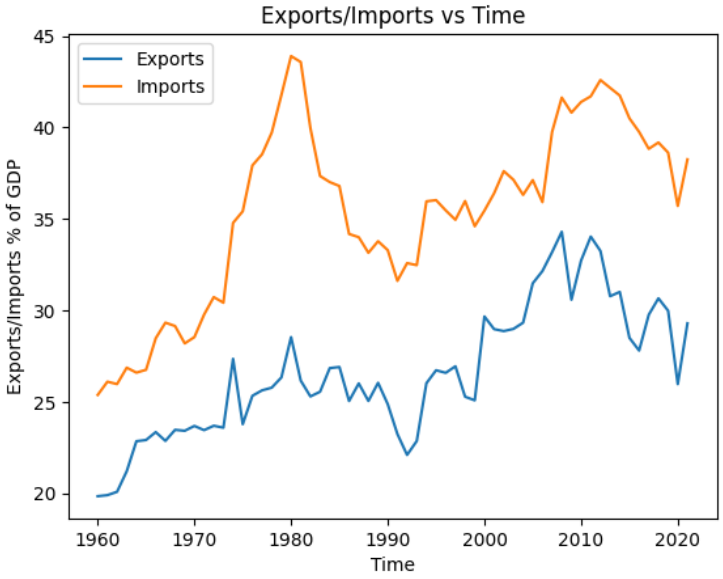

Figure 1: Change of exports and imports as a percent of GDP in sub-Saharan Africa

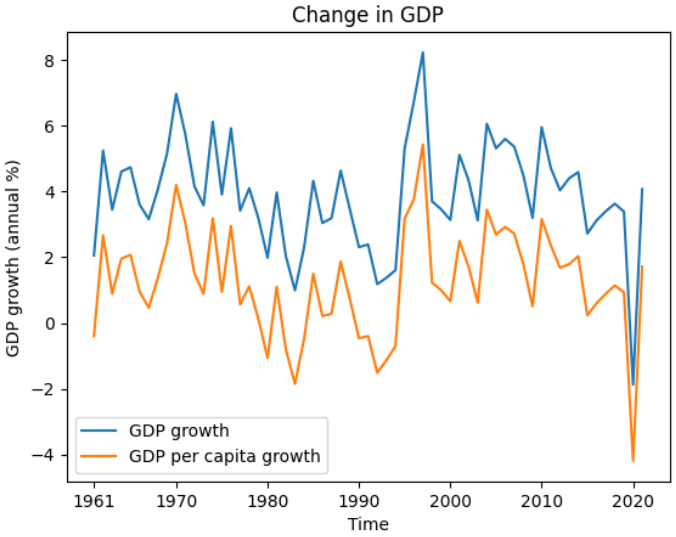

Figure 2: Change of GDP growth and GDP per capita growth in sub-Saharan Africa

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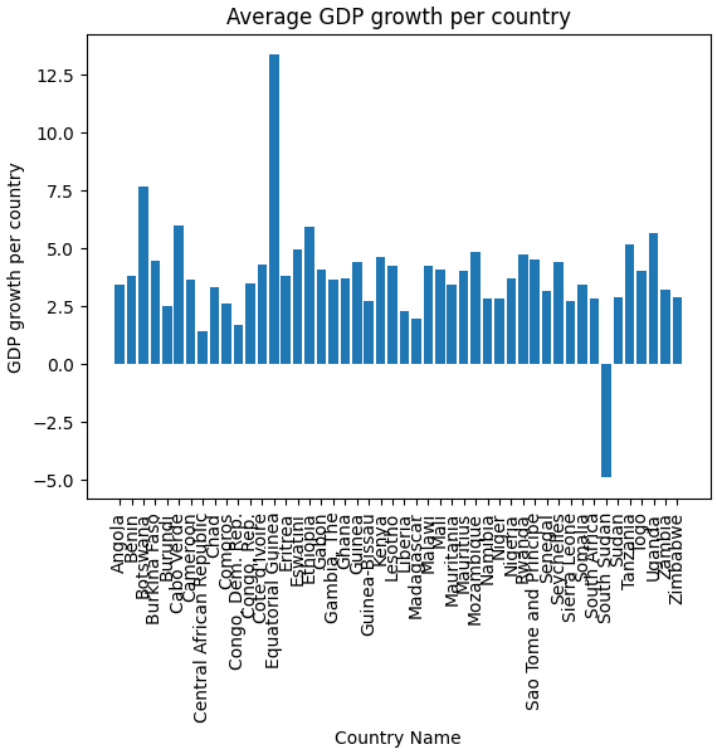

