Tec Empresarial
P-ISSN: 1659-2395; E-ISSN: 1659-3359

INFLATION DYNAMICS IN GHANA OVER THE 1970-2003 PERIOD

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Abstract

In this paper we applied the theoretical model developed by Fullerton in 2004 to analyze inflationary dynamics in Ghana. The nature of the time series data led to the use of an error-correction approach to analyze the relationship among price level, money supply, price of imported inputs and wage levels. Cointegration analysis suggests that price level has a long-run relationship with money supply, price of imported inputs and wage levels. The error correction results for the price equation provide evidence that inflation in Ghana over the 1970 -2003 period has been significantly determined by money supply. The policy advice is that money supply should serve as one main target of curbing inflation Ghana.

Keywords: Inflationary dynamics, Error-correction. Cointegration analysis, Ghana

1: Background

In many developing economies, managing a stable price environment is a challenging policy issue faced by monetary authorities (Fullerton, 2004). Unstable prices create uncertainty, hinder investment, and increase business costs, thereby impeding economic growth. Consequently, there is a widespread need to comprehend the dynamics of inflation in any country of interest. By permitting more effective operations within an economy, a stable price environment is widely regarded as an essential first step towards improving economic welfare. Short-term price stabilization frequently takes center stage in government policy efforts worldwide, despite the fact that the exact disinflation goals stated by monetary authorities may differ. Maintaining a stable price environment becomes one of the core goals of central bank policies when inflation is relatively low. Understanding the nature of price changes is crucial to achieving these objectives in both cases.

Over the past forty years, Ghana has faced the challenge of high and fluctuating inflation rates in its macroeconomy. The period of political turbulence in the 1970s and early 1980s was marked by severe and volatile inflation. Despite the country's gradual economic recovery since 1983, inflation has continued to persist. While there has been some improvement in recent years with lower and relatively stable inflation, Ghana still experiences high inflation rates compared to many other countries (McKay and Sowa, 2004).

Available evidence suggests that inflation in Ghana is primarily driven by monetary factors (Ewusi, 1997). The expansion of the money supply has been influenced by significant government domestic borrowing. For instance, in 1996 and 1997, the domestic financing of government deficits by the Bank of Ghana constituted 18.5% and 29.9% of the money supply, amounting to ¢225 million and ¢5279 million, respectively (Kinful, 2004).

This paper examines Ghana's inflationary dynamics using a theoretical modeling framework created by Fullerton in 2004 and designed primarily for developing nations. The model incorporates factor costs of production, such as labor and imported inputs, in a mathematically consistent manner. The paper is divided into eight sections, beginning with the study's context. The inflation theories, empirical studies, methodology, data sources, and empirical investigations of inflation in Ghana are covered in the succeeding parts, which also cover policy recommendations.

2: Theories of Inflation

Many theoretical ideas have been put out to explain the causes of inflation. A summary of a few of these theories can be found in this section.

2.1: Demand-Pull Inflation Theory

The demand-pull inflation hypothesis states that inflation happens when aggregate demand increases more quickly than the underlying level of supply. A rise in aggregate demand can result from a number of factors, including higher consumer spending, lower interest rates, tax breaks, or boosted consumer confidence. Corporate investment, government spending, and the balance of exports and imports also influence aggregate demand. The aggregate supply curve's shape, which varies between economists of the Keynesian and Classical schools of thought, determines how a shift in aggregate demand would affect the economy.

2.2: The Classical Theory

In order to reach full employment equilibrium, classical economists support a laissez-faire economy that emphasizes free markets and self-adjustment. They think that government action is not necessary to manage the economy toward full employment. Their point of view is predicated on the notion that the labor market functions effectively. If the economy is below full employment, excess labor results in lower wages, which encourage businesses to hire more workers and raise the level of employment to full. The classical economists contend that attempts to increase aggregate demand through reflationary policies will ultimately only lead to inflation. They focus on the Quantity Theory of Money, which suggests that increases in the money supply lead to inflation.

2.3: The Keynesian Theory

Keynesian economists, in contrast, contend that the labor market does not function perfectly. They argue that wages are sticky downwards, meaning that unemployment does not necessarily lead to lower wages. To reduce unemployment, Keynesians advocate for government intervention to boost demand sufficiently and stimulate employment. They assert that the long-run and short-run aggregate supply curves are identical, and reducing unemployment requires reflationary policies to increase demand. Unlike the classical view, Keynesians consider expectations and active intervention as essential components.

