

## **Macroeconomic Determinants of Inflation In Ghana: A Co integration Approach**

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### **Abstract**

This paper examined the macroeconomic determinants of inflation in Ghana using a cointegration approach. The main purpose of the paper is to investigate whether population growth, foreign direct investment, foreign aid, agricultural and service's output have a significance influence on the inflationary situations experienced in Ghana over the study period. The method of analysis was the cointegration analysis. The stationarity properties of all the variables of interest were checked and established. All the variables under consideration were found to be integrated of order one, that is,  $I(1)$ . Johansen cointegration approach showed that there is both long and short run relationship among the variables; therefore, the vector error correction model was estimated. The study identified population growth, foreign direct investment, foreign aid, and service's output as major long run determinants of inflation in Ghana.

**Key words:** Stationarity, Cointegration, Vector Error Correction Model, Inflation,

### **1. Introduction**

Since the existence of man and his quest for development and improvement in life conditions, the world over, has faced several macroeconomic problems like unemployment, over population, economic instability, poverty, to mention but a few. It must be pointed out however that, one of the most tormenting macroeconomic problems facing the world today is inflation which has been mainly characterised by several economic factors, termed as determinants of inflation, which happens within the confluences of time.

Europe has been characterised with the issue of inflation for several years now. For more than two decades the Turkish and Greek economies have been hit by high and persistent inflation. Also, in Asia (Pakistan), the depreciation of the exchange rate and the increase in the value of imports, shooting up of consumer price index (CPI), producer price index (PPI)

and gross domestic product (GDP) deflators have led to inflation. The increase in these deflators was because of the devastating floods that affected agricultural produce. Inflation in Paraguay (Americas) over the past fifteen years has been volatile because of the supply shocks, which do not reflect on aggregate demand pressures or imbalance in the money market.

In Africa, inflation is the major problem faced by countries like; Tanzania, Zimbabwe, Nigeria, and most importantly, Ghana. In the Zimbabwean economy, inflationary periods are highly characterised by nominal monetary growth (money supply), foreign prices; exchange and interest rates, unit labour costs and real income (Chibber et al, 1991). Inflation in Egypt is primarily affected by the rate of growth of money supply, interest rate, depreciation of the exchange rate and trade deficit (Helmy, 2010).

In the West African sub region, inflation has been one of the macroeconomic concerns, in the Nigerian economy, inflation has been one of the macroeconomic issues surrounding policy making on how to control its occurrence. It can also be said that inflation in the Nigerian economy is characterised by increase in money supply, huge government spending (budget deficits), external shocks, growth in domestic credit (bank credits), among other fiscal policies.

In Ghana, inflation has been one of the country's major macroeconomic problems since the late 1960s to the present day. The gradual increase of inflation in Ghana has been as a result of several military interventions and several other factors such as exchange rate depreciation, devaluation of the currency, increase in money supply to finance government deficits, among other fiscal policies. The country has, however, over the years been working towards reducing inflation rate, and is currently hovering in the single digit range as targeted.

Several empirical studies over the years have factored out the determinants of inflation. These studies largely focused on factors like currency depreciation, changes in consumer price index (CPI), money supply, producer price index (PPI), exchange and interest rates depreciation, external shock in the world commodity market, input cost of production, among other factors, as core determinants of inflation. However, these factors are not the only macroeconomic determinants of inflation in the world and probably Ghana. There are several other factors which might characterise inflationary conditions in Ghana. These other macro factors which will be considered in this study include population growth of a country, foreign direct investment, foreign aid, agricultural and the service outputs.

The main purpose of this study is to investigate whether population growth of a country, foreign direct investment, foreign aid, agricultural and service outputs also contribute to the inflationary situations experienced in Ghana over the study period (1964 – 2008). This study is significantly different because these variables (population size of a country, foreign direct investment, foreign aid, agricultural output and the services output), to some extent, have not been considered when it comes to the causes of inflation in Ghana. That is to say that this study bridges the literature gap on the subject matter under consideration.

The hypotheses of the study are as follows;

1. An increase in population size causes the general price level to increase.
2. An increase in foreign direct investment causes the general price level to increase.
3. An increase in foreign aid causes the general price level to increase.
4. An increase in agricultural output causes the general price level to fall.
5. An increase in service output causes the general price level to decrease.

