An Examination on the Determinants of Inflation

Yen Chee Lim and Siok Kun Sek, *Member, IEDRC*

Abstract—This paper examines factors affecting inflation in two groups of countries (high inflation group and low inflation group) using annual data from 1970 to 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. Results also indicate that money supply, national expenditure and GDP growth are the determinants of inflation which impose long run impact on inflation in high inflation countries. In the short run likewise, none of the variables is found to be significant determinants in high inflation countries. However money supply, imports of goods and services and GDP growth has significant relationship with inflation in low inflation countries.

Index Terms—About ARDL model, dynamic panel data, GDP growth, inflation, long-run coefficient.

I. INTRODUCTION

Inflation is a monetary phenomenon and the persistent inflation has widely attracted the attention of the economists all over the world. In common, inflation is defined to be a continuous and persistent rise in the general price level and hence leads to a fall in purchasing power. According to [1], inflation is the one form if taxation that can be imposed without legislation. Generally, inflation has been defined either as monetary phenomenon (for example, [2]) or phenomenon of raising prices (for example [3]-[5]).

There is a general agreement amongst economist that economic inflation may be cause by either an increase in the money supply or a decrease in the quantity of goods being supply. Basically, there are four types of inflation as creeping inflation, walking inflation, running inflation and jumping or hyper-inflation. Economists conclude that creeping inflation is a mild inflation which is not dangerous to the economy and is an important instrument of economic development. Walking inflation occurs when prices rise moderately and the annual inflation rate is a single digit. While running inflation refers to the annual inflation rate is double digits and treated as a signal for hyper-inflation. When the price rises to running inflation, it will affect the deprived and middle classes unfavorable.

Hyper-inflation is the prices rise very rapidly and a condition when the rate of inflation becomes immeasurable and completely uncontrollable. Hyper-inflation occurring when the country imposing it is in desperate need of money.

High inflation and fluctuation in prices is not preferred as it will cause to uncertainty and cost push shock which will affect the stability and performance of economics. Therefore, low inflation and stability in prices is always one of the core objectives targeted by the policymaker in designing the monetary policy.

The study on the determinants of inflation is important as the results will provide higher understanding on the transmission of shocks and the inter-relationship between inflation and economic factors. Hence earlier actions can be taken to avoid high inflation and the negative effects of inflation on economy. There are a lot of studies investigating the causes of the inflation and the findings are many and varied. In this study, we seek to identify the causes of inflation between two groups of countries, i.e. high and low inflation countries. The ARDL model is applied to reveal the short run impact and long run impact of each factor on inflation. Applying the dynamic panel approach, our results reveal that GDP growth and imports of goods and services have significant long run impact on inflation in low inflation countries. Money supply, national expenditure and GDP growth on the other hand, have significant long run impacts on inflation in high inflation countries. These variables have limited short run impacts on inflation.

The remaining paper is organized as follows: section 2 provides discussion on literature review, section 3 explains the data and methodology applied, section 4 summarizes the main findings and section 5 concludes and finalized the paper.

II. LITERATURE REVIEW

There are several empirical studies undertaken to identify the possible determinants of inflation based on different techniques and time period. Although the topic is no more new, there are continuing studies on this topic to reveal the possible factors affecting the movement of inflation. These studies report different results.

The variables that have been repeatedly taken by researchers to explain inflation are money supply, exchange rate, interest rate, inflation expectation, imported inflation and Gross Domestic product (GDP). For instance, [6]-[8] discussed that the money supply is a significant determinant of inflation. However [9] and [10] found that there is no evidence to show money supply affect in inflation.[7]-[9], [11], [12] also reported that exchange rate contributed to the rise in inflation but [13] in her study of determinant of inflation in Ethiopia found that exchange rate has a negative and insignificant impact. Nominal interest rate has positive pressure on inflation as discussed by [8], [11] and [14].