Figure 3: Average GDP growth (1961-2021) in sub-Saharan countries

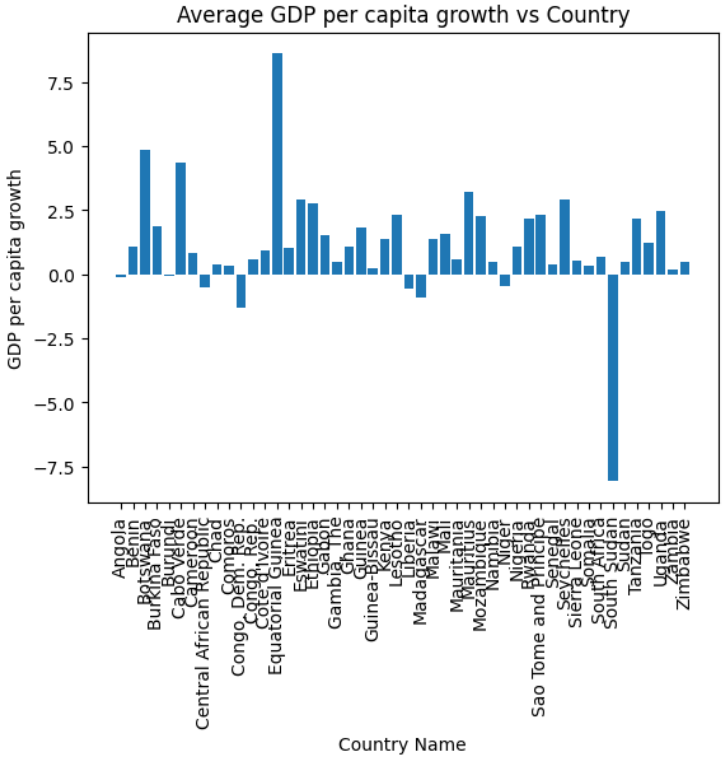

Figure 4: Average GDP per capita growth (1961-2021) in sub-Saharan countries

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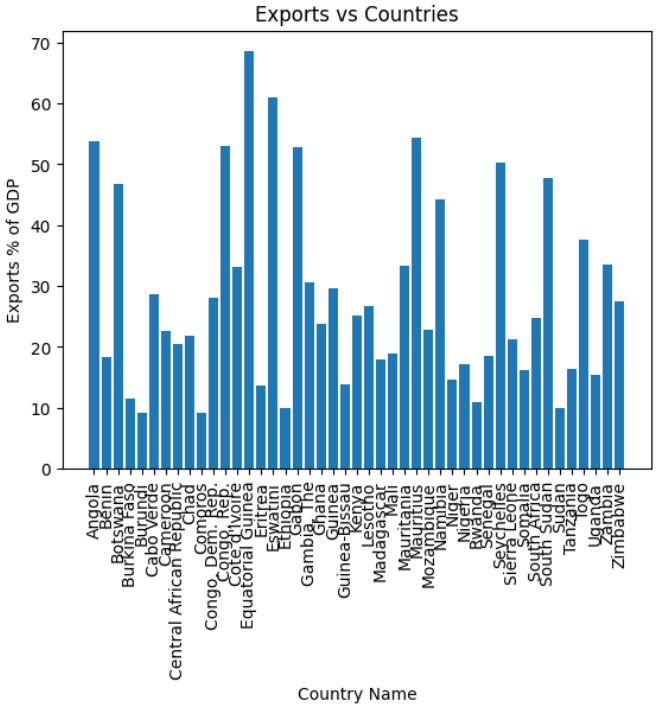

