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DETERMINATION OF INFLATION IN SRI LANKA: AN ECONOMETRIC ANALYSIS USING JOHANSEN CO-INTEGRATION APPROACH

W.I. Sandamali[1], A. Jahufer[2]

[1,2]Department of Mathematical Sciences, Faculty of Applied Sciences,
South Eastern University of Sri Lanka.
[1]iresha95y@gmail.com, [2]jahufer@seu.ac.lk

ABSTRACT

This research study was mainly focused to examine the demand side and supply side determinants of inflation in Sri Lankan on economic and econometric criterion. Also, it was focused to investigate causal relationships among some macroeconomic variables such as Consumer Price Index, Broad Money, Gross Domestic Product and Exports. A time series data set has been undertaken for a period from year 1990 to 2019 to achieve the research objective. The test results revealed that long run and short run estimates have been investigated using Johansen Co-integration and Vector Error Correction approached. Causal relationships have been observed using Granger causality test. The main determinants of inflation in Sri Lanka are the Consumer Price Index, Broad Money, Gross Domestic Product and Exports in the long run equilibrium relationship existed among them. Long run elasticities of price level with respect to Board Money, Gross Domestic Product and Exports are -0.34, 0.48 and 0.63 respectively. Output gap does not have a statistically significant effect on inflation in both the long run and the short run.

Keywords: CPI, GDP, Cointegration, Elasticities

1 Introduction

Inflation is a vital macroeconomic variable. It is often defined as a sustained rise within the general level of costs ie., a persistent rise within the price levels of commodities and services, leading to a fall within the currency's purchasing power. Low inflation environment provides a better environment for economic process, encourages investors, employment opportunities and higher living standards. It's widely accepted that the pursuit of price stability is primary to long-run growth and development and will be the priority of each economy. Higher inflation causes adverse impacts on the economic performance of nations in many aspects and hence, the identification of determinants of inflation is incredibly important. Inflation reduces real value of cash and tends to deteriorate the purchasing power parity of money within the country. Specifically higher inflation weakens export competitiveness and discourages exports. The stabilization of the overall index number has become a significant macroeconomic objective of the monetary authorities in many other countries. An analysis of the economic history reveals that inflation has been a serious issue for policy makers in Democratic Socialist Republic of Sri Lanka.

Basically, Consumer Price Index (CPI) is currently being used as the official measurement of inflation in Sri Lanka. In fact, by the 1950s, inflation was limited to single digit and it remained the same during 1960s and 1970s being 5 percent and 5.9 percent respectively. However, after opening up the economy, inflation noticeably increased up to 12.1 percent by 1978 from 1.2 percent in 1977. Further, this rapid increment in inflation had continued recording 26.1 percent by 1980. Even though, it showed a gradual decline after 1980, again it jumped up to 21.5 percent in 1990. This type of fluctuation can be seen throughout the history of Sri Lankan economy. Especially, after introducing the floating exchange rate regime in 2001 inflation has dramatically increased from 6.2 to 11.6 percent by 2005. The foodflation occurred in the world economy in 2008 and 2009, showing a rapid hike especially in headline inflation in Sri Lanka. Consequently, the CPI increased from 183.5 to 203.7 from January to December 2008 reflecting the effect of external shocks such as oil price and food prices on inflation. Probably, the year-on-year change in CPI has reached all time high by June 2008, ie., 28.2 percent. Not only headline inflation but core inflation also recorded 17.2 percent in July 2008 indicating the severity of inflation. Further, it showed an increasing pattern even in 2011 as the rate of core inflation has risen up from 3.6 percent in January to 4.8 percent in May 2011.

The main objective of this research study is to focus the demand side and supply side determinants of inflation in Sri Lankan on economic and econometric criterion. Also, it is focused to investigate causal relationships among some macroeconomic variables such as CPI, Broad Money, Gross Domestic Product and Exports. To achieve this object a time series data set has been undertaken to study and analyze for a period from year 1990 to 2019.