The authors are with the School of Mathematical Sciences, Universiti Sains Malaysia, 11800 Minden, Penang, Malaysia (e-mail: yencheelim@yahoo.com, sksek@usm.my)

However [12] reported the nominal interest rate has insignificant influence on the inflation. [6] and [7] in their study also found Gross Domestic Product (GDP) has a positive influence on inflation but [11] claim that GDP has negative relationship with inflation. [15] also discussed inflation expectation and imported inflation have positive pressure on inflation.

Previous studies apply 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 Autoregression (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, [6] applied these three methods in his study and probes that money supply, GDP and government expenditures presenting positive impression on inflation. [16] 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[8] 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. [9] also applied Co-integration and Vector Error Correction method to investigate the determinants of inflation in Poland and found that the labour 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, [17] applied Co-integration and OLS method in the study and found monetary is a main factor of inflation in Paraguay. [12] 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, [6], [11] and [15] discussed their study in Pakistan. [16] focused the study in Albania, [9] focused the study in Poland and [18] focused the study in Jordan. There are also a few studies focus on the Gulf Cooperation Council (GCC) country such as [19] and [20].

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.

III. DATA AND METHODOLOGY

The study uses the annual data on inflation, money supply, national expenditure, imports of goods and services and gross domestic product growth. These data are obtained from IMF database covered the time period from 1970 to 2011 in 28 countries. These 28 countries are categorized into two groups as high inflation countries and low inflation countries, see

Table I.

A. Grouping and Variables

TABLE I: THE GROUPS OF COUNTRIES

1. Iran, Islamic Rep.	1. Australia
2. Argentina	2. Canada
3. Uruguay	3. Cyprus
4. Sudan	4. Denmark
5. Burundi	5. Finland
6. Colombia	6. Italy
7. Ecuador	7. Malaysia
8. Ghana	8. Malta
9. Iceland	9. Morocco
10. Indonesia	10. Netherlands
11. Israel	11. Norway
12. Mexico	12. United States
13. Turkey	13. Bahamas
14. Uruguay	14. Singapore

TABLE II: THE DESCRIPTION OF VARIABLES

No.	Variable	Unit	Sources
1	Inflation, (*inf*)	annual %	International Monetary Fund, International Financial Statistics and data files.
2	Money supply, (*m4*)	annual %	International Monetary Fund, International Financial Statistics and data files.
3	Gross national expenditure (*ne*)	% of GDP	World Bank national accounts data, and OECD National Accounts data files.
4	Imports of goods and services , (*imp*)	% of GDP	World Bank national accounts data, and OECD National Accounts data files.
5	GDP growth, (*gdpgrowth*)	annual %	World Bank national accounts data, and OECD National Accounts data files.

*Sources: IMF database.

To carry out the study on the determinants of inflation, we obtain the data from the International Monetary Fund (IMF) database. The variables involved in this study are inflation, money supply, national expenditure, imports and GDP growth. The study uses the annual data from years 1970 to 2011 for 28 countries. These 28 countries are categorized into two groups as high inflation countries and low inflation countries.

The data used in this study include inflation, money supply, national expenditure, imports and GDP growth. Table II shows the list of data with their unit of measurement and sources.

According to IMF database, these data are explained as follows. Inflation is measured by consumer price index reflects the annual percentage change in the cost to the average consumer of acquiring a basket of goods and services that may be fixed or changed at specified intervals, such as yearly. Money supply (*m4*) is an average annual growth rate in money and quasi money. Money and quasi money comprise the sum of currency outside banks, demand deposits other than those of the central government and the time savings and foreign currency deposits of resident sectors other than the central government. Gross national

expenditure (*ne*) defined as the sum of household final consumption expenditure (formerly private consumption), general government final consumption expenditure (formerly general government consumption), and gross capital formation (formerly gross domestic investment). Imports of goods and services (*imp*) represent the value of all goods and other market services received from the rest of the world. They include the value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services, such as communication, construction, financial, information, business, personal, and government services. They exclude compensation of employees and investment income (formerly called factor services) and transfer payments. GDP growth (*gdpgrowth*) is an annual percentage growth rate of GDP at market prices based on constant local currency. Aggregates are based on constant 2000 U.S. dollars. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources.