2.4: Cost-Push Inflation Theory

Cost-push inflation theorists argue that inflation occurs when costs increase independently of aggregate demand. For example, if trade unions exert greater power and negotiate higher wages, it leads to cost-push inflation. Rising costs can also result from firms gaining more market power and raising prices to increase profits. Factors such as increased import costs, commodity price changes, external shocks, depletion of natural resources, and changes in indirect taxes can all contribute to cost-push inflation.

2.5: Phillips Curve Theory

The Phillips Curve, initially discovered by Phillips in the 1950s, suggested a trade-off between unemployment and inflation. This relationship seemed to support Keynesian policies. However, in the 1970s, the curve broke down as stagflation emerged, with rising inflation and unemployment occurring simultaneously. This posed challenges for governments and perplexed economists seeking to explain the situation.

2.6: The Monetarist Theory

Milton Friedman, a monetarist economist, presented an influential explanation of inflation. He developed the expectations-augmented Phillips Curve, which proposed that there were multiple Phillips curves for different levels of expected inflation. Friedman assumed that people anticipate inflation and adjust their wage demands accordingly, avoiding money illusion. He emphasized the importance of controlling the money supply to control inflation.

2.7: Price Expectation Theory

Price expectation theorists highlight the significance of expectations in influencing inflation. They argue that people incorporate their expectations into wage claims, affecting firms' costs and ultimately causing inflation. If people believe that an increase in the money supply will lead to inflation, they will anticipate it and adjust their behavior accordingly. Rational expectations theorists take this notion further, assuming that individuals base their decisions solely on the present situation, instantly anticipating the effects of any changes. This makes it challenging for the government to implement subtle changes to boost demand, as people will anticipate the inflationary impact.

2.8: Wage-Price Spiral Theory

Wage-price spiral theorists posit that demand-pull and cost-push inflation can interact to create a self-perpetuating cycle. This spiral is more likely to occur when the economy approaches full employment. When demand increases, firms expand output to meet it, requiring additional resources, including labor. Consequently, firms offer more attractive packages to attract workers, leading to increased costs. Employees, concerned about maintaining their purchasing power, demand higher wages, further pushing up costs. This cycle continues as higher wages contribute to higher prices, resulting in further wage demands and price increases.

3: Empirical Studies of Inflation in Ghana

Opoku-Afari (2005) employs a latent factor model based on the yield curve to analyze inflationary expectations in Ghana. He observes a significant reduction in inflationary expectations since 2001, with persistence indicating the established credibility of the Bank of Ghana. However, he notes that adverse policies can impact expectations with a relatively high level of persistence. Factors such as anticipated petroleum price adjustments and worsened government fiscal positions influenced inflation expectations in Ghana. Opoku-Afari anticipates a continued downward trend in expectations, which would likely lead to a decline in actual inflation and the achievement of a single-digit inflation target.

Kinful (2004) examines the causal relationship among money, interest rates, output, and prices in Ghana. His analysis indicates that among the monetary aggregates, M2+ has the strongest causal effect on prices, making it the most appropriate

4: The Methodology

In this study, a model developed by Fullerton in 2004 is adopted and applied to the annual time series data from 1970 to 2003.

4.1: Fullerton (2004) Theoretical Model

He started with Harberger's (1963) model which is based on the traditional quantity theory of money equation:

$$MV = PQ, \quad \text{.......} \quad 1$$

where M represents some measure of the money stock, V is the velocity of circulation, P is the price level, and Q is real output. The realism of the model is enhanced by allowing velocity to vary instead of arbitrarily forcing it to be constant. Velocity is assumed to be a predictable function of other macroeconomic variables that reflect the cost of holding cash balances. To utilize percentage changes, the variables can be transformed by natural logarithms and first differenced. Introduction of a time subscript, and rearrangement of the terms, yields the basic Harberger equation:

$$DP_t = DM_t - DQ_t + D(DP_{t-1}) \quad \text{.......} \quad 2$$

where the last term results from substituting for velocity and D represents a difference or backshift lag operator. Harberger directly substitutes for velocity, using the lagged change in the inflation rate to proxy for the implicit cost of holding money. This approach is useful when modeling inflation in countries where government banking system regulations have occasionally caused savings and loan rates to become fixed in nominal terms and temporarily negative in real terms. Unadjusted interest rates from these periods would obviously not provide accurate estimates for the cost of holding idle cash. In economies where financial markets have been allowed to operate more freely, and where appropriate data have been recorded, an interest rate series may also be used to define the last explanatory variable in Equation 2. Equation 2 implies that inflation will vary positively with the money supply and inversely with respect to real output. A statistically significant intercept term will enter the estimated equation if there is a trend in the velocity of circulation. If only contemporaneous lags of M and Q enter in the equation, the parameters for both variables are hypothesized to be unitary. This can be tested empirically with the following specification:

