Journal of Business & Economics
Vol.8 No2 (July-December, 2016) pp. 114-127

Long Run Inflation-Growth Nexus in Developing Economies: Old Wine in a New Bottle

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Abstract

This paper examines the long-run inflation-growth relationship in developing economies by placing emphasis on sectoral heterogeneity and cross-sectional dependence. This relation is explored using a large panel dataset of 113 developing economies over the period 1974-2013. The empirical findings are consistent with a linear negative relationship. An annual increase of 10 percent in average inflation rate tends to reduce the GDP growth by 0.12-0.20 percentage points. Inflation is however found to positively affect economic growth if the value-added share of agricultural sector in the total output exceeds the threshold level of 50 percent. The opposite applies if the value added share falls below this threshold level.

Key words: Cross-sectional dependence; developing economies; economic growth; inflation; heterogeneity.

1. Introduction

Policy issues of attention for the last many decades in developing economies have been: what is the exact nature of the relationship between inflation and economic growth and what should it look like? A lot of work

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Acknowledgement: Authors would like to thank Prof. Michael Landesmann and Prof. Johann Scharler for their insightful comments. The usual disclaimer applies.

has been done in different ways (from using simple OLS to `fancy' econometrics) to investigate this nexus. However, the empirical evidence so far erroneously ignores two vitally important factors.[1] First, because the structure of an economy is comprised of the output shares of different sectors, the symbiotic interdependence of sectors relates them in a way that the output of one sector serves as an input for the other sector(s). The dynamic process of economic growth encompasses a monotonically decreasing share of agricultural and a growing segment of services in aggregate output Singh (2016). Therefore, it is argued that the dynamics of different sectors (*e.g.,* industrial, services and agricultural) of economies are essentially different. For illustration, the growth of industrial and services sectors is more sensitive to inflation variability, international spillovers, and macroeconomic volatility. In contrast, the agricultural sector is typically dependent on fixed natural resources and hence, less sensitive to price variability, uncertainty, and macroeconomic volatility.[2]

Secondly, most of the existing panel data studies on this issue utilize cross-country data with common driving factors (*e.g.,* higher economic integration among countries, globalized trade spillovers, and common spatial and unobserved patterns) and employ methods that consider all economies as a single entity. These common driving forces boost the possibility of cross-sectional dependence (*CSD*) in the panel data that leads to severely biased estimation results (*i.e.,* overly optimistic standard error estimates).[3] According to Hoechle (2007), in most of the cases, the assumption of considering the error terms of a panel model as cross-sectionally independent is inappropriate. Since the underlying empirical models artificially assume that the disturbance terms of panel datasets are correlated within but uncorrelated between subjects, their results do not appropriately adjust the standard errors. Rather a more natural assumption is that the errors are correlated both within the entities as well as between the entities.

[1] For example, Khan and Senhadji (2001); López-Villavicencio and Mignon (2011); Kremer, Bick, and Nautz (2013); Yilmazkuday (2013); Baglan and Yoldas (2014), among others.
[2] For a detailed discussion, see Ayyoub (2016).
[3] A comprehensive discussion can be found in Hoechle (2007).

For the first time, to the best of our knowledge, this issue is examined by taking into account these two potential concerns. More specifically, based on our conjecture, this study aims to answer the following questions: What is the exact nature of the long-run inflation-growth relationship in developing economies? What is the response of growth rate due to marginal changes in inflation rate after taking into account sectoral heterogeneity and correct choice of estimator? Does the value-added contribution of the agricultural sector towards aggregate output play a significant role? Do the central banks of developing economies, in this regard, need to put particular attention toward the agricultural sector growth and inflation?

