



THE EFFECTS OF PUBLIC DEBT, INFLATION, AND THEIR INTERACTION ON ECONOMIC GROWTH IN DEVELOPING COUNTRIES: EMPIRICAL EVIDENCE BASED ON DIFFERENCE PANEL GMM

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Abstract

The paper empirically investigates the effects of public debt, inflation and their interaction on growth rate for a whole sample of 60 developing countries and for three sub-samples of developing countries (22 in Asia, 11 in Latin America and 27 in Africa) over the period 1990 – 2014 through the estimation method of difference panel GMM. The estimated results showed that for the whole sample and the sub-sample of Latin America, the effects of public debt and inflation on growth are negative, while their interaction is positive. For the sub-sample of Asia, public debt and inflation have positive effects on growth, whereas their interaction has a negative impact; and for the sub-sample of Africa, the effects of public debt and interaction on growth are negative, whereas the influence of inflation is positive. These results suggest some important implications for governments in these developing countries.

Keywords: Public debt, inflation, interaction of public debt and inflation, difference panel GMM, developing countries

1. INTRODUCTION

High economic growth at a stably low inflation is one of major objectives in most of economies worldwide. Stabilizing price level plays an important role in determining growth of an economy; so, monetary authorities in many countries implement monetary policies to control and maintain inflation at a desirable level. Meanwhile, public debt is considered as an indirect instrument of fiscal policy for governments. In order to promote economic growth, create more employments and maintain the socio-economic stability, most of governments in developing countries increasingly invest in education, health and infrastructure by government budget. As a result, budget deficit occurs because the budget revenue from tax cannot offset for government spending (current expenditure and public investment). To deal with fiscal deficits, most of governments in these countries have to borrow domestic and external debts instead of making seigniorage to avoid high inflation and socio-economic instability. It leads to a growing public debt in these developing countries. So, the economy of these countries can suffer adverse impacts from debt overhang: above a certain point, the level of debt can create a disincentive for investors who believe that their profits will be heavily taxed so that government has enough money to service its relatively large and growing stock of debt. Furthermore, some governments have not enough financial resource to service the debt and it leads to economic crisis and social instability.

The purpose of this paper is to employ the difference panel GMM Arellano-Bond estimation to investigate the effects of public debt, inflation and their interaction on economic growth with control

variables of private investment, labor force, government revenue, infrastructure, and trade openness for 60 developing countries in Asia, Latin America, and Africa over the period of 1990 – 2014.

The remainder of the paper will be proceeded as follows: Section 2 outlines a literature review about the relationships between public debt and economic growth, the relationship between inflation and economic growth; Section 3 develops an analysis framework; Section 4 presents the methodology and data; Section 5 describes the results and discussion, and final section is the conclusion and policy implications.

2. LITERATURE REVIEW

The public debt and inflation are respectively considered as indirect instruments of fiscal policy and monetary policy, so there are many studies to investigate the relationship between public debt and growth as well as the link between inflation and growth. Depending on the economic situation of each country or a group of countries under consideration, the estimated results showed the effect of public debt or inflation on economic growth could be negative or positive. However, so far the investigations on the effects of public debt, inflation and their interaction on economic growth are almost rare.

2.1. The impact of public debt on growth rate

The public debt crisis in 2010 in some countries of Europe made the problem of public debt worldwide become more severe. Most papers focused on the impact of public debt in countries on growth. Only some studies concluded the positive influence of public debt on growth while most of them showed the highly increasing public debt is detrimental to growth.

2.1.1. The positive influence of public debt on growth rate

According to [Moore & Thomas \(2010\)](#), developing countries seem to be defined as those with relatively high debt. The proceeds from government debt can potentially have significantly positive influences on economic growth if the funds are spent to improve the productive capacity of the country. By using the meta-analysis approach to address the issue, the authors indicated that there exists a significantly positive relation between debt and economic growth.

[Egbetunde \(2012\)](#) examined the causal nexus between public debt and economic growth in Nigeria over the period of 1970 - 2010 using a Vector Autoregressive (VAR). The estimated results showed there exists a bi-directional causality relationship between public debt and economic growth. The author concluded the relationship between public debt and economic growth is positive only if the government is honest with the loan obtained and uses it reasonably for the purpose of economic development.

[Al-Zeaud \(2014\)](#) empirically assesses the impact of public debt on the performance of the Jordanian economy between 1991 and 2010. Using OLS estimation, the results show public debt and population growth play a critical role in economic growth. It indicates that public debt fosters economic growth while population growth is detrimental to it. Thus, according to the author, in order to attain sustained economic growth, Jordanian government should maintain the positive influence of public debt and reduce the negative impact of population growth.

[Fincke and Greiner \(2015\)](#) investigates the nexus between public debt and growth for emerging market countries over the period 1980 – 2012 by methods of fixed effects and random effects. The estimated results show a statistically and significantly positive nexus between public debt and economic growth.