This research paper is composed into five sections. Section two describes Review of literatures. In section three methodologies are explained. Section four illustrates the results and discussions. In the last section conclusions are described.

2. Literature Review

Inflation is a key macroeconomic variable which drive both monetary and fiscal policy. A number of theories have been introduced to explain the determinants of inflation. Further, a great deal of empirical works have been tested the determinant of inflation using different methodologies. Initial theoretical development was started by Phillips (1958) introducing the "Phillip's Curve". The notion introduced by Phillip was moderated by Lipsey (1960) to explain the wage driven inflation. However, Friedman (1968) and Phelps (1967) formulated the Natural Rate Hypothesis based on the difference of the long-run and short-run notion of Phillip. Phillip's curve was also extended by including expectation which is known as Expectations-Augmented Phillips Curve. After that, Blanchard and Summers (1988) introduced Hysteresis Hypothesis. According to this hypothesis, Non-Accelerating Inflation Rate of Unemployment (NAIRU) depends on the actual level of employment. Friedman (1970) mentioned "Inflation is a monetary phenomenon always and everywhere". His argument was confirmed by Laidler and Parkin (1975) indicating that, the inflation may occur due to the expansion of money exceeding the output expansion. Apart from that, Ericsson and Irons (1994) and Hendry (2000a) criticized the methodology adopted by Friedman (1956). They stressed the importance of expanded demand and supply shocks to explain the inflation. In addition, Hendry (2000b) highlighted the appropriateness of the output gap as a representative explanation variable in inflation models.

Several empirical studies have been carried out in the context of Sri Lanka to investigate the subject matter of this paper. For example, Dheerasinghe (2002) attempted to explain the disparity in regional inflation in Sri Lanka and stated the heterogeneity of household spending in different districts in Sri Lanka. However, Dheerasinghe (2002) failed to find region-wise inflation measures but for the whole country. Unlike Dheerasinghe (2002), Saxegaard, et. al., (2010) applied the Bayesian estimation methods to develop a Forecasting and Policy Analysis System (FPAS) to forecast and target the inflation of Sri Lanka. Their results based on eight macroeconomic quarterly time series data from 1996 to 2010 emphasized the significance of the flexibility of exchange rate and usefulness of the monetary measures in inflation targeting in Sri Lanka. In the context of modelling Sri Lanka inflation, Cooray (2007) has applied Errors Correction Model (ECM) along with the co-integration test on the annual data from 1998 to 2006 and emphasized the significance of supply side factors which eventually account for the general price level of Sri Lanka. Similarly, a long-term relationship has been investigated between the price level, real Gross National Product (GNP), the Exchange Rate (ER) and Import Prices (IP). Moreover, this study expressed that with the opening up of the economy, IP and ER movements were appeared to have a significant impact on the general level of prices.

3 Research Methodology

3.1 Data Collection

This research study secondary data for the period from 1990 to 2019 has been used. Annual time series data for the variables Consumer Price Index (CPI) based on 2010 prices, Broad Money (BM), Gross Domestic Product (GDP), Imports (M) of Goods and Services and Exports (X) of Goods and Services were obtained from the annual reports of Central Bank. All the data are in million rupees. The data were analyzed through Eviews software (version 9).

3.2 Model Specification

The purpose of this research study is to determinant the inflation in Sri Lanka and relationships of some macroeconomic variables with inflation. For this purpose, it was included demand and supply factors as given in following model form:

$$\mathrm{LCPI} = \alpha + \beta_1 \mathrm{LBM} + \beta_2 \mathrm{LGDP} + \beta_3 \mathrm{LM} + \beta_4 \mathrm{LX} + \epsilon \quad (1)$$

where L represents natural logarithm.

Log - log model has been employed to have the elasticities of price with respect to broad money, gross domestic product, imports and exports.

