Research article

An application of the LASSO and elastic net regression to assess poverty and economic freedom on ECOWAS countries

Brian W. Sloboda[1,*], Dennis Pearson[2] and Madi Etherton[2]

[1] Department of Economics and Finance, University of Maryland, Global Campus, USA

[2] Austin Peay State University, Clarksville, TN, USA

* **Correspondence:** Email: brian.sloboda@faculty.umgc.edu.

Abstract: The study of poverty has been studied from several different research approaches over the years. This analysis intended to determine which variables tell us about poverty in the Economic Community of West African State (ECOWAS) countries. Many ECOWAS countries have recorded high economic growth rates in the past few decades. However, a recent trend is that this progress is reversing, and poverty rates are increasing. In this analysis, we examined the variables describing poverty in ECOWAS. We used a statistical approach coupled with economic theory to justify the inclusion of the variables used to assess poverty. Furthermore, we include the use of the Fraser Institute's Economic Freedom index for each of the West African States. As far as we know, the economic freedom and poverty of West African states have not been presented for consideration toward African growth rates and poverty rates. With few exceptions, economic freedom research suggests that economic freedom is the foundational ingredient for increasing prosperity and reducing poverty. Then, we interpreted the empirical results and assess the validity of the model as applied to the ECOWAS countries. More specifically, we use the LASSO and elastic net regression to obtain sparse solutions to regression problems. LASSO and elastic net are computational methods that rapidly inform us about the relevant variables for the model. These computational methods' performances will in the context of the number of variables exceeds the number of observations by generating a low mean squared error (MSE).

Keywords: LASSO; elastic net; cross validation; poverty; ECOWAS; economic freedom

1. Introduction

Two in ten people living on the African continent are still living on less than the international poverty line of US $1.25 per day despite the poverty declining by more than half since 2000 [1–3]. Though, significant progress has been made in many developing countries, up to 42 percent of the population throughout the African continent are still living below the poverty line [2]. One of the main drivers in

poverty reduction is the advocation of employment because improved employment conditions could lead to improved welfare and economic growth [4].

A major issue in the Economic Community of West African States (ECOWAS) is the continued persistence surrounding the issue of poverty. With the presence of high poverty, it is identified as a state of total absence of economic opportunities, poor health outcomes, poor living conditions, hunger and undernourishment, lack of education, social deprivation, and hopelessness of the future. These problems have plagued ECOWAS and other developing countries for a few decades. The governments of ECOWAS have been concerned about poverty because ECOWAS is characterized by low-income and high poverty rates. A recent survey on poverty based on the absolute poverty line approach shows that the poor represent more than one-third of the population in Cape Verde and Cote d'Ivoire; less than one-third of the population in Benin, Ghana, and Togo; about half of the population in Burkina Faso, Guinea, the Gambia, Nigeria, and Senegal. About two-thirds of the population was poor in Guinea-Bissau and Niger, and more than two-thirds of the population in Mali and Sierra Leone. The aim of this paper is to use use the LASSO regression to identify in the pre-selected set a small subset of the most important poverty determinants. The LASSO regression also fits well,where we have few observations and many covariates. An important contribution of this paper is that prior studies did not use the Freedom Index as a covariate to explain poverty.

This paper is organized as follows. In Section 2, we reviewed the relevant literature of poverty studies in general and in ECOWAS and explore the connection to economic freedom and its effects on economic growth and poverty. Section 3 delved into the methodology of the LASSO regression and the data sources for this paper. Section 4 we interpreted the results, compare the models and make some conclusions about poverty in ECOWAS countries. In the final section, we presented the conclusions of our research as well as any policy prescriptions.

2. The relevant literature

2.1. Poverty remedies in ECOWAS countries

The Millennium Development Goal (MDG) targeted at reducing extreme poverty and hunger in developing economies by 2015 and this goal was achieved on the global level. However, some countries are still confronted with poverty, and ECOWAS countries are among the countries still struggling to ameliorate their conditions of poverty [5]. ECOWAS countries have also received many funds from the FDI, but some research has been started to examine the impacts of FDI on ECOWAS countries to reduce poverty [6–11]. The importance of sustainable development cannot be discussed in ECOWAS without considering the growth in its agricultural sector. More specifically, the agricultural sector is a major pathway for economic growth in ECOWAS. ECOWAS countries should develop its agricultural sector further to deal with their rising population which generates revenues to promote economic development, create employment, reduce criminal activities provide educational opportunities for their citizens [12]. Despite the importance of the agricultural sector, as researched by Matthew and Adegboye [12], the agricultural sector provided no impact on the economic development in Nigeria. Consequently, they recommendeded that to develop the agricultural sector, the government must invest in research and technology to help to increase the prevalence of the agricultural sector via the establishment of an agricultural fund to finance larger-scale agricultural operations in Nigeria. Omorogiuwa, Zivkovic, and Ademoh [13] also studied the role of the agricultural sector in Nigeria. They concluded

as Matthew and Adegboye [12] that greater emphasis on the research on the development would be required to promote additional economic development in Nigeria.