This work contributes to the existing empirical literature on two emerged points. Firstly, the sectoral heterogeneity of the agricultural sector is taken into account. Secondly, valid statistical inference is ensured in the presence of *CSD* over the time and space, while not only relying on the robust standard errors. The coefficient estimates are reported by employing the *CSD* robust *Driscoll-Kraay (DK)* fixed effects estimation approach.[4] Our major findings based on the panel dataset from all developing countries over the period 1974-2013 can be summarized as follows: The relationship between inflation and economic growth is significantly negative and linear in nature. Almost twenty years after Barro (1995), evidence is provided again that an annual increase of 10 percent in average inflation rate tends to reduce GDP growth by about 0.12-0.20 percentage points. Furthermore, if the sectoral heterogeneity existing in different sectors of the developing economies is taken into account, a threshold level of 50 percent value added contribution of the agricultural sector to GDP growth exists beyond which the relationship turns to be positive.

The remainder of the paper is structured as follows. Section 2 outlines the empirical strategy applied to investigate the relationship between our key

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[4] Driscoll and Kraay (1998)'s heteroscedasticity consistent standard error estimates are robust to very general forms of *CSD* and spatial correlation. Spatial correlation in the disturbances of panel dataset arises due to the factors that cannot be quantitatively measured and play a role as unobserved common factors. For details on the consistency conditions, see Driscoll and Kraay (1998).

variables. Section 3 presents the data description followed by section 4 which elaborates the main results. Section 5 concludes this note.

2. Empirical Implementation Strategy

Following Barro and Sala-i-Martin (1995) and Barro (1995), hypothesis in this study is examined by using a system of regression equations that is based on an extended neoclassical view in which some standard growth determinants are considered as constant. To investigate whether inflation and other relevant factors can explain a linear relationship with the annual GDP growth rate, our basic model derived from the theory is:

$$y_{it} = \beta_0 + \beta_1 \pi_{it} + \beta_2 \boldsymbol{X}_{it} + \mu_{it} \tag{1}$$

where i = 1,2,....,113 denotes the economies and t = 1,2,...,40 is the time for each i. y_{it} is the annual growth rate of country i at time t. π_{it} is the actual annual rate of inflation and $\boldsymbol{X}_{it}$ is a vector of control variables. The disturbance term is specified as:

$$\mu_{it} = \vartheta_i + \varepsilon_{it} \tag{2}$$

Time invariant country-specific effects (*e.g.,* geography and demographics) that can be correlated with right-hand side variables are limited in the error term μ_{it}, which are comprised of the unobserved country-characteristics ϑ_i, and the observation-specific errors ε_{it}.

According to Ayyoub (2016), the agricultural sector is the candidate to explain major differences from the industrial and services sectors. Therefore, authos augment the basic model (1) by introducing an interaction term, $[Inter(\pi \times Agr)_{it}]$, based on inflation $(\pi_{it})$and percentage value added share of the agricultural sector (Agr_{it}) in economy i at time t. Therefore, re-arranging (1) as (3) gives:

$$y_{it} = \beta_0 + \beta_1 \pi_{it} + \beta_2 Agr_{it} + \beta_3 Inter(\pi \times Agr)_{it} + \beta_4 \boldsymbol{X}_{it} + \mu_{it} \quad (3)$$

It is argued that if Agr_{it} moderates the association between π_{it} and y_{it}, then there must be differences between the relationship of π_{it} and y_{it} computed at various levels of Agr_{it}. Equation 3 can be written as follows:

$$y_{it} = [\beta_0 + \beta_2 Agr_{it}] + [\beta_1 + \beta_3 Agr_{it}]\pi_{it} + \beta_4 \boldsymbol{X}_{it} + \mu_{it} \quad (4)$$

Equation (4) describes the relationship between inflation and GDP growth for any fixed value of Agr_{it}.

The term, $[\beta_0 + \beta_2 Agr_{it}]$, belongs to the intercept, and $[\beta_1 + \beta_3 Agr_{it}]$, represents the regression slope. Both depend on the level of Agr_{it}. As value added (percentage) contribution of agricultural sector in the economy changes, so does the intercept of (4), and the slope of the relationship between inflation and GDP growth.