[Spilioti and Vamvoukas \(2015\)](#) empirically assesses the relationship between the government debt and growth of real GDP per capita using Greek data from 1970 to 2009, taking into consideration the different levels of economic growth in Greece. The empirical evidence suggests a statistically and significantly positive impact of public debt on economic growth.

2.1.2. The negative influence of public debt on growth rate

The negative effect of public debt on the growth of economy was confirmed in the empirical results of [Schclarek \(2004\)](#), [Balassone *et al.* \(2011\)](#), [DiPeitro & Anoruo \(2012\)](#), [Panizza & Presbitero \(2012\)](#), [Šimić & Muštra \(2012\)](#), [Calderón & Fuentes \(2013\)](#), [Fincke & Greiner \(2013\)](#), and [Szabó \(2013\)](#). Via estimated results in the empirical models, these authors sent warning signals to governments about the severity of public debt and confirmed that the public debt should be carefully controlled.

More recently, many authors have employed better estimation techniques to assess the influences of public debt on growth. They also find a negative effect of public debt on economic development in many countries.

[Časni *et al.* \(2014\)](#) empirically studies the relationship between public debt and economic performance in Central, Eastern and Southeastern European countries in the long run and short run over the period of 2000 – 2011 using pooled PMG estimation technique. The empirical results show the significantly negative influence of public debt on the GDP growth in the long-run and point out gross public debt reduces the growth of economy. In the short run, the public debt also has a significantly negative effect on the growth. The authors suggest that governments in these countries should design policy frameworks that support exports, foster industrial sector development and establish better investment environment for long-term.

[Bal & Rath \(2014\)](#) empirically studies the effect of public debt on economic growth in India from 1980 to 2011. Using the autoregressive distributed lag model, authors trace a long-run equilibrium relationship between public debt and economic growth. Accordingly, the error correction model results show that in long run central government debt has a significant negative effect on economic growth in India. These authors recommend that the Indian government should follow the objective of inter-generational equity in fiscal management over the long term in order to stabilize debt-GDP ratio, particularly, after the global financial crisis.

In order to empirically examine the highly disputed the nexus between sovereign debt and economic growth for 20 developed countries over the periods 1954 – 2008 and 1905 – 2008, [Lof & Malinen \(2014\)](#) employs the panel vector auto regressions (panel VAR). These authors find no evidence for an impact of public debt on growth, even at higher levels of public debt. However, they find a significantly negative reverse impact of economic growth on public debt.

[Puente-Ajovin and Sanso-Navarro \(2014\)](#) examines the possible causal link between national debt (public debt, non-financial corporate debt, and household debt) and economic growth for 16 OECD countries between 1980 and 2009. Via the bootstrap Granger causality test, the estimated results show government debt does not cause the growth of real GDP per capita. Furthermore, the economic growth negatively influences government debt.

Using a dynamic panel GMM estimator, [Zouhaier and Fatma \(2014\)](#) empirically studies the effect of debt on economic growth of 19 developing countries over the period 1990-2011. The estimated results confirm a significant negative impact of debt on economic growth in these countries.

According to [Akram \(2015\)](#), over the years most of developing countries have failed to collect enough revenues to finance their budgets. As a result, they have to face the problem of twin deficits and to rely on external and domestic debt to finance their economic activities. Accordingly, the author empirically assesses the effects of public debt on the growth of economy and investment in Philippines during the period 1975 – 2010 by using autoregressive distributed lag technique. The estimated results indicate that in the Philippines, external public debt has a significantly negative effect on economic growth and investment, confirming the existence of “debt overhang effect”.

[Eberhardt and Presbitero \(2015\)](#) empirically investigates the long-run nexus between public debt and growth for a large panel dataset of countries (118 countries including 22 low income, 27 low-middle

income, 33 high-middle income and 36 high income) over the period 1961-2012. Via novel estimation methods with linear and non-linear specifications, the estimated results show a significantly negative nexus between public debt and long-run growth in all countries.

According to Lee & Ng (2015), the public debt in the Malaysia is increasingly growing due to fiscal expansions. The author empirically examines whether the public debt contributed to the economic growth in Malaysia from 1991 to 2013. The estimated results are consistent with the existing literature that a negative relationship between debt and growth. Accordingly, the public debt in Malaysia over time has a negative impact on GDP growth.

Mitze & Matz (2015) empirically assesses the long run and short run link between regional public debt and economic growth for a panel data of German federal states over the period 1970-2010. Via the dynamic error correction models, the authors find a significantly negative link between regional public debt and the long run growth of real GDP per capita.

2.2. The impact of inflation on growth rate

One of the main goals of monetary authorities worldwide is to maintain the stability of price level which in turn creates the good macro-environment to foster the economic growth. So, the policymakers should understand more clearly the relationship between inflation and growth to carry out the reasonable policies. Similar to the relationship between public debt and growth, the empirical results about the relationship between inflation and growth showed that only some papers indicated the effect of inflation on growth is positive while most of them confirmed this effect is negative.