2.3 Estimation Procedures

This segment defines the analyzing procedure. Unit root test, lag length selection, Johansen cointegration test, vector error correction model and Granger causality test have been engaged for the analyzing process.

2.3.1 Unit Root Test

Since most time series data have a stochastic process dominated by stochastic trends over time, checking for stationary is critical. Such fluctuated series might lead to spurious regression findings, weakening the policy implications. Experts have refined many techniques for examining the order in which components are integrated. The Augmented-Dickey-Fuller (ADF) technique was used in this study. The ADF test is based on the following model:

$$\Delta Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \gamma t + \sum_i^k c_i \Delta Y_{t-i} + e_t \quad (2)$$

where;

Y_t is a time series (LCPI/ LBM/ LGDP/ LM/ LX), ΔY_t is the first difference of Y_t (Y_t - Y_{t-1}), Y_{t-1} is the lagged value of order one of Y_t, α_0 is a constant, γ is the coefficient of time trend series, α_1 is the coefficient of Y_{t-1}, k is the order of autoregressive process, c_i is the measure of lag length, ΔY_{t-i} is the changes in lagged values, and e_t is the error term.

2.3.2 Johansen Cointegration Test

After the unit root test, examinations for the presence of a long-run association between the variables must be carried out. Cointegration is used to assess the long-run connection among non-stationary time series variables. The series is said to be cointegrated when two or more series are themselves non-stationary; however, a linear combination of them is stationary. The Cointegration tests approach established by Johansen (1988) and Johansen and Juselius (1990) are commonly used to test the long-run relationship between variables. In this method trace test and the maximum eigenvalue test are proposed to estimate the number of cointegrated equations exist in the model. The model could be specified as (Ssekuma and Commerce 2011):

$$Y_t = \mu_1 Y_{t-1} + \mu_2 Y_{t-2} + \ldots + \mu_p Y_{t-p} + U_t \quad (3)$$

where;

Y_t is a (5×1) vector of endogenous variables, P is the lag length, μ_i is the estimated coefficients, and U_t is a (5×1) vector of residuals.

Different criteria are available to estimate the optimal lag length, namely Schwartz Bayesian Criteria (SC), Akaike Information Criteria (AIC), Hannan-Quinn information criteria (HQ), likelihood ratio test (LR), and Final prediction error (FPE). In this study, optimal lag length is based on the lowest values of HQ and SC criteria.

2.3.3 Error Correction Model

Error correction model is often used for data where the underlying variables have a cointegration. This technique is beneficial for estimating both short-term and long-term effects of one-time series on another. Error correction models assess the rate at which a dependent variable recovers to equilibrium following a change in other variables. The error correction model is as follows (Sims 1980):

$$\Delta LCPI_t = a_0\, ect_{t-1} + a_1\, \Delta LCPI_{t-1} + a_2\, \Delta LBM_{t-1} + a_3\, \Delta LGDP_{t-1} + a_4\, \Delta LM_{t-1} + a_5\, \Delta LX_{t-1} + a_6 \quad (4)$$

where;
Δ is the difference operator, ect_{t-1} is the error correction term, a_0 is the adjustment effect, and a_2, a_3, a_4, a_5 are short-run coefficients.

2.3.4 Granger Causality Test

The Granger causality test is used to determine the direction of causation across economic growth and other factors. Two equations are as follows (ElemUche, et. al., 2018):

$$Y_t = \sum_{i=1}^{p} \beta_i \, Y_{t-i} + \sum_{j=1}^{q} \gamma_j \, X_{t-j} + e_{1t} \quad (5)$$

$$X_t = \sum_{i=1}^{p} \alpha_i \, X_{t-i} + \sum_{j=1}^{q} \delta_j \, Y_{t-j} + e_{2t} \quad (6)$$

where;

Y_t and X_t = two variables, e_{1t} and e_{2t} = mutually independent error terms

These two equations were applied to all variables in this study taken two at a time.