This research paper is very important because it is to:

1. sensitise public policy makers to adopt a more convincing policy package that will aid in addressing inflationary conditions in Ghana.
2. serve as a guide to all stakeholders (both in the public and private sector) so as to know what to do per time, in combating this public enemy.
3. serve as an empirical guide to other researchers in other fields of study undertaking similar research.

## **2. Empirical Literature on the Determinants of Inflation**

Inflation is one of the macroeconomic problems facing both developed and developing economies in the world today. There is, however, practical evidences that show that inflation is everywhere a global phenomenon and it is the greatest concern of every economy in controlling the problems and as well stabilising the economy for a rapid economic growth and development.

In the Turkish economy, the study of the trend of inflation was focused on the demand-side determinants (e.g., monetary growth and budget deficits), and partially on some supply-side factors (e.g., nominal exchange rates and oil prices). An empirical study by Kibritçioğlu (2002) shows that the main causes of inflation in the Turkish economy was as a result of expansion of both fiscal and monetary policies by the Turkish government. According to him, the factors that characterise high and persistent inflation in Turkey are high public sector budget deficits; monetisation of public sector budget deficits, massive infrastructure investments of the various governments, such as for the Southeastern Anatolian Project; high military expenditures associated with geopolitical reasons; political instability which results in inflationary pressures due to populist policies that have ensued prior to each general election; persistent inflationary expectations of economic agents; inflationary effects of changes in exchange rates via increases in prices of imported inputs; occasional increases in world prices of major imported inputs (particularly, crude-oil); increases in regulated prices of public sector products which are mainly used as input by the domestic private sector, and/or rising interest rates resulting from the crowding-out effect of public sector borrowing in a shallow domestic capital market.

According to Yergin and Stanislaw (1997), history of the U.S. inflation can be dated back to 1971. In their study, it was found out that the U.S. inflationary periods were highly characterised by the Vietnam War and increased in domestic spending. It was also found out that the U.S. as at this time was running a balance of payment deficits and a trade deficit. There was also a rapid increase in the money supply by 10% in the first six months of 1971. There was also a fall in the value of the U.S. dollar to about 7.5% with respect to other currencies like the Deutsche Mark of Germany. Other factors such as external shocks, emanating from oil price increase, increase in the price of domestic goods and services as well as increase in labour costs. Thus, it can be concluded that inflation in the U.S., then and now, is highly characterised by expansionary monetary and fiscal policy.

Inflation in Australia has been “sky-scraping” since the early 1970s, both in absolute terms and relative to other industrial market economies. Although the costs of this inflation have been difficult to quantify, most economists and policy makers agree that decreasing the rate of inflation ought to be one of the leading priorities for macroeconomic policy (Fahrer and Myatt, 1991). Furthermore, they indicated that causes of inflation in the Australian economy can be attributed to nominal wage growth, leading to a significant increase in money supply in the economy, and inflation. They then recommended that policy to reduce the inflation will

have the desired effect only after the elapse of a considerable period of time, and that aggregate nominal wage growth should be reduced commensurately.

Egypt, like most countries in the world, faces the problem of inflation. A research carried out by E. Helmy (2010) analyzed the dynamics of inflation in Egypt by investigating the importance of the different sources of inflation over the past thirty years and to detect the impact of Egypt's chronic trade deficit on inflation in Egypt. In his model, he used the Granger causality tests, a variance autoregressive (VAR) model, impulse response functions (IRF) and variance error decomposition (VDC) analyses to test for the sources and dynamics of inflation in Egypt. Results of his test proved that inflation in Egypt is primarily affected by the rate of growth of money supply, interest rates, and exchange rate depreciation, leading to trade deficits. He then recommended that if Egypt wants to boost its industrial export capacity and diminish its trade deficit gap, depreciation of the exchange rate, and then indirectly stabilising it at less than the market equilibrium exchange rate as in the case with China, should be considered. Accordingly, he added that important policy implication may be that depreciation of the pound and then stabilising it at a constant below market equilibrium exchange rate through indirect measures although might boost inflation and aggravate the trade deficit in the short run, yet it decreases them in the long run (Helmy, 2010).