Osabohien, Matthew, Gershon, Ogunbiyi, and Nwosu [14] studied the entire set of ECOWAS countries regarding the agricultural sector. Their results indicated that the agricultural sector would provide greater opportunities for the poor to increase their earnings as a means to escape the poverty trap. However, these governments would need to invest more in the agricultural sector to improve productivity and the human capital development of these farmers. Despite the research emphasizing the growth of the agricultural sector throughout the ECOWAS countries, this sector does not imply that the sector needs to be the largest in ECOWAS countries [15]. The author delved further into the agricultural sector in ECOWAS and most developing countries often have low productivity relative to the rest of their economy.

In brief, ECOWAS countries struggle with issues of poverty that hinders economic development of these countries. Policy-makers continue to debate the best path forward to alleviate poverty in ECOWAS countries. The literature delved into the debates about the effectiveness of FDI and the promotion of the agricultural sector to address these challenges confronting the ECOWAS countries.

2.2. Economic freedom and indexes

Though known to have a very rich history and culture, West Africa is currently considered to be a region of severe poverty and violence. Over the past three decades, the region of ECOWAS countries has generally moved backward in terms of economic development primarily due to civil conflicts, armed rebellions and droughts, and natural disasters. Low economic growth has led to increased poverty and hardship. Significant increases in economic growth and reductions in poverty in the region are likely to occur with increases in the economic freedom and opportunities that allow citizens of the ECOWAS countries to make better use of their talents and resources.

In recent years, researchers have renewed their interest in the study of why West Africa and why has failed to develop. Studies have found that a lack of resources, ignorance, or incompetence has played a part in the region's lack of or underdevelopment. However, these same studies have found that what West Africa needs is strong institutions and economic freedom [14, 16]. Economic freedom is one of the most important aspects of the quality of a country's framework and institutions.

So, what is Economic Freedom? Economic freedom constitutes the essence of a market economy and the power of Adam Smith's invisible hand in terms of economic prosperity for society as a whole. Nowadays, there is great awareness of the importance of economic growth of institutional factors related to economic freedom, including the rule of law, security of property rights, the openness of the political process, limitations on the power of the executive, monetary stability, liberal trade regimes, and civil liberties (see, e.g., [17]). However, economic freedom is not only an important element in terms of economic performance. It may also involve considerable repercussions on attaining other political objectives related to human well-being, such as income distribution (see [18], for a survey on the effects of economic freedom).

Since the 1980s, most countries in the world have experienced notable increases in economic freedom, under the widely accepted belief that greater economic freedom fosters efficiency, economic growth, and less poverty (see, among others, [19–33]. However, the ECOWAS member countries have been left out of this trend, and over the last several decades, there have been few if any, changes made to their policies and institutions in favor of economic freedom. The countries, Cabo Verde,

The Gambia and Nigeria, are the only ECOWAS countries in the top quartile at the bottom with the other 12 countries in the bottow two quartiles. Despite some progress in the past 20 years, ECOWAS has an Economic Freedom Index, as measured by the Fraser Institute, mostly in the bottom quartile.[1] This poses a problem because economic freedom has been shown to bring prosperity and growth to a country or economy. Countries that enjoy more economic freedom tend to achieve higher wealth and enhanced living standards which represents a better investment and business climate. In brief, the literature on the impacts of economic freedom on the economic growth of a nation has been studied for quite some time. During the last two decades, numerous studies were conducted to investigate the linkage between economic growth and economic freedom. These studies were empirical and have found a strong, positive impact of economic freedom on the rate of economic growth of a country.

3. Methodology and data sources

3.1. Methodology of the LASSO regression

The Least Absolute Shrinkage and Selection Operator (LASSO) is a penalized regression method derived by [34]. Ridge regression shrinks all regression coefficients towards zero while the LASSO tends to give a set of zero regression coefficients and leading to a sparse solution. However, we take the absolute slope values instead of the square of slopes as done in ridge regression. The LASSO is an estimator of the coefficients in a model, meaning that some of the coefficients are exactly zero, while other coefficients are nonzero. More specifically, the LASSO selects covariates by excluding the covariates whose estimated coefficients are zero and including those that are nonzero. Because of this empirical approach, there are no standard errors used in the estimation of the LASSO coefficients.