Our second concern is to estimate the regression models 1 and 3, which are likely to generate the residuals that are positively associated over time. Furthermore, the possibility of *CSD* cannot be ignored due to possible correlation of the common factors, which has not been considered by the previous inflation-growth literature. Therefore, 1 and 3 are estimated by the method of *Fixed-Effects with DK* standard errors.[5] Results are also compared with the *Prais-Winsten*'s panel-corrected standard error estimator (*PCSE*) that performs well in small panels.[6] The *PCSE* estimates are also robust to the errors that are heteroscedastic, cross-sectionally correlated, and autocorrelated of type *AR*(1). However, the possibility of the *PCSE* estimator to be imprecise cannot be ruled out in case of finite sample properties when the ratio *T/N* is small. Therefore, our preferred *DK* approach also removes

[5] *FE* estimations are preferred instead of the pooled *OLS* regression to capture the dynamic information of our cross-sectional panel dataset, and post-estimation diagnostic tests also make it valid.

[6] For an elaborated discussion, see Beck and Katz (1995).

the insufficiency of *PCSE*.[7]

3. Data and Variables

The unbalanced dataset includes 113 developing (low and middle income) countries, covering the period 1974-2013. All considered economies are listed in the Appendix-A. The data are taken from the World Bank (WDI), IMF (IFS), Penn World Tables 7.1, Polity IV Project and individual country sources. In order to attain permanent and systematic component of the data, 5-year averages of all variables is taken. This is in line with the standard empirical growth literature. For each country, GDP growth rate (percentage) is the dependent variable. Inflation, defined as the growth rate of CPI, is the key independent variable. $\boldsymbol{X}_{it}$ is the *k*-dimensional vector of control variables, which includes the natural logarithm of GDP per capita of the initial period, population growth rate, gross domestic savings and government consumption shares (percentage) in GDP, primary school enrollment as a proxy of human capital, lag of the natural logarithm of exchange rate, the share of exports and imports in GDP as a measure of trade openness, and institutional stability index.

4. Results and Discussion

Keeping robustness of the coefficients in mind, four regressions for this sample are estimated through the conventional *FE* or *within*, *RE*, *PCSE* and *FE* estimator with *DK* standard errors. Our preferred choice of *FE* estimator with *DK* standard errors is complemented by various diagnostic checks and the results are also complemented by a battery of specification tests. For example, to see if the time fixed effects are required, after running the *FE* model, the joint test is examined to see if the year dummies are equal to zero. The result [*p*-value = 0.000] indicates that the time fixed effects are needed in both models. Whereas the results of *FE or within* [column (1)] and *RE* [column (2)] are not different at least in terms of signs, even then the

[7]The *PCSE* is based on a large-*T* consistent covariance matrix estimator that becomes inappropriate when *N* is large.

decision about choosing between these estimators is important. To test for the presence of country-specific fixed effects, the Hausman test is performed under the null hypothesis that the RE model is a better fit than the FE model. Since the *p*-value in both models is less than 0.05, it can be concluded that the *FE* model is more appropriate to run. Therefore, the *FE* estimates are chosen. On the same grounds, *DK-FE* estimates are preferred over the *DK-pooled OLS* estimates.

The *LM* test, to pick from the *RE* and *OLS* regressions, is applied under the null hypothesis that the variance across all cross-sections is zero. After running the *RE*-model, our results of the *LM* test [*i.e., p*-value = 0.0027 and 0.0087 in Model-(1) and Model-(3) respectively] indicate significant evidence of differences across the units (*i.e.,* panel effect) exists. The null hypothesis is rejected and it is decided that running a simple *OLS* is not an appropriate regression. The *Modified Wald* test is also utilized for group-wise heteroscedasticity in *FE* regressions under the null of homoscedasticity. Our results [*i.e., p*-value = 0.000 and 0.000 in Model-(1) and Model-(3) respectively] help to reject the null, thus signifying presence of heteroscedasticity. Since serial correlation is a cause for *SEs* to be smaller than they actually are and a higher R^2, *Wooldridge* serial correlation test is applied to test whether there is presence of serial correlation or not. The results [*i.e., p*-value = 0.000 and 0.000 in Model-(1) and Model-(3) respectively] reveal that the data suffers from the first-order autocorrelation. All these diagnostic tests justify that our choice of picking the *FE* estimates with *DK* standard errors and the inference based on this estimator is econometrically valid.

