

Mohamud, Mohamud Hussein et al.

Article

Unemployment rate and the gross domestic product in Somalia: Using frequentist and Bayesian approach

Cogent Economics & Finance

Provided in Cooperation with:

Taylor & Francis Group

Suggested Citation: Mohamud, Mohamud Hussein et al. (2024) : Unemployment rate and the gross domestic product in Somalia: Using frequentist and Bayesian approach, Cogent Economics & Finance, ISSN 2332-2039, Taylor & Francis, Abingdon, Vol. 12, Iss. 1, pp. 1-13, <https://doi.org/10.1080/23322039.2024.2388234>

This Version is available at:

<https://hdl.handle.net/10419/321568>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.



<https://creativecommons.org/licenses/by/4.0/>

Unemployment rate and the gross domestic product in Somalia: Using frequentist and Bayesian approach

Mohamud Hussein Mohamud, Fartun Ahamed Mohamud, Atta Gul, Abdimalik Ali Warsame, Bashir Mohamed Osman & Seadya Mohamed Ahmed

To cite this article: Mohamud Hussein Mohamud, Fartun Ahamed Mohamud, Atta Gul, Abdimalik Ali Warsame, Bashir Mohamed Osman & Seadya Mohamed Ahmed (2024) Unemployment rate and the gross domestic product in Somalia: Using frequentist and Bayesian approach, Cogent Economics & Finance, 12:1, 2388234, DOI: [10.1080/23322039.2024.2388234](https://doi.org/10.1080/23322039.2024.2388234)

To link to this article: <https://doi.org/10.1080/23322039.2024.2388234>



© 2024 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group



Published online: 19 Aug 2024.



[Submit your article to this journal](#)



Article views: 1426



[View related articles](#)






[View Crossmark data](#)



Citing articles: 2 [View citing articles](#)

Unemployment rate and the gross domestic product in Somalia: Using frequentist and Bayesian approach

Mohamud Hussein Mohamud , Fartun Ahamed Mohamud, Atta Gul[#], Abdimalik Ali Warsame, Bashir Mohamed Osman  and Seadya Mohamed Ahmed 

Faculty of Economics, SIMAD University, Mogadishu, Somalia

ABSTRACT

Gross domestic product (GDP) serves as a vital indicator of a country's economic health, influenced by factors such as unemployment rates, export-import dynamics, and inflation rates. Understanding the intricate relationship between GDP and unemployment is crucial for navigating the dynamic business environment. This study investigates this relationship in Somalia using both frequentist and Bayesian regression approaches. The frequentist approach, particularly ordinary least squares, is chosen for its widespread use and simplicity in estimating parameters by minimizing the sum of squared deviations. Meanwhile, the Bayesian approach is adopted for its flexibility in integrating prior information and updating estimates as new data emerge, providing a probabilistic framework that accommodates parameter uncertainty. Secondary data from the World Bank spanning 1991–2020 were analyzed. The results reveal a significant negative association between unemployment and GDP in both models. Comparative analysis employing mean absolute error, root mean square error, and mean square error indicates comparable predictive accuracy between the two approaches, with the Bayesian model demonstrating slight advantages. Bayesian convergence diagnostics affirm satisfactory model stability. These findings offer valuable insights for policymakers, aiding in the formulation of strategies to address unemployment challenges and stimulate economic growth in Somalia.

IMPACT STATEMENT

The study investigates the relationship between unemployment and GDP in Somalia, employing both frequentist and Bayesian statistical methods. The frequentist approach provides point estimates and confidence intervals based on observed data, while the Bayesian approach incorporates prior knowledge and uncertainty into the analysis, yielding posterior distributions. By comparing these methods, the research aims to provide a comprehensive understanding of how GDP influences unemployment rates and vice versa. The results highlight the strengths and limitations of each approach, offering valuable insights for economic policymakers and contributing to the broader field of economic analysis in developing countries.

ARTICLE HISTORY

Received 18 March 2024
Revised 9 June 2024
Accepted 31 July 2024

KEYWORDS

GDP; unemployment rate; Bayesian modeling; regression linear model; Somalia

SUBJECTS

Agricultural Economics;
Environment & Economics;
Statistics for Business,
Applied economics;
Production Research &
Economics

1. Introduction

Gross domestic product (GDP) per capita and the unemployment rate are fundamental metrics offering crucial insights into economic health and dynamics. GDP per capita signifies the average economic output per person within a specific country. At the same time, the unemployment rate reflects labor market dynamics, representing the percentage of the workforce actively seeking but unable to secure employment. Understanding unemployment is paramount for comprehending both macro and microeconomic intricacies and shaping strategic interventions for growth, development, and economic stability. The ramifications of unemployment extend across social institutions and individual lives, posing significant challenges for both developed and emerging economies.

CONTACT Mohamud Hussein Mohamud  Laalaabte@simad.edu.so  Faculty of Economics, SIMAD University, Mogadishu, Somalia
[#]Present address: Department of Statistics, University of Sargodha, Pakistan.

© 2024 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group

This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. The terms on which this article has been published allow the posting of the Accepted Manuscript in a repository by the author(s) or with their consent.

The interconnectedness of GDP per capita and the unemployment rate underscores their importance, with fluctuations in one often influencing the other. Economic expansions typically coincide with reduced unemployment as businesses expand and create jobs, while economic contractions lead to rising unemployment rates due to business struggles and layoffs. Analyzing this interplay can illuminate broader economic trends, aiding policymakers, economists, and investors in making informed decisions.