B. ARDL Model

The study employs the Error Correction Model based on the Autoregressive Distributed Lag (ARDL) modeling to estimate the relationship between inflation and its variables. The models are estimated using Mean Group (MG) estimator and Pooled Mean Group (PMG) estimator. A Hausman test is conducted to suggest a preferred estimator for the study.

In estimating the determinants of inflation, using the known sources, the general model is specified as follows:

$$inf = f(m4, ne, imp, gdpgrowth)$$

The equation specifies that inflation (inf) is a function of money supply (*m4*), national expenditure (*ne*), imports (*imp*) and gross domestic product growth (*gdpgrowth*). The relationship is investigated by using Autoregressive Distributed Lag (ARDL) model and Error Correction Model (ECM). [21] stated, sufficient augmentation of the order of the ARDL model can simultaneously correct for the problem of residual serial correlation and endogenous regressor. Mathematically we specify an ARDL model with p lags of Y and q lags of X, ARDL (p, q) as [21]: In this paper, we do not consider the fix effect specification.

$$y_{i,t} = \sum_{j=1}^{p} \lambda_{i,j} y_{i,t-j} + \sum_{j=0}^{q} \delta'_{i,j} x_{i,t-j} + \varepsilon_{i,t} \qquad (1)$$

where the number of countries $i = 1, 2, ..., N$; number of periods $t = 1, 2, ..., T$; $y_{i,t}$ is variable for inflation; $x_{i,t}$ are $k \times 1$ vector of explanatory variables for countries i, $\delta_{i,j}$ are $k \times 1$ coefficient vectors; $\lambda_{i,j}$ are scalars and $\varepsilon_{i,t}$ is a disturbance term with a zero mean and a finite variance, σ^2. (1) can be re-parameterized and expressed into an error correction model written as:

$$\Delta y_{i,t} = \phi_i y_{i,t-1} + \gamma'_i x_{i,t} + \sum_{j=1}^{p-1} \lambda^*_{i,j} \Delta y_{i,t-j} + \sum_{j=0}^{q-1} \delta^{*'}_{i,j} \Delta x_{i,t-j} + \varepsilon_{i,t} \quad (2)$$

where

$$i = 1, 2, ..., N \; ; \; t = 1, 2, ..., T \; ; \quad \phi_i = -\left(1 - \sum_{j=1}^{p} \lambda_{i,j}\right); \; \gamma_i = \sum_{j=0}^{q} \delta_{i,j}$$

$$\lambda^*_{i,j} = -\sum_{m=j+1}^{p} \lambda_{i,m}, \; j = 1, 2, ..., p-1 \text{ and } \delta^*_{i,j} = -\sum_{m=j+1}^{q} \delta_{i,m}$$

$j = 1, 2, ..., q-1$, $\phi_i \neq 0$ is the speed of adjustment.

The long-run relationship between $y_{i,t}$ and $x_{i,t}$ can be written as:

$$y_{i,t} = -\left(\gamma'_i / \phi_i\right) x_{i,t} + \eta_{i,t}$$

where $\eta_{i,t}$ is a stationary process and $\theta_i = -\left(\gamma_i / \phi_i\right)$ are the long-run coefficients on $x_{i,t}$ which are same across groups. The panel data model is solved using the likelihood approach where the log-likelihood function can be written as:

$$\ell_T(\Upsilon) = -\frac{T}{2} \sum_{i=1}^{N} \ln 2\pi\sigma_i^2 - \tag{3}$$
$$\frac{1}{2} \sum_{i=1}^{N} \frac{1}{\sigma_i^2} \left(\Delta y_i - \phi_i \xi_i(\theta)\right)' H_i \left(\Delta y_i - \phi_i \xi_i(\theta)\right)$$