Figure 5: Average Exports as a percent of GDP (1961-2021) in sub-Saharan Africa

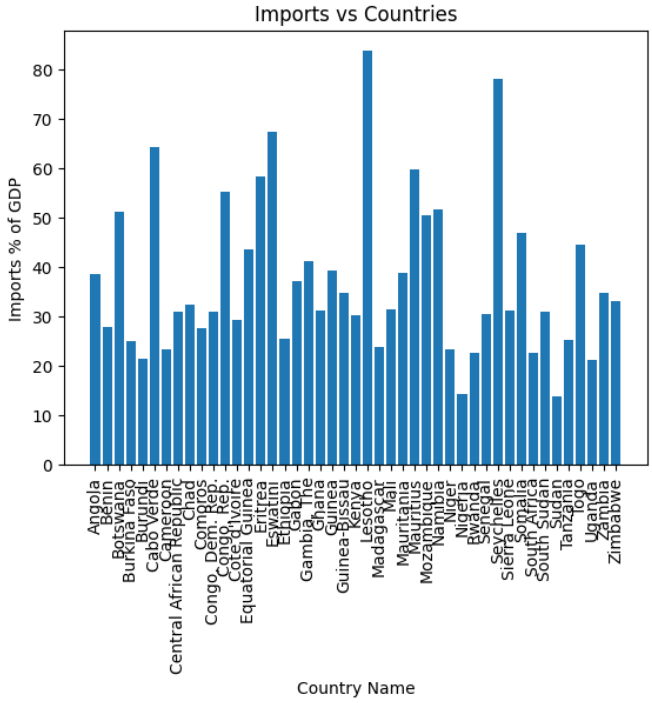

Figure 6: Average Imports as a percent of GDP (1961-2021) in sub-Saharan Africa

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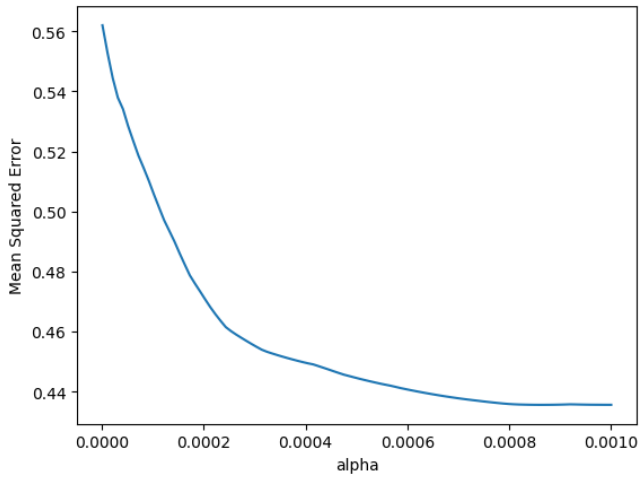

Figure 7: Trade openness index 1, GDP growth: MSE and penalty term (alpha) for Lasso regression

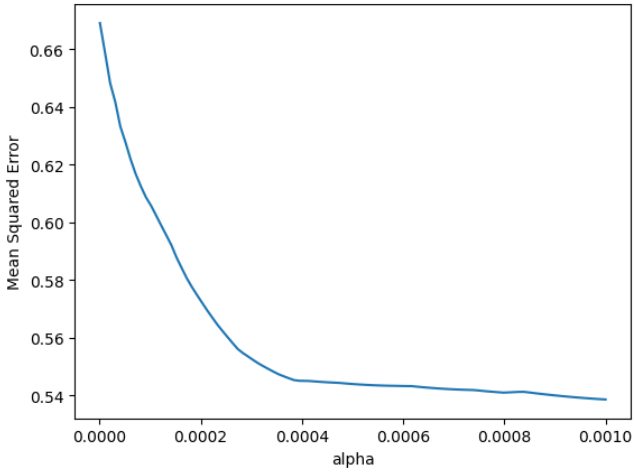

Figure 8: Trade openness index 1, GDP per capita growth: MSE and penalty term (alpha) for LASSO regression