$$DP_t = a_0 + a_1 DMt - a_2 DQt + a_3 D(DP_{t-1}) + u_3 \quad \text{.......} \quad 3$$

where a_1 and a_3 are hypothesized to be positive, and the absolute values of a_1 and a_2 should both be statistically indistinguishable from one. The last argument in the expression represents the disturbance term. Hanson (1985) proposes an implicit cost function dual of an aggregate production function which is homogeneous of degree one. Derived output supply functions from this framework will be homogeneous of degree zero in input and output prices. Equation 4 expresses this relationship using logarithmic first differences:

$$DQ_t = b_0 + b_1 DP_t - b_2 DPI_t + u_4 \quad \text{.......} \quad 4$$

where PI represents imported input prices. When the relative prices of imported inputs increase, output is assumed to decline. The standard homogeneity assumptions for production and derived supply relations imply that $b_1 - b_2 = 0$. The vector of input prices utilized in the derivation of

Equation 4 can be extended to include factor prices beyond those represented by imported materials, equipment, and services. Perhaps the most obvious candidate to further improve the relevance of the framework is labor costs. Doing so yields the following theoretical expression:

$$DQ_t = b_0 + b_1DP_t - b2DPI_t - b_3DW_t + u_5 \ldots\ldots 5$$

where W represents wage and labor costs. In this case, the standard microeconomic assumptions for production and derived supply functions imply that $b_1 - b_2 - b_3 = 0$. Equation 5 can be substituted into Equation 3 to eliminate the output term from the expression to be estimated. This step is exceedingly useful for avoiding interpolation bias in empirical studies of monthly inflation for countries where national income and product accounts are published at quarterly and/or annual frequencies. The resulting equation can be written as follows:

$$(1 + a_2b_1)DP_t = a_0 - a_2b_0 + a_1DM_t + a_2b_2DPI_t + a_2b_3DPW_t + a_3D(DP_{t-1}) + u_6 \ldots\ldots 6$$

Equation 6 can be further simplified prior to estimation. Dividing through by the left-hand side constant term and rearranging terms such that the price series remains as the dependent variable generates the following relation:

$$DP_t = c_0 + c_1DM_t + c_2DPI_t + c_3DPW_t + c_4D(DP_{t-1}) + u_7 \ldots\ldots 7$$

which also has testable properties. As a result of expanding the channels of influence on aggregate price trends, the coefficient on the monetary variable, c_1, is hypothesized to be significantly less than one. With the possible exception of the intercept, all of the regression parameters in Equation 7 are expected to be positive. During periods such as the 1960s and 1970s in developing countries when inflation is accelerating, c_0 is likely to be greater than zero (Clavijo, 1987). This general approach has provided a useful framework for analyzing quarterly and annual inflation rates. But because the implied lag structure is fairly short, it may require additional modification prior to estimation. This possibility does not reflect any deficiencies in the theoretical model as such, but arises due to the fact that data are published at different frequencies.

5: Data Sources

Time series data (1970-2003), employed to carry out the study were obtained from these sources:

- Bank of Ghana Annual reports, various issues.
- Quarterly Digest of Ghana Statistical Service, various issues.
- The State of the Ghanaian Economy, various issues.
- World Bank (2005), World Development Indicators, Washington D.C., USA

Statistical properties of the data (Normality, Covariance and Correlations) are presented and analyzed at the appendix tables A, B and C.

6: Empirical Analysis

6.1: Testing for the Stationarity of the Series

Stationarity is a critical assumption of time series analysis, stipulating that statistical descriptors of the time series are invariant for different ranges of the series. Weak stationarity assumes only that the mean and variance are invariant. Strict stationarity also requires that the series is normally distributed. Time series analysis requires that stationarity be established through differencing or some other technique. The study applied Dickey and Fuller (1979, 1981) procedure to formally test for the presence of a unit root.

In order to overcome some of the problems with Dickey-Fuller test, the study also tested for unit root by using Phillips and Perron tests. The distribution theory supporting the Dickey-Fuller tests assumes that the errors are statistically independent and have a constant variance. In using this methodology, care must be taken to ensure that the error terms are uncorrelated and have constant variance.

Phillips and Perron (1988) developed a generalization of the Dickey-Fuller procedure that allows for fairly mild assumptions concerning the distribution of the errors. Instead of the Dickey-Fuller assumptions of independence and homogeneity, the Phillips-Perron test allows the disturbances to be weakly dependent and heterogeneously distributed. The critical values for the Phillips-Perron statistics are precisely those given for the Dickey-Fuller tests.