The regression results (Table 1 and 2) fully confirm our conjecture about signs of the parameter estimates. All control variables' estimates are in accordance with the standard empirical literature on economic growth. In general, the economic growth in developing countries is enhanced by lagged growth, growth of population, increased share of gross domestic savings, rise in school enrollment, more openness of economies and greater maintenance of institutional stability. An increased share of the agricultural sector in total output and the government spending tend to reduce the level of economic growth. It is claimed that our estimates are robust to the *CSD* of error terms over time and space. This is remarkable to compare the results of *FE* or *within, PCSE* and *RE* estimations with `*FE* estimates with *Driscoll-Kraay SEs*.' Table 1 and 2 demonstrates that the inference relies noticeably on the choice of the estimator. For example, some of the parameter estimates are insignificant in the column (3) of Table 1 and 2 whereas the same estimates are highly significant in column (4). This can be seen (in Table 2) from the variable *School Enrollment.* While *FE, RE* and *PCSE* standard errors lead to the finding that the parameter estimate of *School Enrollment* is insignificant, *DK* estimates indicate that this is significant at 5 percentage level.

To save the space, only key parameter estimates are highlighted. Consistent with our hypothesis, the coefficient of *Inflation* (π_{it}) is not only linear but also, it is negative and highly significant. An annual increase of 10 percentage in average inflation rate tends to reduce GDP growth by about 0.12-0.20 percentage points. Furthermore, if the issue of sectoral heterogeneity is taken into account, a threshold level of 50 percentage value added contribution of the agricultural sector to the GDP exists beyond which the relationship turns to be positive.

4.1 The Basic Model

The basic model (1) is estimated by using lagged GDP growth, inflation, initial per capita GDP, population growth, gross domestic savings, government consumption share in GDP, school enrollment, lagged exchange rate, trade openness and institutional stability as control variables. More clearly, by employing a fixed effect methodology, the clear evidence for the negative linear association between growth and inflation cannot be ruled out. Table 1 reports that the estimated coefficient of inflation is -0.0115 (*DK-SE* = 0.0015). Thus, a 10 percent marginal increase in inflation rate is linked with a reduction in growth by about 0.12 percentage points. Our results of the basic model are in accordance with those of Barro (1995).

Table 1
Basic Inflation and Growth Model Estimates

Dependent Variable is GDP Growth Rate	(1) FE or Within	(2) RE	(3) Prais-Winsten PCSE	(4) Driscoll-Kraay FE SEs
GDP Growth(-1)	0.0506 (0.0373)	0.1876*** (0.0350)	0.1351*** (0.0482)	0.0506*** (0.0124)
Inflation(π)	-0.0115*** (0.0025)	-0.0059** (0.0024)	-0.0070 (0.0043)	-0.0115*** (0.0015)
Initial PC GDP	-4.0420*** (0.5004)	-0.9325*** (0.1503)	-0.9318*** (0.1554)	-4.0420*** (0.4919)
Population Growth	0.4359** (0.1973)	0.0134 (0.1258)	0.0518 (0.1557)	0.4359*** (0.0524)
Gross Dom. Savings	0.0585*** (0.0148)	0.0424*** (0.0083)	0.0458*** (0.0102)	0.0585*** (0.0053)
Gov. Cons. Share	-0.0999*** (0.0290)	-0.0052 (0.0155)	0.0064 (0.0189)	-0.0999*** (0.0114)
School Enrollment	0.0084* (0.0049)	0.0070 (0.0043)	0.0076* (0.0044)	0.0084*** (0.0021)
Exchange Rate(-1)	0.0419 (0.0410)	-0.0071 (0.0316)	-0.0083 (0.0432)	0.0419 (0.0350)
Trade Openness	0.0081 (0.0062)	0.0113*** (0.0037)	0.0121*** (0.0039)	0.0081*** (0.0018)
Institutional Stab.	0.0636*** (0.0110)	0.0521*** (0.0104)	0.0524*** (0.0108)	0.0636*** (0.0044)
Constant	31.5694*** (3.4820)	9.5420*** (1.2189)	9.4522*** (1.2801)	31.5694*** (3.0912)
Observations	598	598	598	598
Country Groups	98	98	98	98
Lags	-	-	-	7
R^2	-	-	0.28	-
R^2-within	0.39	0.26	-	0.39
R^2-between	0.09	0.35	-	-
R^2-overall	0.11	0.30	-	-
Hausman Test	164.75 (0.000)	-	-	-