During 1990–2020, Somalia underwent significant political and economic instability, marked by factors such as prolonged civil war, governance challenges, and the collapse of state institutions. These challenges culminated in Somalia being classified as a “failed state” during certain periods. The protracted conflict and the absence of effective governance structures had profound implications for the country’s economic landscape. The breakdown of law and order, widespread violence, and displacement of populations disrupted economic activities and hindered investment and development efforts. Furthermore, the collapse of state institutions meant the absence of coherent economic policies and regulatory frameworks, exacerbating socio-economic challenges. Such instability undoubtedly impacted key economic indicators such as GDP and unemployment rates. Understanding the ramifications of this instability is crucial for interpreting economic data from this period and contextualizing our analysis of the relationship between unemployment and GDP in Somalia.

Regression analysis, a cornerstone of statistical methods, finds application across diverse fields, including economics, sociology, and medicine (Ugwuowo et al. 2023). Its primary purposes include elucidating relationships between variables and estimating dependent variable values based on independent variables. Ordinary least squares (OLS) is a popular approach for parameter estimation, minimizing the sum of squared deviations from the estimated regression equation. In contrast, the Bayesian method, increasingly utilized in fields like machine learning, medicine, finance, and social science, treats parameters as random variables, accommodating multiple potential values (Bharadiya 2023). This flexibility allows for the incorporation of prior information and updating estimates with emerging data.

The rationale behind incorporating the unemployment rate and the GDP in Somalia remains unclear. The interconnectedness of GDP per capita and the unemployment rate underscores their importance, with fluctuations in one often influencing the other. Economic expansions typically coincide with reduced unemployment as businesses expand and create jobs, while economic contractions lead to rising unemployment rates due to business struggles and layoffs. Analyzing this interplay can illuminate broader economic trends, aiding policymakers, economists, and investors in making informed decisions.

1.1. Research objective

This study endeavors to analyze the relationship between the unemployment rate and GDP per capita using both frequentist and Bayesian regression approaches. By employing these statistical techniques, we aim to provide a comprehensive analysis that explores the nature and strength of the relationship between these two variables. Furthermore, this research seeks to contribute to the existing body of knowledge by offering insights into the nuances of this relationship within the context of Somalia, thereby addressing a gap in current literature.

1.2. Theoretical framework

The theoretical framework of this study draws upon several economic theories and concepts to provide a conceptual basis for understanding the relationship between unemployment and GDP in Somalia.

1.2.1. Phillips curve

The Phillips curve theory, proposed by A.W. Phillips in 1958, suggests an inverse relationship between unemployment and inflation. While originally conceived to explain the relationship between unemployment and wage inflation, the concept has since been extended to include a relationship between unemployment and GDP. According to the Phillips Curve, lower levels of unemployment are associated with higher levels of economic output, and vice versa. In the context of this study, we adapt the Phillips Curve framework to analyze the relationship between unemployment and GDP in Somalia, considering how fluctuations in the unemployment rate may impact economic productivity and output.

1.2.2. *Okun's law*

Okun's Law, formulated by economist Arthur Okun in the 1960s, posits a relationship between changes in unemployment and changes in GDP. Specifically, it suggests that for every 1% increase in the unemployment rate above the natural rate, GDP will decrease by a certain percentage. Conversely, decreases in the unemployment rate below the natural rate are associated with increases in GDP. By incorporating Okun's Law into our theoretical framework, we aim to explore how variations in unemployment levels affect GDP dynamics in Somalia, providing insights into the cyclical nature of economic growth and contraction.

1.2.3. *Human capital theory*

Human capital theory emphasizes the role of education, skills, and training in enhancing labor productivity and reducing unemployment. According to this theory, investments in human capital development can lead to higher levels of employment and economic growth by equipping individuals with the skills needed to participate effectively in the labor market. In the context of Somalia, where educational attainment and skill levels vary across the population, understanding the implications of human capital on unemployment and GDP is essential for informing policy interventions aimed at promoting sustainable economic development.

1.2.4. *Institutional economics*

Institutional economics focuses on the role of institutions, including laws, regulations, and social norms, in shaping economic outcomes. Institutional factors such as labor market regulations, property rights protection, and contract enforcement mechanisms can influence both unemployment levels and GDP growth rates. By considering the institutional context in Somalia, characterized by a history of political instability and weak governance structures, we aim to elucidate how institutional factors may mediate the relationship between unemployment and GDP, highlighting potential avenues for institutional reform to foster economic growth and employment creation.

By integrating these theoretical perspectives into our analysis, we seek to provide a comprehensive framework for understanding the complex interplay between unemployment and GDP in Somalia. By examining the theoretical underpinnings of this relationship, we aim to generate insights that can inform policy interventions and economic strategies aimed at promoting sustainable development and reducing unemployment in Somalia.

2. *Literature review*

Sachs (2010) investigated the impact of labor and product market regulations on unemployment rates using Bayesian model averaging. Analyzing panel data from 17 OECD countries spanning 1982–2005, the study identifies eight institutional indicators as significant determinants of unemployment. Additionally, the study addresses endogeneity concerns through instrumental variable estimation. The results highlight the importance of institutional factors in influencing unemployment rates, offering insights into policy considerations for labor market regulation.

Assaad and Krafft (2016) address the persistent issue of youth unemployment in the Middle East and North Africa (MENA) region, recognized as a significant labor market challenge. Their research aims to enhance the understanding of the dynamics driving youth unemployment in MENA, specifically in Egypt, Jordan, and Tunisia. By utilizing panel and retrospective data from the Labor Market Panel Surveys in these countries, the study investigates the flows into and out of employment and unemployment, providing a comprehensive analysis of the unemployment trends over the past decade. The researchers decompose these trends by examining the contributions of individuals entering unemployment from outside the labor force versus from previous employment, and the changes in the duration of unemployment experienced by these individuals. The study's models for the incidence and duration of unemployment reveal the relationship between individuals' characteristics and their unemployment dynamics. The main results indicate that both entry into unemployment and the duration of unemployment are significantly influenced by personal attributes, thereby offering critical insights into the factors affecting youth unemployment in the MENA region. This research contributes substantially to the literature by elucidating the complexities of youth unemployment dynamics in these countries.