where

$$H_i = I_T - W_i \left(W'_i W_i\right)^{-1} W'_i \qquad \text{given that}$$

$$W_i = \left(\Delta y_{i,t-1,...}, \Delta y_{i,t-p+1}, \Delta x_{i,t}, \Delta x_{i,t-1}, ..., \Delta x_{i,t-q+1}\right) \qquad \text{and}$$

$$\Upsilon = \left(\theta', \phi', \sigma'\right)'; \; \phi = \left(\phi_1, ..., \phi_N\right)'; \; \sigma = \left(\sigma_1^2, ..., \sigma_N^2\right)'$$

In order to maximize the estimation of long-run coefficients θ and the error-correction coefficients ϕ_i, (3) is maximizing with respect to Υ. The maximum likelihood estimators is referred to as the pooled mean group (PMG) estimators by considering the homogeneity restrictions on the long-run coefficients and taking the means of the estimates (see [21] for details).

C. Lag Length Selection

The information criteria are often used as a guide in model selection. There are many lag length criterion can be employed to determine the autoregressive lag length but in this study we estimate the autoregressive lag length by using Akaike information criterion (AIC) and Bayesian information criterion (BIC). AIC and BIC function is largely based on the log likelihood function, the lower AIC and BIC imply the model is closer to be the true model. Stata IC 12 as the statistical software calculates the AIC and BIC based on the log likelihood function defined as:

$$AIC(p) = -2\left(\frac{LL}{T}\right) + \frac{2t_p}{T}$$

$$BIC(p) = -2\left(\frac{LL}{T}\right) + \frac{\ln(T)}{T} t_p$$

where

LL is the maximized log likelihood function for the estimated model.

t_p is the total number of parameters in the model.

T is the number of observations.

IV. Results

A. Lag Length Selection

The Autoregressive Distributed Lag (ARDL) model and Error Correction Model (ECM) are used to investigate the determinants of inflation. In this study, we have an endogenous variable (inflation) and 4 exogenous variables (money supply, national expenditure, imports, GDP growth). We construct the ARDL using different combination up to at most lag one for each variable. Table III shows the results of AIC and BIC for different lag length combinations of ARDL model. The ideal lag length is the minimization of the AIC and BIC functions. Base on the result, we note that ARDL (1,1,1,1,1) is the ideal model for the low inflation countries and ARDL (1,1,1,0,0) is the ideal model for high inflation countries.

TABLE III: LAG LENGTH SELECTION

ARDL MODEL	Low Inflation Countries		High Inflation Countries	
	AIC	BIC	AIC	BIC
(1,0,0,0,0)	2530.94	2556.81	6112.51	6138.48
(1,1,0,0,0)	2528.54	2558.71	6085.29	6115.56
(1,1,1,0,0)	2518.30	2552.75	6077.19	6111.78
(1,1,1,1,0)	2477.73	2516.49	6078.65	6117.55
(1,1,1,1,1)	2439.18	2482.21	6079.89	6123.11

B. Estimation

Table IV presents the estimation result for both groups of countries based on the PMG estimator. There are 4 exogenous variables in our study for low inflation countries which are m4, ne, imp and gdpgrowth. For high inflation countries, there are only two parameters (m4 and ne) involved in our investigation.

From Table IV, we observe that gdpgrowth has significant negative long run impact on inflation low inflation countries. Every 1% increase in gdpgrowth induces to 1.19% increase in inflation in low inflation countries. Therefore, inflation-gdpgrowth trade-off is in low inflation countries.

The positive coefficient on changes in excess money supply implies that increases in money supply have generated long run negative impact on inflation in high inflation countries. Result shows that with 1% rise in money supply will lead to 0.77% increase in inflation. However, there is no evidence shows that excess money supply in long run will influence inflation in low inflation countries.