The LASSO like other regression estimators solves an optimization problem which can be given as

$$\hat{\beta} = \arg\min_{\beta} \left\{ (y - x\beta)^T (y - x\beta) + \lambda \sum_{i=1}^{p} |\beta_i| \right\} \tag{3.1}$$

where $\arg\min_{\beta} \left\{ (y - x\beta)^T (y - x\beta) \right\}$ is the ordinary least squares (OLS) estimator and

$$\|\beta\|_1 = \sum_{i=1}^{p} |\beta_i|$$

is the L1 penalty. Also $\|\beta\|_1$ is not differentiable and requires application of subdifferential analysis. λ controls the strength of the L1 penalty or represents the shrinkage. λ is also called the penalty parameter. Some characteristics of λ in its role in the LASSO regression

- When λ is 0, the LASSO and OLS gives the same result.
- As λ increases, more coefficients become zero; thus, eliminated from the regression.
- As λ increases, the bias also increases.
- As λ decreases, the variance also increases

In practice, in the selection of the parameter λ, the goal is to determine the best model with an optimal balance of the fit and complexity of the regression model. As the LASSO regression is estimated,

---

[1]The Economic Freedom Index is obtained from https://www.fraserinstitute.org/studies/human-freedom-index-2021

the L1 norm is then applied to regression parameters because it penalizes the regression coefficients of the irrelevant variables to be zeros. At the same time, it also penalizes the regression coefficients that are included in the regression. Consequently, regression coefficients of a LASSO model tend to be smaller than the OLS regression coefficients.[2] The underlying analytical details for the λ that determine which coefficients will be zero are quite interesting. We need to use a different approach because the function is not differentiable. Consequently, we cannot determine the partial derivatives to determine the optimum, so we need to estimate the subdifferential in the LASSO. More specifically, the subdifferential generalizes the derivative to convex functions that cannot be differentiable.

The estimation process uses the algorithm of coordinate descent method by fixing all the coordinates except for one. The motif underlying the coordinate descent is to optimize a target function with respect to a single parameter at one time. More specifically, the algorithm of the LASSO cycles iteratively through all parameters until there is convergence. Coordinate descent works well in the LASSO because it has a simple closed-form solution in a single dimension but lacks one in higher dimensions. Keep in mind that the LASSO objective function is a convex function which means that the sequence of the objective functions converges to a global minimum.[3]

3.1.1. Cross-validation in the LASSO regression

In the LASSO regression, we must select the value of λ. That is, the cross-validation mimics the process of doing out-of-sample prediction, and produces estimates of out-of-sample mean square error (MSE) that selects λ with minimum MSE. How does the cross-validation (CV) work in a LASSO regression? Here are the steps to conduct cross-validation in a LASSO:

- Step 1: Given the data, the LASSO regression computes a sequence of λ's as $\lambda_1 1 > \lambda_2 > \cdots > \lambda_k$. λ_1 set all the coefficients to zero, which means no variables are selected.
- Step 2: For each λ_j, do K-fold cross-validation to get an estimate of out-of-sample MSE.
- Step 3: Select the λ^*, which is the smallest estimate of out-of-sample MSE, and refit LASSO using λ^* and the original data.
- Step 4: Then plot the CV, which tells what the minimum mean squared error (MSE) for the different values of λ is generated.

3.1.2. Elastic net

The elastic net extends the LASSO by incorporating a generalized penalty term and is a convex combination of the LASSO and the ridge regressions. More important, the development of the elastic net was conceived as a method that would produce better predictions if the covariates are highly correlated. Zou and Hastie [35] provide the analytical details for the elastic net. Equation (3.2) shows the elastic net regression estimator

$$\hat{\beta} = \arg\min_{\beta} \left\{ (y - x\beta)^T (y - x\beta) + \lambda \left[\alpha \sum_{i=1}^{p} |\beta_i| + \frac{(1-\alpha)}{2} \sum_{i=1}^{p} (\beta_i)^2 \right] \right\} \tag{3.2}$$

---

[2]In machine learning this is called bias.

[3]It was stated that the objective function is convex, not strictly convex. That means there could be more than one solution in a function. Consequently, the coordinate descent converges to one of those solutions, but the solution it converges to is arbitrary because it depends on the order of the solutions.

where α is the elastic-net penalty parameter, not λ.[4]

Given the Eq (3.2), elastic net is the same as a LASSO when $\alpha = 1$. On the other hand, as α shrinks toward 0, the elastic net resembles a ridge regression. For other values of α, the penalty term in the elastic net interpolates between the L1 norm of β and the squared L2 norm of β. In essence, the elastic net is a combination of the LASSO and ridge regressions. Like the LASSO, the selection of α and λ in the net elastic is via the cross-validation method and provides values of α between 0 and 1.

3.2. Data sources

For this paper, we used the World Bank database[5] for reliability and the large quantity of data. Care is needed in the variable selection process because it can be a correlation problem between variables, which usually leads to spurious regression. This happens when two variables are strongly correlated by some exogenous factor not taken into account and due to the fact we can state that one causes the other when it is not the case. Using the LASSO, we can include as many variables as we consider in the model but if these variables are correlated the model will select all of them giving similar weights. We selected the variable poverty headcount ratio at \$3.10 a day, because among poverty indicators available, this one had a large quantity of data over the years, and also \$3.10 a day is poverty but not extreme poverty which will be the case of \$1 a day which is another commonly used indicator. The GINI coefficient is another commonly used indicator to look at but it measures structural poverty at a more aggregate level of the country rather than poverty per individual. In brief, Appendix A1 shows the complete list of the variables used in this paper from the World Bank database and the Fraser Economic Institute. The economic freedom is identified as FI Appendix Table A1.