Ali and Kadhim (2021) utilized both frequentist and Bayesian approaches to forecast unemployment levels in Iraq. Parameters were estimated using the ordinary least squares method for the frequentist approach and the Markov Chain Monte Carlo (MCMC) method for the Bayesian approach. Their analysis demonstrated the superiority of the Bayesian regression model in predictive accuracy, suggesting a concerning trend of increasing unemployment rates over the next two decades.

Rodriguez-Santiago (2022) employed Bayesian Model Averaging to assess the factors influencing entrepreneurship in a dataset covering 117 nations from 2005 to 2019, aiming to investigate the correlation between economic development and self-employment at the macro level. The study investigated variations in self-employment rates, highlighting the importance of unemployment, economic development stage, and labor market frictions.

Fakih et al. (2020) presented a comprehensive examination of youth unemployment in the Middle East and North Africa (MENA) region in the aftermath of the Arab Spring, a period marked by significant upheaval. Their study investigates the microeconomic determinants of youth unemployment using data from 2016, offering insights into the complex dynamics at play. The findings reveal that factors such as gender, education, job concerns, corruption, and societal inequalities significantly impact youth unemployment rates. Notably, the study underscores the importance of gender equality and economic inclusion in mitigating unemployment among youth in the MENA region. By highlighting both challenges and potential solutions, the research contributes valuable insights to the discourse on youth unemployment, informing policy efforts aimed at addressing this pressing issue.

Pandey et al. (2023) applied Bayesian statistical techniques to analyze the GDP of Nepal. Through multiple linear regression models, they explore the relationships between GDP and various factors like exports, imports, population growth, and inflation rates. Their research contributes to understanding Nepal's economic dynamics, offering insights into significant predictors of GDP and their impacts.

2.1. Hypothesis

Building upon the insights gleaned from existing literature, this study hypothesizes that there exists a significant negative relationship between the unemployment rate and GDP in Somalia. Specifically, it is posited that higher levels of unemployment correspond to lower levels of GDP, reflecting the adverse impact of joblessness on economic productivity and output. Furthermore, this study anticipates that employing both classical linear regression and Bayesian regression approaches will offer complementary perspectives on this relationship, with Bayesian methods potentially providing enhanced predictive accuracy and model flexibility. Through rigorous empirical analysis, this research aims to validate these hypotheses and contribute to a deeper understanding of the economic dynamics in Somalia.

3. Materials and methods

3.1. Data

The study utilized secondary data sourced from the World Bank database, covering the period from 1991 to 2020 and specific to Somalia. Economic indicators, including GDP, were extracted for analysis. Somalia's unique socio-political history and economic challenges, characterized by prolonged political instability, underscored the need for a robust analytical approach to understanding the relationship between GDP and unemployment.

3.2. Linear regression model

Linear regression, a widely utilized statistical technique, serves to model the relationship between a dependent variable and one or more independent variables (Alita et al. 2021; Kilmer & Rodriguez, 2017; Kulaylat et al. 2023). For this study, the frequentist method, Ordinary Least Squares (OLS), was employed to quantify the relationship between unemployment (X) and GDP (Y). OLS, a fundamental statistical tool, allows for parameter estimation by minimizing the sum of squared deviations between predicted and actual values of the dependent variable (Cameron & Trivedi 2013). Through this method, the study aimed to provide a conventional baseline for comparison. The model equation is formulated as:

$$Y_i = \beta_0 + \beta_1 X_i + \varepsilon, \quad (1)$$

where Y is the dependent variable (GDP), X_1 is the independent variable (unemployment), β_0 is the intercept, β_1 is the coefficient, ε is the error term (random error).

3.3. Bayesian linear regression

In addition to frequentist regression, Bayesian linear regression was employed to offer a more comprehensive analysis of the relationship between unemployment and GDP in Somalia. Bayesian analysis, a statistical technique leveraging probability assertions, extends the traditional frequentist approach by incorporating prior information and uncertainty into the modeling process (Ayinde et al. 2018; Bharadiya 2023; Banerjee et al 2016; Kelter 2020; Song et al. 2020). In this context, Bayesian linear regression allowed for the incorporation of prior beliefs or knowledge about the relationship between unemployment and GDP. By updating these priors with observed data, the model generated posterior distributions for the regression coefficients, offering deeper insights into the relationship between the variables.

The application of Bayesian regression in this study warrants a robust rationale, especially considering the dataset's limited sample size. Bayesian regression offers a methodological framework that accommodates prior information and uncertainty, enhancing the analysis's depth and reliability.

In Bayesian modeling, the specification of prior distributions holds significant sway over the posterior distribution, thereby influencing the estimated parameters and subsequent model outcomes. In this study, the selection of non-informative priors was guided by a synthesis of existing literature and domain expertise, aiming to integrate pertinent insights into the relationship between unemployment and GDP in Somalia. These prior distributions were tailored to encapsulate anticipated trends in both the direction and magnitude of this relationship, drawing upon historical patterns and theoretical underpinnings.

Furthermore, sensitivity analyses were conducted to gauge the robustness of the results in response to variations in prior specifications. Through systematic adjustment of prior distribution parameters within reasonable bounds, the stability of Bayesian estimates across different prior settings was evaluated. Notably, these sensitivity analyses underscored the consistency of the Bayesian modeling approach, with the principal findings remaining steadfast across a spectrum of prior assumptions.