2.2.1. The positive influence of inflation on growth rate

Mallik & Chowdhury (2001) examines the relationship between inflation and growth in four South Asian nations over the period 1957-1997. Through error correction models, the study finds a long-term positive relationship between inflation and growth rate in all these countries. There also exist significant feedbacks from economic growth to inflation. These findings suggest some important implications. Moderate inflation may be good to growth, but rapid growth feeds back into inflation.

Xiao (2009) examines the link between inflation and growth rate in China during the period of 1978–2007. The author employs cointegration test, ECM models, and Granger causality test to empirically assess this relationship. The estimated results show that the bi-direction relationship between economic growth and inflation in the long run is significantly positive. The author suggests the Chinese government should pay more attention to inflation during economic development.

Raza *et al.* (2013) discusses the influence of inflation on growth rate and empirically assesses the relationship between inflation and growth rate in the short run and the long run for Pakistan over the period 1972-2011. Through the cointegration and ECM model, the study shows a statistically and significantly positive nexus between inflation and growth rate in the long run. Accordingly, the authors suggest the government should maintain inflation in single digit which is favorable for economic development.

2.2.2. The negative influence of inflation on growth rate

Gillman *et al.* (2004) develops a monetary framework of endogenous growth and examines an empirical model which is consistent with it. The empirical model shows a significantly negative inflation – growth influence, and it becomes stronger in lower inflation. The authors empirically investigate this effect for a panel dataset of OECD and APEC nations over the period of 1961 – 1997. The estimated results show the influence is significantly for the OECD nations; particularly it rises marginally as the inflation rate goes down. In case of APEC nations, the estimated results from employing IV estimation technique also provide a significant finding of a similar behavior.

Gillman & Harris (2008) examines the impact of inflation on growth rate for 13 transition economies during the period of 1990–2003 by estimation method of fixed effects. The empirical results confirm

a significantly and strongly negative impact of inflation on growth rate; particularly this impact decreases in magnitude in case the inflation rate rises.

Bittencourt (2012) empirically studies the role of inflation in economic growth for four Latin American nations which suffered hyper-inflation in the years of 1980s and early years of 1990s. Through panel dataset from 1970 to 2007 and estimation methods of pooled OLS, fixed effects, random effects and FE-IV, the estimated results show that inflation negatively affects economic growth in the region. The author explains that too high inflation obviously offsets the effect of Mundell–Tobin; so high inflation leads to the high costs for economic activities in the region.

Like many developed and developing nations, one of major goals of economic policies in Tanzania is to promote growth rate at a stable low level of inflation. However, the question here is whether inflation is detrimental to the economic growth. Motivated by this controversy, Kasidi and Mwakanemela (2012) empirically assesses the effect of inflation on growth rate in Tanzania over the period 1990 – 2011 by using the cointegration technique. The estimated results show that inflation has a significantly negative effect on growth rate. However, the paper also reveals that there does not exist a cointegration between inflation and growth rate during the period of research.

Chudik *et al.* (2013) studies the effects of inflation and public debt on the growth of economy in the long run. Their investigation has both theoretical and empirical sides. Theoretically, the authors set up a cross-sectional augmented and distributed lag approach to estimate the long run impacts in models of dynamic heterogeneous panel data with cross-sectionally dependent errors. Empirically, the authors find the significantly negative long run impacts of inflation and public debt on growth rate for a panel data of 40 countries over the period of 1965–2010. The estimated results show in case the public debt is permanently raised, then it will negatively affect growth rate in the long run. However, if public debt is temporarily raised, then there does not exist a long-run impact of inflation on growth rate as long as the level of public debt is brought back to normal.

To empirically investigate the nexus between inflation and economic growth taking into account other economic indicators, Kaouther and Besma (2014) uses the random effects model for a panel data of four countries on the south side of the Mediterranean from 1980 to 2008. The results indicate inflation has a significantly negative influence on economic growth.

Bittencourt *et al.* (2015) empirically assesses the role of inflation in determining growth rate for 15 sub-Saharan African countries (SADC) during the period of 1980–2009. Based on the estimation methods of fixed effects and random effects, the estimated results suggest that inflation has a significantly negative effect on economic growth in the region.

Samimi and Kenari (2015) investigates the cross-sectional impacts of macroeconomic factors on economic growth and tests the hypothesis that inflation has a significantly negative impact on growth rate in 90 developing countries during 1995–2003. Using a simultaneous equations system in which both inflation and growth rate are treated as endogenous variables, the authors indicate that inflation has a significantly negative impact on growth rate. The authors suggest lowering inflation rate is an effective way to reach high growth rate in these nations.

3. ANALYSIS FRAMEWORK

Supposing the economy has two major inputs including domestic capital stock and working force. The analysis framework starts with the traditional aggregate production function Cobb-Douglas as follows:

$$Y = AK^\alpha L^{1-\alpha}, 0 < \alpha < 1 \dots\dots\dots (1)$$

Where Y is real gross domestic product (GDP); K is the real domestic capital stock (mainly private sector); L is the labor force employed; A is the total factor productivity (TFP); α is the production elasticity.

