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# RESEARCH ARTICLE

## MODELING THE DETERMINANTS OF INFLATION IN SUDAN USING GENERALIZED METHOD OF MOMENTS FOR THE PERIOD 2000-2017

**[1*]Almahdi Musa Attahir Musa and [2*]Faroug Mohammed Khalid Yousif**

[1]Almahdi Musa Attahir Musa , Associate Professor of Econometrics, Department of Econometrics and Social Statistics, Faculty of Economics and Administrative Sciences, University of Bakht Al -Ruda, Sudan
[2]Faroug Mohammed Khalid Yousif, Assistant Professor of Econometrics, Wadmdni, Aljazira, Sudan

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**ABSTRACT**

This paper aims to modeling the determinants of inflation in Sudan via GMM method for the period 2000-2017to help in formulating an effective decreasing inflation rate policy. The paper focused on Gross Domestic Product (GDP), Government Expenditure(GE), Exchange Rate (EX), Consumer Price Index (CPI), Unemployment Rate (UR),and Money Supply (MS)as they are the most important determinants of inflation in Sudan. The paper is based on the following assumptions: the Gross Domestic Product, Unemployment Rate and Government Expenditure well effect negatively on inflation rate, and also there is effect positively between the Inflation Rate and Exchange Rate, Money Supply, and Consumer Price Index. The paper has reached the following conclusions: that the increase in money supply and Consumer Price Index lead to an increasing inflation rate. The reduction of the exchange rate leads to a high rate of inflation. However the increasing in Gross Domestic Product, Unemployment Rate, and Government Expenditure lead to decreasing inflation rate in Sudan. The Generalized Method of Moment is the best Method for estimating the determinants of inflation in Sudan. The paper recommended that the state should adopt effective financial and monetary policy for reducing the increasing in inflation rate and increased production for exporting.



## INTRODUCTION

Inflation can be defined as sustained increase in the aggregate or general price level in an economy which mean that there is an increase in the cost of living. Inflation is also known as the percentage change in the value of the Consumer Price Index (CPI) on a year-on year basis. It can be said that inflation is a continuous issue in all nation in maintaining low living cost, high growth, health economy and as aimed to policy makers' decision. Inflation provides positive and negative impact depending on a country economic condition (Audrey *et al.,* 2007). On the other hand, a moderate level of inflation characterizes a good economy. The rate of 2 or 3% of inflation is beneficial for an economy as it encourages people to buy or borrow more, because during times of lower inflation, the level of interest rate also remains low. However, inflation has its worst impact towards consumers. High prices from day today goods make it difficult for consumers to afford even for the basic commodities in daily life which will disrupts the smooth functioning of a market economy (Kurgan, 1995). The higher income will lead to higher inflation.

***Corresponding author:*** **Almahdi Musa Attahir Musa,**
Almahdi Musa Attahir Musa, Associate Professor of Econometrics, Department of Econometrics and Social Statistics, Faculty of Economics and Administrative Sciences, University of Bakht Al - Ruda, Sudan.

Hence, the government tries to keep inflation under control and moving forward to achieve low or zero inflation. Based on previous researchers, there are quite a number of arguments on the precise relationship between inflation and economic indicators at the macroeconomic level (Philip Chimobi, 2010) Money supply is one of the determinants that affect inflation in Malaysia (Cheng and Tan, 2015; Wimal Rankaduwa, 2005) agreed that, there is a positive relationship between money supply and inflation. Besides, another economic indicator closely related to both money supply and inflation is the national income or the Gross Domestic Product (Maymunah *et al*., 2005) Various studies done on determinants of inflation, focusing on independent variables such as unemployment rate, exchange rate, oil prices (Chong and Tan, 2012) and income (Nadeem *et al*., 1992) However, less studies done on relationship between Gross Domestic Product, Money Supply, Interest Rate, Import Goods and Services, and Government Expenditure with inflation. Therefore, this study will concentrate on the Sudanese economy concept on which Determinants will effect to increase inflation. The variables selected are Gross Domestic Product, Money Supply, unemployment rate, and exchange rate.

## EMPIRICAL STUDIES

(Andersson *et al*., 2009) Analyses the determinants of inflation differentials and price levels across the euro area countries. The import finding a co integrating find that the price level of each euro area country is governed by the levels of GDP (Lim and Papi, 1997). Seek to shed some light on the determinants of inflation in turkey. The main findings are that monetary variables play a central role in the inflationary process that public sector deficits contribute to inflationary pressures (Samuel A. Laryea, 2004). Estimates an inflation equation for Tanzania the results from the econometric regression analysis shows that inflation in Tanzania either in the short run or the long run, is influenced more by monetary factors and to a lesser extent by volatility in output or depreciation of the exchange rate. It is recommended that to control inflation in Tanzania, the government should pursue tight monetary and fiscal policies. In the long run, the government should also pursue policies to increase food production to ease some of the supply constraints. It used an error correction model (ECM) (Altissimo, 2004) Analyzes the long-run determinants of inflation differentials in a monetary union. It finds that a relatively large proportion of it occurs in the Service category of the EU's harmonized consumer price index (HICP).

We then lay out a model of a monetary union with fully flexible prices, the long-run properties of which are analyzed. The result that movements in the real exchange rate are mainly driven by regionally asymmetric productivity shocks in the traded sectors (Totonchi, 2011). Attempts to review and analyze the competing and complementary theories of inflation. The theoretical survey in this research work yielded in six-blocked schematization of origins of inflation; monetary shocks, Demand side, supply-side shocks, structural and political factors (or the role of institutions). It appeared that inflation is the net result of sophisticated dynamic interactions of these six groups of explanatory factors. The paper of causes of inflation has probably given rise to one of the most significant macroeconomic debates in the field of economics. In practice; however, it is not always easy to decompose the observed inflation into its monetary, demand-pull, cost-push and structural components (Lim and Sek, 2015) Examines factors affecting inflation in two groups of countries (high inflation group and low inflation group) using annual data from 1970 - 2011.