Another variable that give long run effect on inflation in high inflation countries is national expenditure. Every percent increase in national expenditure will leads to 0.50%

decrease in inflation.

Imports of goods and services also play an important role in determining inflation for low inflation countries. Negative coefficient on imports implies that it has positive impact on inflation. 1% increase in imports will lead to 0.054% decrease in inflation.

The coefficient of ECT_{t-1} is the speed of adjustment which adjusts for the long run impacts on variables. The results show negative values for both countries and statistically significant at 1% level. The negative values in speed of adjustment induce the impact of shocks on inflation are declining over time.

The finding also shows that there are no short run relationship between inflation and variables for high inflation countries. However, money supply, imports and gdpgrowth have short run impact on inflation in low inflation countries. Every 1% increase in money supply and gdpgrowth will lead to 0.031% and 0.30% decrease in inflation respectively. These two determinants show positive impact on inflation. The result also indicates that imports of goods and services have negative impact on inflation with every 1% rise in imports result 0.39% rise in inflation.

TABLE IV: EMPIRICAL RESULTS OF PMG

Variable	Low Inflation Countries	High Inflation Countries
	Coef	Coef
	($P > |z|$)	($P > |z|$)
m4	0.0710	0.7729***
	(0.162)	(0.000)
ne	-0.0410	-0.5016**
	(0.489)	(0.025)
imp	-0.0541*	-
	(0.096)	
gdpgrowth	1.1935***	-
	(0.000)	
Speed of adjustment	-0.2003***	-0.5280***
	(0.000)	(0.000)
Δm4	-0.0308**	-0.0258
	(0.021)	(0.807)
Δne	-0.0686	2.5953
	(0.598)	(0.336)
Δimp	0.3912***	-
	(0.004)	
Δgdpgrowth	-0.3024***	-
	(0.000)	
Maximized log likelihood	-1042.083	-2267.074
Number of parameters	4	2

Notes:
*** denoted the 1% significant level
** denoted the 5% significant level
* denoted the 10 % significant level

V. Conclusion

This paper investigates the determinants of inflation in two different levels inflation groups on the annual data for the period 1970 to 2011. The study applies ARDL and EC

models to investigate the relationship between exogenous variables (money supply, national expenditure, imports of goods and services and GDP growth) and endogenous variable (inflation) for long run effects and short run effects. The main findings in this study are as follows. For the long run impact in high inflation countries, money supply and national expenditure have significant effect on inflation. National expenditure implies positive impact on inflation but money supply implies negative impact on inflation. In low inflation countries, GDP growth has negative impact on inflation and imports of goods and services have positive impact on inflation. The study for short run effect for both countries shown that there are none of the variables have significant impact on inflation in high inflation countries. The study reveals that all exogenous variables have significant short run impact on inflation in low inflation countries except national expenditure. The findings also indicate that there is only imports of goods and services has negative impact on inflation and the rest of the variables give positive impact on inflation in low inflation countries. Generally the determinants of inflation with the significant negative impact should be controlled to enhance the stability in economy.

