Vector Error Correction Model: Prediction of Bi-Directional Causality between Gross Domestic Product and Wage Growth in Kenya

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***Abstract* — Economic growth and wage growth are very prominent macroeconomic variables in all countries in the World. These two variables are the main signposts signaling the current trends in an economy. To determine the recent behavior of the economy, the government must study and analyze these major variables. The increase in aggregate production in the Kenyan economy has been deteriorating due to the steady rise in the wage bill, especially since the year 2012, in conjunction with the devolved government. An increase in wage rate motivates workers and, in turn, increases the production capacity of a country hence economic growth. An increase in recurrent expenditure implies that the development expenditure will be condensed, which will alter the growth of the economy. The primary goal of this research was to fit vector error correction model on gross domestic product and wage growth data so as to identify the bidirectional causality effects between the two variables. VEC model is superior since it distinguishes between long run and short run relationship among underlying variables in a large sample size. The linear Granger causality test was used to evaluate the causal relationship between the system's variables; hence a causal research design was adopted in this study. This research employed secondary data, which was analyzed using Eviews and STATA statistical software. Data on these target variables was acquired from the World Bank and Central Bank of Kenya. Lastly, this study used yearly time series data for the period 1979 to 2019. It was found that wage growth and GDP granger causes each other and also have a long run relationship since their respective p values were less than 5% significance level. VECM1 (effects of wage growth on GDP) had AIC of -0.2953, RMSE of 1.0039 while the R-squared was 0.7241. Subsequently, effects of GDP on wage growth (VECM2) was found to have an R-squared of 0.7452, AIC of -8.2270 and RMSE of 0.08363. Based on the foregoing findings, it was determined that GDP has more influence on wage growth both in the short and long run. This study thus recommends that the government should keep inflation under control, increase development expenditure to finance projects and fostering a favorable business environment for Small and Medium-sized Enterprises (SMEs) to upsurge total output (productivity) which will in turn, lead to a rise in wage growth, thus a high standard of living for the millions of unemployed Kenyans. Finally, the findings of the current study are expected to be of significance to academicians and also provide appropriate policy options that will help in harmonizing the wage rates, thus managing recurrent expenditure in Kenya.**

***Keywords* — Bidirectional causality, co-integration, economic growth, Johansen Approach, Vector Error Correction Model, Wage Growth.**

I. Introduction

The goal of all developing countries in the world is to achieve high levels of growth of their economy. In addition, these countries have the challenge of maintaining these high levels of growth they have attained. Economic growth is the rise in the productive capacity or output of the economy due to improvement in infrastructure, better health services and improved technology [1]. The growth of an economy is believed of not only as a rise in productive capacity but also as an improvement of the well-being of the individuals of that economy and it is related to technological advancement. Wages entails the total amount of salaries and other benefits paid to private or public employees by the government and private firms [2]. In a country where the employees in all sectors of the economy are motivated by high wage rates, high output levels are achieved. On the other hand, a country with high levels of Gross Domestic Product (GDP) due to an increase

Published on July 21, 2022.
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in expenditure on development projects, especially in technology, demands more labor force. To stimulate economic growth and create employment, the Kenyan government has continued to employ the labor force as part of economic strategy.

Vector Error Correlation (VEC) model, which is a constrained vector autoregressive (VAR) model used with non-stationary series, offers a convenient representation of a cointegrated VAR as it distinguishes between long- and-short run (equilibrium) effects, and hence expectations of much more realistic responses. According to [3], VEC model is a suitable modeling approach if the variables are cointegrated and thus convenient when the long-run prediction is desired. The co-integration component is known as the Error-Correction-Term (ECT) in this instance because the deviance from long-term equilibrium is steadily addressed by a series of partial short-run-adjustments. Further, [3] postulated that the VEC model is considered to be superior to VAR and ARDL models since their cointegration method does not involve pre-tests for unit roots [4]. Although the Autoregressive-Distributed-Lag-Cointegration technique (ARDL) is useful for dealing with variables of various orders that are integrated, such as I (0) and I (1), it will fail if there is an integrated-stochastic drift of I (2). ARDL only indicates a long-run association amongst the fundamental variables in a small sample size, and it implies the addition of "unrestricted-lag" of the regressors in a regression model. This study, therefore, sought to investigate the bidirectional causality effects between GDP and wage growth in Kenya since 1979 to 2019 using VEC Model. The current study's findings were found to be highly reliable for making inferences for long run association among the target variables under the research.

Addressing the role of government wages as a determinant of macroeconomic stability and competitiveness in Europe between 2000 and 2008, [5] indicated that economic growth decreases as government wages increases. His study's findings recommended for the government to avoid negative repercussions on fiscal and economic performance, it should therefore be careful with employment policies and wage-setting. Nevertheless, the researcher did not state the type of methodology used in his analysis. The sample size of 8 years used was also very small and cannot demonstrate a long-term association between wage growth and economic growth. This study fitted VEC model to predict the bidirectional relationship between the GDP and wage growth using a data set for 41 years.