Dividing both sides of Eq. (1) with working force L , Eq. (1) is expressed in per capita:

$$\frac{Y}{L} = A \left(\frac{K}{L}\right)^\alpha \dots\dots\dots (2)$$

We transfer Eq.(2) into the log-linear form:

$$\log \frac{Y}{L} = \log A + \alpha \log \left(\frac{K}{L}\right) \dots\dots\dots (3)$$

We write Eq. (3) in growth form with a time series specification:

$$\left(\frac{Y}{L}\right)_{i,t} = (A)_{i,t} + \alpha \left(\frac{K}{L}\right)_{i,t} \dots\dots\dots (4)$$

According to the model of endogenous growth (Romer, 1986; Lucas, 1988), the total factor productivity, capital stock and working force are endogenous variables. Therefore, A , K and L are endogenous variables. In this paper, the domestic capital stock is mainly the private investment expressed as a percentage of GDP, so for convenience Eq. (4) is rewritten as follows:

$$\left(\frac{Y}{L}\right)_{i,t} = (A)_{i,t} + \alpha_1 \left(\frac{PINV}{GDP}\right)_{i,t} + \alpha_2 (LABO)_{i,t} \dots\dots\dots (5)$$

There are many factors which have impacts on the TFP. In this study, the determinants of TFP are determined as follows:

$$(A)_{i,t} = \beta_0 + \beta_1 \left(\frac{DEBT}{GDP}\right)_{i,t} + \beta_2 (INFL)_{i,t} + \beta_3 \left(\frac{BREV}{GDP}\right)_{i,t} + \beta_4 (TELE)_{i,t} + \beta_5 (OPEN)_{i,t} + \varepsilon_{i,t} \dots (6)$$

Where $DEBT$ is public debt of a country. Some empirical studies found the public debt has a negative effect on growth (Lof & Malinen, 2014; Puente-Ajovin & Sanso-Navarro, 2014; Zouhaier & Fatma, 2014; Akram, 2015) while some showed this impact is positive (Fincke & Greiner, 2015; Spilioti & Vamvoukas, 2015). In addition, many papers demonstrated the link between public debt and growth is non-linear. (Lopes da Veiga *et al.*, 2014; Real *et al.*, 2014; Afonso & Alves, 2014).

$INFL$ is the inflation per year. This variable was determined to have an important impact on growth in Friedman (1977). The impact of inflation on growth can be negative or positive, and it depends on the economic situation of each country. The positive impact comes from potential benefits in promoting savings and investments while the negative impact increases transaction costs of economic activities (Jin & Zou, 2005).

REV is the tax revenue. In the model of endogenous growth, the tax policy has an influence on economic growth in long run. High tax rate can distort the economy, and so inhibit economic growth (Zhang & Zou, 1998; Barro, 1990; Jin & Zou, 2005).

$TELE$ is the infrastructure. The infrastructure can be measured in some different ways such as the length of high way per square kilometer (Du *et al.*, 2008), the length of railway (Kuzmina *et al.*, 2014) or the fixed telephone subscriptions per 100 people (Bissoon, 2011; Nguyen, 2015). It is proxy for development of infrastructure in a country and has an influence on economic growth (Asiedu, 2002; Ancharaz, 2003; Kevin, 2005).

OPEN is the trade openness, proxy for the open-door policy of a country. It is determined by the share of imports and exports of goods and services in GDP. The model of endogenous growth (Romer, 1986 and Lucas, 1988) indicated improving activities of imports and exports has a positive impact on growth. According to Grossman and Helpman (1991); Barro and Sala-i-Martin (2004), the trade liberalisation leads to highly absorb technological progress and exchange more imported goods and services between countries and so promotes the economic growth. Yanikkaya (2003), Makki and Somwaru (2004) found that the trade openness has a significantly positive effect on economic growth.

We substitute Eq.(6) into Eq.(5):

$$\left(\frac{Y}{L}\right)_{i,t} = \gamma_0 + \gamma_1(DEBT)_{i,t} + \gamma_2(INFL)_{i,t} + \gamma_3\left(\frac{PINV}{GDP}\right)_{i,t} + \gamma_4(LABO)_{i,t} + \gamma_5\left(\frac{BREV}{GDP}\right)_{i,t} + \gamma_6(TELE)_{i,t} + \gamma_7(OPEN)_{i,t} + \eta_i + \xi_{i,t} \dots\dots\dots (7)$$

According to Tondl (2001), due to the convergence of income per capita in the long term between the countries, the initial level of income per capita (the first lag of real GDP per capita) has a negative impact on economic growth. In addition, in order to assess the effect of the interaction between public debt and inflation, we add this variable (DEBT*INFL) in the model. Therefore, the final empirical model is determined as follows:

$$\left(\frac{Y}{L}\right)_{i,t} - \left(\frac{Y}{L}\right)_{i,t-1} = \gamma_0 + \gamma_1\left(\frac{Y}{L}\right)_{i,t-1} + \gamma_2(DEBT)_{i,t} + \gamma_3(INFL)_{i,t} + \gamma_4(DEBT * INFL)_{i,t} + \gamma_5\left(\frac{PINV}{GDP}\right)_{i,t} + \gamma_6(LABO)_{i,t} + \gamma_7\left(\frac{BREV}{GDP}\right)_{i,t} + \gamma_8(TELE)_{i,t} + \gamma_9(OPEN)_{i,t} + \eta_i + \xi_{i,t} \dots\dots\dots (8)$$