The Republic of Tanzania, consisting of mainland Tanzania and Zanzibar, has one of the lowest per capita incomes in Africa and a rapidly increasing population which currently stands at 30 million. According to Laryea and Sumaila (2001), the short-run output and monetary factors are the main determinants of inflation in Tanzania. They also pointed out that in the long-run, parallel exchange rate also influences inflation coupled with increase in budget and external current account deficits. In their conclusion, they emphasised that inflationary situations in Tanzania are fundamentally a monetary and fiscal phenomenon.

An empirical study into the field (inflation) was conducted on the Zimbabwean economy. Based on this study, Chibber et al (1989) developed a detailed econometric model of inflation for Zimbabwe. They included both the Structuralists and Monetarists factors of inflation in their model. In their study, they reviewed that nominal monetary growth (money supply), foreign prices; exchange and interest rates, unit labour costs and real income are the determinants of inflation in the Zimbabwean economy.

Egwaikhide et al (1994) tried to establish the direct linkage between exchange rate depreciation, budget deficits and inflation. Their focus was on these key areas; trends in inflation, budget deficit, monetary growth, growth in real gross domestic product (real GDP) and exchange rate during the period (1970 – 1989). In their verification, Egwaikhide et al (1994) established that growth in the central government expenditure eventually led to persistent budget deficits. These deficits were, however, financed through money creation. They also included in their work that there were increases in domestic credit to the government which had two direct effects; it expanded aggregate demand and secondly, it accelerated the growth of domestic money supply. Subsequently, there was an increase in imports as a result of the upsurge in aggregate demand that could not be met by the available supply in the economy (Egwaikhide et al (1994)). They, however, concluded that inflation in Nigeria is caused by both monetary and structural factors.

A research was carried out by Appiah and Boahene (2007) to analyse inflation in Ghana. The main purpose of their study was to determine the major determinants of inflation in Ghana and to know whether inflation is a real sector issue or a monetary issue. They used the ordinary least squares econometric method for their data analysis. In their work, it was observed that inflationary conditions in Ghana can be attributed to factors such as military

interventions during the post-independence era, the growth rate of real GDP, increase in money supply to finance government deficits, devaluation of the currency, exchange rate differentials, and fiscal policy expansion. They recommended that the central bank of Ghana should be independent in controlling the rate of money supply and the government should as well practice inflation targeting as a measure of controlling inflation in Ghana.

Ocran (2007) employed the Johansen co-integration test and an error correction model to analyze inflationary trends in Ghana for over forty years. His paper identified inflation inertia, changes in money and changes in the government of Ghana Treasury bill rates, as well as changes in the exchange rate, as determinants of inflation in the short run. According to him, inflation inertia was found to be the dominant determinant of inflation in Ghana. He, therefore, suggested that to make Treasury bill rates more effective as a nominal anchor, inflationary expectations ought to be reduced considerably.

From the above analysis, it can be seen that most studies conducted concentrated on variables like exchange rates, money supply, inflation inertia, interest rate and currency depreciation as major determinants of inflation in Ghana which the government is closely particular about. In this research work, however, the study seeks to find other causes of inflation apart from those stated above (exchange rates, money supply, inflation inertia, interest rate, currency depreciation). These other variables are population growth, foreign direct investment, foreign aid, agricultural output and service output. The time structures for this research will be a period of over forty-five years which is from 1964 - 2008.

### 3. Research Methodology

#### 3.1 Specification of the Model

Many factors affect the general price increment of a particular country. Some of these factors are interest rates, exchange rates, money supply, input cost (like wages), and depreciation of domestic currency, among others. However, this study seeks to determine whether population growth, foreign direct investment, foreign aid, agricultural output and service output are likely factors that can cause inflation in Ghana. In order to achieve this objective, the model specification by Appiah and Boahene (2007) stated as  $P_t = \beta_0 + \beta_1 M_t + \beta_2 Y_t + \dots + \varepsilon_t$ , was followed; where:  $P_t$  = inflation,  $M_t$  = money supply and  $Y_t$  = real GDP.

Thus, the model specification of this study is given as:

$$\pi = f(\text{Pop}, \text{FDI}, \text{FAid}, \text{AQ}, \text{SQ}) + \text{error}, \text{ where:}$$

$\pi$  = general price level measured as the change in CPI.

Pop = population size measured as population growth rate.

FDI = foreign direct investment measured as FDI as % of GDP.

FAid = foreign aid measured as foreign aid as % of GDP.