4 Results and Discussion

4.1 Stationary Test

Table 1: Unit Root Test

Variable		ADF Test		
	Indicator	Level	1st Difference	Stationary
LCPI	Statistic	-2.7460	-3.5582	I(1)
	P-Value	0.0787	**0.0136**	
LBM	Statistic	-0.9002	-4.7980	I(1)
	P-Value	0.7734	**0.0006**	
LGDP	Statistic	-0.7861	-3.4882	I(1)
	P-Value	0.8081	**0.0160**	
LM	Statistic	-1.6952	-5.0883	I(1)
	P-Value	0.4230	**0.0003**	
LX	Statistic	-2.6334	-4.2821	I(1)
	P-Value	0.0989	**0.0025**	

Unit root test can be used to determine whether the time series data is stationary or non-stationary. The test results are given in above Table 1:

The above test results show that all variables first difference is stationary at 5% significance level. This indicates that each variable is integrated in order 1 and concluded that each variable in the study can be made stationary by taking the first difference. In summary, since LCPI, LBM, LGDP, LM and LX are integrated in the same difference I(1) and these variables are suitable for the long run co-integration test.

4.2 Lag Length Selection

The Table 2 describes lag length selection using Akaike Information Criterion (AIC), Schwarz information criterion and Hannan-Quinn information criterion. According the statistics values the appropriate lag length is 1 where the statistics values are minimum.

Table 2: Lag Length Selection

Lag	LogL	LR	FPE	AIC	SC	HQ
0	198.6171	NA	6.78e-13	-13.82979	-13.59190	-13.75706

1	373.2092	274.3591*	1.61e-17	-24.51494	-23.08758*	-24.07858*
2	401.3211	34.13587	1.55e-17*	-24.73722*	-22.12039	-23.93723

* 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

4.3 Johansen Test

The Maximum Likelihood procedure, suggested by Johansen (1988) is preferable when the number of variables in the study exceeds two variables due to the possibility of existence of multiple cointegrating vectors. Two statistic tests used to determine the numbers of cointegrating vectors are: Trace test and the Maximal eigenvalue test. The Trace test tests null hypothesis that the number of cointegrating vectors equals or less than (r).

4.3.1 Johansen Co-integration Test

Table 3: Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.735380	92.61325	69.81889	**0.0003**
At most 1 *	0.605948	55.38831	47.85613	**0.0084**
At most 2	0.450393	29.31269	29.79707	0.0568
At most 3	0.258520	12.55322	15.49471	0.1323
At most 4 *	0.138623	4.178229	3.841466	**0.0409**

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

According to Johansen co-integration test based on Trace test and Maximum eigenvalue test (Tables 3 and 4), the analysis rejects the null hypothesis that there is no co-integrated vector (None) and there is at most 4 co-integrated vector (At most 4) have been identified at 5% significant level. Since both trace and maximum eigen statistics are higher than that of critical values at two co-integration vectors. Consequently, long run equilibrium can be identified for inflation in Sri Lanka. And VECM long run equilibrium can be interpreted as follows.

Table 4: Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.735380	37.22493	33.87687	**0.0192**
At most 1	0.605948	26.07563	27.58434	0.0770
At most 2	0.450393	16.75947	21.13162	0.1836
At most 3	0.258520	8.374990	14.26460	0.3419
At most 4 *	0.138623	4.178229	3.841466	**0.0409**

4.3.2 Johansen Long Run Results

Long run estimates of inflation model results are in Table 5. The results reveal that board money is found to be directly related to the price level in case of Sri Lanka. The coefficients have negative sign and significant at 5% level suggesting that 5% in increase in board money supply leads to 0.34 negative. Devapriya and Ichihashi (2012) found that a 1% change in growth rate of money supply will induce 0.18 positive

In the same manner, economic growth caused by increased aggregate demand leads to an acceleration in inflation in economy. When the gross domestic product increases by 5%, the inflation rate will increase by 0.48. Bandara (2011) has found that gross domestic product is a key driver of inflation in the long run through the demand side of the economy.