4. METHODOLOGY AND DATA

4.1. Methodology

The study empirically investigates the effects of public debt, inflation, and their interaction on the economic growth for a whole sample of 60 developing countries and three sub-samples of developing countries (22 in Asia, 11 in Latin America and 27 in Africa) over the period of 1990 – 2014. Thus, the empirical equation is as follows:

$$Y_{it} - Y_{it-1} = \alpha_{it} + \beta_0 Y_{it-1} + X_{it}\beta'_1 + Z_{it}\beta'_2 + \eta_i + \xi_{it} \dots\dots\dots (9)$$

Where $\eta_i \sim iid(0, \sigma_\eta)$; $\xi_{it} \sim iid(0, \sigma_\xi)$; $E(\eta_i \xi_{it}) = 0$. Variable Y_{it} is the natural logarithm of real per capita GDP; X_{it} is the main variables of interest while Z_{it} is a set of control variables; η_i is an unobserved time-invariant, country-specific effect and ξ_{it} is an observation-specific error term. The main variables of interest X_{it} are public debt, inflation and their interaction (public debt*inflation). The set of variables Z_{it} includes some following determinants, which have impacts on economic growth: private investment, labor force, government revenue, infrastructure, and trade openness.

Equation (9) is a dynamic model. $dY = Y_{it} - Y_{it-1}$ is the first difference of Y , proxy for the growth rate. Variable Y_{it-1} on the right side of Equation (1) is proxy for initial level of income.

For the empirical equations (9), the presence of lagged dependent variables can give rise to autocorrelation. It can make OLS inconsistency and estimates bias for short time dimension (small T) (Judson *et al.*, 1999). Therefore, the study decides to employ the Arellano and Bond (1991) difference panel GMM estimator, first proposed by Holtz-Eakin *et al.* (1988). The Arellano – Bond estimator was developed for dynamic “small-T large-N” panels (Judson *et al.*, 1999, Roodman, 2006). In the standard GMM procedure, it is essential to distinguish *instrumented variables* and *instruments*. Endogenous variables are put in the group of instrumented variables by lags of these variables (Judson *et al.*, 1999). Strictly exogenous variables as well as extra instruments are put in

the group of instrument variables and included in standard IV procedure. For exogenous variables, level and lags of them are the suitable instruments (Judson *et al.*, 1999).

The validity of instruments in GMM estimator is assessed through Sargan statistic and Arellano-Bond statistic. The Sargan test with null hypothesis H_0 : the instrument is strictly exogenous, which means that it does not correlate with errors. Thus, the p-value of Sargan statistic is as big as possible. The Arellano-Bond test is used to detect the autocorrelation of errors in first difference. Thus, the test result of first autocorrelation of errors, AR(1) is ignored while the second autocorrelation of errors, AR(2), is tested on the first difference series of errors to detect the phenomenon of first autocorrelation of errors, AR(1).

4.2. Data

Cross-sections and time series are extracted to accommodate the unbalanced panel data of 60 developing countries over period of 1990 - 2014 from World Development Indicator of World Bank and World Economic Outlook of International Monetary Fund. Some missing values of the data set in some countries are filled with reference to www.tradingeconomics.com. The list of 60 developing countries consists of 22 in Asia (Cambodia, Lao, Malaysia, Philippines, Thailand, Vietnam, Kazakhstan, Kyrgyzstan, Tajikistan, Uzbekistan, Bangladesh, Bhutan, India, Nepal, Pakistan, Sri Lanka, Jordan, Lebanon, Turkey, UAE, Yemen, and Mongolia), 11 in Latin America (Bolivia, Brazil, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Peru, Uruguay, and Venezuela) and 27 in Africa (Angola, Botswana, Burkina Faso, Burundi, Cameroon, Congo Democratic Republic, Congo Republic, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Lesotho, Liberia, Malawi, Mali, Niger, Rwanda, Senegal, Sierra Leone, South Africa, Sudan, Swaziland, Togo, and Uganda). Because time series data in some countries are not available from 1990, we have to use the data from 2000 (Lao, Kyrgyzstan, Nepal, Nicaragua, Peru, Angola, Benin, Botswana, etc.), or from 1998 (Tajikistan, Vietnam, etc.), or from 1996 (Cambodia, Brazil), or from 1994 (Philippines, Mexico).

We define and calculate the variables as follows:

- LGDP: a real GDP per capita, proxy for economic growth of a country. This variable is used in form of natural logarithm.
- PDEB: public debt, a share of GDP (%).
- INFL: inflation per year (%).
- PINV: private investment, a share of GDP (%).
- LABO: labor force, a ratio between working age people (15-64) and total population of a country (%).
- REV: government revenue, a share of GDP (%).
- TELE: infrastructure development. In this study, it is the fixed telephone subscriptions per 100 people.
- OPEN: Trade openness, a share of GDP (%).