Reference [6], using regression in studying cross-country correlations, established that education is statistically significant and positively related to subsequent labor productivity growth and GDP growth. However, the research conducted by [7] did not indicate the type of methodology employed in their analysis, and the sample size of 14 years used is also small. Most of the studies, including [6] employed a linear regression model in their analysis, which could result in the model being overfit, especially if the regression begins to model the random-error (noise) in the data rather than just the association between the variables. This happens most often when there are too many parameters in comparison to the quantity of samples. To overcome this problem, this research tended to use both the VEC model in forecasting the causality effects between GDP and wage growth in Kenya.

Reference [8] assessed the effect of sectorial wages on Kenya's economic growth using Cointegration and VEC models. He discovered that there exists a significant positive association between public sector wages and the growth of the economy. The study used time-series data from 1984 to 2014 and observed that an increase in public sector wage by 100% would result to a rise in GDP by 17.53%. There was also a significant negative correlation between private sector wages and the economic growth. As a result, an increase in private sector wage by 100% would result to a cut of 0.24% in the GDP growth. However, the study only focused on sectorial wages on economic growth and also assumed a unidirectional causality among the two economic variables. For this reason, the current study examined the bidirectional causality between economic growth and wage growth in Kenya using the VEC model compared to the MLR model. Other researchers have also been using VEC model in their analysis of other variables.

Reference [9] employed Co-integration and ECM in the analysis of the impact of lending interest rate on domestic private investment in Kenya (1971 -2014). The study found that deposit, lending, and real interest rate negatively affects domestic private investment in Kenya. Previous researchers have focused on the uni-direction causality of wage growth on economic growth rather than the bidirectional causality. As observed in the literature review, most of the prior studies have conflicting findings; hence the empirical evidence is inconclusive. Most of the studies were also carried out outside Africa and in developed nations. Studying bi-directional causality between WG and GDP is necessary in identifying the economic variable that has more influence on the other. VEC model distinguishes between long-run and short-run (effects) equilibrium and hence expectations of much more realistic response in forecasting. Using the VEC model, this study sought to fill the existing gap by presenting empirical evidence on bidirectional causality between economic growth and wage growth.

II. Literature Review

The Vector Error Correction Model is an upper version of the VAR Model. When the variables are cointegrated, the VEC model is an appropriate modeling strategy and it is thus effective when long-run prediction is sought. Cointegrated variables, according to [10], are variables that are individually driven by permanent shocks (integrated), but for which there are linear combinations (weighted sums) that are solely driven by transitory shocks (mean-reverting). According to [11], the VEC model comprises the following steps: lag length determination (using Maximum likelihood estimation or Information Criteria), stationarity test (ADF test / Phillips-Perron/ Correlograms), granger causality test, Cointegration test (the Engle and Granger 2-step approach/ the Johansen approach), VEC model estimation, variance decomposition using Wald test, model diagnostic checking (the Ljung-Box test /Breusch-Godfrey Serial Correlation LM Test) and Models Comparison (AIC, RMSE).

(1) is a description of the Vector-Error-Correction-Model (VECM).

$$\Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{t} \Gamma_i \Delta y\, t-1 + \varepsilon_i \tag{1}$$

Where Π and Γi are square matrices, whose elements depend on the coefficients of long run model while comprises the model's endogenous variables. The Π is an m x m matrix comprising parameters of the long-run, Δ is the first difference operator, and is the white noise term. If r co-integration vectors exist, then Π can be represented as the product of two matrices as Π = γβt where both γ and β are g x r matrices. The matrix β contains the coefficients of long-run association while γ encompasses the speed-of-adjustment-parameters, which are also interpreted as the weight with which individual co-integration vector appears in a particular equation.

III. Methodlogy

A. Research Design

A causal research design is a technique for determining the cause and effect relationship among two variables [12]. The study employed a causal research design to establish a cause-and-effect association between GDP and wage growth, as well as to measure the magnitude of the relationship between the two variables under consideration. The current study's major goal was to examine the causation effects between wage growth and GDP in Kenya; hence this design was appropriate.

B. Data Collection and Analysis

The study used secondary data on GDP, public wage, employment elasticity, human capital, private wage, government expenditure, net export, total consumption, and gross private investment (I), which was aquired from the CBK and World Bank. Reference [13] stated that larger sample sizes usually lead to increase in precision, and in VEC analysis, there should be at least 30 observations per variable. The current study used a sample size of 41 years, which was more efficient in VEC analysis. Data analysis was conducted using statistical packages, which included; Eviews version 10 and STATA version 14, to fit the appropriate models.