An Error Correction Model based on the Autoregressive Distributed Lag (ARDL) modeling has been used to explain the short run and long run impacts of each variable on inflation. The results respectively indicate that GDP growth and imports of goods and services have the significant long run impact on inflation in low inflation countries. Money supply, imports of goods and services and GDP growth has significant relationship with inflation in low inflation countries (Husain Alomar, 2007) Attempt to study the factors affecting the behavior of domestic inflation in Kuwait. The results indicate the existence of long run relationship between inflation and the broad measure of money supply and then moved to examine the possibility of short run relationships between domestic inflation and the rest of the variables using Granger causality test which indicates the lack of such relationships. Therefore reveals that domestic inflation is influenced mainly by the development of domestic liquidity which overwhelmed the theoretically expected effect of imported inflation (Hashim, 2014) Analyzes the determinants of Inflation in Malaysian using economic indicators. it extends empirical work on determinants of inflation theory in three ways. First, it examines a much broader set of economic indicators, many of which have been analyzed empirically in different countries. Second, since the economic indicators have different empirical implication regards to different countries, the author analyze it specifically for determinants of inflation based on Malaysian economic performance over the past 33 years, since 1980 until 2012. the study uses Multiple Regression Analysis to identify the determinants of inflation between independent variables and dependent variable. This paper differs from other empirical studies in many aspects: aim, methodology, time period, results and included variables.

## THEORATICAL BACKGROUND

There are different approaches in detecting the determinants of inflation based on the long run estimate and short run estimate. These methods include Co-integration, Vector Error Correction, Granger Causality, Vector Auto regression (VAR), Augmented Dickey-Fuller (ADF), Panel unit root test and Ordinary Least Squares (OLS). Most of the studies apply Co-integration method (for long run estimate), Vector Error Correction (for short run estimate) and Granger Causality. For instance (Totonchi 2011) applied these three methods in his study and probe that money supply, GDP and government expenditures presenting positive impression on inflation (Bandara, 2015) Also applied these three methods in the study of determinants of inflation in Albania. They found exchange rate and money supply have significant influence however real income has insignificant influence on inflation (Adu, 2011) apply Co-integration and Vector Error Correction method in the study and found that real output, nominal exchange rate, broad money supply, interest rate and fiscal deficit are positively contributed towards inflation in Ghana. (Kim, 2001) Also applied Co-integration and Vector Error Correction method to investigate the determinants of inflation in Poland and found that the labor sector, external sector and real exchange rate have positive influence on inflation. There are some papers applied Ordinary Least Square (OLS) to trace the causes of inflation. For instance, (Altowaijri, 2011) applied Co-integration and OLS method in the study and found monetary is a main factor of inflation in Paraguay (Aurangzeb, 2012) also applied Co-integration and OLS method to investigate the causes of inflation in Pakistan and they found that exchange rate, GDP and value of imports are significant however budget deficit and interest rate are insignificant. Most of the studies are focused on developing countries such as Pakistan, Sri Lanka, Ukraine, Albania, Poland, Ghana and Jordan. For instance, (Khan, 2010; Menji, 2009) and (Greenidge and Dianna, 2008) discussed their study in Pakistan (Khan, 2007) focused the study in Albania, (Domec and Elbert, 1998) focused the study in Poland and (Monfort and Peña, 2008) focused the study in Jordan. There are also a few studies focus on the Gulf Cooperation Council (GCC) country such as (Jaradat, 2011) and (Kandil, 2009). In general, most studies focus the analysis in the Developing countries. The common approaches used to investigate the determinants of inflation are Co-integration and Vector Error Correction method. Most of the studies also find that the main determinants affecting inflation are money supply, interest rate and exchange rate. There are vast studies that investigated and

proven that Gross Domestic Product, Money Supply, Interest Rate, Import Goods and Services as well as Government Expenditure are significant towards Consumer Price Index. The relevant literature generated a mixed view regarding the relationship between inflation and inflation determinants. Some of the researches explain that inflation cause to GDP; however some other certain works argue that Government expenditure, interest rate, and unemployment rate granger causes inflation. Different countries also have different effect of inflation determinants. In most developing countries, the determinants of inflation are interest rate, exchange rate, GDP, CPI Unemployment rate, and Money supply. However all the researches related to more information, about inflation and determinants of inflation some of variable had positive effect on inflation and other variables had negative effect on inflation.

## INFLATION

(Amadeo, 2012) stated that inflation is when the prices of most goods and services continue to creep upward. When this occurs, the standard of living falls. It is due to each dollar buys less; therefore, we have to spend more to get the same amount of goods and services (MingYu *et al*., 2012) According to inflation causes economic problems and distortions in the functioning economy that may cease economic growth rate of a country. Inflation is likely to happen when major economic variables change such as fiscal deficit and excess money supply (Friedman, 1982) stated that money growth rate and inflation rate has a positive relationship (Cheng, 2002). Agreed that inflation in Malaysia was controlled well during recent financial crisis compared to other neighboring countries. In research done by (Baghestani, 2010) had analyzed that Federal Reserve gave the accurate information about inflation once the government forecast.

## GROSS DOMESTIC PRODUCT

According to (Sictus, 2010) Gross Domestic Product (GDP), is a basic determinant of a country's economic performance, and is the market value of all final goods and services made within the borders of a nation in a year. The Malaysian economy has performed well over the years due to the country's political stability, the sound financial and economic policies adopted by the government, and the efficient management of its natural resources (Moorthy, 2011) Examined the Gross Domestic Product (GDP) will falls relative with Consumer Price Index (CPI) when food prices rise. The researchers analyzed the increasing in food prices for monetary policy in India. To measure inflation in India, they used between CPI and GDP deflator. The data comes from evidence from US (1960s) to examine whether the 1970s stagflation was due to the OPEC price hike. The results shows when food prices increase, the GDP deflator falls relative to the CPI. As for (Armesh *et al*., 2010) in his study using ordinary least square method in Iran, demonstrates that actual GDP is negatively affected to inflation in the long run.

## GOVERNMENT EXPENDITURE

(Kandil, 2010) in her research stated that money supply, government spending, consumer price are anticipated and unanticipated in fluctuations of real output growth, price inflation, wage inflation and real wage growth where every countries have different effect of monetary and government spending shock. Government spending in variability can cause decrease in price inflation and increase real wage. Hence (Aurangzeb and Haq, 2012) suggested that government borrowing is a major cause of high price levels. In addition to that, a research done by (Cheng, 2002) declared that government expenditure is indirectly related to inflation; in which it is intra-related to exchange rate channel (Olatunji *et al*., 2011) Have examined the recent factors which are affecting inflation in Nigeria. Time series data has been selected for this particular study. In their paper, they have applied Johansen technique to formulate the results. The study reveals that the previous year total imports, previous year consumer price index for food, previous year government expenditure, and previous year exchange rate have negative influence on inflation rate. Therefore, previous year exports, previous year agricultural output, previous year interest rate and crude oil exports have negative impact on the rate of inflation in Nigeria.