REFERENCES

[1] M. Friedman, *Inflation: Causes and Consequences*, New York: Asia Publishing House, 1963.
[2] E. W. Kemmerer, *The ABC of Inflation*, New York: McGraw-Hill, 1942.
[3] G. Ackley, *Microeconomics: Theory and Policy*, New York: Collier Macmilan, 1978.
[4] E. Shapiro, *Macroeconomic Analysis*, 5th ed., New Delhi: Galgotia Publisher, 1944.
[5] H. E. Johnson, *Essays in Monetary Economic*, 2nd Ed., Cambridge: Havard University Press, 1970.
[6] F. Bashir, S. Nawaz, K. Yasin, U. Khursheed, J. Khan, and M. J. Qureshi, "Determinants of inflation in Pakistan: An econometric analysis using Johansen cointegration approach," *Australian Journal of Business and Management Research*, vol. 1, no. 5, pp. 71-82, 2011.
[7] R. Bandara, "The determinants of inflation in Sri Lanka: An application of the vector autoregression model," *South Asia Economic Journal*, vol. 12, no. 2, pp. 271-286, 2011.
[8] G. Adu and G. Marbuah, "Determinants of inflation in Ghana: An empirical investigation," *South African Journal of Economics*, vol. 79, no. 3, pp. 251-269, 2011.
[9] B. Y. Kim, "Determinants of inflation in Poland: A structural cointegration approach," *BOFIT*, Discussion Paper, no. 16, 2001.
[10] H. A. Altowaijri, "Determinants of inflation in Saudi Arabia," *World Review of Business Research*, vol. 1, no. 4, pp. 109-114, 2011.
[11] Aurangzeb and A. U. Haq, "Determinants of inflation in Pakistan," *Universal Journal of Management and Social Sciences*, vol. 2, no. 4, pp. 89-96, 2012.
[12] R. E. Khan and A. R. Gill, "Determinants of inflation: A case of Pakistan (1970-2007)," *Journal of Economics*, vol. 1, no. 1, pp. 45-51, 2010.
[13] S. Menji, "*Determinants of Recent Inflation in Ethiopia*," Bachelor Degree thesis, Unity University, 2009.
[14] K. Greenidge and D. Dianna, "Determinants of inflation in selected Caribbean countries," *Business, Finance and Economics in Emerging Economies*, vol. 4, no. 2, pp. 371-397, 2008.
[15] A. A. Khan, S. K. H. Bukhari, and Q. M. Ahmed, "Determinants of recent inflation in Pakistan," *MPRA*, working paper 16254, 2007.
[16] I. Domec and C. Elbirt, "The main determinants of inflation in Albania," *World Bank Policy Research*, working paper 1930, 1998.
[17] B. Monfort and S. Peña, "Inflation determinants in Paraguay: Cost push versus demand pull factors," *IMF*, working paper 08270, 2008.
[18] M. Jaradat, H. A. A. Zeaud and H. A. Rawahneh, "An econometric analysis of the determinants of inflation in Jordan," *Middle Eastern Finance and Economics*, issue 15, pp. 120-132, 2011.
[19] M. Kandil and H. Morsy, "Determinants of inflation in GCC," *IMF*, working paper 09/82, 2009.
[20] S. A. Basher and E. M. Elsamadisy, "Country heterogeneity and long-run determinants of inflation in the gulf Arab states," *OPEC Energy Review*, vol. 36, no. 2, pp. 170-203, 2012.
[21] M. H. Pesaran, Y. Shin, and R. P. Smith, "Pooled mean group estimation of dynamic heterogeneous panels," *Journal of the American Statistical Association*, vol. 94, no. 446, pp. 621-624, 1999.

Yen Chee Lim is a master student in the program of statistics, Universiti Sains Malaysia. The results summarized in this paper are parts of her master dissertation.

Siok Kun Sek was born in the city of Malacca, Malaysia. She completed her primary, secondary and high school in Malacca. She obtained her bachelor degree in economics from the National University of Malaysia (Selangor, Malaysia), 1997-2000 and master in economics in the same university, 2000-2001. After that she furthered her doctoral study in quantitative economics at Christian-Albrechts-University of Kiel, (Kiel, Germany), 2005-2009.

Currently she is a senior lecturer at School of Mathematical Sciences, Universiti Sains Malaysia (Penang, Malaysia). Her main interest is econometrics/ time series and monetary policy and exchange rate.

Dr. Sek has joined IEEE since 2010. Besides a member of IEEE since 2010, Dr. Sek is also a life member of Malaysian Mathematical Society (PERSAMA) since 2010. She became a member of International Economics Development Research Center (IEDRC) since year 2011. In addition, she also joined The Econometric Society since 2011.