In Bayesian regression, we can write a similar equation to the classical regression model:

$$Y_i = \beta_0 + \beta_1 X_i + \varepsilon. \quad (2)$$

In terms of the probabilistic model, we can say that $\mu = \beta_0 + \beta_1 X_i$ then $Y_i = \mu + \varepsilon$

$Y_i \sim N(\mu, \sigma^2)$ or $Y_i \sim N(\mu, \frac{1}{\tau})$ where τ is precision and $i = 1, 2, 3, \dots, n$.

That is, the likelihood of each Y_i given β and σ^2 is:

$$L(y|\beta, \sigma^2) = \prod_{i=1}^n \frac{\tau^{1/2}}{\sqrt{2\pi}} \exp \left\{ -\frac{1}{2} (Y_i - \mu)^2 \right\} \tau. \quad (3)$$

To estimate the model, a flat (uniform) prior distribution was used since we didn't have prior knowledge about the parameters.

$$p(\beta) \propto 1 \quad -\infty < \beta < +\infty. \quad (4)$$

This prior distribution was joined with the likelihood to give the posterior distribution of the parameters.

$$\text{Posterior} \propto \text{Likelihood} \times \text{Prior}, \quad (5)$$

$$p(\beta, \sigma^2|y) = \prod_{i=1}^n \frac{\tau^{1/2}}{\sqrt{2\pi}} \exp \left\{ -\frac{1}{2} (Y_i - \mu)^2 \right\} \tau \times p(\beta). \quad (6)$$

3.3.1. Incorporation of prior information and uncertainty

Bayesian regression enables the incorporation of prior beliefs or knowledge about the relationship between unemployment and GDP. Despite the dataset's modest size, there might exist pertinent prior information regarding economic dynamics in Somalia. This prior knowledge, when integrated into the analysis, enriches the model's understanding and interpretation of the relationship between the variables.

3.3.2. Flexibility in handling uncertainty

By treating parameters as random variables, Bayesian regression offers flexibility in handling uncertainty inherent in datasets with limited samples. This flexibility is particularly pertinent in economic analyses where variables may exhibit complex interdependencies and fluctuations.

3.3.3. Model stability and convergence

To ensure the reliability of the Bayesian regression model, convergence diagnostics were performed. These diagnostics assess whether the model has converged to a stable solution, mitigating concerns about parameter estimates' reliability. Despite the dataset's size constraints, satisfactory convergence results affirm the model's stability and robustness.

3.3.4. Comparative analysis of predictive accuracy

A comparative analysis between Bayesian and frequentist regression approaches was conducted to evaluate predictive accuracy. Despite the dataset's limitations, Bayesian regression exhibited comparable or superior performance metrics, indicating its effectiveness even with modest sample sizes.

3.4. Comparative analysis of model performance

To ascertain the superior model between the Bayesian and frequentist regression approaches, a comparative analysis was conducted using three evaluation criteria: root mean square error (RMSE), mean square error (MSE), and mean absolute error (MAE). These metrics served as benchmarks to assess the accuracy and predictive performance of each model. Lower values of RMSE, MSE, and MAE indicate better predictive accuracy, reflecting a closer fit between observed and predicted values.

By employing both frequentist and Bayesian regression approaches (Vuong et al. 2020), the study aimed to provide a comprehensive analysis that explores the nature and strength of the relationship between GDP and unemployment in Somalia. This methodological approach allowed for a robust examination of the research question, offering valuable insights for policymakers and researchers.

3.4.1. Root mean square error (RMSE)

RMSE measures the average magnitude of the residuals between observed and predicted values (Richter et al. 2012). It provides a comprehensive evaluation of prediction accuracy, considering both the magnitude and direction of errors. It provides a thorough assessment of prediction accuracy, taking into account both the direction and size of errors. Lower RMSE values indicate better model performance, reflecting a closer fit between observed and predicted values. The mathematical equation for RMSE is:

$$RMSE = \sqrt{\sum_{i=1}^n (z_i - \hat{z})^2}, \quad (7)$$

where n is the total number of samples or observations in the dataset, z_i is the observed value, and \hat{z} is the predicted (estimated) value.

3.4.2. Mean square error (MSE)

MSE calculates the average of the squared residuals, providing an assessment of the overall variance between observed and predicted values. Similar to RMSE, lower MSE values indicate better predictive accuracy. However, MSE places greater emphasis on larger errors due to the squaring operation. The mathematical equation for mean square error (MSE) is

$$MSE = \frac{\sum_{i=1}^n (z_i - \hat{z}_i)^2}{n}, \quad (8)$$

where n is the number of observations, z_i is the observed value, and \hat{z}_i is the predicted (estimated) value.

3.4.3. Mean absolute error (MAE)

MAE computes the average of the absolute differences between observed and predicted values. Unlike RMSE and MSE, MAE does not penalize large errors as severely, making it a useful metric for assessing model performance when outliers are present. Lower MAE values indicate better predictive accuracy, with deviations between observed and predicted values minimized. The mathematical equation for mean absolute error (MAE) is:

$$MAE = \frac{\sum_{i=1}^n |z_i - \hat{z}_i|}{n}, \quad (9)$$

where n is the number of observations, z_i is the observed value, and \hat{z}_i is the predicted (estimated) value.

4. Results

This section presents the findings derived from the regression and Bayesian methodologies utilized in the study. The results are meticulously examined to uncover patterns, relationships, and predictive capabilities offered by each method.