C. Prediction Using a Vector Error Correction Model

Under presentation of VEC model, this study fitted wage growth on GDP and GDP on wage growth. In its reduced form, the right-hand side of each equation includes lagged values of all dependent variables in the system.

1) Fitting Wage Growth on GDP

$$\begin{aligned}\Delta lnY_t = \alpha_{10} + \sum_{i=1}^{p} \alpha_{1i}\, \Delta lnY_{t-i} + \sum_{i=1}^{p} \alpha_{2\,i}\, \Delta lnPBW_{t-i} + \sum_{i=1}^{p} \alpha_{3\,i}\, \Delta lnPRW_{t-i} \\ + \sum_{i=1}^{p} \alpha_{4\,i}\, \Delta lnHK_{t-i} + \sum_{i=1}^{p} \alpha_{5\,i}\, \Delta lnEL_{t-i} + \lambda_i \Phi_{t-1} + \acute{\varepsilon}_{1\,t}\end{aligned} \tag{2}$$

Where; $\varepsilon_{1t},\ \varepsilon_{2t},\ \varepsilon_{3t},\ \varepsilon_{4t},\ \varepsilon_{4t}$ - white noise error terms; p -lag length, Φ_{t-1}- Error correction Term (ECT) that directs the variables $Y_t,\ PBW_t,\ PRW_t,\ HK_t\ EL_t$ to restore back to equilibrium; λ_i- it is the speed of adjustments towards long run equilibrium /coefficient of cointegrating model; α_{ji}- denotes the short-run dynamics coefficients of the models, convergence, to equilibrium; t- Time in years; and i is the VEC model's lag order.

2) Fitting GDP on Wage Growth

$$\Delta lnW_t = \alpha_{10} + \sum_{i=1}^{p} \alpha_{1i} \Delta lnW_{t-i} + \sum_{i=1}^{p} \alpha_{2i} \Delta lnNE_{t-i} + \sum_{i=1}^{p} \alpha_{3i} \Delta lnTI_{t-i} + \sum_{i=1}^{p} \alpha_{4i} \Delta lnCE_{t-i} + \sum_{i=1}^{p} \alpha_{5i} \Delta lnGE_{t-i} + \lambda_i \Phi_{t-1} + \varepsilon_{1t} \quad (3)$$

D. Estimating Significance of Parameters: Wald Test

If (C1) is negative in sign and insignificant, then there exists long run causation "moving" from independent to the dependent variable. CI is called the coefficient of co-integrating model or speed of adjustment towards equilibrium. To test whether each independent variable causes dependent variable, Wald test was used as follows;

Ho: C (2) =C (3) = 0; implies that there is no short-run causation running from one variable to another variable. The 'p' value is compared with the critical-value at 5 percent significance-level. The null-hypothesis is rejected if the probability value is lower than 0. 05.

E. Model Diagnostic/Residual Checking

Breusch-Godfrey Serial Correlation LM Test was used since it is consistent and reliable. This test is more superior to the Ljung-Box-test and best in the case where the explained variables' lagged values are used as independent variables in the model. If the probability value is more than 0.05, the null-hypothesis of no serial-correlation is accepted. Hence, it is concluded that serial-correlation doesn't exist among the residuals, meaning the model is acceptable.

F. Models Performance Comparison

This study used the AIC score values, and root mean square errors (RMSE) to examine the best-underlined models that neither over fit nor under fit the data. RMSE is the most significant fit criterion, especially if the model's primary goal is prediction. Apart from being suitable with a parsimonious model (model with fewer predictor variables), The RMSE is a good indicator of how well the model forecasts the explanatory variable. The closer the value of RMSE is to zero (lower values), the better is the model, i.e., indicate better fit. The RMSE is computed using (4).

$$RMSE = \sqrt{\frac{1}{N}\sum_{t=1}^{N}(y_t - \hat{y}_t)^2} \quad (4)$$

IV. Results and Discussion

A. Fitting Wage Growth on GDP

1) Descriptive Statistics

The minimum, maximum, sum, kurtosis, mean, and standard deviation values of the data under analysis are described using descriptive statistics. The results are presented in Table I.

TABLE I: Descriptive Statistics

Statistic	HK	PBW	PRT	GDP	EL
Mean	4.047958	8.094405	24.1640	4.059351	8.757950
Std. Dev.	3.225005	2.541191	4.590418	2.326112	5.499658
Kurtosis	3.369763	2.951074	3.191950	2.986832	3.002139

The mean of human capital from 1979 to 2019 was 4.04780 % each year with a standard deviation of 3.2250, which shows the variation of human capital from year to year. The means show where the center of the data is located, i.e., averages of the data sets. The standard deviation gives the information about how close or far from the mean are the values of the statistical data sets, i.e., how concentrated data are around the mean. The standard deviation of human capital is generally small, indicating that the values in the data sets were close to the mean on average. Generally, the values in the data sets were close to the mean on average within the study period. Kurtosis is a measure of tail behavior in a given distribution. From the Table 1, all the values are around 3 into two decimal places, indicating a mesokurtic behavior with a mean around zero resembling that of a normal distribution.