AQ = agricultural output measured as agriculture value added as % of GDP.

SQ = service output measured as service value added as % of GDP

It is expected that by the end of the study the following sign of the coefficients would have been achieved; population size (+), foreign direct investment (+ or -), foreign aid (+), agricultural output (-) and service's output (-). These expected signs were formed on the basis of observation, empirics and economic theory. The type of data to be used for the study is mainly a secondary macroeconomic time series data. The study will focus on the time frame from (1964 – 2008). Thus, the sample size of the study is 45 which meet the central limit theory. These years were chosen because this is the periods that the Ghanaian economy started experiencing some level of economic expansion. The sources of data of the study are

from Ghana Statistical Service, World Bank National Account Data, OECD National Account Files and World Development Indicators.

**3.2 Method of Estimation**

First, the stationarity properties of all the variables of interest were established using the Augmented Dicky Fuller (ADF) Test. The reason is that the ADF test is considered superior to the Dicky Fuller (DF) test since it adjusts appropriately for the occurrence of serial correlation. Thus, it avoids spurious regression results. Secondly, if the time series have the same order of integration, then, the cointegration regression as seen above will be estimated in order to examine whether there is long run equilibrium relationship between the dependent variable ( $\pi$ ) and the independent variables (Pop, FDI, FAid, AQ, SQ). The long run equilibrium relationship between the dependent variable ( $\pi$ ) and the independent variables will be expressed as

$$\pi - b_1Pop - b_2FDI - b_3FAID - b_4AQ - b_5SQ = 0$$

Therefore, the coefficient must be transformed accordingly. The stationarity of the residuals/error obtained from the Cointegration regression of the dependent variable ( $\pi$ ) on the independent variables (Pop, FDI, FAid, AQ, SQ) has to be tested using the ADF test with trend and intercept which is commonly used in estimation.

Thirdly, if there is the presence of Cointegration between the dependent variable ( $\pi$ ) and the independent variables (Pop, FDI, FAid, AQ, SQ), then, it is possible to investigate the short run (equilibrium or disequilibrium) relationship between the dependent variable and the independent variables. The Error Correction Model (ECM) for the dependent variable is based on the following dynamic short run equation:

$$\Delta\pi_t = b_0 + b_1\Delta pop_t + b_2\Delta FDI_t + b_3 \Delta FAid_t + b_4\Delta AQ_t + b_5\Delta SQ_t + b_6EC_{t-1} + \epsilon_t$$

where  $EC_{t-1}$  is the error correction term which is supposed to be negative in sign and significant.

**4. Empirical Results and Discussion**

The introductory analysis of the variables is shown in table 1 below. This table shows the summary statistics of all variables used in this study. From the table, the average inflation is 21.18% still high with 37.68 standard deviation. The average population growth is 2.54, while foreign direct investment as a percentage of GDP, foreign aid as a percentage of GDP, agricultural output as a percentage of GDP and service output as a percentage of GDP are 1.64, 6.77, 44.36 and 36.17, respectively. The skewness is a measure of departure from symmetry. From the table, all the variables are positively skewed with the exception of service output. Kurtosis is the measure of peakness or flatness of the data relative to the normal distribution. From the table, the coefficients of the kurtosis of the variables show that inflation and foreign direct investment have peakness or lapto kurtic while the other variables have flat or plato-kurtic except service output which is almost normally distributed. The skewness and the kurtosis together determine whether a random variable follows a normal distribution or not.

**Table 1: Descriptive Statistics of the Variables under Consideration**

Sample: 1964 2008						
	CPI	POP	FDI	FAID	AQ	SQ
Mean	21.18367	2.540279	1.637160	6.770460	44.36313	36.17237
Median	1.293454	2.532426	1.259734	6.184520	44.77906	37.52530

<b>Maximum</b>	143.1118	3.523618	7.945576	16.17922	60.71400	41.73098
<b>Minimum</b>	0.002475	1.679486	-0.660352	1.179786	32.21282	27.25995
<b>Std. Dev.</b>	37.67781	0.431811	1.777522	4.140689	7.956266	3.586926
<b>Skewness</b>	1.884124	0.209992	1.547601	0.393873	0.434003	-1.038802
<b>Kurtosis</b>	5.401548	2.700594	5.679281	1.904100	2.199251	3.156629
<b>Jarque-Bera</b>	37.43836	0.498807	31.42280	3.415387	2.614936	8.139327
<b>Probability</b>	0.000000	0.779266	0.000000	0.181283	0.270504	0.017083
<b>Sum</b>	953.2651	114.3125	73.67220	304.6707	1996.341	1627.756
<b>Sum Sq. Dev.</b>	62463.17	8.204287	139.0217	754.3934	2785.296	566.1056
<b>Observations</b>	45	45	45	45	45	45