4.1. Summary statistics of unemployment (U) and GDP

Table 1 presents the summary statistics of unemployment and GDP for the study period, including minimum values, first quartile, median, mean, third quartile, and maximum values for both variables. These descriptive statistics offer insights into the distribution and variability of unemployment and GDP, which are crucial for understanding the economic dynamics under investigation. The range from the minimum to maximum values showcases the extent of variation in unemployment and GDP over time, setting the stage for further analysis. To provide a broader context, we compare these summary statistics to global averages. For instance, while the average global unemployment rate tends to hover around 5–6%, our study area's mean unemployment rate is significantly higher at 33.25%, highlighting the region's severe employment challenges. Similarly, comparing GDP statistics, the mean GDP value in our study is 151.99, which can be juxtaposed with global GDP trends to illustrate economic performance relative to other regions.

4.2. Linear regression analysis

4.2.1. Linear regression using OLS method

Table 2 presents the results of the linear regression model employing the ordinary least squares (OLS) method. The regression analysis provides a detailed understanding of the relationship between unemployment (U) and GDP. The estimated coefficients, t -values, standard errors, and associated p -values are crucial for interpreting this relationship.

The results indicate a statistically significant negative relationship between unemployment and GDP. Specifically, the coefficient estimate for unemployment is -41.21 , which suggests that for each unit

Table 1. Descriptive statistics of the variables.

	Min	1st Q	Median	Mean	3rd Q	Max	Sd
U	32.69	32.9	33.1	33.25	33.42	35.76	0.584624
GDP	90.73	108.62	140.38	151.99	195.01	239.05	50.72775

Source: Author's calculations using data from the World Bank.

Table 2. Linear regression model using the OLS method.

	Estimate	Std. error	t value	$\Pr(> t)$
(Intercept)	1522.43	479.93	3.172	0.00365**
U	-41.21	14.43	-2.856	0.00800**

Source: Author's calculations using data from the World Bank.

Table 3. Linear regression model using the Bayesian approach.

	Estimate	Est. error	l – 95% CI	u – 95% CI	Rhat	Bulk_ESS	Tail_ESS
Intercept	1541.52	501.54	559.27	2512.41	1	3723	2721
U	–41.8	15.08	–70.94	–12.26	1	3720	2733
Sigma	46.73	6.44	36.41	60.96	1	2996	2389

Source: Author's calculations using data from the World Bank.

Table 4. Comparison between OLS and Bayesian in linear regression model.

Estimation method	RMSE	MAE	MSE
Ordinary least square	43.891	38.19391	1926.377
Bayesian	43.835	38.04255	1916.821

Source: Author's calculations using data from the World Bank.

increase in the unemployment rate, GDP decreases by 41.21 units, assuming all other factors are constant. This finding aligns with the broader economic theory that higher unemployment typically corresponds to lower economic output, reflecting the adverse effects of unemployment on economic performance. The intercept of the model is 1522.43, which represents the estimated GDP when the unemployment rate is zero. The standard error for the unemployment coefficient is 14.43, and the t -value is -2.856 . The associated p -value of 0.00800 indicates that the relationship between unemployment and GDP is statistically significant at the 1% level, meaning there is strong evidence to reject the null hypothesis that there is no relationship between these variables. The intercept's p -value is 0.00365, also indicating a statistically significant result. This confirms that the intercept is significantly different from zero, adding to the robustness of the model.

4.2.2. Linear regression using Bayesian approach

Table 3 presents the results of the linear regression model utilizing the Bayesian approach. The intercept estimate is 1541.52, with an estimated error of 501.54. The 95% confidence interval (CI) for the intercept ranges from 559.27 to 2512.41. The estimate for the variable “U” is -41.8 , with an estimated error of 15.08. The 95% CI for “U” spans from -70.94 to -12.26 . Additionally, the standard deviation (sigma) is estimated to be 46.73, with an estimated error of 6.44 and a 95% CI ranging from 36.41 to 60.96. The Rhat value is 1, indicating the convergence of the model. The effective sample size (ESS) metrics for both the bulk and tail of the posterior distribution are 3723 and 2721, respectively. Similar to the OLS results, the Bayesian model reveals a negative association between unemployment and GDP.

4.3. Comparison between OLS and Bayesian models

4.3.1. Model performance metrics

Table 4 compares the performance of the OLS and Bayesian regression models based on MSE, RMSE, and MAE. The comparison between OLS and Bayesian linear regression models reveals that the Bayesian approach outperforms OLS. The Bayesian model demonstrates the best performance across key metrics, including RMSE, MAE, and MSE. Specifically, the Bayesian model achieves an RMSE of 43.835, an MAE of 38.04255, and an MSE of 1916.821, whereas the OLS model shows slightly higher values with an RMSE of 43.891, an MAE of 38.19391, and an MSE of 1926.377. These results indicate that the Bayesian model provides better predictive accuracy and is more effective in capturing the underlying relationships in the data compared to the OLS model.

4.4. Trace plot analysis for Bayesian regression model

The trace plot presented illustrates the MCMC sampling process utilized in Bayesian regression analysis. Each line represents posterior samples drawn from the distribution of model parameters, with the x -axis denoting the iteration number and the y -axis indicating sampled parameter values. Analysis of the trace plot enables assessment of MCMC convergence and mixing properties. Ideally, the plot demonstrates random fluctuations around a central value, signifying convergence, and satisfactory mixing. Any