2) Lag Order Selection

Before conducting the unit root test, the first step was to find a suitable lag length by selecting the lag length with a corresponding p value of not greater 0.05. The best lag to use is selected as the minimum AIC or the lowest SBIC. If the SBIC and AIC differ, then AIC is chosen because it is superior. SBIC and AIC were used in this study since they reward goodness of fit as evaluated by the function of likelihood. The findings for the best lag are shown in Table II.

TABLE II: DESCRIPTIVE STATISTICS

Lag Order	Pr	AIC	SBIC	HQIC
0		24.0738	24.2915	24.1505
1	0.000	19.7892	21.9253	20.3497
2	0.000	19.1289*	21.0925*	20.2731*
3	0.017	19.5737	23.2198	20.9647
4	0.000	19.76964	23.768	20.8081

In this study, lag 2 was the best one to be used since it had the minimum AIC, HQIC and SBIC values.

3) Stationarity Test

To ascertain that the results of this research were not spurious, it was essential to examine if the data (time series) was stationary before conducting the analysis as indicated in the Table III.

TABLE III: STATIONARITY TEST RESULTS

Variable	ADFTest Statistic	Lag length	Level of Integration	MacKinnoncritical values (5%)	MacKinnon approximate p-value for Z(t)
LNHK	-4.847	2	I(1)	-2.964	0.0000
LNEL	-4.887	2	I(1)	-2.994	0.0000
LNPRT	-3.293	2	I(1)	-2.964	0.0152
LNPBW	-6.014	2	I(1)	-2.964	0.0000
LNGDP	-5.030	2	I(1)	-2.964	0.0000

At the level, the variables were determined to be non-stationary. To remove nonstationarity from the data, the method of differencing was used. The ADF values for all the variables were less than MacKinnon critical value at a 5 percent level of significant after the first difference as indicated in the Table 4. Therefore, the variables were stationary after their first differencing. Subsequently, the probability values of the corresponding variables were less than 0.05, indicating that the hypothesis (null) of no stationarity was rejected.

4) Granger Causality

The STATA output in Table IV presents the results of granger causality test of the variables under the study.

TABLE IV: GRANGER CAUSALITY TEST

Null Hypothesis	Obs	F-statistic	Prob
GDP does not Granger Cause HK	39	0.70310	0.0121
HK does not Granger Cause GDP	39	0.88384	0.0225
GDP does not Granger Cause PBW	39	0.65546	0.0206
PBW does not Granger Cause GDP	39	1.80842	0.0179
GDP does not Granger Cause PRT	39	2.11272	0.0136
PRT does not Granger Cause GDP	39	0.13884	0.0070
EL does not Granger Cause GDP	39	1.09065	0.0035
GDP does not Granger Cause EL	39	0.68300	0.0119
LNGDP does not Granger Cause LNWG	39	0.84973	0.0044
LNWG does not Granger Cause LNGDP	39	0.87709	0.0025

From Table IV, the p-value of GDP and PBW was 0.0206, which was less than 0.05, and therefore the null hypothesis was rejected. It was concluded that GDP Granger Cause PBW at a 5% significant level. The p-value of the second null hypothesis was 0.0179. Thus, the null hypothesis was rejected leading to the conclusion that public sector wages granger causes GDP. Similarly, all the components of wage growth granger cause GDP, and GDP granger cause all the components of wage growth. This showed that bidirectional causality existed among the two variables. This is supported by the p value of 0.0044 (between GDP and WG), which was less than a 5% significance level. Wage growth and GDP also had a p-value (lower) than 0.05, clearly showing that the two variables granger cause each other.

5) Cointegration Test

Table V shows the results of the Johansen Jusalius Cointegration test, which was used to determine if the variables were cointegrated.

TABLE V: JOHANSEN TESTS FOR COINTEGRATION

Maximum rank	Eigen value	Trace Statistic	Critical value (5%)
0		75.8629	68.52
1	0.59120	40.9762*	47.21
2	0.47122	16.1257	29.68
3	0.21862	16.1257	15.41
4	0.15253	6.5046	15.41
5	0.00128	0.0499	3.76

From the Trace statistic in Table V, the first null hypothesis zero or (None) from the column of the number of maximum rank (cointegrated equation) is stated as; H0: No cointegration among all the variables under the study. The null hypothesis was rejected since the Trace Statistic (75.8629) was greater than the 68.52 critical value. This implies that there existed a long-run relationship among the four variables, i.e., the variables were cointegrated. The second null hypothesis (1) states that; there is at least one cointegrated equations among the five variables under study. From table 5 above, the Trace Statistic of 40.9762* was less than the critical value (47.21); hence the null hypothesis was not rejected. Therefore, there was at least one cointegrated equation, that is, the four variables move together in the long run, and we can run the VECM model.