6.2 : Choosing the Lag Length for the ADF Test

Augmented Dickey-Fuller procedure test for the null hypothesis of a stochastic trend (non-stationary) against the alternative of a deterministic trend (staionary). The model is specified as:

$$\Delta y_t = \psi^* y_{t-1} + \sum_{i=1}^{p-1} \Psi_i \Delta y_{t-i} + \mu + \gamma t + \mu_t \qquad \mu_t \sim \text{IID}(0, \sigma^2)$$

Implementation of the ADF test requires the specification of the lag length p. If p is too small then the remaining serial correlation in the errors will bias the test. If p is too large then the power of the test will suffer. In this paper, we selected lag-length using the model selection procedure that tests to see if an additional lag is significant or increases the value of $\overline{R}^2$.

Before undertaking estimations, a unit root test was conducted to make sure that the variables that are used for Granger causality test are stationary (Table 6.1). Here, the null hypothesis is that the series does contain a unit root or it is non-stationary against the alternative of stationarity. The augmented Dickey-Fuller test and Phillips-Perron Tests indicate that Money supply (M2), Price of imports (PI) and wages (PW) are stationary in levels at one or two lags except consumer price index (CPI) which became stationary after first differencing.

Table 6.1

Variable (Level)	**t-ADF**	**Number of lags**	**Phillips-Perron**	**Variable (1st Dif.)**	**t-ADF**	**Phillips-Perron**
CPI	-2.5679	1	-2.6424	ΔCPI	-4.508781*	5.977697*
M2	4.06017*	2	23.7422*	ΔM2	4.36885*	1.65059
PI	15.1611*	2	6.571544*	ΔPI	4.171412*	-2.632833
PW	3.927789**	1	11.54897*	ΔPW	0.321469	0.326536

** Significant at 1%, ** Significant at 5%, Trend and intercept included*

6.3: Test for Cointegration

The ADF and Phillips-Perron tests confirm that there exist no unit–roots in the first differences in the series. This implies CPI is I(1). The next step is to test whether the variables are cointegrated as we are interested in long-run relationships among variables.

The test stipulates that if variables are integrated of the same order, a linear combination of the variables will also be integrated of the same order or lower order. The idea behind cointegration analysis is that although macro variables may tend to trend up and down over time, groups of variables may drift together. If there is some tendency for some linear relationships to hold amongst a set of variables over long periods of time, then cointegration analysis helps us to discover it.

If a linear combination of variables of different order of integration is formed, this linear combination will take on the high order of integration. This is a trivial case. Variables are said to be cointegrated if a linear combination of these variables assumes a lower order of integration. These variables must always be of the same order of integration individually. Thus, they are individually non-stationary, integrated of the same order but their linear combination is integrated of a lower order.

Failure to establish cointegration between non-stationary variables can lead to spurious regressions, which do not reflect long-run equilibrium relationships but rather reflect common trends. In spurious regressions, the results suggest that there are statistically significant relationships among the variables of the model when in fact they are just contemporaneous correlations, not meaningful causal relations.

To overcome this problem, we apply error correction model within the context of Fullerton (2004) inflationary dynamics model. The error correction model provides a useful link between the long-run equilibrium relationships and short-run disequilibria dynamics. When the model involves non-stationary variables; equilibrium is contained in the cointegration relations.

6.4: The Engle-Granger (1987) two step procedure:

In this procedure, the cointegrating vector is estimated by ordinary least squares in the first step, and unit-root tests are performed on the residuals in the second step after correcting for autocorrelation in the residuals. Wee regress LOGCPI on LOGM2, LOGPI and LOGPW to obtain an estimate of the cointegrating vector. OLS estimates provide consistent coefficients of long-run model. Table 6.2 presents the results which reject the hypothesis of nonstionarity in favour of stationarity in the residual. Hence, there is cointegration.

Table 6.2: Testing for the stationarity of the residual

ADF Test Statistic	-4.005002	1% Critical Value*	-3.6576
		5% Critical Value	-2.9591
		10% Critical Value	-2.6181

*MacKinnon critical values for rejection of hypothesis of a unit root.

6.5: Johansen (1988) and Johansen and Juselius (1990) Maximum Likelihood procedure

Next, we carried out cointegration tests using Johansen (1988) and Johansen and Juselius (1990) Maximum Likelihood procedure. This procedure is similar to Engle-Granger (1987) two step procedure but it performs the two steps simultaneously. Because the correction for autocorrelation is performed simultaneously with the cointegration test, the Johansen procedure will perform better in small samples (such as the case with this study-1970-2003) if the maintained assumptions such as those regarding the order of the autoregressive components and the Gaussian errors are true.