Note: Table 1 displays the coefficient estimates from (1) estimated by the estimators in the column headings. The standard errors are reported in parenthesis below the coefficient estimates. The dataset contains annual secondary data, over the period 1974-2013, for a panel of 113 developing economies. The estimations are based on 5-years averages of all variables. The dependent variable is GDP growth rate, and ***, **, and * imply the level of statistical significance at 1%, 5%, and 10% respectively.

Table 2
Augmented Inflation and Growth Model Estimates

Dependent Variable is GDP Growth Rate	(1) FE or Within	(2) RE	(3) Prais-Winsten PCSE	(4) Driscoll-Kraay FE SEs
GDP Growth(-1)	0.0545 (0.0387)	0.2082*** (0.0357)	0.1483*** (0.0485)	0.0545*** (0.0134)
Inflation(π)	-0.0201*** (0.0050)	-0.0196*** (0.0049)	-0.0203*** (0.0071)	-0.0201*** (0.0012)
Agri. Share(Agr)	-0.0459* (0.0256)	-0.0401** (0.0167)	-0.0424** (0.0171)	-0.0459* (0.0197)
Inter(π× Agr)	0.0004** (0.0002)	0.0006*** (0.0002)	0.0006** (0.0003)	0.0004*** (0.0000)
Initial PC GDP	-4.2869*** (0.5315)	-1.1971*** (0.2096)	-1.2401*** (0.2300)	-4.2869*** (0.5999)
Population Growth	0.4696** (0.2016)	0.0097 (0.1255)	0.0542 (0.1520)	0.4696*** (0.0500)
Gross Dom. Saving	0.0598*** (0.0153)	0.0403*** (0.0081)	0.0439*** (0.0100)	0.0598*** (0.0051)
Gov. Cons. Share	-0.1011*** (0.0297)	0.0070 (0.0153)	0.0060 (0.0184)	-0.1011*** (0.0116)
School Enrollment	0.0082 (0.0051)	0.0046 (0.0044)	0.0054 (0.0046)	0.0082*** (0.0021)
Exchange Rate(-1)	0.0397 (0.0431)	-0.0187 (0.0322)	-0.0172 (0.0448)	0.0397 (0.0297)
Trade Openness	0.0072 (0.0065)	0.0103*** (0.0038)	0.0110*** (0.0041)	0.0072*** (0.0016)
Institutional Stab.	0.0574*** (0.0123)	0.0454*** (0.0112)	0.0456*** (0.0121)	0.0574*** (0.0030)
Constant	34.4397*** (4.0163)	12.6267*** (1.9874)	12.9386*** (2.1118)	34.4397*** (4.3710)
Observations	576	576	576	576
Country Groups	97	97	97	97
Lags	-	-	-	7
R^2	-	-	0.29	-
R^2-within	0.39	0.26	-	0.39
R^2-between	0.10	0.39	-	-
R^2-overall	0.12	0.31	-	-
Hausman Test	159.15 (0.000)	-	-	-

Note: Table 2 displays the coefficient estimates from the model (3) estimated by the estimators in the column headings. The standard errors are reported in parenthesis below the coefficient estimates. The dataset contains annual secondary data, over the period 1974-2013, for a panel of 113 developing economies. The estimations are based on 5-years averages of all variables. $Inter(\pi \times Agr)_{it}$ is the interaction term between inflation and value added (%) share of agricultural sector in economy i at time t. The dependent variable is GDP growth rate, and ***, **, and * imply the level of statistical significance at 1%, 5%, and 10% respectively.