6) Vector Error-Correction Model

This section entails VECM and diagnostic test of the residuals as shown in Table VI and VII.

TABLE VI: VECTOR ERROR-CORRECTION MODEL

Maximum rank	Coef	Std. Err.	Z	p
D_lngdp_ce1(L1)	-0.5575	0.217589	-2.56	0.010
Intercept	0.0200	0.024327	0.82	0.009
LNPBW(L1)	-2.0208	1.280741	1.58	0.115
(L2)	-0.5647	0.984460	-0.57	0.586
LNPRT(L1)	0.9915	2.263191	0.44	0.661
(L2)	0.7654	2.167098	0.35	0.270
LNEL(L1)	-0.2537	0.778367	-0.33	0.744
(L2)	-0.1769	0.628078	-0.28	0.778
LNHK(L1)	-0.7468	1.426647	-0.52	0.601
(L2)	2.5660	1.700286	1.51	0.130
LNGDP(L1)	-0.2453	0.203083	-1.21	0.227
(L2)	-0.0513	0.184576	-0.28	0.781

TABLE VII: MODEL SUMMARY

Parameter	AIC	HQIC	SBIC	Log likelihood	RMSE	R-square
Statistic	-0.2953	0.6860	2.4628	69.6098	1.0039	0.7241

$$\Delta lnY_t = \alpha_{10} + \sum_{i=1}^{p} \alpha_{1i}\,\Delta lnY_{t-i} + \sum_{i=1}^{p} \alpha_{2\,i}\,\Delta lnPBW_{t-i} + \sum_{i=1}^{p} \alpha_{3\,i}\,\Delta lnPRW_{t-i} + \sum_{i=1}^{p} \alpha_{4\,i}\,\Delta lnHK_{t-i} + \sum_{i=1}^{p} \alpha_{5\,i}\,\Delta lnEL_{t-i} + \lambda_i \Phi_{t-1} + \acute{\varepsilon}_{1\,t} \quad (5)$$

$$\Delta lnY_t = 0.0200 - 0.0513\Delta lnY_{t-i} - 0.5647\Delta lnPBW_{t-i} + 0.7654\,\Delta lnPRW_{t-i} - 0.1769\Delta lnEL_{t-i} + 2.5660\Delta lnHK_{t-i} - 0.5575\,\Phi_{t-1} \quad (6)$$

In the short run, the constant term was 0.0200, which shows the level of GDP that doesn't depend on the dependent variables. All of the wage growth components had p values more than the 0.05 critical value, indicating that the effects of explanatory variables on the dependent variable were insignificant in the short-run. Public-sector wages, prate sector wages, employment elasticity, and human capital therefore had insignificant effects on GDP in the short run. The R^2 of (0.7241) showed that 72.4% of the variation of GDP was explained in the model while the remaining 27.6% was explained by other factors in the economy. From Table VI above, the error correction term, that is. ce1, was negative in sign and significance since the p-value (0.010) was less than 0.5 critical value. This implies that there is long-run causality running from private-sector wages, public sector wages, human capital, and employment elasticity to GDP.

7) Short Run Causality

To determine whether there existed a short-run causality among the variables, the null hypothesis of no short-run causality running from all components of wage growth to GDP was rejected if the p-value is less than 5% level of significance.

TABLE VIII: SHORT-RUN CAUSALITY

Vector Error-Correction Model	Equations	chi2(2)	p-value
Public Sector Wages on GDP	(1)[D_LNGDP]LD.LNPBW=0 (2)[D_LNGDP]L2D.LNPBW=0	3.58	0.1754
Private Sector Wages on GDP	(1)[D_LNGDP] LD.LNPRT= 0 (2)[D_LNGDP]L2D.LNPRT=0	3.70	0.4484
Employment Elasticity on GDP	(1) [D_LNGDP] LD.LNEL= 0 (2)[D_LNGDP]L2D.LNEL = 0	0.30	0.8628
Human Capital on GDP	1) [D_LNGDP] LD. LNHK = 0 (2)[D_LNGDP]L2D.LNHK= 0	3.09	0.2129

All the p values of the four independent variables were more than the 0.05 critical value, indicating that there was no short-run causality running from public sector wages, private sector wages, employment elasticity and human capital to GDP. In conclusion, there was no short run causality running from wage growth to GDP.