Table 5: Johansen long run results

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Conclusion
LBM	-0.336545	0.160465	-2.097315	**0.0462**	Significant
LGDP	0.481681	0.153871	3.130417	**0.0044**	Significant
LM	0.161073	0.245803	0.655293	0.5183	Insignificant
LX	0.632952	0.297894	2.124756	**0.0437**	Significant
C	-8.673018	0.859721	-10.08818	**0.0000**	Significant

4.4 Vector Error Correction Model

The adjustment process in the short run towards the long run equilibrium is captured using the vector error correction model (VECM). Table 6 discusses the short run results using VECM. Values without brackets are short run coefficients, values in round brackets are showing standard errors and square brackets are denoting t-statistics. The most important thing in the short run results is cointEq1. It shows that how much time would be taken by the economy to reach at long run equilibrium. Negative sign of cointEq1 shows that the economy will converge towards long run equilibrium after taking 5% annually adjustments in the short run however the value of coefficient is statistically insignificant.

4.5 Granger Causality Tests

Granger causality is a technique for determining whether one time series is useful in forecasting another. The results of granger causality are in table 7 based on significant probability values less than or equal to 0.10. These demonstrate that consumer price index is significantly affected by exports of goods and services. Bi-directional relationship is found between exports and consumer price index.

The analysis also has traced out Uni-directional relationship between gross domestic product and broad money; imports and broad money and imports and gross domestic product.

Table 6: Vector Error Correction Short run results

Error Correction:	D(LCPI)	D(LBM)	D(LGDP)	D(LM)	D(LX)
CointEq1	-0.502269	0.722681	0.293845	0.901288	0.323887
	(0.18011)	(0.27962)	(0.39190)	(0.63798)	(0.35580)
	[-2.78866]	[2.58455]	[0.74979]	[1.41271]	[0.91031]
D(LCPI(-1))	0.770906	-0.740250	0.417063	-0.263527	-0.244964
	(0.24059)	(0.37351)	(0.52350)	(0.85222)	(0.47528)
	[3.20422]	[-1.98188]	[0.79668]	[-0.30923]	[-0.51541]
D(LCPI(-2))	0.050431	0.091274	0.457827	0.208701	0.771002
	(0.20769)	(0.32243)	(0.45192)	(0.73568)	(0.41029)
	[0.24281]	[0.28308]	[1.01308]	[0.28368]	[1.87918]
D(LBM(-1))	0.176306	-0.023589	0.438111	0.718567	0.621778
	(0.16906)	(0.26246)	(0.36786)	(0.59884)	(0.33397)
	[1.04287]	[-0.08988]	[1.19099]	[1.19994]	[1.86179]
D(LBM(-2))	-0.074880	0.279417	0.192857	0.266404	0.590370
	(0.12691)	(0.19703)	(0.27615)	(0.44955)	(0.25071)
	[-0.59001]	[1.41815]	[0.69837]	[0.59260]	[2.35477]
D(LGDP(-1))	-0.095115	0.551870	0.176072	-0.172781	-0.331507
	(0.15399)	(0.23906)	(0.33506)	(0.54545)	(0.30419)
	[-0.61768]	[2.30850]	[0.52549]	[-0.31677]	[-1.08979]
D(LGDP(-2))	0.221088	-0.396040	0.010502	-0.305520	-0.308863
	(0.15797)	(0.24524)	(0.34372)	(0.55954)	(0.31205)