4.2 The Augmented Model

In order to address the issue of sectoral heterogeneity, our basic model (1) is augmented by introducing an interaction term, $Inter(\pi \times Agr)_{it}$, between inflation and the value added share (percent) of the agricultural sector in economy *i* at time *t*. It is important to mention that in doing so, the estimates presented in Table 2 do not modify the signs and statistical significance of the coefficient estimates already reported in Table 1. All other parameter estimates are statistically significant with correct signs and do not change significantly as compared to Table 1. Our results demonstrate that keeping all other factors constant, the relationship between inflation and GDP growth, by considering sectoral heterogeneity, can be explained by the value of slope coefficient, [-0.0201 + 0.0004Agr_{it}]. It means that a change in the value added share of the agricultural sector causes the nature of the linkage between inflation and GDP growth to change. For example, if it is considered that the average value added (percentage) share [*i.e.,* 21.048 percent in our dataset] of the agricultural sector, 10 percent increase in inflation will cause growth to reduce by 0.12 percent percentage points. On the other hand, if the maximum value of the value added (percentage) contribution (*i.e.,* 76.76 percent) to GDP is considered, 10 percent increase in inflation tends to encourage the GDP growth by 0.11 percent. By (4), threshold value contribution of agricultural sector is 50 percent, at which the relationship between inflation and GDP growth turns to be positive. In our dataset, this happened only for the economies of Burundi, Chad, Ethiopia, Ghana, Lao People's Democratic Republic, Liberia, Nepal, Niger, Sierra Leone and Uganda.

5. Concluding Remarks

By taking into account sectoral heterogeneity and cross-sectional dependence, evidence has been found that inflation in developing countries come along with the lower economic growth. The empirical findings are consistent with a linear negative relationship. An annual increase of 10 percent in average inflation rate tends to reduce GDP growth by 0.12-0.20

percentage points. However, inflation can only be positively associated with the economic growth if the value-added share of the agricultural sector in total output exceeds the threshold level of 50 percent. The opposite applies to the lower levels. Our dataset indicates that this happens only for a few low-income economies of African region. Therefore, in general, our study invalidates the argument that the central bankers of developing economies, while examining the monetary policy transmission mechanism, need to pay a specific attention toward the agricultural sector. Accordingly, inflation-growth dynamics in low-income African countries might be region-specific. A small sample investigation to probe these differing dynamics might also provide some useful information. Authors leave this question to be answered in future.

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Appendix

A-Complete List of Selected Economies

All empirical estimations are carried out for the countries: Albania, Algeria, Angola, Argentina, Armenia, Azerbaijan, Bangladesh, Belarus, Belize, Benin, Bhutan, Bolivia, Bosnia and Herzegovina, Botswana, Brazil, Bulgaria, Burkina Faso, Burundi, Cambodia, Cameron, Central African Republic, Chad, China, Colombia, Comoros, Democratic Republic of Congo, Republic of Congo, The Costa Rica, Cote d'Ivoire, Dominica, Dominican Republic, Ecuador, Egypt, El Salvador, Eritrea, Ethiopia, Fiji, Gabon, Gambia, Georgia, Ghana, Grenada, Guatemala, Guinea, Guyana, Honduras, India, Indonesia, Islamic Republic of Iran, Jamaica, Jordan, Kazakhstan, Kenya, Kyrgyzstan, People's Republic of Lao, Lebanon, Lesotho, Liberia, Macedonia, Madagascar, Malawi, Malaysia, Maldives, Mali, Mauritania, Mauritius, Mexico, Micronesia, Moldova, Mongolia, Morocco, Mozambique, Namibia, Nepal, Nicaragua, Niger, Nigeria, Pakistan, Panama, Paraguay, Peru, Philippines, Romania, Rwanda, Samoa, Senegal, Seychelles, Sierra Leone, South Africa, Sri Lanka, The St. Lucia, St. Vincent and the Grenadines, Sudan, Suriname, Swaziland, Tajikistan, Tanzania, Thailand, Togo, Tonga, Tunisia, Turkey, Turkmenistan, Uganda, Ukraine, Uzbekistan, Vanuatu, Venezuela, Vietnam, West Bank and Gaza, Yemen, Zambia, Zimbabwe.