8) Long Run Causality

The long run equation of the VEC model is shown in Tables IX and X.

TABLE IX: COINTEGRATION / LOING RUN EQUATIONS

Equation	Chi2	p-value
_ce1	0.00128	0.0499

From the long-run equation where the error correction term was generated, the p-value of 0.000 implies that the (_ce1) is significant, implying that long-run causation between the variables exists. As shown in 3.6 above, there was long run causality running from all the wage growth components to GDP.

TABLE X: JOHANSEN NORMALIZATION RE FOR COINTEGRATION

	Coef.	Std. Err.	Z	p-value
_ce1(L1)LNGDP				
LNPBW	-5.4215	1.9365	-2.80	0.005
LNPRT	-6.8320	1.9862	-3.44	0.001
LNEL	2.6841	0.7130	3.76	0.000
LNHK	-0.2909	0.7461	-0.39	0.697
Cons	-17.2470			

$$ECT_{t-1} = [\alpha_{1i}Y_{t-i} - \alpha_{2\,i}PBW_{t-i} - \alpha_{3\,i}PRW_{t-i} - \alpha_{4\,i}HK_{t-i} - \alpha_{5\,i}EL_{t-i} - \alpha_{10}] \quad (7)$$

$$ECT_{t-1} = [1.000\,Y_{t-i} + 5.4215PBW_{t-i} + 6.8320\,PRW_{t-i} - 2.6841EL_{t-i} + 0.2909 + 17.2470] \quad (8)$$

In the long run, public sector wages had a positive significant impact on GDP whereby an increase in public sector wages by one unit lead to an increase in GDP by 5.4215 units. A unit increase in private sector wages will lead to 6.8320 units rise in GDP, and the relationship is also significant. Employment elasticity had a significant negative relationship on GDP in the Long run. GDP significantly decreases by 2.6841 units as employment elasticity changes by one unit. Human capital on the other hand had a positive insignificance effect on GDP in the long run as the p-value (0.697) was more than the 0.05 critical value. Finally, the constant term (17.2470) is the value of GDP that does not depend on wage growth in the long run. This study findings were in agreement with the previous researchers including the studies of [5], [8] who focused on the aspect of wage growth on economic growth. However, the findings were in contrast to study by [14]) who found that there exists a disconnection between government wages and economic growth in Japan and that government wages increase does not essentially entail significant labor productivity in an economy. In general, there was no short-run causality running from all the components of wage growth to GDP, but there exists a long-run causality running from wage growth to GDP during the study period.

9) Diagnostic Test for the Residuals

The residuals in this model were found to be normally distributed and also absence of autocorrelation in the VEC model.

B. Fitting GDP on Wage Growth

From the findings of this study, lag 2 was the best one to be used in the analysis since it had the minimum AIC and SBIC values. The ADF values for all the variables were less than MacKinnon critical values at the

5% level of significance after the first difference, and therefore all the variables were stationary after their first differencing. Additionally, all the p-values of net export, investment expenditure, government expenditure, consumption expenditure, and age growth were less than 0.05 implying that the null hypothesis of no Granger causality was rejected and concluded that GDP and wage growth Granger cause each other.

1) Cointegration Test

Johansen Jusalius Cointegration test was conducted to determine whether the variables under the study were cointegrated. The results were presented in the Table XI.

TABLE XI: JOHANSEN TESTS FOR COINTEGRATION

Maximum rank	Eigen value	Trace Statistic	Critical value (5%)
0		69.0861	68.52
1	0.56335	30.7701*	47.21
2	0.30816	16.4027	29.68
3	0.25246	5.0549	15.41
4	0.11919	0.1051	3.76
5	0.00128	0.0499	3.76

Vector error correction model was run since there existed at least one cointegrated equation. This was because the null hypothesis was not rejected as the Trace Statistic of 30.7701* was less than the critical value (47.21). All variables therefore move together in the long run, that is, there exist a long run relationship among the five variables (the variables are cointegrated).

2) Vector Error-Correction Model

This section involves VECM and diagnostic test of the residuals as shown below.

TABLE XII: VECTOR ERROR-CORRECTION MODEL

Maximum rank	Coef	Std. Err.	Z	P
D_lnwg_ce1(L1)	-0.2634328		-1.99	0.047
Intercept	0.0291117	0.0147775	1.97	0.049
LNPBW(L1)	0.6160813	0.4463026	1.38	0.167
(L2)	0.359372	0.4517027	0.80	0.426
LNPRT(L1)	0.2250354	0.1660899	1.35	0.175
(L2)	0.1665233	0.1647604	1.01	0.312
LNEL(L1)	0.6742099	0.9100147	0.74	0.459
(L2)	0.9619545	0.9030386	1.07	0.287
LNHK(L1)	0.0284048	0.0247852	1.15	0.252
(L2)	0.0151916	0.0280374	0.54	0.588
LNGDP(L1)	-0.3240082	0.2250817	-1.44	0.150
(L2)	0.2746015	0.206016	1.33	0.183