Table 2 below shows the least square regression of the variables at level. The result shows that the value of the coefficient of determination,  $R^2$ , exceeds the value of Durbin Watson statistics,  $d$ , (that is  $R^2 = 0.6197 > d = 0.4889$ ). This shows that the regression is a spurious one, therefore, the Augmented Dickey-Fuller (ADF) test will be used to check for stationarity of the variables to determine the order of integration.

**Table 2: The Least Square Regression**

**Dependent Variable: CPI Method: Least Squares Sample: 1964 2008 Included observations: 45**

Variable	Coefficient	Std. Error	t-Statistic	Prob.
<b>C</b>	-55.05960	110.8312	-0.496788	0.6221
<b>POP</b>	-19.65382	12.05573	-1.630247	0.1111
<b>FDI</b>	10.93116	3.252916	3.360418	0.0018
<b>FAID</b>	3.706635	1.117597	3.316611	0.0020
<b>AQ</b>	0.448902	1.129759	0.397343	0.6933
<b>SQ</b>	1.748934	2.255817	0.775300	0.4428
R-squared	0.619698	Mean dependent var		21.18367

Adjusted R-squared	0.570941	S.D. dependent var	37.67781
S.E. of regression	24.67995	Akaike info criterion	9.373425
Sum squared resid	23754.90	Schwarz criterion	9.614314
Log likelihood	-204.9021	F-statistic	12.70999
Durbin-Watson stat	0.488853	Prob(F-statistic)	0.000000

Table 3 shows the results of the ADF test for the variables under consideration. From the table, all the variables are not stationary at level, not even at 10 percent level of significance. However, foreign direct investment, foreign aid, agricultural output and service output are stationary at first difference at 5 percent level of significance while inflation and population growth are significant at 10 percent level of significance without constant and trend. Therefore, all the variables, inflation, CPI, foreign direct investment (FDI), foreign aid (FAID), agricultural output (AQ) and service output (SQ), are integrated at first order [I(1)]. As a result, the Johanson's cointegration approach can be used to determine the number of cointegrating equation.

**Table 3: The results of Augmented Dickey-Fuller test (ADF) for unit root.**

Variable	None			Constant			Constant and Trend		
	Level	1st difference	Conclusion	Level	1st diff	Conclusion	Level	1st diff	Conclusion
	t-obs	t-obs		t-obs	t-obs		t-obs	t-obs	
CPI	-0.5654	-1.7720**	I(1)	-0.5901	-1.4905	I(1)	-0.6531	-1.1236	I(1)
POP	-0.2117	-1.6394**	I(1)	-2.2945	-1.6042	I(1)	-1.5668	-2.2042	I(1)
FDI	-0.2164	-7.0985*	I(1)	-0.9142	-7.0827*	I(1)	-1.3638	-7.6285*	I(1)
FAID	-0.3725	-8.8090*	I(1)	-1.5218	-8.7337*	I(1)	-2.3697	-8.7617*	I(1)
AQ	-0.5558	-6.7951*	I(1)	-0.4205	-6.7466*	I(1)	-1.9985	-7.2570*	I(1)

SQ	0.0140	-5.9544*	I(1)	-	-	I(1)	-2.9727	-	I(1)
				1.8579	5.8850*			6.0274*	

\* significant at 5 percent      \*\* significant at 10 percent

Note: The null hypothesis is that the variable has a unit root. The rejection of the null hypothesis for ADF test is based on the Mackinnon (1996) critical values at 5 or 10 percent.

Vector Autoregressive, VAR, is used to determine the optimal lag length for the Johanson cointegration test which is based on the AIC and SBC as shown in table 4. From the result, the optimal lag length based on AIC and SBC are 4 and 3 respectively. Using the selected optimal lag length of 4, the likelihood ratio test, which depends on the maximum Eigen values of the stochastic matrix of the Johanson (1991) procedure for exploring the number of cointegrating vectors was used.