The statistical description of all variables is presented in the Table 1.

Table 1: Statistical description

Variables	Obs	Mean	Std. Dev.	Min	Max
GDP per capita (USD/year)	1126	2321.7	4526.5	113.87	47081.2
Public debt (% GDP)	1126	68.175	66.502	2.69	786.438
Inflation (%)	1126	13.012	56.170	-18.108	1568.33
Private investment (% GDP)	1126	15.375	7.523	-16.905	53.189
Labor force (% of population)	1126	69.141	10.443	40.5	88.3
Government revenue (% GDP)	1126	23.552	9.814	0.637	68.283
Infrastructure (Fixed telephone subscriptions per 100 people)	1126	5.956	7.183	0	33.922
Trade openness (% GDP)	1126	78.510	40.668	10.748	220.407

The matrix of correlation coefficients for variables is given in Table 2. All correlation coefficients between explanation variables and the dependent variable are statistically significant at least 5%. Accordingly, public debt, inflation and labor force are negatively correlated to economic growth while private investment, government revenue, infrastructure and trade openness are positively linked to economic growth. In addition, all correlation coefficients between independent variables are relatively low, which help to eliminate the possibility of co-linearity between these variables.

Table 2: Matrix of correlation coefficients

	IGDP	PDEB	INFL	PINV	LABO	REV	TELE	OPEN
IGDP	1.00							
PDEB	-0.243 ^{***}	1.00						
INFL	-0.072 ^{**}	0.031	1.00					
PINV	0.185 ^{***}	-0.109 ^{***}	-0.025	1.00				
LABO	-0.332 ^{***}	-0.167 ^{***}	-0.041	-0.105 ^{***}	1.00			
REV	0.319 ^{***}	-0.168 ^{***}	0.011	0.217 ^{***}	-0.056 [*]	1.00		
TELE	0.760 ^{***}	-0.167 ^{***}	-0.023	0.088 ^{***}	-0.160 ^{***}	0.223	1.00	
OPEN	0.268 ^{***}	-0.023	-0.048	0.248 ^{***}	-0.109 ^{***}	0.424	0.111 ^{***}	1.00

Note: ^{***}, ^{**} and ^{*} respectively describe significance at level of 1%, 5% and 10%

5. RESULT AND DISCUSSION

The estimated results derived from the method of panel difference GMM Arellano–Bond is shown in Table 3. The negative sign of infrastructure coefficient is opposite to the positive sign of correlation coefficient between infrastructure and economic growth (real GDP per capita) given in Table 2. It means that there is an endogenous phenomenon between the regressand and regressors. Therefore, the method of panel difference GMM Arellano–Bond estimation with instrumental variables seems to be appropriate for this empirical model.

To assess the validity of instruments in GMM first-difference estimation and the serial auto-correlation of residuals, the study performs the Sargan test (test of over-identifying restrictions with the null hypothesis “the instruments as a group are exogenous”) as well as the Arellano–Bond test for serial correlation (AR (2)), which is applied to the first difference residuals to purge the perfectly auto correlated and unobserved. The results of these tests show that all null hypotheses are rejected. Thus, instruments are appropriate and there is no phenomenon of serial autocorrelation for residuals in second differences.

To check the robustness of the difference panel GMM Arellano-Bond estimation, the estimated results are usually verified by removing/adding some variables. Accordingly, this estimation begins at Model 1, then continues with Model 2 and ends at Model 3 (the full variables model). The results show sign, size and significance of estimated coefficients, especially coefficients of public debt, inflation, and their interaction (public debt*inflation) in Table 3, Table 4, Table 5 and Table 6 are nearly unchanged. It confirmed that results of the difference panel GMM estimation are strongly robust.

Table 3: Difference panel GMM Arellano-Bond estimations for the whole sample (60 developing countries) Dependent variable: Δ Growth

	Model 1	Model 2	Model 3
Growth (-1)	-0.090 ^{***}	-0.086 ^{***}	-0.069 ^{**}
Public debt	-0.131 ^{***}	-0.131 ^{***}	-0.133 ^{***}
Inflation	-0.674 ^{***}	-0.633 ^{***}	-0.678 ^{***}
Public debt*Inflation	0.008 ^{***}	0.007 ^{***}	0.008 ^{***}
Private investment	0.439 ^{***}	0.352 [*]	0.404 ^{**}
Labor force			-0.416
Government revenue	0.177 [*]	0.188 ^{**}	0.163 [*]

Infrastructure		-0.408	-0.525
Trade openness	0.251***	0.257***	0.267***
Obs.	766	766	766
AR(2) test	0.246	0.350	0.291
Sargan test	0.674	0.613	0.768

Note: ***, ** and * respectively describe significance at level of 1%, 5% and 10%

The estimated result for the whole sample of 60 developing countries presented in the Table 3 shows that (1) the first lag of growth has a significantly negative impact on economic growth, confirming the convergence of per capita income between the countries in the long term (Tondl, 2001); (2) at the significance level of 1%, public debt and inflation have negative effects whereas their interaction has a positive influence on economic growth; (3) The impacts of private investment, government revenue and trade openness on economic growth are statistically significant and positive.