TABLE XIII: MODEL SUMMARY

Parameter	AIC	HQIC	SBIC	Log likelihood	RMSE	R-square	p-value
Statistic	-8.2270	-7.245733	-5.4690	220.3134	0.08363	0.7452	0.1390

$$\Delta lnWt = \alpha_{10} + \sum_{i=1}^{p} \alpha_{1i}\, \Delta lnW_{t-i} + \sum_{i=1}^{p} \alpha_{2\,i}\, \Delta lnNE_{t-i} + \sum_{i=1}^{p} \alpha_{3\,i}\, \Delta lnTI_{t-i} + \sum_{i=1}^{p} \alpha_{4\,i}\, \Delta lnCE_{t-i} + \sum_{i=1}^{p} \alpha_{5\,i}\, \Delta lnGE_{t-i} + \lambda_i \Phi_{t-1} + \acute{\varepsilon}_{1\,t} \quad (9)$$

$$\Delta lnWt = 0.0291 + 0.2746\Delta lnW_{t-i} + 0.0152\Delta lnNE_{t-i} + 0.1665\, \Delta lnTI_{t-i} + 0.9620\Delta lnCE_{t-i} + 0.3594\Delta lnGE_{t-i} - 0.2217674\, \Phi_{t-1} \quad (10)$$

The level of wage growth that doesn't depend on the GDP was 0.0291(constant term) in the short run. Net export had a positive insignificance effect on wage growth in the short run whereby an increase of net export by one unit leads to 0.0152 units increase in wage growth. A unit increase in total investment leads to insignificance rise in wage growth by 0.1665 units. Consumption expenditure insignificantly impacts wage growth positively in the short run. Additionally, wage growth rises by 0.9620 units per unit increase in consumption expenditure. Lastly, as government spending increases by one unit, wage growth insignificantly increases by 0.3594 units in the short run. The R^2 of (0.7452) indicates that 76.5% of the variation of wage growth was explained in the VEC model while the 23.5% was explained by other factors in the economy and hence GDP is a good predictor of wage growth. There existed a long run causality running from net export, total investments, government expenditure, and consumption expenditure to wage growth as shown by the error correction term.

3) Short Run Causality

The null hypothesis of no short-run causality running from all components of GDP to wage growth is rejected if the p-value was less than 5% level of significance (Table XIV).

TABLE XIV: SHORT-RUN CAUSALITY

Vector Error-Correction Model	Equations	chi2(2)	p-value
Government Expenditure on WG	(1) [D_LNWG] LD. LNGE=0 (2) [D_LNWG] L2D. LNGE=0	2.11	0.0348
Investment Expenditure on WG	(1) [D_LNWG] LD. LNIE =0 (2 [D_LNWG] L2D. LNIE = 0	2.48	0.0289
Consumption Expenditure on WG	(1) [D_LNWG] LD. LNCE =0 (2) [D_LNWG] LD2. LNCE = 0	1.36	0.0491
Net Export on WG	(1) [D_LNWG] LD. LNNE = 0 (2) [D_LNWG] L2D. LNNE =0	1.63	0.0443

All the p values of the four explanatory variables were less than the critical value of 0.05, implying that there existed short-run causality running from government expenditure, total investments, consumption expenditure and net export to wage growth.

4) Long Run Causality

Table XV indicated the error correction term was significance thus existence of long run causality among the variables under the study.

TABLE XV: COINTEGRATION / LOING RUN EQUATIONS

Equation	Chi2	p-value
_ce1	0.04	0.000

The long run equation of the VEC model is as shown in Table XVI.

TABLE XVI: JOHANSEN NORMALIZATION RE FOR COINTEGRATION

Coef.	Trace Statistic	Std. Err.	Z	p-value
_ce1(L1) LNW	1.000			
LNGE	-2.3067	0.6011737	-3.84	0.000
LNTI	-0.1674	0.0831107	-2.01	0.044
LNCE	-0.2874	0.0955058	-3.01	0.003
LNNE	-0.1085	0.037483	-2.90	0.004
Cons	-12.0484			

$$ECT_{t-1} = [\alpha_{1i}W_{t-i} - \alpha_{2\,i}NE_{t-i} - \alpha_{3\,i}TI_{t-i} - \alpha_{4\,i}CE_{t-i} - \alpha_{5\,i}GE_{t-i} - \alpha_{10}] \quad (11)$$

$$ECT_{t-1} = [1.000\,W_{t-I} + 0.1085NE_{t-I} + 0.1674TI_{t-I} + 0\,.2874CE_{t-I} + 2.3067GE_{t-i} + 12.0484] \quad (12)$$