**Table 4: Selection of Optimal Lag Length**

**VAR Lag Order Selection Criteria**

**Endogenous variables: CPI POP FDI FAID AQ SQ**

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-600.2306	NA	280693.8	29.57222	29.82299	29.66354
1	-353.2529	409.6215	9.714602	19.28063	21.03600	19.91984
2	-282.6580	96.42235	2.016996	17.59307	20.85304	18.78017
3	-200.3826	88.29553*	0.291508	15.33574	20.10030*	17.07073
4	-144.3910	43.70077	0.227318*	14.36054*	20.62970	16.64342*

\* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

Table 5 shows the results for cointegrating test. From the table, the Maximum Eigenvalue statistics show that there are five (5) cointegrating vectors at 5 percent level of significance. The null hypothesis of zero cointegrating vector is rejected against the alternative of one cointegrating vector. Similarly, the null hypothesis of at most 1, at most 2, and at most four cointegrating vectors are also rejected against the alternative hypothesis. Therefore, it is concluded that there are five cointegrating vectors specified in the model.

**Table 5: Unrestricted Cointegration Rank Test (Maximum Eigenvalue)**

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.990082	184.5351	40.07757	0.0001
At most 1 *	0.902132	92.96542	33.87687	0.0000
At most 2 *	0.774017	59.49178	27.58434	0.0000
At most 3 *	0.499087	27.65293	21.13162	0.0052
At most 4 *	0.433885	22.75829	14.26460	0.0018

At most 5      0.080701      3.365736      3.841466      0.0666

Max-eigenvalue test indicates 5 cointegrating eqn(s) at the 0.05 level

\* denotes rejection of the hypothesis at the 0.05 level

\*\*MacKinnon-Haug-Michelis (1999) p-values

Table 6 below shows the result of the coefficient of  $\beta$  matrixes in terms of normalised cointegrating coefficient of first equation. This result shows that the long run relationship among the variables. All the variables turn out to be significant and have the expected signs except service output, SQ, which is positive. From the results, population growth, POP, has direct impact on inflation. This shows that as population growth increases by a unit, inflation also increases by 4.2 units. This means that as population keeps on increasing, and as their purchasing power also increases without any increase in the aggregate supply of goods and services in the Ghanaian economy, aggregate demand will be greater than aggregate supply, hence, inflation. Foreign direct investment, FDI, influenced inflation negatively; as a result, a unit increase in foreign direct investment will cause inflation to decline by 21.3 units. This further means that Ghana might be enjoying from the spillover effect of FDI such as technological advancement which has enabled her to increase the supply of goods and services. Hence, the reduction in the general price level as foreign direct investment increases.

Foreign aid, FAID, also influenced inflation negatively. From the table 6, a unit increase in foreign aid will cause inflation to decrease by 3.4 units. This implies that the foreign aids that Ghana receives are being put into the productive sectors of the economy like the Agriculture sector which has expanded the aggregate supply of output and hence, a reduction in the general price level as foreign aid increases. Agricultural output has the expected impact on inflation. From the table, an increase of one unit in agricultural output causes inflation to fall by 0.2 unit. From economic theory, it has been established that as aggregate output increases more than aggregate demand, the general price level will fall. Such is the situation seen from this result.

Finally, service output has a positive effect on inflation. As a result, increase in service output leads to increase in inflation. From the table 6, a unit increase in service output will cause inflation to increase by 6.6 units. This might be due to the fact that, the production cost in the service sector is too high. As a result some amount of the production cost is shifted to the consumer which result in an increase in the general price, hence, inflation. The service output has more positive impact on inflation as compared to agric output. The study concludes that in the long run, population growth, foreign direct investment, foreign aid and service output are significant determinants of inflation in Ghana. While increase in population growth and service output caused inflation to increase, increase in foreign direct investment, foreign aid and agricultural output leads to a decline in inflation in the long run.

**Table 6: Normalised Cointegrating Coefficients: 1 Cointegrating Equation(s)**

Variables	Coefficients	Standard Errors	T – Statistic
POP	4.1723	1.4201	2.938033
FDI	-21.2944	1.0253	-20.7689
FAID	-3.412	0.1821	-18.737
AQ	-0.2121	0.1571	-1.3501
SQ	6.6157	0.2532	26.12836

The stationarity of the residuals/error obtained from the cointegration regression of the dependent variable ( $\pi$ ) on the independent variables (Pop, FDI, FAid, AQ, SQ) has been tested using the ADF test. The result is shown in table 7. From the table, the residuals/error term is stationary with trend and intercept at level.