## EXCHANGE RATE

The rate of inflation in country can have a major impact on the value of the country's currency and the rates of foreign exchange it has with the currencies of other nations. However, inflation is just one factor among many that combine to influence a country's exchange rate. Inflation is more likely to have a significant negative effect, rather than a significant positive effect, on a currency's value and foreign exchange rate. A very low rate of inflation does not guarantee a favorable exchange rate for a country, but an extremely high inflation rate is very likely to impact the country's exchange rates with other nations negatively (Vera, 2010).

## MONEY SUPPLY

In studies conducted by (Husain, 2007), income distribution has conflict claims comes from inflation. Conflict theories can determine by income claims over the existing price from value of output. He also added that supply of money over and above that needed for domestic trade leads to higher inflation, whereby import and export are very responsive to price. The result of incoherent of real wage and desired markup comes from inflation. Furthermore he adds inflation may have conflict when exchange rate increase because exchange rate was depends on inflation or deflation economic state. Based on a study that tested the co integration between domestic inflation and domestic money supply, the results reveal the existence of long run relationship between inflation and money supply (Jalali-Naini, 1997; Ricardo, 1817). Examines the price movement and inflation rate before World War II in Iranian economy. He stated that money supply is the main principle factors of the increase in general price level. Another study in Iran conducted from year 1961 to 2005; using OLS econometric method by (Armesh *et al*., 2010) confirmed that money supply has a positive long run influence on inflation. Money supply also said to have indirect relationship in narrow sense, as found by (Cheng, 2002).

## INFLATION THEORIES

## THE QUANTITY THEORY OF MONEY

It is one of the oldest surviving economic doctrines. Simply stated, it asserts that changes in the general level of general

prices are determined primarily by changes in the quantity of money in circulation. The quantity theory of money formed the central core of 19thcentury classical monetary analysis, provided the dominant conceptual framework for interpret in contemporary financial events and formed the intellectual foundation of orthodox policy prescription designed to preserve the gold standard. David Hume (1711-76) provided the first dynamic process analysis of how the impact of a monetary change spread from one sector of the economy to another, altering relative price and quantity in the process. He provided considerable refinement, elaboration and extension to the quantity theory of money David Ricardo (1772-1823), the most influential of the classical economists, thought such disequilibrium effects ephemeral and unimportant in long-run equilibrium analysis. As leader of the Balloonists, Ricardo charged that inflation in Britain was solely the result of the Bank of England's irresponsible over issue of money, when in 1797, under the stress of the Napoleonic Wars; Britain left the gold standard for an inconvertible paper standard. Ricardo discouraged discussions on possible beneficial output and employment effects of monetary injection (Milton Friedman, 1912-2006). Irving Fisher (1876-1947) spelled out his famous equation of exchange *viz.* MV=PT. This and other equations, such as the Cambridge cash balance equation, which corresponds with the emerging use of mathematics in noneconomic analysis, define precisely the conditions under which the proportional postulate is valid. Fisher and otherneo-classical economists, such as Arthur Cecil Pigou (1877-1959) of Cambridge, demonstrated that monetary control could be achieved in a fractional reserve-banking regime *via*control of an exogenously determined stock of high power money.

## MONETARY THEORY

Monetarism (Early Monetarists, 1530-1596) refers to the followers of M. Friedman (1912-2006) who hold that "only money matters", and as such monetary policy is a more potent instrument than fiscal policy in economic stabilization. According to the monetarists, the money supply is the "dominate, though notexclusive" determinant of both the level of output and prices in the short run, and of the level of prices in the long run. The long- run level of output is not influenced by the money supply (Totonchi 2011) the monetarists emphasized the role of money. Modern quantity theory led by Milton Friedman holds that "inflation is always and everywhere a monetary phenomenon that arises from a more rapid expansion in the quantity of money than in total output. Its earliest explanation was to be found in the simple quantity theory of money. The monetarists employed the familiar identity of exchange equation of Fisher.

## DEMAND PULL THEORY

John Maynard Keynes (1883-1946) and his followers emphasized the increase in aggregate demand as the source of demand-pull inflation. The aggregate demand comprises consumption, investment and government expenditure. 459 When the value of aggregate demand exceeds the value of aggregate supply at the full employment level, the inflationary gap arises. The larger the gap between aggregate demand and aggregate supply, the more rapid is the inflation. Keynesian (Keynes and his followers)do not deny this fact that even before reaching full employment production factors and various appearing constraint can cause increase in public price. This inflation constraint that appears quickly during prosperity is originally resulting from nonproportioned section, branches and or various economic resources that are accounted from natural properties of discipline based on market. Therefore, in one period of prosperity it is completely natural. According to demand-pull inflation theory of Keynes, policy that causes decrease in each component of total demand is effective in reduction of pressure demand and inflation. One of the reductions in government expenditure is tax increase and to control volume of money alone or together, can be effective in reducing effective demand and inflation control. In difficult conditions, e.g. hyperinflation during war that control of volume of money or decrease in general expenditure may not be practical increase in tax can g*et al*ong with direct action for control on demand (Rankaduwa, 2005).

## COST PUSH THEORY

It is caused by wage increases enforced by unions and profit increases by employers. The type of inflation has not been a new phenomenon and was found even during the medieval period. But it was reviewed in the1950s and again in the 1970s as the principal cause of inflation. It also came to be known as "New Inflation". The basic cause of Cost-Push inflation is the rise in money wages more rapidly than the productivity of labor. The labor unions press employers to grant wage increases considerably, thereby raising the cost of production of commodities. Employers in turn, raise prices of their products. Higher wages enable workers to buy as much as before, in spite of higher prices. On the other hand, the increase in prices induces unions to demand still higher wages. In this way, the wage-cost spiral countries, thereby, leading to cost-push or wage-push inflation. Cost-push inflation may be further aggravated by upward adjustment of wages to compensate for rise in cost of living. A few sectors of the economy may be affected by increase in money wages and prices of their products may be rising. In many cases, their products are used as inputs for the production of commodities in other sectors. As a result, cost of production of other sectors will rise and thereby push up the prices of their products. Thus wage-push inflation in a few sectors of the economy may soon lead to inflationary rise in prices in the entire economy. Further, an increase in the price of imported raw materials may lead to cost-push inflation. Another cause of Cost-Push inflation is profit-push inflation. Oligopolist and monopolist firms raise the price of their products to offset the rise in labor and cost of production to earn higher profits. There being imperfect competition in the case of such firms, they are able to administered price of their products. Profit-push inflation is, therefore called administered-price inflation or price-push inflation (McCallum, 1936).