	[1.39960]	[-1.61494]	[0.03056]	[-0.54602]	[-0.98978]
D(LM(-1))	-0.269247	0.341913	-0.203336	-0.067789	0.097749
	(0.14691)	(0.22807)	(0.31965)	(0.52036)	(0.29020)
	[-1.83279]	[1.49919]	[-0.63612]	[-0.13027]	[0.33683]
D(LM(-2))	0.028703	0.034394	0.117606	-0.131652	-0.122629
	(0.13681)	(0.21239)	(0.29768)	(0.48460)	(0.27026)
	[0.20980]	[0.16193]	[0.39507]	[-0.27167]	[-0.45374]
D(LX(-1))	0.252392	0.093380	0.038062	0.686927	0.128871
	(0.16340)	(0.25367)	(0.35553)	(0.57878)	(0.32278)
	[1.54466]	[0.36812]	[0.10706]	[1.18686]	[0.39925]
D(LX(-2))	-0.607994	0.381142	-0.425464	-0.159638	-0.206860
	(0.16870)	(0.26190)	(0.36707)	(0.59756)	(0.33326)
	[-3.60400]	[1.45529]	[-1.15907]	[-0.26715]	[-0.62072]
C	0.025617	0.022036	-0.022972	-0.016066	-0.024047
	(0.01728)	(0.02682)	(0.03759)	(0.06119)	(0.03413)
	[1.48288]	[0.82167]	[-0.61113]	[-0.26255]	[-0.70464]
R-squared	0.690229	0.690930	0.561064	0.430520	0.480827
Adj. R-squared	0.463063	0.464279	0.239178	0.012901	0.100101
F-statistic	3.038441	3.048429	1.743051	1.030892	1.262920

Table 7: Granger Causality Results

Null Hypothesis:	Obs.	F-Statistic	Prob.
D(LBM) does not Granger Cause D(LCPI)	27	1.05924	0.3637
D(LCPI) does not Granger Cause D(LBM)		0.04245	0.9585
D(LGDP) does not Granger Cause D(LCPI)	27	0.56513	0.5763
D(LCPI) does not Granger Cause D(LGDP)		2.25226	0.1289
D(LM) does not Granger Cause D(LCPI)	27	1.07357	0.3590
D(LCPI) does not Granger Cause D(LM)		0.61622	0.5490
D(LX) does not Granger Cause D(LCPI)	27	2.91877	0.0751
D(LCPI) does not Granger Cause D(LX)		1.98090	0.1618
D(LGDP) does not Granger Cause D(LBM)	27	8.65167	**0.0017**
D(LBM) does not Granger Cause D(LGDP)		0.37311	0.6929
D(LM) does not Granger Cause D(LBM)	27	5.61324	**0.0107**
D(LBM) does not Granger Cause D(LM)		2.38252	0.1157
D(LX) does not Granger Cause D(LBM)	27	2.19597	0.1350
D(LBM) does not Granger Cause D(LX)		1.76602	0.1944
D(LM) does not Granger Cause D(LGDP)	27	4.47355	**0.0234**
D(LGDP) does not Granger Cause D(LM)		0.48507	0.6221
D(LX) does not Granger Cause D(LGDP)	27	2.38494	0.1155

D(LGDP) does not Granger Cause D(LX)		0.69118	0.5115
D(LX) does not Granger Cause D(LM)	27	1.34390	0.2814
D(LM) does not Granger Cause D(LX)		0.57944	0.5685

5. Conclusion

The study carries out end of the day also as short run estimates of some factors influencing consumer price level (inflation) in Sri Lanka. The results of the analysis reveal that within the end of the day gross domestic product, imports and exports are contributed in raising decrease due to higher consumer price index. In the short run, the coefficient of error correction term is 0.16 suggesting 16% annual adjustment towards long run equilibrium.

Long run elasticities of price index with reference to board money, gross domestic product and exports are -0.34, 0.48 and 0.63 respectively. Causality inferences are quite interesting implying bi-directional also as Uni-directional relationships among few variables. But board money, gross domestic product, government exports are playing role to possess significant effect on consumer price index. At the end, it's suggested that gross domestic product and imports shouldn't be the maximum amount higher that these all raise the worth level those are not in favor of any economy.

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