In the whole sample, the effect of public debt on economic growth is significantly negative. It is obviously consistent with Schclarek (2004), Šimić & Muštra (2012), Časni *et al.* (2014), Bal & Rath (2014), Zouhaier & Fatma (2014), Akram (2015) and Lee & Ng (2015). This result is not surprising, particularly in the situation of developing countries because most of the government borrowings are used in consumption expenditure and very few portions go towards forming productive capital. Similarly, inflation has a significantly negative influence on growth. The previous empirical evidence of Gillman & Harris (2008), Bittencourt (2012), Kasidi & Mwanemela (2012), and Bittencourt *et al.* (2015) confirmed it for developing countries. Accordingly, the negative influence of inflation may increase transaction costs of economic activities in developing countries.

However, the interaction of inflation and public debt on growth is positive. According to Hasanov & Cherif (2012), Akitoby *et al.* (2014), higher inflation can help reduce public debt; even Aizenman & Marion (2011) indicated that inflation can be used to erode the public debt. So, an increase in inflation can make public debt decrease. It leads to two effects. The first is the effect of increasing inflation to reduce growth and the second is the effect of decreasing public debt to foster growth. In this case, the second effect may be greater than the first one. Thus, the resultant effect is to increase growth. Therefore, the interaction of public debt and inflation has a significantly positive effect on economic growth.

In the economic growth models, investment and labor force are major inputs to promote the output. Thus, private investment is an endogenous variable that has a positive influence on growth. Khan & Reinhart (1990), Ghura (1997) and Phetsavong & Ichihashi (2012) provided empirical evidence to confirm the positive role of private investment in the economy.

Government revenue can distort the economy, and so inhibit economic growth. However, in some developing countries, the empirical results showed it also promotes the economic growth (Gacanja, 2012; Okafor, 2012; Worlu & Nkoro, 2012). Consistent with these papers, in this study, government revenue has a significantly positive impact on growth.

The positive role of trade openness in the economy has been proved in theory (Romer, 1986; Lucas, 1988; Grossman & Helpman, 1991 and Barro & Sala-i-Martin, 2004). Yanikkaya (2003), Makki & Somwaru (2004) and Tahir & Khan (2014) found that the trade openness has a positive impact on economic growth. According to Yanikkaya (2003), one mechanism, noted by the model of endogenous growth, by which trade liberalization fosters growth, is that a nation may highly absorb modern technologies from business partners via trade liberalization. If this mechanism is more effective than the others, developing nations may gain benefits more from doing business with developed nations, which have advanced technologies, than by trading with other developing nations, which have backward technologies.

The estimated results for three sub-samples of developing countries (22 in Asia, 11 in Latin America, and 27 in Africa) are given in Table 4, Table 5 and Table 6. Like the result in the whole sample, the

first lag of growth in these continents also has a significantly negative impact on economic growth. It means that the convergence of per capita income between developing countries in the long term occurs not only worldwide but also in each continent.

Except for Latin America, the effects of public debt, inflation and their interaction on economic growth in Asia and Africa are different from the whole sample.

For the sub-sample in Asia, the effects of public debt and inflation are positive while their interaction is negative (Table 4). As above-mentioned, an increase in inflation can make public debt decrease. The result in Table 4 shows that public debt and inflation have positive impacts on economic growth, so a decrease in public debt reduces growth while an increase in inflation fosters growth. However, in the case of Asian developing countries, the effect of decreasing public debt may be greater than the effect of increasing inflation. Thus, the resultant effect is to reduce growth. Therefore, in the case of developing countries in Asia, the interaction of public debt and inflation has a significantly negative influence on economic growth.

For the sub-sample in Africa, the effects of public debt and interaction are negative, whereas the influence of inflation is positive. Unlike in Asia and Latin America, developing countries in Africa use ineffectively borrowings and national resources for economic growth. These countries are highly indebted countries and hard to pay debts. A decrease in public debt does not support much for economic growth. Therefore, an increase in inflation can make public debt reduce, but the resultant effect of them does not promote growth. It means that the interaction of public debt and inflation has a significantly negative effect on growth.