## STURUCTURE THEORY

About 40 years ago, the concept of structural inflation entered in economic discussion and research. It is related to the effect of structural factors on inflation. Structural analysis attempts to recognize how economic phenomena and finding the root of the permanent disease and destruction such as inflation that evaluates lawful relationship between the phenomena. In the economic structural factor causes, supply increase related to demand-push, even if abundant unemployment production factor is impossible or slow. Therefore, reasoning of less

developed countries, till the time not successful to change in the form of lagging behind structure or not to make attempt for immediate self-economic growth or should compromise with the inflation that is very severe sometimes. This inflation, giving the structural improvement, results as a cost in fact that is given for immediate economic growth. Structuralism, even the group that does not fine necessary for changing the present policy foundation for eradicating inflation, with the control of inflation through government intervention in the market structure and also, by adopting decisive plans for justly division of inflation pressure there is no opposition and in fact stress is done on these arrangement. But, common anti inflation measures especially contraction monetary and budget policy from their point of view, is nothing but only a prescription for stopping the economic growth of non-developing countries, that also through experts that or rationing developed investment countries and world organization under their supremacy and or by understanding less developed economy features are disabled. Rapid and faster growth of the service sector that is related to population growth and immigration is another inflationary factor, which is more emphasized by the structuralism. Remaining structure of distribution network, exclusive quasi and structure some of the developed industry, obstacle structure and heavy cost of works and ten's of other small and big factors additionally to all these structuralism from the aspect of inflationary social policy structure is unaware. It should be noticed that level competition and various society crust for large possession share from National income is one of the main factors of the hidden inflation in the developed investment countries. Structuralism type from this competition in hyperinflation of less developed countries is effective. Competition specially intensifies in condition of fast economic growth and increase social movement. New social group open its way to political grounds and economic activity and with resorting to inflation, attempt is made to strengthen the power and change distribution of income. From this viewpoint, inflation is manifestation change of economic and society is chosen from the fast dynamic growth of economy (McCallum, 1980).

**NEW POLITICAL MACROECONOMICS OF INFLATION**

The major important theories as mentioned above mainly focus on macroeconomic determinants of inflation and simply ignore the role of non- economic factors such as institutions, political process and culture in the process of inflation. Political forces, not the social planner, choose economic policy in the real world. Economic policy is the result of a decision process that balances conflicting interests so that a collective choice may emerge. The new political economy, literature provides fresh perspectives on the relations between timing of elections, performance of policy maker, political instability, policy credibility and reputation, and the inflation process itself. The case for Central Bank independence is usually framed in terms of the inflation bias present in the conduct of monetary policies. However, the theoretical and empirical work suggests that monetary constitutions should be designed to ensure a high degree of Central Bank autonomy. They also overlook the possibility that sustained government deficits, as a potential cause for inflation, may be partially or fully indigenized by considering the effects of the political process and possible lobbying activities on government budgets, and thus, on inflation (Kandil, 2010).The model in this paper used the Generalized Method of Moment (Single equation); it usually represents the following form; This equation shows positive relationship between National Income and Savings rate. Equation one can be rewritten and extend with other variables that determines economic growth (Stock *et al*., 2002).

**METHODOLOGY AND DATA**

**METHODOLOGY**

Generalized Method of Moments estimator paying particular attention to issues of weighting matrix estimation and coefficient covariance calculation. Or treatment parallels the excellent discussion in (Hahn, 2002) those interested in additional detail are encouraged to consult one of the many comprehensive surveys of the subject. The starting point of GMM estimation is the assumption that there are a set of $L$ moment conditions that the $K$ dimensional parameters of interest, $\beta$ should satisfy. These moment conditions can be quite general, and often a particular model has more specified moment conditions than parameters to be estimated. Thus, the vector of $L \geq K$ moment conditions may be written as:

$$\mathrm{E}(m(y_t, \beta)) = 0,\ \mathrm{E}(Z_t u_t(\beta)) = 0$$

$$m_T(\beta) = \frac{1}{T}\sum_t Z_t u_t(\beta) = \frac{1}{T} Z'u(\beta) = 0$$

and finding the parameter vector $\beta$ which solves this set of $L$ equations. When there are more moment conditions than parameters $L \succ K$ Such as system is said to be *over identified*. Though we cannot generally find an exact solution for an over identified system, we can reformulate the problem as one of choosing a $\beta$ so that the sample moment $m_T(\beta)$ is as "close" to zero as possible, where "close" is defined using the quadratic form:

$$J(\beta, \hat{W}_T) = T m_T(\beta)' \hat{W}^{-1} T m_T(\beta) = \frac{1}{T} u(\beta)' Z \hat{W}^{-1} Z' u(\beta)$$

as a measure of distance. The possibly random, symmetric and positive-definite $L \times L$ matrix $\hat{W}_T$ is termed the *weighting matrix* since it acts to weight the various moment conditions in constructing the distance measure.GMM estimator is consistent and $\sqrt{T}$ asymptotically normally distributed, $\sqrt{T}(\hat{\beta} - \beta_0) \to N(0, V)$ The asymptotic covariance matrix $V$ of $\sqrt{T}(\hat{\beta} - \beta_0)$ given by:

$$V = (\sum' W^{-1} \sum)^{-1} \cdot \sum' W^{-1} S W^{-1} \sum (\sum' W^{-1} \sum)^{-1}$$

*For*

$$W = p\lim \hat{W}_T$$

$$\sum = p\lim \frac{1}{T} Z' \Delta u(\beta)$$

$$S = p\lim \frac{1}{T} Z' u(\beta) u(\beta)' Z$$

where $S$ is both the asymptotic variance of $\sqrt{T} m_T(\hat{\beta})$ and the long-run covariance matrix of the vector process $\{Z_t u_t(\beta)\}$ .In the leading case where they $u_t(\beta)$ are the residuals from a

linear specification so that $u_t(\beta) = y_t - X_t'\beta$, the GMM objective function is given by

$$J(\beta,\hat{W}_T) = \frac{1}{T}(y - X\beta)'Z\hat{W}^{-1}{}_T Z'(y - X\beta)$$

$$\sum = p\lim\frac{1}{T}(Z'X)$$

Choice of Weighting Matrix: An important aspect of specifying a GMM estimator is the choice of the weighting matrix, $\hat{W}_T$. While any sequence of symmetric positive definite weighting matrices $\hat{W}_T$ will yield a consistent estimate of $\beta$, (54) shows that an asymptotically efficient, or optimal GMM estimator of $\beta$ may be obtained by choosing $\hat{W}_T$so that it converges to the inverse of the long-run covariance matrix $S$ : $p\lim\hat{W}_T = S$ Intuitively, this result follows since we naturally want to assign less weight to the moment conditions that are measured imprecisely. For a GMM estimator with an optimal weighting matrix, the asymptotic covariance matrix of $\hat{\beta}$ is given by:

$$V = (\sum' S^{-1}\sum)^{-1}\cdot\sum' S^{-1}SS^{-1}\sum(\sum' S\sum)^{-1}$$

Implementation of optimal GMM estimation requires that we obtain estimates of $S^{-1}$.