Test assumption: No deterministic trend in the data

Series: LOGCPI LOGM2L LOGPICON LOGPW

Lags interval: 1 to 1

Table 6.3

	Likelihood	5 Percent	1 Percent	Hypothesized
Eigenvalue	Ratio	Critical Value	Critical Value	No. of CE(s)
0.754136	58.53356	39.89	45.58	None **
0.255669	13.63824	24.31	29.75	At most 1
0.122348	4.189619	12.53	16.31	At most 2

0.000421	0.013467	3.84	6.51	At most 3
*(**) denotes rejection of the hypothesis at 5%(1%) significance level				
L.R. test indicates 1 cointegrating equation(s) at 5% significance level				

The results (Table 6.3) are significant at the 1% for the eigenvalue and the Trace test. Model selection criterion AIC and SBC also support (not reported) the finding of one cointegrating vector. The eigenvalue associated with first vector is certainly dominant over those corresponding to other vectors, thereby further confirming that there exists one cointegarting vector in the model. Normalizing LOGCPI as one, we write an equilibrium form as follows:

LOGCPI - 9.44LOGM2 +5.42LOGPICON + 2.42LOGPW = 0 …………………………..A

Equation (A) represents the long-run relationship by equation (7) in section 4. The signs on the variables involved in the cointegrating relationship are extremely important and need to be carefully analyzed. Apart from M2, signs of the estimated coefficients are not in accordance with what intuition would suggest. In the long-run, an upward movement in money supply is generally expected to be associated with an upward movement in price level. The long-run result indicates that a 1% increase in money supply (M2) will increase price level by 9.4 per cent. This confirms that available evidence that inflation in Ghana has been a monetary phenomenon (Ewusi, 1997).

6.6: Granger Causality

The detection of causal relationships among a set of variables is one of the objectives of empirical research .A degree of correlation between two variables does not necessarily mean the existence of a causal relationship between them; it may simply be attributable to the common association of a third variable. Accordingly, Granger formulated a procedure for detecting a causal relationship among the variables.

The concept of causality in the Granger sense is mainly based on the following two assumptions; First, that the future cannot cause past, it is the past and present which cause future; second, that detection of causality is only possible between two stochastic processes. It is not sensible to talk about causality when two series are deterministic. In this study (Table 6.4), Granger Causality test is carried out to establish the causal the relationship between Price levels (CPI), money supply (M2), import prices (PI) and wages (PW) variables.

Pairwise Granger Causality Tests

Lags: 10

Table 6.4

Null Hypothesis:	Obs	F-Statistic	Probability

ΔLOGM2 does not Granger Cause ΔLOGCPI	23	0.65570	0.73581
ΔLOGCPI does not Granger Cause ΔLOGM2		19.2910	0.05026*
ΔLOGPI does not Granger Cause ΔLOGCPI	23	0.23452	0.95420
ΔLOGCPI does not Granger Cause ΔLOGPI		1.72074	0.42292
ΔLOGPW does not Granger Cause ΔLOGCPI	23	0.26869	0.93808
ΔLOGCPI does not Granger Cause ΔLOGPW		1.16985	0.54576
ΔLOGPI does not Granger Cause ΔLOGM2	23	2.77678	0.29373
ΔLOGM2 does not Granger Cause ΔLOGPI		0.82457	0.66238
ΔLOGPW does not Granger Cause ΔLOGM2	23	2.29876	0.34106
ΔLOGM2 does not Granger Cause ΔLOGPW		1.23338	0.52829
ΔLOGPW does not Granger Cause ΔLOGPI	23	0.36784	0.88593
ΔLOGPI does not Granger Cause ΔLOGPW		0.35430	0.89331

*Significant at 5.1%

The Null Hypotheses that ΔLOGM2 does not Granger Cause ΔLOGCPI is rejected at 5.1%. These results show that there is a one-way causality between Price levels (LOGCPI), money supply (LOGM2). Money supply over the 1970-2003 period helped in the prediction of prices (inflation) in Ghana. With one-way causality, we employ ordinary least squares procedure for our estimations. No causal relationship was however, established by the results in this study between Price levels, price of imported inputs and wages. This again corroborate findings by Atta-Mensah and Bawumia (2003) that the growth rate of M2+ is the main culprit of higher inflation in Ghana.

7: Short-run dynamic specification: The Error-Correction Model (ECM)

The final stage requires the construction of the error-correction model. This involves regressing the first difference of each variable in the cointegration equations onto lagged values of the first differences of all of the variables plus the lagged value of the error-correction term. One of the important issues in the ECM modeling is to choose the lag lengths to be used in the error-correction models. As one lag of a difference term equals second lag of the level, the number of lags in the short-run models will be one less than that applied in the cointegration tests. The results of the Error-correction model is divided into two subsections; the first subsection analyses the unrestricted error correction model while second subsection is on the parsimonious model. The parsimonious form is basically general-to specific approach developed by Hendry et al (1984).