4. Empirical results

4.1. The empirical results from the LASSO

In this subsection, we delved into the empirical results using the poverty headcount ratio at \$3.10 a day (POV32) for the LASSO. In the first step, we estimated the LASSO regression to determine the optimal lambda (λ) via cross-validation (CV). Table 1 summarized the results of the LASSO regression.

The mean squared error (MSE) with this specification is 0.8164812. Then, we plotted the cross-validation plot to show the optimal lambda used in the LASSO, as shown in Figure 1. More specifically, the most optimal point in the cross-validation plot corresponds to the lowest dip point. In theory, researchers would like to see a U-shaped but often in the estimation of the LASSO regression; however, it may often be the case in practice. From Figure 2 we have a slight improvement in the MSE as our penalty λ becomes larger then flattens out and increases rapidly, suggesting that an OLS regression could be overfitting the data.

---

[4]In the net elastic, the ridge penalty is divided by 2 which is merely a mathematical convenience for optimization of the net elastic regression.

[5]The link to the World Bank Database is https://databank.worldbank.org/source/world-development-indicators

Table 1. Results of LASSO regression.

Number of Observations	15
Number of Covariates	33
Number of CV Folds	10

ID	Description	Lambda	Number of Nonzero Coefficients	Out of Sample R-squared	CV Mean Prediction Error
1	first lambda	7.812417	1	0.5053	201.2359
93	lambda before	0.1081931	13	0.6998	122.1392
*94	selected lambda	0.1032756	13	0.7005	121.8544
95	lambda after	0.0985815	13	0.7004	121.8935
100	last lambda	0.0781242	13	0.6994	122.2944
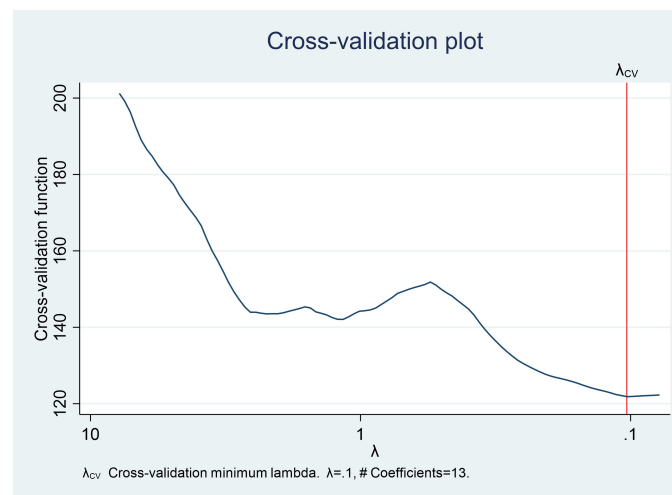
Figure 1. Plot of the cross-validation function from the LASSO regression.

To assess the behavior of the coefficients selected from the LASSO regression as shown in Figure 2.

Figure 2 shows the path trajectory of the fitted regression parameters. Also Figure 2 should be read from right to left or the value of λ from small to large. Those variables that become zero later are stronger because a larger λ is needed to make them zero. On the other hand, those variables that quickly become zero are weak or insignificant. More important, we standardized the coefficients with a mean of zero and a variance of one. If the coefficients are non-standardized, then the coefficients are not dimensionless, and not comparable. That is, no conclusions can be drawn from them regarding predictive importance.
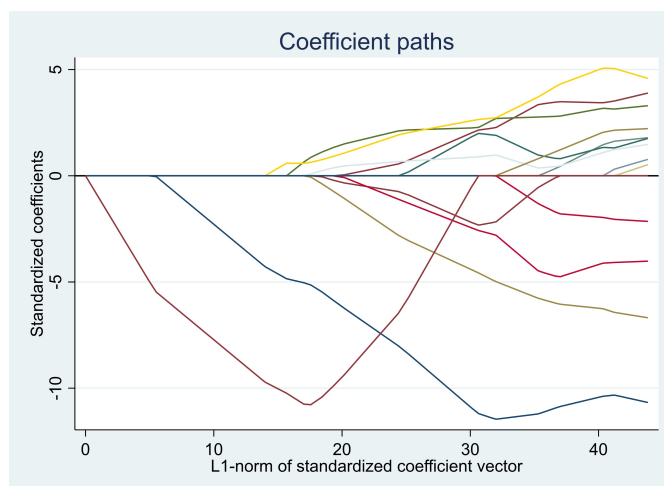
Figure 2. Plot of the cross-validation function from the LASSO regression.

Table 2 shows the coefficients from the LASSO regression. However, we cannot interpret the value of the coefficients because these coefficients are standardized. Next, we present a table with the values of the non-zero coefficients for $\lambda = 0.032756$ corresponding to the least MSE:

Table 2. Nonzero coefficients from the LASSO ($\lambda = 0.1032756$).