**TWO-stage least squares Matrix**: is given by $\hat{W}_T = (\hat{\sigma}^2 Z'Z/T)$ where $\hat{\sigma}^2$ is an estimator of the residual variance based on an initial estimate of $\beta$ . Estimator for variance will be $S^2$ or the no df. Corrected equivalent, depending on your settings for the coefficient covariance calculation.

**WHITE weighting matrix: is** a Heteroscedasticity consistent estimator of the long-run covariance matrix of $\{Z_t u_t(\beta)\}$ based on an initial estimate of $\beta$

**HAC weighting matrix:** is a Heteroscedasticity and autocorrelation consistent estimator the long-run covariance matrix $\{Z_t u_t(\beta)\}$ based on an initial estimate of $\beta$ .User-specified: this method allows you to provide your own weighting matrix (specified as a sym matrix containing a scaled estimate of the long-run covariance $\hat{U} = T\hat{S}$ ).

$$J(\hat{\beta}_1,\hat{\beta}_0) = \frac{1}{T}u(\beta_1)'Z\hat{S}_T(\hat{\beta}_0)^{-1}Z'u(\beta_1)$$

with respect $\beta_1$ form updated parameter estimates. We generalize this procedure by repeating steps 2 through 4 using $\hat{\beta}_1$ as our initial parameter estimates, producing updated estimates $\hat{\beta}_2$ . This iteration of weighting matrix and coefficient estimation may be performed a fixed number of times, or until the coefficients converge so that $\hat{\beta}_j = \hat{\beta}_{j-1}$ to a sufficient degree of precision. An alternative approach due to (55) notes that since the optimal weighting matrix is dependent on the parameters, we may rewrite the GMM objective function as:

$$J(\beta) = \frac{1}{T}u(\beta)'Z\hat{S}_T(\beta)^{-1}Z'u(\beta)$$

where the weighting matrix is a direct function of the $\beta$ being estimated. The estimator with respect to $\beta$ has been termed the Continuously Updated Estimator (CUE). *Coefficient* Covariance Calculation: Having estimated the coefficients of the model, all that is left is to specify a method of computing the coefficient covariance matrix, due to (Windmeijer, 2005; Ghysels, 2002), which employs a bias-corrected estimator which take into account the variation of the initial parameter estimates.

## CONVENTIONAL ESTIMATORS

inserting estimators and sample moments, we obtain an estimator for asymptotic covariance matrix of $\hat{\beta}_1$ :

$$\hat{V}_T(\hat{\beta}_1,\hat{\beta}_0) = \hat{A}^{-1}\hat{B}(\hat{S}^*)\hat{A}^{-1}$$

Where

$$\hat{A} = \Delta u_T(\hat{\beta}_1)'Z\hat{S}_T(\hat{\beta}_0)^{-1}Z'\Delta u(\hat{\beta}_1)$$

$$\hat{B} = \Delta u(\hat{\beta}_1)'Z\hat{S}_T(\hat{\beta}_0)^{-1}\hat{S}^*\hat{S}_T(\hat{\beta}_0)^{-1}Z'\Delta u(\hat{\beta}_1)$$

Notice that the estimator depends on both the final coefficient estimates $\hat{\beta}_1$ and the $\hat{\beta}_0$ used to form the estimation weighting matrix, as well as an additional estimate of the long-run covariance matrix $\hat{S}^*$ . For weight update methods which iterate the weights until the coefficients converge the two sets of coefficients will be identical. Eviews offers six different covariance specifications of this form, Estimation default, Estimation updated, Two-stage Least Squares, White, HAC (Newey-West), and User defined, each corresponding to a different estimator for $\hat{S}^*$ . Of these, Estimation default and Estimation update are the most commonly employed coefficient covariance methods. Both methods compute $\hat{S}^*$ using the estimation weighting matrix specification (*i.e.* if White was chosen as the estimation weighting matrix, then White will also be used for estimating $\hat{S}^*$ ): Estimation default uses the previously computed estimate of the long-run covariance matrix to form $\hat{S}^* = \hat{S}_T(\hat{\beta}_0)$. The asymptotic covariance matrix simplifies considerably in this case so that $\hat{V}_T(\hat{\beta}) = \hat{A}^{-1}$ .Estimation updated performs one more step 3 in the iterative estimation procedure, computing an estimate of the long-run covariance using the final coefficient estimates to obtain $\hat{S}^* = \hat{S}_T(\hat{\beta}_1)$. Since this method relies on the iterative estimation procedure, it is not available for equations estimated by CUE. In cases, where the weighting matrices are iterated to convergence, these two approaches will yield identical results. The remaining specifications compute estimates of $\hat{S}^*$ at the final parameters $\hat{\beta}_1$ using indicated long-run covariance method. You may use these methods to estimate your equation using one set of assumptions for the weighting matrix $\hat{W}_T = S^2{}_T(\hat{\beta}_0)$, while you compute the coefficient covariance using a different set assumptions for $\hat{S}^* = \hat{S}_T(\hat{\beta}_1)$.

## DATA DESCRIPTION

The paper used time series data for Inflation Rate, Gross Domestic Product, Government Expenditure, Money Supply, Exchange Rate, Unemployment Rate, and Consumer Price

Index. This data used for investigating the determinants of inf in Sudan economy 2000- 2017). It processed by using E-views econometric package. The Data symbols, description and sources are depicted in Table (1).