In the short run model, equation 7 is estimated in first difference with the residuals of cointegration regression added as error-correction term. The model is specified as:

$\Delta\, DP_t = c_0 + c_1\Delta DM_t + c_2\Delta DPI_t + c_3\Delta DPW_t + c_4\Delta D(DP_{t-1}) + c_5\, \hat{e}_t + u_7$, Where $\hat{e}_t$ is an error-correction factor and u_7 is the serially uncorrelated error term.

7.1: Unrestricted Model

Table 7.1 presents the unrestricted ECM estimation results. The estimated ECM for Inflation results indicate that intercept, $\Delta LOGCPI_{t-1}$, $\Delta LOGM2$, $\Delta LOGM2_{t-1}$, $\Delta LOGM2_{t-5}$, $\Delta LOGPI$, $\Delta LOGPI_{t-2}$, $\Delta LOGPW$, $\Delta LOGPW_{t-1}$ are significant but the signs of some of the coefficients are unexpected. The coefficient of ECM term $\hat{e}_{t-2}$ is negative indicating that the speed with which adjustment to the long run equilibrium occurs in price levels every year is 26% (but not significant).

Table 7.1 Modeling the Unrestricted Model of DLOGCPI by OLS: The present sample is: 1970 to 2003

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-17.95995	4.911209	-3.656930	0.0033*
$\Delta LOGCPI_{t-1}$	-0.782077	0.241231	-3.242025	0.0071*
$\Delta LOGM2$	9.498601	2.886653	3.290524	0.0065*
$\Delta LOGM2_{t-1}$	24.06158	5.695257	4.224845	0.0012*
$\Delta LOGM2_{t-2}$	6.683844	4.704207	1.420822	0.1808
$\Delta LOGM2_{t-3}$	2.921301	2.700270	1.081855	0.3006
$\Delta LOGM2_{t-4}$	0.174627	2.771892	0.062999	0.9508
$\Delta LOGM2_{t-5}$	7.367204	3.201465	2.301197	0.0401**
$\Delta LOGM2_{t-6}$	0.326854	2.997520	0.109042	0.9150
$\Delta LOGPI$	-2.281554	1.002213	-2.276515	0.0419**
$\Delta LOGPI_{t-1}$	-1.345230	0.813218	-1.654206	0.1240
$\Delta LOGPI_{t-2}$	-3.666976	0.919165	-3.989464	0.0018*
$\Delta LOGPW$	7.709389	1.757730	4.385991	0.0009*
$\Delta LOGPW_{t-1}$	3.988124	1.703400	2.341272	0.0373**

$\hat{e}_{t-2}$	-0.259758	0.218121	-1.190887	0.2567

R-squared	0.735910	Mean dependent var	0.070719
Adjusted R-squared	0.427804	S.D. dependent var	1.353710
S.E. of regression	1.023995	Akaike info criterion	3.185481
Sum squared resid	12.58279	Schwarz criterion	3.905391
Log likelihood	-28.00400	F-statistic	2.388499
Durbin-Watson stat	2.367811	Prob(F-statistic)	0.069150

** Significant at 1%, ** Significant at 5%, Trend and intercept included*

The short run unrestricted model performs quite well as 74% of variation in Price levels is explained by the explanatory variables. It is also a substantiation of the fact that money supply plays a major role in determining inflation in Ghana. The Durbin-Watson (DW) indicates no serial correlation and this is confirmed by the autocorrelation test value of 2.37. The probability value of F-test indicates that the variables were jointly statistically significant at 10%.

7.2: The diagnostic tests for the Unrestricted Model

This ECM equation is not free from econometric problems as Ramsey RESET Test rejects the null hypothesis that the coefficients on the powers of fitted values are all zero (Table 7.2). This means that there are other variables outside the model that will help predict the inflation in Ghana. Studies on Ghana point to inflation expectations, petroleum price levels and exchange rates as significant determinants.

Table 7.2

Ramsey RESET Test:

F-statistic	260.7335	Probability	0.000000*
Log likelihood ratio	86.58702	Probability	0.000000

** Significant at 1%,*

The model has no problem of serial correlation (Table 7.3) as the null hypothesis of Breusch-Godfrey Serial Correlation LM Test that there is no serial correlation in the residuals up to the order 2 is accepted in disfavor of the alternative of the presence of serial correlation.

Table 7.3

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.469165	Probability	0.638624
Obs*R-squared	2.316158	Probability	0.314089

** Significant at 1%, ** Significant at 5%,*

The autoregressive-conditional heteroscedasticity (ARCH) test suggests the absence of autoregressive-conditional heteroscedasticity. The null hypothesis that there is no ARCH up to order 2 in the residuals is accepted (Table 7.4).