Variable	Value
FI—Freedom Index	−10.64813
EC Staff Education Compensation	−6.66526
CEM—Male Children Employed	4.616804
ET Employers Total	−4.02357
FE Fuel Exports	3.868156
ME Manufacturer's Exports	3.288305
GC Government Expenditures	2.215573
SN Adequacy of Safety Net Programs	−2.139957
SPL Adequacy of Social Protection and Labor	1.779321
Agricultural Value Added	1.727414
COS Children Out of School	1.459424
EE Adjusted Expenditures-Education	0.7401486
EMPI Employment in Industry	0.4868795

From the LASSO regression, we observed some areas that impact poverty in ECOWAS: employment, education, government programs, fuel program, and the freedom index. As indicated by the negative sign, the more economic freedom there is the less poverty. As delved into earlier in this paper, previous research studies were conducted over the past few decades that investigated the linkage between economic growth and economic freedom with an important theme from these studies that determined a strong, positive impact of economic freedom on foreign direct investment, political stability, and the rate of economic growth in the respective countries. Based on the LASSO regression results, the governments in the ECOWAS countries should integrate better practices that could enhance

economic freedom for each respective country. The important theme from these studies determined a strong, positive impact of economic freedom on the rate of economic growth of a country. As for staff education compensation, the greater the compensation by educators, the less poverty would exist. ET or Employers Total reflected the labor market meaning that the more employers we have, the more employment will be generated and less poverty as indicated by the negative coefficient sign. Finally, for SN or the adequacy of the safety net programs, if there is a reduction of the adequacy of these programs, there would a reduction in poverty. This is the opposite of SPL or the adequacy of social protection and labor, which would indicate the higher the amount, the greater the poverty rate. As for the remaining education variables, CEM, COS, and EE, the signs are positive. But most striking is the adjusted expenditures for education (EE) which indicates that the greater the education expenditures, the higher the poverty rate.

4.2. Results from the elastic net

In this subsection, we delved into the empirical results using the poverty headcount ratio at $3.10 a day (POV32) for the elastic net. In the first step, we estimated the elastic net regression to determine the optimal lambda (λ) and the different levels of alpha (α) via cross-validation (CV). Table 3 summarizes the results of the elastic net regression.

Table 3. Results of elastic net regression.

		Number of Observations	15			
		Number of Covariates	33			
		Number of CV Folds	10			
Alpha	ID	Description	Lambda	Number of nonzero coefficients	Out of sample R-squared	CV mean prediction error
1.00						
	1	First lambda	5.637558	7	0.4542	222.037
	116	Last lambda	0.0281878	14	0.4668	225.060
0.750	117	first lambda	5.637558	7	0.4542	222.037
	149	lambda before	1.339149	12	0.5865	168.832
	*150	selected lambda	1.278282	12	0.5877	167.708
	151	lambda after	1.220182	12	0.5876	167.765
	232	last lambda	.0281878	21	0.5699	174.961
0.500	233	First lambda	5.637558	7	0.4591	220.031
	348	Last lambda	0.0281	29	0.5205	195.049

The mean squared error (MSE) for the elastic net specification is 21.2645. Then, we plotted in Figure 3, the cross-validation plot to show the optimal of the lambda used in the elastic net. More specifically, the most optimal point in the cross-validation plot corresponds to the lowest dip point as we have in Figure 3. The minimum of λ in Figure 3 tells us the minimum MSE. From Figure 3 we have a slight improvement in the MSE as our penalty λ becomes larger, suggesting that an OLS regression model likely overfits the training data.
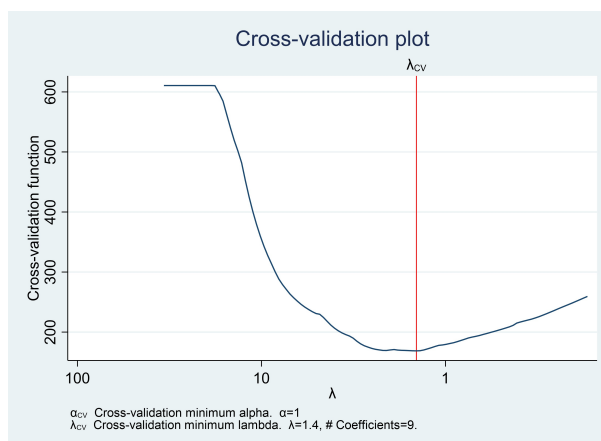
Figure 3. Plot of the cross-validation function from the elastic net regression.

To assess the behavior of the coefficients selected from the elastic net regression as shown in Figure 4.