**The Model Specification**

$$Inf_t = \varphi_0 - \varphi_1 GDP_t - \varphi_2 GE_t + \varphi_3 MS_t + \varphi_4 ER_t - \varphi_5 UR_t + \varphi_6 CPI_t + \varepsilon_t$$

| Variables | Symbol | Description | Source |
|---|---|---|---|
| Inflation Rate | INF | Percentage | World Bank Estimates |
| Gross Domestic Product | GDP | Million SDG | Central Bureau Statistics |
| Government Expenditure | GE | Million SDG | Central Bureau Statistics |
| Money Supply | MS | Million SDG | Central Bank of Sudan |
| Exchange Rate | ER | Million SDG | Central Bureau Statistics |
| Unemployment Rate | UR | Percentage | World Bank Estimates |
| Consumer Price Index | CPI | Percentage | Central Bureau Statistics |
| Imported of Goods | IG | Million SDG | Central Bureau Statistics |
| Interest Rate | IR | Percentage | Central Bank of Sudan |

*SDG means Sudanese Pound

Where:

$Inf_t$ : Percentage of inflation Rate in period t

$GDP_t$ : Gross Domestic Production period t

$GE_t$ : Percentage of Government Expenditure.

$MS_t$ : Money Supply in period t

$ER_t$ : Exchange Rate in period t

$UR_t$ : Percentage of Unemployment Rate in period t

$CPI_t$ : Percentage of Consumer Price Index in period t

$\varphi_0$ : Intercept

$\varphi_1 \ldots \varphi_6$ : Are the slope parameters

$t$ : Time period of sample data

$\varepsilon$ : Stochastic Error term in period t

## EMPIRICAL EVIDENCE

Annex 1 shows the Descriptive statistics of inflation rate, Money Supply, Exchange Rate, Consumer Price Index, Gross Domestic Product, Government Expenditure and Unemployment Rate. Annex 2 shows the results of unit root tests based on the ADF where the inflation rate Unemployment Rate, Consumer Price Index and Gross Domestic Product stationary in (1st difference)with an intercept and Exchange Rate stationary in (2st difference)with an intercept, and Government Expenditure, and Money Supply stationary in (2st difference)with Trend and intercept. Annex 3 indicates the presence of Five Co integrating equations among these variables at 5% significance level i.e. inflation rate, Money Supply, Gross Domestic Product, Exchange Rate, Consumer Price Index, Government Expenditure, and Unemployment Rate. Annex 4 shows the ARCHLM test results provide strong evidence for rejecting the null hypothesis for all series except. Rejecting the null hypothesis indicates the existence of ARCH effects in the residuals series in the mean equation. Annex 5 shows the Generalized Method of Moments out Put.

## GENERALIZED METHOD OF MOMENTS

## TWO-STAGE LEAST SQUARES MATRIX

$$\hat{INF}_t = 0.00043\,GDP_t - 0.0521UR_t + 0.9946CPI_t - 5.26MS_t + 0.2780ER_t + 5.40GE_t$$

T-Stat: (3.5) (- 5.9) (103.6) (- 4.8) (5.9) (2.10)

$R^2 = 0.999$

$DW = 1.66$

$J - St(prob) = 0.75$

**White weighting matrix**

$$\hat{INF}_t = -0.00046\,GDP_t - 0.050UR_t + 0.991CPI_t - 5.27MS_t + 0.2739ER_t + 4.88GE_t$$

T-Stat: (3.6) (- 4.5) (62.6) (- 3.3) (5.8) (2.5)

$R^2 = 0.999$

$DW = 1.61$

$J - St(prob) = 0.64$

**HAC weighting matrix**

$$\hat{INF}_t = -0.0007\,GDP_t - 0.024UR_t + 0.998CPI_t - 1.65MS_t + 0.050ER_t + 3.22GE_t$$

T-Stat: (54.4) (- 14.49) (658.41) (- 32.77 ) (6.15) ( 0.02)

$R^2 = 0.999$

$DW = 1.98$

$J - St(prob) = 0.61$

## CONCLUSION

This paper investigates modeling the determinants of inflation in Sudan using Generalized Method of Moments. The data span from 2000- 2017. The paper employs two univariate specifications of the Generalized Method of Moments (GMM), including Two-stage least squares Matrix, White weighting matrix, and HAC weighting matrix methods that capture most common stylized facts about inflation determinants. Finally the method of analysis was the GMM, unit roots, co integration analysis. The stationary 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 co integration approach showed that there is relationship among the variables; therefore, the Generalized Method of Moments estimated and the HAC

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**Annex 1. Shows the Descriptive statistics of Inflation Determinants**

| | CPI | ER | GDP | GE | INF | MS | U |
|---|---|---|---|---|---|---|---|
| Mean | 17.0194 | 5.658278 | 1337.248 | 30786.35 | 17.25789 | 2.77E+1 | 18.03889 |
| Median | 12.2000 | 2.620500 | 1186.504 | 25463.35 | 12.24700 | 1.91E+1 | 18.05000 |
| Maximum | 37.4000 | 24.00000 | 4500.000 | 99854.70 | 37.39300 | 9.39E+1 | 20.70000 |
| Minimum | 4.90000 | 2.015000 | 352.5020 | 3522.000 | 4.871000 | 3470000 | 15.20000 |
| Std. Dev. | 11.3988 | 5.865251 | 1007.674 | 26959.21 | 11.71426 | 2.92E+1 | 1.975777 |
| Skewness | 0.72989 | 2.068337 | 1.734406 | 1.309901 | 0.720752 | 0.930441 | -0.063869 |
| Kurtosis | 1.93041 | 6.559968 | 6.383052 | 3.992744 | 1.868423 | 2.734984 | 1.391533 |
| Jarque-Bera | 2.45625 | 22.33908 | 17.60827 | 5.886680 | 2.518801 | 2.649839 | 1.952611 |
| Probability | 0.29284 | 0.000014 | 0.000150 | 0.052689 | 0.283824 | 0.265824 | 0.376700 |
| Sum | 306.350 | 101.8490 | 24070.46 | 554154.3 | 310.6420 | 4.98E+1 | 324.7000 |
| Sum Sq. Dev. | 2208.87 | 584.8198 | 1726190 | 1.24E+1 | 2332.806 | 1.45E+2 | 66.36278 |
| Observations | 18 | 18 | 18 | 18 | 18 | 18 | 18 |