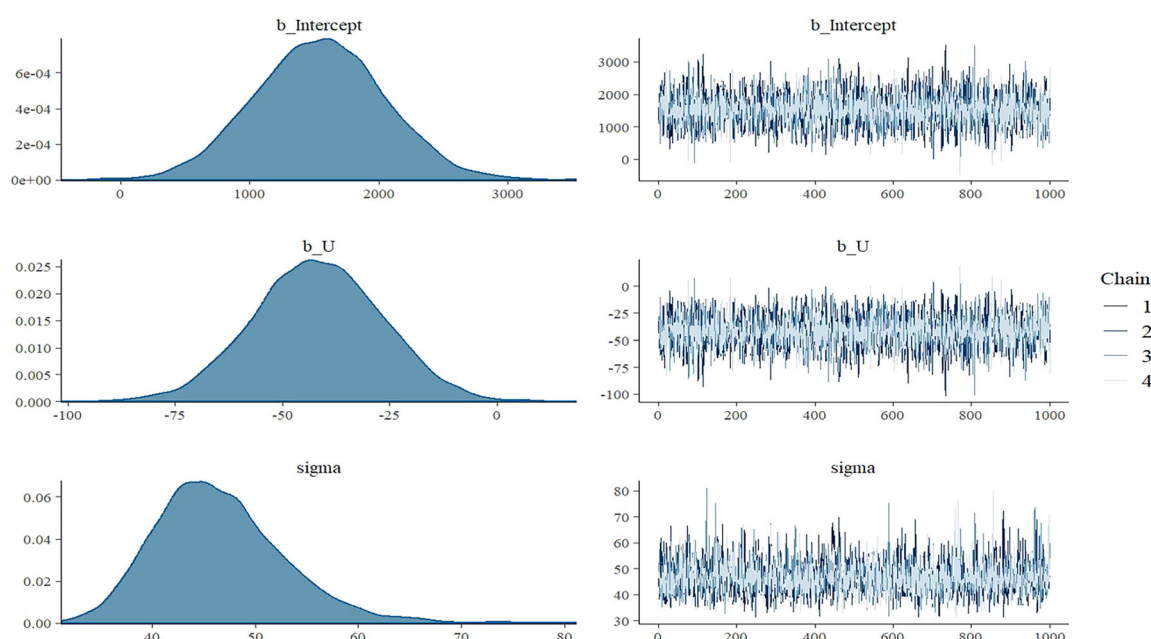


Figure 1. Trace plot.

deviations from this pattern may indicate convergence or mixing issues, necessitating further diagnostic analysis and potential adjustments to the model or sampling algorithm.

Figure 1 presents trace plots, serving as convergence diagnostic tools to evaluate model parameter behavior. Through the MCMC method, parameter values are traced across iterations. Application of the chain rule to each parameter indicates that the four chains employed in the analysis exhibit proper mixing and converge to a stationary sequence. This observation underscores the stability and reliability of the model's parameter estimation process, ensuring the robustness of the Bayesian analysis methodology utilized in the study.

5. Discussion

The results of our regression analyses confirm a significant negative relationship between unemployment and GDP in Somalia, a finding consistent with prior research indicating the adverse impact of unemployment on economic growth (Ali and Kadhim, 2021; Sachs, 2010). The negative coefficients for unemployment in both classical linear and Bayesian regression models underscore the detrimental effects of joblessness on economic output. Understanding this dynamic relationship is imperative for policymakers in Somalia to devise effective strategies for promoting economic development and reducing unemployment rates.

Our study also contributes nuanced insights into the specific context of Somalia, a nation characterized by unique socio-political and economic challenges. By employing both frequentist and Bayesian regression approaches, we provide a comprehensive analysis of the unemployment-GDP relationship, shedding light on the intricacies of this dynamic in a fragile state context. While our findings align with the broader theoretical understanding of this relationship, they also offer context-specific implications for policymakers grappling with unemployment challenges and economic development priorities in Somalia.

In comparing our results to previous literature, it is evident that our study enriches the existing body of knowledge by leveraging a combination of methodological approaches and focusing on a specific geographic context. The slight advantages demonstrated by the Bayesian modeling approach in terms of predictive accuracy highlight the potential of this framework for enhancing economic forecasting and policy formulation, corroborating recent advancements in Bayesian econometric methodologies. Moreover, the convergence diagnostics for the Bayesian model suggest satisfactory convergence, ensuring the reliability of the Bayesian estimates. The trace plot analysis demonstrates proper mixing and

convergence to a stationary sequence, indicating the stability and reliability of the parameter estimation process. These findings enhance the credibility of the Bayesian regression results and assure the model's validity and robustness.

5.1. Limitations and future research

5.2.1. Limitations

While this study provides valuable insights into the relationship between GDP and unemployment in Somalia, several limitations should be acknowledged.

5.2.2. Data limitations

The analysis relies on secondary data from the World Bank, which may have limitations in terms of accuracy and coverage. Future research could benefit from accessing more granular and comprehensive datasets specific to Somalia's economic landscape.

5.2.3. Model assumptions

Both the classical linear regression and Bayesian regression models make certain assumptions about the underlying data distribution and model specifications. Deviations from these assumptions could impact the validity of the results. Sensitivity analyses could be conducted to assess the robustness of the findings to different model specifications.

5.2.4. Causality

While the study identifies a negative association between unemployment and GDP, establishing causality is challenging. Future research could explore causal mechanisms using advanced econometric techniques such as instrumental variable analysis or structural equation modeling.

5.3. Future research directions

Building upon the insights gained from this study, future research avenues could include:

5.3.1. Sectoral analysis

Investigating the differential impact of unemployment on various sectors of the economy could provide a more nuanced understanding of the dynamics at play. This could involve analyzing sector-specific datasets and employing disaggregated econometric models.

5.3.2. Policy evaluation

Assessing the effectiveness of existing policies aimed at reducing unemployment and stimulating economic growth in Somalia could offer valuable lessons for policymakers. Qualitative studies, stakeholder interviews, and policy evaluations could complement quantitative analyses to provide comprehensive insights.

5.3.3. Dynamic modeling

Incorporating time series or panel data techniques could capture the dynamic nature of the relationship between GDP and unemployment over different time periods and geographical regions within Somalia. This could involve employing state-of-the-art econometric methodologies and computational techniques.