Figure 4 shows the path trajectory of the fitted regression parameters of the elastic net. Also, Figure 4, as with Figure 2, should be read from right to left or the value of λ from small to large. Several of the nonzero variables became zero later, which are stronger because a larger λ is needed to make them become zero. As with the LASSO regression, we standardized the coefficients with a mean of zero and a variance of one. If the coefficients are non-standardized, then the coefficients are not dimensionless, and not comparable.
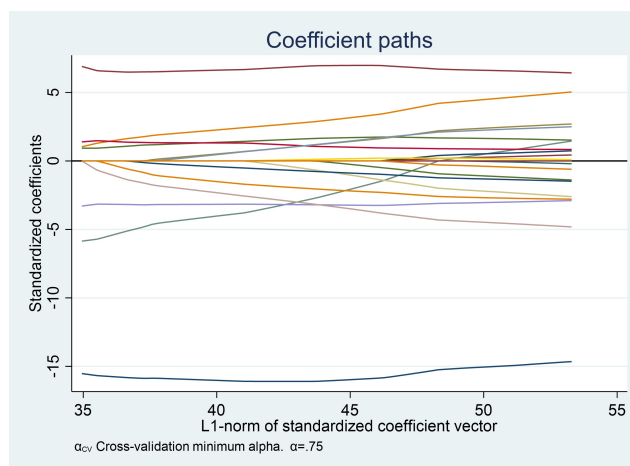

Figure 4. Plot of the cross-validation function from the elastic net regression.

Table 4 shows the coefficients from the elastic net regression. However, we cannot interpret the value of the coefficients because these coefficients are standardized as with the LASSO. Next, we present a table with the non-zero coefficient values for $\lambda=1.278282$ as it corresponds to the least MSE.

Table 4. Nonzero coefficients from the elastic net ($\lambda = 1.278282$).

Variable	Value
FI—Freedom Index	-15.9994
EC Staff Education Compensation	-2.240522
FR Fertility Rate	-1.440816
ET Employers Total	1.334919
FE Fuel Exports	6.61478
GC Government Expenditures	2.37789
SN Adequacy of Safety Net Programs	-3.168602
SPL Adequacy of Social Protection and Labor	1.320671
Agricultural Value Added	0.4510879
CF Gross Capital Formation	-0.3892439
SI Gross Domestic Savings	-4.100957
EMPI Employment in Industry	0.3950347

We observed from the elastic net some areas that impact poverty in ECOWAS: employment, fertility, government programs and expenditures, fuel program, and the freedom index. The variable selection is somewhat similar to the LASSO regression. As with the LASSO regression, the freedom index was prominent indicating there is an important linkage between economic growth and economic freedom because a strong, positive impact of economic freedom on the rate of economic growth of a country would help ameliorate poverty throughout ECOWAS. As for staff education compensation, the greater the compensation by educators, the less poverty that would exist, which has a similar sign as the LASSO. ET or Employers Total reflected the labor market meaning that the more employers we have, the more employment will be generated and greater poverty as indicated by the positive coefficient sign. The latter could be reflective of the lack of dynamics in the labor market. Finally, for SN or the adequacy of the safety net programs, if there is a reduction of the adequacy of these programs, there would a reduction in poverty. This is the opposite of SPL or the adequacy of social protection and labor, which would indicate the higher the amount, the greater the poverty rate. SN and SPL have similar signs as the LASSO. For SI or gross savings, the greater the savings that occur, the poverty rate would decline. For the fertility rate or FR, it shows that as it declines there is an increase in the poverty rate. This relationship demonstrated the connection between fertility choices and economic considerations. The latter would go against that ECOWAS countries have been experiencing higher fertility rates despite the existence of poverty.

5. Conclusions

The West African states founded the regional organization ECOWAS in 1975. The original purpose was economic integration and development. In keeping with conclusions about integration, trade and investment were tools to reach these goals. So far, this effort has been unsuccessful. Trade between countries in the region is still low due to trade barriers and the similarity of production profiles, i.e., primarily agriculture products. ECOWAS's institutions have clear similarities with institutions of the European Union, but have not had the same power to make decisive decisions, nor have decisions been implemented as intended. It is highly uncertain if plans to create a monetary union in the coming years

can be realized.

A stronger positive West African development over the next 20 years would be unexpected, although it is not impossible. West Africa has resources that, if used differently than today, could contribute to improving conditions in the region. Changed income distribution could reduce high levels of poverty. Development in this direction would probably also reduce the risk of future conflict within countries and between them. A change in the distribution of income from natural resources could also contribute to overall positive economic development and integration in the countries and the region. If resources were used to accomplish local economic development, a specialization in the economy could develop. This could then promote more trade between countries in the region, which-in turn-could have a peace-making effect. Countries with extensive economic relations have an interest of avoiding conflict and war. In addition, more stable economic development would benefit not only national societies in general but also state structures. It would reduce motives for corruption. A different sharing of income from natural resources could also stabilize the internal situation in Nigeria. Protests sabotage and armed conflict is partially rooted in discontent connected to income distribution and control over resources.

About the basic research question of this paper, the answer has to be: Yes, ECOWAS does have indicative data that can provide a path to less poverty and substantial long-term growth if implemented by the governments of ECOWAS sufficiently.

Despite the analytical limitations, this research presented the surprising result that ECOWAS potentially has institutions, such as economic freedom, and activities the income distribution and national development opportunities. Research and policy activities should focus on institutional responses which implement these responses involving partners in a structured and transparent process for the ECOWAS region if poverty and growth are to be improved for the better.