Table 7.4

ARCH Test:

F-statistic	0.391016	Probability	0.537667
Obs*R-squared	0.416809	Probability	0.518533

** Significant at 1%, ** Significant at 5%,*

Since our unrestricted ECM results do not provide us expected results we run parsimonious regression. We run regression with the variables which are significant in unrestricted ECM and took the variables which have correct signs in the unrestricted.

7.3: Parsimonious Model

Table 7.5 reports the estimation results based on parsimonious ECM model using the same lag lengths as in unrestricted model. Several interesting observations emerge from the findings. First, the expected sign of the coefficient of ECM term is negative but not significant.

Table 7.5 Modeling the Parsimonious model of DLOGCPI by OLS: The present sample is: 1970 to 2003

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-2.206381	0.984030	-2.242188	0.0345
ΔLOGM2	5.526624	2.501995	2.208887	0.0370
$\Delta LOGPI_{t-3}$	0.171100	0.696173	0.245773	0.8079
ΔLOGPW	1.154315	0.826823	1.396085	0.1755

$\Delta LOGCPI_{t-2}$	0.073978	0.187627	0.394279	0.6969
$\hat{e}_{t-1}$	-0.108831	0.213057	-0.510807	0.6142
R-squared	0.201643	Durbin-Watson stat		2.025785
Adjusted R-squared	0.035319	Prob(F-statistic)		0.333537

The error correction term, which indicates the speed with which adjustment to the long run equilibrium occurs in price levels is 10% and the negative sign shows the existence of equilibrium relationship even though the coefficient is not significant. The F-test with the probability value of 0.333537 shows that the variables are not jointly statistically significant**.**

The variable of interest, which is money supply impacts positively and significantly on price levels in the short run. This indicates that any increase in money supply by 1% will increase prices by 5.5% in the short run. Price of imported inputs and wage levels have positive relationship with price level as expected but they are not significant determinants of price levels over the period.

As a result of expanding the channels of influence on aggregate price trends, the coefficient on the monetary variable, c_2, is hypothesized to be significantly less than one. The Wald coefficient test reports that the null hypothesis that c_2 is equal to 1 is rejected at 10% in favour of the alternative that it is not equal to 1.

Wald Test:

Equation: Untitled

Null Hypothesis:	C(2) = 1		
F-statistic	3.342274	Probability	0.079979
Chi-square	3.342274	Probability	0.067521

With the possible exception of the intercept, all of the regression parameters in Equation 7 are expected to be positive as the results in the parsimonious model indicated.

7.4: The diagnostic tests for the Parsimonious Model

The diagnostic tests of the parsimonious model that are given in Tables 7.6, 7.7 and 7.8 show that there is not a diagnostic problem.

Table 7.6

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.145187	Probability	0.865683
Obs*R-squared	0.390805	Probability	0.822503

Table 7.7

ARCH Test:

F-statistic	0.062386	Probability	0.804655
Obs*R-squared	0.066852	Probability	0.795976

Table 7.8

Ramsey RESET Test:

F-statistic	3.577207	Probability	0.045175
Log likelihood ratio	8.446917	Probability	0.014648

The model has no problem of serial correlation as the null hypothesis of Breusch-Godfrey Serial Correlation LM Test that there is no serial correlation in the residuals up to the order 2 is accepted (Table 7.6). ARCH test suggests the absence of autoregressive-conditional heteroscedasticity (Table 7.7). The regression specification test (RESET) shows that the model is correctly specified (Table 7.8).

8: Conclusion

In this paper, we applied the theoretical model developed by Fullerton in 2004 to analyze inflationary dynamics in Ghana. Cointegration analysis suggests that price level has a long-run relationship with money supply, price of imported inputs and wage levels. The error correction results for the price equation provide evidence that inflation in Ghana over the 1970 -2003 period has been significantly determined by money supply. This confirms the conclusion reached by Ewusi (1997), Bawumia and Abradu-Otoo (2003) and Kinful (2004). The policy advice is that money supply should serve as one main target of curbing inflation Ghana.

References:

1. Atta-Mensah, J., & Bawumia, M. (2003). *A Simple Vector Error Correction Forecasting Model for Ghana*. Bank of Ghana Working Paper, WP/BOG-2003/01
2. Bawumia, M. and Abradu-Otoo, P. (2003) *Money Growth, Exchange Rate and Inflation in Ghana: An Error Correction Analysis*. Bank of Ghana Working Paper, WP/ BOG-2003/05
3. Clavijo, S. (1987). Hacia una Caracterización del Comportamiento de la Velocidad de Circulación del Dinero: El Caso Colombiano 1959-1986. *Ensayos Sobre Política Económica*, 12, 59-79.