5.4. Significance and practical implications

5.4.1. Research significance and practical implications

Understanding the relationship between GDP per capita and the unemployment rate holds immense significance across multiple domains, ranging from economic policymaking to societal well-being. This study offers valuable insights with practical implications that extend to economic, educational, policy, and societal realms.

5.4.2. Economic and commercial impact

Insights derived from this research can guide economic strategies and investment decisions, aiding businesses, investors, and policymakers in navigating economic fluctuations and fostering sustainable growth. By elucidating the dynamics between GDP per capita and unemployment, stakeholders can devise targeted interventions to mitigate unemployment challenges, promote job creation, and stimulate economic development.

5.4.3. Educational and teaching applications

In educational settings, this research serves as a valuable resource for teaching regression analysis techniques and their application in real-world economic contexts. By showcasing both frequentist and Bayesian regression approaches, educators can impart practical statistical knowledge, equipping students with analytical skills essential for understanding and addressing economic phenomena.

5.4.4. Influence on public policy

The findings of this study have direct implications for public policy formulation and implementation. Policymakers can utilize insights regarding the relationship between GDP per capita and unemployment to design evidence-based policies aimed at reducing unemployment rates, fostering inclusive growth, and enhancing societal well-being. Moreover, understanding these dynamics enables policymakers to anticipate and mitigate the adverse effects of economic downturns, thereby promoting resilience and stability.

5.4.5. Impact on society

Beyond its academic and economic implications, this research holds the potential to influence public attitudes and societal perceptions. By shedding light on the complex interplay between economic indicators and societal well-being, this study fosters informed discourse and promotes collective efforts toward addressing unemployment challenges, improving living standards, and enhancing the quality of life for individuals and communities.

6. Conclusion and policy implication

In conclusion, the findings of this study offer robust evidence of a significant negative relationship between unemployment and GDP in Somalia, as demonstrated by both classical linear and Bayesian regression analyses. The negative coefficients for unemployment in both models underscore the adverse impact of joblessness on economic output. This insight is crucial for policymakers and stakeholders seeking to address unemployment challenges and foster economic development in Somalia.

The convergence diagnostics for the Bayesian model indicate satisfactory convergence, ensuring the reliability of the Bayesian estimates. Furthermore, the comparative performance metrics between the OLS and Bayesian models highlight the suitability of both approaches for analyzing the impact of unemployment on GDP. The Bayesian approach, in particular, demonstrates superior predictive accuracy, suggesting its potential for enhancing economic forecasting and policy formulation.

Overall, this research contributes to the existing body of knowledge by offering comprehensive insights into the dynamics of unemployment and GDP in Somalia. By leveraging both frequentist and Bayesian regression methodologies, this study provides a nuanced understanding of the relationship between these variables, thus empowering policymakers with evidence-based strategies for promoting economic growth and stability.

Future research endeavors could explore additional factors influencing unemployment and GDP dynamics in Somalia, such as trade policies, infrastructure development, and demographic trends. Additionally, longitudinal studies could provide valuable insights into the long-term effects of policy interventions aimed at reducing unemployment and stimulating economic prosperity. By continuing to advance our understanding of these complex economic phenomena, we can pave the way for a more prosperous and equitable future for Somalia and its citizens.

The findings from this study have significant policy implications for addressing unemployment challenges and fostering economic growth in Somalia. Given the adverse impact of unemployment on GDP,

policymakers should prioritize initiatives aimed at reducing unemployment rates and promoting job creation. Strategies such as investment in education and vocational training programs, infrastructure development, and support for small and medium enterprises (SMEs) can play a crucial role in enhancing employment opportunities and stimulating economic growth.

Furthermore, the superior predictive accuracy of the Bayesian regression model underscores its utility for informing evidence-based policymaking. Policymakers should leverage the insights provided by Bayesian regression analysis to design targeted interventions and allocate resources effectively. By incorporating Bayesian modeling techniques into policy analysis and decision-making processes, policymakers can enhance the effectiveness of economic policies and maximize their impact on unemployment reduction and economic development.

Ethical approval

This study follows ethical practices during the writing process. We declare that this manuscript is original, has not been previously published, and is not currently being considered for publication elsewhere.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This research was supported by SIMAD University, Somalia (Grant number: SU-PG-2024-0105).

About the authors

Mohamud Hussein is an accomplished academic and researcher specializing in statistics. He completed his bachelor's degree in statistics and planning at SIMAD University, followed by a Master of Philosophy in Statistics from Minhaj University in Lahore, Pakistan. As a lecturer at SIMAD University, Mohamud focuses on applied statistics, quality control, regression, and biostatistics, contributing to the academic community through his research and teaching. His work is integral in shaping the understanding and application of statistical methods in various fields.

Fartun Ahmed is an academic researcher and data analyst with a strong background in statistics. She earned her bachelor's degree in statistics and planning from SIMAD University and completed her master's degree in statistics at Riphah International University. Her research interests lie in applied statistics, Bayesian statistics, and biostatistics, where she focuses on leveraging statistical methods to solve complex problems.

Atta Gul is a dedicated academic researcher currently working in Statistics. He earned his bachelor's degree in statistics from Islamia University of Bahawalpur and a master's degree in statistics from Sargodha University. His research interests are centered on spatial statistics, applied statistics, and time series analysis, areas in which he aims to make significant contributions to the field.

Abdimalik Ali Warsame is a researcher and lecturer at SIMAD University. He holds a Bachelor's degree and Master's degree in Economics from the SIMAD University and University Putra Malaysia, respectively. His research interests are focused on Agricultural economics, Environmental economics, Climate change econometrics Energy economics, and Health economics. He has over 30 peer-reviewed S/SCI-E and Scopus indexed journal articles.