**Annex 2. Shows the Co Integrating Results**

Date: 01/04/18 Time: 10:23
Sample (adjusted): 1982 2017
Included observations: 36 after adjustments
Trend assumption: Linear deterministic trend
Series: U MS IR INF IM GE GDP ER CPI
Lags interval (in first differences): 1 to 1
Unrestricted Co integration Rank Test (Trace)

| Hypothesized | | Trace | 0.05 | |
|---|---|---|---|---|
| No. of CE(s) | Eigen value | Statistic | Critical Value | Prob.** |
| None * | 0.984325 | 386.8238 | 197.3709 | 0.0000 |
| At most 1 * | 0.906189 | 237.2189 | 159.5297 | 0.0000 |
| At most 2 * | 0.684474 | 152.0259 | 125.6154 | 0.0005 |
| At most 3 * | 0.657275 | 110.4995 | 95.75366 | 0.0033 |
| At most 4 * | 0.538790 | 71.94968 | 69.81889 | 0.0335 |
| At most 5 | 0.449315 | 44.08925 | 47.85613 | 0.1081 |
| At most 6 | 0.281951 | 22.61196 | 29.79707 | 0.2657 |
| At most 7 | 0.208086 | 10.68814 | 15.49471 | 0.2314 |
| At most 8 | 0.061611 | 2.289259 | 3.841466 | 0.1303 |

Trace test indicates 5 co integrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

**Annex 3. Shows the ARCHLM test results**

| Heteroscedasticity Test: ARCH | | | |
|---|---|---|---|
| F-statistic | 0.343137 | Prob. F(1,15) | 0.5667 |
| Obs*R-squared | 0.380192 | Prob. Chi-Square(1) | 0.5375 |

## Annex 4. Shows Results of Unit Root Tests

| | | | |
|---|---|---|---|
| Null Hypothesis: D(INF) has a unit root Exogenous: Constant Lag Length: 0 (Automatic - based on SIC, maxlag=3) | | | |
| Augmented Dickey-Fuller test statistic | | t-Statistic | Prob.* |
| | | -6.501787 | 0.0001 |
| Test critical values: | 1% level | -3.920350 | |
| | 5% level | -3.065585 | |
| | 10% level | -2.673459 | |
| Null Hypothesis: D(GDP) has a unit root | | | |
| Augmented Dickey-Fuller test statistic | | t-Statistic | Prob.* |
| | | -8.213356 | 0.0000 |
| Test critical values: | 1% level | -3.920350 | |
| | 5% level | -3.065585 | |
| | 10% level | -2.673459 | |
| Null Hypothesis: D(CPI) has a unit root | | | |
| Augmented Dickey-Fuller test statistic | | t-Statistic | Prob.* |
| | | -6.091074 | 0.0002 |
| Test critical values: | 1% level | -3.920350 | |
| | 5% level | -3.065585 | |
| | 10% level | -2.673459 | |
| Null Hypothesis: D(U) has a unit root | | | |
| Augmented Dickey-Fuller test statistic | | t-Statistic | Prob.* |
| | | -3.976985 | 0.0090 |
| Test critical values: | 1% level | -3.920350 | |
| | 5% level | -3.065585 | |
| | 10% level | -2.673459 | |
| Null Hypothesis: D(ER) has a unit root | | | |
| Augmented Dickey-Fuller test statistic | | t-Statistic | Prob.* |
| | | 5.177158 | 1.0000 |
| Test critical values: | 1% level | -4.057910 | |
| | 5% level | -3.119910 | |
| | 10% level | -2.701103 | |
| Null Hypothesis: D(GE,2) has a unit root | | | |
| Augmented Dickey-Fuller test statistic | | t-Statistic | Prob.* |
| | | -0.438542 | 0.8696 |
| Test critical values: | 1% level | -4.200056 | |
| | 5% level | -3.175352 | |
| | 10% level | -2.728985 | |
| Null Hypothesis: D(MS) has a unit root | | | |
| Augmented Dickey-Fuller test statistic | | t-Statistic | Prob.* |
| | | -4.362108 | 0.0043 |
| Test critical values: | 1% level | -3.920350 | |
| | 5% level | -3.065585 | |
| | 10% level | -2.673459 | |

## Annex 5. Shows Generalized Method of Moments (GMM) Out Put

Dependent Variable: INF
Method: Generalized Method of Moments
Date: 01/04/18 Time: 09:23
Sample: 2000 2017
Included observations: 18
Estimation weighting matrix: Two-Stage Least Squares Standard errors & covariance computed using estimation weighting matrix Instrument specification: GDP U CPI MS ER GE Constant added to nstrument list

| Prob. | t-Statistic | Std. Error | Coefficient | Variable |
|---|---|---|---|---|
| 0.0047 | 3.460406 | 0.000124 | 0.000428 | GDP |
| 0.0001 | -5.909353 | 0.008828 | -0.052167 | U |
| 0.0000 | 103.6202 | 0.009599 | 0.994636 | CPI |
| 0.0005 | -4.766798 | 1.18E-11 | -5.62E-11 | MS |
| 0.0001 | 5.947840 | 0.046746 | 0.278037 | ER |
| 0.0114 | 2.983572 | 1.81E-05 | 5.40E-05 | GE |
| 17.25789 | Mean dependent var | | 0.999710 | R-squared |
| 11.71426 | S.D. dependent var | | 0.999589 | Adjusted R-squared |
| 0.676341 | Sum squared resid | | 0.237406 | S.E. of regression |
| 0.098678 | J-statistic | | 1.658946 | Durbin-Watson stat |
| 0.753422 | Prob(J-statistic) | | 7 | Instrument rank |