From the long-run equation above, the value of wage growth that does not depend on GDP was12.0484, which is the constant term. Net export and wage growth had a significance positive relationship in the long run. This shows that, holding all the other factors constant, a unit increase in net export results in 0.1085 units significant increase in wage growth. Wage growth significantly increases by 0.1674 units per unit increase in total investment in the long run. Also, it was found that consumption expenditure had a positive significant effect on wage growth whereby an increase in consumption expenditure by one unit led to a rise in wage growth by 0 .2874 units. The findings of this study indicated that, as total investment increases by one unit, wage consequently rise by 0.1674 units. The relationship between wage growth and government spending was positive and significant in the long run, as indicated in Table XVI. A unit increase in government spending results in 2.3067 units rise in wage growth. This study findings were in consistent with the studies of [7], [15] who found significant relationship between government expenditure and economic growth. Generally, there exist both short and long run causality running from all the components of GDP to wage growth.

5) Model Comparison

The values of AIC, RMSE, R-Squared, HQIC, SBIC, and Log Likelihood that were employed to compare the models used in this study are listed in Table XVII.

TABLE XVII: JOHANSEN TESTS FOR COINTEGRATION

Parameter	AIC	RMSE	R-squared	HQIC	SBIC	Log likelihood
VECM1 (WG on GDP)	-0.2953	1.0039	0.7241	0.6860	2.4628	69.6098
VECM2 (GDP on WG)	-8.2270	0.08363	0.7452	-7.2457	-5.4690	220.3134

Based on the results from the table above, VECM 2 fitted the data better since it had the minimum values of RMSE, SBIC, HQIC and a larger log-likelihood and adjusted R squared values as compared to the VECM1. It was therefore found that GDP has a greater influence on wage growth both in the short and long run than wage growth has on GDP.

V. CONCLUSION

The study found that there existed a bidirectional causality between gross domestic product and wage growth data in Kenya using a VEC model. Based on the effects of wage growth on Kenya's GDP, there was only a long run causality running from the wage growth components to GDP. This is because when salaries of the Kenyan employees and especially the public sector workers are increased or decreased, the level of output may not change immediately. Some components of wage growth were statistically insignificant and also it may take time for the wage growth to have effect on GPD possibly due to failure in enhancing public sector efficiency. Furthermore, most workers in government parastatals and institutions appreciate having freedom, thus wasting much time, poor communications, management, the high rate of corruption and supervision which results in low productivity. As well, there has been an increase in the number of students enrolling in high learning institutions and many graduates in the country. However, due to low job opportunities in the economy and the presence of an unfavorable business environment, the level of economic growth may remain constant or even decrease.

The study established the short run, and long run causality running from GDP to wage growth in Kenya. As the government increases development expenditure, which generally increases real income and production of a country, more jobs are created, hence lowering the economy's level of unemployment. Thus, through proper management and investing in modern technology in the communication, energy, and transport sectors may enhance the economy's production capacity. Finally, it was concluded that the VECM is a better model in forecasting compared to other models like the multiple linear regression model because it distinguishes between short and long-run relationships among variables under the study.

VI. RECOMMENDATIONS

This study recommended that the government should control inflation, increase development expenditure to finance projects, adoption of new technologies in the communication, transport, and agricultural sectors, and creating a conducive business environment for Small and Medium-sized Enterprises (SMEs) to upsurge total output (productivity). This will, in turn, lead to a rise in wage growth, thus a high standard of living for the millions of unemployed Kenyans.

In addition, it was recommended that policymakers and researchers go a little further and focus on bidirectional causality among the two vital macro-economic variables rather than the assumption of unidirectional causality as it has been the trend previously. Scholars and researchers are encouraged to use VECM in their analyses since it is superior in distinguishing between short- and long-term relationships among the variables under consideration.

Effects of GDP using the income approach on wage growth in Kenya should be conducted so that the findings can exactly reflect how the two important macro-economic variables relate. The researchers should also use more variables on both GDP and wage growth components and a more extensive data set in analysis using the VEC mode

ACKNOWLEDGMENT

Above all I give all the glory and honor to the Almighty Lord for gifting me strength, wisdom, protection, endurance and really good health throughout the period of my studies and through this thesis. My heart felt gratitude goes to my mother Mrs Mburu, my sister Mary Wangari, and my brothers Daniel Kamau, and Kennedy Chege for their moral support, financial assistance and encouragement throughout the duration of my studies. Special appreciations to my supervisors Dr. Gladys Njoroge and Dr. Adolphus Wagala for their intellectual guidance and friendly support during the study. Their inspiration and positive criticisms have been quite important and their advice has molded me into a responsible scholar.

CONFLICT OF INTEREST

The author declares no competing interests.

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