Bashir Mohamed Osman is an academic researcher and lecture at SIMAD University. He holds a Bachelors of Education in math and physics Mogadishu University, Mogadishu, Somalia and Master of Science in statistics at Annamalai University, Tamil Nadu, India. His interesting area is stochastic process.

Seadya Mohammed Ahmed is an academic researcher and lecture at SIMAD University. She holds at a Batchelor's degrees in Economics and Finance - Kenyatta University and Master of Arts Degree in Economic Policy Management - University of Nairobi. Her interesting area is applied economics, micro and macro-economics.

ORCID

Mohamud Hussein Mohamud  <http://orcid.org/0009-0002-8321-6044>

Bashir Mohamed Osman  <http://orcid.org/0009-0003-2003-972X>

Seadya Mohammed Ahmed  <http://orcid.org/0009-0006-9048-4599>

Data availability statement

The datasets used in this study are available from the author upon reasonable request.

References

- Ali, A., & Kadhim, T. (2021). Linear regression model using Bayesian approach for Iraqi unemployment rate. *Annals of Pure and Applied Mathematics*, 23(01), 21–26. <https://doi.org/10.22457/apam.v23n1a04801>
- Alita, D., Putra, A. D., & Darwis, D. (2021). Analysis of classic assumption test and multiple linear regression coefficient test for employee structural office recommendation. *IJCCS (Indonesian Journal of Computing and Cybernetics Systems)*, 15(3), 295–306. <https://doi.org/10.22146/ijccs.65586>
- Assaad, R., & Krafft, C. (2016). Labor market dynamics and youth unemployment in the Middle East and North Africa: Evidence from Egypt, Jordan and Tunisia. In *Economic Research Forum Working Paper Series* (Vol. 993, pp.1–27). The Economic Research Forum (ERF).
- Ayinde, K., Lukman, A. F., Olarenwaju, S. O., & Attah, M. O. (2018). Some new adjusted ridge estimators of linear regression model. *International Journal of Civil Engineering and Technology (IJCIET)*, 9(11), 2838–2852.
- Banerjee, M., Chakraborty, R., Ofori, E., Okun, M. S., Viallancourt, D. E., & Vemuri, B. C. (2016). A nonlinear regression technique for manifold valued data with applications to medical image analysis. In *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition* (pp. 4424–4432).
- Bharadiya, J. P. (2023). A Review of Bayesian Machine Learning Principles, Methods, and Applications. *International Journal of Innovative Science and Research Technology*, 8(5), 2033–2038.
- Cameron, A. C., & Trivedi, P. K. (2013). *Regression analysis of count data* (Vol. 53). Cambridge University Press.
- Fakih, A., Haimoun, N., & Kassem, M. (2020). Youth unemployment, gender and institutions during transition: evidence from the Arab Spring. *Social Indicators Research*, 150(1), 311–336. <https://doi.org/10.1007/s11205-020-02300-3>
- Kayode, A., Arome, A., & Silas, A. (2014). The rising rate of unemployment in Nigeria: the socio-economic and political implications. *Global Business and Economics Research Journal*, 3(1), 12–17.
- Kelter, R. (2020). Bayesian alternatives to null hypothesis significance testing in biomedical research: a non-technical introduction to Bayesian inference with JASP. *BMC Medical Research Methodology*, 20(1), 142. <https://doi.org/10.1186/s12874-020-00980-6>
- Kilmer, J. T., & Rodríguez, R. L. (2017). Ordinary least squares regression is indicated for studies of allometry. *Journal of Evolutionary Biology*, 30(1), 4–12. <https://doi.org/10.1111/jeb.12986>
- Kulaylat, A. N., Tran, L., Kulaylat, A. S., & Hollenbeak, C. S. (2023). Regression analysis. In *Translational Surgery* (pp. 157–163). Academic Press.
- Pandey, R., Chand, D. B., & Tolani, H. (2023). Bayesian multiple linear regression model for GDP in Nepal. *Journal of Statistical Distributions and Applications*, 9(1), 9–23.
- Richter, K., Atzberger, C., Hank, T. B., & Mauser, W. (2012). Derivation of biophysical variables from earth observation data: Validation and statistical measures. *Journal of Applied Remote Sensing*, 6(1), 063557–1. <https://doi.org/10.1117/1.JRS.6.063557>
- Rodriguez-Santiago, A. (2022). Re-evaluating the relationship between economic development and self-employment, at the macro-level: A Bayesian model averaging approach. <https://doi.org/10.9781/ijimai.2022.01.007>
- Sachs, A. (2010). A Bayesian approach to determine the impact of institutions on the unemployment rate. *ZEW-Centre for European Economic Research Discussion Paper* 10-058.
- Song, Y., Zhou, X., Zhang, M., Zhao, W., Liu, Y., Kardia, S. L. R., Roux, A. V. D., Needham, B. L., Smith, J. A., & Mukherjee, B. (2020). Bayesian shrinkage estimation of high dimensional causal mediation effects in omics studies. *Biometrics*, 76(3), 700–710. <https://doi.org/10.1111/biom.13189>
- Ugwuowo, F. I., Oranye, H. E., & Arum, K. C. (2023). On the jackknife Kibria-Lukman estimator for the linear regression model. *Communications in Statistics-Simulation and Computation*, 52(12), 6116–6128. <https://doi.org/10.1080/03610918.2021.2007401>
- Vuong, Q. H., La, V. P., Nguyen, M. H., Ho, M. T., Tran, T., & Ho, M. T. (2020). Bayesian analysis for social data: A step-by-step protocol and interpretation. *MethodsX*, 7, 100924. <https://doi.org/10.1016/j.mex.2020.100924>