The impactful positive results in this research are consistent with previous studies and research. A higher degree of economic freedom creates a better investment climate and likely attracts more foreign investment, improved transparency, and a better institutional framework, amongst others. Economic freedom also creates a sense of confidence for future trade, investment, and economic growth. Countries in the ECOWAS region should pursue policies as indicated by the LASSO and elastic net regressions to improve economic freedom and quality of political institutions concurrently as they move toward remedying the low human development in the region.

Conflict of interest

All authors declare no conflicts of interest in this paper.

References

1. R. Osabohien, O. A. Matthew, O. Gershon, T. Ogunbiyi, E. Nwosu, Agriculture development, employment generation and poverty reduction in West Africa, *Open Agric. J.*, **13** (2019), 82–89. 10.2174/1874331501913010082

2. O. A Matthew, R. Osabohien, T. O Ogunlusi, O. Edafe, Agriculture and social protection for poverty reduction in ECOWAS, *Cogent Arts Humanit.*, **6** (2019), 205–211. https://doi.org/10.1080/23311983.2019.1682107

3. E. Bakhshinyan, L. Molinas, H.Alderman, Assessing poverty alleviation through social protection: School meals and family benefits in a middle-income country, *Global Food Secur.*, **23** (2019), 205–211. https://doi.org/10.1016/j.gfs.2019.07.005

4. *United Nations Development Programme-UNDP*, Poverty in focus. Brasilia: International Poverty Centre, 2006. Available from: https://www.un.org/esa/socdev/unpfii/documents/IPCPovertyInFocus17.pdf.

5. *United Nations*, The 2030 Agenda for Sustainable Development, 2015. Available from: https://sdgs.un.org/goals.

6. I. Soumare, Does FDI improve economic development in North African countries?, *Appl. Econ.*, **47** (2015), 10–33. https://doi.org/10.1080/00036846.2015.1051655

7. S. M. Ucal, Panel data analysis of foreign direct investment and poverty from the perspective of developing countries, *Procedia-Social Behav. Sci.*, **109** (2014), 1101–1105. https://doi.org/10.1016/j.sbspro.2013.12.594

8. A. Bharadwaj, Reviving the globalization and poverty debate: Effects of real and financial integration on the developing world, *Adv. Econ. Bus.*, **2** (2014), 42–57. https://doi.org/10.13189/aeb.2014.020107

9. B. Fowowe, M. Shuaibu, Is foreign direct investment good for the poor: New evidence from African countries, *Econ. Change Restructuring*, **47** (2014), 42–57. https://doi.org/10.1007/s10644-014-9152-4

10. G. Gohu, I. Soumare, Does foreign direct investment reduce poverty in Africa and are there regional differences, *World Dev.*, **40** (2012), 75–95. https://doi.org/10.2139/ssrn.1636352

11. J. M. Mbaku, *Institutions and Reform in Africa: The Public Choice Perspective*, Greenwood Publishing Group, New York, 1997.

12. O. Matthew, F. B. Adegboye, The agricultural sector and economic development: The Nigerian experience, *J. Manage. Enterpr. Dev.*, **7** (2010), 10–15.

13. O. Omorogiuwa, J. Zivkovic, F. Ademoh, The role of agriculture in the economic development of Nigeria, *Eur. Sci. J.*, **10** (2014), 75–95.

14. R. Osabohien, O. Matthew, O. Gershon, T. Ogunbiyi, E, Nwosu, Agriculture development, employment generation and poverty reduction in West Africa, *Open Agric.*, **13** (2019), 82–89. https://doi.org/10.2174/1874331501913010082

15. D. Gollin, Agricultural productivity and economic growth, *Handb. Agric. Econ.*, **4** (2010), 3825–3867. https://doi.org/10.1016/S1574-0072(09)04073-0

16. J. M. Mbaku, Entrenching economic freedom in Africa, *Cato J.*, **23** (2003), 217.

17. D. Acemoglu, S. Johnson, S. J. A. Robinson, Institutions as a fundamental cause of long-run growth, *Handb. Econ. Growth*, **1** (2005), 385–472. https://doi.org/10.1016/S1574-0684(05)01006-3

18. N. Berggren, The benefits of economic freedom: A survey, *Indep. Rev.*, **8** (2019), 193–211.

19. K. W. Farr, R. A Lord, J. L. Wolfenbarger, Economic freedom, political freedom, and economic well-being: A causality analysis, *Cato J.*, **18** (1998), 247.