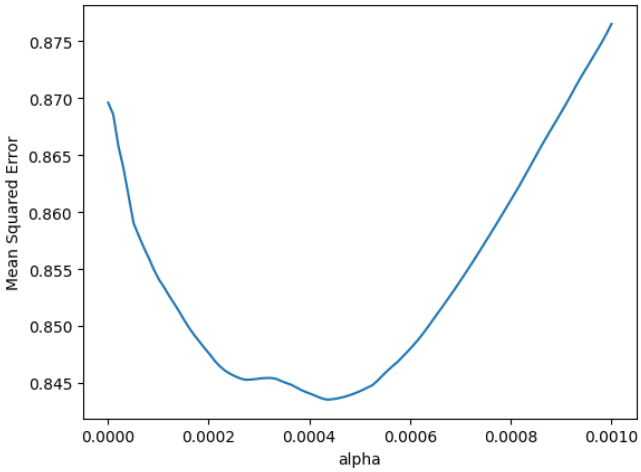

Figure 9: Trade openness index 2, GDP growth: MSE and penalty term (alpha) for Lasso regression

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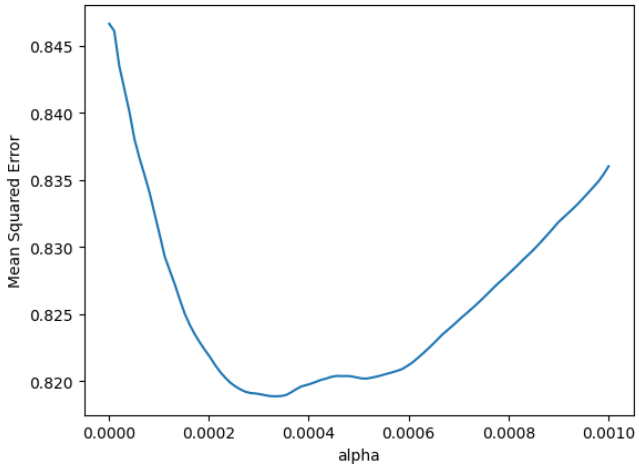

Figure 10: Trade openness index 2, GDP per capita growth:

MSE and penalty term (alpha) for Lasso regression

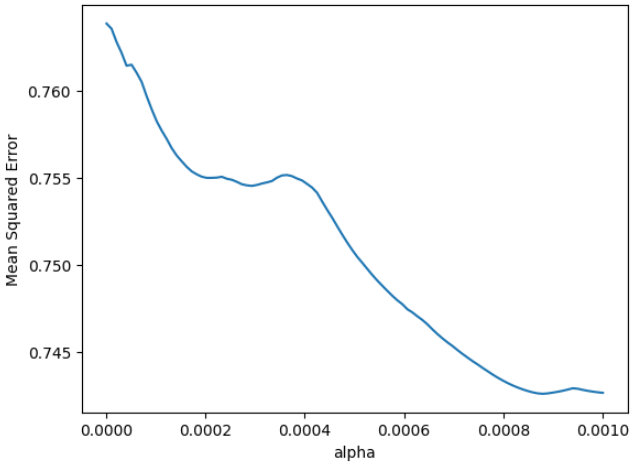

Figure 11: Trade openness index 3, GDP growth:

MSE and penalty term (alpha) for Lasso regression

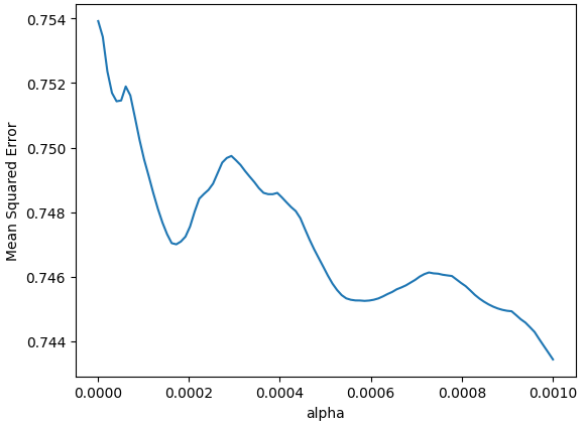

Figure 12: Trade openness index 3, GDP per capita growth:

MSE and penalty term (alpha) for Lasso regression