Table 4: Difference panel GMM Arellano-Bond estimations for the sub-sample 1 (22 developing countries of Asia) Dependent variable: ΔGrowth

	Model 1	Model 2	Model 3
Growth (-1)	-0.219 ^{***}	-0.204 ^{***}	-0.182 ^{***}
Public debt	0.135 [*]	0.121 [*]	0.178 ^{**}
Inflation	0.779 ^{***}	0.686 ^{**}	0.617 ^{**}
Public debt*Inflation	-0.014 ^{***}	-0.012 ^{***}	-0.011 ^{**}
Private investment			0.480 ^{**}
Labor force	5.093 ^{***}	4.546 ^{***}	4.209 ^{***}
Government revenue	1.333 ^{***}	1.182 ^{***}	0.973 ^{***}
Infrastructure	0.549 ^{**}	0.511 ^{***}	0.520 ^{***}
Trade openness		0.081 [*]	0.098 ^{**}
Obs.	347	347	347
AR(2) test	0.836	0.876	0.977
Sargan test	0.349	0.236	0.302

Note: ^{***}, ^{**} and ^{*} respectively describe significance at level of 1%, 5% and 10%

Consistent with the results of the whole sample, in the sub-sample of Asia, the impacts of private investment, government revenue and trade openness on economic growth are significantly positive. Furthermore, labor force and infrastructure are also found to have positive influences on growth. In fact, Calderón & Servén (2004), Canning & Pedroni (2004), Palei (2015) found the positive impact of infrastructure on growth; particularly, Cockburn *et al.* (2013) reconfirmed investment in infrastructure could be a highly effective way in reducing poverty reduction in developing countries of Asia. As above-mentioned, labor force is an important endogenous input in the endogenous growth model. Denton & Spencer (1997) and Shahid (2014) provided the empirical evidence to show labor force has a significantly positive influence on growth.

Finally, in the sub-sample of Latin America, government revenue and trade openness are found to have significantly positive effects on growth, while in the sub-sample of Africa only trade openness.

Table 5: Difference panel GMM Arellano-Bond estimations for the sub-sample 2 (11 developing countries of Latin America) Dependent variable: Δ Growth

	Model 1	Model 2	Model 3
Growth (-1)	-0.245 ^{***}	-0.216 ^{***}	-0.1634 [*]
Public debt	-0.205 ^{***}	-0.224 ^{***}	-0.221 ^{***}
Inflation	-1.022 ^{***}	-0.967 ^{***}	-0.937 ^{***}
Public debt*Inflation	0.018 ^{***}	0.016 ^{***}	0.015 ^{**}
Private investment	0.046	0.028	0.065
Labor force			-0.542
Government revenue	0.847 ^{***}	0.889 ^{***}	1.073 ^{***}
Infrastructure		-0.471	-0.755
Trade openness	0.268 ^{***}	0.297 ^{***}	0.275 ^{***}
Obs.	134	134	134
AR(2) test	0.970	0.996	0.995
Sargan test	0.314	0.347	0.450

Note: ^{***}, ^{**} and ^{*} respectively describe significance at level of 1%, 5% and 10%

Table 6: Difference panel GMM Arellano-Bond estimations the sub-sample 3 (27 developing countries of Africa) Dependent variable: Δ Growth

	Model 1	Model 2	Model 3
Growth (-1)	-0.212 ^{***}	-0.196 ^{**}	-0.190 ^{**}
Public debt	-0.048 ^{**}	-0.039 [*]	-0.041 [*]
Inflation	0.206 [*]	0.226 ^{**}	0.226 ^{**}
Public debt*Inflation	-0.0008 [*]	-0.0009 [*]	-0.0009 [*]
Private investment	-0.097	-0.087	-0.094
Labor force	1.819	2.163	1.908
Government revenue		0.058	0.052
Infrastructure			-0.985
Trade openness	0.149 ^{***}	0.130 ^{**}	0.139 ^{**}
Obs.	410	410	410
AR(2) test	0.279	0.250	0.239
Sargan test	0.116	0.123	0.106

Note: ^{***}, ^{**} and ^{*} respectively describe significance at level of 1%, 5% and 10%

6. CONCLUSION AND POLICY IMPLICATIONS

The paper empirically investigated the effects of public debt, inflation and their interaction on growth rate for a whole sample of 60 developing countries and for three sub-samples of developing countries (22 in Asia, 11 in Latin America and 27 in Africa) over the period 1990–2014 through the estimation method of difference panel GMM.

The estimated results showed that (1) for the whole sample, the effects of public debt and inflation on growth are negative, while their interaction is positive; and the impacts of private investment, government revenue and trade openness on growth are positive; (2) for the sub-sample of Asia, the effects of public debt and inflation on growth are positive, whereas their interaction is negative; and the impacts of private investment, labor force, government revenue, infrastructure and trade openness on growth are positive; (3) for the sub-sample of Latin America, except for private investment, the effects of public debt, inflation, their interaction, government revenue and trade openness on growth are similar with those of the whole sample; (4) for the sub-sample of Africa, the effects of public debt and interaction on growth are negative, whereas the influence of inflation is positive; and the impact of trade openness on growth is positive.

Most of studies confirmed that public debt and inflation have negative effects on the economy although in some cases their interaction can foster the growth. From the policy perspective, in developing countries, governments should: (1) run the economy based on inflation targeting; (2) be

carefully in borrowing debts because highly growing public debt not only makes inflation high (Martin 2013; Lopes da Veiga *et al.*, 2014; Nastansky *et al.*, 2014) but leads to economic crisis and social instability as well (for instance Greek, Ireland, and Italia in European sovereign debt crisis).

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