**Table 7: Testing for the stationarity of the residuals/error**

Variable	None	Constant	Constant and Trend	Conclusion
	t-obs	t-obs	t-obs	
residuals/error	-1.5704	-1.5309	-5.2290	I(0)

The short run dynamics among the variables are explored by employing vector error correction model (VECM). Error correction model allows the introduction of previous disequilibrium as independent variables in the dynamic behaviour of existing variables. Table 8 presents the short run dynamic relationship and the set of short run coefficients in the vector error correction model. VECM associates the changes in inflation to the change with the other lagged variables and the disturbance term of lagged periods. The coefficient of the speed of adjustment is positive and significant at 10 percent. This shows that there is 1.2 percentage point explosion taking place each year towards the long run period. In the short run, the past two years inflation has a significant impact on the current inflation. From table 8, if the past two years inflation increases by a unit, the current inflation will increase by 0.57 unit. Also, the past first and third years of inflation impact positively on the current inflation. From the table, past records of population growth and foreign direct investment have positive and negative impact on current inflation. However, they are not statistically significant. The past records of foreign aid and service output have positive effect on inflation while past records of agricultural output impacts negatively on the inflation as expected. However, they are not significant in the short run.

**Table 8: The Result of Error Correction Model for Short Run Dynamics**

Error Correction: D(CPI)			
Variables	Coefficients	Standard Errors	T – Statistic
The speed of adjustment	0.012222	(0.00730)	[ 1.67393]
D(CPI(-1))	0.041140	(0.23676)	[ 0.17376]
D(CPI(-2))	0.574038	(0.18060)	[ 3.17847]
D(CPI(-3))	0.332179	(0.24490)	[ 1.35640]
D(POP(-1))	-10.3472	(13.2658)	[-0.77999]
D(POP(-2))	14.69923	(21.3222)	[ 0.68939]
D(POP(-3))	-7.12331	(13.3640)	[-0.53302]
D(FDI(-1))	-1.10767	(0.93325)	[-1.18690]
D(FDI(-2))	0.026492	(0.78052)	[ 0.03394]
D(FDI(-3))	0.280676	(0.55747)	[ 0.50349]
D(FAID(-1))	0.160846	(0.20918)	[ 0.76893]
D(FAID(-2))	0.111655	(0.25749)	[ 0.43363]
D(FAID(-3))	0.081147	(0.24214)	[ 0.33512]
D(AQ(-1))	-0.27587	(0.27250)	[-1.01237]
D(AQ(-2))	-0.0173	(0.22786)	[-0.07592]

<b>D(AQ(-3))</b>	-0.17187	(0.20022)	[-0.85841]
<b>D(SQ(-1))</b>	0.125025	(0.32607)	[ 0.38343]
<b>D(SQ(-2))</b>	0.224036	(0.33639)	[ 0.66600]
<b>D(SQ(-3))</b>	0.228410	(0.27573)	[ 0.82838]
<b>C</b>	1.000942	(0.52790)	[ 1.89607]
<b>R-squared: 0.909586 Adj. R-squared:0.827782 F-statistic: 11.11915</b>			

Granger (1996) causality test was performed in order to examine the linear causation between the concerned variables. Granger causality is useful in determining the direction of the relationships. The test is based on the model specified below.

$$Y_t = \alpha_0 + \sum_{j=1}^m \beta_j Y_{t-j} + \sum_{i=1}^n \delta_i X_{t-i} + \mu_t,$$

If  $X_t$  Granger causes  $Y_t$ , then, the current values of  $Y_t$  are determined by past values of  $X_{t-1}$ . The test of  $H_0: \delta_i = 0$ , can be carried out with the F- test. In the view of Granger, the presence of cointegration vector shows that Granger causality must exist in at least one direction. We used the optimum lag length of variables based on AIC, which is  $k=4$  in this analysis. Table 9, presents the results of the Granger casualty test. From the table, the result shows that there is unilateral directional causality between foreign aid and foreign direct investment, foreign direct investment and agricultural output. Also, there is bidirectional causality between foreign direct investment and inflation, agricultural output and population growth.