4. Ewusi, K. (1997) *The Determinants of Price Fluctuations in Ghana*, ISSER. Discussion Paper 1997, University of Ghana, Legon, Ghana.
5. Fullerton Jr., T. M. (2004). *A Theoretical Model of Developing Country Inflationary Dynamics. Macroeconomics* 0407031. University Library of Munich, Germany
6. Granger, C. W. J. (1969). Investigating causal relations by econometric models and cross spectral methods. *Econometrica*, 37, 424-438.
7. Harberger, A. (1963). *The Dynamics of Inflation in Chile. In C. F. Christ (Ed.), Measurement in Economics: Studies in Mathematical Economics and Econometrics* in Memory of Yehuda Grunfeld (Chapter 2). Stanford, CA: Stanford University Press
8. Johansen, S. (1988). *Statistical analysis of cointegration Vectors*. Journal of Economic Dynamics and Control, 12, 231-254.
9. Johansen, S., & Juselius, K. (1990). *Maximum likelihood estimation and inference on cointegration –With applications to the demand for money*. Oxford Bulletin of Economic and Statistics, 52, 169-210.
10. Johansen, S. (1992). *Cointegration in partial systems and the efficiency of single-equation analysis.* Journal of Econometrics, 52, 389-402.
11. Hanson, J. A. (1985). Inflation and Imported Input Prices in Some Inflationary Latin American Economies. Journal of Development Economics, 18, 395-410
12. Kinful, E. (2004). *Causal Linkages Among Money, Interest Rate, Price and Output in Ghana: VECM Analysis*. Bank of Ghana Working Paper, July 2004.
13. Mckay A, Sowah Nii K (2004). Does the Inflation in Ghana hit the Poor Harder? Available at: https://www.semanticscholar.org/paper/Does-Inflation-in-Ghana-Hit-the-Poor-Harder-McKay-Sowa/3dfd610ba235ca5ba6e5e06b78ae6f9006ee1af2
14. Opoku-Afari (2005). *A note on Inflationary expectations dynamic in Ghana*. Working Paper. Bank of Ghana. WP/BOG-2005/17
15. Phillips, P. C. B., & Perron, P. (1988). Testing for Unit Roots in Time Series Regression. *Biometrika*, 75, 335-346.
16. World Bank. (2005). *World development indicators*, Washington, D.C., USA.

Appendix

Table A: Data Distribution

	LOGCPI	LOGM2L	LOGPICON	LOGPW
Mean	6.765987	25.12560	25.19637	4.323016
Median	6.380729	25.17271	25.67788	4.611381
Maximum	11.37231	30.63288	31.17323	9.126959
Minimum	2.617396	19.87260	19.87557	-0.287682

Std. Dev.	2.751603	3.384325	3.886099	3.050850
Skewness	0.051714	0.001686	0.053691	-0.058574
Kurtosis	1.709483	1.717962	1.520496	1.687888
Jarque-Bera	2.374520	2.328480	3.117321	2.458428
Probability	0.305056	0.312160	0.210418	0.292522
Observations	34	34	34	34

All the variables (Table A) are normally distributed because the Jarque-Bera statistics is not significant for all variables and means are approximately equal to their medians. Kurtosis for all the variables is less than 3, hence the distribution is playtykurtic (the distribution is flat). The skewness is supposed to be 0 for normal distribution and what we have in the table is close to zero and so the data are normally distributed.

Covariance Matrix

Table B

	LOGCPI	LOGM2	LOGPI	LOGPW
LOGCPI	7.348635	4.982438	5.618530	4.629077
LOGM2L	4.982438	11.11678	12.67200	9.989001
LOGPI	5.618530	12.67200	14.65760	11.42388
LOGPW	4.629077	9.989001	11.42388	9.033932

Covariance Matrix (Table B) measures the degree to which price level, money supply, price of imported inputs, and wages move in tandem. Positive covariance as shown in this matrix means that the variables move together. A negative covariance would have implied that these variables vary inversely.

Table C: orrelation Matrix

	LOGCPI	LOGM2	LOGPI	LOGPW

LOGCPI	1.000000	0.551251	0.541362	0.568136
LOGM2	0.551251	1.000000	0.992714	0.996768
LOGPI	0.541362	0.992714	1.000000	0.992759
LOGPW	0.568136	0.996768	0.992759	1.000000

Correlation matrix (Table C) shows a measure of the strength of the relationship among price level, money supply, price of imported inputs, and wages.