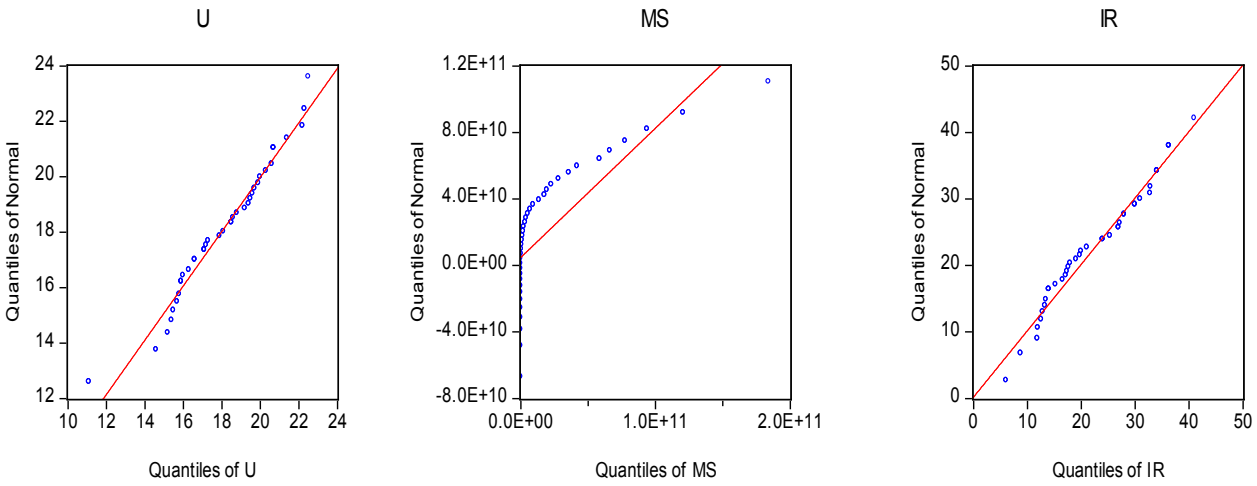
Continue ……

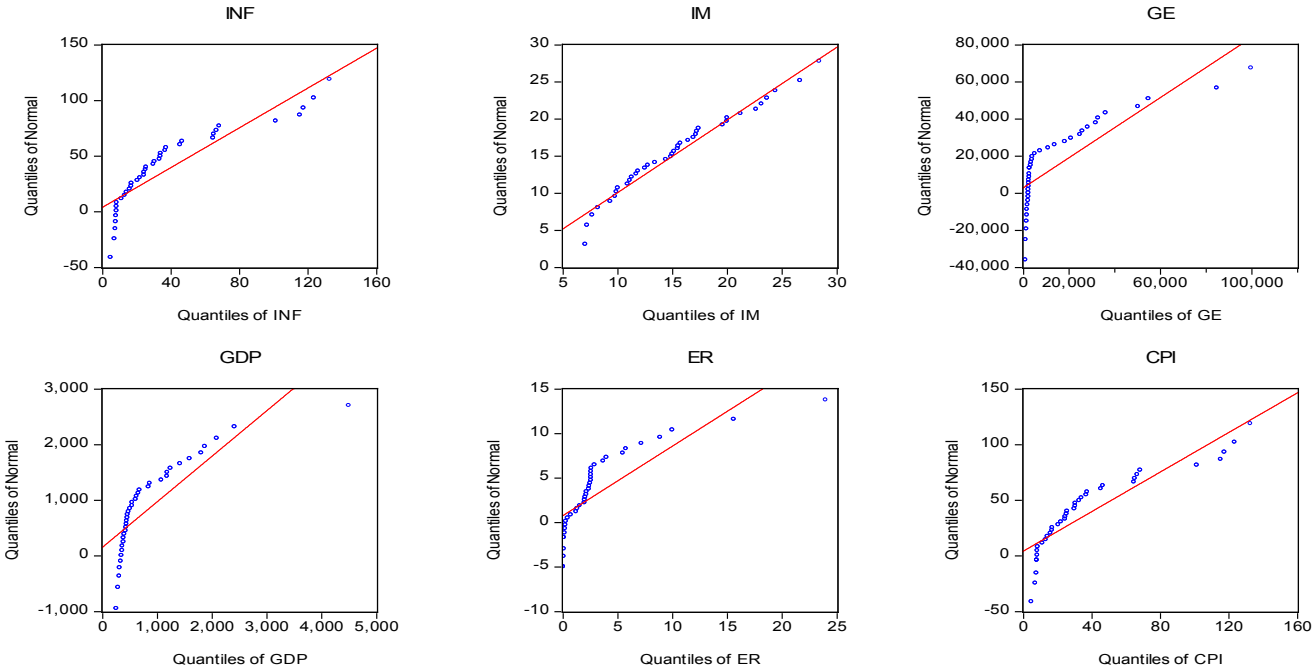
Dependent Variable: INF
Method: Generalized Method of Moments
Date: 01/04/18 Time: 09:28
Sample: 2000 2017
Included observations: 18
Linear estimation with 1 weight update
Estimation weighting matrix: White
Standard errors & covariance computed using estimation weighting matrix
Instrument specification: GDP U CPI MS ER GE
Constant added to instrument list

| Prob. | t-Statistic | Std. Error | Coefficient | Variable |
|---|---|---|---|---|
| 0.0038 | 3.583493 | 0.000127 | 0.000457 | GDP |
| 0.0007 | -4.517838 | 0.011055 | -0.049947 | U |
| 0.0000 | 62.63749 | 0.015822 | 0.991064 | CPI |
| 0.0059 | -3.340182 | 1.58E-11 | -5.27E-11 | MS |
| 0.0001 | 5.814283 | 0.047107 | 0.273891 | ER |
| 0.0257 | 2.545202 | 1.92E-05 | 4.88E-05 | GE |
| 17.25789 | Mean dependent var | | 0.999706 | R-squared |
| 11.71426 | S.D. dependent var | | 0.999583 | Adjusted R-squared |
| 0.686366 | Sum squared resid | | 0.239159 | S.E. of regression |
| 0.206496 | J-statistic | | 1.605481 | Durbin-Watson stat |
| 0.649528 | Prob(J-statistic) | | 7 | Instrument rank |

Dependent Variable: INF
Method: Generalized Method of Moments
Date: 01/04/18 Time: 09:32
Sample: 2000 2017
Included observations: 18
Linear estimation with 1 weight update
Estimation weighting matrix: HAC (Bartlett kernel, Newey-West fixed bandwidth = 3.0000)
Standard errors & covariance computed using estimation weighting matrix
Instrument specification: GDP U CPI MS ER GE
Constant added to instrument list

| Prob. | t-Statistic | Std. Error | Coefficient | Variable |
|---|---|---|---|---|
| 0.0002 | 5.431332 | 8.09E-05 | 0.000440 | GDP |
| 0.0003 | -4.958961 | 0.010594 | -0.052534 | U |
| 0.0000 | 111.8205 | 0.008886 | 0.993690 | CPI |
| 0.0055 | -3.376236 | 1.67E-11 | -5.65E-11 | MS |
| 0.0001 | 5.459116 | 0.052354 | 0.285807 | ER |
| 0.0254 | 2.550916 | 2.07E-05 | 5.27E-05 | GE |
| 17.25789 | Mean dependent var | | 0.999707 | R-squared |
| 11.71426 | S.D. dependent var | | 0.999584 | Adjusted R-squared |
| 0.684516 | Sum squared resid | | 0.238837 | S.E. of regression |
| 0.253554 | J-statistic | | 1.601513 | Durbin-Watson stat |
| 0.614584 | Prob(J-statistic) | | 7 | Instrument rank |




INF
Quantiles of Normal
Quantiles of INF
IM
Quantiles of Normal
Quantiles of IM
GE
Quantiles of Normal
Quantiles of GE
GDP
Quantiles of Normal
Quantiles of GDP
ER
Quantiles of Normal
Quantiles of ER
CPI
Quantiles of Normal
Quantiles of CPI

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