**Table 9: The Results of Granger Causality Test**

<b>Pairwise Granger Causality Tests, Sample: 1964 2008, Lags: 4</b>			
<b>Null Hypothesis:</b>	<b>Obs</b>	<b>F-Statistic</b>	<b>Probability</b>
POP does not Granger Cause CPI	41	0.12122	0.97389
CPI does not Granger Cause POP		0.86713	0.49425
FDI does not Granger Cause CPI	41	3.91023	0.01073
CPI does not Granger Cause FDI		7.63611	0.00019
FAID does not Granger Cause CPI	41	0.45019	0.77146
CPI does not Granger Cause FAID		1.30740	0.28823
AQ does not Granger Cause CPI	41	1.38520	0.26114
CPI does not Granger Cause AQ		0.36698	0.83031
SQ does not Granger Cause CPI	41	0.50543	0.73199
CPI does not Granger Cause SQ		0.93475	0.45632
FDI does not Granger Cause POP	41	0.96156	0.44193
POP does not Granger Cause FDI		0.50915	0.72935
FAID does not Granger Cause POP	41	1.18280	0.33704
POP does not Granger Cause FAID		1.84230	0.14501
AQ does not Granger Cause POP	41	3.28381	0.02305
POP does not Granger Cause AQ		2.44286	0.06674
SQ does not Granger Cause POP	41	1.49649	0.22654
POP does not Granger Cause SQ		1.52964	0.21710

FAID does not Granger Cause FDI	41	5.35786	0.00203
FDI does not Granger Cause FAID		0.83470	0.51326
AQ does not Granger Cause FDI	41	1.07744	0.38397
FDI does not Granger Cause AQ		0.68896	0.60496
SQ does not Granger Cause FDI	41	0.33112	0.85497
FDI does not Granger Cause SQ		0.81240	0.52664
AQ does not Granger Cause FAID	41	0.60269	0.66346
FAID does not Granger Cause AQ		4.37691	0.00618
SQ does not Granger Cause FAID	41	0.58621	0.67492
FAID does not Granger Cause SQ		1.82264	0.14875
SQ does not Granger Cause AQ	41	2.21554	0.08945
AQ does not Granger Cause SQ		0.84481	0.50727

## 5. Conclusion and Policy Recommendations

The study is an attempt to examine the macroeconomic determinants of inflation in Ghana using cointegration approach. The empirical analysis is based on time series econometrics. It is found in the current study that all variables; inflation, population growth, foreign direct investment, foreign aid, agricultural output and service output, turned out to be non stationary at their level but become stationary at their first difference. The results of Johansens's cointegration test indicates that there exist a long run and short run relationship between inflation, population growth, foreign direct investment, foreign aid, agricultural output and service output in Ghana.

The study finds that in the long run, population growth and service output affect inflation positively (that is, as population growth and service output increase, inflation also increases). However, foreign direct investment, foreign aid and agricultural output impact negatively (that is, as foreign direct investment, foreign aid and agricultural output increase inflation declines). However, in the short run, the past two years inflation has a significant impact on the current inflation. Again, the past one year and third years of inflation impact positively on the current inflation. The population growth and foreign direct investment's past records have both positive and negative impact on current inflation. However, they are not significant. The past records of foreign aid and service output have positive effect on inflation while past records of agricultural output impact negatively on the inflation as expected. However, they are not significant. The Granger Causality test shows that there is unilateral directional causality between foreign aid and foreign direct investment, foreign direct investment and agricultural output. Also, there is bidirectional causality between foreign direct investment and inflation, agricultural output and population growth.

Finally, the following policy recommendations are made based on the findings:

- i. Policies should be put in place to increase the aggregate supply side of the economy, Ghana, since population size keeps on increasing.

- ii. Massive education on the use of birth control methods should be made. More women should be encouraged to go to school and be in businesses. This will help check the population growth rate,
- iii. More foreign investors should be allowed into the country through the creation of an enabling environment for them to operate, especially in the Agricultural sector.
- iv. More foreign aid received should be channeled into our Agricultural sector and trained personnel into the Agricultural sector should be encouraged to stay in that field and not somewhere else.
- v. Production cost at the service sector should be reduced.

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