20. J. De Haan, J. E. Sturm, On the relationship between economic freedom and economic growth, *Eur. J. Political Econ.*, **16** (2000), 215–241. https://doi.org/10.1016/S0176-2680(99)00065-8

21. L. C. Adkins, R. L Moomaw, A. Savvides, Institutions, freedom, and technical efficiency, *South. Econ. J.*, **69** (2002), 92–108. https://doi.org/10.1002/j.2325-8012.2002.tb00479.x

22. J. H. Cole, Contribution of economic freedom to world economic growth, 1980-99, *Cato J.*, **23** (1998), 189.

23. B. Powell, Economic freedom and growth: The case of the Celtic tiger, *Cato J.*, **22** (1998), 431.

24. N. Berggren, H. Jordahl, Does free trade really reduce growth? Further testing using the economic freedom index, *Public Choice*, **122** (2005), 99–114. https://doi.org/10.1007/s11127-005-3994-2

25. C. Doucouliagos, M. A. Ulubasoglu, Economic freedom and economic growth: Does specification make a difference, *Eur. J. Political Econ.*, **22** (2006), 60–81. https://doi.org/10.1016/j.ejpoleco.2005.06.003

26. J. Clark, D. Pearson, Economic freedom, entrepreneurship, migration and economic growth, *Clarion Bus. Econ. Rev.*, **6** (2006), 10–23.

27. N. J. Ashby, R. S. Sobel, Income inequality and economic freedom in the US states, *Public Choice*, **134** (2008), 329–346. https://doi.org/10.1007/s11127-007-9230-5

28. R, J. Cebula, Economic growth, ten forms of economic freedom, and political stability: An empirical study using panel data, 2003–2007, *J. Private Enterp.*, **26** (2011), 61–81.

29. R. A. Compton, D. C. Giedeman, G. A. Hoover, Panel evidence on economic freedom and growth in the United States, *Eur. J. Political Econ.*, **27** (2011), 423–435. https://doi.org/10.1016/j.ejpoleco.2011.01.001

30. D. Pearson, D. Nyonna, K. J. Kim, The relationship between economic freedom, state growth and foreign direct investment in US states, *Int. J. Finance Econ.*, **4** (2012), 140–146. https://doi.org/10.5539/ijef.v4n10p140

31. A. Kešeljević, R. Spruk, Endogenous economic freedom and the wealth of nations: evidence from a panel of countries, 1996–2011, *Appl. Econ.*, **28** (2013), 3952–3962. https://doi.org/10.1080/00036846.2012.736948

32. J. C. Hall, R. A. Lawson, Economic freedom of the world: An accounting of the literature, *Contemp. Econ. Policy*, **32** (2014), 1–19. https://doi.org/10.1111/coep.12010

33. A. Melton, D. Pearson, Site selection strategy: Economic freedom and state growth, *Global J. Manage. Mark. Vol.*, **5** (2021), 71–85.

34. R. Tibshirani, Regression shrinkage and selection via the lasso, *J. R. Stat. Soc. B*, **58** (1996), 267–288.

35. H. Zou, T. Hastie, Regularization and variable selection via the elastic net, *J. R. Stat. Soc. B*, **67** (2005), 301–320. https://doi.org/10.1111/j.1467-9868.2005.00503.x

Appendix

Table A1. Description of the variables used in the paper.

Coefficient	Definition
POV32	Poverty headcount ratio at $3.10 a day (2011 PPP) (% of population)
FI	The Freedom Index from Fraser Institute's Economic Freedom index
FE	Fuel exports (% of merchandise exports)
FOE	Food exports (% of merchandise exports)
ME	Manufactures exports (% of merchandise exports)
SI	Adequacy of social insurance programs (% of total welfare of beneficiary households)
SPL	Adequacy of social protection and labor programs (% of total welfare of beneficiary households)
SN	Adequacy of social safety net programs (% of total welfare of beneficiary households)
EE	Adjusted savings: education expenditure [% of GNI (gross national income)]
AFR	Adolescent fertility rate (births per 1000 women ages 15–19)
ADR	Age dependency ratio (% of working-age population)
AL	Agricultural land (% of land area)
A	Agriculture, value added (% of GDP)
EC	All education staff compensation, primary (% of total expenditure in primary public institutions)
CEF	Children in employment, female (% of female children ages 7–14)
CEM	Children in employment, male (% of male children ages 7–14)
COS	Children out of school (% of primary school age)
CSU	Cost of business start-up procedures (%GNI per capita)
CE	Cost to export $US per container
CI	Cost to import $US per container
CSS	Coverage (% All social protection and labor)
DSE	Debt service on external debt (TDS, current $US)
IN	Deposit interest rate (%)
CR	Domestic credit provided by the financial sector (% of GDP)
BF	Ease of doing business index (1 = most business friendly regulations)
ET	Employers total (%of employment)
EA	Employment in agriculture (% of total employment)
EI	Employment in industry (% of total employment)
ES	Employment in services (% of total employment)
GEE	Expenditure on education as % of total government expenditure (%)
FR	Fertility rate, total (births per woman)
GC	General Government final consumption expenditure (% of GDP)
CF	Gross capital formation (% of GDP)
S	Gross domestic savings (% of GDP)
EPS	Gross enrollment ratio, primary, both sexes (%)
ESS	Gross enrollment ratio, secondary, both sexes (%)
ETS	Gross enrollment ratio, tertiary, both sexes (%)